Leading-Edge Motorsport Technology Since 1990

Racecar engineering™

April 2018 • Vol 28 No 4 • www.racecar-engineering.com • UK £5.95 • US $14.50

FORMULA 1

Hello Halo!

We reveal how F1 teams adapted to controversial new head protection system

WRC in focus

Top World Rally teams' tech secrets uncovered

Formula Vee build

Our Brazilian single seater project hits a major issue

BR1 starts testing

Russian LMP1 that's set to challenge for Le Mans win

The evolution in **FLUID HORSEPOWER™** continues...

XRP ProPLUS Race Hose™

NEW... XKS SILICONE OUTER COVER
Gloss black Silicone covering over XK Aramid braid reinforcement. Excellent protection for BOTH ProPLUS & ProPLUS Xtreme.

PROPLUS RACE REUSABLE HOSE ENDS ARE AVAILABLE NOW!

ANTI-STATIC PTFE IS COMPATIBLE WITH ALL AUTOMOTIVE FLUIDS AND FUELS
A highly compressed, non-porous matrix resists fuel permeation and diffusion.

SMOOTH INTERNAL TUBE
Superior flow rates, minimum pressure drop AND ease of clean-out, not possible in convoluted hoses.

PATENTED MANUFACTURING PROCESS
Creates a full PTFE smooth-bore hose for optimal flow with external convolutions for flexibility.

RACE CRIMP HOSE ENDS
Hundreds of styles. Choice of full hex or lightweight turned down swivel nuts. Black is standard, also available in Blue or Super Nickel.

EXTERNAL CONVOLUTIONS
Promote hoop strength for vacuum resistance and supports tight bend flexibility.

A CHOICE OF OUTER BRAIDS
XS: Stainless Steel,
XM: Lightweight XtraTemp Monofilament
XK: Aramid Fiber, XT: Tube only for inside fuel cells
and New XKS: Silicone over Aramid.

ANTI-STATIC PTFE TUBE
A high flowing, smooth bore, PTFE tube with *external* convolutions for flexibility. No *internal* convolutions to restrict flow.

SUPERIOR VACUUM SUPPORT
An engineered design with an externally wound stainless steel wire that provides great vacuum support and tight bend capability.

A CHOICE OF LIGHTWEIGHT BRAIDS:
XM - XtraTemp Monofilament, XK - Aramid and
NEW XKS: Gloss black Silicone over Aramid braid.

ProPLUS Xtreme Race Hose™

Highly Kink-Resistant, Quite Possibly The Perfect Dry Sump Vacuum Race Hose

Follow us on Instagram @XRPracing

Like us on Facebook /XRPinc

Go to www.xrp.com to learn more about the ProPLUS Race Hose™ product line.

An exceptional achievement in race hose technology...

UNITED STATES XRP, Inc.
5630 Imperial Hwy., South Gate, CA 90280
sales@xrp.com tel +1 562 861 4765 fax +1 562 861 5503
EUROPE & UK Protec Fuel Systems Ltd.
info@protecfuelpumps.com tel +44 (0) 121 572 6533

XRP®
THE XTREME IN RACECAR PLUMBING

CONTENTS – APRIL 2018 – Volume 28 Number 4

COVER STORY

COLUMNS

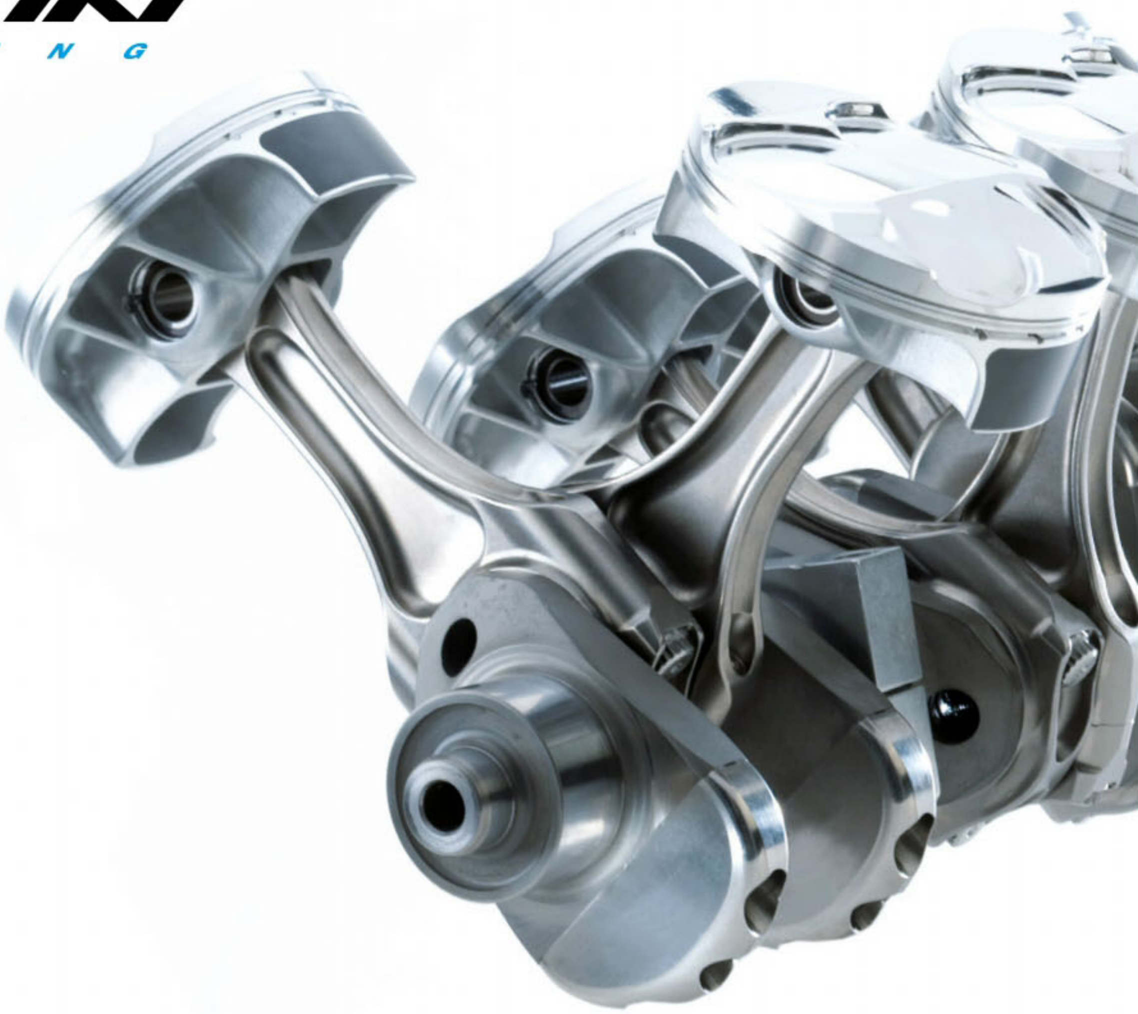
FEATURES

TECHNICAL

BUSINESS & PEOPLE

IndyCar has tested a new cockpit protection device and the results have been very encouraging. Turn to page 16 to find out more

pankl RACING



High Tech | High Speed | High Quality

Pankl Systems Austria GmbH

Engine Systems

A-8600 Bruck/Mur, Kaltschmidstraße 2-6

Phone: +43(0)3862 51 250 0

Fax: +43(0)3862 51 250 290

e-mail: engine@pankl.com

www.pankl.com

Wacky races

Looking back on some of motor racing's oddest pit stops and strangest finishes

Many racing stories become legends, true or not. Some happened a long time before I was there, so I cannot confirm them, but here are a few that have stuck in the memory.

Vittorio Jano was Alfa Romeo's chief engineer. He was of Hungarian descent, having been baptised Viktor Janos. He was a civilised man who enjoyed life, and he was responsible for many iconic cars.

At Alfa Romeo his first design was the 8-cylinder in-line P2 grand prix car. He also produced the P3 model, which later was raced with great success by Enzo Ferrari when he began Scuderia Ferrari in 1933.

Jano resigned from Alfa Romeo at the end of 1937 and moved to Lancia. Among his designs at Lancia was the grand prix D50 for 1954, but after the death of Alberto Ascari and the Le Mans disaster, both in 1955, Lancia left GP racing and Ferrari took over the programme, inheriting Jano.

Jano's contribution to Ferrari was fundamental. With the encouragement of Enzo's son, Dino, Jano's V6 and V8 engines pushed the older Lampredi and Colombo engines aside, in racing. After Dino's death, Jano's Dino V6 became the basis for the company's first mid-engined road car, the 1966 206 Dino. His V6 and V8 displaced Ferrari's V12 focus and their descendants continue to be used to this day.

Lunch control

But it's another unsung Jano innovation that I would like to discuss here: the pit stop lunch. For the first Belgian GP at Spa, in 1925, Alfa had such a superiority for the race Jano had a table installed in the pits so he and the mechanics could sit down and have something to eat and drink as the race progressed.

Legend has it that its two drivers, Antonio Ascari (father of Alberto Ascari) and Giuseppe Campari, were so far ahead during the race that they got out of their cars during the pit stops and sat at the table to have a quick bite to eat. Ascari won and Campari was second. It must be added that by race-end there were no other finishers, so it's quite possible it happened, as the competition had disappeared.

Another racing moment that produced an unusual pit stop happened to Rob Walker during the 1939 Le Mans 24 hour race. Walker was the heir to the Johnnie Walker whisky fortune and a bon vivant, later a team owner, running Stirling Moss, Graham Hill, Tony Brooks, Ricardo Rodriguez and Jo Siffert; and the first and last privateer to win a Formula 1 grand prix as an entrant. He also took the first rear-engined F1 victory at the Argentine GP with Moss and the Cooper-Climax in 1958, the first and only four-wheel-drive win with the Ferguson P99 in 1961 (a non-championship race) and scored a total of nine world championship wins.

Pitting wits

A captivating character, who confided to me at the first Long Beach F1 GP of being chuffed to find he had the same stateroom on the Queen Mary liner that he had once always used when crossing to the US; the liner being now moored permanently as a floating hotel. In his passport he described his profession as 'gentleman', and informally he described himself as 'self-unemployed'. He never had a formal contract with Moss, deeming a handshake adequate. For Le Mans, Walker would dress accordingly, doing the 8pm stint in an impeccable pin-striped dark suit and tie, and donning an informal Prince of Wales check for the Sunday morning stint. Towards the end of the 1939 race the crew flagged him in because they were down to the last bottle of champagne, and they knew he wouldn't want to miss that. 'Oh absolutely, quite right,' was his comment, helping to finish the bottle then getting back out to finish the race ninth. After the race he drove the car back to Blighty, with the champers reserve topped up, of course.

Vittorio Jano is well-known for the creation of the Alfa Romeo P3 but he was also responsible for grand prix racing's first pit stop for lunch

Liquids were also involved at the Monza 1000km sportscar race in 1992, when one of the Spice cars came in to the pits with an overheating gearbox. The only cool liquids available in the pits were several cans of Coca-Cola, which were then duly poured over the offending box to cool it down.

But pit stops can be caused by more painful, personal reasons. Reportedly Eddie Irvine had to pit when his crotch-straps were causing problems during one GP, but the stop was longer than could be expected due to an argument by the mechanics about who would actually fumble around Eddie's nether parts to adjust belts and alleviate the pain.

During pit stops, communication between driver and engineer depends on understanding the problem. When Bruno Giacomelli (the famed honorary Irish driver, AKA 'Jack O'Malley') had to speak with Robin Herd who was engineering his car, the solution for Bruno's lack of English and Robin's lack of Italian was to speak in Latin, Robin having had a classic education and Bruno having studied as a seminarist for the priesthood, probably the only time in history Latin has been used in racing. Presumably understeer was 'infra-directionis'.

Crossing the line

But not only pit stops are crucial to finishing races. You also have to cross the line. In 1919 Andre Boillot won the Targa Florio, doing the 420km distance of the Madonie course, running around Sicily. Arriving at the finishing line Boillot found the straight completely swamped by spectators obliging him to brake and lock up, resulting in a spin just before the line. Both driver and riding mechanic got out and pushed the car backwards over it, but being afraid it wouldn't count as a win, they pulled the car back over the line, turned it around, and then crossed it front-first.

At Avus in Germany, one time, a mixed grid Formula 2 and Formula 3 race had the finishing line in the braking area for a chicane. *Autosport* described the race as 'specially chaotic', not least because the drivers sussed out that the way to get places and win on the last lap was to go full bore past the line and crash after taking the flag. Peter Westbury did exactly that, picking up three places, duly crashing, but still the winner.

Dieter Quester had done the same, but got the number of race laps mixed up, crashing on the penultimate lap when trying this tactic. Quester was also the protagonist of another unusual finish, also at Avus, rolling his DTM BMW car and taking the flag upside down. For the next race, just in case, the mechanics had a huge 'This side up' sticker with an arrow affixed to the dash.

At Le Mans the crew flagged Rob Walker in, because they were down to their last bottle of champagne and they knew he wouldn't want to miss that

Hero dynamics

While the risks are not what they were the stakes are still high in top-level racing

Having been in the Ferrari garage during F1 testing a little while back, one of my abiding impressions was the remarkable composure of the then teenage driver Charles Leclerc. While most youngsters of this age are coping with the transition from school to university or their first job, he appeared to be completely unfazed with this daunting responsibility.

Here was this kid, about to step into an almost priceless, advanced-technology, near-1000bhp machine carrying the badge of the most iconic marque and capable of mind-boggling speed. He was surrounded by a small army of engineers and technicians plus banks of computer screens and communications/data equipment, all of this intensive and hugely-expensive exercise focused totally on him and his ability to deliver exactly as needed. Every action mercilessly recorded, no mistake unnoticed. Oh, and the track was damp.

Living on the edge

Contrast this to grand prix drivers of yesteryear. Most would rock up to the circuit, helmet bag in hand and not much else, to join just a half-dozen mechanics and an engineer. In the case of a few impecunious teams, the race driver doubled-up as truck driver and might well muck-in on various duties, including making the tea. There were few sponsor and press commitments on race weekends. Physical fitness relied on a bit of running rather than gruelling daily gym sessions. Enjoying alcohol over dinner was not uncommon. F1 and sportscar hero Jo Siffert was even known to knock back a pint of lager at lunchtime while testing the fearsome Porsche 917 (perhaps with this beast in its early form he needed to). No simulators to endlessly pound around virtual tracks then, time between tests and races was available for chasing women and having a good time. It was possible to become a grand prix driver on merit alone.

On the face of it, how cool was that? But pressure certainly existed, albeit not the same. Pay was miniscule compared to today; often most of it was a share of the prize money plus product endorsements. Contracts, if they existed at all, were sometimes race-to-race, so the need to obtain results was crucial to make a living. Every opportunity to accept a drive was taken, even when meaning extra risk. Race teams have always wanted to win, so drivers then certainly felt this responsibility, even if only to a relative handful of people rather than the hundreds necessary now to put the car on track. But the big pressure, even if banished to the back of the mind, was the real fear of serious injury and fire – frequently, death itself – due to the cars and tracks of the time.

Not just the drivers. Designers had simple tools with which to work. Decisions on key components were often based as much on empirical practice as on calculation. Testing had no more data-capture than a tyre temperature gauge, clipboard and stopwatch, feedback consisted of verbal communication between driver and engineer.

Times have changed: Jo Siffert, who shared this Porsche 917 with Derek Bell at Spa in 1971, would down a lager during breaks in testing

Suspensions and steering did break, wheels came off and throttles jammed open. Many an engineer must have experienced waking at 4am worrying if he had overlooked anything critical.

Great expectations

To cope with the changing pressures over time has required different mind-sets. The 'live for the moment' attitude of past drivers has been replaced by ultra-professionals groomed from childhood through karting and junior formulae to be prepared for their chance of joining the F1 grid. Despite being supported by personal trainers, sports psychologists and the like, competition for seats is extreme. Everything has to be pushed to the limit.

Intuitive engineering accompanied by a hard-nosed attitude towards driver risks as once existed has morphed into the scientific approach of data collection and painstaking analysis; conceptual vision into a much wider understanding of how performance can be achieved under restrictive regulations. Chief designers are now managers of resources, employing the best technologies as well as many people. It needs a calm head as well as a firm hand in achieving the desired result, never losing control of the many strands that end up producing a competitive racing car. While F1 racing cars of today are infinitely more complex, with many more design and manufacturing aspects to consider, there are fantastic databases and terabytes of hugely powerful computer simulation to assist in this. The buck will still always stop with whoever is in overall charge, but the consequences now, while fear of failure and damaged reputation remain as before, are also measured in millions of pounds if races and points are lost. The same applies to chief mechanics and their crews, who have to cope with ever-increasing levels of technical sophistication.

Under pressure

Originally the team manager's job was fairly straightforward; largely organisational, the hiring and firing of personnel, plus negotiating start money, supplier contracts and driver deals. There was (Ferrari excepted) almost none of the media intrusiveness and exposure that is currently the norm.

The duties of the team manager in Formula 1 are nowadays so multiple and onerous that they are split between several individuals. But even if responsibility is shared, the ultimate call will still fall upon the team principal.

A team principal's need to deploy low cunning and political manoeuvring in the F1 Strategy Group meetings and in negotiating driver contracts has reached new levels, such are the perceived advantages to be gained or lost. Where millions count, sport quickly goes out of the window.

Undoubtedly, the pressures overall upon a contemporary Formula 1 team are far greater overall than 50 years ago, because of the growth in scale, sponsor expectations and the relentless media attention. It requires the ability to mentally compartmentalise, to take in the ramifications of the big picture without succumbing to it. But, to keep everything in context, any mistake, however crucial to results, is thankfully far less likely now to end up in tragedy.

The big pressure, even if banished to the back of the mind, was the real fear of serious injury and frequently death due to the cars and tracks of the time

The reigning champion Mercedes team has taken a conservative approach to Halo, where design and implementation regulations allow some freedom

The Halo effect

Formula 1 2018 hit the ground running in Barcelona with all new Pirelli compounds, aero and the controversial head protection Halo system

By GEMMA HATTON and SAM COLLINS

Formula 1 has ushered in a host of changes for the 2018 season. The new head protection system, known as Halo, is the most obvious from a visual point of view, and has already attracted a lot of negative feedback from the teams. It has also had a significant effect on the rest of the car, in terms of weight and design thanks to a late introduction of the regulation leading in some cases to an all-new chassis design. With new tyres from Pirelli, offering teams a new challenge of working them at different circuits, and longer life power units for this season, teams have had anything but an easy preparation for the season.

The Additional Frontal Protection-Halo (AFP-Halo, or just Halo) is without doubt the biggest visual change between the 2018 Grand Prix cars and those used in 2017. In design terms the Halo is governed by its own specific appendix to the FIA technical regulations. Everything from the shape and dimensions of the device to the material it is made from (titanium alloy Ti6Al4V Grade 5) is defined. However there is still scope for different manufacturers to supply their own products into the category, though each must be homologated independently at the Cranfield Impact Centre. At the time of writing three companies had homologated Halos; CP Autosport of Germany, SS Tube Technology in England and a third company, V System, from which each team must purchase their Halos.

Airflow impact

As can be imagined for such a visually obvious addition to the car, the aerodynamic impact of Halo is noteworthy, and the teams are doing what they can to deal with its impact, particularly on the airflow over the whole car.

'It has a significant downstream effect, especially round the rear wing area,' highlights Andy Green, Technical Director of the team known as Force India at time of writing (the team name is likely to change by the first race in Australia in March). 'It is not designed to be an aerodynamic device, so it doesn't do us any favours in that department and it requires a lot of work to mitigate the issues that it causes. In testing we will make sure we understand that the losses coming off the halo are where we think they are from our modelling tools. If that is confirmed we're confident that the parts we'll bring to the car will sort out those losses.'

It is something being worked on right up and down the pitlane with lots of airflow sensors fitted to cars around the Halo structure and downstream of it. 'Aerodynamically speaking, Halo is certainly not penalty free and I think there is a challenge there to either cope with it in the first instance, let's call it damage limitation, and thereafter think about opportunity and exploitation,' Peter Prodromou, McLaren's Chief Technical Officer for aerodynamics adds. 'It does open up some avenues which are possibly interesting to look at. I am sure there will be a variety of different solutions out there but the scope is quite limited to the allowance around the basic shape, but there is opportunity.'

Aesthetic gain

The rules allow a 20mm area of freedom around the titanium structure, introduced partly for aesthetic reasons but predictably these fairings are being used for aerodynamic gain, as some teams have added winglets and in one case airliner style vortex generators to their Halos.

'In testing we will make sure we understand that the losses coming off Halo are where we think they are'

'It has effects on the cockpit because it is local to that opening. You have got the driver in there and so you've got to make sure you don't have the negative effects there,' Toro Rosso Technical Director James Key adds. 'You've got effects on the engine air intake and effects after that towards the back, so there are a number of different things you have to think about. None of them are massive effects but they all require some level of attention.'

Fitting the Halo is no easy challenge either; not only does the Halo have to be homologated independently, it also has to pass crash tests as part of the chassis homologation procedure. This has proved to be a major issue for teams.

Toro Rosso is one of several teams to try to increase aero efficiency with its Halo design, one of many to choose this option

The 20mm area at the top of the Halo has been exploited differently by the teams. The Haas team has adopted this toothy solution while others have mounted a wing

New rubber from Pirelli is designed to help drivers and teams at particular tracks. Pressure sensors were all the rage in Barcelona as teams completed their aero maps during pre-season testing

‘It takes the weight of a London bus and when you see that test going with that amount of load, it is a bit scary’

‘We always knew it was going to be a challenge so have invested time and money up front to do a lot of test pieces,’ McLaren Chief Technical Officer Matt Morris admits. ‘Obviously, you don’t want to build a complete chassis but we built a few test pieces with dummy Halos and parts of Halos to test how the interfaces would behave and we found some issues. It was close, we didn’t breeze through and there were some heart-stopping moments with particular static tests coming in from an oblique angle. It takes the weight of a London bus and when you see that test going on with that amount of load and everything that moves around – which it is designed to do – it is a bit scary.’

During the chassis homologation tests the Halo has to withstand various loads without it or the monocoque failing. The biggest load applied to the structure is 116kN from above, which has to be endured for five seconds. Longitudinal forces of 46kN and 83kN are applied from the front as well as a lateral load of 93kN from the side. For comparison, the roll structure on top of the car has to withstand 50kN laterally, 60kN longitudinally and 90kN from above.

Weighty issue

To survive these severe loads, the Halo itself has become quite a substantial structure, weighing by regulation 7kg (+0.05kg, -0.15kg). In addition, the monocoque has also had to increase in strength significantly to cope with these tests. This has further increased the weight of the chassis by approximately 12-13kg. Whereas, the 2018 technical regulations have only allowed a minimum weight increase of 5kg to 733kg, forcing teams to save weight in other areas of the car. Interestingly, now at the start of a race a 2018 Formula 1 car will weigh roughly the same as a non-hybrid LMP1 in qualifying trim.

‘From a design perspective, weight is a big part of it. The weight limit did go up, but not by nearly as much as the installation weight of the halo so it put additional stress on all the other parts of the car,’ Green continues. ‘We had to try to optimise the weight in those areas to try and keep the weight limit below the minimum so

Short sidepod concept

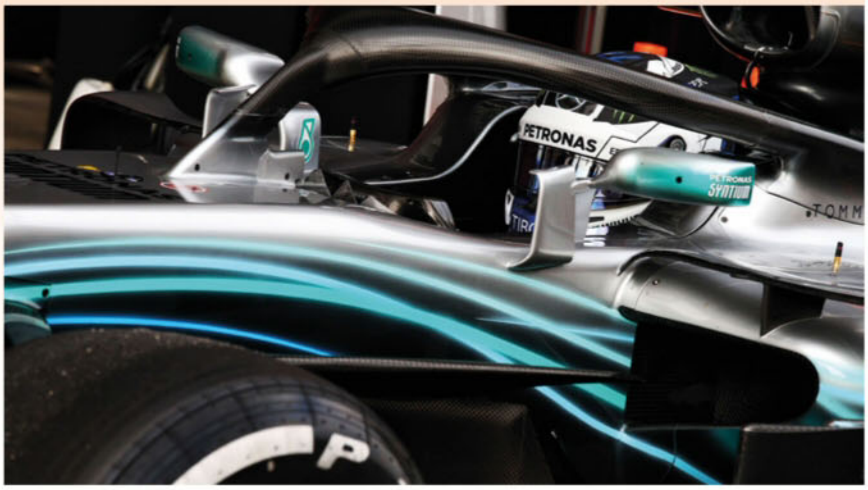
In 2017 Ferrari introduced a new short sidepod concept, relocating the upper side impact structure (a single specification design shared by all teams) and moving the main cooling aperture rearward. A set of box shape aerodynamic elements forward of the duct ensure rules compliance. Ferrari took this approach for aerodynamic reasons rather than those of cooling. In 2018, half the grid featured the same solution, but not all teams agree that it is the right route, with Mercedes, Renault, Force India and others all opting against adopting the concept.

Conservative approach

'Everything you do in aerodynamics has an opportunity cost; there is much more opportunity to make the car worse than better,' claims Mercedes Technical Director, James Allison. 'If you want to pursue a new and different concept, you will expect to find a fair amount of loss before you get back into positive territory. We looked at that concept and felt it would spend too much time being in negative territory before it would perhaps offer any gain at all. If you are a [team] that is a long way down the grid the situation is different it is worth taking that gamble, as you have less to lose and you know that the path you are on is not right.'

It is likely that the relocation of the side impact structure would require a substantial change to the monocoque design, while getting adequate airflow into the cooling system with such a complex arrangement of aerodynamic elements around the leading edge of the sidepod duct is also likely to be a major challenge.

Sidepod design seems to be led by Ferrari, with impact structure relocation for efficient aerodynamic effect



Mercedes has not adopted this same approach, believing that too much time would be lost in development

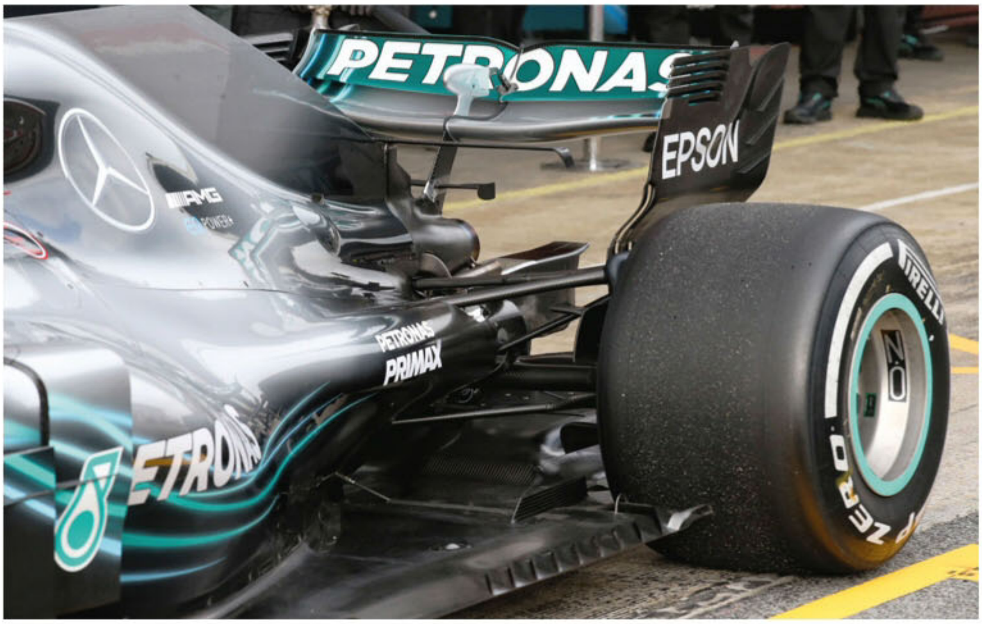
that we can run ballast because the other area that we have to bear in mind is we have to hit a weight distribution target as well.'

Although it was originally introduced as a temporary measure to help Pirelli develop tyres when it became the sole tyre supplier in 2011, the technical regulations still limit every car in terms of weight distribution, with just a 7kg window of freedom. This means that while some teams may be able to build a car under the minimum weight, they cannot get it fully within the distribution window.

Halo kitty

'You only have a very small window of weight distribution so the actual architecture of the car needs to be correct to start with, otherwise you're adding ballast to a car that doesn't need ballast just to get the weight distribution right,' Green says. 'We would have loved to have added a huge safety margin to the whole design so that we would happily sail through the crash and load tests without any issues but that wasn't possible because the weight limit of the car didn't go up enough. We couldn't afford to increase the base weight of the car more than a few kg because we knew we only had a few kg that wecould take out of the car. It was, structurally, incredibly challenging.'

This weight challenge has seen at least one team, Renault, substantially rework the



The loss of the T-wing is not total; some teams are trying to recover some of the effect with lower mounted winglets

rear end of its car as a result, abandoning its cast titanium gearbox casing (something it has evolved over many seasons) in favour of a composite transmission.

While the price of the Halo itself is relatively modest, the cost of developing a chassis to fit it is higher than some of the smaller teams would like. This cost was worsened by the late decision to adopt the Halo as the 2018 AFP solution, with

'You have a small window of weight distribution so the architecture of the car needs to be correct'

With only a 7kg weight distribution, teams have struggled to get the weight down and remain in the window; Renault adopted a composite gearbox casing to reduce weight

teams only informed of this final decision in September, 2017 after a long discussion process.

'Expense-wise it's huge because we had to do a new chassis. We wouldn't have anticipated doing a new chassis this year given the number of changes we made last year. For a team like us we would look to try and get two years out of the chassis if possible. So in that respect it cost us a huge amount to redevelop and redesign the new chassis. It is in the hundreds of thousands, if not million dollar mark, to put the Halo on the car for us,' says Green.

Screening process

The Halo has had a largely negative reception from drivers, teams, the media and fans. This has lead to work continuing on alternative additional frontal protection systems. In 2017 a brief test run was conducted with a clear windscreen fitted to a Ferrari, but while this solution solved the frontal impact requirements, the driver complained of visual distortion. However, Indycar is now experimenting with a similar aeroscreen solution (see p16). Teams prefer the windscreen option not only for aesthetic reasons but also as it is much lighter than Halo with lower requirements on the chassis structure.

The weight increase as a result of the Halo also places an additional demand on the four power unit suppliers, which have also had to increase the life of their power units. Teams can now only use three combustion engines (ICE), three MGU-H's and three turbochargers (TC) during the season, compared to four last year. That's 2,100km of racing mileage not including practice sessions or qualifying. Whereas the energy stores (ES), control electronics (CE) and MGU-K's are all limited to two per season, or 3,150km of racing. This demand for increased reliability will no doubt have forced the suppliers to manufacture more robust units, yet they have had to minimise weight to help teams comply with the minimum weight regulations which have been challenging to achieve with the consequences of Halo. It remains to be seen how successful they have been.

Tyre dilemma

The other major changes for this year come from the tyres. To encourage overtaking and pit stops, Pirelli have added two more colours, and therefore compounds, to their tyre compound rainbow, the Superhard and the Hypersoft, as well as making the entire range a step softer, and introducing new allocation rules. The Superhard is now the hardest compound, adopting the conventional orange colour of the Hard, which has now become the light blue, and the Hypersoft is the softest compound and is light pink in colour. However, to gain a full understanding of these additional compounds we need to reflect on 2017.

The significant aerodynamic changes of the 2017 regulations resulted in an increase in loads of over 20%, demanding the tyres to be extremely robust, leading Pirelli to ramp up the stiffness of their entire compound range. Pirelli also had to develop tyres with little knowledge of the potential performance that the teams could achieve in 2017. Despite 12,000km of testing, the 2014 adapted 'mule' cars that Pirelli used to develop the 2017 compounds only achieved a 10% increase in downforce and therefore the results were unrepresentative and inconclusive. To cope with this, Pirelli went for a conservative approach last year, and having tried and tested their designs for an entire season, the 2018 range is a slightly more aggressive evolution of 2017.

Compounding issues

'The 2018 compounds are from the same family of compounds as 2017,' explains Mario Isola, Sporting Director of Pirelli. 'The reason why degradation was so low last year was because these compounds have less surface overheating and in general behave in a different way. In particular we used the 2017 Soft as a baseline [for 2018] because last year the Soft had a wider working range compared to the other compounds. Last year's Soft is now the Medium.'

From there, the 2017 Soft 'baseline' was then developed and used to create this year's softer compounds (Soft, Supersoft, Ultrasoft and Hypersoft), each decreasing in stiffness in relatively consecutive steps. Although Pirelli, along with some drivers, have commented that the softer compounds of the 2018 range, tested at Abu Dhabi last year were 'much closer

'We used the 2017 Soft as a baseline because last year the Soft had a wider working range compared with the other compounds'

Delivering Excellence Through
Innovation & Technology

RICARDO

Ricardo's advantage is clear

The transmission technology behind a winning Formula 1 partnership.

Formula 1 is unrivalled in every aspect of high-performance motorsport – the speed of its cars, the demands of its tracks, the quality of its drivers and the secrecy surrounding its customers and technologies.

Ricardo can't tell you about the specifics of its 20 year history supplying the very best teams in Formula 1 with the most successful transmission technologies.

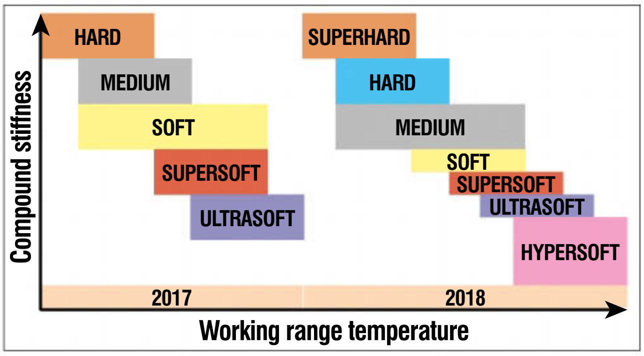
We definitely can't tell you about the components and transmissions we supply, or the teams we supply them to, or the numerous drivers and teams we've supported to victory. We can't tell you about the breakthrough materials and advanced machining equipment we use to deliver products for these extreme-sport applications, either. We can't even tell you who, within our unrivalled team of UK engineers, works tirelessly to ensure every design is optimized to deliver unmatched performance, over the shortest lead times in the market.

What we can tell you, however, is that our capabilities will deliver you a clear advantage across key components in the covert world of Formula 1.

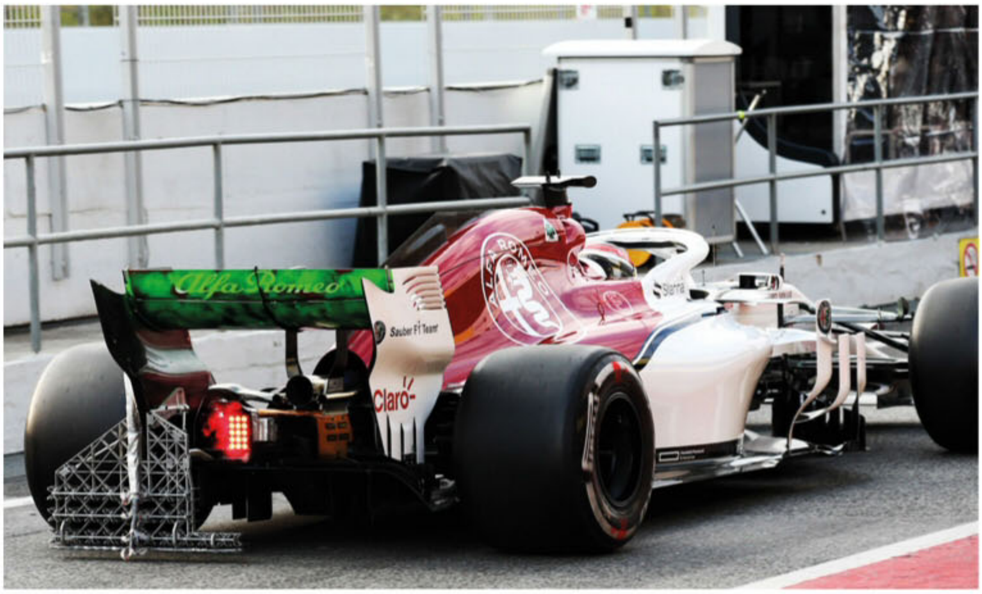
Find out how our experts can help you.

