Leading-Edge Motorsport Technology Since 1990

Racecar engineering™

April 2014 • Vol24 No4 • www.racecar-engineering.com • UK £5.95 • US $14.50

Grand Prix 2014
F1 teams facing new power struggle

Wing fundamentals
The basic principles of setting up frontal aero

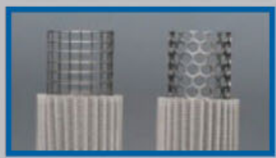
Spotlight on Le Mans
How the FIA plans to control Equivalence of Technology

Volvo S60 R
First sight of the Australian V8 supercar challenger

Xtraordinary All-Fluid Filters

4 DIFFERENT SERIES. . . MODULAR. . .TONS OF OPTIONS

71 SERIES - Our largest capacity filters. 2.47" diameter body, available in two lengths. Reusable pleated stainless steel wire elements: 10, 20, 45, 60, 75, 100 or 120 micron, either standard lightweight wire support core or higher-pressure perforated support core. End caps (sizes -6 through -20) are available in AN style or Clamshell Quick Disconnect. Options include: 15 PSI differential pressure by-pass valve; Inlet end caps with -10 Female ORB auxiliary port for temperature probe, secondary inlet or bypass for a pressure regulator; Outlet end caps with two female 1/8" pipe differential pressure gauge ports to measure pressure drop across the filtering element.



Standard Core vs. High Pressure Core

72 SERIES - Same large-capacity 2.47" diameter body as our 71 Series but with a 2-piece body that couples together with a Clamshell Quick Disconnect for quick service. 72 Series uses the same stainless steel elements, mounting hardware and end fittings as 71 Series.

Stack and Stage
for Maximum Protection
On Race Day

71 SERIES MULTI-STACK - FAILSAFE STAGED FILTRATION

Multi-Stack adapter sections allow the stacking of two or more 71 Series bodies, long or short, so you can combine a variety of filtration rates or backup elements. Use a coarse micron screen element to filter out large debris upstream, followed by a tighter micron second-stage element to get smaller contaminants. Options include: adapters with take-off ports to facilitate the use of a differential pressure gauge which monitors contamination levels in all stages of the filter assembly.

SPACE SAVER SERIES - OUR MOST COMPACT FILTERS

3 Body Styles - 7 Choices of Screens

About 1 1/8" diameter, they fit everywhere and they do the job right for so many applications! 2 sets of O-Rings for a variety of racing fluids. Choose from 10, 20, 40, 60, 75, 100, or 120 micron screens to suit all needs.

SPACE SAVER DRY SUMP - Same space-saving size, these dry sump filters include a coarse-screen #16 mesh filter that protects your pump in high-volume race applications.

INTRODUCING THE NEW 70 SERIES

Compact 1.97" diameter body features a springless design to maximize filtering area in tight spaces. 70 Series filters are ideal for applications where space and weight are of primary concern. Bodies are available with AN-style end caps, sizes -4 through -12, in heavy or lightweight wall versions. 70 Series filter elements come in two varieties: pleated cellulose (10 or 20 micron) or reusable pleated stainless steel wire (10, 20, 45, 60, 75, 100, or 120 micron). Undercut inlet end caps (sizes -4 through -10) offer a maximum weight savings and modern look.

70 SERIES Pleated Stainless Steel or Cellulose Elements

Follow us on Instagram #XRPracing

Like us on Facebook/XRPinc

XRP®

THE XTREME IN RACECAR PLUMBING

Go to WWW.XRP.COM for catalog downloads & new products or contact us for 100-page color catalog.

UNITED STATES XRP, Inc. sales@xrp.com tel 562 861 4765 fax 562 861 5503

EUROPE JLS Motorsport motorsport@lister.co.uk tel 44 (0) 121 525 5800 fax 44 (0) 121 525 4833

COVER STORY

COLUMNS

FEATURES

DARIN MANDY

TECHNICAL

BUSINESS NEWS

University of Bolton

Open Day Saturday 29th March

A Unique Educational Experience

Visit our Centre for Advanced Performance Engineering

UCAS 779L Automotive Performance Engineering BEng (Hons)
UCAS F4G5 Motorsport Technology BSc (Hons)

Open Day Sat 29th March

The **University of Bolton** and RLR Msport have joined forces to create a high performance motorsport engineering centre on campus, **giving students Le Mans LMP2 race team experience**.

This is a unique partnership - we have brought together first-class, on campus learning together with the best in practical motorsport experience.

Employability
We give our graduates the competitive edge in securing careers within the following industries, and many more in the UK and across the world.

- Motorsport & Trackside Telemetry
- Automotive & Mechanical Design
- Engine Performance Analysis
- Chassis Dynamics and Aerodynamics
- CNC, CAD CAM, CFD and FEA
- Specialist 3D Scanning Equipment.

Study on Campus and on the track!

rlr msport

CAPE University of Bolton Centre for Advanced Performance Engineering

Contact us for more information
Email opendays@bolton.ac.uk or call **01204 903942** or **01204 903807**

Fuelling progress

A concise history of chemical warfare in racing – and some great, lost scents

The alchemist Johann Conrad Dippel was born and raised in Germany's Castle Frankenstein in the 17th-century, but this will not be a note on modern F1 noses as worked on by the good Baron, more about the bouquet in racing paddocks. Dippel is noted as the inventor of Prussian Blue, one of the first synthetic chemical dyes. Alchemy has moved on a lot from those days, being rebranded as chemistry and among its myriad products is the fuel that powers our toys, racing cars.

