

Leading-Edge Motorsport Technology Since 1990

Racecar engineering™

October 2017 • Vol 27 No 10 • www.racecar-engineering.com • UK £5.95 • US \$14.50

FORMULA 1

Renault RS17

What's wrong with Enstone team's F1 car?



Formula Student

Autonomous racecars in FS
Germany plus FSUK report



Joest Racing profile

The team that won Le Mans
for both Porsche and Audi



Formula E tech focus

How manufacturer influx is
forcing FE to raise its game

XRP ProPLUS® Reusable Hose Ends

The evolution in **FLUID HORSEPOWER™**



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

 Like us on
[Facebook.com/XRPinc](https://www.facebook.com/XRPinc)

 Follow us on
Instagram
[@XRPricing](https://www.instagram.com/XRPricing)

XRP® 
THE XTREME IN RACECAR PLUMBING

US XRP, Inc. sales@xrp.com tel 562 861 4765 fax 562 861 5503
EU PROTEC FUEL SYSTEMS LTD. info@protecfuelpumps.com tel 44 (0) 121 572 6533

Joest Racing Porsche 908/03 in 1972. The German team will soon be running Mazda's DPI effort in the States but it made its name with Porsche and Audi. Turn to page 48 for its full story



COVER STORY

- 12 Renault RS17**
We put the manufacturer's first ground-up F1 car for seven years under the microscope

COLUMNS

- 5 Ricardo Divila**
Behind the scenes of the WEC's Technical Working Group
- 7 Mike Blanchet**
Why F1 needs to stick with internal combustion
- 9 Peter Wright**
The reason why the ICE age is coming to an end

FEATURES

- 22 Formula E technology**
What next for burgeoning electric series?
- 28 Formula Student**
FSUK report
Cardiff CR13
Hertfordshire UH20
Autonomous cars in German competition
Formula Student and simulation
- 48 Joest Racing retrospective**
A journey through time with an iconic team

TECHNICAL

- 61 The Consultant**
Sorting the suspension on a Subaru
- 65 Aerobytes**
Our DJ Firestorm aero study continues
- 69 Databytes**
Don't miss the bus with CAN design
- 72 Simulator development**
Tricks of the trade from Ansible Motion
- 76 Diolen**
A cheap and practical alternative to carbon?
- 82 Danny Nowlan**
Measuring up a racecar

BUSINESS & PEOPLE

- 88 Business people**
A chat with GT impresario Stephane Ratel
- 92 Chris Aylett**
The MIA's CEO talks about business growth
- 95 ASI Preview**
The countdown to January's show continues
- 98 Bump Stop**

Subscribe to *Racecar Engineering* – find the best offers online
www.racecar-engineering.com

Contact us with your comments and views on [Facebook.com/RacecarEngineering](https://www.facebook.com/RacecarEngineering)

we share your passion



On-Track Accident Damage Cover
Motorsport Commercial & Liability
Road Insurance for Competition, Sports,
High Performance & Modified Cars
Insurance for Event Organisers
Personal Accident & Travel

0115 965 1020

On-Track Accident Damage
Motorsport Vehicles,
Competition and Sports Cars

0115 965 1050

Commercial Policies,
Liability Cover and
Personal Accident



www.reis.co.uk
talk2us@reis.co.uk

Reis Motorsport Insurance is a trading name of Insurance Factory Limited.
Insurance Factory Limited is authorised and regulated by the Financial Conduct Authority (No. 306164).
Registered Office: 45 Westerham Road, Sevenoaks, Kent TN13 2QB.



Brands hatching

The troubles of the WEC from the standpoint of its Technical Working Group

I have been involved in top level endurance racing since my first visit to Le Mans in 1983, and in more recent times I was a part of the Technical Working Group for the WEC, in my capacity as a representative of one of the manufacturers, the now-departed Nissan. So I have some insight into what has been happening lately. But first, a little historical context is needed.

In the 1980s endurance racing was strong and well, but it collapsed as F1 defended its territory and squeezed it down, with Bernie Ecclestone and Max Mosley in the forefront of these moves. The time line is quite damning, and it followed closely, in character, the previous collapse in the early '70s, when the ACO, concerned that the big 5-litre Porsche 917s and Ferrari 512s were getting too fast, limited engines to three litres, the same capacity F1 then had – and this was no accident.

More recently, the ACO relinquished the technical control of its prototypes to the FIA, but the counter-benefit was that there would be a world championship where the same cars would compete, giving an extra incentive for car makers to compete in the category.

Pulling the Pug

But things did not start well for the WEC when Peugeot, which had been fighting with Audi in LMP1, pulled out abruptly before the first race in 2012, due to a major overhaul in the company aimed at stopping it losing money and involving the shutting down of factories and the laying off several thousand employees. Most of the budget for the LMP1 programme had actually already been spent, and shutting down the operation was more expensive than continuing that year, but they could not be seen racing when taking an axe to the employee roster.

The pressure to bring Toyota to the races early has probably conditioned many decisions since that day, and it is sad to see they are the ones who will take the hit now that they find themselves alone in the arena following the departure of first Audi and now Porsche. Even winning Le Mans, Toyota's Holy Grail for so long, might not be the reward it deserves when taken without competition from other manufacturers. So what's gone wrong?

We spent a lot of time in the Technical Working Group working on tech regulations, also on the Cost Reduction group. This eventually included pulling the plug on the cost reduction meetings when a simple cost benefit analysis showed that the cost of paying the overheads for the meetings was not

going to result in any dividends, for after meetings where the number of team members, time in wind tunnels, and so on, had been discussed we had not really made much real progress.

The usual victims of my rants, the ACO and the FIA, were not guilty this time, as the blending of both to run the WEC and clean up the regulations was finally getting somewhere, with some unenforceable rules being tossed out or clarified.

Ouest world

To be a part of the Group, apart from being versed in engineering, semantics, and having been briefed by the manufacturer who you represent in what is the target you have to achieve, it is also important to have taken on board all the precepts espoused in Machiavelli's *The Prince*. And you need a good understanding that politics is not a pretty



Porsche leads Toyota at Le Mans. The former is now on its way out of WEC, despite it having had a big say in the framing of the rules

sight when you are in the midst of it. That said, it is expected, if you are a manufacturer concerned with your brand image, that you will try to steer the technical regulation towards what suits you, either production wise, given your model line, or towards the direction you want to push the consumer.

Hybrids were the future, they proclaimed, and the FIA and ACO duly catered to them, much as when the diesel/petrol equivalence rules were hammered out. The fact is that, at the time, there was a carrot to keep manufacturers that produced diesel powered cars in the game.

The most surreal discussion I have ever witnessed was when a new participant – petrol powered – assembled a 40 page plus technical analysis showing the rules were biased towards diesel. The diesel proponents had an equally weighty tome proving petrol was being privileged by the equivalence. The punch line was when

the FIA representative cut the Gordian knot by proposing that the diesel manufacturer should go to petrol, as its technical analysis showed that it was far better, and that the petrol manufacturer should go to diesel – a logical decision according to their analysis, and one and all would be happy with.

There has been upswings and downswings in competition, with manufacturers coming and going, but Porsche has been in the thick of it since 1951 – with a major 15 year hiatus for the works team from 1998, yet privateers had been running the cars in GTs all the time.

When the factory which had a strong influence in forming the rules through the TWG since its return in 2013 looks at the WEC and decides that it is not the place to present to the world its technological muscle, there are ominous signs. Porsche has done what it wanted, came back with a

bang and a series of wins, and now is going to the new promised land of electric vehicles. Now there is only Toyota as a manufacturer is it still a world championship?

There are also a couple of signs that not only bode ill for endurance racing but for the whole of motorsport. Denso, the number four on the *Automotive News* list of the 100 top global automotive suppliers, is planning to reposition itself by playing an automotive service role, with businesses in diagnostics and predictive maintenance. It also believes that what it sees in its crystal ball is a future that is safer, cleaner, more energy efficient and has far fewer cars.

Chile con car-key

Electric vehicles will make up 54 per cent of all light-duty vehicle sales by 2040, according to Bloomberg (the current number for Europe is 0.6, with France at 1.1 per cent). The price of lithium carbonate, a key component in lithium-ion batteries, has risen from \$4000 a tonne in 2011 to more than \$14,000. Chile could become an energy powerhouse.

So, there are two solid conclusions: don't walk on the road in front of a manufacturer's way to Formula E upon pain of being flattened by the rush; and the ACO, this time aided and abetted by the FIA and now-departed manufacturers who contributed to forming the rules, has driven another stake into endurance racing's heart, just as in periods before. Maybe the ACO changing the sniper scope on its rifle, to target what really matters, will help it in not shooting itself in the foot in the future. If there is one.



Now there is only Toyota as a manufacturer is it still a world championship?

Order Online!



The Motorsport Specialists

You are now able to purchase online from our huge range of Rod Ends and Spherical Bearings, NEO Lubricants, Ball and Roller Bearings, Fasteners, Batteries and much more.

In fact, we have **EVERYTHING** to make your RACE CAR a winner!

Call +44 (0) 1932 225777
abc@autosport-bearings.co.uk

www.autosport-bearings.co.uk





Power politics

Could Formula 1's future lie in it becoming a standard bearer for ICE technology?

While governments around the world continue to legislate on moves away from the internal combustion engine and into the domain of electric, a major OE supplier has indicated that German carmakers are likely to stop developing new combustion engines in six years as they focus on electric cars. Meanwhile, manufacturers are flocking like sheep to Formula E, for no apparent logic other than it has the magic word 'electric' attached to it and some vague notion that it will advance this form of propulsion. Strangely enough, I think that this all offers a positive opportunity for Formula 1.

Clearly there is potential for confusion and some poor decision-making regarding a subject – air pollution from vehicle emissions – that has been around for a long time but on which attention has been focussed in the past couple of years. Unfortunately, this has happened in a way that smacks of political sound bites, knee-jerk reactions and pack-animal panicking rather than careful, factual and sensible analysis of the issues and their solutions prior to implementing such far-reaching legislation. Have none of the lessons from the farcical about-turn regarding diesels been learned, especially the completely incorrect 'expert' information on which the original promotion of diesel over petrol was made?

Alternative facts

One does often see proof that politicians, on many issues, rely far too much on academic and theoretical input and don't ask or listen enough to people at the sharp end for real-world feedback. Worse still, they seldom properly think through the many consequences of their actions.

The same risk of naive thinking being applied to the forced adoption of electric cars is exemplified by the fact that the decisions are being made on a false premise. Contrary to what seems to be public thinking and certainly what is being sold by the various environmental bodies, electric vehicles are not pollution-free. Until all the electrical energy required to power their batteries is produced by wind, sea or solar activity, or nuclear reaction, the pollution is simply being moved from the cities to wherever the fossil fuel power stations are located. It will still inevitably have the same overall effect on

the environment. Whole lifecycle emissions when using electricity produced from burning coal can often be worse than just burning gasoline.

Apart from an all-electric strategy which presupposes there will always be an abundance of electric supply whenever and wherever needed, the adage 'horses for courses' indicates that no one way of powering vehicles is necessarily the best, and it's always wise to retain a Plan B, especially in an ever-changing and unpredictable world.

Plan B

There still remains a considerable amount of efficiency to be found from the internal combustion engine. This is evidenced surely by the remarkable 30 per cent improvement in energy produced v fuel burnt (thermal efficiency) recently attained over just the past three years by F1 engineers from what can still be described as conventional gasoline engines. Extreme lean-burn

as it is consumed, is relatively easy to transport and store and can be used independently of a sophisticated infrastructure.

Which is where the aforementioned opportunity for F1 exists. F1 should boldly stake and highly-publicise the claim that it is the ongoing leading-edge developer of internal combustion engines. Freed from the insistence that the sport must slavishly follow a green agenda tied to complex and expensive regenerative technologies, the focus can be entirely on squeezing the maximum bang per buck from the use of gasoline and/or other sustainable liquid fuels.

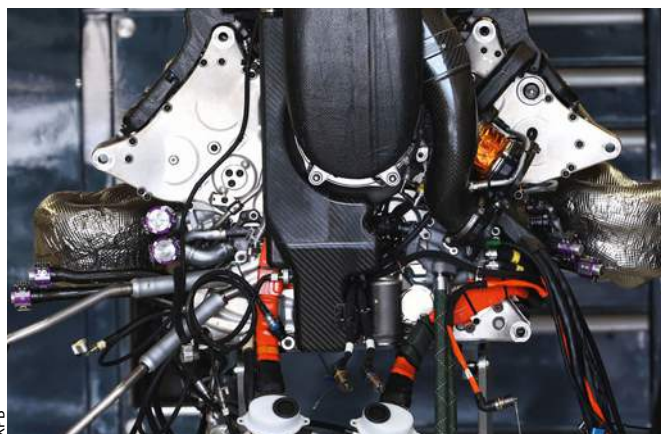
Volume control

In taking this positive stance, it offers the solutions that almost all parties participating in F1 and its millions of followers are seeking. For manufacturers, it provides a valid reason for continued participation; 2040 is still a fair way ahead and there is every reason to believe that a more pragmatic view less obsessed with EVs might be prevalent by then. Hedging bets on alternative motive systems must make sense – as long as it is affordable and the return on investment for manufacturers is favourable. For spectators and most participants the exhaust sound that is a vital part of the F1 drama and excitement can return. If ultra-efficient engine performance development must inevitably rely on forced induction, then supercharger v turbocharger needs a fresh look – maybe a combination of the two. While energy recovery is a worthwhile technology, weight and cost caps

can dictate to what extent using current battery technology. Flywheels, once used successfully by Audi in LMP1, could be reassessed as, unlike existing hybrid systems, they are compact, not unduly heavy and have no effect on engine noise.

There are doubtless other technologies in development that will rapidly continue to enhance a concept which, until recently, had not departed greatly from when it was established for automobile use some 140 years ago.

F1 needs to become the proud and lauded spear-carrier for further breakthroughs in the science of internal combustion engines.



Honda's F1 engine. Should Formula 1 ignore the current fixation on electric cars and concentrate on what it does best – making hugely powerful ICEs?

technologies such as pre-combustion chamber ignition and advanced knock-control combined with new turbocharger designs and advanced fuels and lubricants developed at this level, have led to what is effectively hybrid spark-cum-compression ignition. Undoubtedly there is significantly more to come, some of which may rely on less-conventional ICE motor concepts not yet realised.

Much potential also exists concerning reducing noxious gases released from burning petrol, which remains a very practical energy source. Compared to equivalent battery power it is comparatively light and compact, it reduces in volume and weight

Hedging bets on alternative motive systems must make sense – as long as it is affordable and the return on investment for manufacturers is favourable



AUTOMOTIVE ENGINEERING

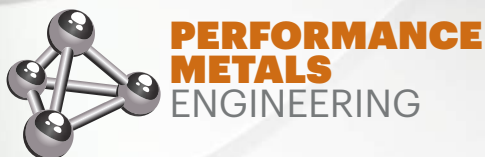
1 & 2 November 2017, NEC, Birmingham

The UK's largest annual gathering of
advanced engineering professionals

PART OF:
**ADVANCED
ENGINEERING**

Join us where the familiar
and the unfamiliar collide
to provide new opportunities
across the engineering
supply chain.

Advanced Engineering is
the industry event where
high-technology manufacturing
sectors converge under one
roof to meet and do business.



NEW for 2017

Register now >>>

+44 (0)20 8843 8800 or visit www.advancedengineeringuk.com

Organised by
EASYFAIRS
Visit the future



Breaking the ICE

Just why does the internal combustion engine seem to be facing its demise?

Since I wrote my column in the August edition of *RE* (V27N8), which predicted we shall shortly be buying transportation as a service provided by autonomous EVs and that the automobile and oil industries will have seriously contracted, both France and the UK have announced a ban on the sale of petrol and diesel cars by 2040. I had suggested readers should make up their own minds what this might mean for motorsport, but then Mercedes withdrew from DTM and Porsche from the WEC, to put their resources into Formula E. That's BMW, Audi, Mercedes and Porsche in FE.

But why is the internal combustion piston engine, which has dominated road transport for over one and a third centuries and has been developed and promoted through motorsport, suddenly be staring its demise in the face? What is wrong with it?

Fire and ICE

Internal combustion engines (ICE) operate by taking in air, the working fluid, compressing it, heating it by using the oxygen to combust a liquid or gaseous fossil fuel, and extracting work by expanding the heated nitrogen and products of combustion. Two main types have emerged dominant: the piston engine and the gas turbine, and these have been combined as the turbocharged piston engine. Each has distinct advantages and disadvantages, which qualify them for particular applications.

The characteristics of an internal combustion engine that matter in an automobile are:

- Efficiency, i.e. fuel consumption
- Drivability
- Emissions: CO₂, NO_x, particulates, hydrocarbons, CO, etc.
- Noise
- Durability
- Energy distribution infrastructure
- Time it takes to refuel

All of which add up to the pleasure and cost of ownership, and the effect on society.

The gas turbine has disqualified itself for road vehicles due to poor part-throttle efficiency and transient response, and has never really been tested in this role for emissions. It showed great

promise at the Indianapolis 500, mainly due to this being a race where full throttle is used for the majority of the time. It is king where it can run at its design point: aircraft, ships, and generators.

Piston engines are pumps/expanders that maintain efficiency over a wide range of speeds; centrifugal and axial compressors and turbines do not. Both types of ICE achieve high efficiency when combustion temperatures are highest, but temperature is limited by the production of NO_x in hotspots in the combustion chambers. Piston ICEs



The internal combustion engine that sits at the heart of the Porsche 919 Hybrid LMP1 is a work of art. But is there any future for ICE technology in automobiles?

lose a lot of heat to cooling systems and exhaust; gas turbines just to the exhaust. The very best of each type achieves peak efficiency at full throttle and at their design engine speed, and 50 per cent is the current peak value achieved by F1 engines and gas turbines that power generators.

CO₂ emissions are a function of efficiency, and the carbon/hydrogen ratio of the fossil fuel burnt.

Torque of the town

Drivability of the piston engine is a function of its torque curve and its throttle response. Peak torque of a normally aspirated gasoline road car engine is at around 3500 to 4000rpm.

Most cars are driven at 1000 to 4000rpm and mainly at part throttle. Six- to eight-speed transmissions are needed to make this engine characteristic acceptable, and often computer

control of gear changes now yields optimum performance and efficiency.

Turbocharging lowers and widens the peak torque to around 2000 to 4000rpm, and TDI diesel engines to 1500 to 3000rpm. Diesels do not suffer from throttling to control output, so part throttle and overall efficiencies are superior, but they produce more NO_x and the dreaded particulates.

The piston ICE has benefited from over 100 years of intense development and can be produced unbelievably cheaply. Along with its essential

gearbox it has over 2000 precision parts, which wear and need servicing.

Readers of *Racecar* are well aware of the pros and cons of each configuration of ICE for road and for race use, and will have their own views on how essential each characteristics is to the pleasure of driving or the watching of expert drivers racing each other.

Charged up

There are around one million vehicles on the road for seven billion people. Many of these have a view about the positive and negative effects of ICE cars, vans and trucks on their lives. Their governments are in the process of deciding that electrical power and EVs are the solution to many of the problems. Whether you believe that the issues of energy distribution and a

charging network, lithium supply, battery recycling, etc. can all be solved, it will be economics that decides; the technologies are here now. It would appear that France and the UK, no doubt to be followed by other countries, have already figured out how to solve these issues economically in the next two decades. Yes, that must mean a full urban and rural charging network to cover all of the UK and France. Well done to Theresa May and Emmanuel Macron! Or maybe they plan for it to be a hydrogen distribution network?

EV's strong point is the electric powertrain. Consisting of one-tenth the number of parts of an equivalent ICE powertrain, it is quiet and peak torque is at zero speed, just where it is needed most. Prime mover efficiency is typically 96 per cent, and the motor industry already considers electric motors and their controllers to



EV's strong point is the electric powertrain, consisting of one-tenth the number of parts of an ICE it is quiet and peak torque is at zero speed

How well FE develops as a product-marketing tool remains to be seen

be commodities. Life expectancy is already 500,000 miles and may rise to one million miles. Servicing is minimal. For a recent standard service of a VW TDI that I own the majority of the cost was for oil, filters etc., and the labour to replace them, none of which is needed on an EV.

No, the problem with EVs is not the powertrain; it is the weight, size and cost of the energy storage medium. The storage of electrons is never going to compete with the storage of liquid hydrocarbons. Whether in lithium-based or some other batteries, or as hydrogen, the filling, storage and conversion processes will never match those of petrol and diesel, except for efficiency. At the moment, the well-to-wheel CO₂ of EVs is only comparable to ICE vehicles, but as more energy is generated by renewables and nuclear (fission?) this will change radically in favour of EVs.

School of hard NOx

Why not hybrids – the best or the worst of both worlds? Hybrids came into existence to allow the manufacturers to sell high-end, high-performance, high-profit models without incurring high taxes triggered by their high fuel consumption and CO₂. What they actually achieve is low NOx emissions in urban use, i.e. commuting, and



Formula E has become a magnet for car makers as they try to bolster their EV credentials

sensible range in inter-city use. But with ever lower NOx and particulate emissions targets, any use of the ICE is a problem, especially as Dieselgate-induced real-world tests take hold.

While road relevant technical development is a product of an involvement in high-level motorsport, it is primarily funded by marketing. Manufacturers look to motorsport to provide two marketing objectives: firstly they wish to promote the brand and create the image for their products; secondly they need to market the actual products they have for sale in their dealerships today.

F1 performs the first of these effectively, but it is becoming clearer that it will not help sell the EVs the industry is gearing up to be their mainstream

products. To maintain its brand-polishing role, F1 will become less road technology relevant as EV sales escalate, but gain a bigger car buying audience by becoming more entertaining.

One factor that is essential is that it attracts the world's best drivers, and to do this the cars and racing must be challenging, and the driver salaries the highest in the world, which requires the motor industry's involvement and funding: a real Catch-22 situation. Formula 1 drivers have proven that they can move to IndyCar

or WEC and succeed, but few drivers have moved the other way with real success. Strangely, neither a Formula 1 to NASCAR exchange nor the reverse has ever really worked. It is only by getting these characteristics right that Formula 1 will survive in the long run using ICEs. How well Formula E, and any new electric vehicle championships that emerge, develops as a product-marketing tool still remains to be seen.

The internal combustion engine is not yet lying on its back with its legs in the air, but its role in mass transport, especially for people, is looking distinctly numbered. Motorsport's response will determine its future role, and access to the business opportunities that go with it.



MIA | MOTORSPORT INDUSTRY ASSOCIATION

www.the-mia.com



The global business network for motorsport and high performance engineering

NOMINATE TODAY - MIA BUSINESS EXCELLENCE AWARDS

Closing date 1 December 2017

The Awards will be presented at the Dinner, NEC, Birmingham on 11th January 2018

Awards available for nomination

- Business of the Year Award with annual sales over £5 million
- Business of the Year Award with annual sales under £5 million
- Service to the industry Award
- Export Achievement Award
- Technology & Innovation Award
- New Markets Award
- Teamwork Award

In association with



Nominate online at - www.the-mia.com



For information and bookings please contact:
Carly Latcham +44 (0)2476 692 600 or email carly.latcham@the-mia.com



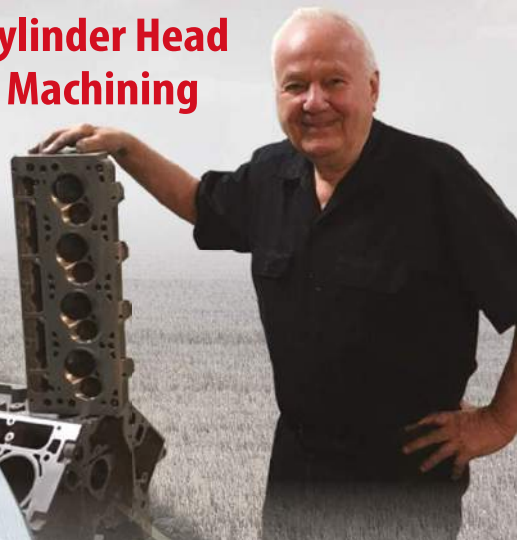
Hear from the Experts!

Pro Stock drag race engines are the pinnacle of engineering for normally aspirated engines. The best air flow through the ports and manifold is critical. A perfect seal between the rings and the cylinder wall is critical. Hear what the experts say about their Rottler machines:

"The Rottler P69 with its advanced software allows me to reverse engineer, modify, and produce absolutely accurate cylinder heads and manifolds faster than any of the systems I've previously used."

– Warren Johnson
The Professor of Pro Stock

Rottler CNC Cylinder Head Machining



Rottler CNC Engine Block Honing

"We have spent countless hours using the Rottler CNC Vertical Honing Machine in the hunt for the proper surface finishes required to achieve perfect ring seal."

Until recently we have been limited to using vitrified or diamond abrasives.

The vitrified stones gave us nice clean cuts and make it easy to hit the target surface finish numbers but consumable costs are much higher compared to diamond stones.

Diamonds can create better bore geometry and give extremely long life but the surface finish is nowhere near as clean a cut and we see lots of debris and burnishing of cylinder surface.

After testing CBN abrasives from Ed Kiebler of Rottler, I was amazed at the surface texture, we now have the best of both worlds.

We have an abrasive with extremely long life and a surface finish that is as good as or better than the vitrified delivered. Little to no debris, no burnishing and almost thread like consistency in the valleys.

We've examined these different abrasives and the surface textures they leave under high power microscope and the results are consistently the same.

CBN honing stones are a real game changer."

– Keith Jones, Total Seal Piston Rings



www.rottlermfg.com

www.youtube.com/rottlermfg
www.facebook.com/rottlermfg
contact@rottlermfg.com

ROTTLER
THE CUTTING EDGE

8029 South 200th Street
Kent, WA 98032 USA
+1 253 872 7050

1-800-452-0534

Works in progress

So far Renault's second year back in F1 as a factory operation has not gone quite to plan, with its RS17 lacking race pace due to a balance issue. But could there be grounds for optimism at Enstone? *Racecar* investigates

By SAMUEL COLLINS



'A lot of the issues which we have had this season stem from the fact that we do seem to have a difficult balance on this racecar'

TECH SPEC



Renault RS17

Power unit: Renault RS17 1.6-litre V6 with MGU-K, MGU-H.

Chassis: Moulded carbon fibre and aluminium honeycomb composite monocoque.

Suspension: Front – carbon fibre top and bottom wishbones operate an inboard rocker via a pushrod system. Aluminium uprights. Rear – carbon fibre top and bottom wishbones with pullrod operated torsion bars and transverse-mounted damper units sited inside the gearbox casing. Aluminium uprights.

Transmission: 8-speed semi-automatic titanium gearbox

Fuel system: Kevlar-reinforced rubber fuel cell by ATL.

Electrics: MES-Microsoft standard electronic control unit.

Brakes: Carbon discs and pads. Calipers by Brembo. Master cylinders by AP Racing.

Wheels: OZ machined magnesium

Cockpit: Removable driver's seat made of anatomically formed carbon composite, with six-point harness seat belt. Steering wheel integrates gear change paddles, clutch paddles, and rear wing adjuster.

Dimensions: Front track, 1600mm; rear track 1550mm; overall height, 950mm; overall width, 2000mm.

Weight: 722kg, with driver, cameras and ballast

Renault's RS17 is the 19th Formula 1 car from the French manufacturer, which has been in F1, on and off, for 40 years. The RS17 is also the latest in a longer line of cars built by the Formula 1 team based in Enstone, which started life as Toleman, then became Benetton, then Renault F1, before becoming Lotus and then finally Renault once again.

The convoluted, and at times troubled, history of the Enstone team means that the RS17 is not only Renault's first Formula 1 car since the 2010/2011 seasons, but also the first completely new car to roll out of Enstone since 2014 – the 2016 Renault was really just a reworked Lotus chassis adapted to house a Renault V6 power unit rather than a Mercedes.

French addressing

When Renault took over the Lotus team at the end of 2015, saving it from financial collapse, it had to set about rebuilding the organisation from the ground up. This was at a key time when development of the 2017 car should have been well underway, and this almost certainly influenced the development of the RS17. Making things even more complex was the uncertainty surrounding the 2017 technical regulations. The tyre sizes were only confirmed shortly before the first race of 2016 and detailed tyre data was not available until much later in the year, and much of that was only based on simulations and estimates. New aerodynamic regulations substantially increased the amount of downforce the cars generate but with development ongoing even the total downforce level was not entirely clear.

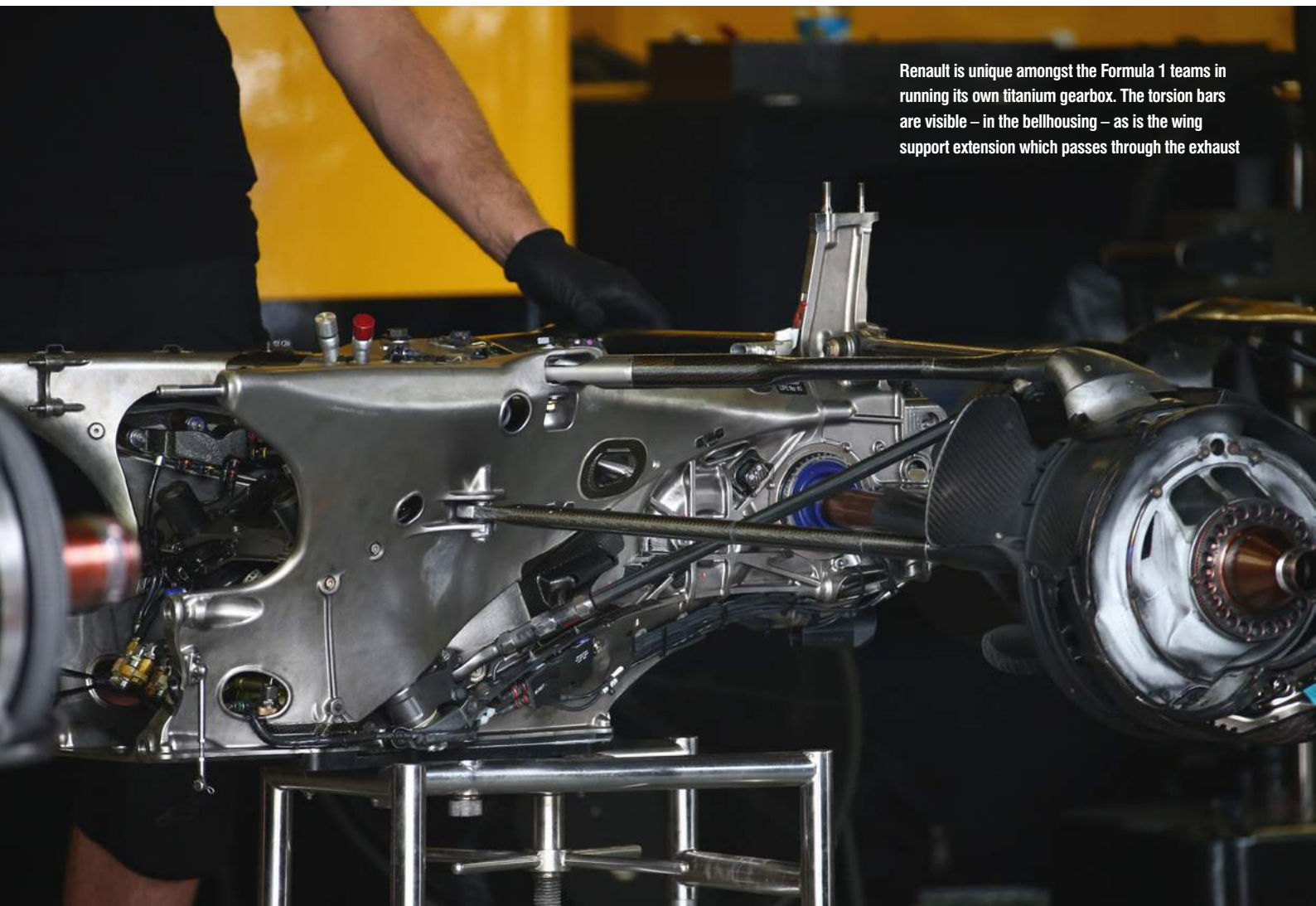
'We were not completely blind during that time, we had some information from Pirelli, though not as much as we would have liked, but enough to lay a car out,' explains Bob Bell, Renault's chief technical officer. 'With the normal amount of variation you can build into suspension set-up in terms of toes and cambers and camber change with bump, you can cope with most things. The centre of gravity position of the car is largely defined by the regulations. Even if we had a lot more data, I don't know if we would have done anything significantly different. It's frustrating that we don't get the data we need, as we would like to be able to make that choice, but it probably has not cost us too much.'

Uncertain loads

However, the uncertainty over tyre performance and aerodynamic forces meant that there was also uncertainty over the loads that the structures within the car would have to withstand. It was clear that with higher downforce levels and higher grip from the larger tyres that cornering speeds would increase dramatically and subsequently the loads through the car would also increase.

'We all run strain gauged suspension at times in testing in order to understand the loads so we can get pretty good data from that,' Bell says. 'The problem is that when we were designing this car we didn't have that data so we had to extrapolate what we previously had and base it on that, but we are reasonably good at that. It meant that during the

Renault's RS17 seems to have a narrow operating window which has caused problems in races. At the mid-season break the team was eighth in the constructors' standings



Renault is unique amongst the Formula 1 teams in running its own titanium gearbox. The torsion bars are visible – in the bellhousing – as is the wing support extension which passes through the exhaust

design process you had to err on the cautious side, potentially making the car stronger than it needs to be. As we get more data on this new generation of tyres perhaps we can pare that back a bit. Actually, reviewing things so far I think we are not generating some of the loads we thought we would. I think part of the reason for that is that the tyres we are having to use are a lot harder than we thought that they would be, compound wise. That reduces the load.'