Email: motorsport@ricardo.com Tel: (UK) +44 (0)1926 319319

www.**ricardo**.com/motorsport



Above: A simplified diagram illustrating the compound changes from 2017 to 2018. This year's compounds are all a step softer, with the 2017 Soft and its wider working range becoming the 2018 Medium. The delta between the Soft, Supersoft and Ultrasoft are much closer, and the Hypersoft is an aggressive step, based on running at the Abu Dhabi test last year. **Right:** Pirelli's new tyres on display in Barcelona – the colours were chosen by the marketing department



Traditional testing methods like flow-vis are still a primary aero tool for F1 teams in testing; here a Haas in the pitlane

together' in terms of the performance delta, the Hypersoft is much more aggressive.

'The Hypersoft is quite a step softer compared to the Ultrasoft,' highlights Isola. 'We don't have a lot of data but at Abu Dhabi, which is a low severity circuit and not that far from a street circuit, the Hypersoft was behaving like a very soft compound. It was about 0.9-1.0 seconds per lap quicker than the Ultrasoft and it was able to run for eight laps on average.' However, Valtteri Bottas at this year's Mercedes launch highlighted how the Hypersoft was only suitable for 2-3 laps during Abu Dhabi testing.

Similar to when Pirelli introduced the Ultrasoft in 2016, the pink Hypersoft has been predominantly designed to give drivers that extra level of grip at street circuits. Depending on the results from Monaco, however, teams might just see the pink tyres at other low severity tracks towards the end of the season.

The aggressive nature of the softer compounds has also led Pirelli to modify the front tyre construction. Not only do this year's tyres feature a rounder profile, incorporating new materials, but the distribution of forces over the contact patch have also improved.

Shooting range

'The other difference for this year is that the working range now decreases consecutively from the Medium to the Hypersoft,' says Isola. 'We don't have this alternating between low working range and high working range compounds. The harder compounds are high working range and the softer compounds are low working range.' Previously, the high working range compounds were the Hard and Soft with the low working range compounds the Medium and Supersoft. The Ultrasoft was Medium to High working range. 'This is important to make the compounds more predictable,' says Isola. 'Teams complained that they would set up the car for the Soft and it was difficult to manage when they put the Supersoft on. Now, with this change in working range it will be much better.'

With regard to the Superhard; 'Forget it,' laughs Isola. 'We're not going to use it. The Superhard compound is an insurance for us in case we have underestimated the development of this year's cars. It's much better to homologate an additional compound to keep in our pocket, rather than introduce a new one. From our simulations we are quite confident that we are not going to use this compound.'

Joy division

This year's softer tyres are not only going to make the drivers happier, but hopefully the fans as well. Softer compounds lead to higher degradation, resulting in larger performance differences between drivers out on track, so promoting more overtaking. To encourage this further, Pirelli have changed their tyre allocation rules. Rather than teams choosing their allocation from three consecutive compounds specified by Pirelli, teams can pick a double step in compound. For example, instead of running the Medium, Soft and Supersoft, teams can use the Medium, Soft and Ultrasoft, as is the case for this year's Chinese Grand Prix. This opens up the options for some interesting strategic decisions, which again could result in more exciting racing.

Although 2018 is an evolutionary year in terms of regulation, once the effects of Halo have been validated on track, teams will be bringing plenty of performance upgrades throughout the season. This, together with the unknown performance of the new tyres and the increased pressure on power units, gives 2018 all the ingredients for an exciting season – let's hope that this is the right recipe.

'The Superhard compound is an insurance for us in case we have underestimated the development of this year's cars'

Screening process

While Formula 1 has embraced the unloved Halo, IndyCar has now started testing a rather different approach to cockpit intrusion safety. *Racecar* investigates

By ANDREW COTTON

Head protection in open cockpit cars has become a major topic in Europe with Formula 1's introduction of the Halo. But it's also an issue in the US and IndyCar has been working with its car builder Dallara to introduce the Opticor screen-based head protection system, which has been retro-fitted to the current chassis for a test.

The Opticor, produced by PPG, was tested on the Phoenix short oval in daylight, dusk and at night by Scott Dixon, and was hailed a success, although there is a long way to go for the system before it can be introduced into competition.

The material has been shown to be stronger, lighter and more impact-resistant than polycarbonate

Main picture: The safety screen performed well when tested at Phoenix and visibility was said to be fine, while there appeared to be no major aerodynamic effect as the lap times were also good **Above:** The Opticor screen is now set to be impact tested by a company that works with the military because IndyCar's own crash sled is unable to propel objects at 200mph and more

The FIA looked at different ideas for F1 cars for some time. It fired a 20kg wheel and tyre at 225kmh into a variety of potential solutions. One was a polycarbonate windshield, the second a jet fighter canopy made from aerospace-spec polycarbonate, while the third evolved into the Halo structure that is being introduced into Formula 1 this year.

Red Bull Racing had also proposed a concept that included an aero screen, but this had shattered in testing and was not taken forward. In 2016 Formula 1 experimented with systems actually fitted to a car, including the Halo, Aeroscreen and then a year later with what was dubbed the Shield at the British Grand Prix at Silverstone. The Shield, tested on Sebastien Vettel's Ferrari, looked pretty enough, but there were issues with reflection and distortion, which also made Vettel feel sick.

Screen saver

IndyCar has clearly got around the vision issue, with Dixon only reporting slight issues with hitting the apex of the corners, which may have had more to do with the mounting of the screen and the proximity of bolts to the drivers' eye-line. 'With PPG's help we had a set of rules we followed when creating the shape of the windscreen,' says Jeff Horton, director, engineering and safety at IndyCar. 'They have years of experience in fighter jets and other vehicles on how to make distortion-free windscreens. We followed those rules and the results are what Dixon ran at Phoenix.'

Unlike with some previous aerodynamic and safety measures, IndyCar has taken complete control of the development of the system. It worked with PPG to set the specifications and enlisted Chris Beatty Designs to draw concepts based on those specifications.

The jet set

The proposed solution was sent to PPG for approval, and the company then produced two prototypes, which were then used by Dallara to provide the CFD for the mounting flange for the attachment to the tub and the windscreen. Indy Performance Composites (IPC) then created that mounting flange.

The screen safety system that was tested at Phoenix was made of proprietary Opticor advanced transparency material by PPG, the same material the company uses in the production of fighter jet canopies. The material has been shown to be stronger, lighter and more impact-resistant than the polycarbonate previously used, according to Horton.

Prior to track testing the screen was also tested in a scale-model wind tunnel and a racing simulator at Dallara, with Harding Racing's driver Gabby Chaves providing feedback after the simulator runs.

'We also wanted to maintain an open-wheel and open cockpit look'

The screen is made from the same high-spec transparent material that its maker usually uses for the canopies of jet fighters

It will be retrofitted to the current chassis, as it was at the test, with a fitting flange incorporated into the Dallara monocoque

Dixon reported that the cockpit was warmer due to reduced airflow. IndyCar says it will solve this by venting air in via a duct

While on the surface it appears that the F1 solution has targeted the large object intrusion issue – such as that which killed Henry Surtees and Justin Wilson – IndyCar's solution is more likely to prevent a small-object intrusion, such as that experienced by Felipe Massa in at the Hungarian Grand Prix in 2009.

'Our goal was to provide additional frontal protection for the drivers,' says Horton. 'We also wanted to maintain an open-wheel, open cockpit look. We do have evidence of smaller pieces of debris potentially causing problems if they impact the driver, so we wanted to provide protection for them. We also want to provide impact protection for larger, heavier objects.'

Screen test

Physical impact testing has not yet started, but IndyCar expects it to begin shortly, although there is no time-scale for the introduction of the system. The team wants to perfect the system for all eventualities before introducing it and the Phoenix test was very much a first look at it.

'We haven't determined the exact company that will do the testing for us,' Horton says. 'We have a relationship with a military based testing company here in the States and will probably use them. We need the ability to project objects at 200mph and more, and our normal crash sled (CAPE) is not capable of that.

While the screen might be expected to affect airflow, particularly to the rear wing, from the lap times posted by Dixon there appeared to be a fairly benign reaction to it. 'According to the CFD studies it appears basically aero neutral on this car. It does add some front weight, which will need to be tuned out with the chassis set-up,' says Horton. 'But as you can see from Scott Dixon's times at Phoenix, there is very little effect, at least on a short oval.'

Warm work

One issue that Dixon found was that the cockpit was a little warmer due to the reduced airflow into the cockpit, and in hot conditions this could pose a problem for the drivers. LMP cars have a mandated maximum cockpit temperature, and now have air conditioning systems fitted. But there is no plan to do something similar in IndyCar. Horton says: 'I don't think we have room in our racecars for any type of air conditioning system. So, at this time we think we will just solve the airflow problem with introducing air into the cockpit with some type of NACA duct.'

IndyCar will certainly introduce the screen to its cars as early as possible, and is now working hard to examine the results of this first aero test, before establishing a firm route forwards. Although the screen is completely separate to that tested by the FIA, IndyCar says it will share its findings with the FIA's safety body.




My other car is an F1 Caterham

One man's dream of building and driving his very own Caterham CT05 F1 car has *almost* come true, but some huge technical challenges have had to be overcome

By SAM COLLINS

Caterham CT05-01 pictured at its last race, the Hungarian GP in 2014. Now the very same car is to hit the track again, thanks to a Formula 1 fan's desire to build and run his own grand prix car

Kevin Thomas is a normal bloke. He works in an office, doing an everyday job and lives in a quiet and pleasantly unremarkable suburb of a city in northern England. He's also a very serious F1 fan. He attends races and tests, but what really sets him apart is in the garage next to his house. When the door raises the noses of a brace of Formula 1 cars are revealed, a 1994 Footwork Arrows FA13 and a 2014 Caterham CT05.

Thomas has been featured in this magazine before, when he was rebuilding a 2001 BAR-Honda 003 in the shed at the end of his garden using parts bought from websites such as eBay. His dream is to have his own F1 car that he can drive himself whenever he wants, and the BAR was the first attempt at achieving that goal. A house move and perhaps something of a reality check brought that project to a close.

'I was building that car myself at home with whatever parts I could get, but there was a real lack of information about it. I didn't know what many parts should look like, on top of that I'm not an engineer and I had never built a racing car of any sort,' Thomas says. 'When a similar but a much more complete car of the same year came up for sale I went to see it. I went there pretending that I was a serious buyer but my real intention was to go and take hundreds of photos of it, so I could work out all of the bits that were missing from my chassis.'

BAR bill

'When I got there the price the guy was asking was so low I had to buy it,' Thomas continues. 'What I had in bits was worth £10,000 to £12,000, but I could get everything for about £10,000 more. Soon after it was mine.' So Thomas ended up with an almost complete

Chassis number CT05-1 was heavily damaged in this crash at the Hungaroring and was awaiting repair when the Caterham team folded at the end of the 2014 season

The chassis as it was found in the corner of the auction room. Because it was damaged it was picked up for just £4200. Another CT05 was sold for £59,000 on the very same day

Early repairs to the monocoque. The biggest problem Thomas has had is sourcing parts to finish the car, nevertheless he wants it to be as close to original as possible

Formula Renault engine mounted in the back of CT05-1. A dose of realism meant any thoughts of a V6 hybrid were soon abandoned in favour of this 4-cylinder 2-litre engine

BAR-Honda 003, but his dream was to have his own F1 car which he could drive whenever.

It's not an unusual desire, indeed there are operations like Ferrari's Clienti Corse which specialise in this, but Thomas is not in that financial league: 'I'm not a millionaire,' he says. 'I have a normal job and normal wages. Most people who buy F1 cars write a cheque for £300,000. I'm not in that world, I'm in the real world. I want to be able to run this car on a budget of around £4000 to £5000 a year, and that includes travel to and from the tracks.'

While this sounds like an impossible dream, his BAR-Honda and a bit of ingenuity allowed him to come very close to achieving it, but only after some disappointment. 'To get it running would take time and effort, and it was time I simply didn't have,' Thomas says.

'As a couple of years passed by I looked at it and it still was not running. I had imagined that I would be able to get a Mugen-Honda V10 for it and some kind of gearbox, but you can't get these things for a car like that. I never gave up on the dream of doing it, though. So then, when the Caterham auction came along I just knew I had to unlock the capital in the BAR-Honda, so as to get something else.'

Buying used

Caterham's financial collapse at the end of the 2014 season saw the entire team's assets come up for sale in a series of public auctions; everything from memorabilia and car parts to complete racecars. But the prices at the auction were high, two of the three 2014 race chassis listed went for £59,000 and £37,000, with the other sold by private treaty at an undisclosed price. But Thomas had spotted something when viewing the lots of the auction; an incomplete 2014 chassis said to be damaged beyond repair.

'It was marked as CT05-3 but I took one look at it and realised that it wasn't, the branding on it was all wrong for chassis No.3 [which raced to the end of 2014],' Thomas says. 'But because of its description I managed to buy it at about £4200. When I worked out that it was chassis No.1 [CT05-1] then I was over the moon. It was the car I had watched testing in 2014 at Jerez.'

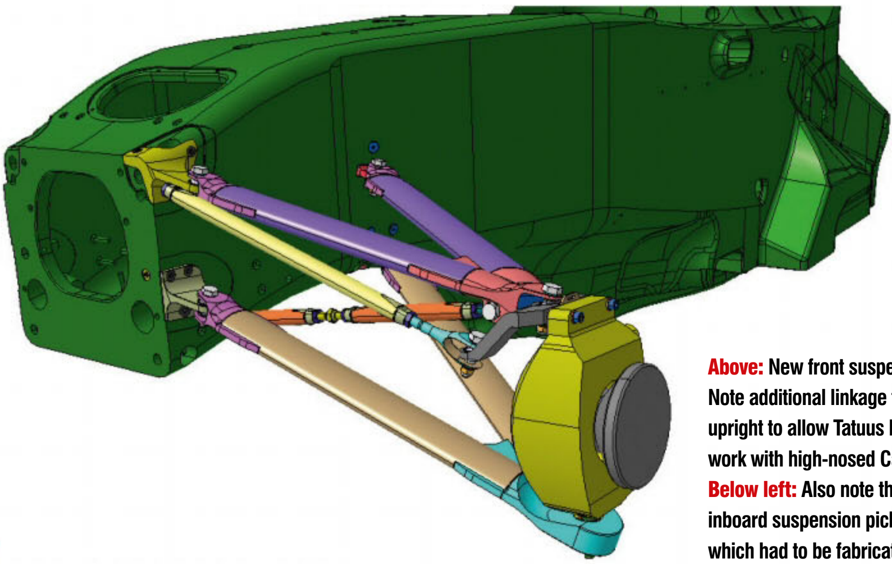
The tub was literally bare, with almost no additional parts, and it was indeed damaged, the result of driver error during the 2014 Hungarian Grand Prix. 'It needed a heck of a lot of work, some of the wishbones had punched through the tub in the crash, and they were still in it,' Thomas says. 'The team had taken it back to the factory and stripped it completely, the roll hoop shroud had been removed, but it was fine. The plan had clearly been to rebuild it but by then Caterham had run out of money.'

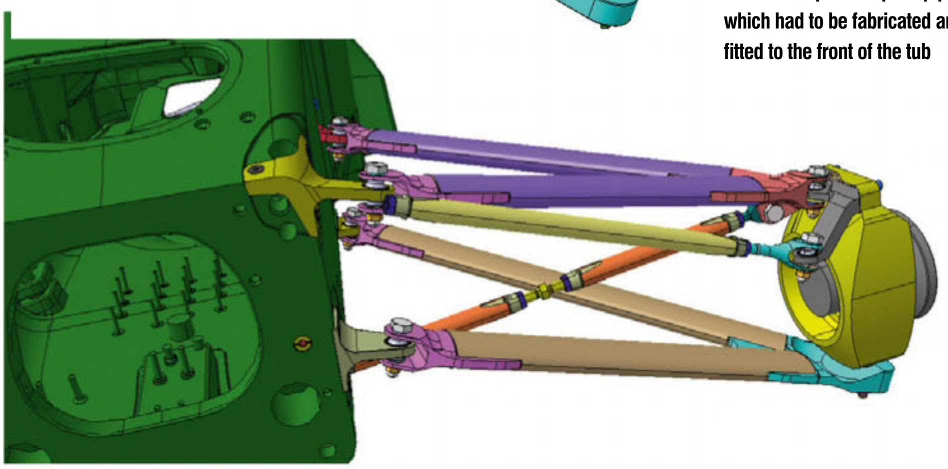
Despite the damage and his total lack of knowledge of how to repair it Thomas was undaunted, he felt that this was the perfect basis to get his own F1 car up and running. 'It was in a ready to repair condition, but had not been repaired. However, it was in a better condition than one of the other three tubs, which had been raced by Kobayashi, that had a crack in it, yet he raced it like that. Even with the damage the tub was still super strong, you

'I'm not an engineer and I had never built a racing car of any sort'

'When I worked out that it was chassis CT05-1 I was over the moon. It was the very same car that I had watched testing at Jerez in 2014'

Frame for the Formula Renault engine and Sadev gearbox; fitted between the rear of the tub and the dummy transmission





Above: New front suspension. Note additional linkage from upright to allow Tatuus layout to work with high-nosed Caterham **Below left:** Also note the new inboard suspension pickup point which had to be fabricated and fitted to the front of the tub

could balance a house on it. Kobayashi spent most of the season in a cracked chassis.'

While information about the design of the CT05 was not hard to come by, a lot of design data being made available following the team's collapse, parts were harder to lay hands on than they were for the BAR that Thomas had now relinquished for the Caterham. 'I only had the bare tub. I managed to get some bodywork bits at the second auction about a month after the first but there was no suspension, uprights, gearbox or power unit. After the team collapsed most of the parts were sold off at the auction and a lot of them simply vanished.'

Power compromise

Formula 1's 2014 technical regulations resulted in the most complex grand prix cars ever built, at that time. At their heart was a 1.6-litre turbocharged V6 power unit featuring an MGU-H and an MGU-K, as well as a substantial battery pack. Merely getting one of these units to run requires significant expertise.

'There was no way to get a V6 hybrid power unit. Even if I could get one I would not be able to run it, financially or in terms of sheer ability,' Thomas admits. 'So I needed something else, and I looked at size as the first criteria. The memorabilia collector and Formula 1 fan in me said that it had to still be a Renault engine, so I found a second hand Tatuus Formula Renault 2.0. The in-line 4-cylinder engine from that car did fit, it was tight, but it would work. It would also be really simple to run.'

Thomas soon realised that the project to re-engine the CT05 was beyond his abilities alone so he roped in Andrew Shedden of AS Pro Engineering. Shedden worked out that the engine could be mounted in a fully stressed arrangement in the rear of the CT05. 'The engine fits to the back of the tub directly, using the original mounts, just by chance the Formula Renault engine mounts work well. It means the engine may sit a little higher, but that doesn't matter to me,' Thomas says.

Gear shift

Mating the Renault engine to the composite casing Red Bull transmission used in the CT05 was very briefly considered before it was ruled out. 'I could not use the Red Bull transmission, that would probably be £400,000 for six months, and I can't afford that, and they probably would not sell it to me anyway. So I decided to use the Formula Renault gearbox, too,' Thomas says.

However, there would be major issues with using the Sadev transmission in place of the Red Bull unit. 'The differential on a Formula 1 gearbox is at the rear of the casing, then the rear impact structure continues rearward and the rear wing picks up off that,' Thomas says. 'But the Formula Renault gearbox has the diff halfway along the casing. That created a bit of an issue as the rear of the car would be too short, and the overall length would not be long enough.

'There was no way I was going to get a Formula 1 hybrid power unit and even if I could I would not have been able to run it'

'I could not change the wheelbase of the car, because that would mean changing the bodywork and lots of other things like the floor. So we either had to move the engine back from the rear of the tub, or put a spacer between engine and transmission and extend the input shaft. So we decided to go for the latter.

The use of the Formula Renault rear end largely defined the rear suspension layout of the CT05, with the metal wishbones taking the place of the composite elements used by Caterham in 2014. It also resulted in a switch from a pullrod actuated rear end to a pushrod layout. The Tatuus had a front track of 1434mm but the Caterham CT05 had a front track of 1800mm, which created yet another minor headache for Thomas and Shedden.

The wheel deal

'I've gone for Formula Renault wishbones and uprights, but the difference in track is made up in the wheels and spacers,' Thomas says. 'We could now mount wheels that look right, but if I don't use a Formula 1 wheel, it's a problem as it will have to have high profile tyres, otherwise it simply won't look right. Formula Renault uses low profile tyres, so it might be that I have to get a set of wheels made for the car.'

The CT05 was one of two 2014 cars to use a pullrod front suspension layout, the other being the Ferrari F14-T, something its designers claimed was done for technical reasons. But for Thomas it was another challenge, with the Tatuus wishbones and uprights being retained. 'I found some 2013 Caterham front uprights, but to use those I would have to get discs and bells made up for them and that would be silly money. So that was one of the big reasons I had to get Andrew involved because the suspension would have to change, and that is beyond my ability. The Formula Renault chassis has a flatter nose, and the CT05 is higher, so to use those uprights we have to overcome buckling; the angle would be too great,' Thomas explains.

The rear wing assembly actually comes from a Force India but the pylons that support it are original Caterham components

The front impact structure and nose. Sadly the prettier nose from later on in the 2014 season would not fit chassis CT05-1

Pickup line

Shedden redesigned the inboard suspension pickup point, which have had to be fabricated and fitted to the front of the CT05 tub. The use of the Formula Renault parts has also allowed a number of other systems from it to be used, including the complete Tatuus brake set-up, with steel discs taking the place of the carbon/carbon layout used on the CT05 originally.

'It means we can use Formula Renault brakes, which is super cheap, and this car will not be as fast and won't need the braking force of F1 brakes,' Thomas says. 'Until we get the car finished we will not be sure on the weights, but we might well be lighter than a Formula Renault. It is still a very light car, built to a minimum weight of 690kg, with 145kg of that weight taken up by the power unit and 20 to 25kg of that in turn accounted for by the battery pack.'

Rack and ruin

While many parts could be used from the Tatuus the relatively small size of the CT05 prevented this in some areas, especially with the steering and suspension. Originally the CT05 had torsion bars and dampers (as well as an interconnected suspension system) fitted, but the components which made that up were impossible to come by, let alone utilise. Additionally, the power assisted steering system was also missing and the space available for it meant that no off-the-shelf system could be used.

'The steering system was especially difficult, it was bespoke, tiny, complex, and there was no way I could get it working without the right software. Space is the real issue, you can't just go out and buy a small rack like that, or the internal suspension parts. So a lot of that we are having to design and make from scratch, but in the first

The Caterham is still in the process of being built but it's expected to hit the track some time this year. Its owner's next project is to do the same with his Footwork, this time with a more powerful engine

'The steering system was especially difficult; it was bespoke, tiny and complex and there was no way I could get it working without the right software'

year running – this year – the only springing will come from the tyres. Hopefully it won't be too hard, but I'll probably end up needing new fillings in my teeth. The steering will not be power assisted so last week I joined a gym, though bear in mind the car will only run for 10 to 15 minutes at a time so I hope it won't be too bad – even so it will have proper downforce so it could be tough,' Thomas says.

The bodywork of the car follows much the same philosophy as Thomas adopted with his BAR project, if the correct bodywork could not be located then parts from other cars could be adapted to fit. 'As there was no front or rear wing with the tub I had to find what was available,' Thomas says. 'There is a memorabilia seller in the UK who gets a lot of Force India parts, and mounts them in frames for fans to put on the wall. I bought a pair of 2014 Force India endplates from him and a set of wing elements in the frames for front and rear, took them out of the frames and put them together. So the car has Force India wings on it, supported by original Caterham pylons that just about fit.'

The ugly truth

The CT05 was met with an astonished gasp when it was first launched at Jerez in Spain, and often appears in lists of the ugliest F1 cars of all time, thanks to its cheese wedge nose. Later, during the 2014 season, a more aesthetically pleasing nose was fitted to the car, but for Thomas only the original version was an option.

'It wasn't the prettiest of noses, but I had to go with it, not only because I want to keep it as original as possible, but also I have no choice. Chassis No.2, No.3 and No.4 had an adaptation to the monocoque to allow the car to be fitted with the revised nose, but my monocoque lacks that. Luckily I managed to find an original CT05 front crash structure in the Netherlands, and along with it a spare engine cover.'

More of the same?

Using the original crash structure Thomas found an original mould for the nose structure, he made up the cheese wedge nose in fibreglass, ensuring that the car was both original looking and safe. The latter is important as Thomas will drive this racecar himself, despite having only a few laps in a Formula Renault at Thruxton and an experience day session in an old Forti Corse FG03 in terms of experience.

'It's just for me, because I want to do it, I want my own Formula 1 car. Maybe I won't be all alone on track for long either,' Thomas says, before admitting that he now plans a similar project for his Footwork, this time with a more potent engine. He also points out that there are others watching this project with interest. 'I know of at least one other person on the look out for the right monocoque to do the same thing as this,' he says. 'Also, using a Formula Renault or similar engine, maybe we could get a few of us together, enjoying racing our own F1 cars for fun. That's what I would like.'


Performance
comes from
within

BRave new world

If Toyota falters there's a real chance that a privateer LMP1 entry could pick up the pieces at Le Mans this year – and if early impressions of the BR1 are anything to go by, then that car might very well be Russian

By ANDREW COTTON

The LMP1 privateer class has come to life this year, largely because the chance of an overall podium for a privateer has risen dramatically. With Audi and Porsche withdrawing from the hybrid category in 2016 and 2017 respectively, Toyota has found itself as the sole manufacturer entry in the World Endurance Championship's top class. And with just two Toyotas entered in the WEC and at Le Mans, the privateers now have something very tangible to aim for.

There is even the chance that bad luck could hit the TS050s, paving the way for the first privateer win at Le Mans since Champion Racing's triumph with an Audi in 2005, and the first privateer constructor to win since Rondeau in 1980. There is, of course, also the chance that a reliable LMP2 car could also sneak the win, too, but the ACO and FIA have taken steps to ensure that the LMP1 privateers fill the large gap between hybrid LMP1 and LMP2 pace.

Tweaks to the LMP1 category mean that there is only one class now; there is no distinction between hybrid and non-hybrid in the final standings. In order to make the racing between the hybrids and non-hybrids closer, the regulations have been angled towards increasing the performance of the non-hybrid cars so that they are theoretically competitive on lap time against the manufacturer hybrids. In fact, the FIA has recently clarified that the performance gap between Toyota and the privateers at Le Mans must be around one second a lap in all conditions. This will be the case for both qualifying and the race.

Currently, non-hybrid cars have a minimum weight of 833kg (compared to 878kg for a hybrid car), they have 210.9MJ/lap of gasoline energy at Le Mans (compared to 124.9 MJ/lap plus 8MJ of hybrid energy for a manufacturer), and they also have a maximum fuel flow of 110kg/h (compared to 80.2kg/h for a hybrid).

'I am quite confident that people will realise that without spending huge money they can be competitive at Le Mans'

The Dallara-built BR1 joins new cars from fellow privateer LMP1 builders Ginetta and ORECA in the premier class of the WEC for the new 'super season'

The front suspension has been changed from the LMP2 spec because of the narrower monocoque at the front, the different sized tyres and the shedding of weight from the chassis

The non-hybrid cars also have 52.9kg of fuel per stint (compared to 35.2kg for a hybrid); it's a generous allocation that could spring some surprise results in the WEC this year. However, these are regulations declared by FIA/ACO at the time of writing. It may come to pass that in certain circumstances the fuel flow will become a powerful tool they can used to adjust the performance of privateers.

Gone, thankfully, is the moveable aero regulation that the ACO said it would use to help the privateers; giving straight-line speed with a DRS on what are normally public roads, even though it had never been tested.

Eyes on the prize

In a clean race, the manufacturer should have the advantage, the hybrid taking the factory cars a lap further per stint. However, there is always a chance of a slip up, be it mechanical, in traffic or weather related. It is a thought that has undoubtedly appealed to the privateer teams and gentleman drivers who have their eyes on the ultimate prize, and there could be as many as 10 LMP1 cars in the WEC for the 13-month 'super season' that starts at Spa in May.

Three chassis manufacturers have stepped into LMP1; BR Engineering and Ginetta with bespoke chassis built to the new regulations, and ORECA with an updated LMP2 version of the car that will be run by Rebellion Racing.

'I think the next three Le Mans will be a unique opportunity to win the race,' says Dallara's chief designer Luca Pignacca, who worked with project leader Antonio Montanari and Russian engineers and team members from SMP Racing to create the BR1. 'If everything works well, Toyota will win. But it is 24 hours, there are two Toyotas, and an LMP1 non-hybrid should normally be on the podium.

'Experience showed that in the past Toyota had a few problems, and people realise that with a non-hybrid car, it is really not impossible to win the overall race,' Pignacca adds. 'I think that if we show that the car is reliable and doesn't cost much, I am quite confident that people will realise that without spending huge money they can be competitive at Le Mans.'

The Dallara-built chassis is homologated as a BR Engineering car, named BR1, and it is the Russian company that owns the intellectual property. It also handles the sale of the cars to customers. For some that may be off-putting, competing against the car constructor is rarely considered an advantage, but American team Dragonspeed has taken that option, and there are rumours of a further chassis sale soon which would bump up the LMP1 numbers further.

Driver friendly

The low weight of LMP1 has pretty much driven the chassis design concept, with almost 100kg having to be taken out of an LMP2 design (930kg) to reach the base weight for LMP1.

Russian engineers have worked with Dallara to create the BR Engineering car, which was designed around the SMP Racing team's drivers from the outset. They sat in the mock-up in the workshops to decide on seating position and cockpit ergonomics, for example.

The team has gone down the newly established route of having spring-loaded pedals and a fixed seat, rather than the seat on runners. 'The driver can unlock and lock the pedals from the dash panel, getting 50mm of travel for fine adjustment,' says Montanari. 'This is obviously in addition to three fixed positions on the monocoque hard points, getting a total

The low weight of LMP1 has pretty much driven the chassis design concept, with almost 100kg having to be taken out of an LMP2 design

Dallara's Luca Pignacca at the launch of the BR1 in Bahrain. He worked closely with project leader Antonio Montanari and personnel from BR Engineering to create the new LMP1 car

The Xtrac gearbox is carried over from the Dallara LMP2. The casing, and therefore the rear suspension design, is similar regardless of the engine installation that's chosen for the BR1

'There is no drag penalty for carrying a turbo engine and I am curious to see which is going to be the winning engine'

adjustment of 130mm. We intentionally decided to squeeze the monocoque as much as possible for weight and aerodynamic reasons; therefore there is not a huge amount of room for tall drivers. Nevertheless, we had pretty tall drivers onboard and so far it looks good.'

Designing for these drivers, and with the general fitness levels required to run at LMP1 pace, meant fewer compromises needed to be made in terms of accommodating larger drivers. That led to a new tub design, with lightweight materials, a higher footbox, improved front suspension design and a new steering rack design to be housed in the narrower nose, compared to the LMP2 base car.

'We started from the LMP2 monocoque that was already good, but the name of the game in LMP1 is weight saving, more than anything else,' says Pignacca. 'The car must weigh 100kg less than the LMP2 and that is a lot. Fortunately, we had a good base from which to start, because the LMP2 car carries a lot of ballast with the Gibson engine, but we had to redesign everything to save weight. We had to use different materials for the monocoque, so we went more extreme with everything.'

Russian steps

As detailed in our April 2017 issue, V27N4, the LMP2 Dallara is focussed heavily on being a customer car, and therefore does not go to the same lengths as the Audi R18 chassis that was also built by the Italian company, in terms of materials and safety. The BR1 is somewhere between the two extremes. 'With LMP2, for example, you need to accommodate gentlemen drivers as well, so some are very tall, and big, and they must fit in an LMP2 monocoque,' says Pignacca. 'In LMP1, the size of the monocoque is slightly smaller, and we tailored it around the SMP drivers. We went a little higher with the footbox, but everything must be redesigned or you won't reach the target with the weight. Someone [Ligier] used expensive materials for LMP2 and for me this was conceptually wrong because LMP2 must not be [for] this, we used, let's say, high end materials for LMP1.'

Conceptual differences

The LMP2 design already incorporated the Zylon panels in the chassis, which meant a saving of weight and increase in stiffness, but Montanari is clear these are two different concepts. 'There is very little in common, it is just the concept,' says Montanari. 'The monocoque shape is different, smaller, narrower, everything is designed with the weight target in mind. We have used different materials, but we also changed the production process in order to optimise every carbon layer overlap. There is a massive effort behind it, as the weight target is very low.'

The front suspension is also optimised, in part because of the narrower monocoque at the front, in part because of the different size tyres, and in part because of the weight. It is also, says Pignacca, the IKEA philosophy; the second time you do the job, you will do it better. The third element is more sophisticated, says Montanari, but overall the system is based on the LMP2 car. 'We had a good base from LMP2; we believe the car is a very good car,' says Pignacca. 'We had a small problem with the front splitter, but the rest of the car was a sound car; Cadillac love the car and it goes fast with it. We didn't need to change a lot with the suspension pick up points; it was a general optimisation. We went lighter, more extreme with the geometry of the monocoque to reduce the drag, and we have used all the

‘We changed the process to optimise every carbon layer overlap’

Three BR1s have been taken by SMP Racing while one has gone to Dragonspeed. It’s been designed to take AER or Mecachrome turbo engines, or Gibson normally-aspirated units

QUICK SPEC

BR Engineering BR1

Chassis: Dallara

Engine: Choice of AER twin turbocharged unit; Gibson V8 LMP1 spec; or Mecachrome V6 turbo LMP1 engine

Clutch: Tilton

Brakes: Brembo

Power steering: Kayaba

Wheels: OZ

possibilities that the regulations gave us, but this was mainly with the aero.’

The new tub needed to be crash tested, but passed with flying colours. ‘The crash tests, both the static and the dynamic, are quite demanding,’ says Montanari. ‘Nevertheless, we are proud to say, we did pass all the mandated crash tests at the first attempt, and saved quite a lot of weight at the same time. We are investing a lot in composite material research and FE analysis, and these are what push you to do more and more in that direction.’

Engine options

The company leaned heavily on its simulator to help with the design process, and there are actually two slightly different chassis designs; one for a turbo installation from Mecachrome or AER, the other for the normally-aspirated Gibson engine. ‘The aero package is different, the cooling and radiator ducts are very different; there is no intercooler, but the car from outside does not look really different,’ says Pignacca. ‘There is no drag penalty for carrying a turbocharged engine and I am curious to see which is going to be the winning engine. At the moment the fuel flow is the same for both the engines, both the engines are good. The AER is quite a light engine, so at the end of the day the weight will be similar because with the turbo engine you have to carry the intercoolers. Aero-wise, there is not really a big difference. The AER [engine] requires not so much cooling.’