By the 1860s Friedrich August Kekulé von Stradonitz published a paper on the structure of benzene, suggesting that the structure contained a six-membered ring of carbon atoms with alternating single and double bonds. He said that he had discovered the ring shape of the benzene molecule after having a daydream of a snake seizing its own tail.

The snake wriggled on, and by the 1920s, Grand Prix fuel was blended with gasoline, ethanol, benzol, a mixture of benzene, xylene and toluene, evolving by the late-1930s, ethanol being replaced by methanol with higher specific energy and increased blending octane. As the selection of fuel was free, teams had their own blends, with substances such as benzene, methanol, acetone and nitrobenzene. Engines would not have survived the night without the fuel being drained immediately after practice and races – Mercedes-Benz's brew had 86 per cent methyl alcohol, 4.4 per cent nitro benzol, 8.8 per cent acetone, 0.8 per cent ether.

The choice of elements is rather big, and the list ends up being unintelligible to me, as a mechanical engineer. My remit is simply to know that the amount of oxygen that can be used to burn fuel is the main object – hence that giant-killer, the restrictor. Limit the oxidant, limit the power.

In 1976, all racing in Brazil was restricted to ethanol. Argentina, however, continued racing with petrol. To enable equivalence of power with different fuels, the ethanol-powered Brazilian cars could use additives. And once, when taking off from Ezeiza Airport in Buenos Aires with a Brazilian F2 team, I noticed the engine builder in the seat beside me clutching a bulging backpack rather nervously. He explained that he hadn't been able to find any transport company willing to deliver the additives to Cordoba, where we would race, so he had decided to take the one-litre cans of nitro as hand luggage. The smokers on board the plane became understandably nervous.

Nitromethane is particularly volatile, and can generate about 2.3 times the power of gasoline when combined with a given amount of oxygen, making it a favourite additive (when allowed) to bump up those horses in the engine. Tipping the can in drag racing can sometimes be a bit excessive, leading to multiple bits of smoking metal scattered around the asphalt. It is certainly not something you want to be sitting beside in a bumpy flight in an Aerolineas Argentinas plane.

In the interest of maintaining the health of mechanics and drivers by the late-1960s, the FIA progressively increased the list of banned additives. In the 1970s regulations specified the use of high-octane gasoline, as sold in gas stations in France, Italy, Germany and England with an octane rating of RON 101.

I recall the slog down to Canvey Island refinery to get our supplies, as the fuel station in the forecourt sold 'pump' fuel, but not many others. An added bonus was the dispensing of chamois leather we had to use to filter the contaminants, usually water condensing in the reservoirs at the fuel station. Eventually, the preparation of special fuels for racing was allowed, as long as they fit the template, no matter how different from the forecourt fuel, provided the RON 102 restriction was respected. This continued to the end of the 1980s, while oxygen and nitrogen content were also limited to 2 per cent. Then limits on benzene, lead content and density limits were applied. We saw dozens of new blends during seasons.

Biomass-derived ethanol takes race fuel full circle back to its origins

Meanwhile, turbo engines pushed the use of specialised blends with high levels of toluene and an anti-knock additive TEL (tetraethyl lead). Considering that these mixes were highly toxic and demanded protective clothing and masks, it was entirely rational that by 1992 the FIA declared it would be illegal to use anything else but substances found in unleaded 'super' commercial petrol.

By 2008, fuel had to comply with EU standard EN228, being detailed in Article 19 of the F1 technical regulations dictating the composition and physical properties, such as limiting the upper and lower of the volatility curve by setting upper and lower bounds. Fuel specs stagnated for a while, although it was still supplied by the refiners as racing fuel.

This changed in 2010, when Article 19 was revised by eliminating the volatility parameters, using only the Reid Vapour Pressure and final boiling pressure, eschewing the max and min RON, using the revised RON/MON average minimum of 87. The 2014 turbos will have an interesting number of new blends to gulp, as long as they conform to EN228, and the biomass-derived ethanol closes the circle to those original fuels.

All this entails different operating procedures, mass chromatography and spectrometry – not usually part of the kit you expect to find at racetracks.

Which leads me on to the elusive smell of racetracks that unmistakably make you know you are there, and totally impossible to reproduce on the printed page. (*Racecar* scratch and sniff, anyone?)

The olfactory universe at a racetrack remains something of an enigma. But like the ethanol in American tracks or Le Mans diesels, once you poke your nose inside you catch the details, for instance, a tiny, unclaimed nitrobenzene effect that suddenly brings to mind, but only after the perfumer's gone medieval on its formula.

Benzene, methanol, acetone and nitrobenzene, the smell of Castrol R, spent methyl hydrate, the smell – when hot – of asphalt and from the hot tyres a tang of shredded long chain polymeric structures of rubber being abraded and heated to produce its own distinctive bouquet, not to mention the foul odour of cooked gearbox or differential oil, particularly nauseous and boding ill to the car that emits it...

Ah, one does miss the odour of Castrol R.

One engine builder couldn't find a transport company willing to deliver cans of nitro to a race, so he decided to take them as hand luggage

40
1974-2014
YEARS
OF INNOVATION

Stop the spending war

Could homologation be a tool to reduce costs and help bridge the performance gap?