Weight expectations

Even with the uncertainty over the loads leading to some structures such as the transmission casing and monocoque being perhaps stronger than they really need to be, and as a result of that likely heavier than they need to be, weight was not a problem for the Renault RS17, according to Bell. 'We were okay in terms of weight and weight distribution, I've not heard many complaints about that. But for several teams I think it will have been tight. In the situation next year where we have to carry the weight of Halo, possibly within the current weight limit, then that will be a challenge. Just hitting the minimum weight will be tough.'

As the RS17 was being developed it became clear that while the overall loads on

the car would increase it was not too difficult to manage them, but there were some loads which were much harder to get a clear understanding of what would be required to cope with them. 'Depending on the load case you are looking at there are different demands,' Bell says. 'Some of them are really very subtle but have quite a profound effect. One of them, for example, is the inputs we are seeing from the kerbs, which has caused issues for us and other teams in recent years. It is one which troubled us a bit over the winter as it is hard to quantify with new cars, wheels and tyres. Some of those load cases are quite insidious, not just steady state, it's quite a transient load. It was load cases like that which were more problematic for us than perhaps the more obvious aero and lateral loads which tend to be fairly steady state. Those were reasonably well understood and we could deal with that.'

French polish

When the new car was rolled out for its formal launch at the Royal Agricultural Hall in London it was clear that the team had made something of a step forward with the RS17, though overall the car had a fairly conventional design. It features double wishbones all round with pushrod actuated torsion bars at the front and pullrod

actuated bars at the rear. Yet it was immediately apparent that the car did differ from many others on the grid, especially with its continued usage of a cast titanium transmission casing, something which has been a feature of all recent cars to roll out of the Enstone factory.

'Sticking with a titanium casing is something we have asked ourselves about many times over the years and we are constantly re-evaluating it,' Bell says. 'Using the cast titanium is something we are very familiar with and have used for a number of years. We have been able to refine that in terms of things like reducing wall thicknesses etc. and it is very competitive with a composite box. We will re-evaluate it again next year as technology moves on. We have done composite boxes in the past so it's not new to us. The materials choice today is really down to using composites or cast titanium, although Williams use cast aluminium. When you look at the numbers on the materials selection the result is really not black and white in favour of one solution or the other, it's very close between titanium and composites. There are factors other than overall weight or specific stiffnesses. It can be influenced by lead times between the two in terms of manufacturing. There is a bit of an element of cost too. It's not clear cut.'



The bargeboard area has been freed up for 2017 and hence it's also been the subject of much aerodynamic development by all the Formula 1 teams, and Renault is no exception, filling the space with this array of flicks



The aluminium uprights have to cope with higher loads this year due to the extra downforce and wider rubber available. Renault says that not knowing what these loads would be was frustrating during the RS17's design

Bell also says that the manufacturing process of the transmission casing is not actually that much easier than using composites. 'You can do most things you want with either material, it may be slightly easier with a metal box, but the manufacturing of a cast box is not easy,' he says. 'There are not many people in the world who can cast them well enough, machining can be tricky, too. You have to do very deep bores inside a gearbox and that means that it can be tricky to get the accuracy you want.'

On the upper surface of the RS17's transmission casing there is a small vertical extension, this is the rear wing pylon mounting point and it passes directly through the centrally positioned exhaust tailpipe. 'If you can keep the temperature of the titanium down it's not too tricky, so it's only a matter of getting some

cooling air in there,' Bell says. 'The support itself does not sit in the exhaust flow. Instead there is an aerodynamic fairing made from the same material as the tailpipe around it. There is a small performance loss with having to put that shroud inside the tailpipe. It was largely all calculated on paper, but we were careful in testing. There was no need for testing on rigs as the material properties of titanium at high temperatures are well understood. All we had to do was ensure it stayed under those temperatures.'

Tight package

Also mounted in the transmission casing are the inboard rear suspension components, including the torsion bars, which are in extremely close proximity to the turbocharger mounted on the rear face of the Renault V6 engine. 'Packaging

'The material properties of titanium at high temperatures are well understood, so all we had to do was ensure it stayed under those temperatures'

is getting a lot more busy, it's not as bad at the front as it is at the gearbox, but all round everything is getting squeezed,' Bell says. 'As the torsion bars get hotter their performance changes, the stiffness of the bar will change with temperature, so will its strength and we are particularly sensitive to that. We don't play games with the bar rate with temperature. So we have to ensure that those elements run at a known and stable temperature. After about five to 10 laps most of the underbody temperatures tend to stabilise. It won't keep building over the course of the race. But even that variation is not enough to cause variation to the spring rates. If you had an air spring system, and some teams do, you have to be very careful as they are very much influenced by temperature change.'

Adjustability

With the uncertainty surrounding not only the loads through the car but the performance characteristics of the tyres, some teams admit to having designed in a lot more adjustability into their suspension systems this year, but according to Bell Renault is not one of them. 'I don't think we have designed the suspension with more scope for adjustment than normal,' he says. 'Of course, there are degrees of accommodation for the desire to change suspension geometry, it could be a change of gearbox casing or a change of a bracket mounted to that casing. I think we have enough scope to accommodate anything we need to do within the scope we have got without doing that.'

One area of the suspension where some teams, thought to include Mercedes, did have to make a last minute adjustment was in relation to how the systems operated relative to aerodynamic load. Some teams had solutions which would see the rear of the car sit up at low speed and squat down at high speed in order to improve aerodynamic performance. The practice was at least partially outlawed part-way through pre-season testing.

'We didn't need to change anything in terms of the suspension, we were probably not as mature as the other teams in that area as you can probably imagine,' Bell says. 'Even with the clarification there is still scope for what you might call unconventional hydraulic elements,



'A higher complexity level does not always mean that it's more sensitive'

the sport has not yet finished the debate on that for the future; should it be draconian and specify the conventional simplistic system or should it allow something more sophisticated, potentially something like semi-active suspension? That debate is not over. I tend to subscribe to the view that if the public cannot see it then it's probably not worth spending a lot of money on. I think we are moving into a different era now where we have good differentiation between cars, but it has to be things that the public can

see. That is the great thing with bodywork, everyone can see it. Hydraulics and computers buried deep in the car nobody can see, the public cannot see and we as the teams don't want to talk about it, I don't know if that is the best thing for the sport. Perhaps a simplistic approach is better for the sport and it is probably cheaper, and that is no bad thing.'

The bodywork on all 2017 cars is drastically different to those of 2016 by regulation, with larger swept back front and rear wings and far

more complex bargeboards. But one area where there is notable differentiation between the current cars is the cooling arrangement, with some teams opting to relocate some of the coolers from the sidepods to the centreline of the car. The Enstone team was one of the earliest adopters of this solution and so it is no surprise to see it feature on the RS17. Its roll hoop is clearly segmented with separate ducts feeding underbody coolers as well as the main airbox duct feeding combustion air to the V6 engine.

Cool pack

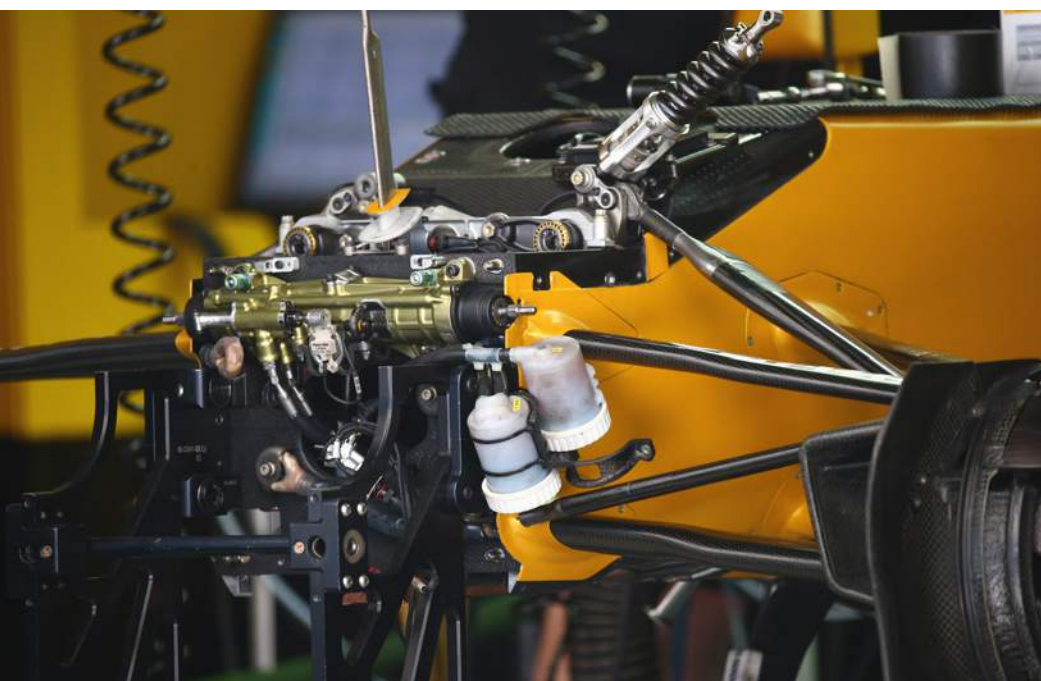
The higher cornering speeds of the new cars also have an impact on the overall cooling packages, with a much higher percentage of the lap spent at full throttle compared to 2016 the power units produce more heat than they did previously. However, comparing the RS17 to the RS16, the cooling apertures do not appear to have increased in size at all.

'In terms of the basic layout of the cooling concept it is in broad terms similar,' Bell says. 'But we have worked a lot on the cores to make them more efficient, you see that the internal concept is quite a step on. Most teams will have a facility to test cores and look at fin design and cooling capability, some internal and some outsourced. It's quite a normal process and it's something we look at and it does not feature in the aerodynamic test restrictions. We outsource the manufacture of our cores. Over time we just get better and better at squeezing stuff in so we can get bigger cores in for the same external sizing. So that deals with the increased cooling requirement. We have got generally better design of the intake and ductwork to offer higher energy air to the cores and better airflow management after it has passed through the radiators. It all adds up to improve the overall efficiency of the system, and that deals with the inevitable rise in engine performance which inevitably means more heat to be dealt with.'

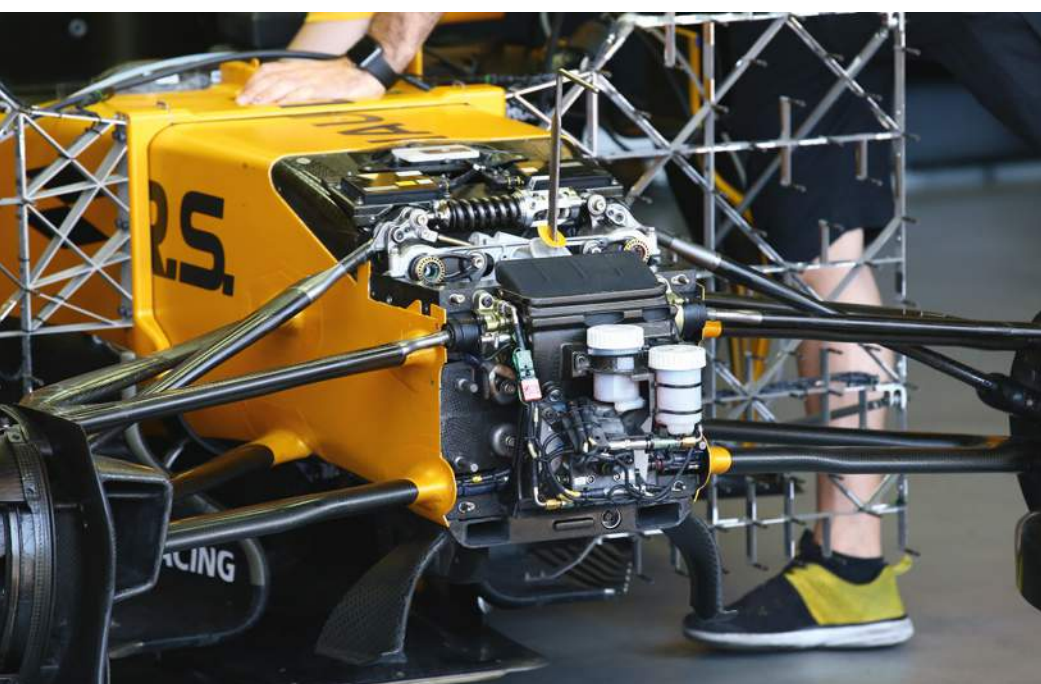
Aero detail

The overall aerodynamic package of the RS17 is also fairly conventional, but like every F1 car on the grid this year it features a large amount of small, intricate elements, especially in the bargeboard area, which is a new area of development freedom in 2017. Many onlookers have suggested that this level of complexity would make for cars that are overly sensitive to external influences (such as when running in dirty air) but all may not be as it appears.

'There is some truth in the statement that highly complex parts are highly sensitive, but it's also not entirely true,' Bell says. 'Aerodynamics is not an entirely intuitive subject, I guess that one reason for that is that you can't actually see the medium you are working with. So if

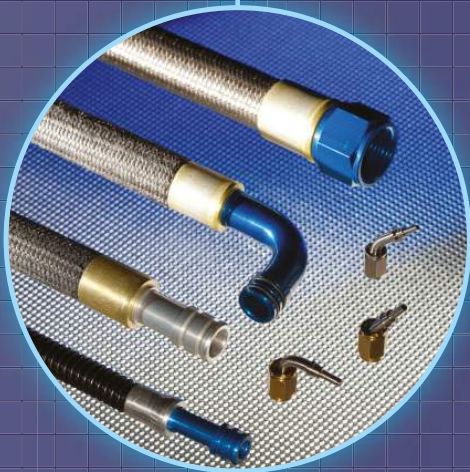


Front bulkhead is partially stripped showing the torsion bars and the third element. Front suspension is made up of carbon fibre top and bottom wishbones and uses an inboard rocker actuated by pushrods. Rear is pullrod operated torsion bars

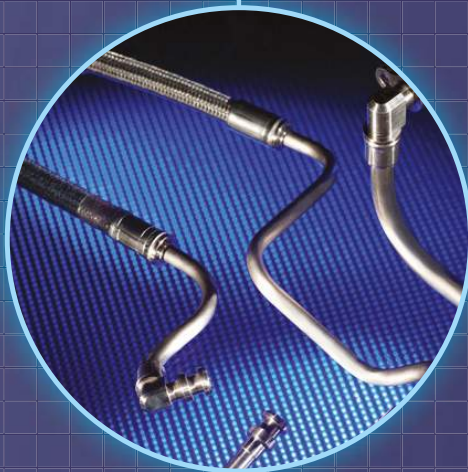


Complete front bulkhead. Note the staggered positioning of the master cylinders. Bob Bell says that packaging across the car, and indeed all F1 cars, is getting trickier every year, though he says the front of the car is less challenging than the rear

INTELLIGENCE CONNECTED



Flexible Hose and Fittings



Rigid Lines and Swagelok



Filtration

It's not by accident that, over the years, we have developed many successful partnerships with customers throughout motorsport – particularly in F1, endurance racing and WRC.

By applying intelligent analysis of their problems in the area of fluid transfer in high performance, high energy situations, we have established ourselves capable of providing innovative and cost-effective solutions.

SERVICES:

- 3D cad design service
- hose assembly
- hard-line manufacture
- cnc machining
- filtration design
- laser marking

PRODUCTS:

- **Titeflex smoothbore and convoluted hose products and fittings**
- **Swagelok fittings and hard-line system solutions**
- **Pall Filtration systems**
- **CIRCOR Industria solenoid valves**

FHS

MOTOR RACING

INTELLIGENT CONNECTIONS

Maintain system integrity, save weight, cut costs.
Make the connection now.

To find out how the quality of your own fluid transfer requirements can be improved, call our Technical Sales Team on

+44 (0) 1753 513080

'How can you represent the car in a high speed corner or a low speed corner when the shape of the tyres is different in a wind tunnel?'

you look at a rear wing it could be the case that a single element rear wing pushed to the maximum could be far more sensitive than a multi element wing which is generating the same performance. So a complexity level does not *always* mean that it's more sensitive.'

Sensitive rear

Yet, all that said, Bell also says that some of the more complex parts of the RS17 and other current cars *are* highly sensitive, and points to the rear end of the RS17 as an example. 'We have

what we call drum flicks, which is the cascade of wing profiles on the inner face of the rear drum,' he says. 'They are quite sensitive things and quite highly loaded. They tend to be more affected by the flow around the wheel than the end plate is, for example. Keeping those parts working at the optimum is really quite tricky as there is a lot going on – the rotating body, the rubber tyre which is deforming – it's hard to know what shape it is under all conditions. Then there is the brake duct flows and thermal effects, it's all very tricky to get right.'

Perhaps making the development of this area, and indeed other parts directly influenced by the air flow around the wheels, more difficult is again the uncertainty about the tyre behaviour during the car's design phase. When Pirelli supplied its first wind tunnel tyres to the teams the Italian firm was working on assumptions and estimates regarding the aerodynamic loads that the new cars would generate.

'If you set the wind tunnel model tyres on the table they are a pretty close match to the real thing geometrically, but of course they don't sit unloaded on the car, they sit very heavily squashed, and the trick is for Pirelli to provide us tyres that match the deformed shape under representative loads,' Bell says. 'The other complication there is that the load is constantly changing so the shape is constantly changing, and we are interested in the performance of the car through its speed range. How you do that in a wind tunnel, representing the car in a high speed corner or a low speed corner where the shape of the tyres is different, that is a really tricky problem. Pirelli provide us with the tyres and they do their best to match the real tyre shape, they can manage it under one load case, but getting them to do it for every load case, and indeed finding a way of loading a wind tunnel model tyre, remains a complex problem.'

Using CFD to work around this variance in tyre bulge shape is also seemingly not an option as a result of the restriction on the amount of computational power the teams can use each season. 'In CFD we tend to model less in terms of different car attitudes,' Bell says. 'In the wind tunnel we tend to drive through a matrix of ride heights, roll angles and yaw angles. In CFD that is a much longer process and very demanding on resources, so we cut that matrix down a lot in CFD. We can model the tyre to get it closer to what we are interested in but it is computationally very intense, it takes a lot of runs and a lot of processing and of course we are limited on that. We have to allocate our precious CFD time to things which bring the most gain.'

Season so far

The first half of the 2017 season has been mixed for the Renault team. It sits eighth in the constructors' championship, just behind Toro Rosso and Haas. Curiously, only one of the team's drivers, Nico Hulkenberg, has scored points, with the other, Jolyon Palmer, struggling somewhat. Two sixth place finishes are the best the team has achieved so far, but Bell is aware of an issue with the car which, if resolved, could bring a significant performance boost. This is described, vaguely, as a 'balance issue'.

'There probably is not a car on the grid where its creators and its drivers are happy



The front brakes, with interesting curved disc section. RS17 uses carbon discs and pads, calipers are courtesy of Brembo while master cylinders are supplied by AP Racing. The racecar has shown some aero sensitivity around the rear brake area



Front wishbones are noticeably beefier than last year's to cope not only with the higher loads from cornering but also more unpredictable loads from kerbs. While Renault was cautious when it came to strength it did not design in extra adjustability



Innovation Experience

HIGH PRECISION CNC MACHINING &
WINDFORM ADDITIVE MANUFACTURING

Automotive application, combination of Windform Additive Manufacturing and high-performing CNC Machining.
Courtesy of Ilmor Engineering



CELEBRATING OVER 45 YEARS OF PRODUCING EXCELLENCE

Our Italian craftsmanship and professional skills make us the choice partner in gaining technical advantages in **High Precision CNC Machining** and **Advanced 3D Printing Service** that few others can guarantee.

Producing quality, reliability, innovative solutions and speedy delivery service are our distinguished features.

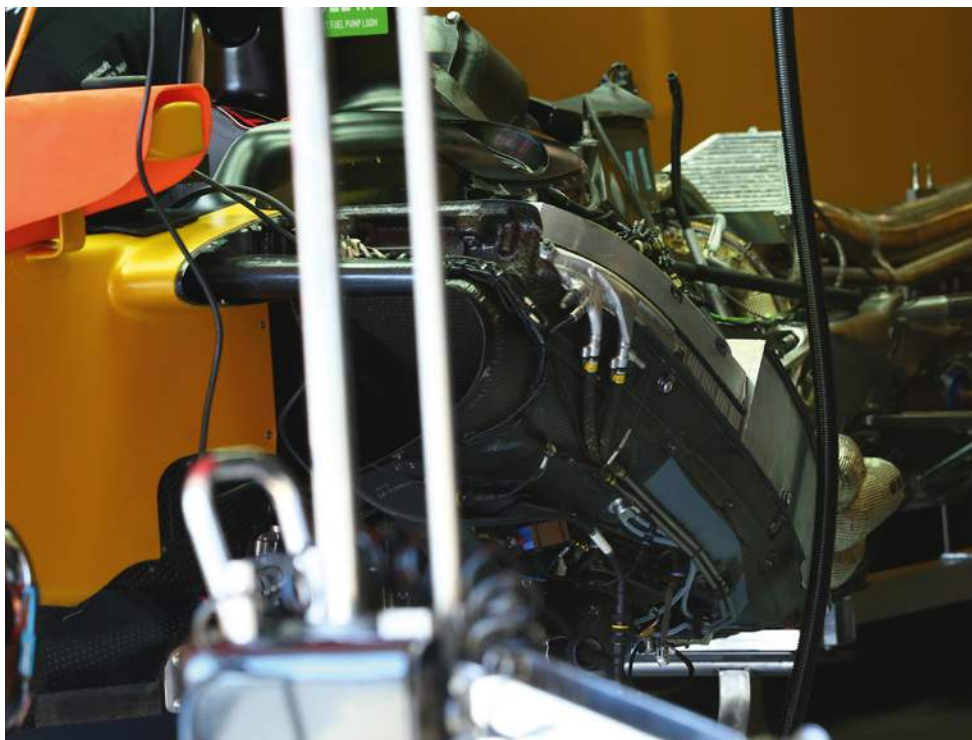


www.crp-group.com

LONG-STANDING EXPERIENCE

info@crp-group.com

‘During the design process you had to err on the cautious side, potentially making the racecar stronger than it needed to be’



This shows coolers mounted in sidepod of RS17, with the charge air cooler visible. Cooling concept is broadly similar to last year, but the team's worked hard to increase efficiency in the cores to cope with the demands of more full-throttle running

DRS code

During pre-season testing it was felt by some that the rear wing mounting of the RS17 did not comply with the regulations, as it connected directly to the DRS actuator housing rather than first to the rear wing main plane.

The design was altered ahead of the Australian GP, but Bells says it wasn't a big change. 'The regulation

about how the pylon should blend into the wing plane and the DRS, I wouldn't say it is entirely black and white. We interpreted it in one way and other people interpreted it differently. As a result we were requested to change it, but it was a very minor change. It was really just adding a little carbon fairing on it. It was quite trivial. It had no aerodynamic impact at all.'



To meet the regulations a plate had to be added to the underside of the rear wing pylon for the season opener in Australia

with the balance, it is something which is never right,' Bell says. 'That said, I think a lot of the issues which we have had this season stem from the fact that we do seem to have a difficult balance on this car. It demonstrates fairly typical racecar characteristics; notably, nervous entry, mid-corner understeer and nervous exit [lack of traction]. They all demonstrate that to some greater or lesser degree. But I think we suffer more from it this year and the car seems quite sensitive. It is sensitive in terms of environmental conditions, whether it's track temperature or wind, the balance on this car seems to suffer a bit more.'

Snap chat

This issue with a narrow operational window is one which has been seen an increasing amount recently, notably with the Peugeot 908 LMP1 car a few years ago, and then more recently with the 2016 Audi R18. It is also thought to be the weak point of the 2017 Mercedes, and it is clearly a problem with the RS17.

'We can find we are competitive in FP3 but come qualifying we just lose relative pace,' Bell says. 'It seems that our car is just a bit more on edge most of the time than the others. We are constantly trying to balance out the mid-corner understeer with a lack of traction on the exit, we never quite get there and the drivers are never confident enough to really lean on the car, so we have work to do in that respect. I think the basic pace is in the car, in qualifying, with low fuel and new tyres the pace is there, but in the race with old tyres and a heavy fuel load those balance characteristics become more of an issue.'

Problem solving

However, solving a racecar's narrow operational window is not a simple fix, as the root cause of the problem is not always immediately evident. 'To widen out that operational window you have to first understand where the instability is really coming from,' Bell says. 'Is it an aero effect, is it something on the car unduly sensitive to high yaw angles, is the issue in the mechanical domain, is it that the suspension geometry is not quite right for the tyres? Most likely it is thermal management of the tyres. You can't quite get them in the right temperature range. It could be a combination of all of those things. It's quite complicated to understand that, it's difficult to know what to change, but when you do crack it there is a lot of performance to come.'

If the Renault team can resolve this issue with its chassis then it should produce stronger results in the second part of the season, and as the team's restructure starts to bear fruit it seems likely that the RS17 will move closer and closer to the front of the pack.



Open architecture simulators and software that put you in control



With our open architecture hardware and software, a Cruden DIL simulator is a ready-to-run tool that's easily customizable to your needs.

- Works with existing vehicle modelling packages (VI-grade, IPG, CarSim, VeDyna, SIMPACK, dSPACE ASM, AVL VSM, Dymola etc.) or our fully open Simulink Vehicle model (CVSM)
- Apply your own motion-cueing algorithms
- Incorporate your own hardware
- Panthera simulator software suite works with any desktop, static or motion simulator

Cruden supplies flexible, durable, high performing simulators and their modular components: hardware, software (Panthera), vehicle models, content and screens and projectors. We can have you up and running quickly, starting from a desktop application to a full simulator package, backed up with support, maintenance and consultancy.

Find out more - www.cruden.com

Race Car and component development

Driver training

Race preparation and strategy

Race Car set-up

Current thinking

Formula E has suddenly become the hot ticket for manufacturers in motorsport, but this will mean its tech regulations will now be under ever-closer scrutiny. So how does the all-electric championship intend to keep the car makers plugged in to FE in future seasons?

By SAM SMITH



If ever there was a breakthrough season then the third season for the FIA Formula E championship was it. Audi, BMW, Mercedes and Porsche all made announcements that they would join fellow prestige brand Jaguar in the all-electric series and in so doing triggered a seismic shift within the motorsport industry. Add to that the significant interest from both Nissan and Fiat-Chrysler and suddenly you have the ingredients for one of the most fascinating motorsport shows for decades.

This was the big headline news during the latest season in a championship which many said wouldn't survive its first season. Those naysayers were oh-so-close to being right, however. After just three races in season one of the championship, back in the first few months of 2015, it all nearly imploded in an all too familiar motorsport tale of unpaid bills and

recriminations. The stability that came on the back of investment from Liberty Global and Discovery Communications saved the day and since then a solid platform has ensured the championship could flourish. In all, 10 teams took part in the 2016-17 season, including Panasonic Team Jaguar, the newest entrant.

But with many new manufacturers now announcing their imminent arrival in the series the technical regulations will come under scrutiny, and the organisers will have to adapt to meet the needs of the big spending teams.

Regeneration

Season five (2018-19) will see a vital juncture for Formula E. This is when the second-generation car and battery will be introduced. The whole project is being managed by the FIA with the technical assistance of Spark Technologies and

Dallara on the chassis design and manufacturing side, and McLaren Applied Technologies on the new 'doubled' 54kW/h battery.

The new battery will be the linchpin technology for the next generation Formula E cars and a prototype went through its first full race simulation test in May. Professor Burkhard Goschel, who is president of the FIA's Electric and New Energies Championships Commission, told *Racecar* in Paris back in May that progress was being made with the battery, but that the aggressive time-frame of the planned track testing of the unit will be a challenge.

'It is proceeding well but we know that it is tight time wise and we will see this summer where we are at the end, but all signs which are coming out are looking positive,' said Goschel. 'We made some first tests. There have been two samples at the end where they stayed

The new battery will be the linchpin technology for the next generation of Formula E cars



Main picture: Season three champion Lucas di Grassi leads the field in Montreal. For season five FE is set to get a big increase in battery power

Above: Mid-race car swaps will be a thing of the past by FE's 2018-2019 season, though the championship is expected to still have pit stops

at the same energy content with 54kW/h, and so it is all looking positive in this way, but there are still a lot of things to do.

'It [a full simulation] has been done and it shows up as being very positive and we can show that simulation is nearly the same as reality,' Goschel added. 'We still have some issues with the timing; we just have to [sort out] the main issues with the functional testing.'

Professor Goschel also confirmed that the biggest challenges with the battery will be cooling and weight. 'One issue always with the battery and the electrical drive is the cooling because the load in our case is a very, very strong one,' he said. 'We will be re-charging very deeply, and the inner-resistance goes up and so the requirement for cooling is going up. From the first season we have managed it, and I think we can manage it now too.'

Power ranger

One of the main challenges for the battery manufacturer is weight, and although Goschel says that the limits are 'tight', he also believes that the battery size and weight will be within the required range. Power from the new battery will be increased in season five, to be 200kW for the race and 250kW for qualifying. This compares with the 300kW of energy released over short periods by an LMP1 hybrid car.

It's understood that the new generation battery will have a significantly greater energy density as it uses a large number of small format cells rather than a smaller number of large format cells, as is the case with the current Williams Advanced Engineering supplied unit, which has five modules made from 11x3 cells. The cell number within the new battery is believed to be 209, which is an increase of 44 cells over the first generation of battery.

Incidentally, McLaren Applied Technologies' Anthony Law will be the engineering lead for



Jaguar was the first prestige brand to commit to Formula E, but its struggles in its first season show FE is no easy option



The original Formula E aero package on Renault E.dams racecar in season two (2015-2016). Many expected FE to fail during its first season back in 2014-2015



Mercedes has decided to ditch long-standing DTM programme to join a host of other manufacturers drawn to FE. German car makers seem especially keen to bolster EV credentials

the Formula E project. Law joined McLaren from Ricardo in 2010 and will answer to Rodi Basso, who joined MAT as motorsport director from Magneti Marelli in the summer of 2016.

Four seasons

So, what about next season? Many see it as a fallow one for Formula E, with new manufacturers coming and with new technology in season five, they say season four will be just a holding pattern. In truth, it will be anything but, as development testing of the vital season five kit will be intense.

Also, for the upcoming season of 2017/18, which gets underway at Hong Kong in early December, there will be tweaks to the FE package, while an increase in the amount of power available to drivers during races will see a 170kW to 180kW upgrade.

The hike in available power has the potential to increase focus on energy management in races. 'I think the effect on energy management will come down to what the FIA decides to do on race length,' Andretti team principal Roger Griffiths, who also heads up the Formula E Teams' Association says. 'If the races are longer, or even the same length, having the extra power will make it a little harder to complete the race. But perhaps people will have made efficiency improvements to their overall powertrains, so this may compensate for some of it.'

Meanwhile, teams are also sure to be developing brake-by-wire systems this year and

next in readiness for the 2018-19 'Judgement Day' season. These systems are already common in Formula 1 and in sportscar racing, so companies such as Porsche, which has recently announced it's to leave LMP1, could have a head start with this technology.

Active braking is also set to be one of the features that is likely to be introduced to Formula E as it continues to explore its long-term technical roadmap. Although some teams are already known to be working on active braking systems for their future packages, Goschel said that a final decision is yet to be taken. 'We can do [brake-by-wire], yes,' he says. 'It is under investigation at the moment on how we go in to this. It is not decided yet but we have some ideas to step forward on the efficiency on one side, and [also] to make the series more dynamic. This could include using a front axle in the future, so it gives totally different energy management.'

Electricity bills

But in other areas of development Goschel was more cautious, particularly when it comes to ensuring the costs for the championship are kept at sustainable levels, which will include keeping a spec battery. 'One thing we want to keep is a specified battery unit, because manufacturers may want their own battery, but we have to keep the costs down,' he says. 'This is a main issue because we have a lot of expensive series [in motorsport] and they can fail.'

'Formula E is a whole package and we have to discuss if we integrate front axles, or if we want to discuss which energy storage system we have and how to manage it,' Goschel adds. 'We have some room open for adapting technology to keep costs down, but to make the racing exciting, too. But the races will get faster, this is our intention.'

Active braking

Some of the leading technical directors in Formula E confirmed that work on active braking systems will be high on the agenda for season five of the championship. 'For season five the main difference will be the power during qualifying with 250kW, and in the race 200kW,' said DS Performance technical manager, Xavier Mestelan Pinon. 'We will also work on a brake-by-wire system, this is the big new thing. This technology will help us to make more re-gen which is important because Formula E is an energy race. But at the same time you need to create some [energy], so [active] braking technology it will help the teams.'

An optimal pedal feeling for the drivers will be a key challenge for the teams should active braking become part of Formula E. One of the main difficulties, for both the teams and the drivers, will be controlling the recuperation phase, as braking characteristics have to stay stable and brake balance constant.

Manufacturers are believed to be working on their own active braking systems, while an

Teams like Porsche could have a head start on brake by wire technology

Driven Does More, With Less.

Independent Testing Reveals Driven Racing Oils Provide More Horsepower With Less Wear!

Engine dynamometer testing, detailed surface measurements and used oil analysis results all confirm the Driven system of lubricants reduces wear by 62%. Driven also provides 2% more horsepower and lowers temperatures by 6 degrees compared to traditional, high zinc racing oils. Developed for and used by NASCAR champions, Driven Racing Oil provides bespoke products proven to outperform standard synthetic oils and even "high zinc" racing oils. Trusted by professional racing teams around the world for more than a decade, Driven delivers protection and performance you can count on.