Montanari adds: ‘Considering different engines and different architectures from the beginning, the change does not have a big impact on the car. Regarding the cooling, for instance, we accounted for enough space to accommodate radiators suitable for the most demanding engine. Obviously many components are specific for each installation, which is normal, but they are all pretty tidy and clean. So, staying within this size there won’t be big changes; going bigger it is feasible, but this may have a bigger impact as well.’

Also carried over from the LMP2 car is the power steering and the gearbox concept from Xtrac, although the internals are different even from turbo to normally aspirated due to the different rev ranges. The casing, and therefore the rear suspension design is similar regardless of engine. The car has been designed with the Cosworth electronics, another carry-over from LMP2, although with the AER engine Life Racing will be used as the control unit. Brakes are Brembo calipers and master cylinders and, while the company also supplies the brake material, there is no homologation period as there is in LMP2, and so it is possible for a team to switch and run with another company such as AP.

Tyre uncertainty

One of the big unknowns, however, is the front tyres. The BR Engineering car was built with Michelin in mind, but at time of writing there was no clear decision from the manufacturer

'We're proud to say we passed all the crash tests at the first attempt'

on what the tyres would be; a development of those originally made for the four-wheel-drive Toyota, bespoke tyres for each constructor, or a non-hybrid tyre on which the BR Engineering, Ginetta and ORECA chassis would run. It's important, as the basic concept from each of the chassis manufacturers is different.

While Ginetta has focussed on front aero and switching on the front tyres, Dallara took a slightly different approach, looking for overall car balance. 'With the new rules, it's always difficult to have enough front downforce, but you have to have a car that is efficient, so it has to be the right balance of downforce and drag to have a winning car,' says Pignacca. 'With the regulations, they facilitate the front end with respect to LMP2, you can [also] use a lot of features not allowed in LMP2, but because we had a lot of experience with LMP1 cars in the past, we already had some good ideas.'

Dallara has concentrated on overall aero balance rather than focusing on the front end, which has been Ginetta's approach

There is a suspicion that the introduction of the new regulations will be delayed until the 2021/22 winter season, which would give the BR Engineering car four years at Le Mans, from 2018 until 2021. Three cars have been taken by SMP Racing, while one has been sold to Dragonspeed and will be run with the Gibson engine. The second customer has yet to be announced. However, it seems that while there is only one manufacturer in LMP1 right now, privateers are once again circling.

The target pace of the non-hybrid cars is high; last year Toyota qualified at Le Mans with a 3m14.791, and it is a challenge to meet that pace with a privateer chassis and customer engine compared to the integrated design of a manufacturer LMP1 car. 'It is a high pace, but they gave us hopefully enough fuel, so until we go to Le Mans, or the first race at Spa, we will not really know, but if the FIA and ACO calculations are correct we will be close in performance,' confirms Pignacca.

Could it be that the privateers will be on it in qualifying and possibly in the first stints? And, could it be that if anything should happen to Toyota we could also be looking at the first win by a Russian constructer at Le Mans?

SEEN: Toyota TS050 Hybrid

This is the car that BR Engineering and other privateer LMP1 manufacturers and teams will be hoping will slip up, or break down, at Le Mans.

The Toyota TS050 will be campaigned in the 2018/19 'super season', which runs from May this year until June 2019 and encompasses two editions of the Le Mans 24 hours. Its specification has remained largely the same as last year, except for some improvements to the cooling.

Toyota's latest offering had started its testing programme at the time of writing and had successfully completed a shakedown at the Aragon circuit in Spain plus a full endurance test at the same venue. The car was due to have two more endurances tests before the WEC prologue at Paul Ricard in April. Much of the publicity surrounding Toyota's campaign has revolved around its signing of F1 star Fernando Alonso as a driver.

Pace notes

Racecar caught up with the WRC to check out the technical developments of the manufacturer teams as the reinvigorated World Rally Cars raced into their second season

By MARTIN SHARP

Now that the cars are going into their second year, is there much more performance to find?

Main picture: Ford hit the ground running with a win on the season-opening Monte Carlo. Wider sills have brought an aerodynamic benefit while the lower rear suspension arms have also been modified
Below: The Ford Fiesta WRC used up its engine development jokers last season and it came into 2018 with a similar powerplant, but M-Sport has also worked on fine-tuning the engine's control strategies

The 2017 World Rally Championship saw a new regulation package aimed at bringing the spectacle back to rallying's premier series. Most agreed that it did this, with faster cars and a far more open battle for the championship than the WRC has been used to in recent times, including seven different rally winners.

These new regulations featured an increase in power from 300bhp to 380bhp, the reintroduction of a central active differential and a more aggressive aerodynamic package. But for the manufacturers and teams new rules meant new challenges, and also a restrictive development regime based on a joker system. This same system remains for 2018, with three jokers for the engine and the same for the chassis – there were five jokers for the chassis last year, as the teams got to grips with the new regulations. The question is, now that the cars are going into their second season, is there much more pace to find, and if there is, how will the works teams of M-Sport (Ford), Toyota, Hyundai and Citroen go about unlocking it?

Ford Fiesta WRC

Testing of the current world champion rally car in late 2017 and early 2018 was essentially about optimising its set-up for events. Chris Williams is chief rally engineer at M-Sport, the company that runs and builds the car: 'We had some new stuff we wanted to try; that was last year, so we carried some of that forward [to 2018] to validate it again,' Williams says. 'We did jokers at the end of last year; changes to the centre diff, sills and half of the rear quarters.'

Those widened side sills Williams talks of are actually a key change to the car. 'We were looking for durability; but we gained more than just durability,' he says, referring to the belief that the wider sills help to promote the retention of optimum aerodynamic balance over the length of a stage.

A change has also been made to the lower rear suspension arms on the Fiesta. This has also been a success, although Williams says the level of performance improvement is 'hard to measure, but we do believe it's better'.

Having used the quota of three 2017 engine jokers the powerplants in the cars on the opening round of the 2018 WRC, the Monte Carlo Rally in January, were ostensibly similar to those used in 2017 Rally Australia, although with some changes: 'In general, we've picked up a bit of performance; through non-joker parts and we've found a few things,' Williams says. This work mainly concentrated on further fine-tuning of engine control strategies.

Ford US's shift to a new level of support for the plucky M-Sport squad, on the back of last year's championship-winning success, now offers Williams potential extra assistance and he visited Ford Performance in Dearborn, Michigan, in December to assess possible

Toyota has worked on the front end aerodynamics and there are now two extra dive vanes. Revised front fenders help to improve the front downforce while also helping the cooling

areas of mutual benefit: 'They have a fairly large amount of technology and facilities; some of it's piggy-backed on to mainstream engineering and some of it is unique, which is interesting. The technology side alone is quite interesting. Whether we can get that to help us on WRC I don't know, but let's say they should be able to help us. It's very much a; "Can we help you?" [attitude] they have. The decisions are still ours to make, so what we potentially have from them is access to technology, machinery and facilities that we wouldn't have otherwise.

'That's a good thing,' Williams adds. 'We'll be able to spend time with the whole car doing things that we wouldn't normally have done. We may plan all these projects that we want to do; but don't think these are the only projects we're doing this year because every week – or every two weeks – we'll come up with a new idea and rate it against all the projects that are going on now and try to position it in importance.

'If we come up with a really good idea and think that's better than anything else we're doing I'm going to drop everything else, so we're going to do that,' Williams adds. 'That's how we operate, and if we see a performance advantage in an idea that tops pretty much everything that's going on we need to get it on the car as soon as we can. Every week there's something new – not everything's successful, but the moment you stop thinking about things like; "Oh, we can make that a little bit lighter by doing this" or "we can change that around by doing that", then your car's going to stop developing. It's all in the detail; I don't think there's any big chunks now; well, not so many big chunks, where you can go: "Right; we're going to change everything around". That's not where we are with this today.'

Toyota Yaris WRC

Three brand-new Yaris WRC chassis appeared on the Monte Carlo Rally; also for this season Toyota picked the three cars from 2017 which had done the least work or had the fewest repairs.

Team staff numbers have been reduced, which chief engineer Tom Fowler says 'makes working easier, effectively, because you've got to tell fewer people what's going on.'

While the team has chassis jokers remaining available, all those it has played are at the front end of the car. For instance, the shape and size of the air inlet is significantly different. It is now rectangular and this is related to changes made to improve the car's cooling.

It was identified in 2017 that the aerodynamic balance target had not been met and there was a need to shift the balance percentage more to the front, because the rear aero treatment – which remains the same as last year – is particularly effective. There are two extra dive vanes (carrying Panasonic livery on the picture above) on each side at the front, and there are now cooling openings between each dive vane on either side. Last year the front bumper and splitter was a one-piece arrangement requiring the entire assembly to be substituted after stage damage. The latest version is now split, allowing the lower third of the bumper to be unbolted and replaced. This development required two chassis jokers. The vertical strakes at the sides of the front splitter were rubber and easily detached on impacts; these are now carbon fibre.

Slightly revised front fender shapes and new fender openings both help improve the front downforce and, more importantly, aid cooling. 'The new fender, basically, is almost the same shape as the old one,' says Fowler. 'It's more around getting the openings in the right places, and the openings are also related to cooling. The top opening on the upper surface is connected to the cooling system and the rear opening is basically about brake cooling and evacuating air from the wheel-arch.'

High altitudes and temperatures caused major cooling difficulties for the Toyotas in Mexico last year, and solving this involved a combination of CFD, wind tunnel data and evaluation on a full-size car. The wind tunnel gives an indication of the big directions to take, such as the shape of the bumper opening, then CFD helps with optimising internal airflows, while temperature and flow sensors in the test car help indicate the level of success.

However, the low ambient temperatures of Monte Carlo and Sweden meant not all new cooling measures were used on these two opening events of the championship, partly

At Toyota it was identified that the aerodynamic balance target had not been met in 2017 and that there was a need to shift it more to the front


REIGER®
SUSPENSION
DRIVEN BY THE AMBITION TO BE THE BEST
THE BEST SHOCK ABSORBERS FOR:
RALLY - RALLYCROSS - RALLYRAID - AUTOCROSS - MOTORCROSS - ENDURO - TRIAL - QUADS - SIDECAR
Reiger Suspension BV
Molenenk 5a
NL - 7255 AX Hengelo Gld
+31 (0)575-462077
www.reigersuspension.com
info@reigersuspension.com


SST®
TECHNOLOGY
ENGINEERED BY DESIGN
Design and manufacture of high performance exhausts, precision fabrications and thermal management solutions
RADIATORS AND HEAT EXCHANGERS
EXHAUSTS AND PRECISION FABRICATIONS
TITANIUM DRIVER PROTECTION SYSTEM
SST are the only UK manufacturer of the Additional Frontal Protection Halo (AFP-Halo)
FIA APPROVED
MANUFACTURER: SST Technology
MODEL: SST-DPS-ProTi
HOM. NO: AFP.003.18-T
FIA STANDARD: 8869-2018
SUPPLIERS TO F1, INDYCAR, TOURING AND SPORTSCAR, RALLY AND PERFORMANCE AUTOMOTIVE SECTORS
SST Technology
Oxfordshire T: +44 (0) 1865 731018 E: info@sstubetechnology.com
www.sstubetechnology.com

In common with its rivals, aerodynamic refinements define the majority of joker-derived improvements to the 2018 Hyundai

because some result in a slight detriment to the overall performance of the car.

'We have increased the air flow through the car; we've increased the capacity of the radiators; we've got additional coolers that we didn't have last year; we've changed the strategy of how we use the fans; we changed the strategy of how much torque is available to the driver when the engine temperature is increasing – basically everything that can possibly be done,' Fowler says.

The driving lights are now inside the bumper rather than outside, hence the aerodynamics are now the same as when they're not fitted. There are three options here: no lights, lights entirely inside the bumper with a clear cover, or uncovered lights which protrude a few millimetres. Last year the driving lights protruded around 15cm. Fowler says: 'You do get better frontal aero performance with your lights inside the bumper. Effectively you run the normal front bumper but with lights in it.'

The Hyundai's splitter design is similar to the 2017 version but is now integrated into the front bumper. The i20's engine has a modified exhaust manifold, after the first iteration experienced problems with cracking, plus new fuel injectors and pistons

In the engine bay, an update for the Monte Carlo Rally altered the characteristics of the Toyota's power band and thereby enhanced both driveability and traction.

Hyundai i20 Coupe WRC

In common with most off its rivals, aerodynamic refinements define the majority of the joker-derived improvements to the 2018 Hyundai WRC. After CFD work in April 2017, the concept was in place by July and jokers were homologated on October 1 last year.

Revisions incorporate the front bumper and its lower section. Here the splitter design is similar to the last iteration, yet this is now integral to the front bumper.

Previously, the splitter and bumper were homologated as two parts and the 2017 experience showed substantial damage to both of these parts on-event, and replacement of the entire assembly is easier in service. The front bumper changes required two jokers because of its steel connection to the front fenders. A new rear wing takes up a third chassis joker, although the modifications are not easily noticed.

The fourth joker homologation is a new rear fender with a slightly different shape to achieve more downforce. The fifth and final chassis joker is a new rear bumper, which encourages more air to be drawn out from the central tunnel.

The team also used up its three 2017 engine jokers; a modified exhaust manifold after cracking was experienced with the first iteration, plus new fuel injectors and pistons.

Hyundai's drivers report sensing an improvement in response and torque from the latest unit. New camshafts and valve timing are promised and team principal Michel Nandan tells us: 'This should happen around July, but if we have some good results it will be before; but that could be a bit tight because the first homologation is for the beginning of March.'

Geometry-related suspension developments are ongoing; particularly at the rear – which will involve some 2018 chassis joker parts – with small kinetic non-joker changes at the front.

The car's single 43/57 front/rear torque split option has remained for all surfaces. Nandan says: 'We tested some other ratios but didn't find a really big difference, so we prefer to leave it like that because this is something that we can homologate whenever we want.'

While the brakes and cooling system specifications remain the same for this season, following the fuel filter problems encountered by the team in Mexico last year Hyundai has concentrated on making the fuel delivery system '100 per cent bulletproof,' Nandan says.

In 2020 teams will be allowed entirely new World Rally Car homologations, and Hynudai


JRM
ISO9001 Accredited Teir 1 supplier to major UK and International OEMs, SMEs and private clients.
JRM Manufacturing Centre
State-of-the-art precision DMG CNC 5-axis machinery, full manufacturing and fabrication facilities as well as expert engineering and rigorous quality control allows us to deliver the perfect product. For one-offs, prototyping or large production runs, we can deliver consistent parts or products, for any industry, from your drawings or by reverse engineering at a great price. Not got that far yet? JRM's specialist design engineers can help bring your concept to life.
www.jrm-group.com | +44 (0) 1327 307150 | athornton@jrm-group.com


ATL
AERO TEC LABORATORIES LTD
HIGH PERFORMANCE
SAFETY FUEL CELLS
STANDARD OR CUSTOM
SAVER CELLS
RANGING FROM 10 - 170L
NEW!
60 LITRE D-CELL
DESIGNED TO FIT EASILY INTO THE WHEEL WELL OF MOST CARS! OPTIONS & ACCESSORIES AVAILABLE
FIA APPROVED
MANUFACTURER: ATL LTD
HOM. NO: ATL 565
FIA STANDARD: FT3-1999
CHECK YOUR REGULATIONS
VEHICLES IN GROUPS N, A, R1, R2, R3 AND E-I RUNNING TO APPENDIX J OF THE FIA SPORTING CODE NOW REQUIRE AN FIA CERTIFIED FUEL CELL
CUSTOM FUEL SYSTEMS
INTERNAL COLLECTORS & SURGE TANKS, FUEL PUMPS, FILTERS, FOAM BAFFLING & MUCH MORE!
HISTORIC REMAKES
RETAIN ORIGINAL LOOK BY USING EXISTING OR RE-MADE CONTAINER
ATLLTD.COM
+44 (0)1908 351700 sales@atlltd.com

Citroen has made a change to the static torque split options in the epicyclic gearing of the centre differential. It is also working hard on optimising the power curve of the C3's engine

is planning ahead, says Nandan: 'For sure there will be a new i20 coming on the market – we don't know yet how it will be [or when]. It will be maybe a little bit late for 2020. I think it could be for sure for 2021. But it will be an i20 similar to what it is [now], but a new version.

'There are two options; whether we do a totally new car with a new model in 2020, or keep this model and just improve it,' Nandan adds. 'I hope to start looking at developing concepts at the end of this year, or the beginning of next year. It depends on the development of the road cars, really. But normally we should be able to start a bit this year, we don't know when as yet; but otherwise it will be next year, at the beginning of the year.'

Citroen C3 WRC

Citroen's latest chief engineer, Christophe Besse, replaced his predecessor Laurent Fregosi in time for Rally Poland last year. He inherited a car which showed lacklustre performance on gravel throughout the 2017 season, despite Kris Meeke's Rally Mexico victory.

Besse's priority is therefore improving performance, durability and driveability of the C3 WRC on the gravel. Since he joined the team a vast amount of detail modifications have been made to the rally car; one of the more noteworthy ones being a change to the static torque split options provided by the epicyclic gearing in the centre differential.

However, Besse says that the advantages derived from this should not be overstated. 'I would say there is not one thing; it's just the addition of a lot of small things and of course the torque split is one of these,' he says. Before Besse joined the team the front/rear torque split for gravel was 36/64, which provided 'not enough [torque] for the front,' he says: 'We have two [torque split options] because we want to use something different on tarmac compared to gravel; on tarmac we have 28/72. We are also allowed to use on tarmac the one we use on gravel now, which is 48/52. The 28/72 split option is the best for a fully dry tarmac rally.'

That torque split change required a (2017) joker to improve car performance, but most of the rest of the total five available 2017 chassis jokers deployed addressed reliability issues.

Meanwhile, the engine jokers played last year were aimed at reducing unit weight – the only performance-related change was a slightly improved turbocharger. But work on optimising the power curve continues. 'It's a long-term job; we do it every time, but we don't need a joker for it,' Besse explains, pointing out that this work mainly involves adjusting the engine control maps to suit circumstances.

Although Besse says the team is 'quite happy' with the tarmac specification, he adds: 'I think we miss some [front and rear] wheel travel on the tarmac specification, so we are working on this, but it is not a high priority because we need to improve first on the gravel.'

The team uses its own Citroen Racing developed and built dampers on tarmac events, but Ohlins for gravel: 'It was possible for us, even on gravel, to do something with our damper; we did it in the past. But we thought that it was quicker to have the Ohlins,' Besse says.

Two of the three available 2018 chassis jokers are planned for homologation at the start of March, to be ready in time for Rally Mexico. One of these addresses gravel specification rear suspension geometry. Front geometry developments are also under way on the car, but jokers are not needed for these.

Aerodynamic development plans are more long-term. Data from 2017 will be analysed, then correlated between the wind tunnel, CFD and the real rally car. The plan then is to understand these parameters in the first part of 2018, then to try new ideas in the wind tunnel in the second part of this year and the first part of 2019, to prepare for 2020's new homologation, which will also be based on the C3 model.

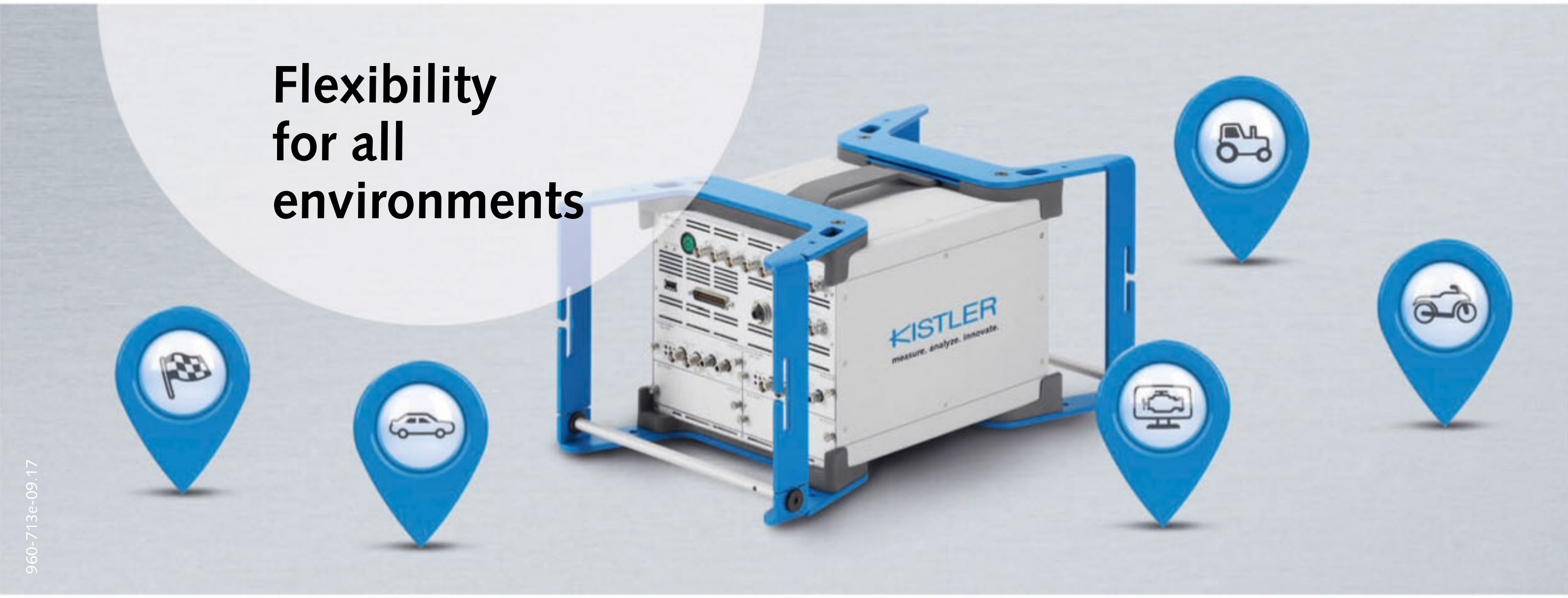
Besse says: 'If we find something which is only on one part of the car and is only one joker we can decide to go for it. [But] with the budget we have available we really need to try to concentrate on the new [for 2020] car.'

Each development Citroen makes represents small improvements. For example, it was discovered that the rear differential oil was occasionally below its normal temperature range at the start of a stage. This was because the cooling was found to be too aggressive. 'The problem is that we cannot change the bodywork to improve the cooling: each time it's a joker and we don't have a lot,' Besse says. The solution to this problem was the simple expedient of altering the actuation characteristics of the rear diff fan.

At the time of writing it's difficult to say which of the four major players is winning the WRC development war right now, as the Monte Carlo – as it often is – was a bit of a topsy-turvy affair, and the true state of play might not be known until Portugal in late May, by which time the World Rally Cars will have sampled a variety of surfaces and conditions. But one thing is for sure, the new WRC cars are still delivering when it comes to sheer spectacle.

Citroen's priority is improving performance and driveability on gravel

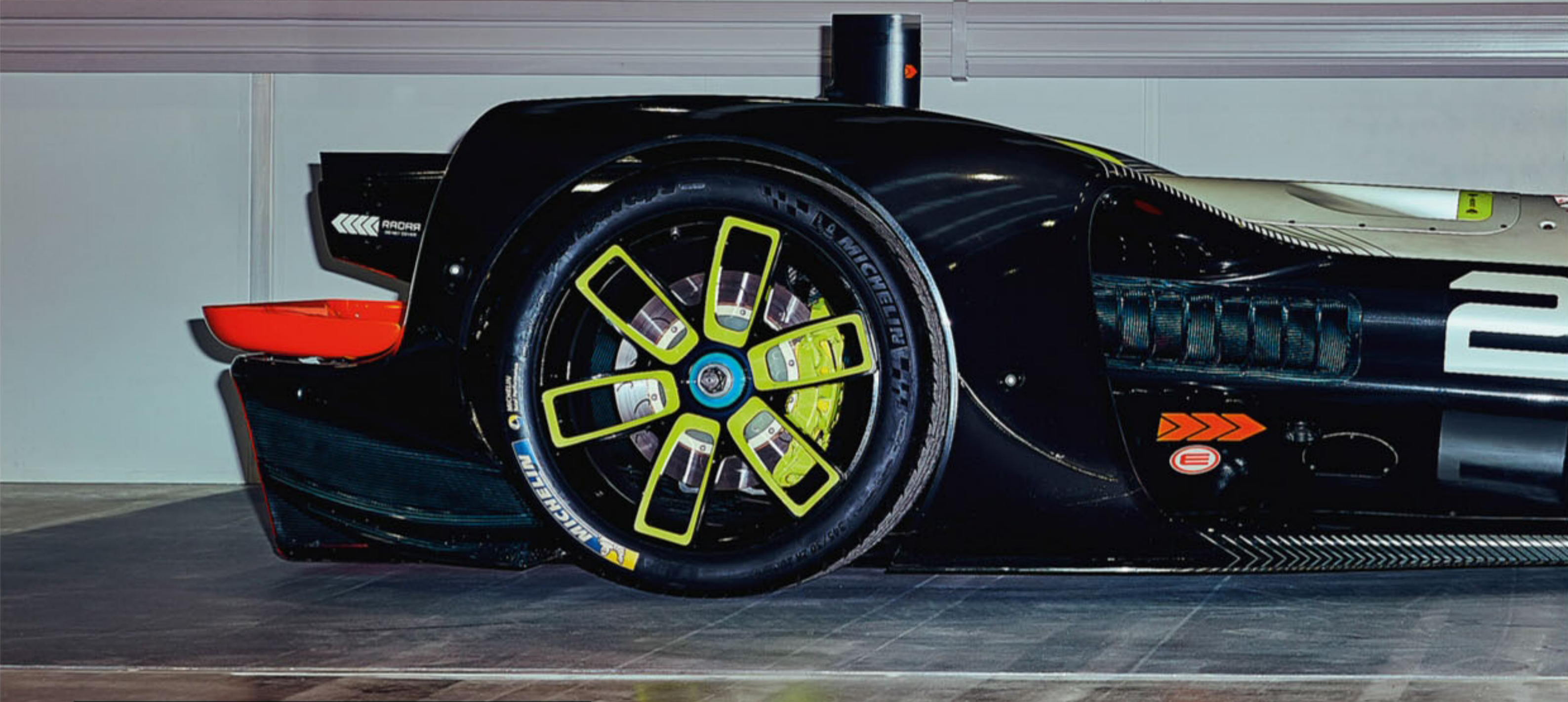

Lane MOTORSPORT
WE CONNECT TECHNOLOGY
VAD FOR SOURIAU 8STA CONNECTORS
ULTRA MINIATURE HARSH ENVIRONMENT CONNECTORS
MIXED POWER AND SIGNAL CONNECTORS
HERMETIC CONNECTORS
DEDICATED ASSEMBLY TOOLING
FUEL PROOF HEAT SHRINK BOOTS
ULTRA LIGHTWEIGHT ACCESSORIES
+44 (0) 1403 790 661
LANEMOTORSPORT.COM
MOTORSPORT@FCLANE.COM
SOURIAU
CONNECTORS
Weald
ACCESSORIES
HellermannTyton
HEAT SHRINK BOOTS
ONLINE SHOP
FOR AFTER HOURS ORDERING


Flexibility for all environments
KISTLER
measure. analyze. innovate.
960-713e-09.17

Robot **wars**

With driverless cars in both Roborace and Formula Student autonomous racing looks here to stay – but which of these classes will provide the best development path for this new technology?

By GEMMA HATTON



TECH SPEC

Robocar

Chassis: Carbon fibre.

Battery Power: 540kW.

Motors: Four 300kW motors providing 1200Nm torque.

Suspension: Double wishbone, pushrod front and rear with third element heave spring.

Top Speed: 320kmh (200mph).

Lift/drag ratio: 3:1.

Perception System: Two radars, 5 LIDARs, 15 ultrasonic sensors, six machine cameras and GPS inertial system.

Electronics: TAG ECU, 2 Nvidia Drive PX2.

Dimensions: width, 2.0m; length, 4.8m.

Gross weight: 1000Kg.

Ulrich Baretzky, Audi Sport's head of powertrain, said at a recent MIA conference: 'Only when half the grid go clockwise and the other half go anti-clockwise and there are no crashes will I trust autonomous racing.' A fair point perhaps, given that future mobility will require us to put our lives in the virtual hands of a computer as we get moved around by AI technology.

Like Baretzky, I too have major trust issues with computers after many accidental deletions, although this is probably user error. But if I can't trust my laptop to save a document, then how am I going to trust an autonomous car to save me when that traffic light turns red?

Driver droids

The answer to all this might be motorsport. As is the case with most futuristic mobility technologies, there is no better platform to prove concepts than racing. For AI this comes in the form of Roborace, the world's first fully autonomous race series. Its mission is to develop driverless cars that successfully and safely race each other at 200mph, therefore proving that driving you to the local shops is, in comparison, an easy task for AI technology.

You might assume that Roborace is just going to be a larger version of slot car racing; where computer controlled racecars appear to be on rails, evenly separated from each other. However, motorsport is about entertainment, and Roborace is no different.

'Simply taking the human out of the car and racing in the traditional format is not going to be entertaining for the fans. Especially if we replace the driver with computers, which people think will only allow safe racing,' says Bryn Balcombe, chief strategy officer at Roborace. 'We are fully focused on defining a set of technical and sporting regulations that promote side by side racing. We can determine how much track space each car needs to leave within the software, so rather than having driver's dive up the inside, cause damage and heading off into the pits, we can start to define the balance of performance around a corner. For example, instead of the inside always being the fastest route, the car on the outside could have torque vectoring available, so that it's faster to go round

Main image: The Robocar may be short and sleek but it still weighs in at 1000kg. These electric-powered cars are set to support Formula E races
Inset right: Look, no hands! A driverless Formula Student car makes a splash in Germany. The UK will also run an autonomous FS class this year

'Simply taking the human out of the car and racing in the traditional format is not going to be entertaining for the fans'

the outside of the corner. We could open up the option for multiple racing lines, rather than one optimum line, increasing side by side racing.'

OEMs will use Roborace as a testing platform to experiment with technologies such as lane-keeping and adaptive cruise control, but these all need to be tested against real road situations. 'We're talking about having formats that involve traffic on the circuit that the cars have to race through. Now that sets a completely different challenge for the perception and decision making skills of the autonomous systems. The racing line will no longer be the optimal path around a race track that you can spend weeks defining in the simulator beforehand. It will be completely random and will depend on how the cars react to the changing situations of cyclists, cars and trucks,' says Balcombe. 'Although this is what the industry wants, it also hits a sweet spot for entertainment. Seeing 200mph cars closing on 60mph trucks will be fantastic. This perception of speed is lost when 20 cars are all racing round within 10mph of each other.'

Despite there being no physical driver, the performance of the Robocars (they will be called Robocars when the series is up and running, but in the meantime the development mule is actually called a Devbot) will still rely heavily on driver skill, it's just an AI driver instead. Braking points, grip level and where to overtake all need to be calculated, decided and performed in real time by the AI driver. 'Imagine covering the driver's visor so he can't see out. It's still the same driver but if you don't give him the data he can't drive as fast,' Balcombe says. 'If you can manipulate the perception systems to improve the amount and quality of data coming in, then you can achieve higher overall performance.'

Transformers

Once this data has been perceived, the next challenge is to compute it. Trying to replace the complex analysis conducted by the human brain with a computerised one is an almost impossible task. Drivers are continuously running hundreds of models in their mind; analysing the grip variation and how this will be affected by track conditions, tyre wear, brake temperatures and thousands of other parameters, and then adjusting their driving style accordingly. Furthermore, the brain learns from experience, so at every corner, a driver will optimise the car's stability, speed or position for that all important lap time gain. Characterising this analysis with algorithms whilst teaching the software to learn from its experiences is the challenge set for the Roborace teams.

'Our competition is not about mechanical performance or eking every last bit out of the tyres or aero, we already have Formula 1 and sportscar racing for that,' Balcombe says. 'What we are doing is providing an effective platform that teams can then integrate their algorithms onto so that they are fully focused on developing that AI driver skill-set.'

Robots in disguise

The platform of the Robocar is split into three layers. First, there is the vehicle hardware which comprises all the components and systems you would find on a conventional racecar such as the chassis, aerodynamics, powertrain and tyres. Next, is the vehicle intelligence layer which consists of all the sensing and perception equipment, essentially replacing everything

Roborace has used Devbots to prove and develop the AI hardware and software before integrating it into the Robocar. Based on an LMP chassis the cars have no bodywork so engineers can quickly and easily access all the systems during the testing

Batteries and inverter unit on the Devbot. On the Robocar the 540kW batteries will be mounted underneath, through the hollow base of the car

Similar to the set-up on the Robocar, the Devbot has five LIDARs, achieving a full 360-degree view around the car. A LIDAR on the front left corner along with a machine camera and an ultrasonic sensor underneath is shown on the left. On the right a LIDAR in front of the rear wheel, along with an ultrasonic sensor, is shown

Both the Robocars and the Devbots benefit from two radars, one of which is at the front while the other one is at the rear; to give spatial information on the car's position within the environment

the driver uses to perceive the outside world. The third and final layer is the AI driver software which is fundamentally the 'driver's' personality, and it's this layer that the teams will develop.

The hardware

In terms of vehicle hardware, the Robocar chassis is fully carbon fibre and the futuristic aerodynamic package achieves a lift to drag ratio of 3:1. The narrow fuselage impressively houses a 540kW battery, four 300kW motors as well as the gearbox and inverters. Weighing in at 1000kg it is essential to keep the centre of gravity in the car low and so the battery box is actually mounted from beneath the car.

The car features double wishbone suspension with a pushrod front and rear together with a roll bar and third element heave spring. The steering and braking systems are both hydraulically actuated with the latter also featuring an override system.

On the perception side, each Robocar is equipped with two radars; one at the front and one at the rear, which detect objects and give spatial information about their location relative to the car. A full 360-degree view is achieved through the use of five LIDARs; two at the front, one at the rear and another two that act like wing mirrors. Each utilises four laser beams that scan across 145 degrees, measuring the distances from other objects at a minimum range of 0.3m. Then there are six machine cameras, three at the front, two again acting like wing mirrors, and one at the rear, which gives a more holistic view; for example, determining what is the track tarmac and what is the run off area. Finally, 15 ultrasonic sensors are spaced around the car for close range, low speed sensing, similar to modern parking sensors.

'We also use a GPS inertial system which is a fusion box that uses two antennas to give a heading and is supplemented by the inertial unit which gives accurate yaw, pitch, roll as well as longitudinal and lateral acceleration,' Balcombe says. 'So if the GPS fades in and out, which is often the case on city circuits such as Hong Kong, you can still run off your inertial sensor, radars and LIDARs.'

Path finders

Both the vehicle hardware and the perception systems are supplied as standard, which leaves the challenge of path planning to the competitors. 'There are many theoretical

'Everything that affects the performance should be software defined'

FSG's autonomous class has a very different philosophy to Roborace, focussing on the entire car rather than just the AI system

Most Formula Student driverless teams use combined data from LIDARs and cameras. In this way they can not only detect the position of objects, but they can also identify the colour of cones so they know which is the left or right side of the track

algorithms on how autonomous vehicles could decide which path to take, but the simplest method is to do it in two stages,' says Timo Voelkl, Roborace technical director. 'Firstly, geometrically define the curvature of the path within the track limitations recognised by the perception systems. Then for each point, solve for the driving speed. It's not a calculation competition, it's a knowledge competition because it's not about making the best solution in a known environment, it's about making the best solution in an unknown environment and this is what the OEMs want us to help develop.