Anyone who has been curious (or kind) enough to read my column will have perceived by now that I am not a fan of too much technical restriction and uniformity when it concerns motor racing. At the same time, sustainability of costs has to be addressed, and so also must the performance gap caused mainly by the differences in budget available.

Which got me thinking that the powerful tool of homologation should be directed less at design and manufacture, and more at controlling the peripheral costs of going racing.

Focusing on the LMP1 premier class of the World Endurance Championship, for instance – including the Le Mans 24 Hours – the performance gap between the factory and private teams has become an increasingly major issue. Audi has been exemplary in its consistent participation, but one only has to look at the history of prototype racing to see that works competition programmes ebb and flow. In times of ebb, the non-works teams need to be there to fill up the grids, which is why in order for these medium-weight stalwarts to keep participating they need the potential to sometimes upset the formbook and bloody the nose of the heavy-weights.

So where does homologation come into this?

What if – at the year's first championship round – in addition to the standard ACO homologation pre-race, homologation should take place of a single car specification per LMP1 marque and entrant that cannot be fundamentally changed for a set number of events? Only normal suspension and wing setting adjustments permitted, but no alternative items to be fitted except – say – dive planes, Gurney flaps and gear ratios. This would prevent very expensive aero options being on hand in order to fit and give a performance advantage that might become evident only during the practice sessions. The cost of designing, developing and manufacturing such components is high, along with their multiple spares – privateers generally cannot afford this level of expenditure, so it would instantly remove one performance disadvantage for them. As the calendar currently stands, this first homologation period would encompass Le Mans – a second homologation would be permitted at the following event (Austin) to run until season-end.

Therefore, manufacturers would almost certainly have to optimise the initial specification for Le Mans – ie lower downforce levels – which would compromise their cars' performances at the preceding races, and maybe give privateers an opportunity to shine in these as a result.

If the second homologation specification proved to be a wrong move, the entrant could revert to the initial homologation. During both homologation periods, changes could be permitted on appeal strictly and unambiguously on the grounds of safety and reliability. Should this upgrade in turn result in an obvious performance increase, then a penalty (weight, fuel allowance) would be immediately applied.

Following the theme, how about a limit of one complete car's-worth of replacement parts allowed per competing car at every round of the championship? Replacement to be defined as like-for-like and as presented at scrutineering. Pragmatically, at 12- and 24-hour events two cars' worth could be permitted for a limited number of particularly vulnerable items, such as nose assemblies. Repairs to damaged parts could be permitted subject to inspection for safety reasons before re-fitting. As well as reducing the advantage gained by works teams by taking more risks on speed over reliability due to the existence of back-up resources that privateers cannot match, it also presents a true test of endurance racing resourcefulness – much of which has disappeared along with the mega-budgets. Factory drivers

LAT

How to implement cost-reduced racing - reduced development parts

would also doubtless exercise more circumspection while overtaking and not just barge slower cars out of the way as tends to be the practice now, slowing lap times which over the course of a race can affect its outcome.

I am not suggesting that LMP1 should be dumbed down to LMP2 level, and I know full well that manufacturers won't want to be beaten by private entrants and therefore could shy away from participation. But the works outfits will always have the advantage, because they can deploy more technology and R&D, will get tyre manufacturer support right from the concept stage, can afford more testing and to employ the best people – including drivers. It's also in their own interests to ensure full grids and to have the means by which young drivers and other personnel can gain experience in endurance racing and work their way up to the top level – a pool of talent from which they can then recruit.

There is no reason I can see why a similar but more expansive approach to homologation cannot also be taken with F1. One of the major factors determining competitiveness is the rate of development, especially aerodynamic, that has become increasingly de rigueur in recent years – to the point of unsustainability. So fixing the cars' aerodynamic specifications via homologation at the first event, followed by further homologations at approximately 1/3rd and 2/3rds into the season (20 races, remember, vs endurance racing's eight), would significantly reduce expenditure and close the large performance gap between top and lower-budgeted teams.

Although CFD and wind tunnel time is already limited in F1, the tooling and manufacture race-by-race of a multitude of development parts with their spares – many of which may be discarded if they don't display a positive improvement – is considerable and has an impact also on overhead costs in providing facilities to meet this constant demand. As for the LMP1 example, issues of safety and reliability would be allowed for, perhaps also a one-off wildcard during the season to encourage some 'out-of-the-box' thinking necessary for F1 to remain the premier motor racing shop window for our sport.