**"Ed Pink Racing Engines uses Driven Racing Oil in every engine we build.
It is the best insurance for long engine life that you can get."
- Ed Pink, Hall of Fame Engine Builder**

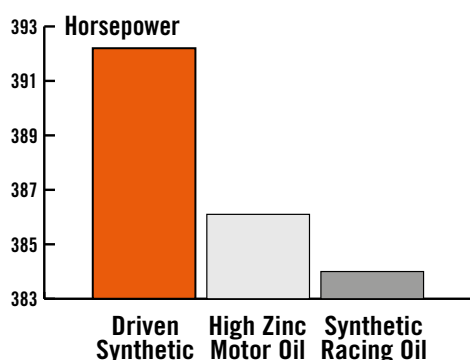


CAMSHAFT WEAR REDUCTION

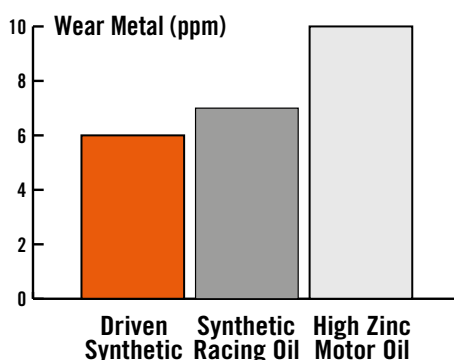
Camshaft wear is measured in microns, and the human eye can only see down to 40 microns. As a result, two camshafts can "look good" but differ in wear by as much as 62%. Because the total amount of wear is less than 20 microns, the difference can not be discerned visually.



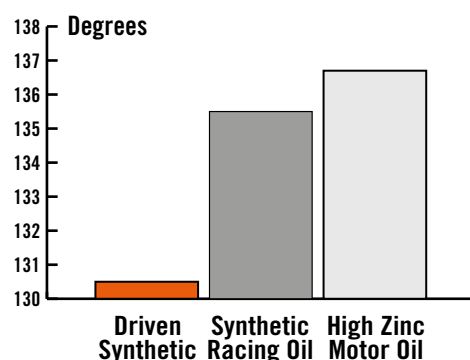
HORSEPOWER INCREASE



USED OIL ANALYSIS



OIL TEMPERATURE



For more information or technical assistance, please visit DrivenRacingOil.com or email Tech@DrivenRacingOil.com



Porsche is ending its hugely successful LMP1 programme, which netted three Le Mans wins in three years, to race in FE



City centre racing is a key part of Formula E. Electric racecars do not have the noise issues associated with ICE-running cars

independent system is already in existence for the Formula E racecars, thanks to the German braking specialist LSP. This system, known as IBSe, can be controlled via the axles or on independent wheels.

Trickle charge

Mestelan Pinon also confirmed that DS Performance was sharing knowledge with its burgeoning road car division on a variety of engineering solutions. 'At DS we are very comfortable with [these regulations] because all the engineering we [want to do] is part of this. The reason we do Formula E is to increase the knowledge of our technology for the road car department. We share everything. This is not a marketing discussion, this is reality. In the past we did not do so much R&D for road cars.

'As an example, the racecar is something like 700 volts, and in the future it may be very close to 1000 volts,' Mestelan Pinon continues. 'In road car technology they use something like 400 volts, so for the efficiency it is not so good. Currently they don't have the capacity to do things with a higher voltage because they don't have the right component. So thanks to the Formula E championship we can take more risk and move forward and do it more quickly.'

Sparking debate

Several Formula E drivers told *Racecar* that they would also like to see a front MGU implemented in the future in addition to regenerating energy via the braking system. 'I think the FIA are in the right direction for sure,' Lucas di Grassi said. 'I would like to see an MGU on the front to recuperate more energy. I would also use an electronic differential on the back, two motors for each wheel to control the acceleration, because this makes much more sense for an electric vehicle. We will see what the future holds, but we need to try and look at a closer time-frame for these to come in.'

But this second preference for di Grassi, torque vectoring, is unlikely to be introduced until at least season eight (which is in 2021 to 2022) as it is viewed as a significant driver aid. 'Torque vectoring makes life easier for the driver,' Goschel says. 'It should be a common discussion, like the front axle discussion ... But [talking about] this causes a lot of tension and excitement. I think that if a racecar is going like it is on rails, then it is not so exciting. So we should take care on this point.'

Care will also have to be taken as the Formula E championship goes in to its exciting new manufacturer era, too. But things are looking very good for the championship right now; and who would have bet on that part way through season one?



'The reason we compete in Formula E is to increase the knowledge of this technology for the road car department'

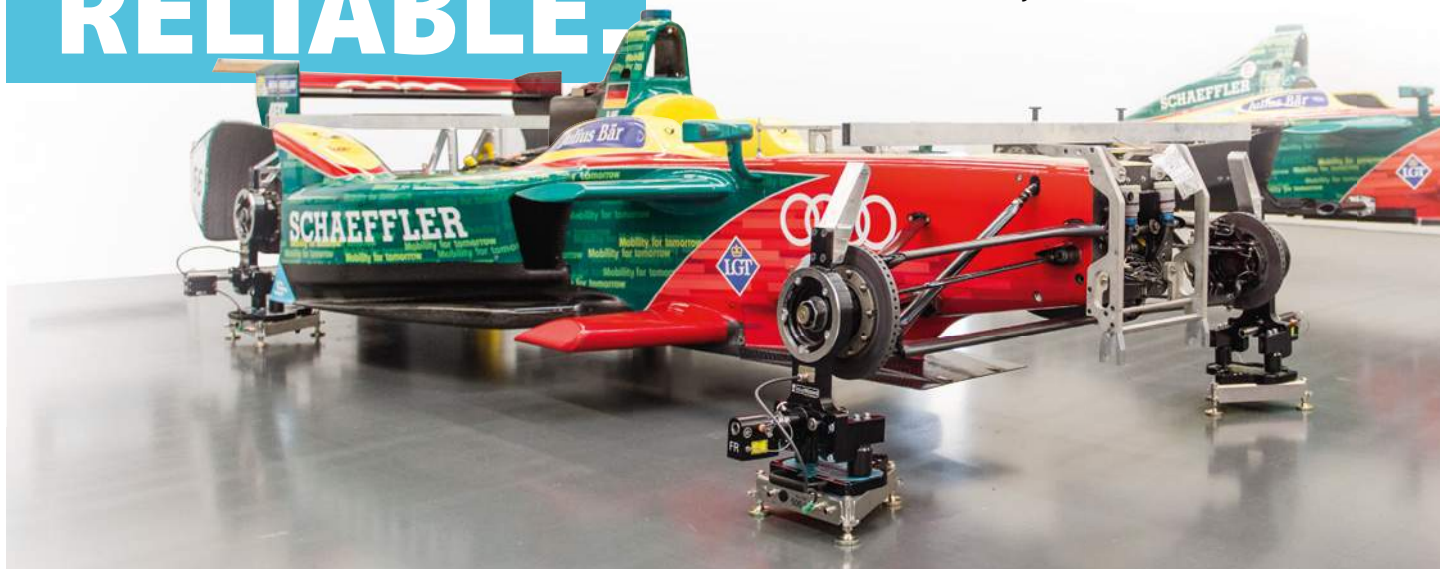
**QUICK.
PRECISE.
RELIABLE.**



Discover the future today.

Our cutting-edge laser based wheel alignment system has landed in Formula E.

The Setup Wizzard – where technology translates to victory.



Dornierstraße 7
33142 Büren / Germany

T +49 (0)2955 / 4849-594
F +49 (0)2955 / 4849-950

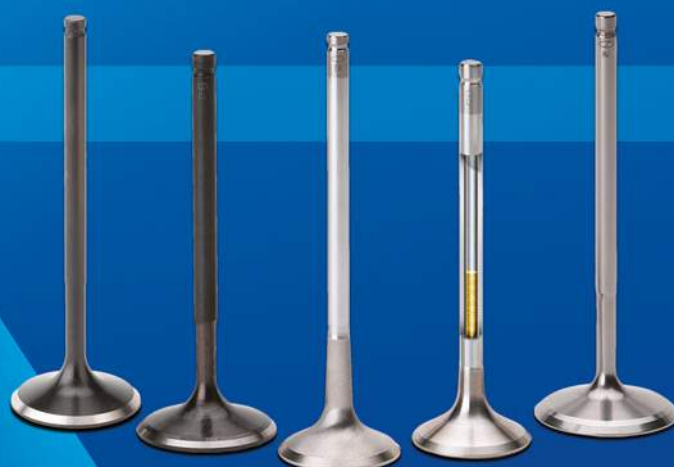
teubert@cp-autosport.com
www.cp-autosport.com

www.facebook.com/cpautosport
www.facebook.com/setupwizzard

**QUALITY
PERFORMANCE
RELIABILITY**

WWW.SUPERTECHPERFORMANCE.COM

-  VALVES
-  PISTONS
-  RODS
-  HEAD GASKETS
-  COMPONENTS



University Challenge

The entry might have been down for this year's Formula Student UK extravaganza but the level of innovation was as high as ever. *Racecar* was at Silverstone to witness all the action

By JOSH KRUSE



Birmingham challenged the winning Cardiff entry throughout the competition, dominating the Endurance test and just missing out on the overall victory

As is the custom in Formula Student, it didn't take long for a fire to break out in one of the cars

The first Formula Student winner of the UK competition, which was celebrating its 20th edition this year, was crowned after Cardiff University narrowly beat the University of Birmingham. The team from Wales overcame an initial scare, when it failed to make the design final, to achieve strong scores in the cost and presentation events while topping the Sprint dynamic event with a maximum score of 150 points.

Yet while that was welcome, there was a different atmosphere surrounding the 2017 edition, and it was noticeable when walking into the paddock for the first time how many empty

garages there were compared to 2016. The paddock was decidedly empty by comparison to previous highly successful years. There was good reason for this, though, as Formula Student UK was hit this year courtesy of the incompatible non-SAE approved rules adopted by Formula Student Germany (see box out). This, coupled with the fact that other Formula Student events, FS East and FS Italy, were running simultaneously, and FS Netherlands run on the same week, meant that European team entries dropped significantly.

At the beginning of the season, the proposed rules of the German and UK events



Brunel University's entry, which was 11th overall, had an interesting nose. Wet weather was a feature of the event but it failed to dampen the teams' enthusiasm



Wolverhampton's uprights were highly intricate and quite a feat of engineering given the tight space allowed with those tiny Formula Student wheels and tyres



The University of Central Lancashire's (UCLAN) racecar had interesting and very intricately machined rear suspension, boasting perforated wishbones with some imaginative profiles



Detail of the front suspension showing damper actuation on the UCLAN entry. Despite the innovative approach the team could do no better than a midfield finish at this year's event



The entry was down this year due to conflicting events in Europe and also the announcement earlier in the season of a different set of technical regulations for the German FS competition

differed too greatly and teams were left with a choice of which competition to contest, as the modifications required to compete in both were too great and costly for some teams. Germany later amended its rules making it easier for teams to compete in both, but this came too late for some who didn't have the budget to make the necessary changes and register for both competitions. There was also a handful of teams who didn't return after disagreeing with disqualifications handed out at the conclusion of the 2016 UK Formula Student event.

With a sharp exodus from the UK competition, it perhaps gave an insight into

what Formula Student UK might look like once Brexit negotiations are finished.

That said, there were still many teams who made the journey to Silverstone. Salesian Polytechnic University topped the distance travelled, covering over 9000km from Ecuador to make it to the event, while India was also well represented at this year's FSUK.

Herts burn

The dynamic events began on Saturday, and as is custom in Formula Student a fire didn't take long to break out in one of the cars. The University of Hertfordshire had completed its

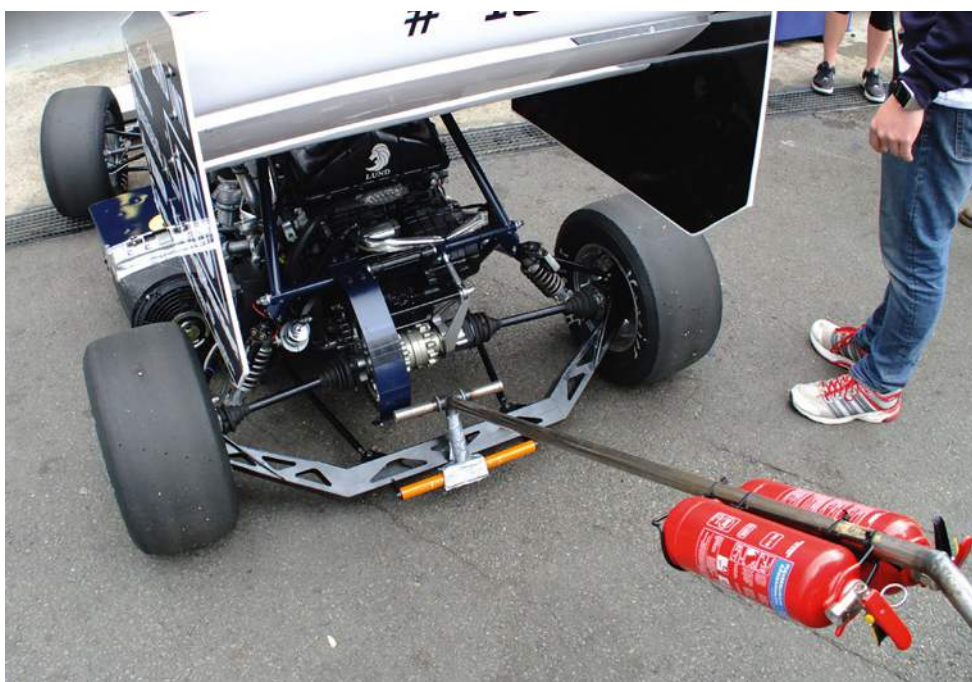
first run when, through no fault of its own, a battery blaze prevented it from going a second time around. Hertfordshire managed to fix the battery issue and return for the Sprint event and then set a time on a wet track quicker than some teams registered on a dry track.

The rain held off for the acceleration event and the final six teams had an even playing field to fight for maximum points. Queens University Belfast, University of the Basque Country, Poznan University of Technology, Loughborough University, Cardiff, and the University of Aberdeen made up the top six teams for Acceleration. Belfast won the event





The Delhi Technological University team travelled some 7000km to compete and impressed many with its very smart entry



This rear beam suspension set-up was just one of the many imaginative approaches used by the FS teams at Silverstone

Racecar Engineering says

Formula Student is made up of 13 different organisations across the Globe, who each run their own competition in their respective country. To prepare students for the motorsport industry, teams are encouraged to take part in as many of these competitions as possible. However, to achieve this, teams need to be able to compete with the same car at these different competitions and therefore require consistent regulations. This is why the FSAE Rule Committee was initiated to generate an overall set of regulations and, aside from minor changes relating to the running of each competition, the technical requirements were to remain the same.

This year, however, Formula Student Germany (FSG) issued a new set of regulations which included significant differences to the FSAE rules. One of the main changes relates to the engine size which is unlimited for FSG, yet restricted to a maximum displacement of 710cc for FSAE. There are also

differences in the dimensions of the front wing; to comply with FSAE, the front wing can be no longer than 700mm from the front of the tyres, and no wider than the outside of the front tyres, whereas FSG rules only restrict the front wing height.

These technical changes make it difficult for teams to optimise cars for both FSAE and FSG competitions and so they may force students to only compete in specific events such as FSG, which is arguably the most popular. There are also concerns regarding the sporting aspects of the FSG rules, which are diluting the educational experience for the students.

There are ongoing discussions between the 13 organisations to try and retain consistency throughout the worldwide competitions for 2018. *Racecar*, along with others, believes that achieving this is essential to secure the future of the world's most successful learning platform for the engineers of tomorrow.

Gemma Hatton

The Endurance event tested every aspect of these Formula Student racecars

two-tenths of a second clear from Basque Country with a time of 4.064 seconds.


However, it didn't take long for the heavens to open and saturate the Sprint course which meant teams had to sit and wait in the garages for the downpour to pass. That said, there were some ambitious attempts by a handful of teams like Manchester Metropolitan, Sunderland and Delhi, to try and complete the course during the downpour, which lasted a couple of hours.

It was during the Sprint event that one of the favourites ran into a major setback. The driver of the University of Bath car, which won Formula Student Czech last year, made a slight mistake on the wet circuit, hitting one of the cones and causing the front wing to split in half. Yet despite this problem, Bath still managed to register a time quick enough for fifth fastest, but it was left with a long repair job overnight.

Hot Bath

The Endurance event tested every aspect of the universities' cars. Here teams send their drivers out on a 22km course which includes a driver change halfway through, with a hot restart. Outfits like Cardiff and Karlstad set their times only two seconds apart from each other, though 13 seconds behind winner University of Birmingham, but Bath's nightmare run in the dynamic events continued. During its first stint, small puffs of smoke began to waft from the rear of the car and it continued to expel more on each passing lap. When the car returned to the track after its restart and driver change, it only took a handful of laps for the engine to fail completely, and then caught fire.

Hertfordshire was another casualty of the Endurance test. Having repaired damages from the fire caused by a faulty battery the previous day, the team then failed to complete the test when a failed rear brake caliper cost it a chance at a top 10 finish overall.

New for 2017 was a Super Sprint event for teams who wanted to attempt to set the fastest lap around the Endurance course. Teams had 10 laps with the fastest time set counting as their entry, if a cone was hit the time would be disqualified. Due to scrutineering, recent Endurance event finishers didn't have the time to participate, which was a pity, but the event itself was entertaining. As there were no points to be won drivers could take risks and put on a show for the spectators. All this meant that, despite the slimmer entry this year, there was plenty to enjoy at Formula Student 2017. 

PUT THE **DATES**
IN YOUR DIARY NOW!

15, 16, 17 **NOVEMBER**
2017
COLOGNE
GERMANY

NO ENTRY TO THE GENERAL PUBLIC

Professional
MotorSport
WORLD EXPO 2017



**BOOK
YOUR
BOOTH
NOW!**

PROFESSIONAL MOTORSPORT WORLD EXPO 2017
Tel: +44 1306 743744 Email: philip.white@ukimediaevents.com

www.pmw-expo.com



The Pryce is right

With a racecar that paid homage to a Welsh hero Cardiff University was a worthy winner of this year's event. We took a closer look at its innovative CR13

By JOSH KRUSE

This year Cardiff University's CR13 became the first car manufactured in the UK to take overall victory in Formula Student. The team named its car Gwyneth, after Tom Pryce's mother, as 2017 marks 40 years since the Welsh Formula 1 driver's tragic death in Kyalami.

The CR13's overall concept was focussed on lightweight and cost-effective performance. To pass the crash test the team used an impact attenuator, while also at the front is a two-element front wing with additional elements such as gurney flaps and canards. This way, the team isn't driving the air too hard at the front of the vehicle as it wanted a smooth flow, so as to not take up too much energy. The energy saved can then be used further back on the car on the side wings. 'We have the high and the low side wings, these are in addition to the front and large rear wing in an effort to really increase

our coefficient of lift and drag and bring those lap times down,' technical team leader Luca di Marino says. 'The reason for this is that the powertrain this year is slightly heavier than it was before, and in events such as Skid Pad, we actually see a decrease of performance, because the engine is not such a factor in that event.'

At the heart of the CR13 is the Triumph 675 Street Triple engine. The team favoured the Triumph over last year's Aprilia SXV 550, which produced around 50bhp, because it found that too unreliable. Cardiff couldn't participate in any of last year's endurance events due to engine failures, so it developed a relationship with Triumph in Hinkley, which also sees it sponsored for discounted parts and engines. Cardiff also switched to E85 fuel for this year.

Probably the most interesting design aspect on the CR13, and maybe even the entire Formula Student field, is the exhaust

layout chosen by the students. The design of the exhaust was based on the theory that was used on old jet planes that were required to land on aircraft carriers. Since they needed to lose a large amount of speed coming into land, the engineers put an exhaust outlet on the top of the flaps that extend for landing. By having the exhaust on top of the flap, it made the stall speed lower to reduce speed more. Cardiff used a similar concept on its racecar.

Welsh rare bit

The exhaust design meant a number of variables had to be balanced: the weight, the noise attenuation, torque curve and minimising negative aerodynamic effects. If you put the exhaust in front of the main roll hoop you have to shield it. The shielding means extra mass, so the team decided to go behind the roll hoop instead (also, by having two separate cams it provides for a better noise attenuation).

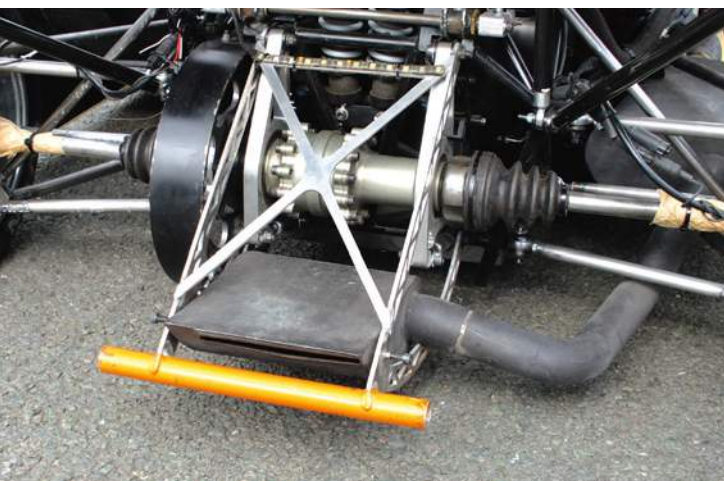
'From there we sort of knew roughly where everything was going, so we thought, okay, the first [silencer] sort of has to go between the wishbones, and the second one is going to be around behind the differential somewhere,' di Marino says. 'My colleague came to me and said, "this is what we're planning on doing and where we are planning on having it, can you run some CFD on this?" So I spoke to my team – I'm also chassis and aero leader – we ran a case, we actually found an overlying science in this position that produced lift, so we thought we can't be having this! We worked very hard to make all of this downforce, so I brought it up to my colleague, Alex, and I asked him, "do you think we could make this into an aero form?" He said, "don't be silly, we can't do that, none of the theory supports that kind of thing. I don't know what it's going to do about the noise attenuation, we don't know how the back pressure is going to be." Eventually we tried it, we ran a CFD kit and we found the aero force signs negated the lift, so it produced a very small amount of downforce as it was.'

Cardiff then pushed the concept a bit further by putting an exit slot on the underside of the back box, adding energy to the flow beneath the car and aiding the diffusion of the air beneath it, resulting in around 500 grams of downforce at 50 metres per second. 'We're very

'The exhaust treatment looks quite cool, it's like a blown diffuser from Formula 1'



The CR13 had an early scare when it failed to make the Design final but it went on to become the first British FSUK winner



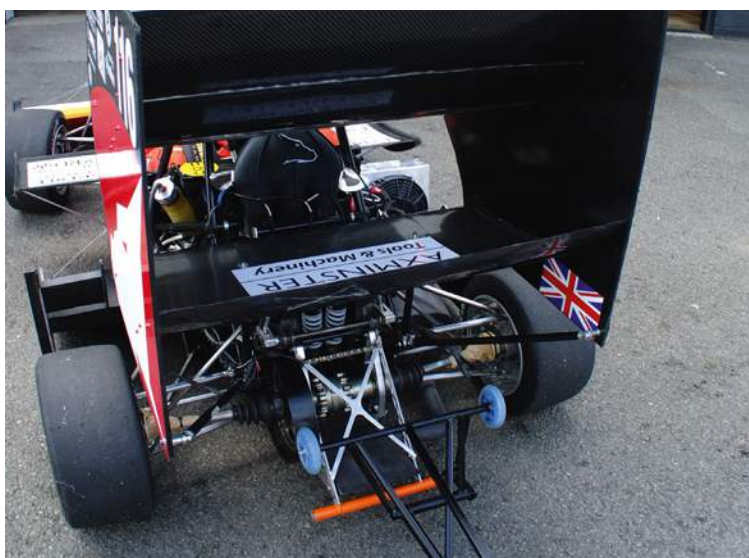
Cardiff's unique exhaust treatment was the talk of the paddock. It's actually an aerodynamic device in its own right, while exhaust flow also has an aero effect



Front dampers and spring assemblies are mounted on the upper side of the car's bodywork. Cardiff switched to Avon race rubber this year as it warms up quickly



The aero philosophy is not to work the air too hard at the front of the car so as to make better use of the side wings and the three-tier, six element, rear wing stack



The Cardiff racecar is motivated by a Triumph 675 Street Triple which replaces last year's Aprilia SXV 550. The team has also switched to E85 fuel this year

happy with this, because otherwise it is a part that would have been doing nothing but noise attenuation, and now it's doing a couple of jobs, and it looks quite cool too. It's like a blown diffuser from F1,' di Marino says.

Above the unique exhaust layout is a large, three-tier, six-element rear wing. It may look imposing, but the design isn't too complicated. By cascading the wings Cardiff has minimised the negative effect between them and gained advantages from each wing on their own. The team also says it does not run aggressive angles of attack on the wings.

Dragon class

For the chassis, the Cardiff team runs a hybrid of an aluminium honeycomb monocoque at the front and a spaceframe at the rear, which weighs 14kg. Despite admitting it would have loved to run a carbon fibre monocoque at the front of the car, a cost versus benefit analysis did not give it the numbers it needed so it stuck with the existing design from 2016.

'It was more effective for us to use the aluminium honeycomb, it provides excellent stiffness for a very similar weight. Our monocoque weighs about 14 kilograms, and

with a carbon fibre monocoque you would be looking at about 10 to 12 kilograms, so it's not too far out,' di Marino says.

What was also unique with the Cardiff entry this year was that it had the bracing supports moved as far forward as possible, so that it could have free choice of the diameter and thickness in the rest of the tubing for the spaceframe. The team ran some analysis and found which tubes were highly loaded and which had high stress and high strain, then strategically reduced the diameter of some tubes and increased the diameter of others.

This reduced the mass of the spaceframe by some three kilograms, with no effect on its torsional stiffness, giving a chassis that weighs roughly 30kg with the spaceframe's 13.7kg and the monocoque's 14kg, plus other bits.

Tyre change

Another example of the attention to detail taken which gave Cardiff an edge in the dynamic events was the switch to Avon A92 10in tyres. It's a small but important change, as the team found the Avon tyres have an optimal warm up performance compared to the Hoosier tyres. Given the events are generally very short, the

team now knows that its tyres will be up to temperature after one lap.

Cardiff has also introduced a new steering wheel for the CR13, a custom 3D printed SLS part made from glass-filled nylon. The wheel has two paddles for the gearshifts, with ergonomically designed paddles on them. A simple but effective addition, it helps the drivers know when they've engaged in a gear while the car is shaking. With just tenths of a second separating lap times, optimising everything around the driver can be worth seconds in certain events.

To help minimise the time spent switching between three pedals, the Cardiff team also installed a hand clutch on the steering wheel. 'We used the hand clutch because we found that there was a competitive advantage to downshift without using a foot clutch,' di Marino says. 'So it's more like a go-kart, it has two pedals at the box and then semi-automatic shifts at the wheel. The reason for this is when you have three pedals, like in a standard car, you have to move your foot from the brakes to the clutch and this takes time, that time can be spent accelerating or decelerating, maximising lap times.'



Herts and minds

The University of Hertfordshire scooped this year's Design prize with its now-turbocharged UH20 – but this clever piece of engineering is about much more than just adding boost, as *Racecar* discovered

By JOSH KRUSE



The University of Hertfordshire's UH Racing team took top honours in this year's Class 1 Design event with its 2017 challenger, the UH20. An upgrade from last year's Herts Formula Student entry, the team kept the same Honda CBR 500R engine that was introduced in 2016, along with its custom sump. The big difference for this year, however, is a turbocharger. By turbocharging the UH20 Hertfordshire has upped its power to approximately 80bhp, a hefty increase that equates to a power to weight figure of 400bhp. Having traditionally always run pushrod and pullrod suspension set-ups, UH Racing took a different approach to this year's car and made the switch to direct damping, taking out all of the compliance and effectively going back to basics for increased performance. 'It sounds a bit strange, but that's what we've managed to do,' team leader Joe Mulvey says. 'We've also gone for a more aggressive aerodynamic package this year, so you will see there's the addition of side wings on both sides and a triple element front wing and rear wing. We felt last year we didn't have enough downforce, so we really tried to push that. There's a couple of trick bits on the car this year as well, so there's an in-house designed pedal box which is quickly adjustable by the driver himself, and it's very lightweight as well, there's a lot of weight saving there.'

Ace of Herts

UH Racing also has in-house manufactured brake calipers as well as an electronic gear shifter. To accompany the electronic gear shifter Hertfordshire developed its own dashboard, new for the UH20. Tariq Willis, who is the head of electronics, designed the dash system using Arduino and coded it himself. Not only is it a nice feature to add to the car that complements the design, but it also saves money for the team on the cost report, which can be worth up to 100 points.

Another direction the team took for 2017 was to move away from using a diff and instead run a spool as a weight saving measure, which is also cheaper and beneficial for the cost report. The introduction of the spool has been

Aerodynamic improvements over last year's car include the addition of side wings and triple element front and rear wings

'We've gone for a much more aggressive aero package this year'



The UH20 has in-house built dashboard, brake calipers and pedal box, the latter has proved a great weight saver. The team has binned its regular diff and instead now runs a spool, also as a weight saving measure



University of Hertfordshire's UH20 took top honours in this year's Class 1 Design event and placed 16th in the overall standings



Herts has turbocharged its Honda engine. Note that the dampers are mounted directly to the uprights, which has led to the team ditching the car's anti-roll bars



UH20 uses a tube frame chassis. The car is a little heavier than last year's entry but that's largely down to add-ons and the turbo, while power to weight is better

successful for UH Racing – it had managed to clock up over 200km of testing prior to the event at Silverstone, incidentally, much more than the team has managed in the recent past.

Thanks to the use of the spool instead of a diff Hertfordshire is now also using a single inboard brake at the rear, which helps reduce the weight of the system. Because the team switched to direct dampers, it also ditched the anti-roll bars as it found these were unnecessary if the car was set up correctly in the first place.

The car is rather smart, too. 'We're really happy with how the car looks,' Mulvey says. 'All of our bodywork is nice and shined up. It's made by the students; we actually go down to

one of our sponsors, RP Aero Systems, and they loan us their facilities for approximately a week, and we lay everything up ourselves.'

Home to boost

The team initially developed two versions of the Honda CBR 500R for this year; a naturally aspirated high compression version, and the turbo system. Having run them back to back and then weighed up the pros and cons – how heavy they were, reliability and power output – Hertfordshire opted to run the turbocharged system based on the facts in the decision matrix. It also runs custom cams which help to reduce the overlap and increase the lift on the cams.

At the time of entering the UK competition, the UH20 weighed 205.5kg. While that figure is around 6kg heavier than last year's car, the introduction of a turbo to the engine accounts for almost 10kg, and additional bodywork elements also contributed to the weight gain, as Mulvey explains: 'We have added the side wings in, we've got the more aggressive aero package, and we have added a number of features to the racecar, so actually we have saved weight on last year's car, but we have added a lot of features in that bring up that extra weight,' he says. 'But we're happy with it, in terms of the power to weight figures it's a big improvement on last year's car.'



Game of drones

The brave new world of autonomous vehicles will still need real people with experience of the technology to engineer its cars – which is why Formula Student Germany introduced a competition for driverless machines this year

By GEMMA HATTON



Driverless Formula Student debuted at Hockenheim. The rain during the dynamic events at FSG increased the challenge for the autonomous teams even further as the reflections of the water on the tarmac distorted the signals from the sensors

Some organisations predict that autonomous vehicles could account for up to 75 per cent of all cars worldwide by 2040. Key manufacturers such as Toyota, Audi and BMW are aiming to bring their first fully autonomous vehicles to market over the next few years; with Tesla introducing its car in 2018. A single prototype of these cars can produce over 100TB of data per day, which is equivalent to the entire F1 grid over a race weekend. We are about to witness some of the biggest innovation changes in the history of the vehicle as driverless technology will undoubtedly revolutionise the automotive world, and our day to day lives.

Formula Student provides the perfect platform for developing the engineers of tomorrow and, therefore, its competition has to encourage students to design concepts that

are at the forefront of modern technology. In 2010 Formula Student Germany (FSG) was the first to introduce an all-electric class into its competition and four years later the world's first FIA Electric Championship, Formula E, began racing. This year, FSG was again leading the way by allowing the teams to adapt their 2016 contenders to compete in the first Formula Student Driverless competition.

'We all know autonomous vehicles are essential to the future of automotive, so our aim is to allow students to learn about these new technologies to prepare them for their future professional engineering careers,' says Ludwig Vollrath, member of the FSG board. 'Of course, there will be racing, and therefore race winners, but Formula Student is an international design competition. We wanted to incorporate an autonomous series into Formula Student, not

for the purpose of establishing autonomous racing, but to help students develop skills in autonomous technology by using the fun and excitement of building a racecar.'

Drop the pilot

The first announcement of 'Formula Student Driverless' was made a year ago, and 15 teams, from five different countries, competed in this year's event. This enthusiasm for the competition was partly down to the rules of upgrading an existing car to be autonomous, rather than having to build a whole new car. Consequently, the driverless competition was a more affordable alternative for not only lower budget teams, but also for universities who wanted to expand into running multiple teams. However, this format still judges the performance of the car, rather than just the



Formula Student has to encourage students to design concepts that are at the forefront of modern technology

autonomous technology, FSUK wanted to avoid these sorts of potential risks and instead have a safe environment in which to test. Therefore, test days will also be organised, where once teams have proved their code in the virtual environment, they can then test it on a real car.

Regardless of the regulations, the driverless competitions are likely to follow a similar format to the Combustion and Electric classes, like at FSG this year, where teams completed a range of static and dynamic events.

Get away driver

As well as the traditional Skid Pad and Acceleration challenges, driverless teams also had to race on a new course in the Trackdrive event, instead of the Endurance circuit used for the Combustion and Electric competitors. With the overall judging focus shifted towards the design of the autonomous vehicles, the static events accounted for up to half of the overall points available (compared to a third for the Combustion competition, for example). Similar to the other classes, teams were tested on their business plan, cost analysis and the overall engineering design. However, another event called Autonomous Design was added to examine the specific autonomous systems that featured on each team's car.

Autonomous competition also allows engineers from a wide range of other disciplines to learn and compete through the platform of Formula Student. 'To deal with these new technologies, teams will have to work with fellow students from information technology, computer science and electronic departments,' Vollrath says. 'I think this is a big challenge, because they will now have to incorporate more advanced sensor systems, data storage, algorithms and coding into their design.'