'We want to try and make motorsport more accessible, which is why we are an open platform. Our aim is to be a 'championship of intelligence' and to achieve that we need to skew our competition solely around the development of AI software,' Voelkl adds. 'Ultimately, everything that affects performance should be software defined and if we end up with active suspension and other technologies in the future then those just become extra actuators which need to be controlled through software, increasing the challenge for the teams. Once the championship is fully software driven, then we can open it up to development, which is similar to Formula E's strategy.'

Formula Student

This software-focused approach is completely opposite to the other player on the nascent autonomous racing scene, Formula Student Germany, where last year 15 teams took on an autonomous racing challenge for the first time. Formula Student UK will follow suit this year.

To get the world's first driverless Formula Student competition off the ground FSG decided that teams could adapt their 2016 cars to include AI technology, instead of building a completely new car. But this strategy actually skewed the competition towards those with the best mechanically performing cars and not necessarily the best AI performing cars.

Once the AI systems have located the position of the car within the environment, the algorithms then calculate the fastest route, which the car simply follows and the performance at this point is purely down to the mechanical hardware. Teams who had fast racecars before will be again fast, regardless of how effective their AI algorithms are.

Retro-fit

Integrating AI technology into an old car actually proved to be quite the challenge. The electronics, cooling and AI hardware were difficult enough, but adapting the car to also include overrides and safety systems made the task even more problematic. 'The majority of FSG cars failed scrutineering because of their emergency brake and steering systems, it was nothing to do with the autonomous software,' says Balcombe. 'That's what FSUK are trying to avoid; they want to improve safety by standardising those systems, and get the teams to focus on the software that's implemented on top of the hardware platform.'

With this in mind FSUK will supply a standardised platform to the teams, similar to Roborace, to ensure that each car is fully equipped with the necessary safety features. However, Formula Student is an engineering competition and by limiting the task to simply

Integrating AI technology into an existing car proved to be a challenge


Intelligent Fully Featured Battery Power Control Systems
POWERBOX
HP 8441
NEW
Cost Effective
Practical
Incredibly Versatile
Fully programmable power control in a user friendly package.
Future Upgrade Path to HP8440.
Main Features:
- 180 Ampere continuous.
- 34 Output channels controlled as a function of conventional switches, CAN inputs or Virtual channels. With wiper Park on dedicated channels.
- Weight 496 gr.
MEMBRANE PANEL
CAN Controlled Membrane Switch Panel.
Tactile Operator Feedback.
Multi Tap Capability.
Warning LED's.
Available With Your Custom Design.
POWERBOX
HP 8440
HP ELECTRONIK
Main Features:
- 200 Ampere continuous.
- Programmable Inrush Currents
- 34 Individually Programmable Output Channels
- 11 Conventional Switched Inputs
- 32 CAN Input Channels
- 20 Virtual Logic Channels
- CAN Export Facility
- Weight 680 gr.
Future Proof With Firmware upgrades
OVER 1000 UNITS SOLD WITH PROVEN RELIABILITY
ENGINEERED & PRODUCED WITH OUR EXPERTISE IN HOUSE. LEARN MORE AT HPELEC.DK
HP ELECTRONIK
Lundvej 17-19, Lund
7400 Herning · Denmark
Tel. +45 9626 4333
Fax +45 9626 4233
info@hpelec.dk
www.hpelec.dk


The Rottler
EM69P
The Ultimate Solution for Engine Machining
The new EM "Engine Machining" CNC Machining Centers are built on Rottler's 95 years of design and manufacturing experience. We are dedicated to providing customers even more flexibility for engine parts machining, digitizing and porting, and custom parts manufacturing, making Rottler EM Machining Centers the most technically advanced industry-specific system to date.
NEW ROTTLER 4C SOFTWARE
Allows 3D CAD Solid Models to be imported (and created) at the machine.
Create complex 3D tool paths direct from the CAD geometry.
ROTTLER
THE CUTTING EDGE
Linear Roller Bearing Slideways for faster movement and improved positioning accuracy
24 position ATC Automatic Tool Changer for increased versatility and productivity
Increased Spindle Power & Torque for Billet and Casting machining
Maximum Functionality - operators can machine blocks and cylinder heads as well as create custom parts all in one machine
ROTTLER
Find us at the PRI show - Booth 5129
1-800-452-0534
8029 South 200th Street, Kent, WA 98032 USA+1 253 872 7050
rottlermfg.com
www.youtube.com/rottlermfg www.facebook.com/rottlermfg contact@rottlermfg.com

'Just focusing on the software is not really what Formula Student is about'

generating and optimising algorithms, it is also limiting the skills learned by the students.

'From a software point of view, of course it would be nice to have a running platform already, so you can get started on developing the high level algorithms right away,' says Robert Oehlmann, software leader at e-gnition Hamburg Driverless FS team. 'However, just focusing on software is not what Formula Student is about. Being involved in all the different disciplines required to build a racecar and then bringing that knowledge together to come up with a design solution is the ethos behind Formula Student. In that respect, the FSG approach is opposite to Roborace and Formula E, who started with a standard platform and then gradually opened up the rules.'

Most of the Formula Student driverless contenders combine data from LIDARs and cameras to determine their position on track and then begin the path planning process.

'The LIDARs can see at least 100 metres ahead and collect data on the position of objects,' says Lukasz Bleszynski, autonomous team leader at KA-RaceIng FS Team. 'The cameras then help us to determine what type of objects these are, for example identifying whether the cones are blue or yellow which we can then use in our algorithms to determine which is the left or right side of the circuit.'

Learning lines

To support the teams at their first driverless race FSG allowed them to do a track walk – with their AI drivers. 'Similar to how real drivers walk the track and memorise apexes, and racing lines, teams were allowed to bring all kinds of measurement devices to help their computer systems to memorise the track,' says Nils Albrecht, manager at e-gnition Hamburg Driverless FS team. 'We took our LIDAR sensors to get a basic map of the track to help with the perception of our first lap. Other teams, however, went a step further and used GPS to record the complete track layout which meant that when it came to the first run, these teams were no longer relying on sensor data at all and were just following a pre-recorded track.'

This has now been banned, so when the racecars line up at the start, the race track will be completely unknown, and therefore a true test of the effectiveness of each team's perception and algorithm strategies.

The perfect lap?

Regardless of the differing approach of each autonomous racing category, the most interesting aspect of this revolution in racing is the potential for perfection. Computers can monitor all the changing conditions of a race at a much higher frequency than the human brain. It can then run through its integrated theoretical models and react with the optimum solution. Therefore, in theory, autonomous racecars are capable of utilising all the grip, all of the time, no matter the scenario; perfection.

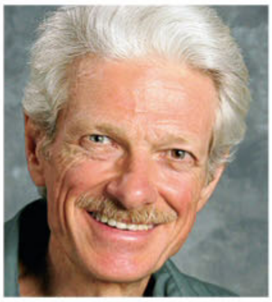
Unfortunately, us humans are still limiting the performance of these machines as, ultimately, the AI output will only be as good as the models and methods programmed by the developer. The challenge of going racing with AI is fascinating and will undoubtedly lead to the development of innovative technologies. But is this actually a form of motorsport? Or is autonomous racing more of an experiment, rather than entertainment?

The cameras provide a more holistic view of the surroundings, allowing the car to identify whether objects are cones, barriers or other autonomous FS vehicles that it is sharing the track with

This year's car from KA-RaceIng features three LIDARs at the front to increase the field of view. The team also removed some aero devices to minimise obstructions – because of the rather steady speeds of these cars they do not require much downforce


HOLINGER
INNOVATIVE DESIGN
GEARED TO WIN
GEARBOXES
BELL HOUSINGS
DIFFERENTIALS
PADDLE SHIFT
HISTORIC PARTS
ENGINEERING
SERVICE
MAINTENANCE
NEW
X12 Transaxle
- 1100Nm 24h
HOLINGER EUROPE
Talk +49 8686 984426
Write info@holinger.de
Look www.holinger.de
HOLINGER ENGINEERING
Talk +61 3 976 179 64
Write info@holinger.com.au
Look www.holinger.com.au
HOLINGER AMERICA
Talk +1 949 362 8750
Write info@holinger.us
Look www.holinger.us


THERMA
MOTORSPORT
Temperature
is our Business.
The sophisticated Specialist in
Thermo Sensor Technology for Motorsports.
Sensors for tyre and braking systems
Sensors for exhaust gas systems
Sensors for fluids
Display devices and transmitters
Thermocouples Accessories
Individual solutions
You need a special solution or a individual adjustment of our standard products? Simply contact us.
Therma Thermofühler GmbH . Schreinerweg 8 . 51789 Lindlar . Germany . Tel.: +49 2266 8026 . www.therma-motorsport.de



The other side of the tracks: tilting trains

Could Pendolino technology ever be applied to racecars?

QUESTION

I have heard that tilting trains are being considered as a way of attaining higher speeds on old railways. Is this actually feasible? Expanding on that a bit, if it works for trains, what about for trucks, buses or even cars?

THE CONSULTANT

There probably is considerable potential for achieving greater speed and safety in trains on existing tracks through better chassis design.

Tilting trains, which lean into the turns, are actually used in some countries. To be useful for increasing cornering speed, they have to be active: they have to have some mechanism that moves the mass of the locomotive or rail car toward the inside of the turn with respect to the rails. This requires a lot of force. It cannot be done with passive suspension.

It is possible to make the train tilt into the turn passively, without the cg moving to the inside. The earliest tilting trains were like that. They were called pendulum trains. They had a very high roll axis and the rail car would lean inward as the cg swung outward. The object of this was to improve passenger comfort rather than increase speeds. In fact, this would actually decrease safe cornering speed. It was found that passengers got motion sickness on these trains. Literature I've seen attributes this to people being unaccustomed to seeing the landscape tilt. I'm sceptical of that, based on my experience as a passenger on motorcycles and in airplanes. I'm more inclined to suppose that there were under-damped oscillatory motions. I've experienced motion sickness due to that in softly sprung, poorly damped automobiles.

For historical reasons, plus economy and ease of track construction, trains everywhere are inordinately tall and narrow. Their cg height is much greater than the spacing of the tracks and wheels (the gauge, in railroad parlance), generally at least by a factor of 1.5 and sometimes by as much as a factor of two or more. That gives a limiting lateral acceleration of no more than a third of a *g* and perhaps as little as a quarter of a *g* before the whole massive affair overturns. That's if the tracks are level, there's no wind, and the cargo doesn't shift. It is possible to bank the turns, but not a lot if the track takes tall cars with liquid or bulk cargo that can shift, which may be moving very slowly or have to be parked on the turn.

A Williams FW31 and a Virgin Trains Pendolino. As on this train, a tilting system on a car would need to be active

XPB

Designing actively suspended trains must be pretty challenging. If there is just one accelerometer at the locomotive, there has to be a system that delays the tilting of the cars because they enter and leave the turns after the locomotive does, sometimes by quite a lot. Alternatively, each car has to have its own accelerometer and actuation system.

For road vehicles, we don't have to contend with that, but the system does have to have very quick response and generate very large forces. It might be that this could be done fairly easily in vehicles with air suspension, perhaps using a fairly simple inertia valve. I don't know of any attempts to do this. This would still be active suspension, even if it's completely mechanical, because the compressed air would come from some outside source.

One idea that has occurred to me for trains concerns stopping them. Braking in trains is ordinarily limited by the coefficient of friction of smooth steel wheels on smooth steel rails. This can be surprisingly high under ideal conditions – as much as 0.6 – but it drops dramatically if there are any contaminants or wetness. I would think that for emergency stopping it would be possible to have sets of shoes that are applied to each side of the rail, like rim brakes on a bicycle. These would be for emergency use only, and would be up out of the way in normal use. They would be used to augment the existing air brakes.

The system has to have very quick response and needs to be able to generate large forces

Correction

Some half a dozen readers or so have pointed out to me that although it is legal to add ride height adjustment on a street class autocross car when this is a feature of aftermarket shocks, it is not legal to actually use that feature to change the ride height (see last month's issue, V28N3). Or at least, that's the intent of the rule, and the way it's enforced. When they say the lower spring perch has to remain in stock location with respect to the hub, they mean in all three axes. Evidently, the thinking is that you can have a non-stock setting on any stock adjustment, including ride height, and you can add a non-stock ride height adjustment, but you can't have a non-stock setting on that.

Interestingly, if a car has inverted shocks and the adjusting collar is above the spring, it would theoretically be possible for the car to be in compliance with the letter of the regulation and still be lowered. But I'm not sure if there are any eligible cars that this would apply to.

Playing the percentages

The implications of moving the engine back in a New Zealand short oval racer

QUESTION

I'm am working on a proposal to Speedway New Zealand [the governing body of NZ short oval racing] to get a rule change regarding engine set-back in our class. Currently our No.1 plug has to be in line with the centre of the front stubs. I am going for a 6in set-back which will put us in line with both Australian and American rules for these classes. My own car weighs 2390lbs, the engine weighs 441lbs. The wheelbase is 103in so a 6in set-back would be 5.8 per cent of the wheelbase, and the engine weighs 18.45 per cent of the total car weight.

Is there an equation to work out the increased rear percentage? I wondered if dividing 18.45 per cent by 5.8 per cent might be it, but I honestly don't know. Any help would be appreciated.

THE CONSULTANT

You would multiply 18.45 per cent by 5.8 per cent, i.e. .1845 x .058. That works out at just over one per cent. You would gain a percentage point at the rear and lose a percentage point at the front.

You would also be moving the bellhousing, the clutch, the transmission, and the starter back by the same amount. That would then get you perhaps another fifth of a point.

We can state that as a general principle, moving a given percentage of the car weight back a given percentage of the wheelbase will increase the rear percentage by the product of those two percentages (expressed as decimals, of course).

This works even for items located outside the wheelbase. For example, suppose we have a battery that is one per cent of the car weight. Suppose that the stock location is on the front wheel well, five per cent of the wheelbase forward of the front axle line. When we put the battery in the car, the front axle load increases by 105 per cent of the battery weight, or 1.05 per cent of total car weight, and the rear axle weight decreases by five per cent of the battery weight, or 0.05 per cent of the car weight. Taking side-view moments about the front contact patches, the battery creates a forward pitch moment equal to one per cent of car weight times five per cent of the wheelbase, and this is reacted by a decrease in rear wheel load equal to that one per cent times five per cent, divided by the wheelbase.

Taking moments about the rear contact patches, the battery acts on a moment arm 105 per cent as long as the wheelbase and this is reacted at the front by an increased tyre load equal to 105 per cent of the battery weight.

Now, suppose we move the battery to a location in the trunk, 10 per cent of the wheelbase behind the rear axle. We have then moved one per cent of the weight 115 per cent of the wheelbase. The rear axle now bears 110 per cent of the battery weight and the front axle is lightened by 10 per cent of the battery weight. So the rear percentage, compared to the previous condition, changes by an amount equal to 110 per cent plus five per cent of battery weight, or 1.15 per cent of car weight: again, the percentage of car weight that the battery comprises, times the percentage of the wheelbase that we moved it.

Roll reversal in the racecar

Could accelerometers be used to vary the spring rates of outer wheels in corners?

QUESTION

As a wannabe racer, and graduate from the Bondurant race drive school, my goal is to design and build a racecar, putting my aeronautical engineering experience to use.

Audi came close to isolating bump from roll with its LMP1 car. Roll could be effectively countered with the use of devices which respond to accelerometers, but this would be active suspension

I have long been interested in anti-roll solutions, particularly with respect to isolating bump springs from roll. Audi had almost done it with their late, great LMP1 car, but I don't think that in their solution bump and roll are completely isolated. I have an idea to vary the spring rate of the springs; in this case the rate of the outer wheels would be increased in turns, and reduced on the straights. This would then eliminate anti-roll bars.

It would be activated by accelerometers, which would respond to increasing lateral *g* as the corners are entered.

Question: Is this a reasonable concept to pursue? If so, would it run foul of rules regarding active suspension?

THE CONSULTANT

The short answer is yes, and yes. It is definitely possible to counter roll with various types of devices acting in response to an electronic signal from an accelerometer.

This has been done, and it does work. Really, what it takes is alteration of ride height on the inside and outside suspensions, rather than spring rate or wheel rate. One system uses anti-roll bars with moving mounts for this, rather than eliminating anti-roll bars.

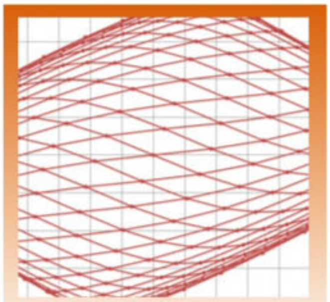
This really needs to be done in an appropriate front/rear proportion, just like anything else that resists roll.

However, to accomplish all this, it is unavoidably necessary to have the accelerometer trigger something that will actually mechanically move some part of the system, using an energy source other than the motion of the vehicle itself. That will then make the system active.

CONTACT

Mark Ortiz Automotive is a chassis consultancy service primarily serving oval track and road racers. Here Mark answers your chassis set-up and handling queries. If you have a question for him, please don't hesitate to get in touch:

E: markortizauto@windstream.net
T: +1 704-933-8876
A: Mark Ortiz
155 Wankel Drive, Kannapolis
NC 28083-8200, USA



Slip Angle provides a summary of OptimumG's seminars

Formula Student 101

OptimumG engineer Claude Rouelle's 101 top tips for Formula Student teams continues with some thoughts on dampers, chassis rigidity, and even finding sponsorship for your FS project

Formula Student is really a project management and engineering design competition based on a racecar, rather than a true motorsport discipline

Besides his leading role at renowned vehicle dynamics consultancy OptimumG, Claude Rouelle also offers his services as a design judge in Formula Student competitions. Which means he's well-placed to advise those looking to take part in Formula Student events …

26. Let's start off where we finished last month, with a quote from Albert Einstein: 'We cannot solve our problems with the same thinking we used when we created them'. No more comment needed here.

27. There are two kinds of people: People who win and people who make excuses. Choose what kind of person you want to be.

28. What makes a car perform is tyre grip. The first thing that influences a race tyre's grip is its temperature. The first thing that influences tyre temperature is damping. Sometimes an over-damped car makes the car half a second slower because it is more difficult to drive, yet one second faster because you can generate more lateral and longitudinal accelerations.

29. The ideal damping in heave is not the ideal damping in roll and pitch. In heave, the dampers control the chassis movement and the tyre deflection against the forces acting on suspended and non-suspended masses. In roll, the springs and the anti-roll bars control the chassis and tyre movements against the forces and moment acting against these masses *and their inertias*. It is difficult to get the most from heave and roll control unless you decouple heave and roll stiffness and damping.

30. Formula Student competition is *not* motorsport. It is good training if you want to work in motorsport, but it is not motorsport. It is a project management and engineering design competition based on a racecar. The best proof is that a so-so car can get a pretty good result with a very good driver. Formula student is about preparing future engineers for their career. Focusing on car performance only is

There are two kinds of people: the people who win and the people who make excuses. Choose what kind of person you want to be

The good race engineers know what the ideal tyre temperature is – it is simply the one they had when they were winning races

good but not enough. You need to explain, with an engineering approach, *why* your car is good and what could make it better.

31. Put your steering wheel straight. Is your rack centred? Do you have a tool to lock your steering rack in its centred position? Now measure your left and right wheelbase. Are they the same? If you have more than 1.5mm of difference (that is about one per cent of the wheelbase), you have real issues with your jigs or your manufacturing process, or both.

32. No two dampers are the same. Put the same bump and rebound damper setting on two different dampers and test them on a dyno. You will most probably see big differences. To have two dampers giving the same force *vs* velocity curve, you could need different bump and rebound settings. That is the very reason you need to use a damper dyno.

33. Many water coolers are way too big and, consequently, too heavy. They also create unnecessary aerodynamic drag. With good inlet and outlet ducts inside your sidepods, you can significantly increase your cooler efficiency.

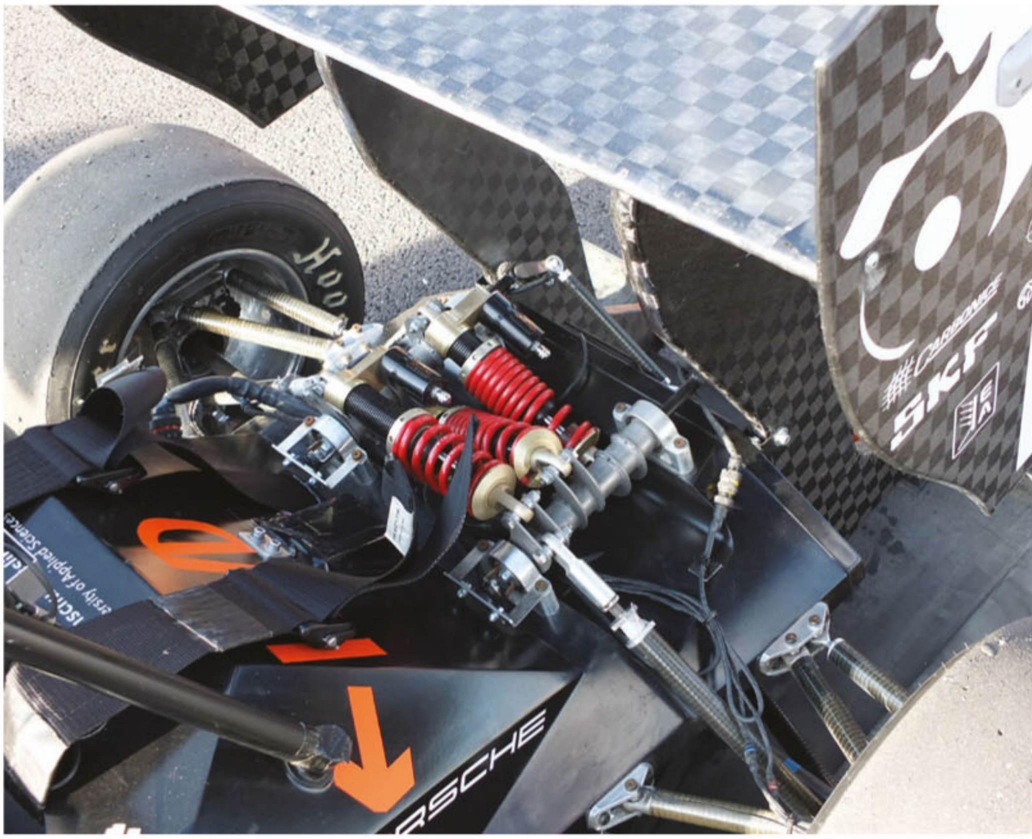
34. Here's a recipe for tubular chassis design: Minimum of tube, minimum of nodes (ideally three tubes per node), and maximum of triangulation. That is how you can get both high chassis stiffness and low mass.

35. Most students do not understand, or they simply underestimate, the importance, of chassis and suspension compliance. Nothing is rigid; 0.2mm of deflection here and 0.3mm of deflection there, and suddenly your front camber or you rear toe is far, far away from what you thought it was. From the driver input (steering wheel, brake pedal, throttle) to the tyres' contact patch, there are dozens of non-linear springs, dampers, and hysteresis that compromise the racecar's response to that driver input. Compliance is the biggest enemy of your driver's control and confidence.

36. Chassis torsion stiffness FEA analysis does not mean a thing unless it has been compared with workshop measurement. If the two numbers are not the same, that's okay, providing you can explain why that's the case.

37. If you simulate or measure the chassis torsion stiffness, you need to apply realistic loads at suspension pickup points instead of irrelevantly at the front and rear bulkhead.

38. A soft spring in series with a stiff spring is still a pretty soft spring. There is no point in having a very stiff chassis and compliant suspension wishbones.



The first thing that influences a race tyre's grip is its temperature and the first thing that affects this is damping. It's also worth remembering that no two dampers are quite the same, so damper dynos are vital

To achieve both high chassis stiffness and low mass with a tube frame there is a simple recipe to bear in mind: minimum of tube, minimum of nodes (ideally three tubes per node) and maximum of triangulation

You can’t solve engineering problems without engineering inputs

39. Camber compliance from rims can easily be 0.7-degree per *g*. If your car takes 3*g* in lateral, your dynamic camber calculation is already wrong by two degrees compared to a simplified kinematics software simulation. That is from the rim only.

40. Designing a suspension with rod ends in bending is simply criminal.

41. The same goes for suspension linkages axis that do not pass through a chassis node.

42. Single shear is a bad idea. Toe link rod end attachment on an upright is an example of this. Another example is a rocker axis on the chassis. One of the biggest sources of compliance that makes the real, measured wheel versus the spring motion ratio different than the one calculated without FEA is the deflection in the region of attachment of the rocker axis on the chassis.

43. The last thing you should be drawing is the chassis. The chassis is nothing more than a big bracket that holds everything.

44. Good race engineers know what the ideal tyre temperature is – it is the one they had when they were winning races. Pretty much the same can also be said for the tyre pressure.

45. You can’t solve engineering problems without engineering inputs. That is why, for example, you need tyre force and moments models. Unless you use extensive and expensive trial and error (but then that is not what Formula Student is really about) I don’t know how you can design suspension without a relevant tyre model.

A single tyre is in itself a complex system that’s subjected to a multitude of variables, from driving styles to track conditions, which is why a tyre model only gives you an indication and not a perfect prediction

There are plenty of stickers on this car but gaining a proper sponsorship deal for Formula Student is tough and a team needs to persuade a company it will be getting more than just decals in return for its support

46. A tyre is a complex system that includes many different sciences, it is part engineering and part black magic. Track and ambient conditions that could change lap after lap, car set-up, driver’s style, etc. That is why a tyre model only gives you an indication, not a perfect prediction of what the tyre forces and moments will be on the track.

47. You should be spending as much time testing and developing your racecar as designing and manufacturing it, especially if you are a new team. The two most common Formula Student weak points that I see are the driver’s lack of skill and a lack of car reliability. How do you train your drivers and improve your car reliability if you do not test it? Professional teams with zillions of dollars and hundreds of people still manage to break things during races. How can the members of a little, inexperienced Formula Student team believe their car will be reliable without testing? Three to five months and 500 to 1000Km of efficient testing before the competition is an absolute minimum. You will reduce your lap time much more by testing your car one month earlier than by spending one more month designing it.

48. Some students can’t give design judges a precise number on testing time and distance. You need to carry a notebook all the time which contains your test run sheets that show all the test data: the start and end set-up, start and end time of each run, numbers of laps ran, lap time, tyre temperature, pressure and temperature, atmospheric conditions, track temperature, driver comments, set-up change, and so on.

49. Unless your design decisions are backed up by in-lab tests and on-track validation, you won’t impress anybody. Remember, this is a design competition, not a simulation competition.

50. You just can’t ask for money from a sponsor so that you ‘can put his company stickers on your car and have fun building and running your mini Formula 1’. Ask yourself what is the win-win situation for both you and your sponsor.

Next month: *Don’t miss points 51 to 75*

CONTACT
Claude Rouelle
Phone: + 1 303 752 1562
Enquiries: engineering@optimumg.com
Website: www.optimumg.com
OPTIMUM G


VAC MOTORSPORTS
World Leading Performance
SAMSONAS MOTORSPORT TRANSMISSION
Gearboxes and Gear Sets
Rally, Drag, Hill Climb, or Road Racing
For BMW, Mitsubishi, Subaru and More
Dog Gearboxes Available for 4, 5 and 6 Speed Units
CP CARRILLO
Forged Pistons
Pistons Available From CP and JE
Part of VAC Stroker and Turbo Kits
Perfect For High Performance Applications
Dailey Engineering
Billet Dry Sump Kits
Increases HP and Reliability
4-cyl, 6 cyl, V8 & V10 applications
Full Kits with Pumps also available
tilton VAC
Clutch & Flywheel Kits
Rally, Race, & Carbon Clutches
Lightweight Flywheel included!
Twin & Triple Disc Clutches in 5.5" & 7.25"
JE PISTONS
SCHRICK
ARP
ARROW
SAMSONAS MOTORSPORT TRANSMISSION
COMETIC
CP CARRILLO
+1.215.462.4666
www.vacmotorsports.com
2501 Snyder Ave, Philadelphia, PA 19145, USA
sales@vacmotorsports.com


Call us first...
Trident
Racing Supplies
MasterCard
VISA
Unit 23 Silverstone Circuit Towcester Northants NN12 8TN
T: 01327 857822 F: 01327 858096 www.tridentracing.co.uk

Shaving the drag from an LMP3 car

Our Ligier JS P3 aero study begins with some Gurney removal

We have had the privilege of putting a current spec Ligier LMP3 car in the MIRA full-scale wind tunnel recently, and over the next three issues we'll see the effects of some fascinating configuration changes. Bolton-based RLR Motorsport team principal Nick Reynolds was quite clear about his objectives for our session on his team's Ligier JS P3: 'I want to find out the most efficient way down the straights.' It would seem that track data showed the Ligier had greater drag than its Norma and Ginetta opposition, so the quest for our session was to find drag reductions, while also preserving or improving aerodynamic balance and efficiency.

Before we get into the testing, let's remind ourselves of the aero package allowed in LMP3, with a brief tour around the Ligier.

Since the category's inception in 2015 LMP3 has had its own aerodynamic limitations, with somewhat smaller diffuser volume than in LMP2 and a rear wing limited to a single element of 300mm maximum chord and 1600mm maximum span. Thus, although the front end package is not, in general terms, dissimilar to that of an LMP2 car, total downforce is effectively limited by the diffuser and wing restrictions and it is obviously short of that produced in LMP2.

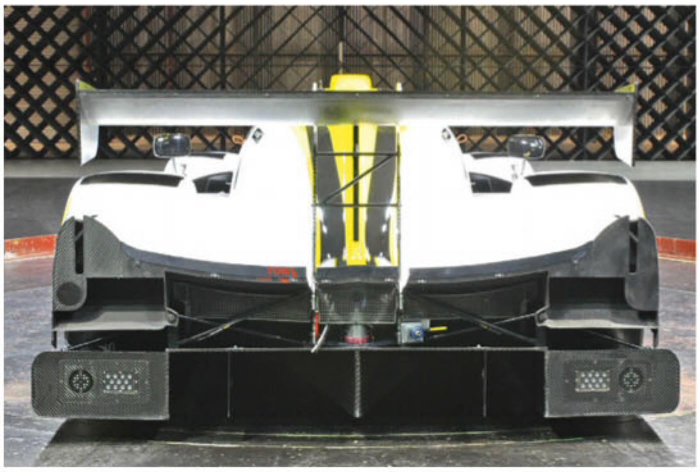
The Ligier features the now archetypal LMP-style raised splitter incorporating a large chord wing profile across the raised underside. Air from this area is channelled out behind the front wheels, and a view from the rear with the nose off shows how open the car is in this region, albeit shielded with curved vanes between the wheel arch and the sidepod. Some of the air that passes above the splitter is ducted to the water radiators in the sidepods and to the front brake cooling. A single pair of optional large area dive planes are fitted to the outer corners of the front wheel arches. Moving aft, the regulation-defined floor feeds into the relatively simple rear diffuser. The modestly cambered single element rear wing (the profile is free within dimensional limits) is fitted with the obligatory 25mm Gurney (except for the Le Mans support race where it may be removed). There is also an optional rear body Gurney. The front and rear wheel arches feature mandatory 'air extractor' apertures.

Regrettably, it was decided that absolute coefficients or force values were too sensitive for publication, so our studies

The Ligier had greater drag than its Norma and Ginetta opposition

Ligier JS P3. Front end aerodynamic treatment is not dissimilar to that of an LMP2 car

Clean exit for under-splitter air aft of front wheels; note the curved vane before sidepod



Regulations dictate that a simple rear diffuser and wing is used, limiting total downforce

The rear wing features modest camber and is fitted with a mandatory 25mm Gurney flap

Table 1: The effects of removing the rear body Gurney (RBG)

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front*	Δ-L/D
Without RBG	-8.4%	-9.1%	+2.3%	-15.5%	+3.77%	-0.6%

*Absolute rather than relative difference in percentage front.

Table 2: The effects of removing the rear wing Gurney (RWG)

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front*	Δ-L/D
Without RWG	-5.1%	-3.3%	+5.7%	-8.8%	+3.48%	+1.8%

*Absolute rather than relative difference in percentage front.

The optional rear body Gurney was removed in an attempt to take drag out of the Ligier

Race tape achieved some modest benefits – the arrows show where it was applied

Straight away more than eight per cent of the drag was removed with this simple modification

Table 3: The effects of taping over some cooling inlets

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front*	Δ-L/D
Step 1	-	+1.2%	+2.4%	+0.3%	+0.5%	+1.1%
Step 2	+0.2%	+1.4%	+1.2%	+1.7%	-0.1%	+1.1%
Total	+0.2%	+2.6%	+3.6%	+2.0%	+0.4%	+2.2%

*Absolute rather than relative difference in percentage front.

here are restricted to 'delta values' between configuration changes. Nevertheless, to put some context on the Ligier's aerodynamic performance in the MIRA fixed floor wind tunnel, we will state that the starting -L/D (efficiency) value was almost exactly the same as the Ginetta LMP3 we tested in late 2015, but the Ligier did indeed have a higher drag value, as was suggested earlier.

The Ligier's aerodynamic balance as delivered to the wind tunnel saw 32.3 per cent of its total downforce on the front axle. This seemed to be on the aerodynamic understeer side of well-balanced, given that the static weight distribution saw 43 per cent on the front axle, which Reynolds confirmed is a means of avoiding high speed oversteer as rear tyres generally degrade faster than fronts.

Gurney removal

There were some obvious low hanging fruit with respect to making drag reductions on the Ligier, the first of which was the rear body Gurney, and **Table 1** shows the percentage changes that were achieved when this was removed. Straight away then, more than eight per cent of the drag was removed with this simple modification, and because body Gurneys tend to be rather blunt instruments as downforce generators just nine per cent of the total downforce was lost.

Clearly, the downforce loss was at the rear, and the resulting shift in balance produced a %front figure of just over 36 per cent, which on a superficial basis was a better balance than the starting configuration.

As mentioned previously, the rear wing Gurney is mandatory wear in LMP3 at all venues except Le Mans, where it may be removed. Following the removal of the rear body Gurney, it was logical to look at the effect of removing the somewhat smaller wing Gurney, and **Table 2** shows the percentage changes arising from its removal.

In this instance drag was reduced by another five per cent, this time for the loss of just 3.3 per cent total downforce. Interestingly, a smaller percentage downforce loss at the rear compared to the removal of the rear body Gurney was matched with a bigger gain in front downforce, this no doubt because the rear wing is much higher than the rear deck, and so the bigger vertical component of the wing's lever arm had a greater effect on the forces felt at the front tyres. The overall effect on the %front value was almost as big as the rear deck Gurney achieved.

Magic tape

The virtues of race tape are well-known to Aerobytes readers, and as usual one of the things to be tried in our session was to tape over some cooling inlets to see if drag reductions could be achieved.

This was done in two stages; first the driver cooling inlets in the tip of the nose and at the base of the front screen were covered, along with the top part of the front brake cooling inlets (arrowed in the photo); and second, part of the main radiators, not visible in our photo and within the sidepods, was taped over. The changes are shown in **Table 3**.