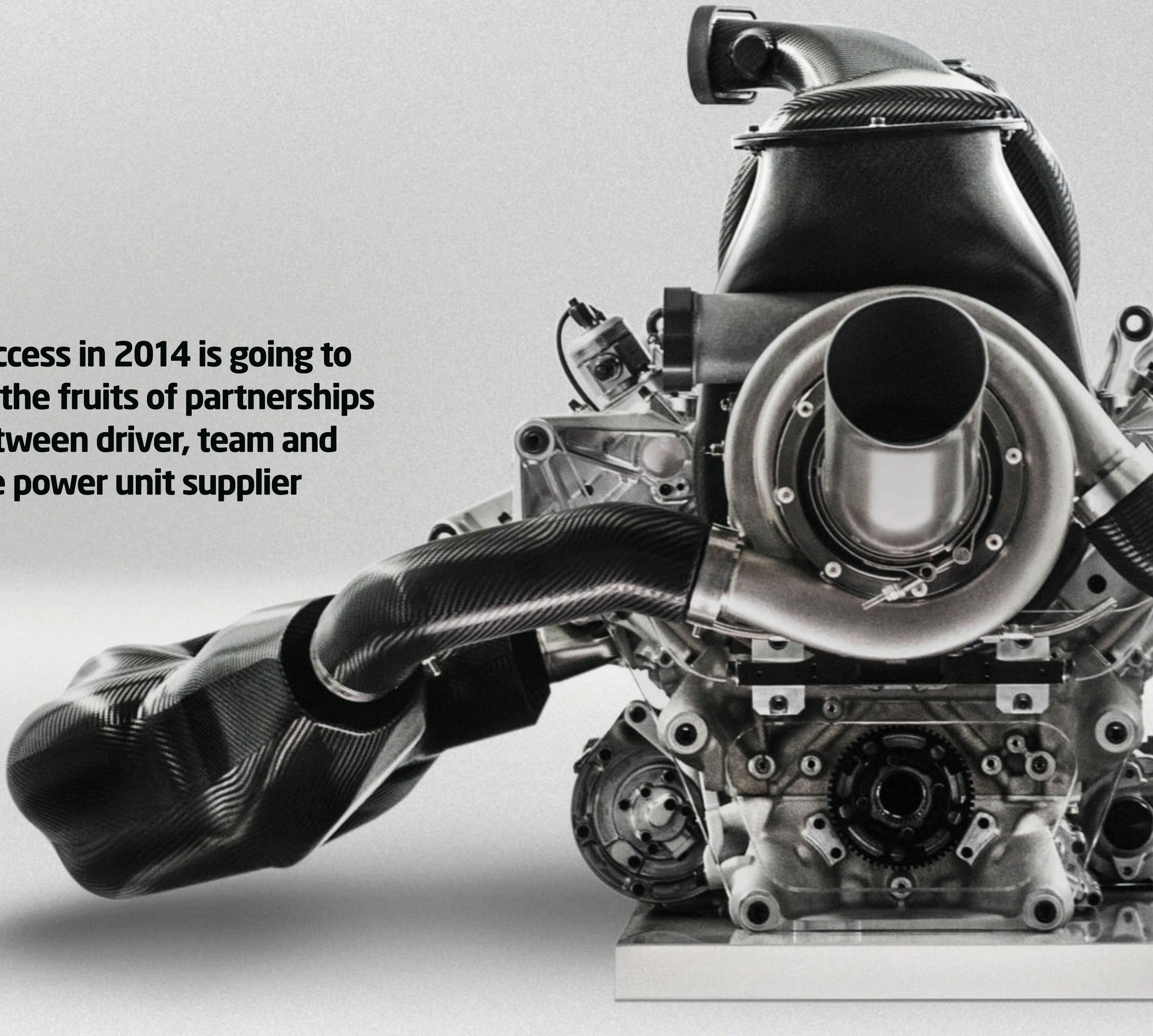
Such measures would not reduce the purity of competition, nor the spectacle – indeed they may enhance both. Isn't this what motor racing should be about, rather than a spending war?

How about a limit of one complete car's-worth of replacement parts allowed per competing car at every round of the championship?

What's in the pipeline?

With the season opener in Melbourne fast approaching, Peter Wright looks at how engineers are dealing with the details of the new regulations

BY PETER WRIGHT



Success in 2014 is going to be the fruits of partnerships between driver, team and the power unit supplier

> **To achieve the fuel consumption reduction target involves more efficient IC engines, more energy recovery, and a reduction in drag**

Driving from Malaga airport towards Jerez for the first public tests of the new-for-2014 F1 regulations, I had little idea what to expect.

With radically new power unit (PU) regulations – you mustn't call them engines any more – and significant changes to the aero regs, making predictions about performance would be hopeless. Likewise, with cautious but informationless statements emanating from all three PU manufacturers, and it being quite clear that the true aero performance of the cars was unlikely to be evident at this first test, I set to musing about the fundamentals behind the development of the new PUs. Mercedes, Ferrari and Renault – how could they be rated according to industrial might?

Mercedes, as part of Daimler AG, lacks nothing in terms of R&D expertise in materials, combustion, and simulation, nor in resources. In Mercedes AMG HPP at Brixworth they have a fully-resourced F1 engine and ERS facility, manned by the best of Cosworth and Ilmor. Mercedes had, by reputation, the most powerful 2.4-litre V8 of the last few years.

Renault's industrial resource is probably not as great as Daimler's, but without knowing how much of Nissan can be called upon, this may be unfair. Viry produced an adequately powerful and very fuel-efficient V8, and this expertise will be useful in 2014.

Ferrari, though small in itself, has so much high-performance powertrain experience, and has the might of Fiat, Fiat Research, and indeed all of Italy behind them.

All three have extensive experience of turbocharging racing engines, ERS and simulating racecar performance. I mentally placed Mercedes ahead of Renault and Ferrari in equal second. Four days at Jerez would prove little, but maybe some indications would emerge. How right this proved to be!

FUELLING PARTNERSHIPS

Success in 2014, more than ever before, is going to be the fruits of partnerships between driver, team, and PU supplier. What exactly is it that they are all trying to do? The FIA has set the objective: to perform at close to existing levels while using a third less fuel. The last part of this is simple and clear: each car will have an allocation of 100kg of fuel for each race, an average of two-thirds of what they used in 2013.