This is also broadening the variety of event sponsors, incidentally, as companies such as Google and Apple are using their expertise in big data to invest in autonomous tech and so are intrigued by Driverless Formula Student. But it's ultimately down to the teams to perform.

'The teams have a huge challenge,' explains Deakin. 'They will have to interpret data from a huge array of sensors such as Radar and LiDAR, as well as GPS and vision cameras for the car to determine its location on track. Advanced vehicle models will then have to be used to calculate whether the car is on the limit of

performance of the autonomous systems. Therefore, a team with a previously fast car is likely to do well, even if they don't have the best autonomous design.

To level out the competition one step further, Formula Student UK (FSUK) has decided to take a different approach with its driverless format, which it's aiming to introduce next year. 'We are hoping to provide teams with an entire platform with the support of a company who already manufacture autonomous vehicles,' explains Andrew Deakin, chairman of FSUK. 'Essentially, these autonomous vehicles will already be running with the supplier's code, so we will then allow the university students to replace that code with their own software that they've developed and tested. Rather than a vehicle dynamics competition, whoever produces the best autonomous code will win.'

As well as providing this platform, FSUK sponsor Mathworks – which currently supplies software to all of the teams – can also supply software to be used to develop the code. 'It still needs to be finalised, but in principle teams will be able to write their code using Mathworks and we're also looking into other software packages for teams to test their concepts within a virtual environment,' Deakin says. 'Therefore, aside from the physical computer, it should essentially be free for teams to not only develop their code, but to test to see if it works.'

Losing control

Another main driver for this platform approach was safety. If teams develop their own autonomous vehicles, it could be tempting to complete mini test runs in their local car parks. However, with so much still to learn about



The algorithms compute the ideal speed and steering angle it will need



The driver looks on as algorithms propel his car around the track. His main job now is to hold the umbrella to keep the electronics dry. FSG was the first competition to run a class for autonomous cars, but FSUK will also do so next year



There are different coloured cones for each side of the track to help the stereo camera systems, which can pick out the different colours, to distinguish between the right and left side of the road. The finishing area is made up of orange cones



Redundant drivers now spell out 'FSG'. Formula Student Germany attracted 115 teams this year, 65 of which competed in the Combustion class and 35 in the Electric category. There were 15 cars in the first Driverless Formula Student competition

adhesion to maximise performance whilst maintaining control. Then the algorithms will have to decide every few milliseconds on what action to take in terms of steering, accelerating and braking. It's almost a PhD level of academia, rather than undergraduate.' FSUK is currently consulting with industry and universities on the exact format of the event. Any interested parties can contact it at fs@imeche.org.

The Formula Student Driverless concept seems set for a bright future, particularly after the success of the FSG event in Hockenheim. China will also debut its version of the driverless challenge, featuring six teams, in September.

The technology

AMZ Racing from ETH Zurich University made history at this year's FSG event. Not only was its entry the world's first driverless Formula Student car to complete a successful run, but the Swiss team also won the first ever Driverless Formula Student competition.

As highlighted above, the regulations allowed teams to upgrade previous electric or combustion cars with autonomous technology to then compete in the Driverless class. Although this avoided teams building a car from scratch, the complexity of designing a driverless vehicle, especially with no previous reference or baseline, remained a phenomenal challenge. 'The most difficult part for us was the uncertainty because this has never been done before,' says Fabio Meier, project leader of AMZ Racing Driverless. 'We had to essentially figure things out based on a few papers and experience from other fields and adapt it to motorsport. Also, our 2015 electric car, which we used as the base model, was already a complex prototype; we then had to add the hardware and software of the autonomous systems as well as design the algorithms. It is the combination of all these multiple layers of complex systems that made it so difficult, but we learnt a lot.'

Unhuman error

In general, the biggest challenge in conventional motorsport is fine tuning the performance and reliability of the car. Once handed over to the driver, usually they will perform as expected, unless they are having an off day, where they may drop a couple of tenths a lap. Autonomous vehicles on the other hand rely on sensors, algorithms, vehicle models and computers to drive; adding a whole new element of variability. 'The algorithms can fail at any time or the sensors can send distorted signals for a fraction of a second which can disrupt the whole system,' Meier says. 'You then have issues relating to programming, memory, interference and unexpected situations – there are so many failure sources which we have



Our driving force is your performance



For over 40 years we've been manufacturing performance focused engine components. Our British made quality means you'll find us at the heart of the world's most powerful engines.

Discover innovation at
arrowprecision.com



'To deal with these new technologies teams will have to work with fellow students from the IT, computer science and electronics departments'

never had the opportunity to test before. A human driver is very good at adapting to those scenarios and so in that respect is much smarter than the onboard computers.'

Sensor ability

There are essentially three main stages to how an autonomous vehicle works. First, the onboard sensors have to scan and detect the constraints of the track and the car's location. Secondly, algorithms are used to determine the most effective route for the car whilst vehicle models define the required speed and steering angle. The third and final stage is when the mechanical components react to this information and the car starts to move.

AMZ Racing decided to integrate two types of sensors to 'see' the track environment: a LiDAR

mounted between the nose and the front wing, and an inertial stereo camera system, which required complex synchronisation.

The LiDAR (light detection and ranging system) is made up of 16 lasers arranged in layers that all rotate about the vertical axis. The lasers scan the environment immediately in front of the car in concentric circles and any objects ahead disrupt these circles and are therefore detected. This is how the system filters out the location of the cones and the constraints of the track.

The stereo camera system also helps to identify the location of the cones, but can distinguish colours as well. Therefore, to help this cone detection algorithm, the cones on the left side of the track are a different colour to the right. Once the constraints of the

track have been defined, these are converted into functions which are then used by the solvers to determine all the possible trajectories around the detected cones.

'We also have a discovery model, which is for when we don't have a track map yet,' Meier says. 'We drive one lap in this mode which builds up a map of the circuit and we can then locate the car within this map from the second lap onwards. Ideally, you want the track map defined before you start the race, so we also use a device which includes some of the sensors to scan the circuit during the track walk.'

Hands free

The algorithms and vehicle models are then used to define which of these trajectories is not only the fastest, but also possible to achieve within the performance limits of the car. In this way, at every point along the trajectory the algorithms know the ideal speed and steering angle it needs to achieve. These commands are then sent to the controllers through the ECU. For autonomous steering, a steering actuator was integrated which is essentially a belt attached to the steering column and a motor with a high transmission ratio gearbox. The system generates an output steering command at 5Hz (five times per second) and, each time, the entire calculation is completed again to achieve reliability and optimum performance.

'One of the biggest challenges was not only determining what sensors we needed, but also the computing power,' Meier says. 'In addition to the ECU we already had for the low-level car control, we also included a master and a slave computer. The rugged master computer is from industry and essentially manages the majority of the processing and the slave is an Intel i7 computer with a high single core performance, but consumes more energy and therefore generates more heat. So, we then had to think about how to keep these computers cool.'

As ever, safety is a primary concern and the regulations required teams to incorporate a Remote Emergency System (RES) within their designs. This is where an emergency brake system is triggered wirelessly from a remote control. The teams also use this to activate the starting procedure of the car at the beginning of dynamic events, avoiding any contact with humans once live. Similar to F1 and FE, different coloured lights are located on top of the roll hoop to indicate the operating state of the car.

The 15 driverless teams that competed in FSG not only made history, but also proved that autonomous technology is ripe enough for them to build racecars in under a year – an achievement that will surely capture the attention of many industries worldwide.



There were different approaches to locating the LiDAR (light detection and ranging) sensors. UAS Augsburg (top picture) situated its LiDAR on top of the monocoque, while ETH Zurich put it between the nose and the front wing (bottom picture)

ELECTRONIC THROTTLE BODIES



MOTORSPORT ABS



POWER BOX PBX90



CAS M ANTI-COLLISION RADAR



MOTORSPORT MOBILE WHEEL ALIGNMENT



MOTORSPORT IGNITION COILS



MOTORSPORT FUEL PUMPS



MOTORSPORT SENSORS



PROGRAMMABLE WIPER MOTORS



Motorsport Systems Ltd, are a UK based dealer of Bosch Motorsport products. With an innate understanding of the motorsport industry, we specialise in delivering a personal service that gets your parts to you, on budget and on time. For further information on the products detailed above, please do not hesitate to call or email info@motorsport-systems.co.uk.



MOTORSPORT
SYSTEMS

01684 291122
www.motorsport-systems.co.uk

Homework

Simulators are no longer the preserve of high-end organisations and they have now even become an integral part of some Formula Student teams – but just how are students employing this technology?

By GEMMA HATTON

Whether it's for driver training or to use as an engineering tool, simulator technology has now trickled down into nearly every tier of motorsport – including Formula Student. FS teams across the globe are now starting to abandon their gaming chairs and are feeling the benefit of what the modern advanced motion cueing platforms have to offer.

'Formula Student cars are very unique and the competition is unlike any other form of motorsport,' says Robin Bailes, team leader of Oxford Brookes Racing, one of the UK's most successful Formula Student outfits. 'New drivers cannot jump in the racecar and be fast straight away, even if they do have a background in karting. They often require a lot of training to get used to the feel of a Formula Student

car, and us having access to a simulator has helped with this massively.'

Compared to karting, Formula Student demands a much more transient driving style. The narrow twisty circuits with limited straights require quick reflexes and they make it difficult to establish the racing line. The cars usually have a high power to weight ratio and the recent shift towards giant aerodynamic kits results in plenty of grip in the corners, too. 'The simulator is also useful for training the drivers for events such as the Skid Pad,' Bailes says. 'Driving round the constant radius circles of the figure of eight track requires you to drive at a constant speed whilst trying to find the limit. For this, you need to drive smoothly and not be aggressive with the throttle or steering. By using the simulator, we could focus our drivers on being smooth

with their inputs. And when they raced in the actual event, they knew what to expect.'

Oxford Brookes Racing uses the single seater platform at Base Performance Simulators for an agreed number of hours per month. In 2015 Base Performance upgraded this simulator to include a Moog 6DOF motion system, and with the adjustable pedal box and six-metre wraparound screen, a fully immersive driving environment has been created.

However, to make the simulator realistic for the Formula Student drivers, a vehicle model has to be developed which correlates to the Formula Student car. This correlation is the biggest challenge facing any racing team that uses a simulator and can take months to achieve. Only when the model fully replicates the characteristics of the real racecar, can



‘There is currently a high demand for young engineers with simulator experience’

the drivers train reliably and can accurate conclusions on set-up changes be made.

‘We spent a lot of time developing the model using real data and correlating it with data from the simulator. However, having car data with all the sensors collaborated and working correctly is difficult to come by in Formula Student,’ Bailes says. ‘For the 2014 and 2015 car models, I was pretty much doing all the work based on one run’s worth of data, because that’s all we had.’

Fine tuning

Once the vehicle model has been developed from the data, the drivers are then used to finely tune the behaviour of the simulator. ‘It takes a long time to adjust the motion cueing system to get the right feel of the car,’ explains Oskar

Hellsten, a driver of Sweden’s Chalmers FS team, which uses a Cruden simulator. ‘If you don’t modify the model, sometimes the motion can feel more like driving a rollercoaster than an actual car. You have to tune the motion down so the simulator is sensitive enough for the driver to feel the small behaviours of the car, and even the bumps on the track.’

Although it is impossible to fully simulate the behaviour of the real car, once a correlation is achieved, teams can then start to investigate set-up changes and utilise the platform as an engineering tool as well as for driver training. ‘The simulator really helped us in 2016 when we moved from 13in to 10in wheels, because it allowed the drivers to get a feel for the different tyres and consequent inertias,’ Bailes says. ‘In 2015 we investigated gear ratios, and by using

Oxford Brookes Racing used the Formula Student UK Silverstone layout on the 6DOF Moog platform from Base Performance Simulators to analyse its set-up changes

the FSUK Silverstone track on the simulator we could work out the best solution. Obviously, shorter ratios are best for acceleration, but the straights at the Silverstone track mean you need to avoid topping out. You also need to consider the number of gear changes, these lightweight cars don’t take long to brake, so if you have to change down three times, you will already be halfway around the corner.’

Aero balance studies can also be investigated on the simulator, and although they might not be fully accurate, they still help to identify the right direction of development. ‘This is the first year we will be using a Drag Reduction System on the rear wing,’ highlights Axel Niklasson, another driver from Chalmers Formula Student team. ‘We used the simulator model to incorporate the effect of the DRS and it helped give us a first indication of how much cornering you can do with the rear wing open.’

Suite shop

This shift towards using simulators as an engineering tool has been helped by recent software developments. Panthera is an industry leading dedicated simulator software suite developed by Cruden and is used by OEMs and race teams worldwide. It consists of a number of modules and uses high-end vehicle models that are either developed or interfaced with Matlab Simulink. The software also contains controllers for motion platforms, steering feedback, pedals, dashboard, audio as well as a scripting engine to customise the simulation. One of the main benefits is the rendering performance, which can generate over 120 frames per second at WQXGA resolution, whilst achieving latencies of under 10ms.

‘The open architecture of the Panthera software is highly important for universities because it offers them the opportunity to modify their vehicle models where and when they want,’ explains Martijn de Mooij, technical development manager at Cruden.



'We used the simulator model to incorporate the effect of the DRS'

'With traditional gaming software you can change basic parameters from setting one to setting two, but with Panthera you can design every aspect of a complete vehicle model. For instance, you can modify the multi-body model of the suspension from a MacPherson strut to a De Dion, which you could never do in a game. The students really have to delve into the engineering behind the models, which is the best preparation for a career in the motorsport or automotive industry.'

A free version of Panthera is available to download, with no licenses required, making it perfect for Formula Student teams. 'Panthera is an engineering tool, so its main advantage is

the more sophisticated interface and the visuals, they are a world apart from anything else we've used before,' says Nick Boaz, general manager of Base Performance Simulators.

Feel real

In addition to these engineering capabilities, the realism achieved with Panthera can help provide the perfect platform for driver training. 'We focus on getting the drivers in the right mindset and familiarising them with the tracks, so we have to ensure they are as accurate as possible,' Boaz says. 'Our professional drivers have been crucial throughout this process because they can identify the finite detail such as bollards that

are the wrong colour or bumps in the track that shouldn't be there and this detail is important.'

Panthera also has a live set-up tool, so rather than having to leave the track, make a change and re-load it, set-up changes can be made whilst the driver is still in the car. These instant changes allow Base Performance to tune the car to the driver's liking within two to three laps. This can save over half an hour, allowing Base's customers to maximise their driving time in each session.

Base Performance has recently integrated Cruden's Panthera software into its single seater 6DOF motion platform, and is looking to do the same with its GT simulator this winter.

The affordability of Panthera also makes it ideal for teaching university students outside of Formula Student. With effectively unlimited licenses, universities can fill computer labs with the Panthera software and students can develop their own models using Matlab Simulink and then physically drive their set-up on the motion platform. 'Students could design their own power steering controller, for example, and their desktop simulation might conclude that there are small spikes within the calculation,' explains de Mooij. 'By driving this model on the simulator they can actually feel these spikes, so they are really engaged in the task because it's a much more end to end experience for the students.'

Class act

Simulators are now being seen as an academic tool for teaching, research and recruitment and this is why universities are starting to invest in these motion platforms. A perfect example is the CASTER (Chalmers Automotive Simulator Technology Education Research) project at Chalmers University. The University purchased the A646-D3 Cruden simulator, but the programme is entirely run by students. 'The simulator is integrated into over four engineering courses from bachelor to masters level,' says Jon Jaleby, project manager of CASTER. 'We try to inspire and create engineers who have a better understanding of what their design will result in. By enabling students to work with the internal model of Panthera, we can create a more dynamic learning process.'

Students can also sign up to become members of CASTER, so that everyone from all disciplines can increase their vehicle dynamics knowledge whilst learning how to run and develop an advanced motion platform. The latter skills are becoming essential for any modern motorsport or automotive engineer as there are more simulator engineering jobs on the market than ever before.

One of the main projects that CASTER is involved with is the collaboration with the Chalmers Formula Student Team, where CASTER members developed the vehicle models for the



Formula Student teams have embraced simulators and found uses for the technology in both driver training and racecar development. Some universities are now also using them for teaching and research. The Chalmers simulator is pictured



Chalmers University purchased its own Cruden A646-D3 platform simulator, which is entirely run by the students under a project dubbed CASTER. This initiative helped develop the vehicle models for the establishment's Formula Student Team

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



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

VMEP



VISION MOTORSPORT
ENGINEERING PRODUCTS LTD

CHASSIS
SET UP AND
PIT AND PADDOCK
EQUIPMENT

CHASSIS SET UP EQUIPMENT

- SET UP FLOORS (CAR AND KART)
- PAD LEVELLERS
- BUMP STEER GAUGES
- TURN PLATES
- FOUR WHEEL LASER TRACKING

PIT AND PADDOCK EQUIPMENT

- FLIGHT CASE (FOR SET UP FLOOR) AND BESPOKE CASES
- TWO STAGE AIR JACK FEET (RANGE OF SIZES AVAILABLE)
- LASER LEVELLING

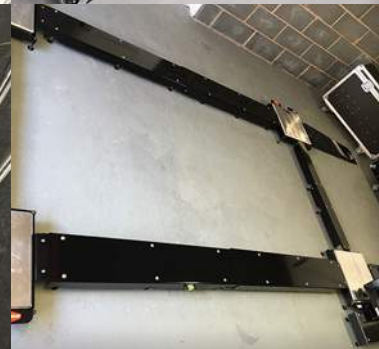
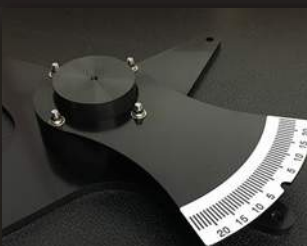
SERVICES

- VEHICLE SET UP
- ARRIVE AND DRIVE IN CLUBMANS SPORTS PROTOTYPE SERIES

WWW.VMEP-LTD.CO.UK

info@vmep-ltd.co.uk

[f @vmepproducts](https://www.facebook.com/vmepproducts)



team to then tune (as previously discussed). This approach allows the university to benefit from having a practical engineering tool which can be integrated into courses and dissertations, whilst enabling members of the Formula Student team to improve their skillset through developing the performance of the car.

The University of Hertfordshire has invested in a Cruden 6DOF simulator and Oxford Brookes is now following suit, with a Base Performance simulator that will be installed later this year; both running the Panthera software.

‘Simulators are very much a part of modern day vehicle development, both in automotive

and motorsport,’ says de Mooij. ‘But, like any engineering tool, a simulator is only as good as the engineers working with it and there is currently a high demand for young engineers with simulator experience. That’s more than just pushing start and stop, it’s really being able to set up experiments and understand the limitations and the challenges of running a simulator. I think every vehicle engineering university should integrate a driver-in-the-loop simulator into their coursework, because the chances are that over 90 per cent of their students will need to work with a simulator in their professional lives.’

Masters of illusion

The goal of any simulator is to provide a realistic driving environment, where the driver is fully engaged with every aspect of the motion platform. This engagement does not come from replicating the racecar’s physical movement to stimulate muscle memory, but from the mental engagement of the driver with the sim. This is achieved through convincing the complex coordinated cues of the driver’s vestibular system, which in turn tricks the driver’s mind into thinking they are driving a real racecar.

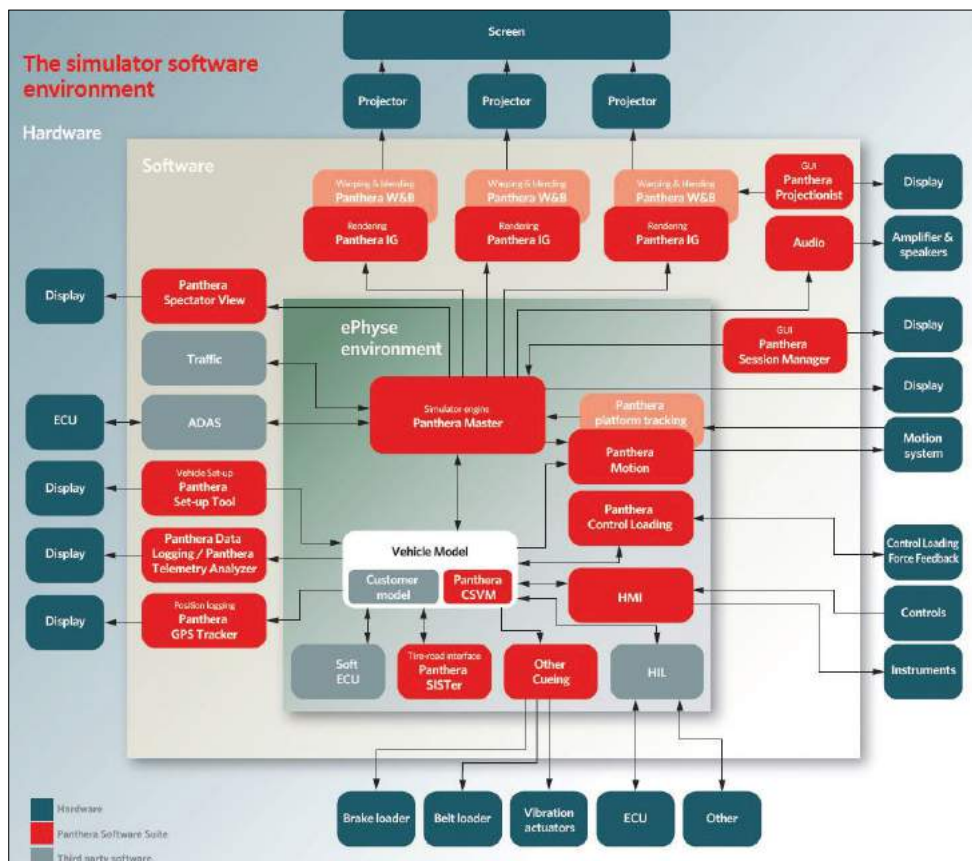
The human vestibular system is the labyrinth found within the inner ear and perceives and processes our sense of balance and spatial orientation. It is essentially a miniature organic gyroscope which is made up of three semi-circular canals and the vestibule. Linear accelerations in the x, y and z axes are detected by the utricle and the saccule which are organs within the vestibule. Yaw, pitch and roll is sensed by semi-circular canals that are filled with fluid and orientated in different planes. During a movement, tiny hair cells transmit information on these types of acceleration, stimulating the vestibular nerve to send messages to the brain.

Virtually real

The biggest challenge throughout the development of simulators has been to engineer mathematical models that enable the simulator to provide accurate motion and therefore the sensory cues to trick this vestibular system. For a fully immersive driving environment, these sensory cues need to replicate every sensation of driving a real car. These include high quality visuals and audio, as well as the motion of the sim and force feedback on the steering wheel, seatbelt and pedals. Some simulators even have air bags around the seat and the belts, which inflate under braking and cornering to simulate the effect of g-force on the body.

Achieving realism has obvious benefits as driver feedback is likely to be more reliable and valid, helping to draw more accurate conclusions on set-up. On top of this, it also helps avoid motion sickness, which occurs when there is a time lag between a driver’s input and the reaction of the system.

Drivers are often more susceptible to motion sickness because their reactions and senses are highly refined and therefore more easily disturbed; increasing the challenge for simulator engineers. The only way to design around this is to minimise this time lag in the system, also known as latency. This is why huge investments are made to ensure that the mechanics of the motion platform are as efficient as possible, so the latencies are too small for the brain to recognise.



An overview showing how all the modules of the Cruden Panthera software suite integrate into the simulator environment



With the very best simulators immersion in the virtual world is the aim and to help foster the illusion a real monocoque will be used in conjunction with a wraparound screen. Torque forces will also be applied through the steering wheel and the belts

The Lightest, Most Flexible Hose and Fitting Combination Available!

USA North Carolina

704.793.4319

sales@bmrsusa.com

California NEW!

714.415.0080

socalsales@bmrsusa.com

UK Slough

01753.545554

sales@bmrsuk.com

www.bmrs.net

Brown & Miller Racing Solutions



Professional Race Hose & Fittings



Lane MOTORSPORT

SMALLEST CONNECTOR BIGGEST PERFORMANCE!

WWW.LANEMOTORSPORT.COM

MOTORSPORT@FCLANE.COM

+44 (0) 1403 790 661

NEXT DAY DELIVERY
FROM STOCK

24h



NEW ULTRA COMPACT SIZE 01 8STA SERIES CONNECTORS



SIGNIFICANT SIZE & WEIGHT REDUCTION - 20% AGAINST SIZE 02



ULTRA - LIGHTWEIGHT ACCESSORIES



EXCELLENT RESISTANCE TO MOTORSPORT FLUIDS



ANTI - VIBRATION DESIGN



DEDICATED ASSEMBLY TOOLING



MANUFACTURED BY

SOURIAU
CONNECTORS

Weald
ELECTRONICS
ACCESSORIES

HellermannTyton
HEAT SHRINK BOOTS



Joest in time

The demise of Audi's LMP1 programme seemed to signal the end for Joest Racing, yet barely a year on and the legendary sportscar team is preparing for its comeback with Mazda. Which gives us a fine excuse to look back on its glorious history

By **SERGE VANBOCKRYCK**

Eleven of Audi's 13 Le Mans wins have been achieved by the now 80-year old Reinhold Joest's eponymous team, as have seven American Le Mans Series titles and two WEC titles. No wonder Mazda's leadership has turned to the team from Wald-Michelbach, Germany, to get its American DPI programme in the IMSA WeatherTech Championship on the road to success from the 2018 Daytona 24-hours onwards. With Joest at the helm, that is almost guaranteed.

But it was by running, developing and building Porsches that Reinhold Joest, then

based in the small village of Abtsteinach (population 2000), made a name for himself. The name Joest Racing officially doesn't appear on an entry list before 1972, and the team's website even claims as late as 1978 as the official birth year of the team, but Reinhold Joest entered his Porsche 356B Carrera in hillclimbs in West-Germany under his own name (then spelt 'Jöst') right from the very beginning in 1962.

He was successful from the word go, too: he won his first ever event in Eberbach and went on to win the German national hillclimb title twice in the next five years, before switching to

road racing and making a name for himself at every major race track on every continent. Also, the mechanics who had joined him on his first adventures in the early '60s would stay with the team for decades to come: Rudi Hartmann, Lothar Beier, Dieter Ruppenthal, Jürgen Hordt.

By 1966 Joest had already made his mark at the Nurburgring 1000kms for the first time. That year, he won his class in his Porsche 356B, officially entered by the Scuderia Lufthansa, the West German airline which would become a faithful sponsor for many years. The Nurburgring Nordschleife would go on to



Left: Joest Racing won the 1980 Daytona 24 Hours with a Porsche 935. The German team had a very strong relationship with Porsche for over 30 years
Above: Joest Racing was one of the few teams to be given the opportunity to buy a Porsche 908/03 in 1972. The car is pictured at the Nurburgring

become Joest's happiest hunting ground, with six class wins and two overall victories.

After a brief spell driving Fiat Abarths, he invested in a Porsche 906 for the 1968 season; a car he used in local events. But the following season marked the big breakthrough for Joest as a driver, competing in seven races in the 1969 World Manufacturers Championship with compatriot Helmut Kelleners in the Ford GT40 owned by Hans Lehmann. Those races, probably more than any other, laid the foundation for Joest's exceptional talent for endurance racing, for he finished every race he entered, scoring

class wins at Monza, the Nurburgring and Watkins Glen and finishing a competitive sixth in his first Le Mans 24 Hours. But in early 1970 a bad road accident left him in hospital for many months, to the point that he did not compete at all in that season. But he would be back with a vengeance the following year.

The pig time

In 1971 Joest raced the ultimate beast of that era, the Porsche 917K of the Team Auto Usdau, usually with Willi Kauhsen as a co-driver. Joest's methodical approach saw to it that they finished

all their races bar one, while his skills aboard the 917 hadn't escaped the attention of Porsche's motorsport leadership, who invited him to join the works Martini team for the 1971 Le Mans 24 Hours, his first factory assignment. Joest and Kauhsen were tasked with racing what would become one of the most iconic racing Porsches in history: the famous 917/20, aka the Pink Pig.

Porker scratchings

However, a brake failure ended Joest's race in the Pink Pig prematurely and nearly cost him his reputation. It appears the Porsche engineers had calculated the 917/20's brake pad wear on that of a 917K, but had forgotten to take into account the lesser aerodynamic drag of the 917/20 on the long straights. Thus the car braked harder each time, using up its pads at a much faster rate. The car had been scheduled to have a brake pad change a few hours after the accident, so the engineers immediately assumed that driver error was the cause of the accident. However, period documents show that the 917/20's brake pad wear seriously increased from practice to the race. Fortunately for Joest, the contacts he had by then made with the Porsche management would prove to be extremely valuable over the next three decades.

The first result of these was that Joest Racing was one of the few teams offered the





Joest upset the apple cart at the Le Mans 24 Hours for the first time in 1972, when he took a car from a museum – a four-year old Porsche 908 Langheck – to a third-place finish



Joest's first overall victory at Le Mans was in '84 with a 956, in the absence of the works team



Joest turned its attention to IMSA in 1991 with the 962C, here winning at Daytona

chance to buy an ex-works Porsche 908/03, the ultra-lightweight flat-8 racers Ferdinand Piech had had developed for just the Nurburgring 1000kms and the Targa Florio, where the 917Ks were too cumbersome to handle. Joest (he was now spelling his name this way) bought chassis 008, the 1970 Targa Florio winner, and used it in all corners of the world, constantly developing the handling, powertrain and aerodynamics of the car. In 1972 he finished on the podium in several Interserie races and won the non-championship Interlagos 500kms race in Brazil.

That year he also finished in an incredible third place overall at the Le Mans 24 Hours. With his own 908 not really intended, or suited, for the long straights at Le Mans, Joest rented a four-year old 908 Langheck coupe from the late Jo Siffert's private collection. Porsche's R&D boss Helmut Bott had made the suggestion to Joest to dust off the museum piece; Bott's right-hand man, Peter Falk, ran the operations on-site at Le Mans while Joest was sharing the wheel with Michel Weber and Mario Casoni.

The 1973 season was even busier than the previous one for Joest Racing and its 908/03. When Reinhold wasn't racing a Carrera RS for the Porsche factory team at Spa or Le Mans, he shared the wheel of the 908 with Casoni

in the other WMC races. Yet it was with Swiss Porsche legend 'Stumpen-Herbie' Muller that Joest achieved his biggest success to date, with a dominant win in the end-of-season Kyalami 9 Hours race in South Africa. For this race, incidentally, Joest had picked up sponsorship from none other than Audi...

For the 1974 season Joest Racing bought a second Porsche 908/03 which the team used to run paying drivers. Joest and Casoni again concentrated on the WMC, but with less success than they enjoyed the season before.

Turbo's charge

The postponement until 1976 of the new Group 5 and Group 6 rules meant that Porsche did not have a works programme for the first time in many years, but the void was filled by offering three customer teams, of which Joest was one, the chance to install the 911/78, 2142cc, turbocharged engine from the previous year's Carrera RSR Turbo in the back of their 908/03s. For a hefty price tag – and the factory warning that the original 908/03 transaxle might have difficulty coping with the extra power – Joest's chassis 908/03 008 had its rear frame reinforced at the factory, while brakes, driveshafts and parts of the suspension were borrowed from

the 917. Equipped with the engine cover and rear wing assembly of the 917/10 in order to produce enough aerodynamic grip, the Typ 908/03 Turbo was a powerful little monster.

While it was a handful to drive, Joest – and his co-drivers, Rolf Stommelen, Jurgen Barth and Volkert Merl – mastered it to perfection and won numerous races, including the 1976 World Championship opening round at the Nurburgring. In 1978, Joest won the Vallenlunga, Monza and Salzburgring rounds of the European Sportscar Championship on his way to the title, and added half a dozen Interserie races to his tally for good measure.

By 1979, then governing body FISA allowed Group 6 cars to compete in the World Manufacturer Championship, albeit without the possibility to score points. That, however, was enough for Joest to dust off and rejuvenate his venerable 908/03 Turbo, put a twin-turbo Typ 935/73 engine from the 936/78 in it and add a 936-inspired bodywork. At the first opportunity in Dijon, Joest, Volkert Merl and Mario Ketterer struck hard and beat the hitherto untouchable 935 brigade by four laps. At Brands Hatch, Joest and Merl repeated the feat, this time beating the Le Mans winning Kremer team and its revolutionary 935 K3. The same teams and cars

The factory warned that the 908 transaxle might not cope with the power

VARLEY RED TOP™

THE ORIGINAL RACING BATTERIES



The Varley Red Top range has for many decades been the battery of choice for the professional and clubman in motorsport. These sealed lead acid batteries are compact and powerful enough to be used in all race series, however they are heavier than their modern counterpart, Lithium Ferrous Phosphate. Formula Student teams, using motorcycle engines of around 600cc, have until recently focussed their attention on the Varley Red Top 8, a small 12V 8Ah battery weighing only 3kgs.

VARLEY LITHIUM™

Recently we introduced the Varley Lithium range of Lithium Ferrous Phosphate batteries. First off was the Li-16, a 12V 16.1Ah battery the size of a Varley Red Top 15 but with the cranking capability of a 30, and weighing only 3.2kg. This was followed by two smaller versions, the Li-5, 5.5Ah weighing 1.1kg and the Li-3 2.4Ah at 0.5kg. The Li-3 has been proven with motorcycle engines up to 750cc and the Li-5 is gaining popularity in Formula Ford 1600 as it copes well with running without an alternator.



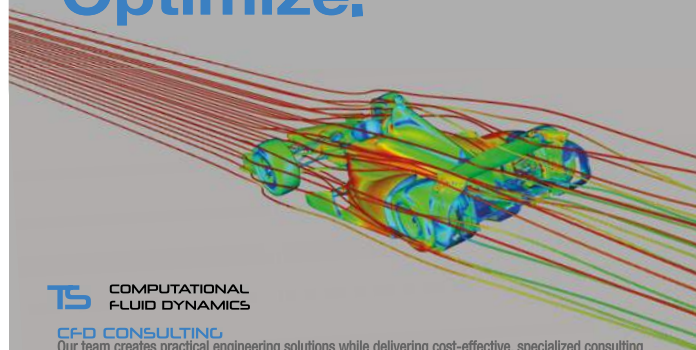
sales@dmstech.co.uk

varleyredtop.com

+44(0)1794525400

TOTALSIM

Evaluate.
Understand.
Optimize.