In fact, no drag reductions were achieved at all here, but instead small downforce gains were found, with a modest front bias. These might be considered useful when the car is in qualifying trim, when the inevitable reductions in driver, brake and engine cooling might be deemed tolerable in the quest for maximum downforce and a sharp front end when going for that all-important quick lap.

Next month we will be examining the impact on drag as the rear wing is swept through its working range, and also the effect of removing the front dive planes

Racecar's thanks go to RLR Motorsport.

CONTACT
Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk.
In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

Produced in association with MIRA Ltd
A HORIBA COMPANY MIRA
Tel: +44 (0) 24-7635 5000
Email: enquiries@horiba-mira.com
Website: www.horiba-mira.com

Mixed Up

Racecar revisits the ongoing Ricardo Divila-inspired Brazilian Formula Vee project to find it's not only now called Formula Up but it's also hit a major snag – an enforced switch from a longitudinal to a transverse engine layout

By RICARDO DIVILA

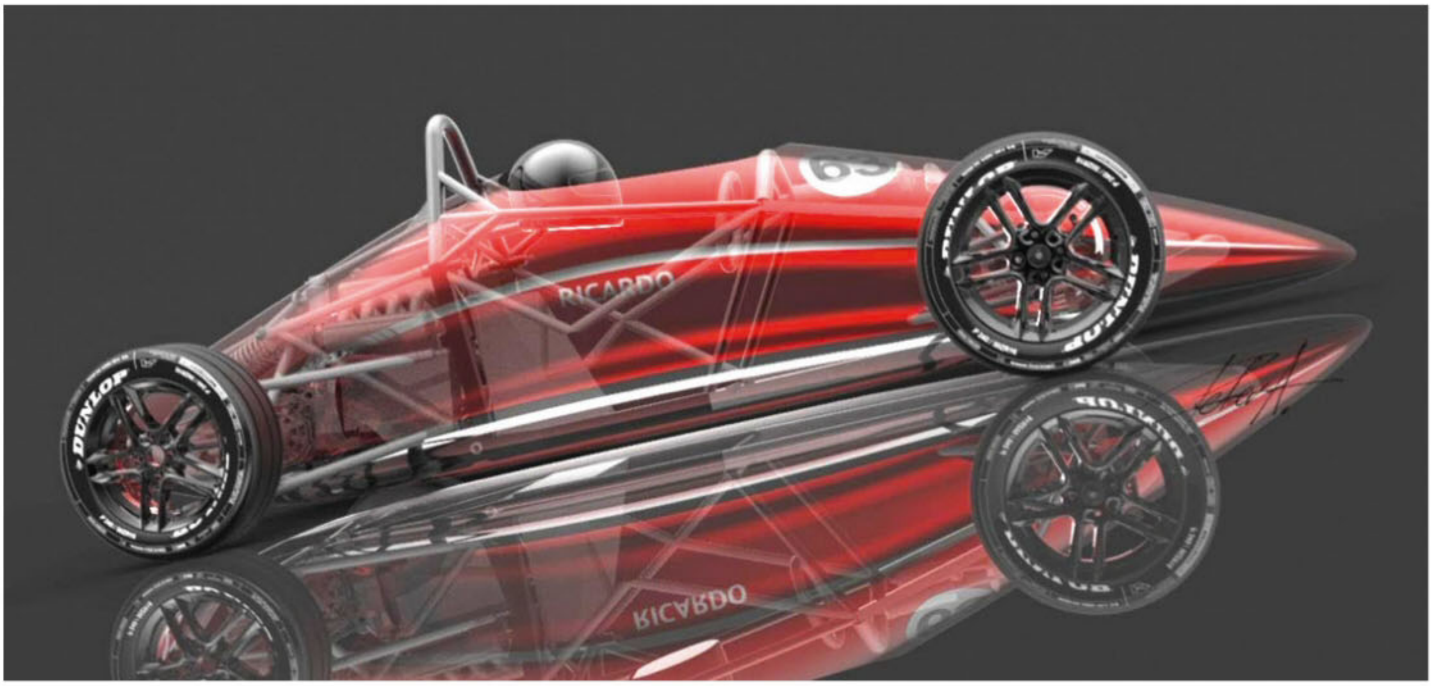
In previous articles (April 2017 V27N4 and December V27N12) we ran through the concept and design philosophy of our spec entry-level Brazilian Formula Vee project. In this instalment, we get into the practical problems – unexpected and predicted – as we chart the evolution of our single seater.

The business model stated three uses for the new car: a racing single spec model, which would also be used for a driving school, and for track days. Most of the cars were to be owned by the championship organiser and they would make use of the older classic trailing link front suspension and swing axles on the rear.

Early on in the design process it was seen that having a commercial link with Volkswagen was important, so that parts could be sourced directly from the manufacturer at a discounted rate, rather than buying from dealers or sourcing from scrapyards and then refurbishing – as had been done previously in Brazilian Formula Vee.

For the cash-flow of the project the cars had to be tough, especially with the school use and track days with inexperienced drivers, who were hard on the equipment. Particularly fragile, on the older cars, were the gearboxes, as a direct short-throw gear-linkage made the input loads on gears and synchro rings much higher than the ones encountered on the production car, plus the old gearboxes now had higher power being put through them. This resulted in an average of two boxes out of 18 cars being

This meant a complete re-design of the chassis and layout, transverse engines being particularly difficult to install in a single seater



The new car will now be called Formula Up, in deference to Volkswagen marketing in Brazil. This CAD rendition shows how the entry level single seater could look when it's finished

Formula Vee has been around for over 50 years and there are now versions of it all over the world (South African Vee pictured). In Brazil it's now getting a long-awaited update

broken or rendered unservicable at every track outing, cutting down income and increasing the maintenance and rebuild workload.

The contact with Volkswagen then resulted in its interest in introducing the newer 1-litre turbo, transverse 3-cylinder, direct injection VW Up engine and naming the championship Formula Up, to fit in with its marketing needs. This engine was launched in 2015, having a nominal 127bhp rating which could be upgraded to 272bhp on the twin-turbo version used in the small Audi. All this from a standard plain vanilla road car, having a dealer service every 20,000km or so. A fully 21st century engine, good thermal efficiency and weight.

That is the good side. On the bad side, although the design brief stayed the same as far as cost and build and maintenance considerations were concerned, several points now had to be reviewed in depth.

Turning point

For a start, this all meant a complete re-design of the chassis and layout; transverse engines being particularly difficult to install in a single-seater because of width – this would not be such a problem with a sportscar type chassis.

Most of the wishbones, uprights, front rockers and damper mounts stayed as they were, but the rear rockers, dampers and pushrods were a completely new design, the engine layout demanding a complete re-positioning to accommodate the bulk of the engine/gearbox unit. The dampers and rockers now had to come off the rear of the engine block, a new sub-frame being designed. This was a particularly difficult task, the front and rear dampers being the same for cost reasons, and several alternative layouts were tried out until an adequate solution was found.

Polar position

The fuel tank position was also altered, which helped the CG position, and a slightly bigger cockpit section was designed, as the engine gearbox mass had shifted backwards. Many detail component positions had to be shifted forwards to correct the CG, slightly increasing the polar moment of inertia.

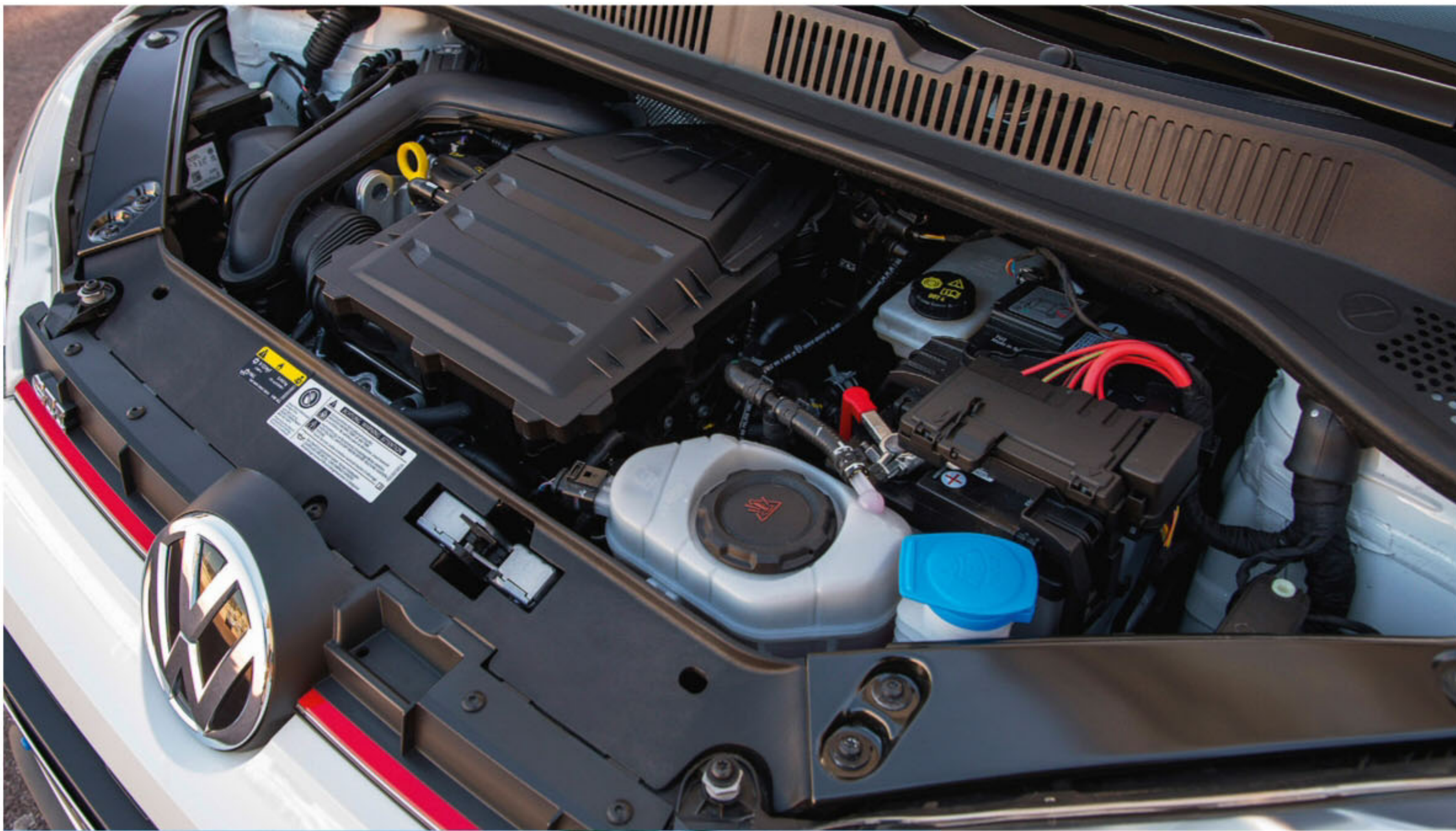
As mentioned, to install the engine in the chassis necessitated a complete rethink of the rear sub-frame, which was originally detachable to allow easy maintenance and engine changes on the first design; where the gearbox was not a load bearing item. Now power unit and gearbox had to move back on the chassis to maintain the wheelbase and weight distribution.

Also, whereas the in-line engine installation consisted of a single pick-up on the front of the engine and two on the gearbox-bellhousing (these the originals from the production car), on the transverse version there would be one on top of the cambelt drive cover at cam cover level, and a very asymmetric one on the gearbox mount, some 400mm lower.

Up scaling

There would also be a cross tube closing the bay picking up on the lower side of the frame, entirely changing the load path from front to rear suspension. The fact that the alternator sat exactly in the path of the cross-tube forced its re-location, swinging it around to clear the cross tube. This also gave the opportunity to run a bigger pulley on the alternator, reducing the power loss from it – as the racing car would have a reduced electrical power demand, not having lights, wipers, radio or electrical ancillaries, while running constantly at a higher RPM range, with no idling or low RPM cruising in high gears. So it seems we can score this one as a draw then: a

Many detail component positions had to be shifted forwards to correct the centre of gravity, slightly increasing the polar moment of inertia



Top: The turbocharged transverse 3-cylinder direct injection engine in the VW Up. Pictured is the new GTi version of the unit
Above: With antiquated suspension, and parts hard to source, the current Brazilian FVee is in desperate need of a makeover

not totally standard engine and ancillaries, but an improved power level.

As the gearbox was coupled to the engine block this made the whole unit load bearing, unlike the longitudinal engine that sat in a sub-frame and only took transversal loads fed in through the swing axles through the gearbox casing and out to chassis by way of the bellhousing-chassis mounts.

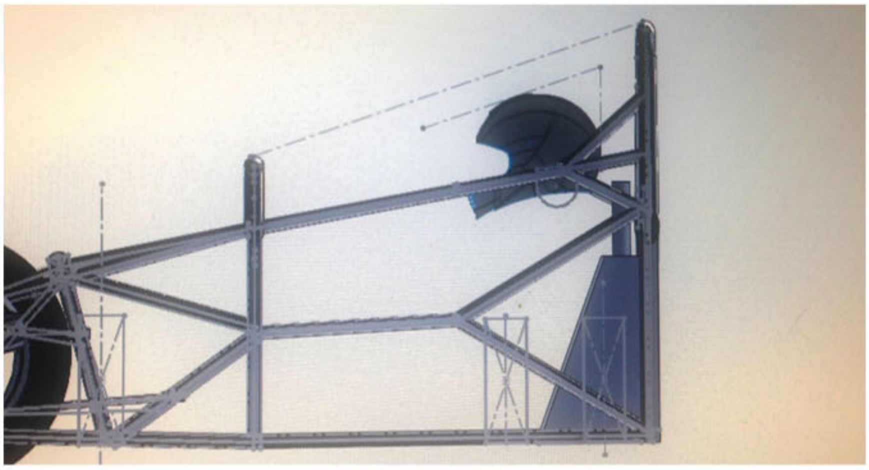
Because the load paths changed considerably the chassis tubes around the main hoop had to be repositioned, the main node for the rear frame being lifted and the whole unit having to go through more FEA analysis to bring it back to the design torsional stiffness and a design life with safety margins.

Scavenge test

The engine would also have to be rotated on a transverse axis to give a usable driveshaft CV angle and enough plunge, as only the inner CV could cope, the outer one pinned, as derived directly from a front-wheel-drive production car.

The manufacturer wasn't able to give assurances about the oil pump scavenging with engine rotated by a further 10 degrees forward, plus the anticipated 1*g* plus forces that would be encountered under braking (equivalent to 45 degrees of tilt), so research was needed in that department to ensure the engine would not be starved of oil. To that end a frame was built with

The original longitudinal-sited unit is a snug fit and in line with conventional single seater engine packaging



First version of the car was designed with the spaceframe a separate entity from engine-bearing sub-frame

No car manufacturer will let its software code out into the world to be modified for motor racing

The extra width of the transverse unit from the VW Up is clear, but that was just the start of the problems for the team. The engine switch meant many changes, particularly to the rear suspension

the entire unit mounted (engine and gearbox) complete with loom, fuel system and exhaust, so it could be fired up and tilted to 65 degrees to check oil pump pick-up would work. The modern layout of engine and internal baffling on the sump was found to be adequate, no oil pressure drop being observed, luckily, as the cast aluminium sump would make any internal added baffling very complex and increase cost and complexity – the initial concept demanded the engine and gearbox had to be standard and unmodified in any way.

Up shifting

Having an effective cable-shift, but forcing the lever to be on the left-hand side of car for the routing, it was very difficult to run the cables from the conventional right-hand side to the gearshift on the left-hand side of the racecar, given that the driver was now in the way.

But experience with other cars with left or right hand shift showed that any driver can get easily accustomed with shifting on either side; witness the right-hand drive and left-hand drive cars on the road in different countries.

Another looming problem was the immobiliser systems that are fitted to modern cars. The electrical loom and sensor array inherent in modern engines (it is a full throttle by wire, turbo control and double lambda ECU control system) plus the fact that the immobiliser chip is twinned to each particular car and the individual electronic key, are very difficult to eliminate, as part of the security system, and impossible to hack. To add insult to injury the immobiliser chip is cast into the plastic of the dashboard fascia. No manufacturer will let the software code out into the world to be modified for motor racing, as it could be used to steal any car of that type.

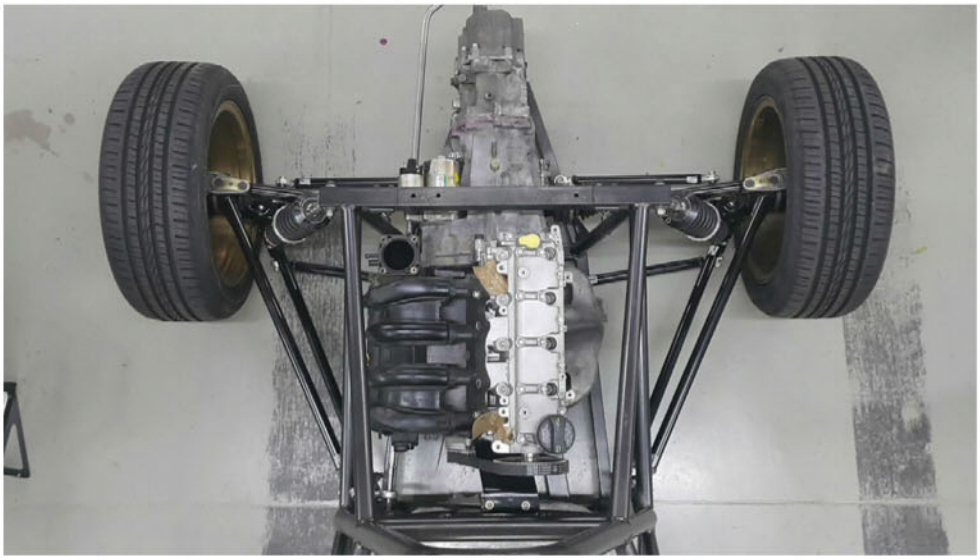
All the items mentioned above needed additional R&D work and design time, iterating all the predicted load paths, installation and access needs, a big departure from the known operating parameters of the longitudinal engine that had been used for enough time to iron out all the problems. Given these obstacles it became even more important to solve the gearbox problems on the existing cars, as launch of the new model now depended on the re-design and new technical problems brought in by much more complex electronics, the gear linkage system and other issues.

Knowing that these problems were going to push the final design and development of the new chassis back, it became imperative to upgrade the gearbox to cope with the harsh use and added power, and for this to be done at a minimal cost to the existing racecars. The current SP2 gearbox from the Volkswagen Kombi with the longest final drive was by now costing around €600 rebuilt. It had been useful because on the Kombi it had an adaptor plate to mate it to the E111 in-line 4-cylinder engine.

Rational ratios

The gearbox from the Passat, produced in Brazil, could cope with the torque and power, had five gears with a better gear spread (with the original Kombi ratios first was too low to use at starts, just sitting there spinning wheels, so just third and fourth was used in races after second was used at the start). Even more importantly the Passat 'box could be sourced new for the same cost, or rebuilt from used for €250. The

Fuse brackets have now been incorporated into the chassis design to help protect the spaceframe from damage in a crash



New suspension has been fitted to car with the original layout. It was two seconds quicker than swing axle version in testing

A frame was built to mount the engine/gearbox unit so it could be fired up and tilted 65 degrees to check oil pump pick-up

It became imperative to upgrade the gearbox to cope with the harsh use and the added power

downside was the lack of input shaft length to incorporate an adaptor plate to correct for a different bolt pattern. In keeping with the low-cost philosophy, making bespoke input shafts brought the modification to an unacceptable level. The work-around was thus to cut bosses off the boxes, PCDs (pitch circle diameter) being similar, and weld new bosses on the box. A secondary problem then emerged as these boxes are still being cast by the foundry that had been producing them for over 40 years, and they are still using a magnesium alloy.

Conversion kits

To supply the material so we could machine and weld on slugs required a minimum order of 500kg from the foundry, so the work-around ended up with us finding an electric induction oven and melting down scrap gearbox casings to produce the slugs that were needed. Once this hurdle was crossed the conversion kits could start to be manufactured.

The second major problem was that the layout of the Passat gearbox only had one side plate, unlike the original Kombi box, so the classic swing axle was now out of the question.

Examining the obligatory independent suspension that needed to be installed, this then had the necessity of incorporating upright and links, while having a minimum of work to be done on existing chassis, all of which had to be converted to the MKII spec, and also there were time and cost constraints. Using a modified production item ended up being a reasonable compromise.

Strutting stuff

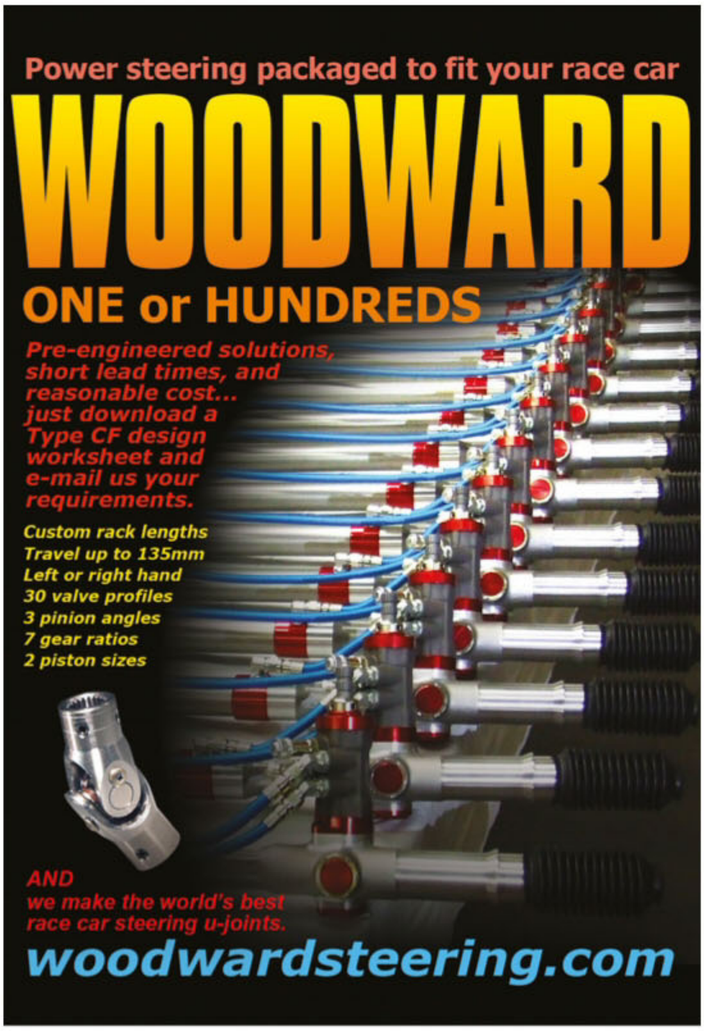
The Macpherson from the VW Polo fitted the bill perfectly. Cutting off the strut and welding a pair of cross tubes to fit the links and damper, plus running a five-link suspension cut the cost again, as no wishbones had to be manufactured, just a link with two threaded ends on three of the links, the other two just having a flat plate that bolted on to the production pivots. The whole unit, used inverted, requiring a geometry that looked decidedly unusual but catered to matching the roll centre ground level of the front and the camber gain from the swing axle.

The entire drivetrain from the Polo was used from the output flange of the gearbox (matching splines to the diff) to the hubs. The driveshaft length dictated the rear track, but, again, the production track was quite close to that required, so gave a good compromise.

The other alteration to the unit was to tilt the whole engine gearbox combination five degrees to raise the gearbox output flange height to align with the wheel centres to minimise CV plunge, there being only one plunging CV, the other being captive (usual in the outer CV of front-wheel-drive cars).

The front engine mounts were the same, but as the rear actually came off the gearbox,


AH FABRICATIONS
AH Fabrications
Specialist in Aluminum
and Titanium TIG welding
Alloy welding, design and fabrication
of Air, Fuel, Water and Oil systems.
Standard UK product range or made to
order based on your pattern or drawing.
40 years experience
in the motorsport industry
A H Fabrications, Unit 56
Ramsden Road, Rotherwas Ind
Est, Hereford, HR2 6LR
Email: sales@ahfabrications.com
Web: www.ahfabrications.com
Tel: 01432 354 704
Fax: 01432 359 762


Power steering packaged to fit your race car
WOODWARD
ONE or HUNDREDS
Pre-engineered solutions,
short lead times, and
reasonable cost...
just download a
Type CF design
worksheet and
e-mail us your
requirements.
Custom rack lengths
Travel up to 135mm
Left or right hand
30 valve profiles
3 pinion angles
7 gear ratios
2 piston sizes
AND
we make the world's best
race car steering u-joints.
woodwardsteering.com


D.A.T.A.S. LTD.
Data Analysis Tools And Simulation
RaceSim version 2.7.x
• Expert: Steady state, transient,
4 post, optimisation, strategy, etc
• Standard: Low cost lap simulation
• NasCar: Stock cars with live axle
• RaceSimE: For Formula E electric vehicles
• RaceAlyzer: Race strategy tool
• Sports & GT: Driver reference & BoP sim.
Consultancy
• Vehicle Dynamics
• Racetrack support
• Software Development
Multi Media
• Photo realistic virtual animations
• Technical Features for TV
• Animated virtual walk thro' grid
D.A.T.A.S. LTD. THICKTHORN HALL NORFOLK NR9 3AT
TEL: +44 (0)1603 506526 +44 (0)7802 770345
http:// www. datas-ltd.com e-mail: info@datas-ltd.com


DOCKING engineering
Advanced Cooling Systems
Water Radiators
Intercoolers
Oil Coolers
Heat Exchangers
System Design
Ancillary Products
Manufactured to your requirements
by the UK's leading supplier.
Email info@dockingengineering.com
Tel +44 (0) 1327 857164
Fax +44 (0) 1327 858011
Web www.dockingengineering.com
Certified to CAA & AWS
Welding Standards
Unit 15 Silverstone Circuit
Silverstone, Northants
NN12 8TL, United Kingdom

The other alteration to the unit was to tilt the whole engine and gearbox combination five degrees to raise the gearbox output flange

Left: Loom from the VW Up. It is a full throttle by wire, turbo control and double lambda ECU system. The immobiliser proved a headache for the team **Above:** A MacPherson strut from a VW Golf was inverted and machined to make an upright for the new racecar – an inspired and low cost solution **Below:** The current spaceframe design (in the foreground) with x-bracing, and original (behind) which will need the chassis tubes around the main hoop to be repositioned for strength. Note the rust!

the new box would be mounted differently, leaving the original bushes on the chassis available for the front lower parallel links, when fitted with a U bracket made of sheet steel.

Fuse bracket

The brackets were designed as fuses, so the wear and tear of accidents would not damage the main chassis; breaking a cheap component, easily replaceable. The mounting points on the chassis were simple bushes with through bolts and nuts, an additional safeguard to avoid stripping threads through accidents or accidental cross-threading by mechanics on assembly and maintenance.

The fuse-bracket concept was also incorporated into the old chassis with the five-link suspension and has proved itself in the first school day shunt with the new model. Pulling off the corner it was repaired in less than 20 minutes, tracking not being needed as the links had been pre-set at the design length, a large part of the time being used to check the rest of the car and mounts for any additional damage.

The base rear swing axle suspension only had one pick-up on the chassis, the front point of the radius rod, which controlled the fore and aft forces from the wheel and the toes, all other loads being taken out through the swing axle, pivoting on trunnions on the side plate.

Easy fit

The new independent rear used the same front pick-up point through a C section bracket with the two radius rods, the two lower front parallel links picking up on the previous geabox/bellhousing mounts, leaving only the toe link inner points and the inner top link points to be added, a total of four additional busses to be added to the base chassis. These were the only additional points to require jigging, making for a quick upgrade kit, which is easily fitted even far away from the factory.

The updated old chassis was tested and proved nearly two seconds faster than the base swing axle model, having much improved traction, a more balanced handling and better grip. The good match and camber gain in roll given by the five-link suspension plus the better toe control and roll centre height (the swing axle is at the gearbox output flange centre and the independent at 80mm) were fully responsive, as per the design brief.

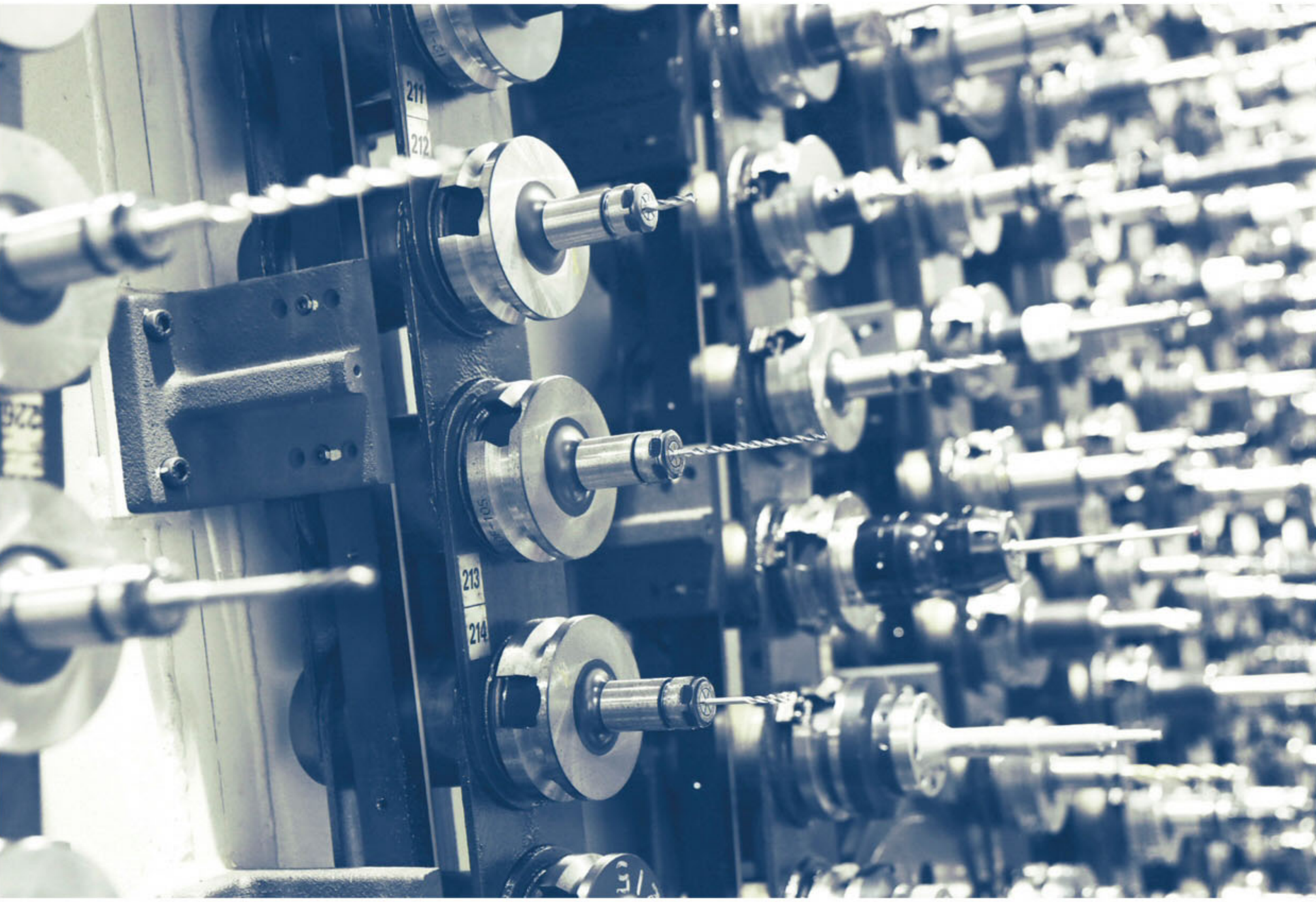
The next chapter of this saga will cover in more detail the calculations and design decisions for the transverse engine car, this piece having now, hopefully, given a good overview of the huge knock-on effects of seemingly small changes to a design.

Automation station

Today's machining industry is shifting towards automated technologies to minimise human intervention and increase accuracy – *Racecar* investigates the engineering behind this trend

By GEMMA HATTON

GIBSON TECHNOLOGY

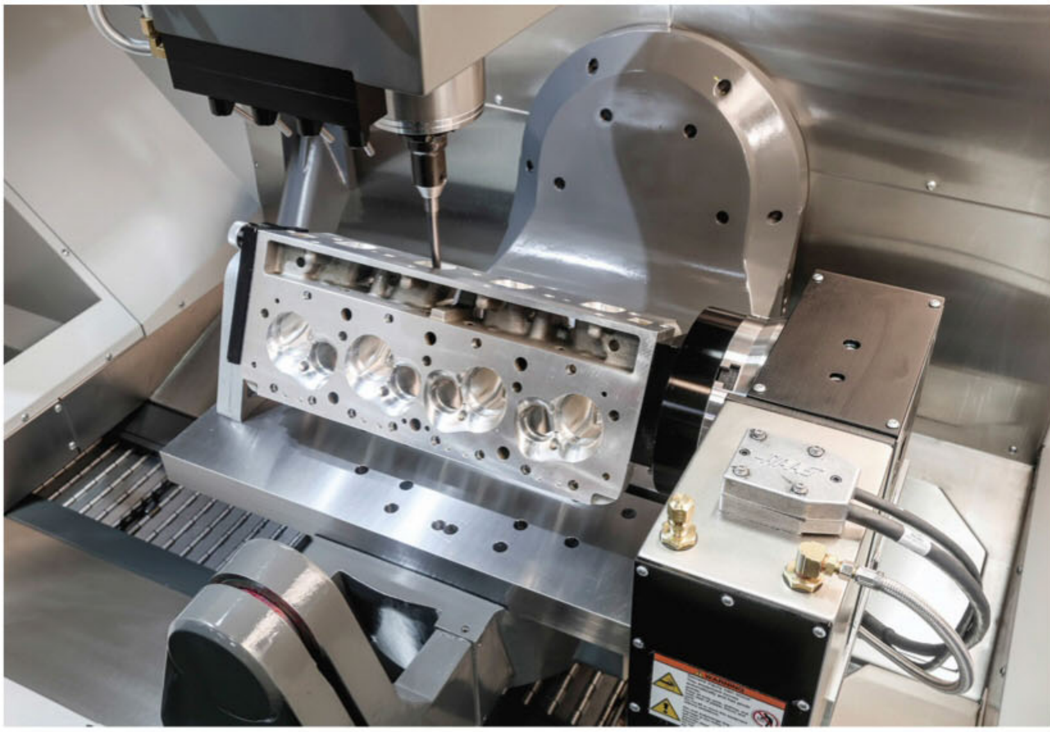


Tooling carousels can hold hundreds of types of tools, which the machine can automatically load when required. This minimises operator involvement while reducing downtime

'The operator can just tap a few icons and the software writes all the complex code in the background, without them even realising it'

A modern Formula 1 car consists of up to 80,000 components, all of which have been machined at some point during their manufacture. That's before counting the number of redesigned, or replaced parts or prototypes and spares that never actually make it onto the car. Hundreds of thousands of individual components come together to create the racing cars of today. Producing this sheer quantity of parts, along with their rapid development cycles, is only made possible by machines.

Machine technology is not only becoming more accurate and reliable, but the results more repeatable. Unfortunately to achieve that, machines are removing the human element from the process because we are not accurate enough anymore. Human error is one of the biggest challenges facing the machining industry today, which is why companies are shifting towards automation. However, automating these complex machining processes whilst maintaining ultimate accuracy is an extreme engineering challenge.