Meeting the first part, performance, is a bit more complex. To achieve the fuel consumption reduction target involves more efficient IC engines, more waste energy recovery, both kinetic and exhaust, and a reduction in drag. A reduction in mass would also contribute, but this quickly became impossible once all the new systems required were specified. The reduction in drag is to come from a reduction in downforce. When the regulations were finalised in 2011, no one knew how fast the cars would be in 2013, especially as the full exhaust blowing capabilities were not known. How clever the aerodynamicists would be in interpreting the 2014 bodywork regulations was also not known, and so just how the performance of the 2014 cars will compare with those of 2013 remains to be seen.

Maximum downforce/drag levels are going to be around those for Spa and Canada in 2013, which doesn't mean there will be no downforce loss at the faster circuits. 100kg fuel is not going to present a limitation at the slow and medium circuits but it will on fast circuits, and so drag will have to be reduced, along with downforce.

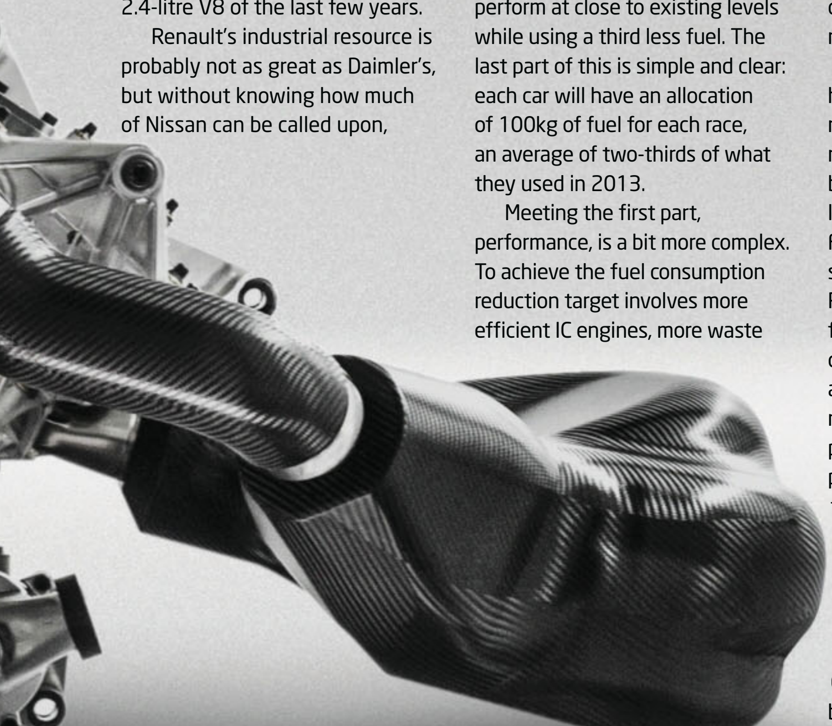
Before trying to delve into how each driver, team and PU manufacturer might go about meeting these objectives in a better way than their competitors, let us look first at how the FIA will apply these new and sportingly decisive regulations. Regulating the total quantity of fuel used requires both a means of regulating that quantity very accurately and a maximum flow rate rule, to prevent PU designers producing very high maximum power units for qualifying and the last lap of the race. These two measurement tasks can be performed by a single sensor, and the FIA, after an extensive search, have sourced such a device from Gill Sensors, which will form the basis of both the 2014 F1 and WEC regulations.

The Gill flow rate sensor uses ultrasonic pulses to measure the velocity of the flow relative to the speed of sound in the fluid. With the mass flow output dependent on the bulk modulus, density, temperature and pressure of the fluid, sensors are independently calibrated with each fuel used by a team.

Because of this, each sensor does not have to be identical to the others (reproducibility) but must be repeatable. Early indications are that an accuracy of ±0.25 per cent has been achieved. Very good, even in an application where everyone wants it to work accurately, but the real test will be in the application where perhaps the user does not want it to be accurate. 0.5 per cent power equals around 0.07 seconds per lap or 3-4 seconds over a race distance. The sensor is mounted between the low-pressure and high-pressure fuel pumps and any return flow from the fuel injectors must be returned downstream of the sensor. The WEC will use up to three sensors per car – two to provide a reliable average reading, and one, if required, for return flow. In F1 the sensor must be mounted in the tank; in WEC on the outside of the car, beneath a cover.

The FIA ECU will monitor the 100Hz signal from the sensor along with RPM, and must deal with any measurement of excess flow due to signal noise. This excess flow will be put into a virtual 'pot', and provided the flow is instantaneously below the limit at any given RPM, the 'pot' will leak out its contents at a prescribed rate. The 'pot' must not 'overflow'. The quantities and rates for this system are not yet decided, awaiting hard data from the cars, but it is planned to limit mean overshoots to less than 0.5 per cent. Attempts to use this method of smoothing the signals to gain extra flow rate are punishable.

The sensor also totalises the fuel flow. The value is zeroed after the parade lap and must not exceed 100kg at the finish line. The PU's ECU and the FIA will be provided with the totalised value for each car, and it is up to the PU not to exceed limits. FOM TV will also receive the values such that they can be used in graphics to illustrate what is going on between competing drivers. Fans should be able to take this on, as most car drivers are used to using their 'range' displays to control driving in search of a fuel station.



The power unit with the best method of combusting fuel, sharing the released energy between pistons and turbine, with the least friction, heat and pumping losses, will achieve the highest output

By far the best way of understanding the complexity of the technical regulations and what they allow the PU to do is to study Appendix 3 of the Technical Regulations. The diagram titled 'Power Unit Energy Flow' explains it all and saves lots of reading, cross-referencing and head scratching (see p12).