TS COMPUTATIONAL FLUID DYNAMICS

CFD CONSULTING

Our team creates practical engineering solutions while delivering cost-effective, specialized consulting

CFD SUPPORT

Our support team can provide training and support for leading-edge OPEN and commercial tools

CFD APP DEVELOPMENT

Our developers can create custom Web Apps to run your CFD workflows repeatedly and reliably

CFD HARDWARE

Our team can provide complete, cost-effective hardware solutions that are designed for CFD

TotalSim brings decades of results oriented experience in top level motorsports to customers in all industries

Multiple locations in US and the UK ready to serve you

TOTALSIM^{US}

Dublin, Ohio and
Pasadena, California
+1.614.255.7426
info@totalsim.us
TOTALSIM.US

TOTALSIM^{UK}

Brackley
Northants, UK
+44(0)1280.840316
info@totalsim.co.uk
TOTALSIM.CO.UK

RFC-89



NEW
2ND GENERATION
FIA & ACO APPROVED
RACE CAR REFUELLING SYSTEM

KRONTEC

HIGH PERFORMANCE COMPONENTS

- RE-ENGINEERED COMPACT DESIGN ONLY 1038 GRAMM
- ADVANCED SURFACE COATING OF SAFETY CRITICAL COMPONENTS
- FULLY GUIDED NIPPLE TO REDUCE SPILLAGE AND IMPROVE SAFETY
- TOTALLY INTERCHANGEABLE WITH CURRENT RFC-88-SYSTEM
- OPTIMIZED FUEL FLOW WITH CFD TECHNOLOGY



Abbildung: Strömungsgeschwindigkeit Detailsicht

KRONTEC MASCHINENBAU GMBH | WALHALLASTRAßE 19 | 93083 OBERTRAUBLING
WWW.KRONTEC.DE | RFC@KRONTEC.DE | TEL: +49 (0) 9401 5253-0

Its very own Joest-Porsche 936C looked the business in every way

would finish in the same positions one year on at the 1980 Nurburgring 1000kms, when Barth and Stommelen in the 908/03 Turbo beat John Fitzpatrick, Dick Barbour and Axel Plankenhorn in their 935 K3/80. Joest Racing would go on to use the racecar until the end of the 1983 Deutsche Rennsport Meisterschaft (DRM) season, long after the Group C cars had made their debut on the sportscar scene.

Carbon copy

If anyone doubted the strength of Joest Racing's connections to the Porsche factory, those doubts were quickly eliminated when the team owner presented his 1980 Le Mans challenger in May of that year in Hockenheim. Officially

dubbed a Porsche 908/80, and just as officially announced as a car built by Joest himself based on his experience with his own 908/03 Turbo, the Martini-sponsored car was in fact a factory-built 936, a carbon copy of the one Joest had raced to a third place in Le Mans in 1978.

At a time when business was slow for Porsche, its CEO Ernst Fuhrmann had decided to stop the prototype racing programme altogether and use the front-engined 924 for motorsport instead, since the 924 was then intended as the successor to the 911.

The motorsports people, however – Bott and Falk – decided to have a fourth 936 spaceframe chassis built for Joest (the other three Porsche 936s were in the company's

museum collection) from which he could build up the racecar himself with an engine and bodywork he had bought over the counter.

While the car looked like an identical twin of the 1977 Le Mans-winning 936, so did Joest's co-driver: none other than 'Monsieur Le Mans' himself, Jacky Ickx, who famously quipped about the 908/80: 'only the cigarette lighter sits in a different position'. Joest and Ickx fought a race-long battle with the local Rondeau team in a very wet Le Mans 24 Hours, but ultimately gearbox issues cost them the win. Still, the team had success with the 908/80, with both Joest and Jochen Mass winning rounds of the Interserie championship, and winning the Kyalami 9 Hours together in 1981, while Bob Wollek used the car – by now officially renamed 936-004 – to win the 1982 DRM. The 1981 Kyalami victory was Joest's last race, although he would climb aboard a racecar one last time in Zolder in March 1983 when he set up the 936 for Leopold von Bayern, who was to drive it in the DRM.

DRM drama

Busy with his 908/03, Joest Racing was one of the last of the regular Porsche customers to invest in a 935, in 1978. That year Joest raced a standard customer-spec car in the DRM, supported by his faithful sponsor, Liqui Moly. Unfortunately, during the race run as a support event to the German F1 Grand Prix at Hockenheim, he crashed heavily in practice, writing off the car and ending up in hospital. He wouldn't make his comeback until the last round of the year, also the last time he would race in the DRM himself. The following season, Joest Racing looked after the customer 935 owned by Hamburg oil merchant Volkert Merl, and ran its own 935 – built up by the team from a bare factory-supplied shell – for Stommelen, both cars now entered under the Liqui Moly banner. Despite meticulous preparation, Stommelen would only win the non-championship 'money race' at the Norisring, with Merl finishing on the podium just once. It was, after all, 1979, the season in which Klaus Ludwig and the Kremer Porsche 935 K3 dominated the championship with 10 wins from 11 races.

Daytona delight

The 1980 season started in the best possible way for Joest Racing, with a dominant victory in the Daytona 24 Hours for the Liqui Moly 935 driven by Stommelen, car owner Merl and Joest himself.

For the DRM season Joest had reworked the aero, engine and rear subframe on Stommelen's old car for Merl, and built up an entirely new one for Stommelen from a bare factory shell. With Joest replacing the rear of the chassis with a spaceframe to house the engine, gearbox and suspension, his cars were henceforth being referred to as 935J. Stommelen immediately



Le Mans 24 Hours 1989. The Joest-run Porsche 962C Group C racer scored a podium finish behind the then unbeatable Sauber-Mercedes. Reinhold Joest, in the pink jacket and headset in the background of the picture, supervises the pitstop



For the 1990 WS-PC season Joest was very much the works Porsche team, with a budget and key personnel from Stuttgart



ADVANCED ENGINE RESEARCH

HIGH PERFORMANCE RACE ENGINE SOLUTIONS

WeatherTech Sportscar Championship



Indy Lights



CONCEPT : DESIGN : MANUFACTURE : TEST : DEVELOP : RACE

AER wishes continued success in 2017 to all its Competitors



P63 Indy Lights Mazda



P60 AER V6 WEC



P91 Mazda DPi

ADVANCED ENGINE RESEARCH LTD – BURNT MILLS INDUSTRIAL ESTATE – BASILDON, ESSEX SS13 1LE
Tel: +44 (0)1268 274421

www.aerltd.com



Porsche's WSC95 was in reality a 1991 Jaguar XJR-14 chassis with the roof chopped off, mated to a 935/85 engine and 956 transmission. Joest won Le Mans with it in '95 and '96

won the opening round of the season at Zolder and Merl won the second round at the Nurburgring. Merl also finished in the top five in 10 of the 11 remaining rounds, but tensions mounted between Stommelen and Joest, to the point that the driver was released mid-season. He was replaced by F2 hotshoe and DRM veteran Manfred Winkelhock, who finished the season with two wins from six starts.

Whale tale

It was at the behest of sponsor Liqui Moly that Joest started another formidable project for the 1981 season. After the 936 'replica' from the year before Reinhold Joest recreated the famous 935/78 Moby Dick to be raced in the DRM by Manfred Winkelhock for the Liqui Moly Equipe. But just before the season started driver and sponsor defected to the Zakspeed Ford team and Joest was thus stuck with a brand-new 935/81, but without a sponsor and driver.

While matters were taken to court, Joest did a deal with Jochen Mass to race the car hoping to find a major sponsor along the way. Some sponsorship was picked up, but when after the third round of the championship at Hockenheim – which Mass won – gentleman-driver Gianpiero Moretti expressed interest in the car, Joest immediately rented it to the Italian, who raced it in the American IMSA championship.

Joest built a second 935/81 for John Fitzpatrick Racing, who successfully debuted the car at Le Mans in '82 with a fourth place overall behind the three unassailable works 956s. Two years later, in 1984 when Group C and IMSA GTP

prototypes reigned supreme on both sides of the Atlantic, Joest still won the Sebring 12 Hours with a Porsche 935, with two of the three drivers never having seen the car or track before.

With the advent of the new Group C class in the World Endurance Championship, but with Porsche not yet selling its new 956, loyal Porsche customers like Joest or Kremer were facing a difficult choice. They could, for one year only, continue to run their 935s and have no chance at winning races, or they could ally with another constructor like Lola or March and run a Cosworth-powered Group C car, but then risk falling from grace in Stuttgart. Or they could use their in-house talent and experience and build their own Group C Porsche. Both Kremer and Joest did exactly that and when Joest Racing presented its very own Joest-Porsche 936C it looked the business in every way. It bore a striking resemblance to the 936 he had built two years earlier, but with a roof and doors.

The car, which had a slightly longer wheelbase, used the Typ 911/78 mixed-cooled 2.6-litre engine from the 1977 Le Mans winning 936/77 and transferred its power via a Typ 920/50 5-speed gearbox. But the 1982 season belonged to the new ground-effect Porsche 956 and, except for a third place in Silverstone, the spaceframe 936Cs WEC score card would remain unusually empty. However, the results achieved by Wollek in the 'old' 936 in the DRM were enough to earn the coveted Porsche Cup for both the driver and the team.

When Porsche announced it would sell 12 of the all-conquering 956s to customers, Joest

was among the first to place an order, as did his long-time customer, Dieter Schornstein. Joest Racing started the 1983 season with a win in the opening round of the DRM in Zolder, thus claiming the first-ever privateer 956 victory.

Yet while that win could have been categorised as easy, against an opposition of just three other private 956s, an uncompetitive Ford C100 and some grid-fillers, Joest's win at the opening round of the WEC in Monza came as a total shock. Not only had Bob Wollek and Thierry Boutsen beaten four other privateer 956s, but also those of the Porsche works team, as well as the works Lancias. Later it was established that Joest's engine man, Michel Demont, had already tweaked the engine and, amongst other things, had used custom-made Mahle pistons. It was the first time ever the factory 956s had been beaten by another Group C racecar, and where Ford, Lancia, Rondeau, Sauber, Lola and March had failed before, Joest Racing had succeeded.

Joest Racing was by far the most competitive of all the privateer Porsche 956 users that year, with Wollek claiming the DRM championship as well as the European Endurance Championship and yet another Porsche Cup.

Le Mans glory

For the 1984 season, Klaus Ludwig and Henri Pescarolo became the lead drivers for Joest Racing as Wollek had defected to Lancia. A lot was expected from drivers and team alike and a second place at the Silverstone WEC round was followed by Joest's greatest moment of

Joest's win in the opening WEC round at Monza came as a total shock ➔



Aerodynamic sensors for embedded testing



TEXYS
Z.A. des Chamonds
Rue Édouard Branly
F-58640 VARENNES-VAUZELLES
Tél. : +33 (0) 386 212 718
Fax : +33 (0) 386 212 449

Lechar et la Souris - 03 86 71 05 85

POWERFUL MATERIALS.
ENGINEERED WITH PRECISE MEASUREMENTS.
CREATED TO WITHSTAND THE MOST EXTREME VALVETRAIN APPLICATIONS.

IT'S IN OUR
DNA



Ferrea
RACING COMPONENTS

Tech Line: 954-733-2505 • Toll Free: 888-733-2505 • Ferrea.com f t i

Joest Racing stayed loyal to the 956 for as long as the rules allowed

glory thus far: victory at Le Mans. True, the works Porsche team had stayed away over politics with the FIA, but Joest had still beaten 15 (!) other 956s and 962s, plus a gaggle of other competitive cars including the works Martini Lancia team. A brand new car and running the old mechanical Kugelfischer injection instead of the new electronic Motronic had done the trick.

Loyalty points

While Porsche introduced the long-wheelbase Typ 962C for the 1985 season and beyond, Joest Racing stayed loyal to the 956 for as long as the rules allowed. And successfully so, too. Over the next two seasons, Joest Racing won the now-named Deutsche Sportwagen Meisterschaft (Jochen Mass, 1985), the Interserie championship (John Winter, 1986) and the ADAC Supercup for Teams (1986), as well as the

1985 Le Mans 24 Hours (with the very same chassis, 956 117, this time beating the works Porsches courtesy of a high-compression engine, custom-made electronics and fine-tuned aerodynamics), the 1986 Fuji WEC race (last WEC race for the 956) and the 1986 Kyalami 500 non-championship race (which was the last-ever race for a 956).

Joest Racing's 1987 WS-PC campaign, now with only 962Cs and the returning Bob Wollek as a lead driver, didn't start as had been planned, with the absolute low point reached at Le Mans, when both cars retired within the first seven laps of the race with blown engines because of poor quality fuel supplied by the organisers. The works Porsche team won the race, but dropped a bombshell a few days later by announcing its immediate retirement from the world championship. For the remaining rounds, the Rothmans colours were transferred to the lead Joest Porsche 962C, as were works drivers Derek Bell and Hans-Joachim Stuck and some of the new fully water-cooled works engines.

Yet despite the best possible efforts by the Joest team, the drivers and the Porsche engineers, some Interserie and Supercup victories were all that could be claimed. The Porsche 962C was nearing the end of its development cycle, and though still ultra-reliable the competition had clearly caught up.

The works

The 1988 season was one to forget, but Joest Racing's loyalty to Porsche saw some Weissach engineers work weekends in the office and spend some holidays at the race tracks. The result was a shock win at the 1989 Dijon WS-PC round with Wollek and Frank Jelinski beating all the works teams. A third place in Le Mans again emphasised the stamina of the 962C when on a good day for the 1990 WS-PC season Porsche's Norbert Singer managed

to persuade the board to allocate a budget and personnel to Joest's campaign, making the team the de facto works squad. But it was too little, too late, as Mercedes had the world championship in a vice-like grip.

With the 962C effectively outlawed from the world championship in 1991, Joest Racing turned its attention to the IMSA championship in America, all the while continuing to develop the 962C. The team fought valiantly against more modern competition and won the Daytona 24 Hours in 1991 and also scored the Porsche 962's last IMSA win in 1993. But at the end of that year, the sportscar days were temporarily over for Joest Racing, and the team had to look elsewhere for business.

High Calibra

Having established itself as the most successful private racing team in German motorsport history, Joest Racing wasn't without a factory contract for long. The Porsche 962Cs had barely been moved to Joest's private museum when a trio of Opel Calibra V6 4x4s was delivered to the workshops for Joest's next mission: the DTM. Le Mans winner Manuel Reuter and Formula 1 World Champion Keke Rosberg were signed to lead Opel Team Joest's attack, with Joest stalwart John Winter joining the squad in a third car for what would be his last season with the team. With their Cosworth-built engines the cars were fast but not quite reliable and only one win in the non-championship race at the Donington Park invitational race was chalked up by the Opel.

For the 1995 season the DTM went international, thus giving birth to the International Touring Car Championship, or ITC. Seven DTM rounds in Germany counted for both series, to which five rounds abroad were added to create the ITC. Over the winter Rosberg had set up his own team while Joest Racing now ran four cars. Results weren't exactly brilliant with only the odd podium finish in both the DTM and the ITC. But for the 1996 season, Opel's new boss, Walter Treser, pulled out all the stops. Zakspeed was brought in as a third team while Opel Team Joest now ran old foxes Reuter and Yannick Dalmas, and young guns Alex Wurz and Oliver Gavin. However, with costs spiralling, Opel announced early on it would not continue in the ITC in 1997, as did fellow competitor Alfa Romeo. But the swansong ITC season did bring the titles to Opel Team Joest and Manuel Reuter.

For Joest Racing the Opel programme had meant little more than running and maintaining the cars with little room for the team's signature technical forward-thinking, but fortunately the team's contract allowed it to stay involved in sportscars. When, in 1994, the works Porsche team made a surprise comeback to Le Mans



Reinhold Joest's career in sportscar racing has been extraordinary, he's led his eponymous team to a long list of top level race wins working alongside Porsche and then Audi. Mazda in the US is next



The sun came down on Joest Racing's relationship with Audi at the final WEC race for the R18 in Bahrain at the end of 2016



CD34

THE BEST JUST GOT BIGGER



- > 8in widescreen LED backlit TFT
- > 9 tri-colour shift lights
- > 200Mbyte data-logging memory
- > Fully configurable layouts
- > Up to 100 display pages



www.gems.co.uk

THINK Automotive



Think Automotive are specialists in oil cooling systems and all aspects of vehicle plumbing. We are the manufacturer and distributor of Mocal® products.



We stock and distribute the finest automobile products, such as oil coolers, hosing, hose fittings, filler caps, water pumps, oil pumps, heaters, gauges and more.

Tel: 020 8568 1172

Web: www.thinkauto.com

Email: info@thinkauto.com





The last Le Mans 24 Hour win for Joest was with Audi in 2013, one of 11 the team has won with the German marque. Joest also won the race as part of the Bentley effort in 2003

with the Dauer 962 'road car', it was the men at Joest Racing who ran the cars to Porsche's 13th overall victory. Two years later, Joest picked up the WSC project Porsche had shelved in 1995 over politics with the American IMSA organisation. For six months, the Joest people worked hand in hand with Porsche's Norbert Singer to turn Stuttgart's weirdest racecar yet (a 1991 Jaguar XJR-14 chassis with the roof chopped off and mated to a Typ 935/85 engine and Typ 956 transmission) into a race-winning machine. Several days in the wind tunnel resulted in a heavily revised front suspension and overall aerodynamics, and a car that could spring a surprise at Le Mans, which is exactly what Joest did in 1996.

But when, after the race, Porsche gave Joest the winning Porsche WSC95 for his private collection, it didn't quite expect him to run the car again in La Sarthe the following year. Few one-car teams have ever won at Le Mans, but Joest Racing mastered that challenge to perfection as well, again beating the works Porsches in the process. It was also the second time Joest managed back-to-back Le Mans victories with the very same chassis.

Porsche swansong

Having been beaten twice by the same privateer outfit, Porsche thought it best to integrate Joest Racing into the works team for the 1998 24 Heures and give the WSC95 a thorough update in the process. But with the revised aerodynamics and 911 GT1 powertrain, the cars had lost their grunt and retired early in the race.

One can only guess what could have been had Joest's prototypes been allowed to run in their victorious spec from 1996 and 1997, especially given the fact that both factory 911 GT1 98s, which finished first and second, had each spent over half an hour additionally in the pits for repairs. It was, in any case, the last time Joest Racing would run Porsches.

The Audi years

Around the same time another German car manufacturer was preparing an assault on the world's most gruelling endurance race and was in need for a team with the experience and know-how to make this happen: Audi. The team it chose to mastermind the logistics of its operations was Joest Racing. And thus in 1999 Audi made its debut in Le Mans, while Reinhold Joest, Ralf Juttner and other Joest Racing regulars wore Audi's four rings on their team gear for the first time in their careers.

Audi's first year in sportscar racing saw Audi Sport Team Joest run a pair of open-top R8Rs in the ALMS and Le Mans, and Audi Sport UK (run by Richard Lloyd, that other Porsche 956/962 stalwart) a pair of R8C coupes at just Le Mans. After a hefty winter test programme Joest scored a first podium finish at Audi's very first race in Sebring. At the marque's second event, at Le Mans, the Joest Audis repeated the feat, with Frank Biela, Emanuele Pirro and Didier Theys finishing in third overall behind the winning BMW and a Toyota.

From the outset it was clear that Joest Racing's involvement with the Audi sportscar

programme would not include any technical development but just the management, logistics and strategy, which is where Joest and Juttner excelled even more than ever before. Once the 2000-spec Audi R8 had lost its innocence, Audi Sport Team Joest racked up the victories in amazing numbers, helping Audi to become the most successful manufacturer in any motorsport discipline of the 21st century, whether it be sportscars, Formula 1, rallying, touring cars or IndyCar.

When, in 2003, Joest's works Audis weren't racing at Le Mans, Juttner and other key Joest Racing team members could be found wearing British Racing Green gear in deference to their employer for the weekend: Bentley. Even two of the three winning drivers were on loan from Joest: Dindo Capello and Tom Kristensen – the Dane has won seven of his staggering total of nine Le Mans wins aboard Joest-run cars, a statistic that is as unique as it is exceptional.

To be continued

It is, quite frankly, next to impossible that any other team or manufacturer will ever achieve a similar record list of victories as Joest. Since that very first hillclimb, Reinhold Joest and his men have carefully created a legendary achievement in their own time. Joest started his driver's career with a win in Germany in 1962 and ended it with a win in South-Africa in 1981. And his team emulated that 35 years later when the chequered flag fell for what looked to be the final time in Bahrain in 2016. Until Mazda called in the summer of 2017...



It's next to impossible that any other team will achieve a similar record



Call us first...

Trident
Racing Supplies



Unit 23 Silverstone Circuit Towcester Northants NN12 8TN
T: 01327 857822 F: 01327 858096 www.tridentracing.co.uk

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"



SCHRICK

ARP
automotive racing products

ARROW
RACING

SAMSONAS
MOTORSPORT TRANSMISSION

COMETIC

CP CARRILLO

+1.215.462.4666

www.vacmotorsports.com

2501 Snyder Ave, Philadelphia, PA 19145, USA

sales@vacmotorsports.com

pankl
R A C I N G



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

HEAT EXCHANGER SERVICES

Our ISO graded 'clean room' is available for complete core cleaning and particle cleanliness assessment on radiators, oil coolers and chargecoolers.

Core Cleaning

Ultrasonic, Power Flush, Pulsation, Agitation & Flow Bench

Particle Assessment

ISO 16232, Microscopic & Optical Analysis, Size & Count

Calorimetric, Flow & Pressure Testing

Radiators, Oil, Gearbox, KERs & Chargecoolers

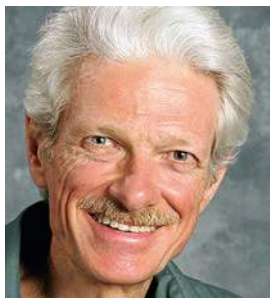
Core Race Preparation

Cleaning, Filtration, Drying
Oil Conditioning and Sealing



www.youngcalibration.co.uk
+44 (0)1273 455572

Unit 4, Ham Business Centre, Brighton Road, Shoreham by Sea, BN43 6RE



Lusty Justy: sorting the set-up on a rally car

A client discusses his Subaru traction woes with the Consultant

CORRESPONDENT

I read your article on independent rear suspension for dirt track racing in a recent edition of *Racecar* (V27N7). We run a mid-engined rear-wheel drive rally car in gravel hillclimbs and sprints. The original car was written off and we are in the process of designing a replacement. We have always suffered from excessive wheelspin so are trying to come up with a better rear suspension set-up. Our first car had the rear suspension as per early Subaru WRX – two parallel arms and a forward link with MacPherson strut. We are looking to improve the rear suspension from a traction point of view only. Everything else works really well, but we suffer from excessive wheelspin. We have good struts and have tried various roll centre adjustments etc. We are considering a wishbone bottom arm with a steering link. Here are the rest of the car details: turbo Subaru engine 400+bhp, mid-mounted with Albins sequential transaxle; 65 per cent rear weight bias (heavy transaxle behind rear axles); big shaft MacPherson struts front and rear (MCA Suspension, Australia); springs 250lb front, 180lb rear, no sway bars; small Subaru Justy body, 950kg total; subframes front and rear; outboard brakes. We have tried various rollcentres and have tried adjusting anti-squat by moving forward link pickups.

My questions are: are struts inferior to double wishbones for traction? Which is going to be our best option? Starting point for anti-squat on dirt? Angle top of strut inwards more, or forward or back? In front or behind hub centre at bottom? Assuming we stay with the MacPherson strut, which is going to be the best bottom arm set-up for traction? Stay with the 2x parallel lower arms and a forward link (early Subaru WRX), single lower arm with steering link and forward link (early Toyota MR2), or an A-arm bottom with steering link? And where should we mount the top of the strut in relation to everything else in terms of anti-squat, etc?

THE CONSULTANT

A few questions from me first. Are there ever any asphalt bits on these courses, or does the car always run on the gravel? Can you provide

your rules, or a link to them? Finally, what does that transaxle have for a diff?

CORRESPONDENT

Every course is different, the events are ralliesprints or hillclimbs that take place around our local area. So the road surface changes a bit, but it is always on the gravel. We run in the Unlimited class, so there are basically no rules. The diff is a plate-type LSD, I think around 60lb breakaway from memory.

THE CONSULTANT

No rules? So why are you running a steel sedan with two-wheel drive? At Pikes Peak they have a class they call Unlimited where the racecar has to be production based and I guess there are some body and wing rules but practically anything goes mechanically, and another class they call Open, where the cars can be scratch-built single seaters but have to be two-wheel drive and can't have forced induction.

I am happy to help you with the suspension, but that will only get you so far. If you really want a huge improvement, quick and cheap, add a big splitter on the front and a giant wing above the roof. Better yet, build an open wheeled single seater with your existing powertrain and as much wing as you can hang on it. Or am I missing something here?

CORRESPONDENT

We do have some rules, I guess it would be similar to Pikes Peak Unlimited. The wing can only be 100mm above the roofline and the width of the body. We are limited on the size of the front splitter due to it getting ripped off on rougher roads or cutting corners. We run a flat underfloor and rear diffuser so our aero is pretty well balanced. More aero won't help with getting traction off the start line though.

The car is very quick on fast open roads, but it is the slow speed traction that is costing us. Most of our events are timed from a standing start, and getting off the start line or out of tight corners with 400bhp in a 2wd is the issue. Our closest competitor runs a Toyota MR2 AW11 with a mid-mounted 500bhp Nissan engine. We are very closely matched but his

car is much faster off the start line or out of hairpin corners – it gets more traction and we can't figure out why. We run the same tyres. His car has a single lower arm with a steering link and forward link on the rear. In theory the things that will affect our straightline traction are tyres, shock absorbers, spring rates, diff, suspension geometry. We have tried several variations of all of the above. Changing shock absorbers has made the biggest difference so far in getting the rear tyres to bite.

THE CONSULTANT

Now I see why you're focusing on the suspension. My guess would be that the MR2's simply got more static rear percentage than you have. Ordinarily, your 65 per cent is considered to be about the practical upper limit, but on a slippery surface you could probably get away with a bit more. I don't know how the engine weights compare but I would expect a V6 to be heavier than a boxer 4-cylinder. If he has a similar transaxle to yours, and similar total car weight, he would then have more static rear. I take it you have no minimum weight, and no ballast?

Do you set brake balance so the rears lock before the fronts, so the driver can use the brakes to toss the car in on the entry to a corner? Do you use the handbrake to turn the car? As set up now, does the car corner on three wheels? How much of the bodywork is plastic or lightweight material?



Subaru Justy. The car in question is based on this little runabout but packs a 400bhp engine. It is used for gravel-track hillclimbs

Do you set the brake balance so the rears lock before the fronts?

It looks like your current front springs are really stiff for use on dirt

CORRESPONDENT

The MR2 is about 150kg lighter and probably closer to 55/45 rear split I would imagine. I would have thought the extra weight over the rear wheels would help us with traction. It may be all to do with shock absorbers.

We run the same brakes front and rear with more rear bias, and use the handbrake for hairpin corners. The car does not lift a wheel when cornering. Most of the panels are original steel or alloy but the car's been gutted, is as light as possible; with fibreglass bonnet, plastic bumpers. No minimum weight or ballast.

THE CONSULTANT

It may be that you can get some further improvement with shocks. It may also be that control of power delivery can be improved. I don't know what your rules on traction control are, but that would obviously help.

Now, let's get to the original question: is it worthwhile trying to increase the anti-squat; how do you do that in a strut suspension; what is the best configuration for the lower control arm and the system as a whole?

First, is it worthwhile? Anti-squat helps by raising the car and therefore increasing the amount of rearward load transfer for a given forward acceleration. It's tempting to think that the jacking force loads the wheels more than it really does; it makes the suspension push the car up, so that must push the wheels down. But since there's nothing keeping the sprung mass from just rising, all we really do is unload the springs and raise the car a bit.

How much improvement are we talking about? Suppose the c.g. height is 1/6 of the wheelbase, the static rear percentage is 65 per cent, and the car can accelerate forward at 0.4g. That would be a coefficient of friction between 0.5 and 0.6. Then 0.4/6, or 1/15, or between six per cent and seven per cent of the car's weight transfers rearward. If we can raise the c.g. by 10 per cent, or about an inch and a

half, we increase that by 10 per cent of its previous value, or about two thirds of a point. That will get us about one per cent more, or about .004g more, forward acceleration. Not much, but it can't hurt.

Note that how much the car lifts depends not only on how much the rear squats or lifts but also on how much the front lifts. Front suspension geometry doesn't affect this in a rear-drive car (except for the motion ratio on the springs) because there is no significant ground plane force at the front contact patches. How much the front lifts depends on the front springs, or more precisely the wheel rate. With softer springs it lifts more. With soft rebound damping it lifts faster, but the springs determine how far it lifts. Therefore, you might consider going softer on the front springs and adding an anti-roll bar to get the elastic roll resistance back to where it was with the stiffer springs. In fact, if you are currently running no anti-roll bars you might consider using them.

It looks like your current front springs are really stiff for dirt. Assuming a 0.9 spring to wheel motion ratio, 240lb/in springs would give a wheel rate just under 200lb/in. You have about 300lbs of sprung weight per wheel in front, so that's a static deflection of only about an inch and a half, or around 150 opm (2.5Hz) frequency. That's stiff tarmac car territory.

At the rear, assuming the same motion ratio, you've around 150lb/in and 600lbs sprung weight per wheel, for a static deflection of around 4in and a frequency of about 90 opm (1.5Hz). That's just a little too stiff for dirt.

You could set the car up so it has a lower frequency in front than in back, as is common in front-engined cars. With the same rear springs as at present, you'd want about a five inch static deflection. That would call for a wheel rate around 60lb/in or a spring rate around 75 or 80lb/in. You would get about three times the front end lift under power that you get now. You'd then need to add an anti-roll bar that would provide around about 135lb/in/wheel at the wheels to get similar cornering balance to what you have now.

In any independent rear suspension, the jacking coefficient under power depends on the side-view motion path of the hub as the suspension moves. For anti-squat, you want the motion path to lean backward at the top and forward at the bottom. It's also best if the path is concave rearward. Given a free hand, with a strut I would want a lateral link and toe link, and a leading link in place of the Toyota's trailing link. This should anchor somewhere near hub height at the hub carrier and back and lower than that at the frame.

I would try for at least 100 per cent anti-squat as a middle setting, and try to provide


adjustment from there. That would be a link angle of around nine, ten degrees from horizontal, nose up. Increase the anti-squat until you get wheel hop, then back off a bit.

If the longitudinal link anchors to the hub carrier fairly close to hub height, the side view strut angle has little effect on anti-squat. If the strut is close to vertical in side view and the system has anti-squat, the strut will swing rearward at the bottom as the suspension compresses, and forward as it extends. It's okay as long as nothing runs out of angular travel.

But the side view angle of the strut matters for anti-lift under braking. This is why I wanted to know if you turn the car with rear brake. With outboard brakes, if the system has anti-squat and the strut is close to vertical in side view, the system will have a greater jacking coefficient in braking than under power. This means that as you increase anti-squat, you will very likely be limited by wheel hop in braking before you are limited by wheel hop in power.

To get away from this, you need to incline the strut back at the top. The leading link and the strut needs to make an angle of less than 90 degrees. The strut should lean back around 20 to 30 degrees. This gives a side view instant centre behind and below the hub. The hub carrier should rotate rearward as the suspension compresses and forward as it extends. It is possible to achieve similar effects with a lower control arm and a toe link. You incline the arm's pivot axis up at the front. Ideally you would also like it angled in top view, in at the front, out at the rear. That makes the hub motion path concave rearward. However, I would opt for the leading link instead, because it would probably be easier to provide anti-squat adjustment that way.

Of course, all of this will be affected by considerations of packaging and load paths. The leading link would also have to have a frame structure to attach to, and this then has to be adequately rigid. This may or may not be practical.

Front-view inclination of the strut does not affect anti-squat or anti-lift. It does affect camber properties and roll centre height. 

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, get in touch.

E: markortizauto@windstream.net

T: +1 704-933-8876

A: Mark Ortiz

155 Wankel Drive, Kannapolis
NC 28083-8200, USA



Unlike this more typical rally Subaru the car is mid-engined and rear-wheel drive, but suffers with poor traction out of the turns

-35mm Worlds apart

Our technology centre is the most advanced in Europe.

That is how we can achieve a negative radius of up to -35mm. Extreme engineering and precision that other performance cam manufacturers in Europe cannot match. All our camshafts and ancillaries have been developed by the best to be the best.

N°1

Kent Cams – the best in Europe:

- No.1 for product development expertise
- The greatest performance increase of any single modification
- The widest range of camshaft ancillaries produced on site

- The most advanced technology:
Negative radius to -35mm
CBN wheels with constant surface speed
Multi-angle lobes with CNC dressing
Marposs 3D C and Z axis position probe
Microphonic wheel dressing
Lotus Concept Valve Train software



**HIGH PERFORMANCE
ENGINEERING**

www.kentcams.com

Cams + Pulleys, Belts & Chains :: Valves & Valve Springs :: Performance Cam Kits & Valve Spring Kits :: Followers & Tappets

HEIGHT GAUGE

HARDNESS TESTER

SURFACE, ROUNDNESS

TURNED PARTS

BORE GAUGING

CALIBRATION

NON-CONTACT MEASUREMENT

**WHATEVER YOUR MEASUREMENT NEED
BOWERS IS YOUR PARTNER IN PRECISION**



BOWERS GROUP

Telephone: 08708 50 90 50
www.bowersgroup.co.uk
sales@bowersgroup.co.uk

The Bowers Group offers organisations across the globe a range of quality metrology instruments to assist them in the creation and development of exceptional products designed to meet the exacting needs of today's markets.