CMM (Coordinate Measuring Machine) uses probes, lasers and scanners to continuously monitor tolerances of machined features. This inspection process is fully integrated to ensure any errors are recorded and automatically accounted for

RAMTIC (Renishaw Automated Mill Turn Inspection Centre) consists of carousels that are plugged into each machine and automatically load the tools and materials. Up to 30 machines can be run by only two operators supported by kitting staff

'Everyone in the machining industry at the moment is talking about IOT (Internet of Things), there is a real push for more integration, automation and software-based solutions,' explains Mark Terryperry, Applications Engineer at the US-based company Haas CNC. 'Our next generation of controllers are built with better networking capabilities, which makes them easier to integrate with robots so that the machines can run lights out. Also, we can access the machines from our desktop, so as I'm talking to you now I'm looking at the status of my machines on my laptop. These are innovations that just weren't possible a few years ago.'

Birth right

A part is first born in the virtual world of CAD (Computer Aided Design) software as a solid model. Once created, CAM (Computer Aided Manufacture) is used to translate the dimensional information of this solid model into a language the machine can understand. This code automatically defines the required tool paths, when to change the tool, as well as the sequence of machining processes required to manufacture the specified part. The software then controls the machine to carry out these processes via CNC (Computer Numerical Control). Before, during and after manufacture, CMM (Coordinate Measuring Machine) plays an important role. This is where various types of measurement systems, usually in the form of probes, are constantly measuring the dimensions of features as they are being machined to ensure they are within tolerance. If not, this information is fed back to the machine, which can then account for any errors by automatically adjusting offsets.

'We have pioneered a software package called 4C which combines all four of these types of control,' explains Anthony Usher, VP Sales and Marketing at Rottler. 'The result is a CNC machine that you can design things in, whilst eliminating the complex coding process because it's all done semi-automatically. Quite often engine builders are scared of CNC machines because they are worried they will not understand the code, and will have to spend months learning how to program the machine. Therefore, to help them improve their accuracy and reliability, we have had to revolutionise the software to get CNC into their hands. I often equate it to the iPhone. In the past, you would have had to write complex code to get your phone to go onto the internet or take a picture. When the iPhone came out, it had icons and apps that did the hard work in the background for you, so anyone could make a call. We have done the same with our machines; the operator can just tap a few icons and the software writes all the complex code in the background, without you even realising it.'

By automating the coding process, operators no longer have to spend days learning how to write code. All they need to know is the design they want and a quick guide on how to tell the 4C software, and they can begin machining.

'Take the example of porting cylinder heads,' highlights Usher. 'Traditionally, operators destroy their hands and knuckles from the consequent vibrations of continuously holding grinding tools, but this is completely avoided with our 4C software. We use digitising which is where our Renishaw probe automatically measures the inner and outer dimensions of the ports, and then converts this into a digital format that is displayed on the machine's screen. The operator can then use the mouse to draw the exact shape of the ports they want, hit 'cycle start' and the machine takes over. Within minutes, the port is finished exactly how the operator would have done by hand. So, not only is the operator able to use their knowledge and experience to create the best port design, but the machine does it automatically, so they don't have to learn any of the code.'

Time lord

Time is money and if there's one thing a manufacturer wants to avoid in their machine shop, it's downtime. This is when the machine is either off, or idling, and not producing parts. Downtime can be a result of maintenance or

'Operators destroy their hands and knuckles from continuously holding grinding tools, but this is completely avoided with our 4C software'

5-axis machines have the capability of machining a part from start to finish, creating intricate shapes out of a billet of material

repair, but also between processes as materials and tools are loaded into the machine. One of the best strategies to minimise this is the unique RAMTIC (Renishaw Automated Mill Turn Inspection Centre) system developed by Renishaw who use it for their own manufacturing processes.

'Tooling carousels are preloaded with the raw material and tools for the job,' explains Anthony Spill, Production Engineer at Renishaw. 'This is done offline while the machine is still running, so as soon as the machine finishes, the old carousel is disconnected and the new one 'plugged in'. The machine identifies the carousel number and therefore all the components it has. All the operator has to do is press 'Go' and the first wing of material is automatically loaded into the machine. The beauty of this system is we minimise downtime so, for 30 milling machines, we only need two operators, supported by kitting staff, to run them.'

It's not just one carousel per job; each carousel can contain enough material and tools for up to four different jobs. With so many components, it is essential to ensure that not only are the correct ones loaded, but that they are located in the right place and in the correct orientation. Empty carousels are plugged into a system at the re-kitting station where software automatically calculates the amount of material required along with the various tools for the different jobs. All the operators need to do is physically pick up the pieces and populate the carousel, like a puzzle with instructions.

Life lessons

With each of these carousels capable of running for 72 hours or more without any human involvement, the next task to automate is part and tool setting. When working to tight tolerances, tool wear can greatly affect accuracy. The life of each tool is calculated and automatically tracked by software. This is the same software that dictates how to populate the carousels, and so will only recommend tools with enough life to complete the number of jobs. However, tool wear also needs to be tracked during machining, and this is done by the NC4 automated tool setter from Renishaw. This system uses a laser beam projected between a transmitting and receiving head and as the tool descends or moves sideways, it breaks the beam, allowing it to measure the tool geometry and the effective diameter whilst the tool is spinning, as well as any dimensional changes caused by thermal effects. Therefore, this system detects if the tool is within tolerance, or if there has been any damage.

'Detecting tool breakage is absolutely critical,' explains Spill. 'The last thing you want is to have your operators come back to the machine after eight hours and find they've got eight hours of scrap components because the tool broke. When a breakage is detected, the machine alarms out, telling the operators there is an issue and it stops manufacturing. This helps us achieve minimal downtime because the operators can address the issue straight away.'

One of the ways to minimise tool damage is to use high pressure air or liquid coolant which is channelled through the spindle and therefore applied directly to the tip of the tool. 'With non-ferrous materials such as aluminium which are relatively soft, it's essential that we get any chips out of the way quickly, so that the tool doesn't load up and essentially weld itself to the material,' explains Terryperry. 'The coolant is a cutting oil so it's extremely slippery and provides great lubrication, whilst the high pressures of 300psi or 1,000psi systems forcing debris away, allowing us to push the tools harder and faster.'

Keeping cool

Without coolant, the heat generated from the friction of machining processes would break the tools, regardless of their material hardness. Therefore, particularly for large volume manufacturing, it is vital to ensure that the coolant doesn't run out. This used to be a responsibility of the operators. However, now it is down to sensors to detect when coolant levels become too low and switch on tanks to refill the coolant whilst the machine is running. Despite the array of cooling strategies, tools still wear, and so do the mechanisms and fixtures within the machine as the machine gets older, which is yet another parameter that requires careful control to maintain high tolerances.

'Annually we check our machines with laser interferometry, but this is relatively time consuming to setup. However, you know the day after you've done the laser check that

3D vision

We have covered 3D printing technology many times in this magazine, but never on the large scale of a HP Jet Fusion 3D printing machine, of which XYZ Machine Tools are the official reseller. Delivering 30 million droplets per second across each inch of workspace, building at speeds of 4,500cm^3 per hour, this machine is approximately 10 times faster, yet half the cost of conventional material extrusion or laser sintering processes. This is thanks to HP's Multi Jet technology, which is then coupled with fusing and detail agents to generate layers that are only 0.07mm thick, creating parts with impressive dimensional accuracy and detail. Printing within such fine tolerances requires precise temperature control to avoid irregularities as the different layers fuse together. This is why heat is automatically applied or reduced throughout the different stages of the printing process. The combination of all this technology results in a machine capable of creating 27,300 gear components within an 82-hour cycle, compared to 1,000 and 2,160 parts using other 3D printing techniques.


Mazak SMART BOX

'The last thing you want is your operators to come back to a machine after eight hours and find scrap components because the tool broke'

the machine is accurate, but what about after several weeks?' explains Andy Holding, Marketing Manager, CMM Products Division at Renishaw. 'This is why we have the QC20-W ballbar system to allow us to quickly check the calibration of the machines.'

The ballbar is a telescopic bar which contains several precision machined magnetic balls, with cup joints at either end and an integrated position sensor. One end is attached to the centre of the machine table and the other to the spindle of the machine. This spindle follows a prescribed spherical path in all three axes around the centre point and if the spindle position is out of tolerance along these paths, the magnetic balls will move and sense this change. This movement then induces a current within the position sensor and this signal is transmitted via Bluetooth to the machine. The results are compared with the original calibration measurements and analysed to diagnose any machine errors which may require remedial or preventative maintenance.

'Once the machine is calibrated, you can quickly use the ballbar to complete a trace of the 'ideal' working space. In the event of any collision or damage during machining, the ballbar system can be reinstalled and another trace can be conducted. By analysing the traces in software you can measure the positioning accuracy of the machine and identify the type and amount of any errors which may be corrected by maintenance, or by adjusting parameters at a controller level,' says Holding.

There is no doubt that the biggest revolution in machining of recent years has come in the form of 5-axis machines. Utilising their capabilities together with advanced software and CMM has resulted in an array of multitasking machines that can create solid models, convert them into code, calculate the required machining processes, complete them with high accuracy, monitor tolerances and tool wear. They are even capable of conducting the finishing processes and final inspection.

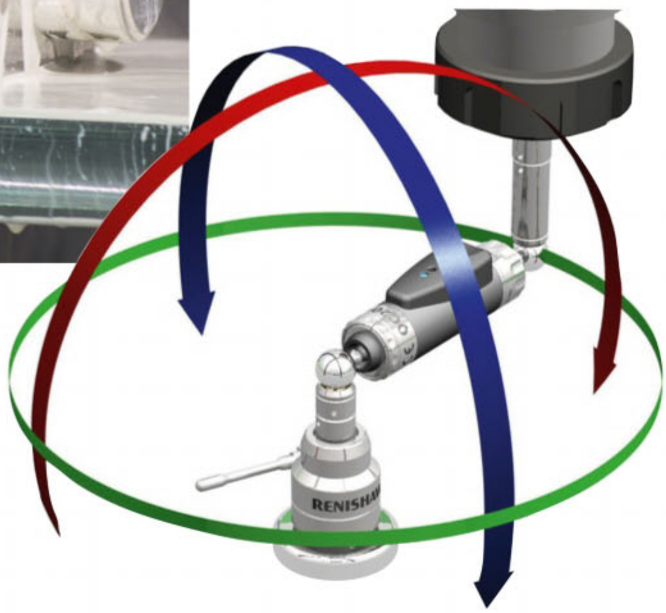
Complete package

'Due to the complexity required by the motorsport industry, components are very high value, which means cycle times are extremely long. That's why you need a robust process to ensure control throughout the entire machining phase,' explains Lawrence McCann, UK applications manager for the Japanese parent company Yamazaki Mazak. 'Extensive integration between your 5-axis machine, CAD, CAM, CMM and software results in the best blend of technologies. This allows one machine to not only carry out the manufacture of a component from start to finish, but constantly adjust itself based on an automatic feedback loop of measurements to achieve the highest tolerances, regardless of the conditions.'

There will always be some level of human intervention throughout the machining of a part, even if it is simple validation. But overall, the amount of work carried out by operators has diminished rapidly compared to past practices. As the demand for volume and accuracy of parts continues to increase in racecar construction alone, as well as further applications, it is hard to see when or how this trend will reverse.

GIBSON TECHNOLOGY

Liquid coolant is blasted at 1,000psi to the tip of the tool, reducing the temperature generated from friction. Coolant is also responsible for removing swarf which can sometimes weld itself to the part



Renishaw's ballbar follows a circular path in three axes to measure the working space of the spindle. This can be overlayed with the 'ideal' working space to calculate any machine ageing

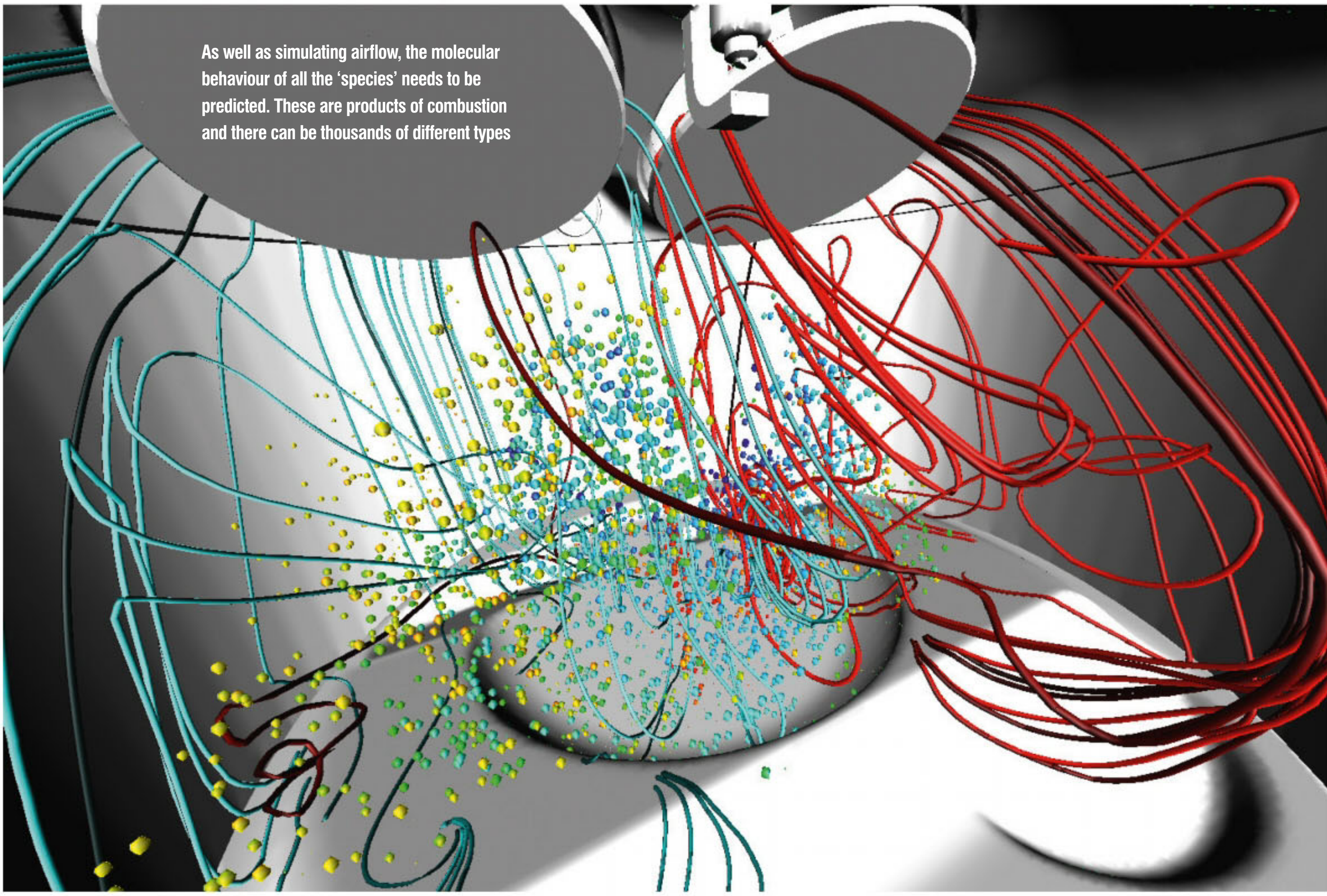
Clever coatings

Another strategy to increase both component and tool life is through the use of coatings. These reduce manufacturing cost while increasing the speed of machining processes, and maintain high accuracy and precision over time. Carbon-based coatings, such as DLC (Diamond Like Carbon) are perfectly suited to the most extreme wear conditions and high sliding speeds. Oerlikon Balzers, a global technology leader for wear reduction coatings (BALINIT & CAVIDUR families of coatings), is launching a new carbon-based coating to raise the bar in high-end racing applications.

Meshy business

There are few tasks as complex as replicating the workings of a racing power unit in the virtual domain – *Racecar* talked to leading lights in the engine modelling sector to reveal the secrets of this rapidly developing technology

By GEMMA HATTON



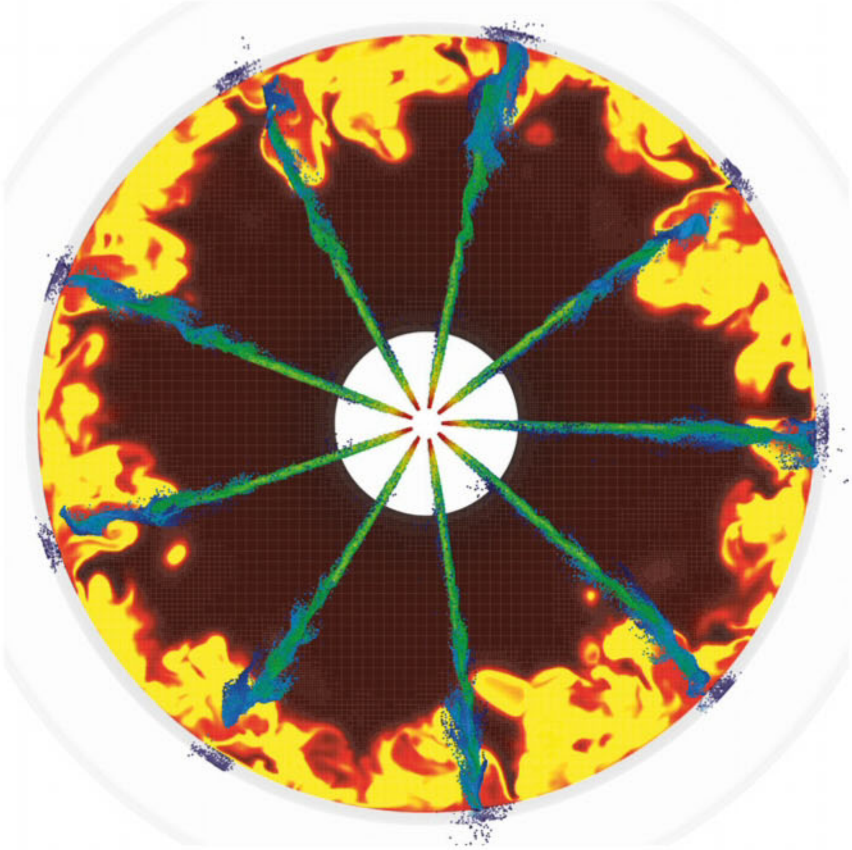
As well as simulating airflow, the molecular behaviour of all the 'species' needs to be predicted. These are products of combustion and there can be thousands of different types

In last month's issue we delved into the science behind modern engine design (V28N3). This month we will be going a step further, entering the virtual environment to discover how companies are characterising the phenomena of combustion with equations to simulate and optimise engine performance.

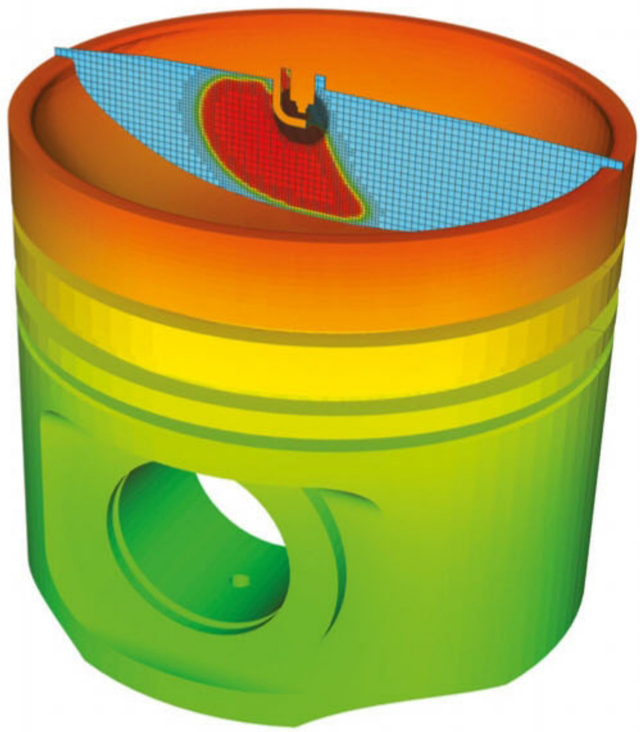
Today's Formula 1 engines generate approximately 950bhp, with some rumoured to exceed 1000bhp. To generate that amount of power the engine needs to complete 200 ignitions in the time it takes you to blink. This equates to a total of 46,000 combustion events within a single lap of an F1 circuit. To replicate that in the virtual world is a monumental challenge – so where do you start?

As we discovered last month, swirl and tumble are crucial in maximising the amount of air burned with each droplet of fuel as modern regulations continue to encourage lean burn. Both techniques are initiated through clever design of the intake ports, and this is therefore one of the first of the models that needs to be implemented.

'In-cylinder flow simulation includes at minimum one, often multiple, engine cycles,' says Maik Suffa, group product manager Fluid Dynamics and Multiphysics Systems at AVL. 'The macroscopic structure of the flow within the cylinder is initially defined by the mass and velocity of the incoming air as well as the port and piston designs, the valves, valve seats and valve timings. The standard turbulence model deployed with AVL Fire is the k-ζ-f model. In contrast to the widely-used k-ε or k-ω models, the three-equation k-ζ-f model combines the stability of two equation models with improved accuracy for both flow and heat transfer. This is visible especially when simulating swirling



This shows a CONVERGE Large Eddy Simulation (LES) of fuel injection, ignition and combustion in a heavy-duty diesel engine. As developments in computing power continue to increase we could see a shift to LES simulation in the next 10 years



Adaptive Mesh Refinement (AMR) in CONVERGE. Here it's been used to resolve the turbulent flame front in this single cylinder petrol DI engine simulation. The gas-phase flow and combustion has been coupled to the solid piston heat transfer calculation

or tumbling flows in combustion engines. Furthermore, the model doesn't require finer grids compared to the two equation models, it can be used on relatively coarse grids without losing robustness while still improving accuracy.'

Next to be modelled is the fuel injection, and this system is designed to achieve an evenly defined distribution of fuel within the turbulent in-cylinder airflow. 'Simulating fuel injection requires the handling of multi-phase flow phenomena,' Suffa says. 'Conservation equations for both the gas and the liquid phase need to be solved simultaneously. With respect to the liquid phase, the fuel spray simulation is based on the Discrete Droplet Model method. The droplets are tracked in a Lagrangian way through the computational grid, which is used to solve the gas phase equations. Both the gas and liquid phase are fully coupled.'

Fuel break-up

But it's not just about tracking the movement of the fuel droplets; their behaviour and interaction also needs to be simulated. This includes any primary and secondary break-up, turbulence dispersion, distortion, drag, collision and coalescence as well as the interaction with system boundaries which can lead to wall film formation.

'The intensity and frequency of the primary fuel break-up is related to the turbulent velocity fluctuations induced by the flow in the injection nozzle. Therefore, our Fire software allows the output of the injection nozzle simulation to be utilised as input to the fuel primary break-up modelling,' says Suffa. 'This link is made via a so-called nozzle-file which contains a record of the time dependent velocity, turbulence, density and temperature of both the liquid and gaseous fuel phases exiting the individual nozzle orifices. During the subsequent in-cylinder spray simulation, the data written into the nozzle file is used to initialise the start locations and properties of the droplets and hence the primary break-up.'

Spark life

As the piston reaches TDC, the fuel and air mixture is ignited. To guarantee fast and complete combustion, a moderate flow velocity, high turbulence kinetic energy and a stoichiometric mixture around the spark plug must be achieved. Advanced ignition models, such as the recently developed CADIM (Curvature And Diffusion Ignition Model) will allow detailed modelling of the spark and the energy transfer between spark and mixture. This is another pre-condition for an accurate combustion solution.

'The combustion process can be effectively simulated by CFD software,' Suffa says. 'Generally there are two types of combustion models. The first category is called intrinsic combustion models, which includes models such as the ECFM [Extended Coherent Flamelet Model] family or the recently more popular flame tracking models. These models will solve a relatively small number of reactions involving only a few species. They are fast and run in parallel with the CFD solver.'

In combustion modelling for spark-ignition engines the biggest challenge is the exact computation of the flame propagation whilst predicting the consequent molecular behaviour of all the species involved in the burning process. In SI engines this is often overcome by using explicit flame tracking models, such as the FTPM (Flame Tracking and Particle Method). This method is popular because it can precisely calculate the time-dependent flame position and so predict heat release as well as emissions. This is achieved by deploying sets of Lagrangian particles. Reaction mechanisms are then applied in regions before and after the flame, which allows the computation of pre-ignition, heat release and emissions.

These 'species' are defined as the products of combustion and alongside the three main chemical compounds of CO_2 (carbon dioxide), O_2 (oxygen) and N_2 (nitrogen) there are also thousands of different variants of species, all of which need to be accurately modelled.

'Defining the mesh is a constant balance between having a fine resolution for increased accuracy, while maintaining a coarse resolution to reduce computational time'

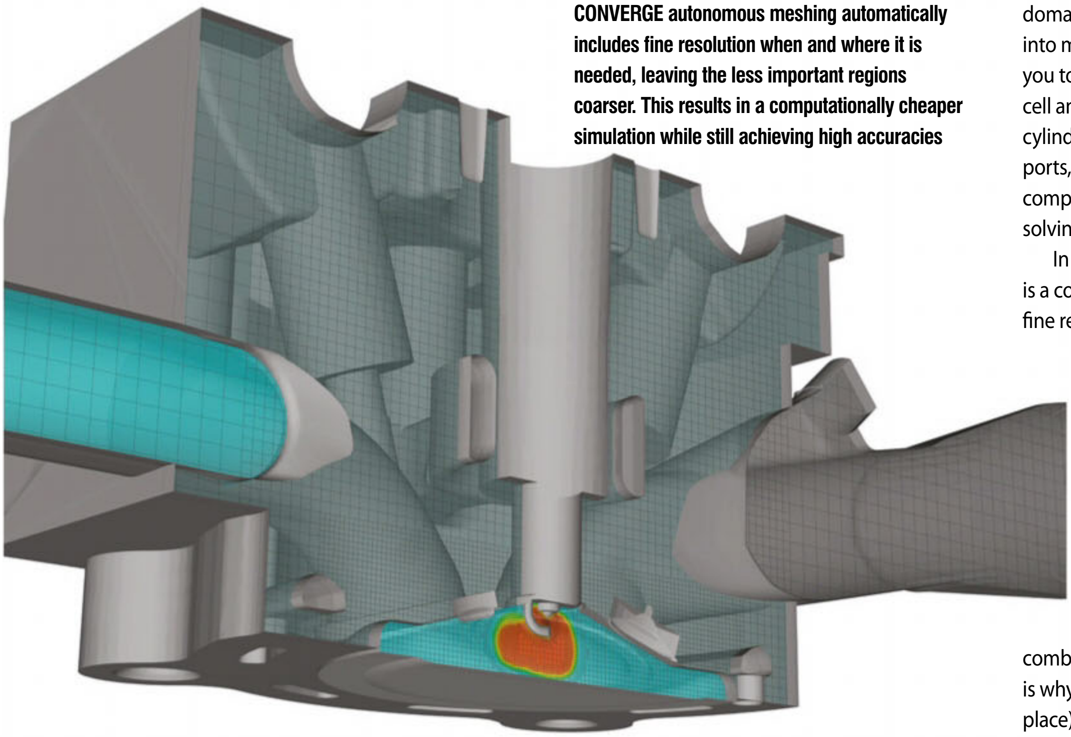
'Solving large reaction mechanisms comes with a time penalty'

'The second category of combustion modelling is referred to as detailed chemistry or reduced chemistry, which is rather confusing terminology,' Suffa says. 'We call it detailed, because we are solving mechanisms of higher complexity compared to when using in-build models. For example, instead of simulating 10 to 20 species, detailed reaction chemistry often deals with 200, even 2000 species. However, even the most complex mechanisms still can't directly reflect the chemistry of the real fuels, which is why some people still refer to this category as reduced chemistry.'

Time dependent

Of course, solving large reaction mechanisms comes with a time penalty, which is directly dependent on the number of involved species and reactions. Furthermore, the reaction mechanism must fit exactly to the specific fuel that is being simulated. A suitable reaction mechanism reflects the different characteristics of gasoline, diesel or other fuels as well as the varying qualities of these fuels.

'The prediction of global values, such as pressure or temperature traces is relatively simple, even with intrinsic combustion models,' Suffa says. 'By solving detailed reaction mechanisms it is possible to compute the chemistry of a specific air/fuel mixture with all its local variations much more accurately. Therefore, in spark-ignited engines a good combustion solution requires sophisticated models to track the flame, to compute reaction chemistry in pre- and post-flame zones and account for the interaction of chemistry and turbulence. Also, what many people forget: a combustion simulation can only be as good as the models used to simulate flow, turbulence and heat transfer, fuel injection, fuel wall interaction and ignition. All these models are essential and must perform well. Only then can you start thinking about modelling combustion, otherwise your simulation will be just wasted development time and money.'



CONVERGE autonomous meshing automatically includes fine resolution when and where it is needed, leaving the less important regions coarser. This results in a computationally cheaper simulation while still achieving high accuracies

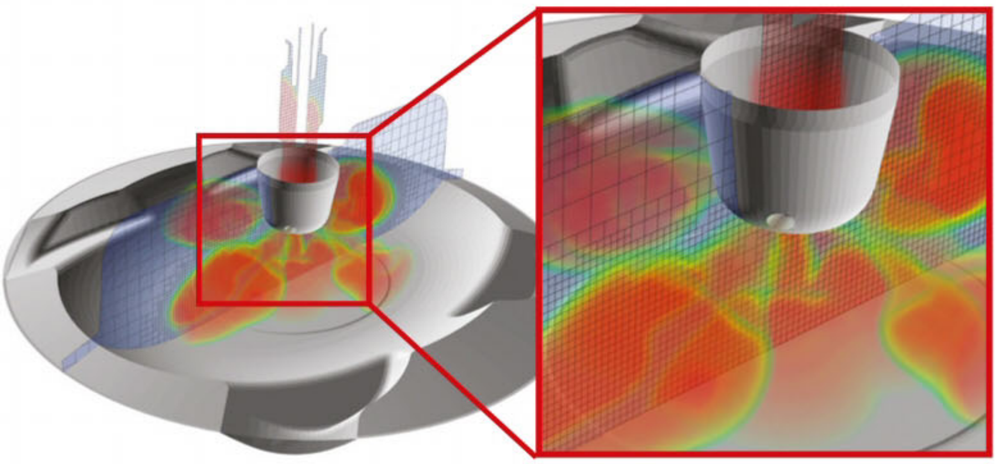
Navier Stokes

Now we have a rough run down of how combustion events can be characterised by theoretical equations, the question is how to compute them in CFD software? 'The Navier Stokes equations are the governing equations for fluid flow and we use numerical methods in CFD to represent the partial derivatives of these equations and ultimately solve them,' explains Kelly Senecal, co-owner and VP of Convergent Science. 'However, similar to any CFD problem, you have to discretise the overall geometry or domain which means you have to divide it up into millions of cells, creating a mesh. This allows you to solve the Navier Stokes equations at each cell and at every timestep. The challenge with in-cylinder simulations is that the geometries of the ports, valves and pistons tend to be extremely complex which makes defining the mesh and solving the equations much more difficult.'

In any CFD simulation, defining the mesh is a constant balance between having a fine resolution for increased accuracy, while maintaining a coarse resolution to reduce computational time. To get around this issue, often the resolution is only increased in areas of interest, such as the area under the spark plug, while larger cells are used in areas of less interest. Where and when to increase the resolution is mostly user defined, however, with engine modelling in particular it is difficult to know what the combustion process is going to look like (which is why the simulation is being done in the first place) and therefore where to refine the mesh.

Refining the mesh

'You would have to use a fine resolution across the whole domain just to make sure you catch all the areas of interest and that can get expensive because that's a lot of cells to solve for,' Senecal says. 'We have developed an Adaptive Mesh Refinement (AMR) technique which solves this problem because the user no longer has to guess where to refine the mesh, the solver does it automatically using all the local information of the flow as it is solving it. AMR looks at the curvature or second derivative of the variable it is trying to solve, whether that be velocity or temperature and so on. If there is a high curvature in the velocity or temperature field then the code will automatically add more resolution in that area to resolve the flow



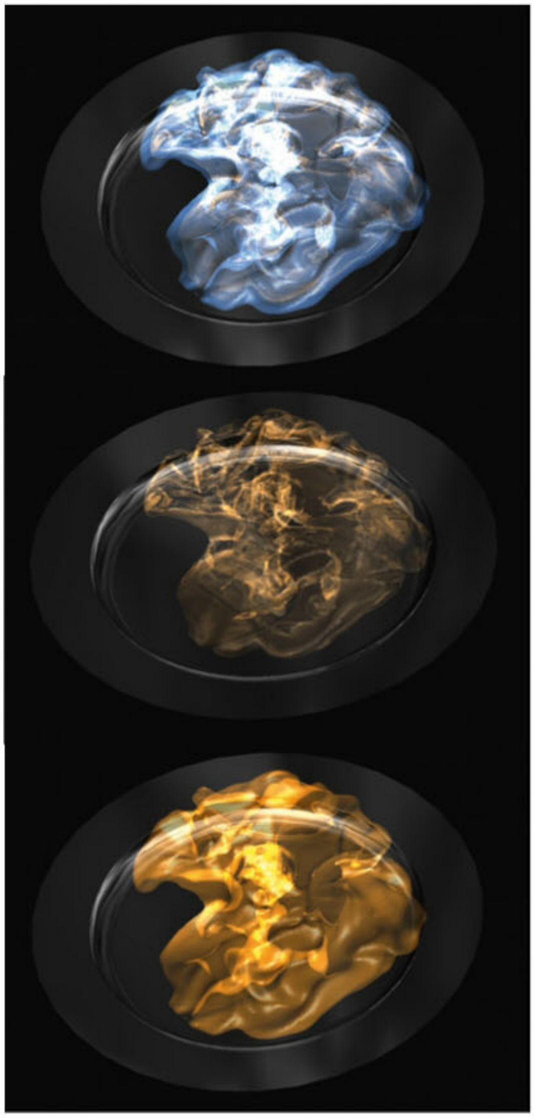
The automatic and adaptive meshing capability allows engine designers to explore configurations that were previously far too difficult to mesh. Note the differences in mesh resolution depending on the area of interest

feature pattern. It does this at every timestep, so it is adding or removing cells dynamically as and when it needs to, to best solve whatever the flow situation is at that particular timestep.'

Ideally, to achieve a fine mesh in areas such as the valve seat, the code has to refine in all three directions. This essentially means the original cube-shaped cells are chopped in half along all three axes. The benefit of this method is that the flow is not influenced because you are simply resolving in all three directions, however, in doing this you are adding more cells which of course increases time and cost.

'This is where boundary layer meshing comes in, because this refines the mesh normal to the boundary and so the shape and aspect ratio of the cells is very different,' Senecal adds. 'Therefore, the code is resolving at high resolution close to the boundary, but a coarse resolution away from the boundary. The results from this method are just as good as resolving in all three directions, but the efficiency is greatly improved. This type of boundary layer gridding, coupled with our patented autonomous meshing algorithms, is another revolution in meshing, and one that is a big part of our next version of CONVERGE software.'