Of particular note is the fact that the MGU-H and MGU-K are permitted to pass energy between them directly in a way that does not have to suffer the losses, which can be as much as 15 per cent, of intermediate storage in the energy store (ES), and with no limit on power. In effect, this means that the turbo can be 'connected' directly to the crankshaft with similar efficiency to a train of gears, but under the control of the MGU control unit.

To understand how this new and complex PU will be used in racing, it is first necessary to understand – as far as is possible – exactly who controls what. The driver's throttle pedal is a torque demand. The regulation stipulates that the relationship between the pedal position and torque demand must be a fixed relationship, and that the driver may have two alternative maps – one for dry tyres, and one for wet. The PU software decides what mix of torque generators – ie engine and/or MGU-K – delivers the demanded torque. The FIA monitors this demand: the PU software output to the torque generators, the torque entering the transmission, and the torque going to the wheels. These last two are derived from new for 2014, homologated torque sensors.

The FIA's interest is traction control. They want to check that nothing about the torque control originates anywhere other than at the driver's right foot. They also want to check that the instantaneous, per-lap, and per-race limits on energy and energy flow rate (ie power) are adhered to, and it is the job of the PU software to achieve this. However the teams, via the drivers, do have some influence on the per-lap figures. At this point some numbers may be useful:

100kg/hr maximum fuel flow rate equates to 1.11MJ/second, or 1111KW, with a fuel of, say, 40MJ/kg energy density. This represents the input power of the fuel to the PU.

Note that the F1 fuel regulations do not specify any energy density limits. WEC uses a standard gasoline of 39.55MJ/kg. It is considered that the F1 fuel specifications limits what is possible to vary energy density, and this approach allows the all-important fuel industry partners to be involved in PU development. There are limited trade-offs between energy density and octane number, which is more important for efficiency than flame speed in these relatively low-revving engines compared to the V8s. 1-2 per cent variation in energy density is expected.

Although we don't yet know specific details regarding MGU-H performance, it could theoretically produce 40-60kW power over and above the needs of the compressor. The actual output will depend on the acceptable backpressure of the turbine, which will impact the output

(Above) exploded view of Renault's new F1 power unit; (left) problems for the Red Bull RB10 in testing at Jerez, as Daniel Ricciardo was forced to stop on the circuit, and a fire extinguisher was put on the case

and efficiency of the piston part of the engine.

Unsubstantiated figures doing the rounds indicate that the pure turbo-IC part of the PUs are giving around 520cv, or 388kW. With, say, 50kW at full power from the MGU-H, this rises to 587cv. Therefore, with a 1111kW input fuel power, as a pure turbo-IC engine the efficiency would be 35 per cent, and as a turbo-compound engine 39.5 per cent. Pretty impressive if achieved. For qualifying, this is what is relevant, but for races where total fuel is limited, the total energy available matters more. 100kg fuel equals 4000MJ. At Monza, this is 75.5 MJ/lap over 53 laps, which can be turned into 29.8MJ at 39.5 per cent efficiency at full power. Ignoring part throttle PU use for the moment, we can put this 29.8MJ in a pot for use during an average lap. Bear with me!

It is unlikely that the MGU-H will generate any significant energy for storage in the ES, as it is always best to pass it directly to the MGU-K whenever there is a surplus, which is generally at full power.

The MGU-K is permitted to pass 4MJ/lap from the ES to the wheels at 120kW, which means for 33.3 seconds. This could certainly be used if there are 4MJ in the ES available. However, the ES can only receive charge from the MGU-K at 120kW for 16.7 seconds to meet the 2MJ/lap limit. It is going to be a challenge to harvest 2MJ each lap but, for simplicity's sake, let's assume an average of 2MJ of energy is available each lap. Therefore total average energy per lap equals 29.8+2MJ = 31.8MJ.

The average race lap time at Monza is 89 seconds, so average power equals 357kW, or 479cv. This equates to 81.6 per cent of the maximum power of the turbo-compound engine, on average, or 70 per cent of the maximum power of the 680cv of the entire PU (remember: the MGU-K is limited to 120kW even if drawing energy from the MGU-H), on average. Drivers use around 70 per cent full throttle at Monza, so this makes some sense. These figures involve many assumptions, but are indicative of the race energy and power equations. The PU suppliers and teams will work the actual numbers to the nth degree and arrive at optimal settings for every part of every lap in qualifying and in the race, when there is a varying fuel load and hence car weight.