The Bowers Group of Companies



Spot the winner

960-388e-03.16

Maximum precision and uncompromisingly rugged design: these are the hallmarks of our motor racing sensors. They can withstand harsh conditions on racing circuits with supreme ease, steering your vehicle to success – lap after lap. Wherever and whenever you need technical support, we are ready to assist with our complete, customized solutions and full-scale professional service across the globe.

KISTLER

measure. analyze. innovate.

www.kistler.com

CARTEK
MOTORSPORT ELECTRONICS

2017 PRODUCT RANGE



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



Trimming the aero on a DJ Firestorm

The UK hillclimber gets its flaps tweaked and rake adjusted

The latest variant of the DJ Firestorm uses the compact, lightweight 2.5-litre V6 Cosworth KF ex-DTM engine to help give it nimble handling. But with a power deficit to the competition, aerodynamic efficiency is important and, along with the usual quest for a good aero balance, this was part of our focus in the MIRA full-scale wind tunnel.

In baseline configuration the car appeared to have a somewhat rear-biased aero balance but by the end of the session various means of refining the balance had been established, and the session's best figures showed good progress. Balanced set-ups at other downforce levels could also be divined from the data and trends that were recorded, but **Table 1** shows the baseline and best numbers from our session. Although total downforce was less in the 'best' configuration, drag was also down, balance was in the optimal range, and -L/D (efficiency) had improved.

The simplest way of adjusting the car's balance was via wing flap adjustments. For expediency just two alternative flap angles at front and rear were evaluated, and their effect on the car's aerodynamic balance (%front) was plotted, allowing interpolation on the linear part of the lift slopes.

Winging it

The rear wing baseline setting was one hole from maximum, so a middle position (hole 4 of 8, position 1) and the maximum setting (position 3) were also evaluated (**Figure 1**). At its maximum setting the rear downforce gains were tailing off, but between positions 1 and 2 the lift slope would be essentially linear. With a range from 34.2 per cent front at position 1 to 28.9 per cent front at position 2 we can see there was approximately 1.8 per cent front change per adjustment increment. So, for example, dropping the rear flap to hole 3, one

down from position 1, would have changed the balance to 36 per cent front.

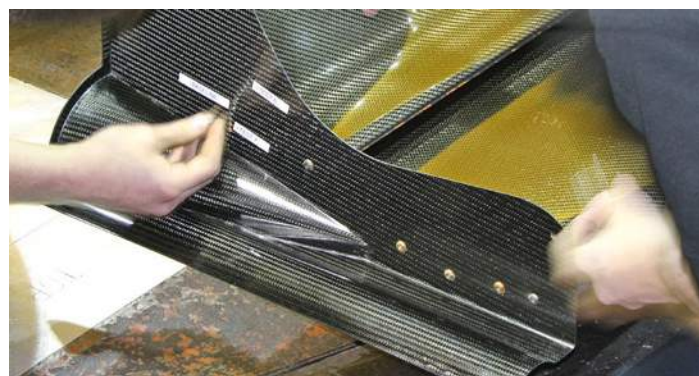
The front wing baseline setting was hole 5 of 12 (flap angle 25 degrees), so one hole from minimum (position 1) and one hole from maximum (position 3) were evaluated (see **Figure 2**). In this case the linear part of the lift slope would extend from position 1 to position 2 and most probably slightly beyond this, perhaps to 30 degrees, or two more adjustment holes. Unfortunately, in requesting 'one from maximum' prior to the session your writer failed to realise what angle this would create, and at that setting the wing had clearly stalled.

Nevertheless, we can interpolate between positions 1 and 2 and calculate that with a range of 14.6 per cent front to 28.9 per cent front there was approximately 4.8 per cent front per adjustment increment.

By extrapolation, setting the front flap to hole 6 would have changed the balance



The DJ Firestorm is light but not as powerful as rivals, so a good aero package is vital



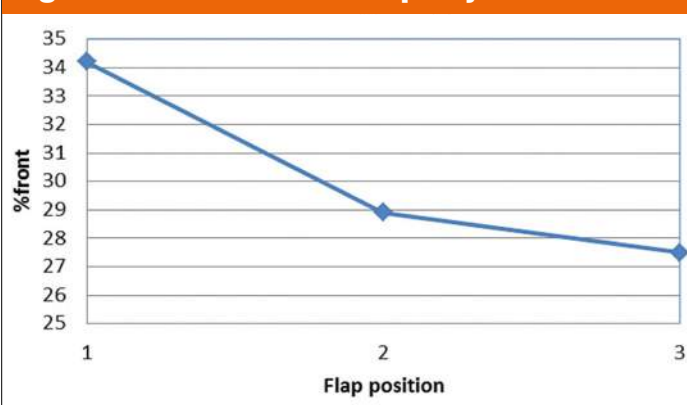
Front flap adjustments produced marked balance shifts, with more scope for work here

Table 1: Baseline and best numbers on the DJ Firestorm

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline	0.775	1.892	0.547	1.345	28.9%	2.443
Best	0.699	1.741	0.650	1.091	37.3%	2.492

Lowering the whole racecar by 15mm decreased total downforce, despite a front downforce increase, and decreased drag

Figure 1: Effect of rear flap adjustment

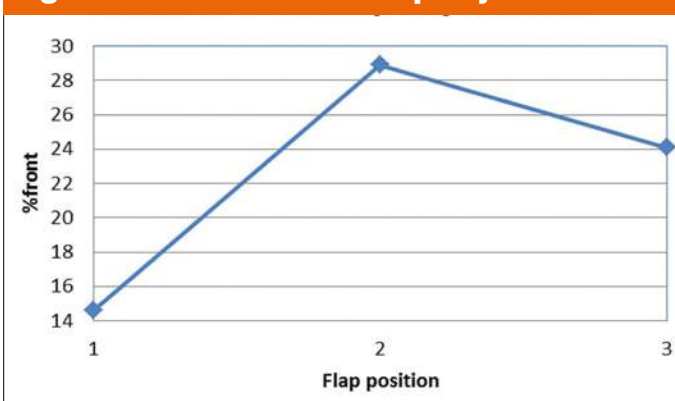


Flap adjustment was the simplest way of adjusting balance. Interpolation between tested positions provided a balance change value for each available adjustment increment



Moving the beam wing yielded some interesting results and is a worthwhile modification

Figure 2: Effect of front flap adjustment



Interpolation and limited extrapolation of the front flap data showed that further improvements were available, despite these not being tested during the session

Table 2: The changes arising from rake adjustments

	Δ CD	Δ -CL	Δ -CLfront	Δ -CLrear	Δ %front*	Δ -L/D
FRH down 15mm	+6	+52	+56	-4	+2.1%	+45
FRH and RRH down 15mm	-20	-91	+28	-119	+3.0%	-58
RRH down 15mm	-22	-150	-35	-115	+0.5%	-129

*Absolute rather than relative difference in percentage front.

Table 3: The effects of moving the rear beam wing relative to the baseline

	Δ CD	Δ -CL	Δ -CLfront	Δ -CLrear	Δ %front*	Δ -L/D
40mm forwards	-1	-48	+16	-64	+1.6%	-59
80mm forwards	-2	-85	+32	-118	+3.2%	-106
20mm downwards	-5	+8	+3	+5	+0.1%	+24
40mm downwards	-9	+19	+6	+14	Nil	+53

*Absolute rather than relative difference in percentage front.

to 33.7 per cent front, and hole 7 would have yielded 38.5 per cent front (with a higher total downforce level and better -L/D than baseline, too). Regrettably, we did not try these settings, but our confidence in these limited extrapolations is good.

Rake it up

The car's driver requested that we look at a small range of rake adjustments to see if there was a big aero balance shift. So three coarse adjustments were made using the suspension pushrods; the front was lowered 15mm from the baseline; front and rear were lowered 15mm; and the rear only was lowered 15mm. **Table 2** shows the differences (as Δ or delta values) in counts relative to baseline, where one count is a coefficient change of 0.001.

Lowering the front ride height (FRH) by 15mm had the expected effect, with an increase in front downforce (possibly mostly from the front wing) and a commensurate forwards balance shift. Assuming the car could be dynamically kept clear of the ground with a lower front, and was statically legal against the

40mm regulatory minimum, this would appear to be beneficial and more efficient.

Lowering the whole car by 15mm decreased total downforce despite a front downforce increase, and decreased drag. This suggested a reduction in mass flow under the car. It was noticed that the car compressed quite significantly on its suspension as air speed increased. However, the car features a 25mm stepped underbody to mitigate choking under the outer sections of floor as ride height reduces. So were we seeing a combination of reduced static ride height plus dynamically decreasing ride height combined with the wind tunnel fixed floor's boundary layer choking the underbody flow? If so then we would not necessarily expect a similar response on track.

Lowering the RRH only by 15mm had a similar effect to lowering the whole car except front downforce reduced as well, and as such there was minimal balance shift. Interestingly, the balance shifts in the previous two cases were not particularly large, either.

Next, we looked at the beam wing. We have seen in the past that these not only add their

own increment of downforce but they also help to generate more underbody downforce by increasing the mass flow under the car. So, was the beam wing optimally positioned?

Beam counters

Two further forwards positions and two lower positions were evaluated, with the results in **Table 3** as delta values relative to the baseline. Note that through clever machining of the test end plates, the upper wing tier remained in its baseline position throughout; the beam wing was moved relative to everything else.

The responses were clear cut. Moving the beam wing forwards reduced rear downforce linearly, suggesting the dominant influence was reduced leverage on the rear wheels by the beam wing. However, moving the beam wing downwards caused total downforce to increase but without any balance shift, and the numbers suggested moving it lower again might continue to increase downforce. This implied that the interaction with the underbody was enhanced by lowering the beam wing. And from what we learned above about ride heights we might expect this effect to be more significant on track than in the fixed floor wind tunnel. Efficiency increased by 2.2 per cent in the tunnel, so this looked worthwhile. *Racecar's thanks to Richard and Alex Summers and the DJ Engineering crew.*

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

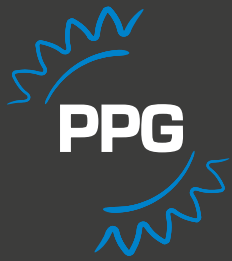


Tel: +44 (0) 24-7635 5000

Email: enquiries@horiba-mira.com

Website: www.horiba-mira.com

The interaction with the underbody seemed to be enhanced by lowering the beam wing



PFITZNER

Performance Gearboxes



Designed to perform. Engineered to last.
Proven in competition.

HIGH PERFORMANCE MOTORSPORT GEAR SETS AND SEQUENTIAL SYSTEMS THAT UTILISE OEM CASINGS AND COMPONENTS
SUBARU WRX SEQUENTIAL GEAR SYSTEM // HONDA B & K-SERIES HELICAL AND STRAIGHT CUT DOG



ppgearbox.com.au

RCM

david@ppgearbox.com.au sales@rogerclarkmotorsport.co.uk



#coolgearsforcoolcars



180 MPH WITHOUT MOVING AN INCH

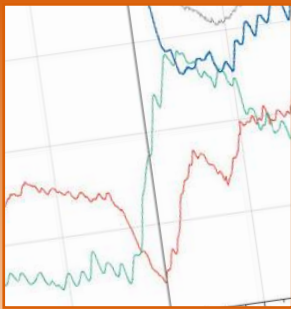
Take cutting-edge wind tunnel technology. Add a 180 mph rolling road.
And build in the best in precision data acquisition capabilities. When we
created the world's first and finest commercially available full-scale testing
environment of its kind, we did much more than create a new wind tunnel.
We created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



+1 704 788 9463

INFO@WINDSHEARINC.COM

WINDSHEARINC.COM



Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

The canny way to design your CAN

When configuring CAN architecture there are a number of things you need to bear in mind – as explained in part 1 of our new CAN series

Back in 2014 we explained a little bit about CAN, in terms of how you generate a CAN stream, what the IDs mean, gains and offsets, bits and bytes, etc.

Back then a lot of the on-car systems were relatively simple and didn't feature their own controllers. But as modern day racecars become more and more complex, many previously trivial ancillary components and systems on a car now have their own in-built controllers and strategies. Many of these then exhibit different behaviours and outputs based on

different scenarios and circumstances. The result of this is that these systems now require their own data feed from the rest of the main car electronics and sensors, whereas traditionally it simply provided power to turn on, or at most provided a simple PWM signal with varying duty.

CAN do attitude

The thinking behind this increased control is that it's to improve performance and flexibility, and generally speaking it does this, but it also brings along additional complexities. Most of these systems

utilise the data already available to the central car systems and communicate via CAN to the main car data-loggers; engine ECU etc. Using CAN as the default communication method means that the on-car wiring is simplified by sending numerous data channels over two CAN wires instead of duplicating lots of different digital and analogue inputs to individual control units. This means the quality of your wiring looms and CAN network is critical, to maintain integrity and reliability of the car.

This article highlights some of the aspects to consider when designing



Modern GTs can often have more than 10 different units on the car all reliant on CAN for data and control messages. Headlight channels need careful attention

How does your system react when there is a failure on the CAN bus?

Table 1: The units reliant on CAN in a typical GT car

1. Engine ECU (sometimes separate transmission ECU as well)	2. ABS system
3. Transmission system actuator	4. Scrutineering system
5. Transmission system compressor	6. Camera system
7. Driver switch panel	8. Headlights and tail-lights
9. Steering wheel	10. Scrutineering; position light panel
11. Data-logger	12. Power steering system
13. Driver display	14. Alternator
15. Power management unit	

Table 2: Spreadsheet of entire CAN bus architecture

ID	TX Offset + 0x08		
Dir	ECU TX		
Rate	100Hz		
Bits	Name	Scaling	Notes
0-15	TPSA	(X / 10) [°]	
16-31	TPSB	(X / 10) [°]	
32-47	PPS	(X / 10) [%]	
48-36	fbw target Tps	(X / 81.92) [%]	

the car loom and CAN architecture of the system. As cars become more and more complex, and in the drive to save weight and cost, the loom is designed to utilise data that is already available on the car. This element of loom design is critical to get right, to avoid costly and time consuming redesigns. A typical GT car can easily have more than 10 different units on the car all reliant on CAN for their data and control messages (Table 1). The complication here is working out an effective CAN architecture where you can get the relevant data to the relevant units correctly and efficiently. Here are some tips.

1. Spread the load

Due to the nature of CAN, it would be impossible to put all the units in Table 1 on a single CAN bus, because the amount of data being transmitted along a single bus would overload it.

2. Minimise bridging

Think about what units need to receive what data. It is common for the ABS system to send wheel speed signals to the ECU. So it would be efficient to have these two units in the same CAN bus, rather than having the ABS talking to the power management, and then duplicating the wheel speed channels on a different bus from the power management unit to the ECU. This creates unnecessary CAN traffic which uses up valuable CAN space.

3. Integrity

As well as the general wiring guidelines for CAN – such as making

sure your CAN low and high are in twisted pairs, making sure the bus is terminated at both ends only, that there are no spurs in the system etc – it is also important to think about the dangers of rogue CAN signals from other devices.

For example, all of the Cosworth systems that interface with a Cosworth Engine ECU feature a Cosworth validation word in the CAN stream. This is effectively a handshake protocol to ensure the integrity of the CAN bus, and is there as a safety precaution to protect the car and

instead reports a denied shift and sets the CAN stream status to failed.

4. Clashing CAN IDs


With all this CAN traffic from multiple devices each CAN frame has its own separate ID. It is important that these IDs are all different as the last thing you want is the ABS system to be looking for an engine rpm channel, but then quite suddenly instead it receives a headlight flash control signal in its place instead!

It is generally recommended to put together a spreadsheet of the

is CAN-controlled lights. If you hit the corner of the car and you lose a headlight, then if you have the engine ECU, transmission system actuator, or any other key component on the same CAN bus, the bus is then likely to fail; meaning it is now a racecar stopping situation just because you lost a headlight.

Therefore, it is advised to keep key components needed for the car to operate on a separate CAN bus to other, not so key, generally ancillary based systems. In addition, if you have both front headlights on the same bus, losing one headlight in a corner accident then means you will lose both headlights as the CAN bus is broken. The last thing you want in the middle of the night in the Spa 24-hours is not to have any headlights.

6. Failure strategies

How does your system react when there is a failure on the CAN bus? Be aware of this and think about different scenarios. I have already touched on an ECU example. Going back to the headlights example, generally if the CAN link is removed to units such as headlights, if there is still power to them, they typically default to an on condition, so you can still see where you are driving. 

COSWORTH

Produced in association with Cosworth

Tel: +44 (0)1954 253600

Email: ceenquiries@cosworth.com

Website: www.cosworth.com

The complication here is working out an effective CAN architecture where you can get the relevant data to the relevant units correctly and efficiently

driver from damage if there are issues with the CAN bus. For example, if a gearshift paddle request is transmitted from a CAN switch board in the steering wheel to a Cosworth ECU, if the Cosworth validation word is not received with it, the Cosworth ECU will ignore the CAN stream. This is because the ECU cannot validate where this CAN signal came from, it could have come from another device on the bus, a failing component etc.

So instead of simply processing the unidentified, rogue shift request which may damage the car or even worse cause an accident, the ECU

entire CAN bus architecture noting each CAN frame, its contents and its ID for each CAN bus on the car.

Not only will this highlight any clashing IDs or duplicated channels it also serves as a handy reference if you need to monitor the bus or add extra channels or devices at a later date, because you can quickly see which IDs are free (Table 2.)

5. Damaged unit

But what happens if a unit is damaged or fails? Think about what items are vulnerable if there is an accident. The best example of this



COSWORTH

For unrivalled performance

Think **inside**
the box

For full details visit our website or contact us

sales.electronics@cosworth.com
www.cosworth.com/LMP-DPi

UK: +44 (0)1954 253600 • US: +1 (317) 808 3800



Ansible Motion's Stratiform-style primary motion machine is used by F1, NASCAR and IndyCar teams, as well as road car manufacturers

Keeping it **real**

When it comes to driver immersion on a simulator the devil is very much in the detail – *Racecar* took a trip to Ansible Motion to discover the technical touches that make a good sim great



Drivers and engineers need the most realistic experience possible to derive maximum benefit from a simulator

Today there's a whole generation of racing drivers who rely on simulators to prepare for race weekends and for developing cars. For some, sims have even become a healthy source of revenue, offering good pay and steady income all through the year.

With ever tighter test restrictions and rules that forbid drivers from racing in other categories at circuits they'll visit later in the year (FIA F3 for one), simulators are making significant inroads into replacing real track time. And whilst sims still can't replicate the paddock cafe that's still an intrinsic part of a day's testing at many race tracks, they are getting very good at replicating the track experience itself.

A number of dedicated simulator manufacturing companies are now flourishing, each finding a niche within the burgeoning market in motorsport and automotive for their products. Whatever the sector or application, there is a growing demand for a more realistic and immersive experience from both drivers and engineers alike.

This demand has seen some forward-looking sim manufacturers move away from the legacy 'hexapod' machines that provided those early, simplified experiences of movement to drivers. For while hexapods in motion might be entertaining to watch, vehicle engineers and professional drivers can't ignore the fact that racing cars typically do most of their business near the ground plane and, as such, the motions provided by a carnival ride or aircraft-style simulator simply isn't going to simulate a real car very well.

Virtual virtues

Drivers and, to more or less the same extent, their engineers, need the most realistic experience possible to derive maximum benefit from a simulator and to see it as a tool for increasing performance. 'Unless a simulator can generate 100 per cent mental engagement from the driver, it won't be an effective vehicle development tool,' says Phil Morse, technical liaison at Ansible Motion. 'We want a driver to hop out of our simulator and start discussing set-up changes just as they would if they had stepped out of a real car.'

Since the firm's beginnings in 2009, Ansible has continued to focus on stimulating the driver's senses while they are engaged in a simulation. Retaining its unique, patented Stratiform-style primary motion machinery that is used by F1, NASCAR, IndyCar and automotive, it's developed an array of methods to deliver the supplementary cues that deliver additional layers of realism. 'The big cues such as motion and graphics are, by and large, well understood, but we wanted to go further and bring in additional levels of detail,' Morse says.

Supplementary cues are not new; seatbelt tensioners, audio and haptic feedback devices, as well as pedal and



The Rear View Emulation adds to the immersive experience. It's very useful for multi-class sportscar simulations where the drivers need to look out for faster cars about to lap them

‘Helmet loading is a particularly useful supplementary cue for drivers in certain scenarios such as ovals and sweeps’



Glancing in a wing mirror every now and then is an automatic action for a driver so the RVE brings an extra touch of reality. Even if it's only peripheral the driver needs to be aware of it

steering wheel loaders have all been around for many years. But Ansible Motion maintains this is just the tip of the iceberg when it comes to bringing simulation to life.

Rear view

One refinement is Ansible Motion's Rear View Emulation (RVE) system. According to Morse: 'For categories where dealing with traffic is important, the view of cars coming up in your mirrors is actually a contributor to the driver's workload, even when there is no conscious recognition of it or direct gazing by the driver. Just think of a GT application in WEC where there is a stream of prototypes barging their way past – a driver needs visual awareness of this, even if it's only peripheral. With RVE we can now replicate this so drivers can experience these conditions, and throw in a realistic wing mirror glance at the end of a double stint.'

Morse says it's not just sportscars that find looking behind important. 'NASCAR is a great example of where we have created more

realistic driving environments in our simulators with RVE "mirrors" at the top of windscreens,' he says. 'In NASCAR, the in-car mirrors are quite large, so they can consume a significant part of the total field of view. So here we have a case where its absence would be really conspicuous.'

Aside from the visual cues, Ansible Motion has started to deliver its latest version of its Helmet Loading System (HLS) to race teams in a wide range of different series, too. Already finding favour with drivers, the electro-mechanical device offers the ability, instantaneously, to apply up to 4.8Nm of torque safely with higher torque options on offer.

'Helmet loading is a particularly useful supplementary cue for drivers in certain scenarios such as ovals and sweeps,' Morse says. 'HLS provides sustained and transient kinaesthetic sensations, so a driver feels these perfectly timed, subtle indicators that add to the illusion of being in a real racecar.'

Hard wired

Another area of focus right now involves the ever greater integration of motorsport hardware into the simulator. 'It's all about getting the most representative results,' Morse says. 'If you look at just how complex steering wheels have become, for example, they now have a double digit count of buttons and multiple paddles, meaning the driver workload has exploded. You've also got traction control, speed limiters, battery management and DRS, etc. By replicating these precisely, the race teams can assess how the driver copes with the real-life workload.'

'The sim then also becomes an effective tool for determining what can be done to optimise this,' Morse adds. 'In a championship like Formula E, where the energy management is so crucial and with drivers expected to stay on top of its consumption and regeneration, Ansible Motion brings that experience alive by allowing seamless integration with the real onboard systems that matter.'

With the small details making a big difference, the next question is, what comes next for this tech? 'Simulator development is never ending,' says Morse. 'There is always the forward march of graphics and computational processing, and vision technology – higher resolution projection systems, lower latency graphics pipelines, and so on.'

'We operate a dedicated R&D centre, and our team is always exploring new ideas and possibilities,' Morse adds. 'We've recently created some new switchgear that allows race teams to switch from one category of car to another in less than 45 minutes – that's including a full cockpit swap. We don't see supplying a driving simulator as an end in itself, far from it. We're providing a tool, hopefully a good one, a useful one. But, of course, there are always things we can do to make it better.'



The Helmet Loading System is fitted to the top of the race seat and it applies torque loads to simulate cornering force

ROD ENDS & SPHERICALS

MOTORSPORT QUALITY



contacts in English, Deutsch, Français, Italiano

AURORA® • RODOBAL® • Seals-it®

technical support, flexible service, broadest range in stock in Europe, worldwide express shipments to OEMs and distributors

inch sizes
metric sizes

ROD ENDS ACCESSORIES:
lateral seals
protection boots,
jam-nuts
right-hand, left-hand
bearings and boots
installation tools

Getecno srl - Genova, Italy

fax +39 010 835.66.55
phone +39 010 835.60.16

web: www.getecno.com
e-mail: info@getecno.com

Champions Choose

PRO FABrication
Racing Exhaust Systems



Custom Headers



Mandrel Bends



Merge Collectors



CNC Flanges

Sales@ProFabrication.com • 704.795.7563 • ProFabrication.com

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

DOCKING
Advanced Cooling Systems

Water Radiators
Intercoolers
Oil Coolers
Heat Exchangers
System Design
Ancillary Products

Manufactured to your
requirements by the
UK's leading supplier.

E info@dockingengineering.com

Tel 00 44 (0) 1327 857164

Fax 00 44 (0) 1327 858011

Website www.dockingengineering.com

Unit 15 Silverstone Circuit • Silverstone Northants • NN12 8TL • United Kingdom

The white stuff

Since 1981 carbon fibre has been at the heart of high-end racecar design, offering low weight and high strength, but could Diolen provide a cost effective and practical alternative?

By **ELIZABETH APTHORP**

Advanced Motorsport Engineering MSc Student at Cranfield University

The carbon tub is now as familiar a sight in racing as the chequered flag. This is the first of the breed, McLaren's MP4/1



Carbon composite materials are now commonplace in modern chassis design, taking over from aluminium at the start of the 1980s thanks the revolutionary McLaren MP4/1. In its first season, it proved its strength at the 1981 Italian Grand Prix, when John Watson stepped from the wreckage of his car unscathed after a crash.

The reason the leap was made from metal to composite can be explained by fundamental principles. Materials are often characterised by two qualities: strength and stiffness. Strength is the ability to withstand a load without failure or plastic deformation. Whereas, stiffness is the extent to which a material resists deformation to an applied load. Metals, such as steel and aluminium, have been used for years due to their high strength and stiffness properties.

Carbon fibre also has these properties. However, carbon fibre gains a significant advantage in the area of *specific strength* – strength per kilogram. In racing, light-weighting

is required in order to remain competitive, but strength is also required in order to maintain structural integrity. Carbon fibre composite is a lightweight, strong solution. However, by opting to use carbon fibre composite, the costs increase, and so does the complexity.

High fibre

Metals are considered isotropic because their material properties are the same in all directions. Whereas, unidirectional CFRPs (carbon fibre reinforced polymers) are considered transversely isotropic because their material properties change when measured in relation to the fibre direction. This is the first fundamental difference between metals and carbon fibre composites. Metals have strength in all directions, whereas the strength in carbon fibre composites is mostly in the fibre direction.

In racing, carbon fibre has been the wonder material of the last three decades. But does that mean we should stop exploring other materials?

For instance, why not look at Diolen? This is a white polyester fibre, or PET (polyethylene terephthalate) to be correct. It is not a new material; it has been around for years in many different industries, such as the marine industry, where it is used in kayaks, jet-skis, lifeboats etc. It is also distributed by FR Safety Yarns GmbH and Co as Diolen SAFE for trains, buses, aircraft, ships and more. In the initial processing, a flame retardant property is introduced by using a phosphor-organic compound. This property doesn't degrade with time or wear. So, does Diolen have a part to play in racing?

Diolen code

The basic material properties of Diolen are what makes it interesting from a racing perspective. By understanding these basic material properties and applying them correctly, a radical engineering solution can be found which dramatically increases performance. Comparing Diolen to other fibres (carbon,

Carbon fibre has been the wonder material of the last three decades



John Watson had carbon to thank after he emerged unscathed from a crash at Monza in the McLaren MP4/1



Diolen is ideal for side intrusion panels and was used for this purpose on the MSV 013 Formula 4 racecar

glass, aramid), it has very low density and high abrasion resistance. However, its Young's modulus is below 50 per cent of that of carbon. Thus, if stiffness is critical, Diolen may not be appropriate. The most interesting property is that the fibres have extremely high strain-to-failure properties. A data sheet from Polyester High Performance (PHP), an Indorama Ventures company, lists the 21 variants of Diolen, with one type, 'Diolen 54S', claiming an elongation-to-break of 27 per cent! For comparison, carbon fibres are around the one per cent mark. This high strain-to-failure gives Diolen the potential to be used as an excellent impact material if applied correctly.

In order to understand why Diolen might be useful for impact structures, we first need to understand what we want from an impact structure. For a front crash structure, the aim is to absorb most (if not all) of the impact energy. In Formula 1, a carbon fibre nose box is used. In this case, it is desirable for the part to shatter into a million pieces, rather than peel like a banana. This is because the impact energy is absorbed during the process of creating lots of

tiny pieces. Thus, carbon is an excellent choice of material because of its low elongation-to-break properties, which allows local fibre breakage to control in-plane crushing and thus absorb impact energy. Diolen would not be effective in this application due to its high strain-to-failure properties. The fibres would not break and the part would not shatter and thus the impact energy would not be well absorbed.

However, Diolen may be effective in a different impact structure: side intrusion panels. One example where Diolen has been used for this purpose is the MSV 013 Formula 4 car.

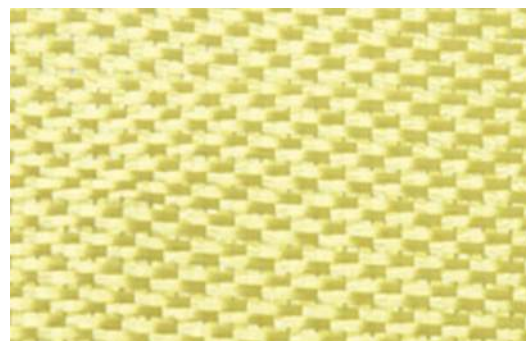
Side protection

For side intrusion panels, a carbon piece shattering is not desirable. The aim is to protect the driver from the impacting object, but also prevent the car crushing the driver.

Diolen could actually be extremely useful here, as when the fibres are impacted, they will elongate and not break. This could then prevent penetration into the cockpit. In order to take advantage of its strain capability, space would need to be allowed for the deflection



Carbon's strength is in the direction in which the fibre is woven



Aramid, better known as Kevlar, is widely used in motorsport



Diolen is a white material with high strain-to-failure properties

of the panel – so that it can absorb the impact energy and not hit the driver.

A short set of impact tests were carried out in order to get a better understanding of Diolen's capabilities. Three panels were compared: a base panel of pure carbon fibre; a carbon fibre panel reinforced with aramid; and a carbon fibre panel reinforced with Diolen. Aramid, better known by its brand name, Kevlar, was chosen as the comparative material because it is a well-known impact material and is used extensively in racing. Aramid is a p-phenylene-terephthalamide (PPTA), which is the simplest form of the ABBB para-polyaramide. What this means is the fibres have chain molecules which are aligned along the fibre axis in order to utilise the chemical bond strength. The aim of the testing was to validate a claim that Diolen has 80 per cent of the impact properties of aramid, but at a fraction of its cost.

The testing was carried out in accordance to the British Standard ISO 18352. The requested lay-up was: [-45/0/45/90]_{2s}. The base panel consisted of 16 plies of carbon fibre. The reinforced panels replaced four carbon plies



Table 1: Lay-up configuration for impact test panels

No.	Material	Lay-up	Plies
1	Carbon	[-45/0/45/90/-45/0/45/90/90/45/0/-45/90/45/0/-45]	16 c
2	Aramid	[-45/0/45/a90/-45/0/45/a90/a90/45/0/-45/a90/45/0/-45]	12 c + 4 a
3	Diolen	[-45/0/45/d90/-45/0/45/d90/d90/45/0/-45/d90/45/0/-45]	12 c + 4 d

where c is carbon, a is aramid and d is Diolen.

Fig 1: Force against time for drop tower impact test

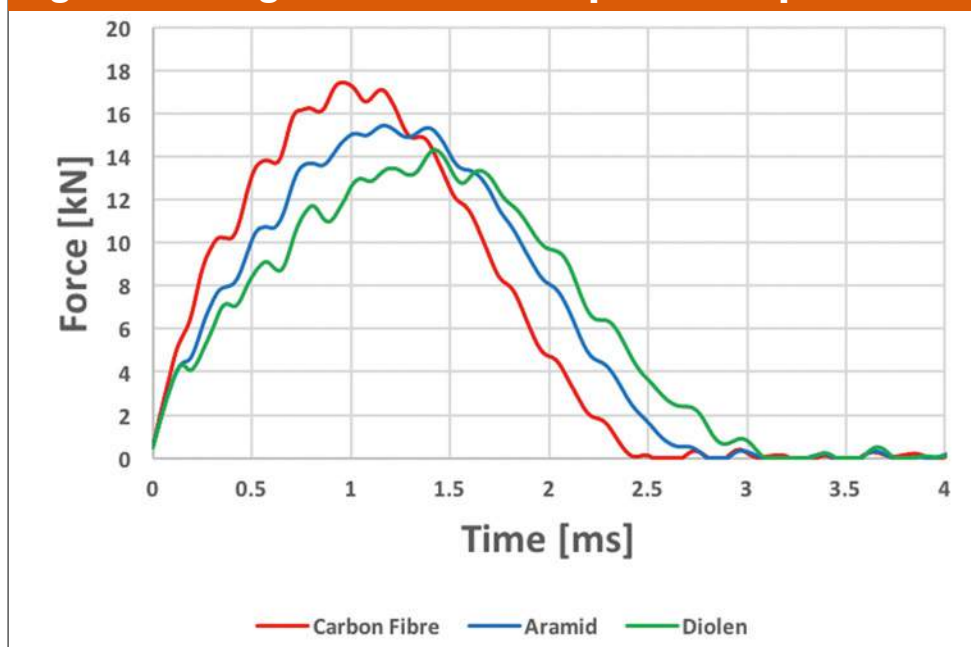
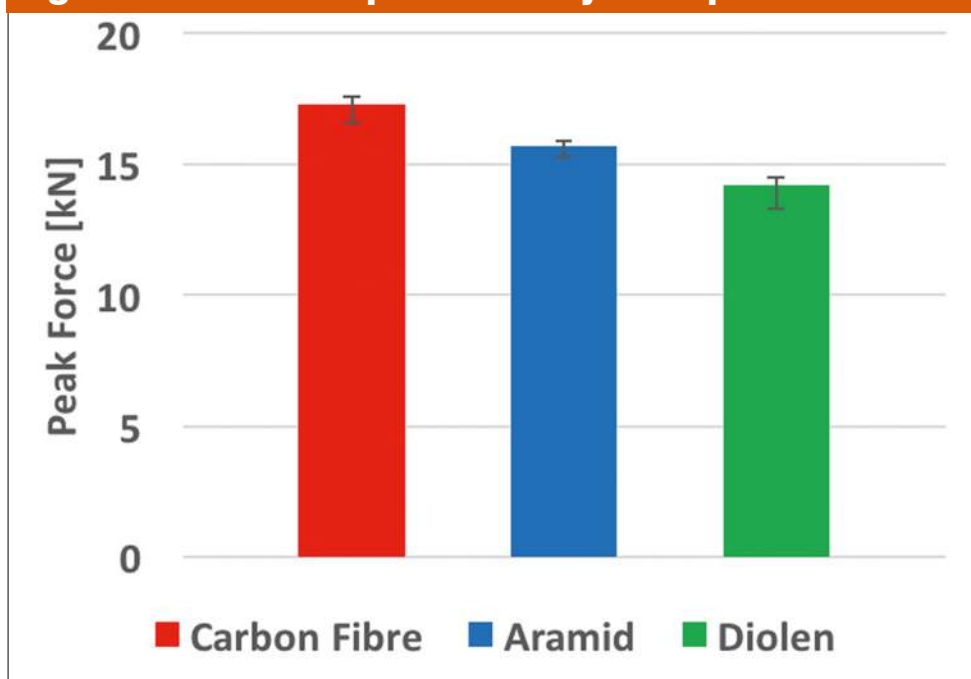


Fig 2: Peak force experienced by each panel



Its high strain-to-failure gives Diolen the potential to be used as an excellent impact material – if it's used correctly

with the reinforcement material, as can be seen in **Table 1**. All material was sourced from EasyComposites. Five panels of each configuration were impacted with 46.9J of energy using a drop tower.