The beauty of this type of automatic meshing is that it is coupled together with the solver



Predicting the flame propagation is the biggest challenge in engine modelling, particularly as hundreds of thousands of species are generated and each one has its very own molecular behaviour

Problem solver

The beauty of this type of automatic meshing is the fact that it is coupled together with the solver, so rather than having to wait for the mesh to be generated before running the simulation, the code defines the mesh and solves it simultaneously. All the users need to do is supply the CAD geometry of their cylinder, define the base mesh size and turn on AMR for the variables of interest.

'Generating the mesh has traditionally been one of the bottlenecks when it comes to simulating engine CFD, because it can take a very long time, and even once it's done there can be issues with skewed cells or anomalies,' explains Senecal. 'By taking all of that away from the user and putting that into the CFD code, the user can now spend more time analysing the results and do real engineering.'

The wider picture

Zooming out from in-cylinder simulation, there are many other areas of an engine that need to be modelled, such as the airflow through the intake and exhaust manifolds, the interaction between the mechanical components, as well as the lubrication and cooling strategies. Accurately modelling how all these systems interact is essential to obtaining reliable power and heat release outputs.

The propulsion system physical models can then be integrated into the vehicle model by means of physical connections describing action-reaction relationships. This allows driveability, performance and diagnostics to be optimised as well as proof of new concepts such as the 2014 F1 hybrid powertrains and the hybridisation of ancillaries in endurance racing.

'We create the vehicle models by first building up the individual assemblies such as the air intake, the exhaust system, the combustion models and the mechanics,' explains Mike Dempsey, who is managing director at Claytex. 'Once we've tested and calibrated each system, and the engine as a whole, and are happy with the results, we integrate it into the overall vehicle model.

'Often the biggest challenge is integrating the control system which could have been created in many different ways and might not even exist as an executable model, only as the real physical controller,' Dempsey adds. 'Once you start simulating the whole vehicle context, you need to have the controller as part of that model to operate the engine correctly and it needs to be provided with the right inputs.'

A further challenge of building up and simulating a vehicle model is managing the different timestep requirements of each sub system to capture accurate data without increasing computational performance.

'Most simulation occurs in the purely virtual environment and uses a variable step solver which adjusts the timestep depending on how quickly things are happening within the simulation,' explains Dempsey. 'However, when you are running in real time and you are integrating HIL [Hardware in the Loop] rather than just simulating in the virtual environment, you can end up running different parts of the model at different timestep rates. A combustion model, for example, will run at 0.1-0.2ms timestep, because any larger timestep will lose the detail. Driving simulators on the other hand typically run at 1ms, so managing the different timesteps within the same overall system can be very challenging.'

Crunching numbers

Hundreds of thousands of equations are required to run these engine models and each of these complex equation structures can only be solved by iteration at every timestep, which can take an extremely long time. Therefore, these equations need to be reformulated so that the individual system becomes smaller or the need for iteration is removed; making it much easier for the solver to deal with once the model is compiled; improving efficiency.

'Dymola, which is the simulation environment we use, performs automated symbolic manipulation,' Dempsey says. 'This takes those complicated systems of equations and manipulates the algebra to end up with the most efficient set of equations possible and therefore runs with a smaller number of equations. The trick is to reduce the number of equations without eliminating any of the details in the model, and this is where Dymola uses a range of complicated maths techniques to achieve this. So rather than relying on the simulation engineer having extremely good maths skills, it relies on the maths skills of Dymola, which has been programmed by specialists in symbolic manipulation.'

Scalar model

Let's take the example of a 4-cylinder engine model with direct injection, a high pressure fuel pump and hydraulically actuated variable cam timing with full multi-body mechanics running on a dynamometer. This type of simulation can originally have up to 195,830 scalar unknowns and the same number of scalar equations. Once translated and compiled after symbolic manipulation, this reduces down to only 73 scalar continuous time states and 19,484 scalar time varying variables.

'The important thing is not to get confused between symbolic manipulation and automated model reduction,' says Alessandro Picarelli, chief engineer at Claytex. 'The former rearranges the equations to make them easier to solve, without changing the physical details within the model. The latter is where you start with your original detailed model and run a function which reduces the amount of detail in the model, so it becomes less predictive, but it runs quicker.'

Chemistry cluster

As well as manipulating algebra to improve efficiency, the way in which the simulation is computed can also be manipulated to run faster. For example, chemistry clustering is one way to speed up combustion simulations.

If a set of cells experiences very similar conditions, such as pressure, temperature, A/F ratio and amount of EGR, these cells are put into a group. Chemical reactions are then solved for the group rather than for each individual cell. This saves valuable computing time.

'The result obtained for the group represents the result for each cell in the group,' explains Suffa. 'But as you are solving reactions on the level of groups, the required resources will be significantly lower compared to solving them per cell, which is also similar to In-Situ Adaptive Chemistry Tabulation. Here the reaction chemistry itself is reviewed for relevance at each iteration. Irrelevant parts of the mechanism are not solved. Again this helps to minimise the computer resources that are used.

'Another promising technique is in-advance tabulation of the reaction kinetics where one separates the solution of the flow and the solution of the reaction chemistry,' Suffa adds. 'The reaction mechanism is solved for a limited number of conditions, i.e. combinations of pressure, temperature, EGR and Lambda, which are expected to occur in the flow domain. The outcome is a multi-dimensional table containing the combustion results. During the actual CFD simulation this table is continuously being searched through trying to match as closely as possible the tabulated conditions with those obtained during the CFD simulation for each individual cell. For very large mechanisms applied to large computational grids this technique offers tremendous speed-ups.

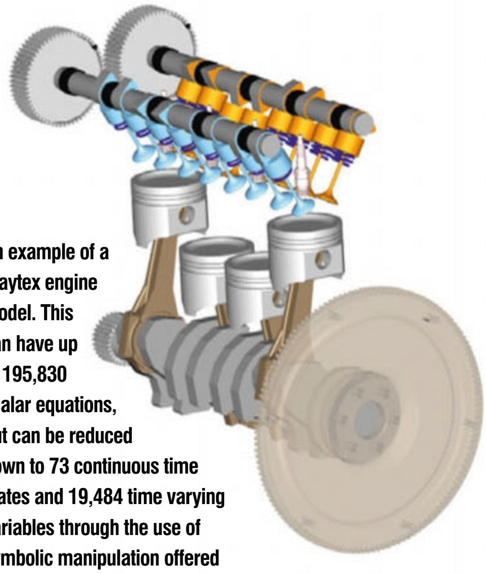
'But this is not the end of the line,' Suffa continues. 'I expect in future the utilisation of Graphics Processing Units (GPUs) for solving reaction chemistry. This has the potential to further speed up combustion simulations.'

'The trick is to reduce the number of equations without then eliminating any of the details in the model'

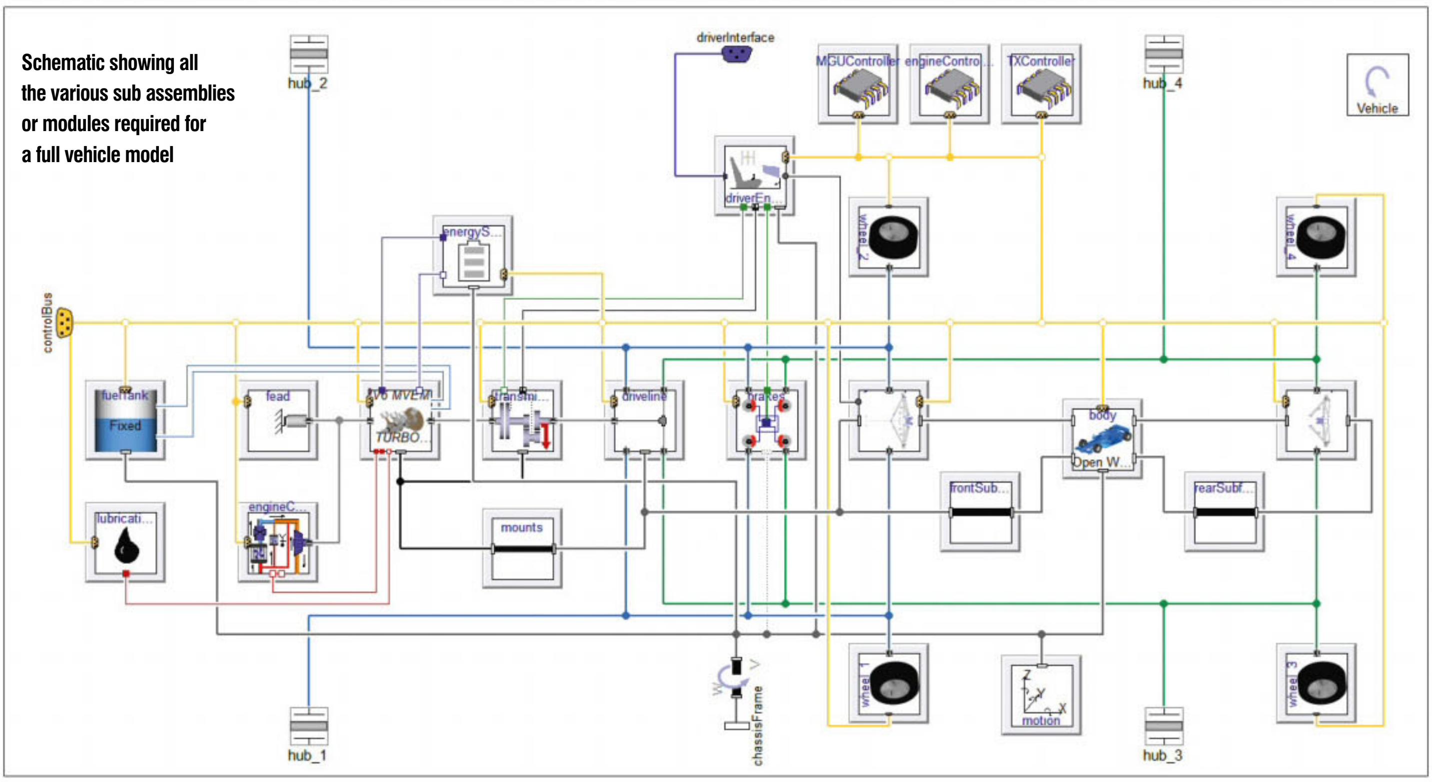
The future

The current limitations in computing power mean it is still not possible to solve DNS (Direct Numerical Simulation) without the use of models. 'The modelling comes in when you start to simulate flows that involve turbulence,' says Senecal. 'Currently, we can't achieve the required resolution on today's computers and so we can't resolve all the turbulence scales within the system, but we can resolve some, and model the rest. The most common way to do that is use the RANS (Reynolds Averaged Navier Stokes) and k-ε type turbulence models which are the workhorses of engine CFD. However, more people are starting to use LES (Large Eddy Simulation), which is a compromise between RANS and DNS, where you use a finer mesh but you're still not resolving everything. The increased resolution of LES makes it more realistic, but it is therefore more expensive.

'However, as computers get faster, the number of processors increase and codes become more scalable, we can start to run bigger problems, making LES more feasible,' Senecal adds. 'Maybe in 10 years time we will see it become more mainstream.' The question now is, will there be another revolution in simulation technology in the meantime?



An example of a Claytex engine model. This can have up to 195,830 scalar equations, but can be reduced down to 73 continuous time states and 19,484 time varying variables through the use of symbolic manipulation offered by the Dymola modelling environment



Schematic showing all the various sub assemblies or modules required for a full vehicle model

The sim of pride

Racecar's wizard of sim explains why he believes chassis simulation needs to be a fundamental part of every race engineer's approach

By DANNY NOWLAN

Simulation can help you understand what the racecar is capable of, while it also gives you the framework to ask the right questions

A few months ago I wrote an article on why simulation needs to be one of the first things you do when running a car (RCE V27N9). I outlined where racecar simulation fits into the pecking order and gave you a taste of what you can do with it based on what I've seen using it over the last 20 years. In this article I'm going to be returning to the same theme, but this time I want to come at it from a different point on the compass. In particular I'll explore the benefits of what happens when simulation is a fundamental cog in your engineering process, and we will illustrate this with a number of case studies.

In a nutshell simulation is a tool that can help you understand what the car actually is, and gives you the framework to ask those questions you couldn't otherwise resolve. If you treat simulation this way it will be one of the most valuable tools you'll ever use in engineering a racecar. If you try and use it as a magic wand you will forever be doomed to disappointment. Let's put this another way, with a tool like ChassisSim you have the ability to use race data to reverse engineer what you don't know about the car, and then use this as a representative environment to start playing the what ifs. Whether you agree with simulation or not, to not even consider something like this is just lunacy.

Blank checks

The other thing that I want to say is I'm not just writing this because I have a vested financial interest in doing so. And also, remember that the lessons I am sharing here comes from hard fought experience in categories as diverse as GP2 and LMP1, right through to V8 Supercars, and amateur/semi professional race teams. I consider it my duty to pass on these lessons.

The first reason that simulation needs to be one of the integral cogs of race engineering is it gives you the ability to start filling in the blanks of what the car is doing. Take the example of correlation you see on an oval in **Figure 1**. This has been taken from actual data so I've had to blank out scalings and data numbers. However let me walk you through the channels.

The top trace is speed, the second trace is steering, the third trace is front pitch the fourth trace is rear pitch and the final trace is acceleration. Please note, by front pitch we are talking the average of the front damper displacements and by rear pitch we are talking the average of the rear damper displacements. In rough terms what we are seeing here is that down the straights the correlation is okay, but in the corners the simulated pitches indicated by the black traces diverge significantly.

Most people would look at **Figure 1** and conclude the simulation is flawed, but what this has actually just told you is there is a hole in the aeromap. One of the big suck-you-ins with simulation is that so many engineers are

Many engineers are so obsessed with correlation they actually forget you learn the most when data doesn't add up

Figure 1: Pitch data indicating discrepancies on an oval

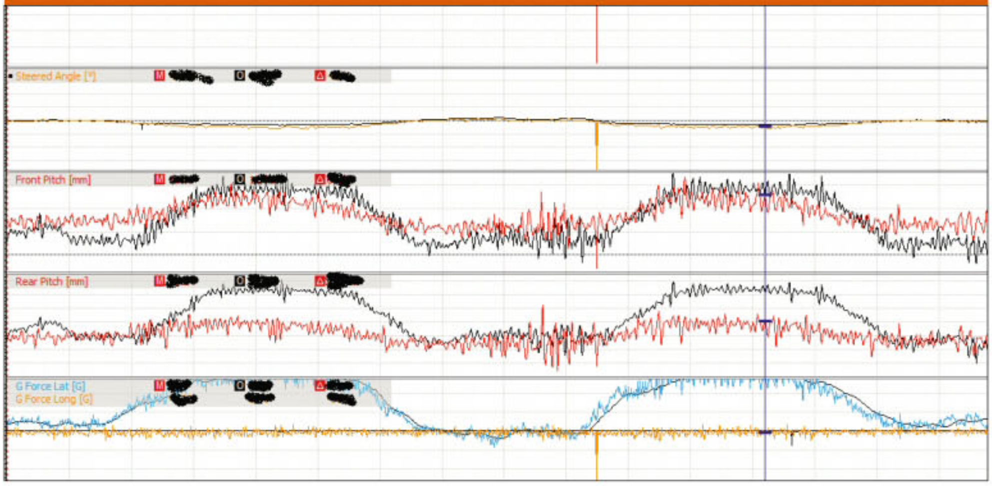


Figure 2: Initial correlation of suspension geometry

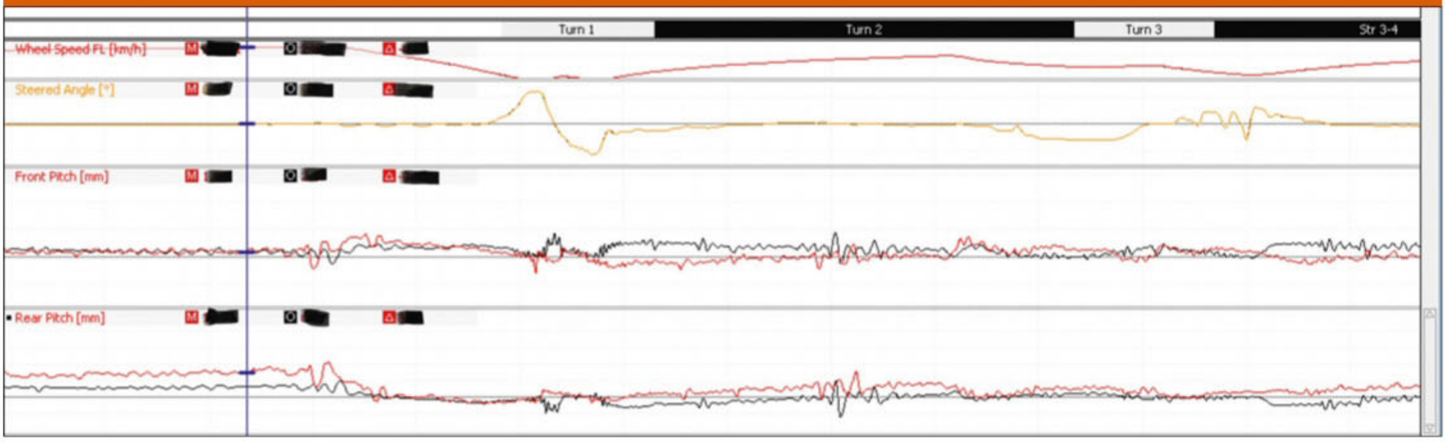
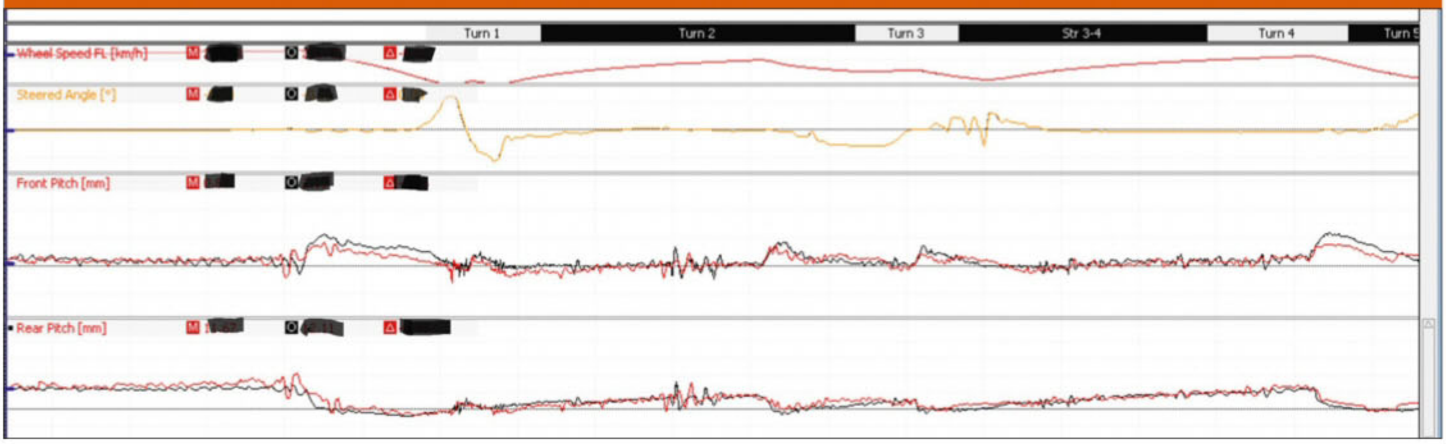


Figure 3: Correct suspension geometry correlation



obsessed with correlation they actually forget you learn the most when data doesn't add up. It gives you the opportunity to question what is in front of you and, more importantly, resolve those gaps in your knowledge.

In this particular case what the correlation has shown you is that from static ride height to moderate ride height we have a good representation of the aeromap.

However, in the corners where the racecar is compressed the current aeromap has over-estimated the downforce. Nothing can answer these questions like simulation, which is why it makes a fantastic check and balance.

The next case study is to show you how you can use track replays to help understand your suspension geometry. The beauty about a track replay simulation is that it takes the actual racecar inputs, like steer angle, throttle and speed, and replays what the car did. Consequently it forms a fantastic sanity check.

Figure 2 shows some actual customer data, from when I was trying to sanity check what was going on with this racecar's suspension geometry. Since this is a live customer car I've had to blank out all scalings. However, let me walk through the traces – as always actual is coloured and simulated is black.

The first two traces are speed and steer angle. Since this is a track replay they are identical. What this means is we have a genuine apples *vs* apples comparison. The last two traces are front and rear pitch. The front pitch is not really too bad, but the rear pitch was in the order of 10mm too short. Also, the aero numbers that where needed to get there were a little odd.

The data was indicating the pitch centre was higher than it should be

When you see something like this on a track replay simulation it is a tell-tale sign that something has gone bang with the geometry measurements. This car had quite a lot of torque (around 500Nm) and a CLA range between 1.8 to 2.5. So typically with this kind of car, with a low pitch centre down the straights, you'll see the front dampers barely register but the rears are registering typically between 10 to 20mm depending on the motion ratio and spring rate. What the sim data was indicating was the pitch centre was higher than it should be.

So, on a hunch I lowered the rear pitch centre and put the aero numbers to where they should be. The end result is shown in **Figure 3**.

As in **Figure 2** actual is coloured, simulated is black, while the items plotted here are also identical to **Figure 2**. As can be seen the rear pitch correlation is significantly better than what is in **Figure 2**. Also, while there is some tidying up to do with the front correlation the overall trends are the same. The end result of all this is that when the supplied rear geometries were re-examined there was an error found in the datum. This error led to the high rear pitch centre. Without simulation this error would have been much more difficult to find. But with simulation this is what you have at your finger tips.

Hidden variables

The other reason that simulation needs to be an integral cog at the centre of your engineering process is that it allows you to look at the variables that would be highly difficult, if not impossible, to review on an actual racecar.

A very good case in point concerns the suspension geometry. As we all know, to measure cambers, roll centres and pitch centres on an actual racecar can be very difficult, bordering on the impossible. With simulation it comes out in the wash, and there is an excellent case in point to show this in **Figure 4**. The plot here is a simulation of a Formula 3 car. The first three plots are speed, steer and throttle. The fourth plot is front cambers, the fifth plot is rear cambers, the sixth plot is front and rear roll centre and the last plot is front pitch centre.

One of the things that race, performance and data engineers have always wrestled with is what does the suspension geometry look like and what should it be. With simulation you now have a tool that investigate this matter directly, and what it is doing in a corner. It is the perfect compliment to suspension analysis tools such as SusProg or WinGeo.

Figure 4: Plot of suspension geometry variables

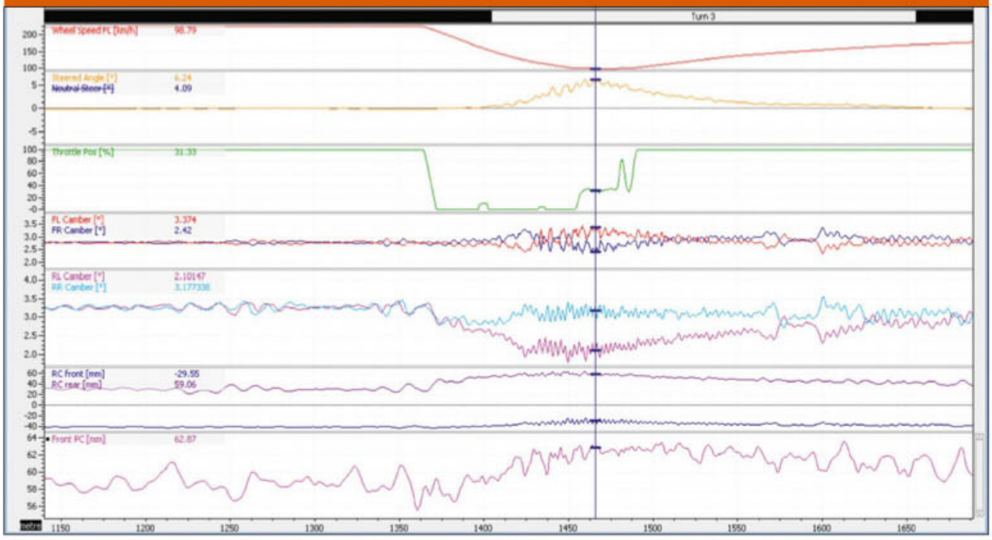
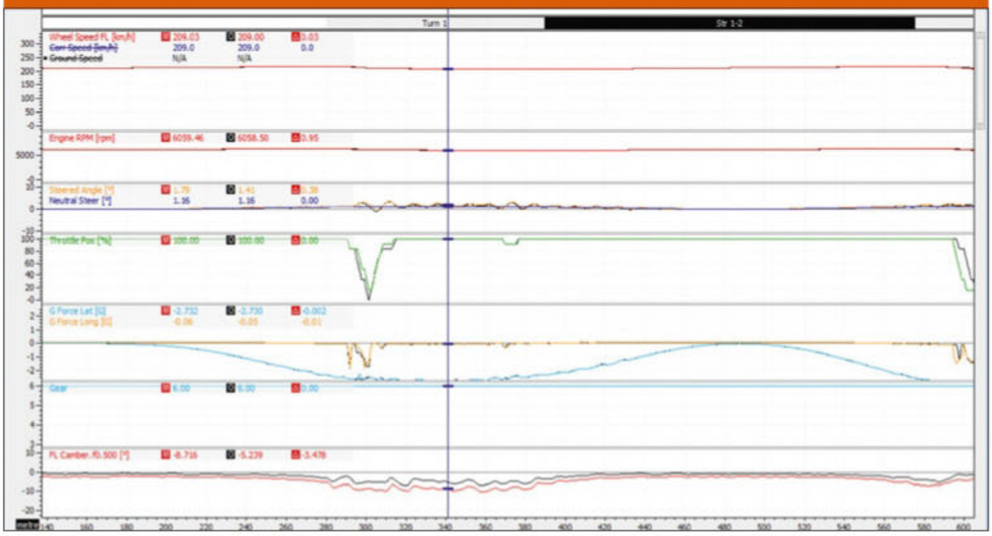


Figure 5: Plot of stability index



Stability index

The other thing that simulation brings to the party is the ability to log racecar handling. If I had $50 for all the vague discussions I have heard in the past about car handling I would have a personal fortune that would rival Warren Buffet! I can't speak for the other simulation packages, but ChassisSim has the ability to log the stability index. I have discussed the stability index at length in previous articles but the bottom line is it's a measure of the moment arm between the centre of the lateral forces and the c.g. The great news is when you make adjustments you can now log these. An example of this is shown in **Figure 5**.

The coloured trace is a Formula 3 car with an aero distribution of 38 to 40 per cent on the front axle, the black is the aero distribution at 43 to 45 per cent. The final plot is of most interest because it shows the stability index.

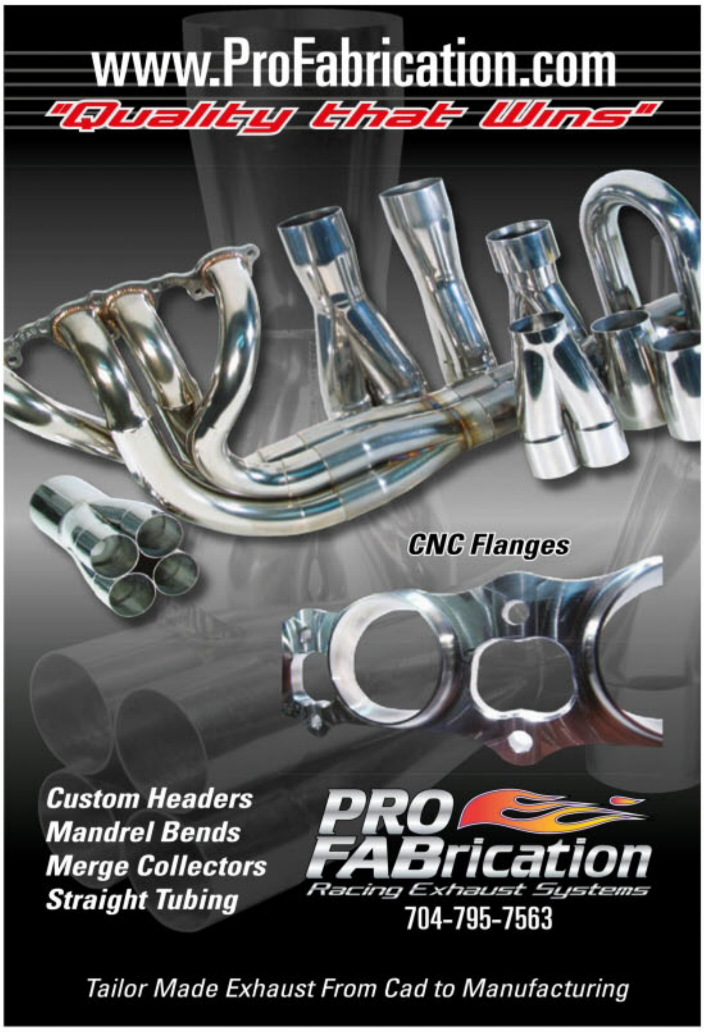
Mid corner the standard stability index is -8.7 per cent. With the aero change this has changed to -5.7 per cent. It is still stable but it has been reduced. The nail in all this is that you now have the ability to finally cross reference your driver feedback against what is going on with the car. This cross referencing is invaluable, because if you get a driver who is spooked by the car, you can now get the answers you need.

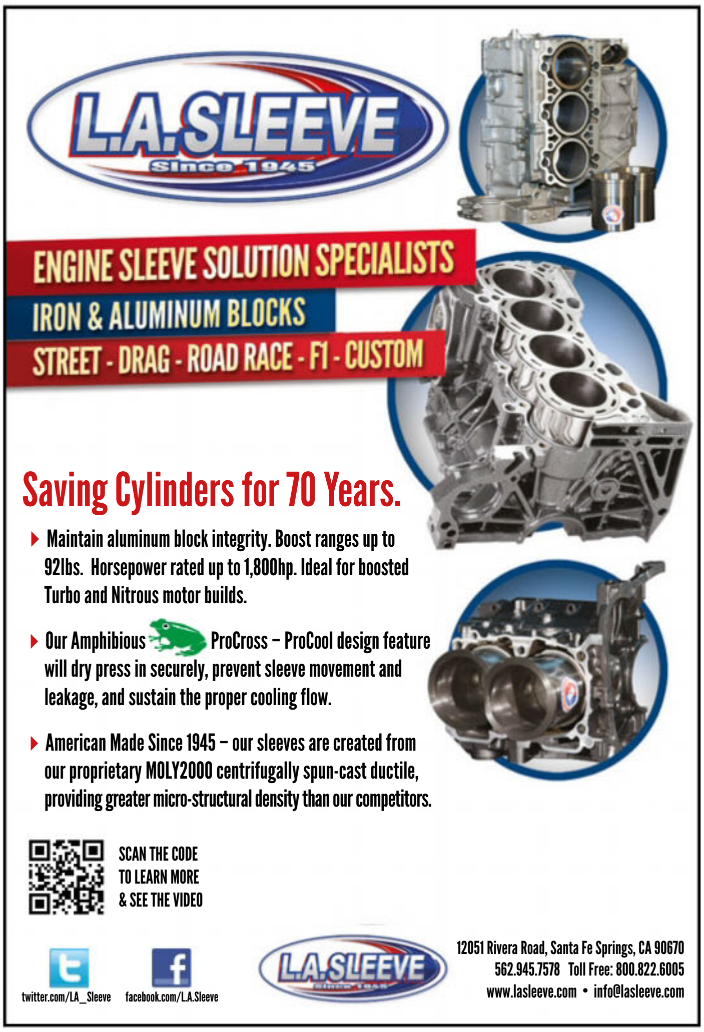
Summing up

In closing there are many reasons that simulation needs to be at the heart of your engineering process. As we discussed in our first two examples simulation can expeditiously fill in the blanks of things you don't know about the car, or pick up something that is wrong in your measurements of the car. This knowledge is invaluable. Also, once the simulation is up and running you can readily log and investigate the parameters that are difficult or impossible to log on the car. The geometry and stability index are excellent cases in point.

If you use simulation as a way to fill in the blanks of what you don't know about the car, and use it to ask the right questions, it will become a tool that you can't do without.