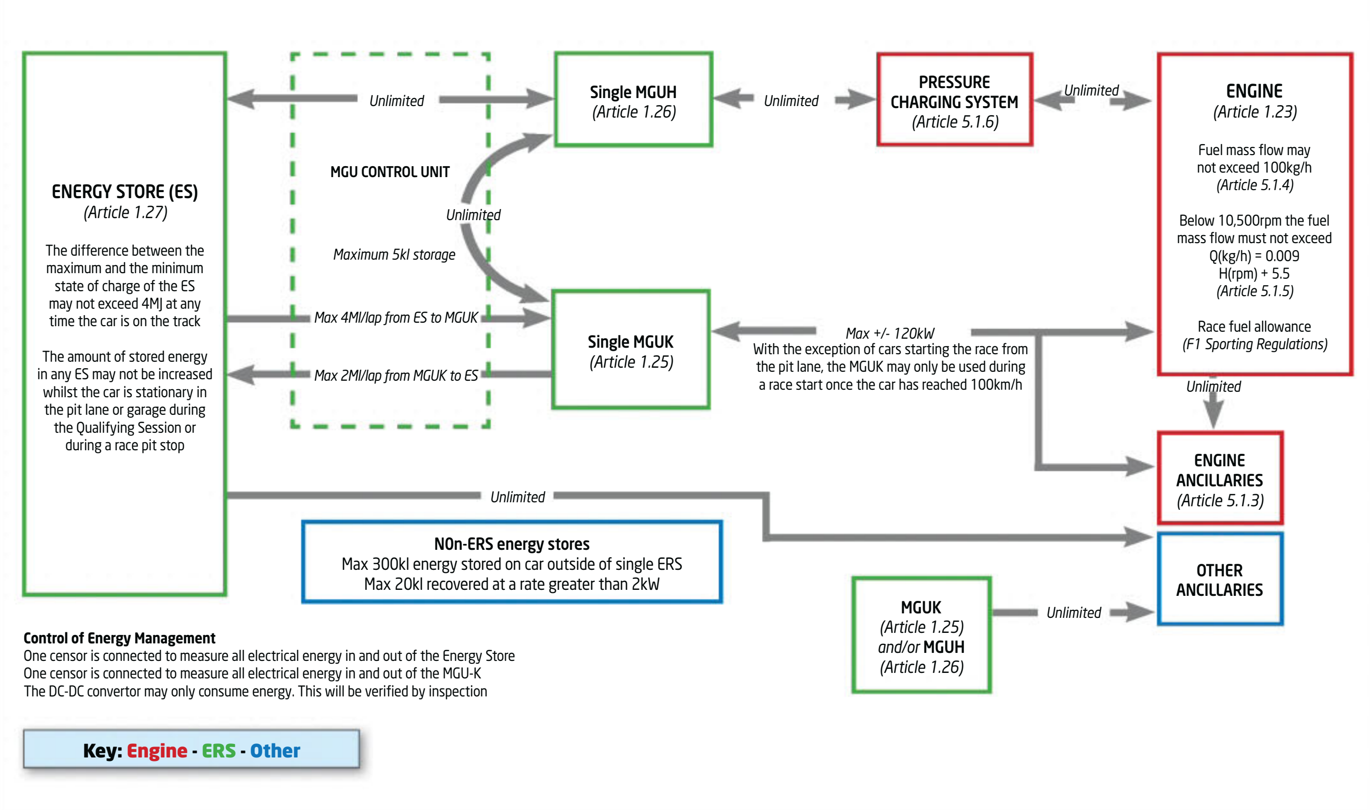
Qualifying presents a particular set of opportunities: the driver simply has to maintain the maximum throttle possible for as much of the time as possible and – though limited by the maximum fuel flow rate – he is not constrained by total fuel used during his fast lap. The guy who uses the most fuel is likely to be on pole! At the same time, he needs to start his fast lap with 4MJ available in the ES. It is unlikely that he will try and harvest all this on multiple warm-up laps, as this would be to the detriment of his tyres. He cannot charge the ES in the pits or garage during either qualifying or the race. So, for each of the Q2 and Q3 sessions, the ES needs to have been topped up to 4MJ at the end of the preceding session, leading to two or more hard-braking slowdown laps at the end of Q1 and Q2. A second lap on a set of tyres looks difficult in the time available, with the need to recharge the ES.

The race is far more complicated. The calculations above relate to an average lap. Conditions during the race vary enormously: wet/dry, safety car, fuel weight, race position, tyres etc, and will require a continuously evolving strategy for performance versus fuel use. The PU software is permitted to reduce power once full-throttle is applied and there is an excess of traction over wheel torque, so fuel can be saved. The driver can always lift early on the straight (the optimum technique for fuel saving) and he can short-shift. He is only likely to do this on instructions from the team and this is likely to to be communicated with a tone in his earphones, so he does it right.

Although not in the regulations, it is believed that the teams will fit a boost button, so that full power can be demanded regardless of the target fuel for that lap, for overtaking or preventing being overtaken. The excess fuel used will have to be won back. It is obviously easier to regain fuel budget overspent early in the race than the same overspend in the last few laps. Expect real-time strategy computing to be going on in the garage and back at the factory throughout the race.

It is believed that teams will fit a boost button for overtaking, so that full power can be demanded regardless of the target fuel for that lap

POWER UNIT ENERGY FLOW



The name of the game is simply 'performance per unit of fuel' and provided the fuel-used information is made available to viewers in an understandable way, they will observe the performance and should be able to follow the game.

How each PU supplier and their teams have set out to achieve this best 'performance per unit of fuel' is pretty hard to determine. The level of secrecy, screens, shut garage doors etc means little has been seen of the PUs. When engine covers have been removed in plain sight, most of the PU is hidden beneath heat shields. Even if they were not, there is little to be learned from an assembled PU, as everything of interest lies inside the hardware and software, well out of sight. However, from observing the running and listening to the talk at Jerez, it is possible to see where the main challenges are and gain a glimpse of some of the solutions being tried. It was quickly evident that getting everything to work together in harmony was the greatest challenge and that, while Mercedes and their principal teams were on top of it, Renault, and Red Bull in particular, were not. Failure to do so quickly manifests itself as a reliability issue where powerful, hot, fast-rotating, high response-rate systems are involved. 'The team that comes up with the simplest, reliable strategy for looking after the powertrain can win,' said Pat Symonds. However, development will happen very fast and just who is really 'on top of it' will only become evident in the racing environment.