The results show a significant difference between the three panels. The force against time plot (**Figure 1**) illustrates how each of the panels acted under impact.

Panel beating

The area under each curve presents the impulse energy experiences of each panel. And thus, each area is equivalent. Where the difference lies is in the duration of impact. For the panel reinforced with Diolen, the impulse acts over 3.1ms, whereas for the pure carbon panel it's over 2.5ms. This results in a larger force being experienced by the pure carbon panel than the panel reinforced with Diolen (**Figure 2**).

The maximum force experienced by the Diolen reinforced panel was 19 per cent less than that of the pure carbon panel. Similarly, the maximum deceleration of the Diolen reinforced panel was 19 per cent less than the base carbon fibre panel (**Figure 3**). This behaviour is thought to be due to the Diolen deflecting 22 per cent more than the base carbon panel. This greater deflection is due to the high strain-to-fail property of the Diolen fibres (**Figure 4**). The results are summarised in **Table 2**.

The Diolen reinforced panel not only outperformed the pure carbon panel, it also greatly outperformed the aramid reinforced panel. At today's prices, the carbon fibre costs £21.50 per linear metre, the aramid £19.00 and the Diolen only £4.80. Thus, Diolen is about a quarter of the cost of aramid. The aim of the testing was to prove that Diolen has 80 per cent of the impact properties of aramid at a fraction of the price. The results have in fact shown that Diolen has almost 120 per cent of the impact properties of aramid.

White light

The aramid panel was 96 per cent the weight of the carbon, the Diolen 95 per cent the weight of the carbon. Therefore, the Diolen reinforced panel is lighter, cheaper and has greater impact resistance. FIA impact tests require the component to experience a deceleration below a maximum allowable limit. By reinforcing panels with Diolen the maximum deceleration is reduced by 19 per cent, which could be the difference between passing and failing a test.

Although these results look very promising, it is important to understand that only one type of Diolen fibre and one type of aramid fibre were compared in this study. There are 21 different Diolen fibres and countless aramid fibres available to buy. In this case, the Diolen outperformed the aramid, but if either of the fibres had been different, the outcome could have been different. The other key point to remember is that although the Diolen has





HIGH SPEC COMPOSITES LTD

TAKING CARE OF ALL YOUR COMPOSITE NEEDS

FORMULA ONE

MEDICAL

MOTO GP

WORLD TOURING CARS

LE MANS

WORLD RALLY CARS

INDYCARS

HOME AUDIO

AUTOMOTIVE

PARALYMPICS



Tel: +44 (0) 1869 243254

Email: enq@hscomposites.co.uk

**UNIT4, HOME FARM,
BANBURY ROAD,
CAVERSFIELD, BICESTER,
OX27 8TG**



**CHERWELL
BUSINESS AWARDS 2016
WINNER**



WWW.HSCOMPOSITES.CO.UK



Fig 3: Peak deceleration experienced by each panel

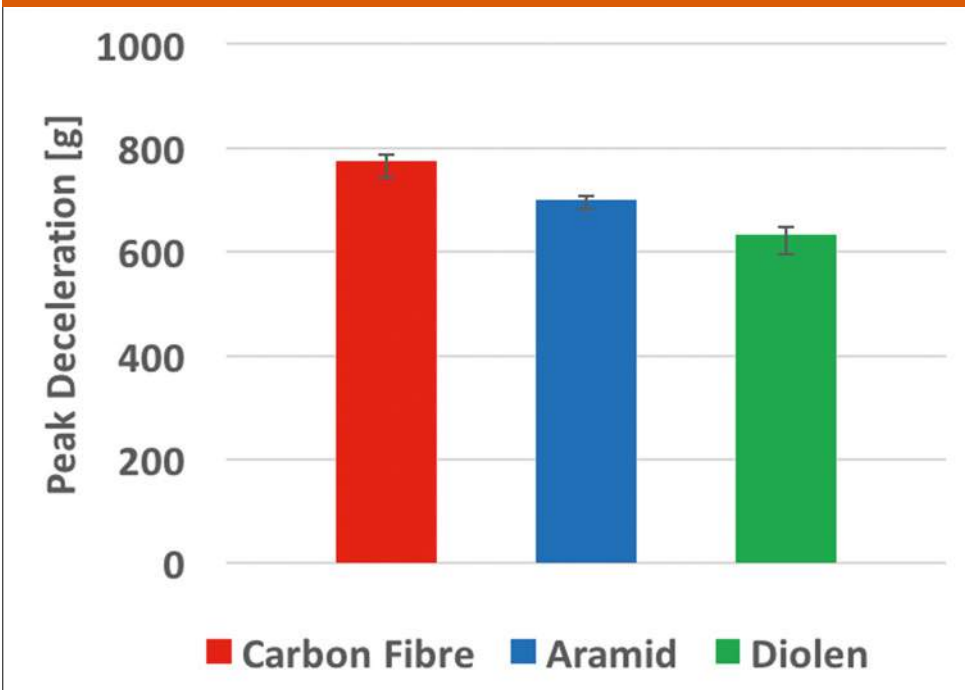


Fig 4: Peak deflection experienced by each panel

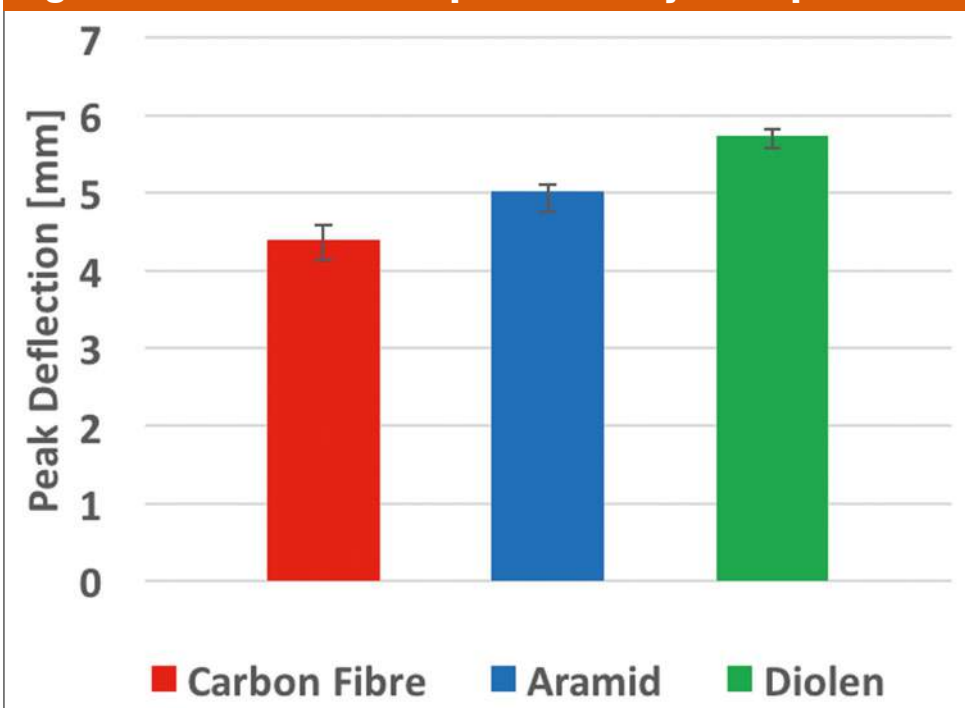


Table2: Summary of impact test results

No.	Material	Peak Force [kN]	Peak Deceleration [g]	Peak Deflection [mm]
1	Carbon	17.3	774	4.40
2	Aramid	15.7	701	5.02
3	Diolen	14.2	633	5.74

The results have shown that Diolen has almost 120 per cent of the impact properties of aramid

performed well in this test, it only describes one aspect. Diolen has very low stiffness, and in some components stiffness is key, and the desire for a stiff component can outweigh the desire for increased impact resistance.

Regulation issues

As always, FIA regulations depend on interpretation. Article 15.3 h) of the Formula E regulations state that side-intrusion panels must be 'constructed from 16 plies of Zylon and two plies of carbon'. Similarly, article 15.4.7 of the Formula 1 regulations state that side-intrusion panels must be: 'constructed from seven plies of Zylon and two plies of carbon'. In addition, the Formula 1 list of permitted materials includes: carbon, aramid, poly(p-phenylene benzobisoxazole) e.g. Zylon, polyethylene, and polypropylene. However, there is no mention of polyester fibres (e.g. Diolen). Therefore, it seems that for these race series a Zylon plaster on the side of the monocoque is mandatory. Surely, some of the world's greatest engineers could come up with a cheaper, safer, integrated solution if allowed the freedom to do so? This freedom is demonstrated in Article 15.3.8 of the Formula 4 regulations, which states that side impact panels shall be: 'constructed from S2 Glass or a FIA approved substitute.' This regulation allows other materials to be explored and utilised, which could result in an advantage.

Diolen is available as a dry-mat fibre, which for some race series will suit their needs. But many race series use pre-preg materials, where the fibre is pre-impregnated with resin for easy handling and lay-up. Diolen is compatible with epoxy and can withstand temperatures up to 250degC. At present, there is no Diolen pre-preg supplier, and this presents a barrier to use.

Carbon dated?

There are many combinations of fibre and resin available, different combinations will produce different material properties. Understanding and utilising these properties, but also understanding the limitations, is where significant advantages can be made in racing. Further to this, applying materials correctly is paramount to using them successfully.

When engineers select a material for a given application, they are choosing a discrete variable: material A or material B. Such a decision, if applied to a chassis for example, could result in a mass difference as big as 50kg, which could be the difference between winning and losing. The importance of understanding the properties of materials and their limitations is paramount to producing a successful racecar. A better understanding of materials at the micro level will create more gains at the macro level.

Diolen has been around for many years. Is it the new super material that will wipe out carbon? No, it's not. But it could be used effectively to increase performance, while it's also cheap, and the numbers don't lie.



TOP QUALIFIER

Around the world or around the track, you won't find a higher quality line of bearings and rod ends with Aurora's proven 40 year track record.



Aurora Bearing Company
901 Aucutt Road
Montgomery IL. 60538



Complete library of cad drawings and 3D models available at:
www.aurorabearing.com

Ph: 630-859-2030



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 5G
Ramsden Road, Rotherwas Ind
Est, Hereford, HR2 6LR**

**Email: sales@ahfabrications.com
Web: www.ahfabrications.com
Tel: 01432 354 704
Fax: 01432 359 762**



GDS
GRANDDESIGNSYSTEMS

Our NEW EcoWall System

Designed and costed to replace the magnetic frame system, EcoWall is a new composite panel that is weatherproof and completely seamless.

Features

- Fast to build
- Ultra smooth finish
- Supplied in brilliant white
- Ideal for graphics
- Wipe clean
- Waterproof

Tel: +44 (0)1280 702 510
sales@granddesignsystems.co.uk
www.granddesignsystems.co.uk

Grand Design Systems Ltd
Unit 6, Boundary Road,
Buckingham Road Industrial
Estate, Brackley, NN13 7ES


www.WOODFORDTRAILERS.com
HIGH QUALITY TRAILERS FOR CLUB, PRIVATE AND PRO MOTORSPORTS



Woodford Trailers Limited
14 Great Central Way
Daventry • Woodford Halse
Northants • NN11 3PZ

Telephone: 01327 263379
Email: sales@woodfordtrailers.com

Made to measure

Measuring up the racecar is a fundamental skill of the race engineer – but to get it inch-perfect there are certain rules you need to follow

By DANNY NOWLAN



Measuring up a single seater is relatively straightforward but you do need to make sure the floor the car sits on is level

One of the most critical skills in racecar vehicle dynamics/racecar engineering is measuring up a racecar. The reason is that without this all the time and effort you'll expend on data analysis and simulation is useless. This might sound silly, because on paper it should be one of the most straightforward things you'll ever do. However, the practicalities are a different matter and most people either make a mess of it, or are so intimidated that they never start.

Yet the truth is that measuring up a racecar is a very straightforward process. You just need to be patient and deliberate about the task at hand.

In this article we are going to work you through a hands on example of a car I measured up. Since this is a live customer car I won't give you the specifics, but I'll show you the process.

Firstly, our goal in measuring up a racecar is to get a firm handle on the kinematic attributes of the car. In particular our goals here are:

- Measure wheelbases and tracks
- Suspension geometry co-ordinates
- The motion ratios

This, ladies and gentlemen, is our hit list. It really is as simple as that.

In terms of equipment, you are going to need a tape measure and a rule. A 300mm and

a 500mm rule are great to have to hand. Also, if you have access to a Faro arm, you would be crazy not to use it. That said, everything we are about to discuss can be done with tape measure and rule and they will get you very close.

In order to get started there are a number of preparation steps we need to take. Firstly, we want the car with equivalent masses and hot tyre pressures. If it is an open wheeler/sportscar get the floor off. If you are measuring up a touring car/GT car get the car on a hoist so you can get underneath it. Also, do this with a friend, especially if it's your first time. The other thing I would highly recommend is if you have access to

Our goal is to get a firm handle on the kinematic attributes of the car

a machine shop, manufacture some thin set-up wheels or use motorbike wheels with the same loaded radius as the tyres. What this does is it exposes all the points. When I worked in A1GP we had carbon set-up wheels which exposed all the points and they were a lifesaver.

Your first port of call is to measure up the suspension geometry. To this end **Figure 1** is about to become your best friend.

Measuring up

While **Figure 1** won't win any technical drawing prizes, what it does is give you a systematic way of filling in your suspension geometry parameters. The critical thing here is that you measure across the car. What this does is it minimises your error. Also, choose a fixed longitudinal datum. For an open wheeler/sportscar this is usually the front bulkhead or mounting point of a bellhousing at the rear. For a touring/GT3 car choose the front lower control arm point or any other suitable reference.

Vertically, you measure to the ground, but there are some tricks of the trade here. Open wheelers/sportscar are very straightforward. You are usually on the ground and you just have to ensure your reference ground plan is level. If you are measuring up a touring car and the wheels are off, choose either the contact patch as your vertical datum or some other fixed point. Then when you put the car on the ground, measure the deflection of the tyre and translate the chassis points accordingly. What I do is measure from the top of the tyre to the upper point on the wheel guard. The other thing that you can do is, when the car is back on the ground, make sure you double check the vertical points to the ground. However, like with the open wheeler, ensure the ground plan is level. A spirit level is your best friend in this regard.

Another thing that is incredibly useful in this endeavour is a plumb bob. This is a string with a bolt attached to it, so hardly hi-tech. But where this comes in handy is measuring across the racecar, as shown above right. What this does is it makes your life so much easier because it gives you a ready made reference to measure the points. You'd be insane to leave home without it.

For good measure

The other thing is, when you measure a racecar up you must evaluate as you go. The biggest mistake that I see made in measuring up a racecar is that people take hours measuring up points, pack everything away, and when they start plugging in the data, because if they have made a mistake, the numbers they have make no sense. If you evaluate as you go you will not have that problem, and one tool is about to become indispensable, and that's the ChassisSim Suspension geometry interface (**Figure 2**).

You don't have to use ChassisSim. You can use OptimumK, SusProg, WinGeo, or whatever takes your fancy. The key thing is you evaluate as you go, because if you have screwed up you'll

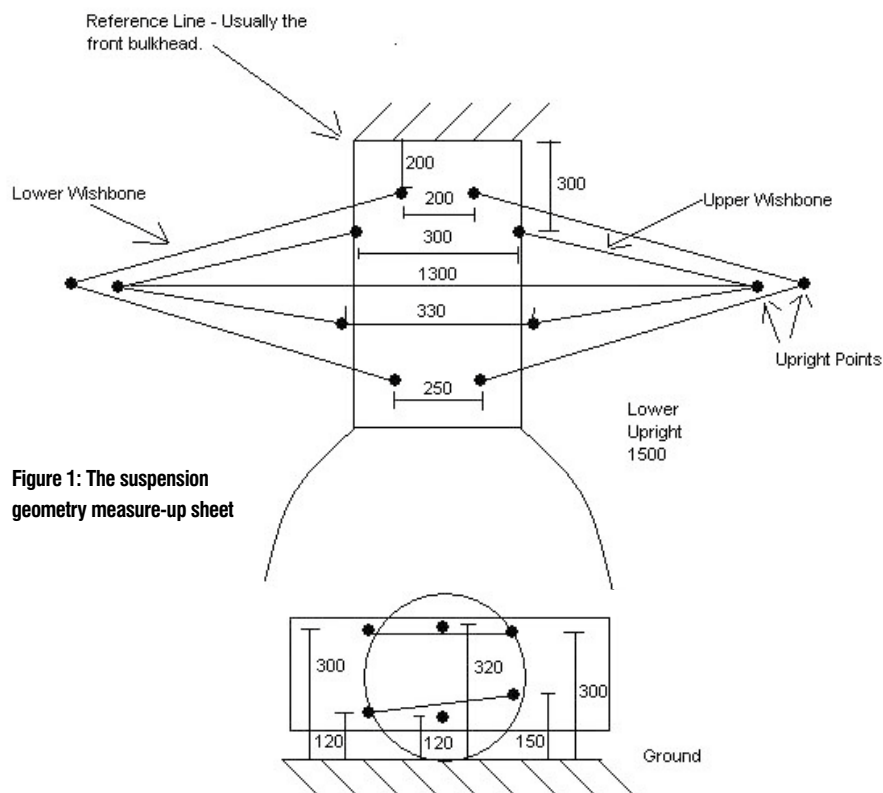


Figure 1: The suspension geometry measure-up sheet



Using a plumb bob. This low-tech device is useful as it gives you a ready made reference to measure the points across a car

	x (mm)	y (mm)	z (mm)
Point 1	-110	15	183
Point 2	410	15	188
Point 3	0	720	177
Point 4	-54	162	393
Point 5	352	168	383
Point 6	49	640	360
Point 7	0	0	0
Point 8	0	0	0

Results:

- Roll Centre: -35.078 mm
- Anti Dive: 21.5% anti-dive
- Anti squat: -3.9% anti-squat
- Castor Angle: 14.990 deg

Fixed Roll centre properties:

- Roll centre flag (0-free, 1-fixed): 0
- Fixed Roll centre value: -37.623662

Figure 2: The ChassisSim suspension geometry interface

If you screw this up everything else you do will be useless, because the numbers that you'll use to engineer the car belong in Fantasy Land



It's important to get the racecar back on the ground and visually check it to make sure no obvious errors have been made

see roll centres in the order of +/- 500mm or anti-dive/Anti-squat numbers in the order of 1000 per cent, and you will know something is amiss. With the car right there, if something like that happens, you simply go back and double check the points.

The other thing you do in line with this theme is to get the car back on the ground and visually check it. A prime example of this is shown on the left. With something like this, if you were to see a roll centre of -100mm you would know something is not right because the lower control arm is angled slightly up.

Motion ratios

Our next task is to measure up the motion ratios and the importance of this can not be understated. When we measure motion ratios we are deducing the following relationship:

$$MR = \frac{\text{damper_disp}}{\text{wheel_disp}}$$

The reason this is so important is it dictates the wheel rates by the following formula:

$$WR = MR^2 \cdot K$$

If you screw this up everything else you do will be pretty much useless. This is because the numbers that you will use to engineer the racecar belong in Fantasy Land as opposed to the race track. The other critical thing here is that we want to measure from full droop to full bump. This is very important.

The great news here is that it is, in fact, really quite simple to make this happen, and the procedure is outlined in **Figure 3**.

Bar work

The critical thing here is we take the springs off and disconnect the roll bar on one side. We want the bar connected on one side so we can measure its displacement. The other important thing here is that we have a fixed level so we can measure wheel displacement.

You will then measure spring displacement, and bar displacement, and plot as you go. It is actually that simple. Also, when you are measuring bar movement you want to be measuring the perpendicular distance of the bar to its centre point. This is illustrated in **Figure 4**.

When you are doing this there are a few practical issues you'll have to sort out. Once again, for an open wheeler or a sportscar it's actually really straightforward. You shouldn't have to do that much but as a precaution remove the damper gas pressure or strap the

Table as fixed reference to measure wheel movement

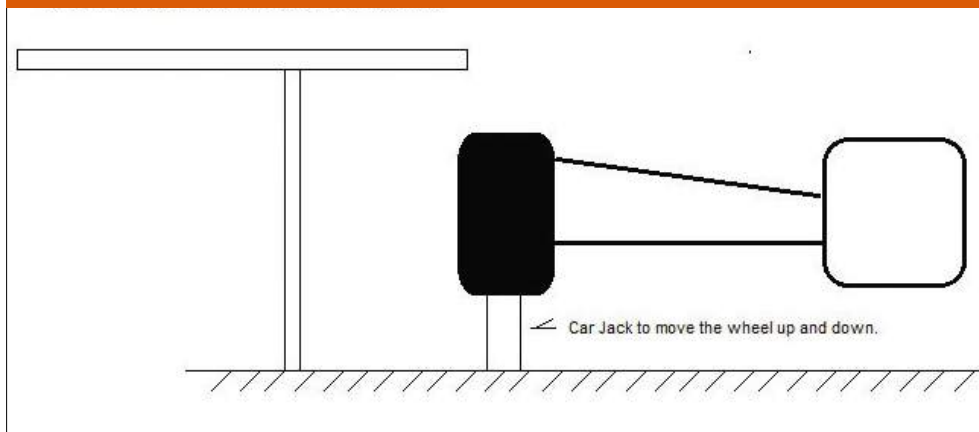


Figure 3: The motion ratio measurement procedure – it is vitally important that you measure from full droop to full bump

Bar length

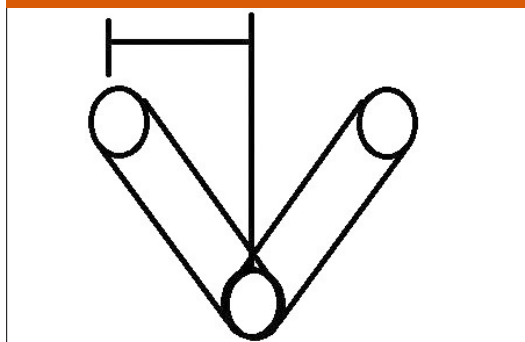


Figure 4: Measuring bar movement; always to the bar's centre point

 **AUTOSPORT**
INTERNATIONAL

THE RACING CAR SHOW

EUROPE'S MOST **INNOVATIVE** MOTORSPORT SHOW

LARGEST
INFLUENTIAL
GROUNDBREAKING
ADVANCED
AUTHORITATIVE
CUTTING EDGE



11TH-14TH JAN 2018

NEC BIRMINGHAM / UK

REGISTER NOW

AUTOSPORTINTERNATIONAL.COM

11TH-12TH STRICTLY TRADE-ONLY DAYS

When you have measured up the motion ratios and geometries properly, you can start to use the simulator to fill in the blanks



On a touring car or a GT car you measure the wheel movement to the wheelarch

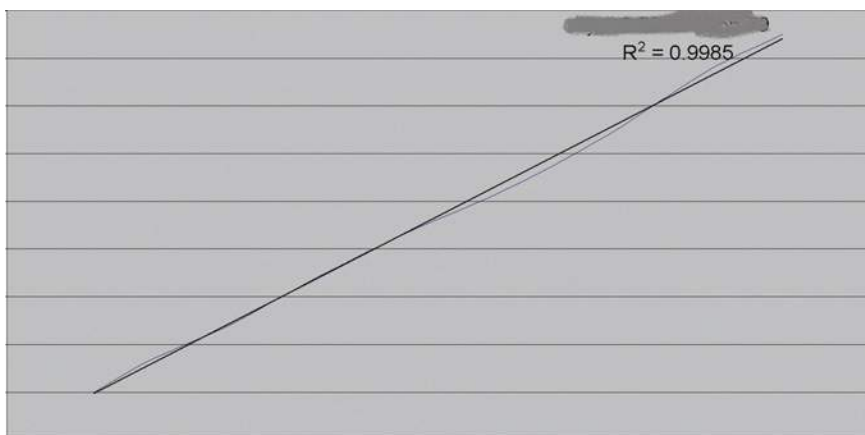


Figure 5: Actual result of damper movement vs wheel movement. You are looking for consistent results here

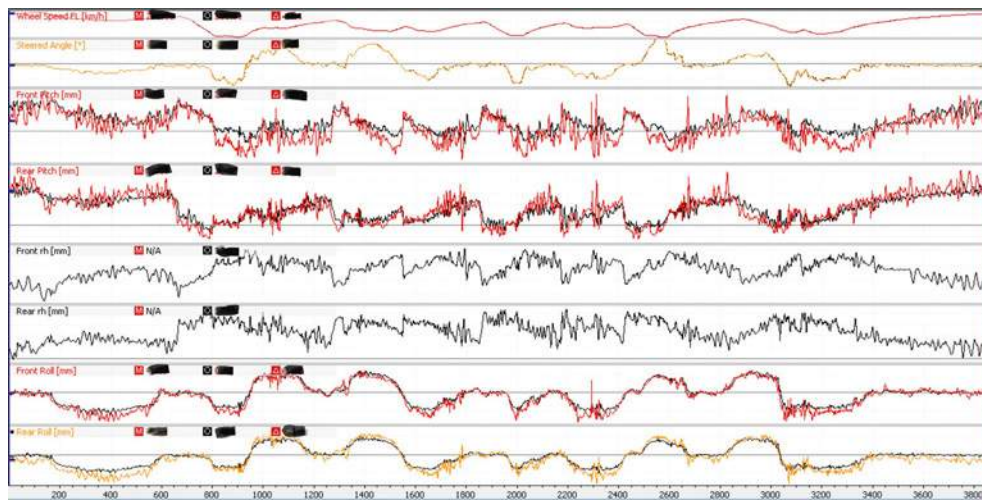


Figure 6: Track replay simulation of actual vs simulated after measuring up. Coloured trace is actual while black is simulated

car down. On a touring car or a GT car this might not be practical, though. In this case you measure your wheel movement to the wheel arch. This is shown in the picture on the left. When you are measuring this you plot as you go and you are looking for consistent results. You are actually looking for something that is continuous. The only exception to this will be if you're near a black hole, and then racing will be the last thing on your mind. **Figure 5** is an example of something that passes muster.

For the reason why this is acceptable, notice how the bottom points are completely consistent and the upper points average out to be the same. If you see something like this on your read-outs then you know you have the motion ratio measurement nailed.

Another dimension

So the critical question is, why bother with all this? After all, isn't manufacturer data supposed to come in a fax from God Almighty himself, and you can't do this unless you have a Faro arm? Well, **Figure 6** is a key example of what happens when you measure up properly.

As always, coloured is actual, black is simulated. Also, to ensure the inputs were the same the track replay portion of ChassisSim was used. There are some local differences and this is down to the aero model needing some refinement. However, in terms of global pitch amplitudes under braking and acceleration and roll in cornering there is precious little difference.

Also, when you have measured up the motion ratios and geometries properly, you can then start to use the simulator to fill in the blanks of the parameters that you don't have, in particular the c.g height.

On top of all that, even if you have the car drawn up in CAD, you still need to do this measuring up process anyway. The key reason you do this is that it forms a vital check and balance. As a case in point, I have lost count of the number of times when a CAD projection/geometry program has said the motion ratio was one thing, but when it was measured it was something totally different. Consequently this is one step you do not skip.

Ruling the rule

In closing, measuring up a racecar is actually a very straightforward affair. The most important thing is to be patient, deliberate and evaluate as you go. That's all there is to it, really. If you understand all these things everything will slot into place. Also, as we saw from **Figure 6**, the proof is in the pudding.

If you master this skill then everything that you do with your data analysis and simulation will be that much easier, and this ultimately lays the foundation for race wins.

A big shout out to Nick Ashwin from NA Autosport Engineering in Brisbane, Australia, for assisting me with this article and allowing me to use his racecar as an example in these pages.





Specialists in Motorsport Hydraulics & Fluid Transfer



Earls Performance
15/16 Silverstone Technology Park
Silverstone, Northants.
NN12 8TL

01327 858 221
sales@earls.co.uk
www.earls.co.uk



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



Suppliers of Race, Fast Road, Classic & Commercial Products

Tel: 01933 778335

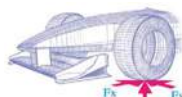
www.LMAautoparts.co.uk

Fax: 01933 778341

sales@LMAautoparts.co.uk

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

Remote Control Systems

Design and manufacturer of cables and controls

Gearshift • Throttle • Handbrake • ARB • Body and Splitter Support • Bonnet and Boot

RINGSPANN (U.K.) LTD.

Gordon.Riseley@ringspann.co.uk • Tel.: 01234 - 342511 • www.ringspann.co.uk

Interview – Stephane Ratel

Monsieur GT

The man behind the hugely successful GT3 concept, plus a bevy of thriving championships, talks GT convergence and ‘GT4 Plus’

By **ANDREW COTTON**

XPB



‘You need constant evolution, because it is like we are on a bicycle; you stop and you fall over’

If one thing characterises international sportscar racing at the present time it is change. The WEC is in a state of flux, with a question mark over LMP1 after the withdrawal of Audi and now the decision of Porsche to also quit, while there seems to have been a shift in focus, too, with many teams and manufacturers looking to the United States for their sportscar futures. Yet amidst all this turmoil and upheaval, one thing remains the same: Stephane Ratel and his myriad GT series are still going strong.

That’s not to say Ratel and the SRO operation he founded 25 years ago are resting on their laurels, though, and as always there are new initiatives in the pipeline. But it’s never change for the sake of change, for Ratel knows why GT3 has been so successful, and he’s keen not to dilute the formula. The word ‘convergence’ is back on the table, an amalgamation of sorts of GTE and GT3, an initiative first driven primarily by the GT3 manufacturers looking to get their products into GTE and now by GTE car makers wishing to get their cars into GT3, but Ratel says that talks are now progressing constructively.

‘[GT3 racing] would die if we did something silly like [allow] the GT Ford [which currently races in GTE] in to GT3,’ Ratel says. ‘We fell into that trap before. This could get more professional, but it is like the stock market. If it overheats, it could be in danger, and it could crash from the top down.’

Drawing a line

Yet while GT3 is in good health, to the outsider there is nothing quite as complicated as sportscar racing in general and GT racing in particular. There were unnecessary costs associated with producing GT3 and GTE cars, and convergence looked to address this. The concept revolved around GT3 and GTE cars sharing common components but this never got off the ground due to a disagreement over whether to use competition or production based powerplants, and the cost of high performance parts in GTE cars being passed to customers in GT3, hiking the price of Ratel’s core cars. ‘The irony is that Porsche killed convergence until they thought it would be nice to have the mid-engine Porsche in GT3,’ says Ratel. ‘I was not that keen because it was the whole GT1 story starting again.’

‘The problem is that the Porsche is a GT Prototype, and the FIA does not do case-by-case. Either they allow something, or they do not allow something. If we said to Porsche [that we would] allow this car, the FIA would then say that all GTE cars could become GT3 homologated and only the engine is different. Then you have a GTE homologated in GT3, which is a prototype and that will kill it. I will never be in favour of this.’

However, Ratel is not against some degree of convergence between the two, and this indeed has now come to pass. ‘What I have been in favour of is that some elements between the two categories could be harmonised. There were silly differences between the two, like the wheelbases. We said okay, there was a list of differences between the two which the manufacturers, wisely, in the majority, agreed to allow

things [such as dampers, for instance] to be common, and didn’t allow others. There was a little step within harmonisation, but GTE and GT3 are different categories.

‘We made a list of what could be harmonised and what could be different, but the fundamentals of them remain different, which is this: one is a production car, one is a prototype,’ Ratel adds. ‘There is no convergence there to the best of my knowledge. Manufacturers have agreed that a GTE chassis will not be a GT3 chassis.’

Plus fours

Another change that was on the cards within SRO’s GT portfolio was the idea of introducing a new ‘GT4 Plus’ category. The thinking was that the McLaren 570S, for instance, could not reasonably be balanced with the Porsche Cayman, currently the base car in GT4. The thinking was that perhaps a separate category could cater for these high performance cars. ‘A number of people have said there is a big gap between GT4 and GT3, and that is correct,’ Ratel says. ‘If you take a McLaren that develops 570bhp, and an Audi that is developing 600bhp, and you put them in this class, [and you reduce the power to] 380 or 400bhp, you could alternatively put the normal engine that they have in it, and it seems simple. People got excited about it and we said yes, it could effectively complement GT3.’