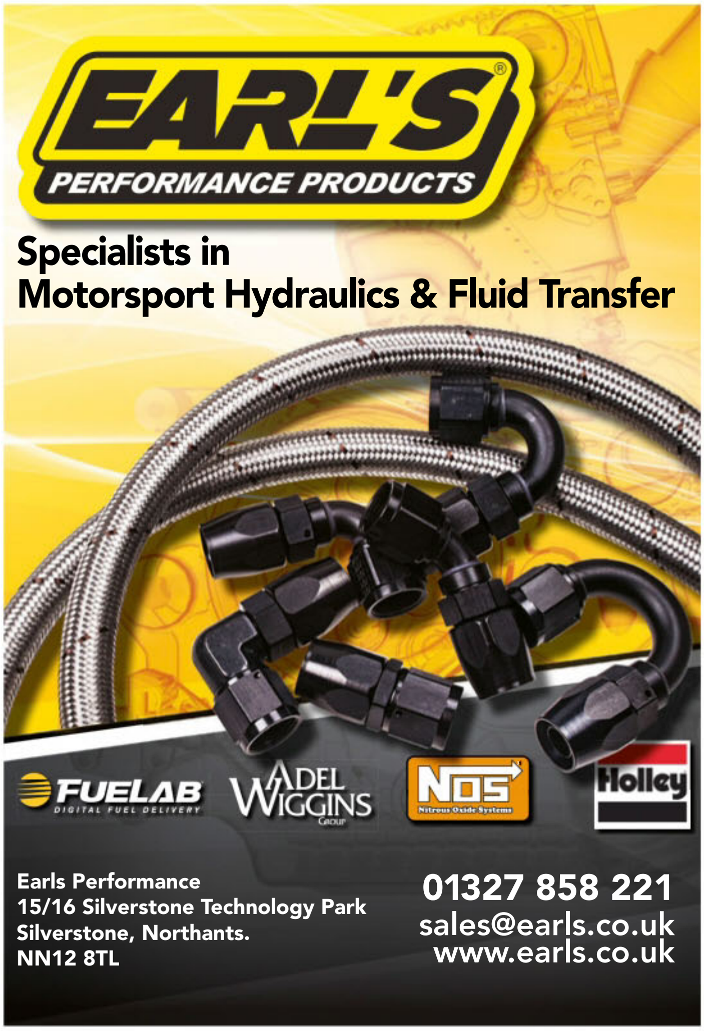

Setrab
ProLine
Oil coolers and Intercooler cores
Reliability
Flexibility
Know-how
Visit us at www.setrab.com/proline


www.ProFabrication.com
"Quality that Wins"
CNC Flanges
Custom Headers
Mandrel Bends
Merge Collectors
Straight Tubing
PRO FABrication
Racing Exhaust Systems
704-795-7563
Tailor Made Exhaust From Cad to Manufacturing


L.A.SLEEVE
Since 1945
ENGINE SLEEVE SOLUTION SPECIALISTS
IRON & ALUMINUM BLOCKS
STREET - DRAG - ROAD RACE - F1 - CUSTOM
Saving Cylinders for 70 Years.
Maintain aluminum block integrity. Boost ranges up to 92lbs. Horsepower rated up to 1,800hp. Ideal for boosted Turbo and Nitrous motor builds.
Our Amphibious ProCross – ProCool design feature will dry press in securely, prevent sleeve movement and leakage, and sustain the proper cooling flow.
American Made Since 1945 – our sleeves are created from our proprietary MOLY2000 centrifugally spun-cast ductile, providing greater micro-structural density than our competitors.
SCAN THE CODE
TO LEARN MORE
& SEE THE VIDEO
twitter.com/LA_Sleeve
facebook.com/LA.Sleeve
L.A.SLEEVE
12051 Rivera Road, Santa Fe Springs, CA 90670
562.945.7578 Toll Free: 800.822.6005
www.lasleeve.com • info@lasleeve.com


Motorsport Essentials
Gauge Fittings
Oil, Fuel & Water Hoses
Silicone 3 PLY & 4 PLY & Vacuum Hoses
Linkage Parts & Suspension Rod Ends
Brake & Clutch Hoses, Spares & Fittings
Hose Clips, Joiners & Fittings
Fan Thermostat Switch Kits
Electrical Accessories
LMA
Autoparts & Hydraulics
Suppliers of Race, Fast Road, Classic & Commercial Products
Tel: 01933 778335
Fax: 01933 778341
www.LMAautoparts.co.uk
sales@LMAautoparts.co.uk


PEGASUS
Beta
Exclusive North American
Motorsports Distributor for Beta Tools
Stocking distributor of
silicone hoses
US importer of
Jabroc® skid plate sheets
Stocking distributor of
MS21071 Apex Joints
(all sizes, ¼" to 1 ¼")
... and much more!
Pegasus Auto Racing Supplies • New Berlin, WI USA
800-688-6946 • 262-317-1234
PegasusAutoRacing.com
Racers serving racers around the world since 1980


EARL'S
PERFORMANCE PRODUCTS
Specialists in
Motorsport Hydraulics & Fluid Transfer
FUELAB
DIGITAL FUEL DELIVERY
ADEL WIGGINS
NOS
Holley
Earls Performance
15/16 Silverstone Technology Park
Silverstone, Northants.
NN12 8TL
01327 858 221
sales@earls.co.uk
www.earls.co.uk


CARTEK
MOTORSPORT ELECTRONICS
NEW!
POWER DISTRIBUTION PANEL
CARTEK are pleased to announce the new Power Distribution Panel is now available. This product is a full redesign of their successful but bespoke, Power Control Panels, with the main aim of allowing the user to customise and configure it themselves
The CARTEK Power Distribution Panel is a fully integrated, fully electronic solution to power distribution in race and rally cars. Designed to replace 16 Fuses, Relays and Switches as well as a variety of control systems, these units therefore greatly simplify the wiring, reducing build time, saving weight and maximising reliability.
The 140x195mm panel only weighs 625g and is enabled with short circuit and over-current protection.
2 x Multicoloured Sticker Packs Included
Key features:
-16 User Configurable Channels (no Laptop required)
-7 Selectable Amperage Settings: (0A, 5A, 10A, 15A, 20A, 25A, 30A)
-Choice of Functions such as: Momentary, Latching, Flashing etc
-2 Backlight Settings
-Status LED for each Channel
-ECU and Switch Inputs available
-Dedicated Wiper Control Module
BATTERY ISOLATOR XR
The new Battery Isolator XR can output a signal to shut down the CARTEK Power Distribution Panel as well as isolate the Battery.
WIRELESS CONTROL SYSTEM
Use the Wireless Control System to communicate with the CARTEK Power Distribution Panel or ECU/Dashboard
For more information go to www.CARTEKMOTORSPORT.com

Power politics

Why the prospect of introducing hybrid technology to the DPi class has split opinion within the IMSA paddock

By ANDREW COTTON

Introducing hybrids is not easy: Audi ran hybrid and non-hybrid versions of the R18 at Le Mans in 2012. A hybrid car won, but the system was switched off

The head of the FIA technical department, Gilles Simon, has recently stated that he wants to have hybrid technology in the top LMP1 class, including privateer entries in Le Mans and the World Endurance Championship, while he also wants to maintain the link to the IMSA WeatherTech Sportscar series to allow its manufacturers to race at Le Mans. Which, ultimately, could mean hybrids in DPi.

Privately, sources at the FIA admit that there is no clear direction that has been agreed by the manufacturers and governing bodies, and discussions on whether to make a standard hybrid system compulsory, and what storage or power would be desirable, are ongoing.

The split between the philosophies has always been a thorny issue, with a drive for high technology in Europe, and entertainment in the US. Matching the two has consistently led to compromises that have kept the two entities apart, and that state of affairs may very well continue under the new rule set.

In the IMSA paddock, there is no agreement in place. It was hinted that one manufacturer, Ford, was pushing for a high capacity hybrid, no doubt with a view to racing it at Le Mans in the future. Honda admitted that, if it was an option, it would be interested, while Mazda said a firm 'no' to the technology. Cadillac refused to comment, as there was no clear indication that the American brand, Corvette, or parent company GM would be in alignment.

Regulation issues

The ACO was adamant that it will present its new regulations at Le Mans 2018, but left the door open to delaying their introduction to 2021. 'Our target is to introduce the regulations latest at Le Mans in 2018, and for me it's possible to have a car ready for 2020, but if manufacturers say 2021, it's not a problem,' confirmed WEC promoter Gerard Neveu.

There is some common opinion on the hybrid system, if it was to be introduced. There is a push to have only a rear KERS system to recover energy, thereby preventing a four-wheel-drive system and potential set up and running issues for the teams. That, in turn, would likely lead to a maximum of 4MJ storage.

This would make it simpler for the teams in terms of calculating boost strategies, and a lower storage capacity would help prevent the need for such systems as brake by wire that deliver the same braking pressure to the pedal whether the hybrid system is regenerating, and therefore helping braking force, or not. It would also then prevent teams from having to hire multiple engineers to manage these systems. 'We don't want to go down this route,'

‘What appears to have caused the challenges in the LMP1 category was the unbridled advancement opportunity for that level of technology’

Mazda’s motorsport boss John Doonan says that hybrids do not fit in with its current racing philosophy

confirmed Neveu. ‘We are working with IMSA and we have to work it out together.’

Some points in the future regulations puzzle are already close to a final decision. The aero regulations, in which the cars are balanced on their lift/drag ratio, seem to have been agreed, for a start. Therefore, the FIA’s system developed for GT racing should take centre stage.

ACO sources also indicate that the WEC could open up its regulations to allow multiple fuel suppliers, admitting that development costs would be higher, but that the sponsorship fuel companies would bring could cover that cost. This would open the door to F1 powertrains, although this crossover has been technically possible since 2014, and no one has done it yet.

Doonan gloom

At Daytona manufacturers were sceptical. ‘There are no plans in the racing programme,’ said Mazda’s John Doonan in response to the hybrid question. ‘From a broad audience standpoint we are analysing our options and we have them on the road car, but from a racing strategy it is not in our plans. Just from a cost standpoint and what we have seen in global sportscar racing, it would be a situation where something that is now growing and becoming prominent is not broken so let’s not do anything to upset what we’re doing now. I think for people who are in it already, to make a significant investment in R&D it is not easy to go back and ask for more funds.’

Over the Daytona race weekend, IMSA announced an extension to its homologation of the DPi cars, so the new generation cars will still be around in 2022. Ford is therefore considering an extension to its GT programme, which is currently scheduled to finish at the end of 2019, to bridge the gap between this finishing and the start of its DPi programme in 2022.

LMP1 lessons

IMSA President Scott Atherton says that the bodies should learn from the previous mistakes that have led to Porsche and Audi withdrawing from LMP1, partly due to the high costs of hybrid development. ‘At this moment we have the luxury of time on our side, but for us to make a commitment like that, based on where we are today where hybrids do not feature in the DPi platform, in order to give our existing manufacturers the lead time necessary, and for those that are developing programmes that are arriving here to compete, you want to get that word out as soon as possible,’ said Atherton over the Daytona 24 hours weekend.

‘Those conversations are taking place openly within the FIA, the ACO and IMSA, but also with the manufacturers and one of the visions here would be to incorporate the technology but in a defined way so it has a limitation to it. It would incorporate the technology in a way that avoids the most recent experience of what we all witnessed within the LMP1 ranks.

‘What appears to have caused the challenges in the LMP1 category was the unbridled advancement opportunity for that level of technology,’ said Atherton. ‘When you get manufacturers with that competitive nature that they have in that environment, and there is no structural limit put to the technology involved, you end up with what has recently occurred where manufacturers have made decisions to curtail their involvement, and we have been through that ourselves.’

Whatever the decision is, the likes of JDC Motorsport and BAR1 will have to be taken into consideration. If hybrid is compulsory and the now famous ‘Appendix B’ that would balance a hybrid and non-hybrid car is not required, the privateers need to be listened to.

Ford is looking to step up to prototypes under the new regulations and is said to be pushing for high powered hybrid systems

Cadillac is dominating the US prototype scene and won at Daytona. It could not comment on its position on hybrid use in DPi

Interview – Paul Bellamy

Electro magnetic

The World Rallycross boss tells us about the championship's electric future and why food and music will help bring new fans to the sport

By MIKE BRESLIN

'We have a very young millennial audience, 75 per cent of them are under 35'

When Formula E was launched in 2014 some thought it had missed a trick in opting for a single seater and selling itself as a sort of electric F1. Surely, rather than changing cars mid-race, why not have shorter races? And if you're really after a younger audience, then why not *very* short, action packed races? In effect, why not rallycross?

Since that time Formula E has done well enough, but rallycross has come on in leaps and bounds, and in common with the electric series the World Rallycross Championship (WRX) has attracted manufacturers with VW, Audi, Peugeot – and now Renault, we're told – all involved in some shape or form. But that's not all, WRX is now also set to go fully electric itself, probably as soon as the season after next, in fact.

World Rallycross and the FIA now has nine car makers in serious talks about its electric future, according to Paul Bellamy, managing director for WRX at promoting company IMG, while Peugeot has gone on record to say that it was the prospect of electric rallycross that persuaded it to opt for the discipline as its main factory motorsport effort, now that the Dakar programme has finished. 'We are having regular conversations with manufacturers and the FIA on what electric might look like, in terms of regulations, and in terms of the cost of the cars,' Bellamy says. 'Rallycross is absolutely set up to run electric, because it's short, sharp racing. The electric prototype rallycross car is very, very fast, and they look exciting.'

Bellamy says that a switch to electric will now probably happen in 2020, and as to whether it would be a class within the WRX, or a separate series, he said: 'That's all under discussion, but I would see electric being the world championship … The supercars, as they are now, they may then be part of another international series.'

Crossed wires

Two years is not so very long for such a big change, and Bellamy admits this is the main concern. 'It's just time really,' he says. 'I think we need to make sure that the regulations are right at the very start, and mostly that we keep costs under control.'

To that end the championship will use a spec battery, and probably a spec base chassis. But with so many manufacturers potentially becoming involved, surely there's a risk of budget inflation? 'For us all the teams are privateers, but some are more manufacturer backed than others,' Bellamy says. 'We want to keep that balance, and make it affordable racing, as it doesn't do anybody any favours for the costs to go through the roof.'

With this in mind WRX has already started to take some cost cutting measures, such as major testing restrictions and a raft of technical measures that have been put in place for this season – including new limitations on engines, turbos, tyres, gearbox ratios and aerodynamic parts.

But with rallycross so suited to electric-drive cars, and with so many manufacturers seemingly interested, could it be that WRX might usurp Formula E? Bellamy says that's to miss the point of both categories. 'We don't see ourselves as in competition with Formula E. Electric is such a big part of the future for vehicles; so it's the same way that Formula 1 and WRC live together, that we live together with Formula E. It is totally different racing, with totally different cars.'

Cross pollination

Before WRX goes electric it still has its current product to sell, though. 'Getting the message out there is the biggest task now,' Bellamy says. 'I know that the sport of rallycross, certainly at world championship level, is as exciting as anything you will see. So what we need to do, and it's our biggest challenge, is get that message to a whole new audience. I know, once I can get them to a rallycross event, the people who aren't necessarily motorsport enthusiasts, I can say "just give me three minutes of your time". It's a short sharp form of entertainment, and I need to get people to see it; those potential converts to rallycross, without destroying its traditional elements.'

One of the ways WRX aims to do that is by tapping into IMG's other businesses. It's a huge organisation and its reach extends beyond sport, and to that end the UK round of the championship has now been switched from Lydden Hill (the birthplace of rallycross) to Silverstone, where it will be the central aspect of a new event called Speedmachine at the end of May. 'The concept was taking something like a world championship in motorsport and adding other elements to it,' Bellamy says. 'We had a number of festivals we were involved with already at IMG; The Taste of London Festival, and The Big Feastival, which basically incorporates music and food. So, we

said, let's take something else that we've got, which is world championship motorsport, and let's put that at the heart of it. And that's how it started; motorsport, a live music element, and also a food festival, across a weekend. And we've got this fantastic venue at Silverstone, we've got access to the whole circuit, and so casting out further, what about the ability of consumers to drive cars around the track?'

Crossing the world

This hybrid of motorsport, music, food festival and track day, might prove to be a great way to attract new fans in Britain, but it should not be forgotten that WRX is also one of just four FIA-sanctioned world championships. It is also the only one with a round in Africa – its Cape Town event introduced last season – and this year there will be a round in the US, at Austin in Texas, too. But America is very much the territory of the Global Rallycross Championship (GRC).

'I don't see us in competition with GRC,' Bellamy says. 'It's very important to have a domestic rallycross series in America. We go into countries, and we only do one event there and then we're out, so it's important for us to have healthy domestic series in all the countries we go to. In the UK there's a healthy championship; France has one, Sweden and Norway have the Nordic. I don't see any of those as competition, the competition I see, really, is the competition for a young audience. That's where our competition is; beyond motorsport.'

And this competition is not just from other sports; it's far broader than that. 'It's entertainment,' Bellamy says. 'We have got a very young, millennial, audience; 75 per cent of our audience is under 34. And in the next few years we are competing for their attention; whether they are watching Netflix, or television or Youtube or playing e-gaming, whatever they're doing that forms part of their entertainment in their spare time, that's what we're competing against.'

But does that mean that the sell is all about media exposure? Bellamy says no, spectators at events are still important. 'We need to have a crowd. We always have two paymasters, and the one is the digital and the TV audience, and then equally important is the live audience; because that creates the atmosphere that comes across on television. They are equally important and we have to cater for both of them.'

The next challenge, then, could be convincing this live audience that electric really will be as spectacular as the flame-belching Supercars they have come to know and love.

Peugeot has committed to World Rallycross and eight other car makers are currently talking with WRX as it gears up for its proposed switch to electric power, which will probably be in 2020

RACE MOVES

Ron Walker, the man behind the Melbourne-based Australian Grand Prix and one of F1's most influential promoters, has died at the age of 78. Walker was a successful businessman in the city and was given the job of promoting its F1 race after he steered its unsuccessful bid for the 1996 Olympics. He was also chairman of the Formula One Promoters' Association, before stepping down in 2015 due to ill health.

Lena Gade, the former Audi LMP1 race engineer, has moved to IndyCar, where she will oversee the James Hinchcliffe entry at Schmidt Peterson Motorsports. Gade moves to SPM from Bentley Motorsport, which she had joined in the wake of Audi's World Endurance Championship departure at the end of 2016. She engineered three Le Mans-winning cars during her time at Audi.

Ben Kennedy is now general manager of the NASCAR Camping World Truck Series. Kennedy will oversee all aspects of NASCAR's truck racing championship, working closely with **Brad Moran**, the Truck Series managing director, and **Jeff Wohlschlaege**r, managing director, series marketing.

Steve Brabeck, the co-owner of Australian Supercars operation DJR Team Penske, has died after a long battle with cancer. Brabeck initially become involved with the team as a sponsor when it was still known as Dick Johnson Racing in 2009, and went on to become a major shareholder; keeping a 20 per cent stake in the outfit when it morphed into DJR Team Penske in 2015.

Perry Kapper has rejoined Australian Supercars squad Shell V-Power Racing as its chief designer, following his departure from Nissan Motorsport – where he was engineering manager – at the end of the 2107 season.

It's been reported that Former McLaren F1 team principal **Martin Whitmarsh** is to return to Formula 1 in a consultancy role with the FIA, where he is to advise on the introduction of cost control regulations. He is also a member of Formula E's Global Advisory Board. Whitmarsh left F1 in 2014 and since then he has been involved with yachting, as part of the BAR America's Cup effort.

Darren Sansum has joined IndyCar as its new managing director of engine development. Sansum comes from Toyota Racing Development's NASCAR programme – Toyota has won the past two manufacturer championships in the NASCAR Cup series. Sansum has also worked for Ford, Cosworth and Ilmor in the past. At IndyCar Sansum will oversee powerplant development and he will monitor the engine competition between Honda and Chevrolet.

Aimee Thoennes, who has been executive assistant at the Sports Car Club of America (SCCA) for the past 15 years, has now taken the member services manager position, where she will be responsible for the operations of the member services department. She replaces **Derrick Frakes**, who has moved to the information technology department, where he has taken on the role of software systems engineer.

There have also been moves within the marketing department at the SCCA (see above). **Rick Myers**, region development manager, and **John Burchardt**, membership marketing manager, now work directly with **Chris Robbins**, the new director of region development.

Well-known NHRA drag racer and NASCAR engine builder **Bob Glidden** has died at the age of 73. During a hugely successful driving career Glidden won 85 events and 10 championships, before retiring to concentrate on developing engines for some of NASCAR's Ford-running Cup teams.

Rob Crawford has joined the newly formed Australian Supercars outfit 23Red Racing as crew chief on its Will Davison-driven Ford Falcon. Crawford is a former Holden Racing Team stalwart, but he left the team in 2011 to join Kelly Racing. Since the end of 2013 he has worked as a consultant in the GT racing arena. **Rob Palermo** is to be Davison's race engineer at 23Red.

OBITUARY – Gerard Welter

Gerard Welter, the well-known independent Le Mans car builder, has died at the age of 75.

Welter designed and entered a long line of unusual prototypes that raced at the 24 hours from 1976. In the early years these were conceived with the aim of grabbing headlines by reaching the highest possible speeds down the Mulsanne Straight – before the chicanes were put in place at the end of the 1980s. From then on Welter concentrated on attempting to bag pole position with his cars.

In 1988 Roger Dorchy officially hit 251mph (405kmh) in one of Welter's WM cars and seven years later a WR-Peugeot driven by William David claimed outright pole position – the car name having switched from WM to WR by now.

However, with an emphasis on straight-line speed the WM and WR cars were never the best on the twisty bits, while they were also hugely unreliable, the team's only finish coming in 1980, when it bagged fourth place.

Welter was very much the enthusiastic amateur, and away from the track he worked for Peugeot, with which his team often had a strong connection. He was the French firm's design director for nine years until he retired in 2007 and he is often given the credit for the styling of the Peugeot 205.

Gerard Welter, who built the WR and WM Le Mans specials, died in February

Beyond the outlandish specials that made Welter's name he also entered a Peugeot 905 Spider at Le Mans in the early '90s, while in the 2000s there were Peugeot-powered and then Zytek-engined prototypes until his last appearance in 2010. Comeback attempts included the GreenGT hydrogen fuel cell car, plus a project for a bio-methane powered racecar, both of which were intended as Garage 56 entries.

Gerard Welter 1942-2018

NASCAR bolsters management team to boost its non-US series

NASCAR has undertaken a recruitment drive and also made key changes within its management structure as it looks to aid the development of its series running outside the United States.

Chad Seigler has filled the new position of vice president, international business development, while Jim Cassidy is now NASCAR's chief international officer, tasked with growing the brand around the world. Cassidy will now oversee all international competition: the NASCAR Pinty's Series in Canada, the NASCAR's Mexico Series and the NASCAR Whelen Euro Series.

NASCAR has also announced it's appointed Jimmy Small as senior director, international business development and partnerships. Small, who has been the president of Iowa Speedway for the past four years, will report to Siegler.

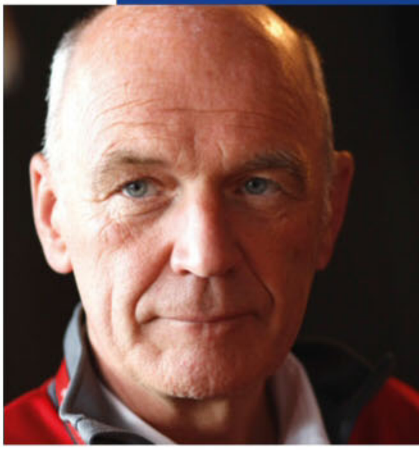
Meanwhile, Celeste Griffin-Churchill has taken on the new position of senior director, international, while Joe Balash remains in his current position as director, international competition, and Bob Duvall stays in his post as senior director, international and weekly/touring business development.

Jim Cassidy has a global brief as chief international officer for NASCAR

Commenting on Cassidy's appointment, Steve O'Donnell, the executive vice president and chief racing development officer at NASCAR, said: 'Jim brings nearly two decades of racing operations and industry leadership experience.

'He has worked tirelessly to grow our existing motorsports properties outside of the United States and will now lead our efforts to identify important growth opportunities internationally for our sport and its growing fan base.'

RACE MOVES – continued



The former head of Audi Sport, **Wolfgang Ullrich**, has been appointed as a special adviser by the Automobile Club de l'Ouest, the organiser of the Le Mans 24 hours. Ullrich, who retired from Audi last year, will advise senior management, including ACO president Pierre Fillon, on financial, technical and marketing matters.

High performance engineering company KWSP has appointed **Edward Smith** as its head of Heritage Engineering. With more than 20 years' experience in motorsport engineering, Smith joins from Palmersport, where he oversaw a variety of racecar and performance vehicle projects, notably its FIA Formula 2 car in partnership with Williams, and the more recent BRDC British F3 car in collaboration with Tatuus.

Derrick Finley is now the crew chief on the Front Row Motorsports No.34 Ford in the NASCAR Cup Series. He filled the same role on the team's No.38 car in 2017. Finley has been with the organisation since 2011.

Nissan Motorsport's Australian Supercars operation has signed up highly-experienced American **Nick Ollila** as its technical director. He brings more than 40 years of experience to the team. He worked in F1, NASCAR and IndyCar with Penske from the 1970s, before spending some 20 years leading NASCAR aero programmes for top level outfits.

Phil Keed is no longer the race engineer for **Fabian Coulthard** in the Australian Supercars series, with **Mark Fenning** being promoted from within the Shell V-Power Racing operation to take his place. Fenning has spent most of the last decade working in other roles at the Queensland-based Ford-running outfit.

Brendan Gilhome, the head of aerodynamics at Toro Rosso, has now left the Italian F1 team. Gilhome arrived at Toro Rosso in the summer of 2013, having previously worked as lead aerodynamicist at Mercedes and as the group leader of aerodynamics at Sauber.

Andy Scriven has died at the age of 57, passing away two months after he was seriously injured in a cycling accident close to his home in North Carolina. The British racecar designer latterly worked for Crawford Composites, and designed its Formula 4 and its new Regional Formula 3 car, but in the past he was better-known for his work with sports prototypes. He worked at Tiga, designing its Group C2 car, and with Jaguar in Group C. In the States he plied his trade in NASCAR and IndyCar with Penske, amongst other projects.

Will Phillips has returned to KW Motorsport, the motorsport engineering company he founded in 2002, to head up its new on-demand motorsport consultancy division, KW Racing. In recent years Phillips has filled the high-profile position of vice president of technology at IndyCar.

David Hyatt is to replace **Jimmy Small** (see story on left) as president of Iowa Speedway. Hyatt brings nearly 30 years of motorsport industry experience to bear in his new role, most recently serving as president of The Motor Racing Network.

◆ Moving to a great new job in motorsport and want the world to know about it? Or has your motorsport company recently taken on an exciting new prospect? Then email with your information to **Mike Breslin** at **mike@bresmedia.co.uk**

The numbers game

Why motorsport needs to use its vast data resource to boost its appeal

What has future audience growth to do with motorsport engineering? The answer is 'everything'. Motorsport engineers hold the keys to data which can increase tomorrow's motorsport audience, increase sponsorship and bring new income to our sector.

In February, the MIA called a meeting in London to initiate a 'Motorsport Audience of the Future' strategy aiming to double our global audience in the next five years. This will increase revenues by developing and applying innovative technologies to deliver new experiences through new platforms and methods of entertainment.

Motorsport Valley UK is lucky to be located alongside the UK's world-leading creative and digital business sector. These exceptional companies use virtual, augmented and mixed reality, based on digitalised data, for film, TV and online audiences. The Harry Potter series relies on these creative companies to turn fiction into 'reality' and entertain millions – just imagine the impact their talent will have on motorsport audiences.

Data rich

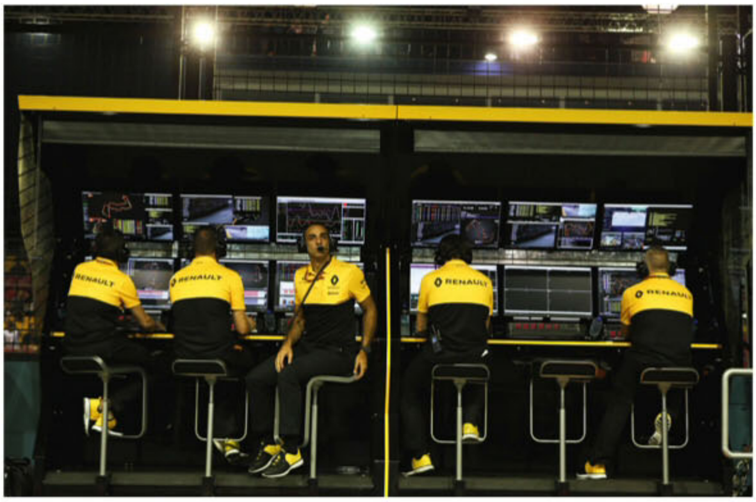
Low technology sports have already increased their audience using data. Hawk Eye at Wimbledon uses data from a ball and racquet, for instance. But motorsport creates more data than any other sport in the world, and data is the heart of digital entertainment. The MIA is encouraging engineers to use some of their engineering or human performance data to deliver more entertainment and boost future incomes. By collaborating through the MIA with the UK's creative companies – special effects, video games, film, TV, digital etc. – we will find a language and visual capabilities for motorsport which will attract a far larger audience.

Motorsport captures data for internal, competitive use – we know more about aerodynamics than we know about our audience. Yet this data is also the valuable lifeblood which creative people use to entertain an audience.

The change of Formula 1 ownership is the catalyst for the MIA to create this new strategy for growth. The previous F1 owner had a business model which didn't greatly value the paying audience nor digital or online activity. Bernie Ecclestone's income came from TV broadcasting rights and race hosting fees, leaving the local promoter to attract live audiences.

Liberty has a different background, it appreciates the logic and value in doubling the F1 audience. Ross Brawn says that at the top of the list of technical changes is the word 'entertainment'. At long last, we will see activity to increase audience numbers which will bring higher incomes, not just to F1 but all other series. Promoters will have to wake up to their new responsibilities to deliver higher digital audience numbers if they want their series to survive.

Loyal European and American motorsport audiences are declining, we can expect strong growth in digital and social media audiences from China, India and Russia where the demand for digital entertainment is high. The power and significance of these online audiences cannot be overestimated for future motorsport income, as they do not rely on attending specific race events.



If there's one thing Formula 1 has plenty of it's data and some engineers admit very little of this is confidential – so shouldn't it be used to help improve the entertainment product?

Poor relation

It's true major sports events need full grandstands to make audiences feel they 'wish they were there', a desire which can be met by creative digital content reaching an enormous audience of all ages. To understand the size of this new business opportunity, F1 has 12m followers yet the National Football League (USA) has 1.1bn. Lewis Hamilton has 15m but just one footballer, Ronaldo, has 144m.

To underline that automotive marketing budgets chase audience numbers Yokohama Tyres spends £40m a year on Chelsea Football Club shirts and Chevrolet £47m on Manchester United shirts. These automotive spends on the football shirts of just two teams would make a big difference to an F1 team, let alone teams in other series. Motorsport simply must change fast and work with creative communicators to build a new audience and capture these budgets.

New audiences

Our future demanding audience is rapidly changing. 75 per cent of 12 to 15-year-olds have a social media profile and 85 per cent have their own smart phones; under 16-year-olds, for the first time, now spend more time online than watching TV.

The MIA was able to share with its members advanced notice of an upcoming chance to bid for £4m of UK government funding, part of its Industrial Strategy, to collaborate with the creative industries to deliver a demonstrator. This collaboration will show how we can, jointly, reach new audiences and mutually increase commercial value. Details will be available on the MIA website (www.the-mia.com) shortly. I expect Formula 1 and other race series will be involved in this bid.

Some may say engineering data must stay confidential, but I don't believe motorsport can afford to ignore the changing entertainment world with which we must engage. Most of this data, once used, has little value to engineers, but it can be used to generate significant new income from new audiences.

I approached some leading engineers who agree very little data is confidential and critical. They felt that if it can be used to bring new income into the sport, they would find ways to allow access to it, in partnership with creative companies. This positive attitude is welcome and will, I am sure, see the start of a new drive to bring new audiences and value to motorsport shortly.

If you want to see what the future may hold just take a look at either www.magicleap.com or www.ncam-tech.com and begin to appreciate how we can move forward into a new and exciting dimension. If you want to benefit from these changes, check out www.the-mia.com for the latest news of our Motorsport Audience of the Future initiative.

Motorsport creates more data than any other sport in the world

Racecar engineering
The International Journal of Motorsport Technology

PIT CREW

Editor
Andrew Cotton
@RacecarEd

Deputy editor
Gemma Hatton
@RacecarEngineer

News editor and chief sub editor
Mike Breslin

Sub editor
Henry Giles

Design
Dave Oswald

Technical consultant
Peter Wright

Contributors
Mike Blanchet, Sam Collins (associate editor), Ricardo Divila, Simon McBeath,Danny Nowlan, Mark Ortiz, Martin Sharp

Photography
James Moy

Deputy managing director
Steve Ross **Tel** +44 (0) 20 7349 3730
Email steve.ross@chelseamagazines.com

Advertisement Manager
Lauren Mills **Tel** +44 (0) 20 7349 3796
Email lauren.mills@chelseamagazines.com

Sales Executive
Stephen Upfold **Tel** +44 (0) 20 7349 3775
Email stephen.upfold@chelseamagazines.com

Circulation Manager Daniel Webb
Tel +44 (0) 20 7349 3710
Email daniel.webb@chelseamagazines.com

Publisher Simon Temlett

Managing director Paul Dobson

Editorial and advertising
Racecar Engineering, Chelsea Magazine Company, Jubilee House, 2 Jubilee Place, London, SW3 3TQ
Tel +44 (0) 20 7349 3700
Fax +44 (0) 20 7349 3701

Subscriptions
Tel: +44 (0)1858 438443
Email: racecarengineering@subscription.co.uk
Online: www.subscription.co.uk/chelsea/help

Post: *Racecar Engineering*, Subscriptions Department, Sovereign Park, Lathkill St, Market Harborough, Leicestershire, United Kingdom, LE16 9EF

Subscription rates
UK (12 issues) £86
ROW (12 issues) £98
racecar@servicehelpline.co.uk

Back Issues
www.chelseamagazines.com/shop

News distribution
Seymour International Ltd, 2 East Poultry Avenue, London EC1A 9PT
Tel +44 (0) 20 7429 4000
Fax +44 (0) 20 7429 4001
Email info@seymour.co.uk

Printed by William Gibbons
Printed in England
ISSN No 0961-1096
USPS No 007-969

THE CHELSEA MAGAZINE COMPANY LTD
independent publishing company of the year 2015

www.racecar-engineering.com

Diminishing returns

While the FIA tries to firm up a ladder that leads teams, drivers and engineers to Formula 1, fixing a problem that didn't really need to be fixed, there is a more pressing issue that may hit organisations and competing teams; costs. The FIA is intent on driving down costs to a level that is affordable to as large a market as possible and, while this is commendable in terms of business, it creates another problem, and this impacts the chassis manufacturers that are tasked with new safety measures. As the drive for safety continues with the future introduction of Halo, to go along with the Zylon side impact safety panels, the weight of the safety equipment in the racecars is rapidly rising, and compensations have to be made elsewhere.

This could come in the form of material choice, or with clever design, but there are regulatory restrictions on the former and only so much that you can do with the latter. The cost of making the racing chassis is rising, while the price of the car is being lowered to an affordable point. It is driving chassis manufacturers to the brink of not wanting to compete for the FIA tenders or any other one-make series, and moves the sport closer to series that are simply a sponsored solution from a manufacturer.

> **We need open competition, with intelligently-written regulations that encourage innovation**

If it gets to the stage that a chassis manufacturer is at best breaking even on the sale of a chassis while the spare parts are also cost capped, what is in it for the company? This is not a long-term strategy that could work. All it does is drive out competition in the market and independent chassis manufacturers are faced with choosing between a large global programme, or winding up their business.

In the UK, Ginetta is going great guns and producing lots of cars. It is one of the biggest chassis suppliers in the world and yet has not joined the FIA tender process for one-make series. It went with LMP1, where competition is open for now, although I do worry what is to come in 2020/21. The FIA limited the chassis manufacturers in LMP2 to just four manufacturers, and could easily do so again with its top class in the mistaken belief that this saves money.

This magazine has been consistent in its call for open regulations, and to stop this artificial manipulation of the market. While the FIA tries to figure out what should be the future technology in Formula 3 cars, and identify a target price before it opens the category to tender, it must stop and consider where every other business is going and open up the market to competition. This is the essence of racing, after all, and does mean that people are competing for business by trying to to produce a faster racing car.

My solution for LMP2 was entirely different to that imposed by the FIA. If a chassis manufacturer wants to run at Le Mans in LMP2, it must have sold two cars in Asia, Europe and the US. Eight chassis, including the two at Le Mans, would open up the market for all concerned. Chassis manufacturers would have to produce fast, reasonably priced cars, and those other series would all have benefited too. I mentioned this to the ACO at Daytona and the immediate response was; 'define sold'. What sort of world is this, that we can't work out what is a simple transaction?

With Michelin having signed a long-term deal with IMSA, widely thought to be for a decade, all other tyre manufacturers have been pushed out of these markets. It's the same with Pirelli in GT racing around the world. It makes sense in that there is no tyre development war, but it closes the doors to sponsorship opportunities, to competition and to development potential. Michelin has hinted that it would be up for opening up the grid to other tyre manufacturers, but for now wants to get its feet under the table, and what an opportunity this is for it. By taking over the entire grid, it has access to LMP2 cars (still open tyre supply in the WEC and ELMS), GT cars (almost exclusively on Pirelli other than in national series such as the British GT and VLN), to LMP3 and to the TCR cars. With such experience on all of this different machinery, I can see a point that Michelin will start to muscle in on others' territories and begin a period of global domination.

I was quite heartened to hear from the ACO that on the table for the new LMP1 regulations is an open fuel supply deal similar to Formula 1, although the French organisation will need alchemists to keep the balance between the cars, in addition to its other headaches. But I do worry about the chassis manufacturers and their relationship with the governing bodies, and in particular for the future of lower formulae such as Formula 3. We need open competition, with intelligently-written regulations that encourage innovation, but right now it feels as though we are getting more prescriptive, and I hate to think where this will end.

ANDREW COTTON Editor


Some teams already know the secret...
It's Quicker™
Scan code, or contact us to learn more about our V3 Disc Technology.
verizon indycar series
OFFICIAL BRAKE SUPPLIER OF THE VERIZON INDYCAR SERIES
PFC BRAKES
www.pfcbrakes.com
USA 1.800.521.8874
UK +44(0) 1295 221 020