However, it seems that this will not now happen. ‘We made a little enquiry,’ Ratel says. ‘We presented the idea to the manufacturers and they said they understand the concept, but it doesn’t work. If you put in the 600bhp engine, the cooling doesn’t work, the gearbox, the electronics, it’s a different car. So,

Shining a light on GT3. The category has been hugely successful but Ratel is wary of manufacturers taking over. Picture shows GT cars battling through the night at this year’s Spa 24-hours



it doesn't work, we forget about it.' But Ratel certainly doesn't regret considering this: 'You need constant evolution, because it is like we are on a bicycle; you stop and you fall over,' he says. 'You always have to look ahead. It seemed like a good idea, but it was the wrong idea. I admit it.'

So, having established that GT3, GT4 and GTE are very much different animals, where does the former now sit in the global motor racing scene, and what of the future for it, and for motorsport in general? For Ratel, that's simple; it is clearly manufacturer racing in formula cars, and customer racing in GT. 'Formula E and Formula 1 is really the same thing,' he says. 'It has the same owner and the same vision and they will merge one day. Customer sport? Of course there are challenges, and that's why we reacted so strongly with our [driving standard] penalties [where pro drivers automatically take the responsibility and punishment for clashes with amateurs]. If you push my gentlemen out, you will kill my business.'

This is all tied in with Ratel's belief that manufacturers should not be allowed to take over in GT3, that the grid is built from the back, not the front, and that his European Blancpain Endurance Series is drifting dangerously close to becoming too professional. 'The risk is that in two years we will have 35 factory cars in Blancpain Endurance,' he says. 'The ideal is 20 pro, 20 pro-am and 15 amateurs.'

Spending wisely

Ratel, inevitably, has his own idea of how a manufacturer should approach a GT3 racing programme. His Intercontinental GT series, with races on five continents for customer cars, is a World Championship in all but name, but with customer-supported cars, which saves on travel costs. 'I have currently, if you think about it, three very large manufacturers, potentially, with a little bit of cash available, and what are they going to do? They should keep it to one side, mostly, and then spend it wisely and with this money follow my idea; support the teams in Asia, in Australia, in the Pirelli World Challenge, in GT Asia, and in British GT, it is a fraction of the money that you are spending. If you give the guy in the British GT championship €200,000 he is jumping with joy. It works. They can have a platform. The principle is that you sell cars to a team that is sufficiently financed, that with a bit more help you can support them, [but] you don't underwrite the programme. Then it is stable. We have to convince the teams and manufacturers that we are in the same boat.'

RACE MOVES

XPB



Renowned all-rounder **Stéphane Sarrazin** is to expand his newly-formed rally team in to sportscar racing. The former F1 and WRC driver, who currently drives for Toyota in LMP1 as well as racing with Techeetah in Formula E, is to enter a Ligier LMP3 in the Asian Le Mans Series. Sarrazin Motorsport also intends to campaign an ORECA LMP2 in the WEC in 2018.

Harry Scott Jr, a team owner in the NASCAR Cup Series from 2013 until 2016, has passed away. Scott started in NASCAR as a co-owner of Turner Scott Motorsports with **Steve Turner** in 2013, the operation entering cars in the Camping World Truck Series and the Xfinity Series. Later that season Scott bought the assets of Phoenix Racing, a team competing in the NASCAR Cup, renaming it HScott Motorsports. The team closed its doors at the end of 2016.

Matt Braid, the managing director of Australia's premier motorsport series, Supercars, is to leave the organisation at the end of the 2017 season. His departure is said to be due to a change in his personal circumstances which means he is now unable to travel extensively.

Professor Helen Atkinson has been appointed pro-vice-chancellor and head of School of Aerospace, Transport Systems and Manufacturing, at Cranfield University. She comes to Cranfield from the University of Leicester, where she had been head of the Engineering Department and, most recently, graduate dean.

Ron Carnell, who was the competition manager for Duckhams Oils from the late 1960s – and was with the firm during its highly visible 20-year plus tie-up with the works Van Diemen Formula Ford squad – has died at the age of 81.

Brandon Igdalsky has joined NASCAR as managing director of Event Marketing and Promotion. He comes to the organisation after serving as president and CEO of Pocono Raceway. He will report to executive vice president and chief racing development officer **Steve O'Donnell**.

NASCAR has made a number of promotions in its marketing arm. **Evan Parker** has been appointed managing director of Content Strategy, while Scott Warfield has been named managing director of Digital and Social Content and **Jeff Wohlschlaeger** has been appointed managing director of Series Marketing.

Pat Santello, who was active as an entrant in top level US single seaters and USAC dirt track racing in the 1960s and 1970s, has died at the age of 91. Known as the last team boss to turn up to Indianapolis with his racecar on a trailer, Santello had a best finish of seventh in the Indy 500 in 1977.

Mark Smith, the owner of NASCAR Cup team TriStar Motorsports and motorsport powerplant firm Pro Motor Engines, has died at the age of 63 after a long battle with cancer. Smith had fielded cars in the Xfinity Series since 2010 and also in the Cup Series from 1989 to 1997, 2012 to 2013, and this season. The team will continue under the leadership of Smith's son, Bryan.

Sarrazin Motorsport (see box out above left) has employed **Philippe Charissoux** as its sportscar team manager. Charissoux will also continue working as the chief operation officer of KCMG Composites, the sister company to the 2015 Le Mans 24-hour class-winning KCMG LMP2 team.

Former race engine builder **Colin Holt** has died at the age of 81. Holt was well-known for the Lotus twin-cam powerplants he developed and built for over 40 years, especially for 1600cc Formula 3. He worked in a wide range of motorsport operations before establishing his own business in 1974.

Michael Limb, a former chairman of the Motor Sport Association (MSA), the UK governing body, has died at the age of 84. He retired from the MSA in 2003 and was subsequently awarded an OBE for services to motorsport.



Hisatake Murata steps up to lead Toyota motorsport

Hisatake Murata, the man behind Toyota's LMP1 powertrains, has stepped up to become the new head of the Japanese car giant's Germany-based motorsport operation.

Murata has been promoted from his position as general manager of motorsport development to become president of Toyota Motorsport GmbH in Cologne, which includes the responsibility of heading Toyota Gazoo Racing, the banner under which both its WEC team and its World Rally Championship effort compete – though Tommi Makinen will continue to run operations at the WRC team.

Beyond Toyota's current high-level motorsport campaigns, Murata will also be responsible for other activities at TMG, which include R&D projects for Toyota Motor Corporation, work for other organisations, and customer motorsport. He will work in close cooperation with Rob Leupen,

managing director and vice president business operations at TMG, and Pascal Vasselon, vice president technical engineering.

Murata replaces Toshio Sato in the post, who took over at TMG

in 2015 and has now moved to a new position within Toyota's powertrain division.

Murata's motorsport CV stretches back to the late 1980s and encompasses CART, IndyCar, and Group C programmes,

before he was given the responsibility for the hybrid technology that is at the heart of the Toyota LMP1 car.

'I am proud to take this new role at TMG,' Murata said. 'Since the beginning of our hybrid LMP1 project, I have built up a strong relationship with TMG members, so I am looking forward to working together even more closely as we push to succeed in all areas.'



Hisatake Murata has now been given full control at Toyota Motorsport GmbH

XPB

RACE MOVES – continued



NASCAR Cup Series crew chiefs **Adam Stevens** (Joe Gibbs Racing), **Brian Pattie** and **Matt Puccia** (both of Roush Fenway Racing) were each fined \$10,000 for lug nut infractions at the Pocono round of the series.

Former Ferrari F1 man **Joerg Ross** has been signed up by Aston Martin as its chief engineer, Powertrain. He will be responsible for the development of Aston Martin's engines, transmissions and electrification, reporting to vice president and chief technical officer, **Max Szwarz**. Ross joins Aston Martin from Maserati, where he served as head of Advanced Powertrain.

Tony Parella has taken a controlling interest in the Trans Am Race Company (TARC), through his Parella Motorsports Holdings concern, after buying the shares previously owned by **Mike Miller**. Minority share owners **John Claggett**, **Simon Gregg** and **David Jans** remain in their current roles within TARC.

The MSA has recently appointed **James Betchley** as training officer, working in its Development Department. Betchley has been with the MSA for the past 10 years in the Competition and Clubs Department, most recently as assistant manager with responsibility for allocating MSA stewards to motorsport events – a task he will continue to undertake in his new position.

Two NASCAR Xfinity crew chiefs were suspended following the Watkins Glen round of the series. The No.9 crew chief, **Dave Elenz** of JR Motorsports, and the No.28 crew chief, **Steven Lane** of JGL Racing, were suspended for one and for three races respectively. The No.9 Chevrolet failed post-race body height inspection, while the No.28 Toyota failed a weight check.

Former McLaren boss **Ron Dennis** has joined the UK Ministry of Defence's Motorsport to Defence Advisory Panel as its co-chair. One-time CEO of GlaxoSmithKline, **Sir Andrew Witty**, is the other co-chairperson, while **Major Tim Peake**, the well-known Army Air Corps officer and European Space Agency astronaut, is also on the panel.

Chris Taylor and **Lee Cunningham**, the front and rear tyre changers on the No.78 Furniture Row Racing NASCAR Cup Series Toyota, were suspended for three races after a heated exchange with members of another team during the Brickyard 400 round of the series at Indianapolis. The decision to suspend the pair was taken by Joe Gibbs Racing which, as a technical partner, supplies the pit crews to Furniture Row. **Kip Wolfmeier** and **John Royer** stood in for the duration of the pair's suspension.

Chris Gayle, the crew chief on the No.77 car in the Monster Energy NASCAR Cup Series, was fined \$50,000 and suspended for two races after a rear suspension violation was discovered on the Toyota he tends at the Pocono round of the series. Former Australian Supercars race engineer **James Small** took his place during the period of the suspension.

Nielsen joins Formula 1 tech group as sporting specialist

F1's ongoing recruitment drive has seen the hiring of Steve Nielsen, until the British GP the sporting manager at Williams, who has now joined the group of specialists that is being put together by F1 managing director, motorsports, Ross Brawn.

Nielsen started work with Formula 1 in August; in the motorsport division with the job title of sporting director.

Brawn has been building up his team of personnel with F1 technical and management experience throughout the season, with the aim of advising F1 as it plans for the future, especially in relation to the 2021 season, when the new engine regulations are set to come in.

Earlier this year Jason Somerville was brought in as head of aerodynamics while



Steve Nielsen has left Williams to take up a post with new Formula 1 group

XPB

Craig Wilson joined Formula 1 as its head of vehicle performance.

Nielsen has a wealth of experience in Formula 1. Since the late '80s he has worked at Lotus, Benetton, Renault, Tyrrell, Honda, Arrows, Caterham, Toro Rosso and Williams, mostly as a team manager or sporting director.

Brawn said: 'I have known Steve for many years and have seen at first hand his skills and ability. His appointment will strengthen the working group we are setting up to work with the FIA and the teams.'

'Steve's main responsibility will be related to sporting and organisational matters,' Brawn added. 'For example by attending the meetings of the Sporting Working Group.'

♦ 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

KEEPING YOUR DATA **SAFE AND SECURE** IN EXTREME CONDITIONS



- Shock and vibration resistant
- Extreme temperature resistance
- High speed data transfer
- Up to 128Gb capacity
- Miniature, unbreakable design
- Waterproof - IP68/IP69K sealed, even unmated

The Fischer Rugged Flash Drive is an extremely tough memory stick, specifically design for safe storage and transportation of sensitive data under even the toughest of conditions.

Suitable for use with ruggedised computers and data loggers, the unique Fischer interface secures access to your data while the robust, durable housing provides full protection in extreme environments.

THE **RELIABLE** EXPERT

fischer
CONNECTORS

www.fischerconnectors.com

SUPER-B
lithiumbattery

THE MOST COST EFFECTIVE WAY OFF ADDING LIGHTNESS

MADE IN HOLLAND

THE NUMBER 1 LITHIUM BATTERY

SB12V25P-SC
4.5kg 1500 cranking amps

WWW.SUPER-B.COM

+44(0)7412608539

Setrab
ProLine

Oil coolers and
Intercooler cores



Reliability

Flexibility

Know-how

Visit us at www.setrab.com/proline



Room to grow

Why the industry now faces as many opportunities as it does challenges

The MIA Business Growth Conference, which 250 delegates attended at Sahara Force India before the British GP, was positive, motivating and exciting. It's clear from the motorsport business leaders who spoke, and the delegates' questions, that our industry is taking a positive approach to the challenges and opportunities being created at this time of relative uncertainty.

Otmar Szafnauer, COO of the Force India F1 team, reminded us that as we survive and succeed in the world's most highly competitive industry on a daily basis, so we are in a great position to take advantage of the opportunities being created. To hear the views of all the successful business leaders go to www.youtube.com/user/motorsportindustry.

The exciting business of motorsport combines high performance engineering with sports entertainment delivered on a global stage. The alchemy of these constituents gives our business sector unique advantages. Collaboration is vital if results are required fast – by working together, and building your network, you will out-pace your rivals. But at times like these your business competitor can often be your best collaborator and most valuable ally. Be sure you identify where you can benefit from working with others who can share their most valuable experience.

Fast track

We need to focus on what we are good at and stick to building on core capabilities. Motorsport demands suppliers to deliver results super-fast – much, much faster than most other industries. Engineering is enjoying a period of rapid innovation, where top-quality supplies are needed to be created and delivered quickly. It's difficult for other supply chains to respond to this challenge without substantial costly change – but your training and experience in successfully delivering motorsport solutions is being increasingly recognised as an enormous asset. So, take this opportunity to promote your capability to the full.

We were reminded that customers are our most valuable asset, so we must look after them well. Check what they are doing, what they are looking for and where their future lies. Stay close to others in this sector to hear of changes and opportunities quickly. Work hard to build

your network of contacts which can provide invaluable market intelligence.

Pat Symonds, who is now with Formula 1 working on a strategic review under Ross Brawn, provided insights into the future at this top level of our business. Fan engagement and entertainment is at the heart of its plans, so by 2021 expect to see substantial changes and investment in this area.

Rodi Basso of McLaren Applied Technologies confirmed this, saying data collection and use is growing fast everywhere. Data collected in motorsport will be a valuable asset used to entertain fans, opening up new opportunities to broadcast our technology capabilities to the world.

Statistics from recent global research by Nielsen Motorsport caught my eye as Nigel Geach reported: 'One in three urban Chinese are interested in

central to these fans. We can benefit from engaging with this fast-growing change in entertainment.

It's clear, from a host of recent announcements, that we should accept the rapid increase in the use of electrification in transport and mobility. The world's automotive manufacturers are moving fast to electrify their fleets to meet virtually impossible emission standards – not by 2040, but within the next five to ten years. Motorsport companies must prepare, without delay, to embrace similar changes in motorsport as we rely entirely on consumers and their motoring habits, which will be powered by electricity sooner than we realise.

Silent running

How will electric powered motorsport entertain people as it must? When will touring cars, DTM

or Australian Supercars move to electric power to satisfy their OEM customers? Our new, young audience won't identify with sounds of the V12 internal combustion engine – they will only know of, and expect, motorised entertainment to be silent.

We can't hold back progress, and as we are in business, we must plan to benefit from these changes. I encourage you to prepare to grab a slice of this new business as we enter, more widely, the initial development and implementation phase.

The UK government is investing over £250m of taxpayers' money into electrification across automotive to make the UK a centre of innovation and excellence for electric powertrains.

This should be music to all ears in Motorsport Valley, as we can expect at least the same will be invested by many companies across the board.

We are now operating in the most innovative period in transport and mobility for over 100 years, so you have to make the most of it.

The annual MIA EEMS conference, the day before Autosport International in January 2018, will focus on how motorsport will capture the enormous business potential of electrification and entertain our customers, whilst also servicing demand from the automotive companies who will rely on electric power in the future. What an exciting challenge – please plan to attend this valuable informative conference but, in the meantime, feel free to send your views to info@the-mia.com.



WTCC in Beijing. Recent research has shown that one in three urban Chinese are interested in motorsport. The MIA has recently opened a liaison office in China

motorsport'. Race tracks are being built at a fast rate throughout China, so we can be sure China is becoming a valuable but complicated new market. Now is the time to learn more to gain advantage over your competitors. To help its members do so, the MIA recently opened a liaison office for Greater China with offices in Shanghai and Hong Kong, staffed by experienced motorsport people, to help find contacts and uncover new business.

In the game

The Nielsen research also showed that '40 per cent of motorsport fans are keen on E-Sport'. Motorsport is amongst the most popular in this new global sports entertainment. The exceptional quantity of data generated by 'real' motorsport is going to be

Our industry is taking a positive approach to the challenges being created

THE 2017 PERFORMANCE RACING INDUSTRY TRADE SHOW



THE BUSINESS OF RACING STARTS HERE

PRI2017
Indianapolis
December 7-9, 2017



CONNECT WITH MORE THAN 1,200 RACING INDUSTRY SUPPLIERS

Discover new racing products & business opportunities at PRI, the world's largest gathering of motorsports professionals.



TECHNOLOGY



IDEAS



BUSINESS

**RACE
ONLY**
CREDENTIALS REQUIRED

Learn More at www.pri2017.com

SUBSCRIBE TO MOTORSPORT'S LEADING TECHNOLOGY MAGAZINE

Get the latest product developments, technical insight and performance analysis from the leading motorsport technology publication every month.

INSIDE EACH ISSUE

- **Unrivalled analysis** of major events including Formula One, the World Rally Championship and the World Endurance Championship
- Detailed racecar **design and innovation**
- Features from leading industry engineers and the **latest product developments**



TO ORDER

www.chelseamagazines.com/racecar-P709
+44 (0) 1858 438 443 (quote code CRCEP709)

AVAILABLE WORLDWIDE

DIGITAL EDITION ALSO AVAILABLE WORLDWIDE

for tablet, smartphone and desktop. To order go to:

www.chelseamagazines.com/racecar-CRCED709





Show business

Worried about how Brexit could impact your motorsport operation? Then this year's ASI is a must-attend event

The timetable for Brexit negotiations to conclude means that the UK's withdrawal from the European Union is scheduled to take place in just 18 months, at the time of writing. With long lead time pieces often being produced and developed in the UK, this means that time is running short for teams and manufacturers to make up their minds whether or not to commit to UK-based motorsport suppliers.

Yet, as is well known, the majority of the F1 grid is based in the UK. That includes teams, suppliers and manufacturers that also have interests around the world. The LMP2 manufacturers on both sides of the Atlantic deal with UK companies for the electronics, gearbox and engine supply, and that won't change in the foreseeable future. There is also a wealth of expertise on these shores that will not just simply dry up, whether you're looking at mechanical, electronic or material supply.

The only question is; how much will it cost? Right now, it has never been cheaper to do business with UK companies, but after Brexit, and after the uncertainty over whether or not there will be trade-free access to and

from Europe has lifted, many teams will be committed to their suppliers already for the new regulations scheduled for Formula 1, the WEC, the DTM/Class 1, the World Touring Car Championship and so on.

The Autosport International Show is a more critical event to be at than ever; to meet with suppliers, with international and national trade bodies through the Motorsport Industry Association, or with teams and manufacturers that will be looking to secure business beyond the 2019 deadline. Held in Birmingham's NEC, the Autosport Engineering Show held in association with *Racecar Engineering* will be a go-to place for purchasers and suppliers alike.

British manufacturing and expertise, in simulators, in battery technology, thanks to a huge investment from the UK government, in hardware and in software is of a world standard and the Autosport International Show is the place to start your long-term planning with UK suppliers. *Racecar Engineering* will be there in full strength to bring you the latest in what British manufacturing has to offer the rest of the world, and we are excited to be the exclusive partner to the Engineering show once again.

There is a wealth of expertise on UK shores that will not simply dry up after Brexit



Radical is a regular at ASI show. It and other UK companies will be eager to discuss the implications of Brexit

AUTOSPORT INTERNATIONAL

11 to 14 JANUARY 2018

PUBLIC OPENING TIMES:

Saturday: 9:00am to 6:00pm

Sunday: 9:00am to 6:00pm

NEW FOR 2018, child ticket prices for those under 16 have been reduced. Full ticket price information is as follows:

Standard: Adult £35pp, Child (6-15yrs) £17

Ticket includes entry into Autosport International, the Live Action Arena and Performance Car Show (children under five years of age go for free). Ticket price includes the £2 booking fee per ticket.

Paddock Pass: Adult £46pp, Child (6-15yrs) £27.50pp

Ticket includes entry into Autosport International, the Live Action Arena and Performance Car Show (children under five years of age go for free). Access to backstage Paddock area in the Live Action Arena, Paddock Guide and access to driver autograph sessions.

Family Pass: £87 (2x Adult and 2x Child of 6-15yrs).

Ticket includes entry into Autosport International, the Live Action Arena and Performance Car Show. Valid for standard tickets only. The price includes booking fee charges.

VIP Club: £127 (no VIP Child ticket available).

Ticket includes entry into Autosport International, the Live Action Arena and Performance Car Show. In addition VIP Club includes free parking, seat at VIP enclosure in the Live Action Arena, complimentary drinks and canapes, VIP gift bag and much more.

For more, visit www.autosportinternational.com

Racing's £500m trade show

In a complex current global business landscape, Autosport International's dedicated trade show is the perfect place to showcase the latest cutting edge technology, materials and components to buyers from around the world in an industry boasting an annual turnover in excess of £9bn.

Autosport International 2018 will be attended by business leaders from the aerospace, marine defence and the motorcycle industry, plus the relevant stakeholders involved within the UK's motorsport and high performance engineering sector.

The show brings together a truly global hub for automotive, motorsport and advanced engineering companies to do business on two dedicated trade days. Over a third of Autosport International trade day attendees found new suppliers that they wouldn't have otherwise considered using last

the world including market leaders such as Brembo, Hewland and Xtrac.

A number of changes are to be made to the 2018 show in order to aid exhibitors do business in a formal and appropriate style. New meeting areas are to be created across the show floor for international businesses to come into the show and conduct talks in private. The Autosport Engineering press office will offer exhibitors an area to publish the latest news and conduct business talks and interviews in a private environment. Autosport International 2018 is the perfect setting for members to connect buyers and suppliers of motorsport technology, alongside the International Business Lounge and MIA Business Excellence Awards Dinner (held after the first trade day at Autosport International).

As part of the extended range of network events and business-focused

Four out of five trade day visitors say Autosport International is the meeting place of the British motorsport industry

year, and almost three quarters of visitors said the show has a great range of motorsport exhibitors to help source new products/suppliers and to keep up to date with industry innovations.

Big spenders

Over half-a-billion pounds are spent during and following Autosport International making the NEC in Birmingham the heart of the global motorsport industry and the perfect place to illustrate the technological advances in motorsport. Four out of five trade day visitors say Autosport International is the meeting place of the British motorsport industry.

Meanwhile, the Autosport Engineering Show is at the heart of innovation and technology with the automotive and motorsport business sectors, offering a dedicated B2B environment attracting over 26,000 registered trade visitors including over 250 specialist companies from across

activities, the Motorsport Industry Association (MIA) will also be running a number of workshops at Autosport International 2018 along with Talk Shop, a new forum giving exhibitors an additional opportunity to host their own seminars where they will be able to go into detail about their products and topics within the industry.

TT time

Tony Tobias, head of Autosport Engineering, said: 'Building on the success of the 2017 show, we are making 2018 the best hub for trade delegates to do business. The automotive and motorsports industry is evolving massively and Autosport Engineering is the centrepiece for motorsport excellence, showcasing the perfect crossover of technology with different industries. If you are in the motorsport and specialist engineering sectors, then Autosport Engineering is the place to do business!' 

Products at ASI

For over 40 years, racing teams and drivers from across the globe have turned to **Goodridge** for its highly-developed fluid transfer systems. Confirmed for the 2018 show, Goodridge provides a truly bespoke service, either via build-to-print or full service support, for a comprehensive range of fluid transfer applications.

Manufacturing in 10 facilities globally and supplying customers around the world with a unique combination of design, innovation, reliability and outstanding service its state-of-the-art CNC machinery carries out the tube manipulation for the OEM, automotive, motorcycle, motorsport, defence and specialist industrial sectors. Find Goodridge on **Stand E260** and for more about the products Goodridge has to offer then go to: goodridge.com

It's not without good reason that the majority of teams in top tier motorsport trust **Eibach** and its knowledge of race spring systems to deliver results. Confirmed for 2018, the world leader will be on hand to discuss its latest products, which are used and loved by some of the motorsport industry's very biggest names.

In the WRC, M-Sport relies on Eibach to deal with a whole host of varied conditions – from tarmac to sand, ice and snow – while F1 teams require the special characteristic curves and performance parameters Eibach can offer. Dealing with the smallest tolerances, weight and construction dimension optimisation, as well as offering reliability under extreme permanent load, makes motorsport the perfect testing ground for Eibach.

Its ERS line has evolved over the years to be the world's most prominent, comprehensive and

superior race spring system. This offers the race engineer multiple set-up options. Make sure you pay a visit to the Eibach **Stand E1260**. Read more about Eibach in motorsport here: eibach.com/de/en/products/motorsport

Leading racing alloy wheel specialist, **EVO Corse**, is now confirmed for Autosport International 2018. Purveyors of the highest-quality racing alloy wheel, EVO Corse uses the best CAD/CAM technology and structural FEM simulation, for maximum optimisation of strength/weight ratio.

Located in northern Italy, the EVO Corse production process uses a procedure that is more expensive than that which is needed for a normal alloy wheel, ensuring the highest performance gains without compromise.

The rim contour of EVO Corse wheels is different from that of the regular wheels because it is already optimised for racing tyres, one reason it is the official supplier to the most prestigious teams both in rally and track competitions.

EVO Corse also supports the likes of the up-and-coming British rally driver Chris Ingram, who is currently topping the ERC Junior U27 Championship.

EVO Corse tells us it uses advanced technology for calculation and simulation in the racing wheel market and dedicates much of its efforts to new product development and experimentation, offering personalised and tailored solutions to customers.

Make sure you visit **Stand E1170** to find out about the latest technological advances used in alloy wheel production.

To read more about EVO Corse then visit: www.evocorse.com



VBOX VIDEO



CIRCUIT TOOLS driver training software

- Synchronised video and data
- Dual camera 1080p
- Ultra-smooth video
- Class leading driver training software (Windows, macOS & iOS versions)
- 10Hz GPS data logging
- Configurable pre-record buffer
- Camera preview over WiFi
- CAN interface

VBOX VIDEO HD2 captures stunning video in full 1080p HD with real-time graphical overlay.

Supplied in a rugged, water resistant case, with two cameras, internal GPS logger, backup battery supply, up to 30s video pre-buffer and real-time graphical overlay, **VBOX VIDEO HD2** represents the ultimate in tough, reliable motorsport video loggers.

VBOX VIDEO HD2 comes with **CIRCUIT TOOLS**, an intuitive analysis software package designed to help drivers improve their track performance and accelerate the learning process, ultimately leading to better lap times.



VBOX VIDEO HD2 available to order online

Professional racing drivers share their experience on advanced circuit driving techniques in our **FREE eBook**:
www.vboxmotorsport.co.uk/ebook

www.vboxmotorsport.co.uk

PIT CREW

Editor

Andrew Cotton
 @RacecarEd

Deputy editor

Sam Collins
 @RacecarEngineer

News editor and chief sub editor

Mike Breslin

Design

Dave Oswald

Technical consultant

Peter Wright

Contributors

Elizabeth Apthorp, Mike Blanchet,
 Ricardo Divila, Gemma Hatton,
 Simon McBeath, Danny Nowlan,
 Mark Ortiz, Sam Smith,
 Serge Vanbockryck

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

Circulation Manager Daniel Webb

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

Publisher Simon Temlett

Managing director Paul Dobson

Editorial

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

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) £86.00
 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

Racing into the future

The last week of July gave a snapshot of the identity crisis that continues to surround motor racing, as Mercedes announced its withdrawal from the DTM, Porsche confirmed that it would leave the World Endurance Championship, and both opted for a presence in Formula E. Meanwhile, more than 60 cars run by customers, some with manufacturer support, started the Spa 24-hours.

The leap into Formula E is not necessarily for manufacturers to advance their electric technology, although that will undoubtedly happen as currently restricted parts of the car are opened up for development. According to German magazine *Sport Auto*, in which Michael Steiner, member of the Executive Board for Research and Development at Porsche AG, was interviewed, the majority of improvements in emissions will come from the internal combustion engine. Very little improvement is needed in electric to meet the government standard, while hybrid development is key, which does rather beg the question: why did Porsche stop its hybrid LMP1 programme?

A lot of Porsche's future strategy will depend on what happens with the new F1 engine regulations. There were rumours that their introduction would be brought forward to 2019, which would hasten Porsche's departure from the WEC. However, their scheduled introduction in 2021 would allow Porsche to fully evaluate the regulations while, if Honda needed an all-new engine for 2018, it would give it an extra year of competition. Porsche took the decision to leave the WEC at the end of 2017 anyway, and its involvement in F1 is as unclear as ever, but the company will be part of the process for establishing future engine regulations regardless.

It seems that the hybrid regulations will continue, although very little has been made of the incredible advances in thermal efficiency in the mainstream press. Perhaps what is going on with production cars, particularly in Germany where Porsche has had to (temporarily) withdraw the sale of the diesel Cayenne SUV and recall its already-sold cars for a software update, will change how racing is presented. Perhaps the incredible achievements of engineers in Formula 1, and the WEC, will be put front and centre of an advertising campaign in a bid to restore confidence in a brand. But when was the last time anyone read in the mainstream press about an MGU-H or MGU-K? Does the paying public even care, or do they just want their racing to be entertaining?

If the advance in ICE technology is key to the future of motoring, then Formula 1 and any other racing series must have this as the central point of its decision-making process.

It wasn't so long ago that Audi's Ulrich Baretzky was busy advocating the publication of CO2 and fuel consumption figures for racing cars. Yes, they will be frightening at first, but at least improvements will be easy to quantify as fuel is measured to the millilitre. As one engineer at the Spa 24-hours pointed out, we spend far too much time looking back at history, and not very much time looking forwards, which is what Formula E, and the Electric GT Championship, is doing. Racing is so pre-occupied with the result that it cares little for how that is achieved. Perhaps it is time now for manufacturers to publish the figures for its racecars, and create a culture of transparency. Maintain the competition but introduce some corporate responsibility (although that was what led Max Mosley to introduce hybrid regulations to F1 in the first place.) Manufacturers have to re-establish trust with their customers.

Everything can be viewed as an opportunity and as Stephane Ratel points out, manufacturers can have a headline programme, and promote itself through customer racing. What are the top class options? For F1, it is at a critical point in establishing its future. For touring car racing, I thought Class 1 cars would be brought under the FIA banner in the WTCC, and that was clearly one plan that was considered. However, it now seems that

Class 1 is dead following Mercedes' withdrawal from the DTM which has also failed to establish the global platform on which BMW made the decision to enter. The events are clearly popular and the series must try to keep them going, with different hardware, such as GT3 cars, or even GTE, to fill the gap, although Audi still maintains its support of Class 1.

For the WEC, opening up its regulations to allow DPi must be a consideration, but first it must scale down its programme to accommodate the privateers that will be the bedrock of the series for at least the next two years. Toyota still believes that Peugeot will come in and bring hybrid. Meanwhile, the TCR cars, or the BTCC cars, could form the new WTCC regulations, instantly creating a potential grid although, again, the costs of travelling around the world with one team, all the mechanics and freight, may be too much without manufacturer support.

I hope that transparency in all series including Formula E, will be part of the future. The identity crisis that I have written about before is still ongoing. While students learn how to manage autonomous cars, and manufacturers jump to electric racing for now, the argument for technology vs entertainment, and competition vs environment, continues.

ANDREW COTTON Editor

Manufacturers in motor racing have to re-establish trust with their customers

To subscribe to *Racecar Engineering*, go to www.racecar-engineering.com/subscribe or email racecar@servicehelpline.co.uk telephone +44 (0) 1795 419837

* Racecar Engineering, incorporating Cars & Car Conversions and Rallysport, is published 12 times per annum and is available on subscription. Although due care has been taken to ensure that the content of this publication is accurate and up-to-date, the publisher can accept no liability for errors and omissions. Unless otherwise stated, this publication has not tested products or services that are described herein, and their inclusion does not imply any form of endorsement. By accepting advertisements in this publication, the publisher does not warrant their accuracy, nor accept responsibility for their contents. The publisher welcomes unsolicited manuscripts and illustrations but can accept no liability for their safe return. © 2017 Chelsea Magazine Company. All rights reserved.

* Reproduction (in whole or in part) of any text, photograph or illustration contained in this publication without the written permission of the publisher is strictly prohibited. Racecar Engineering (USPS 007-969) is published 12 times per year by Chelsea Magazine Company in England.



WORLD'S FIRST ONLINE Motorsport Engineering Degrees

FdSc Motorsport Engineering - BSc (Hons) Motorsport Engineering

NEW for January 2018 - MSc Advanced Motorsport Engineering*

* MSc subject to validation. All degrees awarded by our academic partner Staffordshire University



NMA Students at Silverstone GP - NMA Mosler MT900 - GT Cup 2017

**The only TRULY FLEXIBLE route to gaining
your Motorsport Engineering Degree**

- APPLY ONLINE, choose your own start date & study from anywhere in the world
- Earn while you learn, study flexibly around work & family commitments
- 40% lower fees than other universities
- Access to student loans for UK students
- Latest industry standard CAD & Simulation software FREE

**NMA now has students from Formula 1,
The World Endurance Championship & The World Rally Championship!**

More Championships than any other™



Patented Continuous Wound
Carbon Disc featuring...

V3 ^{DISC}
TECHNOLOGY



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