If we put to one side the aerodynamic and tyre contributions to the performance, a) because they have been widely covered elsewhere; b) because aerodynamics, and probably final tyre specifications too are nowhere near definitive; and c) because the job of the engineers involved is not so different from previous years, even if the regulations have changed, then we can concentrate on powertrain performance, weight, and braking.

POINTS OF INTEREST

- The two throttle maps for wet and dry tyres are thought to provide enough scope for qualifying and the race. No software changes are permitted in parc fermé – the FIA can check every time the PU is fired up. Automatically!
- The FIA gathers around 100Gb of data at each event.
- Although the main engine ancillaries must be driven by the engine, other fuel and coolant pumps, the drive-by-wire throttle etc can be electrically powered from the ES. 48V is becoming the norm for this.
- The cars need a small startup battery to power up all the main systems. There is nothing to stop the PU being started by the MGU-K.
- It is believed that all the core engines employ pneumatic valve closing. This doesn't make obvious sense from a weight, cost or reliability viewpoint, as 15,000rpm is well within the capability of steel springs. The only reasoning I could obtain for this was that pneumatic is what the designers know best these days.
- Although no PU pictures show turbo waste-gates, there was much talk of them being fitted in case of MGU-H failure. The waste-gate exhaust would have to join the main exhaust pipe and if fitted, is probably hydraulically operated.
- I would hate to realise, post-Jerez, that all my dyno running and hardware-in-the-loop simulations had not been born out on the track. There must be a lot of worrying going on in some factories.

POWERTRAIN OUTPUT

The output of the thermal part of the PU, the turbo-compound engine, is all about efficiency. The manufacturer who finds the optimum way to combust the fuel, share the released energy between pistons and turbine, all with the least friction, heat and pumping losses, will achieve the highest output and be able to use it for the longest time. The additional output from the mechanically coupled MGU-K is pretty well a double-sized KERS system from last year. The battery ES, while able to


45 Years of Experience Engineering and Manufacturing Racing Fasteners
ARP
automotive Racing products
Manufactured in the U.S. – Raced All Over the World
ARP fasteners provide strength and reliability for every type of racing.
All ARP fasteners are engineered and manufactured entirely in our own ISO 9001 and AS9100 registered facilities in Southern California.
Honda Racing/HPD relies on ARP fasteners in their IndyCar engines.
HONDA
Made In USA
ISO 9001 Registered
ANAB ACCREDITED
AS9100 Registered
Download our 2014 catalog
www.arp-bolts.com
1863 Eastman Ave • Ventura, CA 93003
Outside the U.S. +1.805.525.1497 • Toll-free in the U.S. 1.800.826.3045

output 10 times the energy of previous years, per lap, is only about twice the size, because it is sized by the power it must accept while charging and discharging. However, with that power able to be turned on for much longer, cooling requirements for the storage, control and MGUs are significantly greater.

COOLING

In addition to the need to dissipate the greater energy losses in the more powerful ERS, the cooling system must also cope with the turbocharger's heat input to the charge air. For maximum power, the cooler the charge-air, the better will be the volumetric efficiency. However, at least under race conditions where performance/unit energy is paramount, this is not necessarily so. PU developers and their fuel partners will know the optimum charge temperature for efficiency, and the system can then be designed accordingly.

Ferrari has determined that air-water-air cooling for the charge-air works best, and their teams' cars display by far the smallest radiator intakes. One would think the extra heat transfer interface would be less efficient, but type and construction of radiator (air-air versus water-air) comes into it and there is great progress being made into radiator core technologies.

Renault only specifies air-air; and Mercedes offers a choice of either, but only Mercedes AMG Petronas is believed to be the only one to offer a choice.

Intriguingly, and contrary to the pictures of the Mercedes PU published so far, Mercedes has split the compressor from the turbine, locating the former at the front of the engine and the latter at the rear. In between, mounted in the V, is the MGU-H being driven/driving the turbine and compressor via shafts. This arrangement allows all the cold parts and charge-air ducts to be mounted forward and the hot parts at the rear. The air-water heat exchanger is also mounted low down at the front of the engine. Mercedes studied literally dozens of layouts, analysing them for performance, efficiency and packaging, and built and dyno-tested quite a few before coming up with what they have built.

Mercedes AMG Petronas is believed to have gone down an air-water-air route of cooling but offers its customer teams a choice

RESPONSE

Turbo engines have the reputation of providing the driver with turbo lag, ie a delay between throttle demand and engine response. Modern turbocharged road cars overcome this with tiny turbos, and variable geometry – not permitted in F1. The turbines on the new PUs use a larger turbine than is required, just to drive the compressor in order to extract energy from the waste exhaust gas stream, and so they have higher inertia. To meet the FIA's requirements that the PU responds to a torque demand within a certain time (TBD once track data is available), the MGU-H is used to accelerate the turbine and compressor.

The MGU-K can respond almost instantly and here the FIA will be watching to ensure fast torque modulation is not used for any form of traction control or even ABS at the rear wheels.

TRANSMISSION

2014 sees all-new, eight-speed gearboxes, with ratios that are fixed for the season, although in 2014 alone there will be one change permitted to the homologated ratio-set to allow for learning. The 2013 V8s needed seven speeds to cover the useable torque band, and it is considered that five or six should suffice with the wide torque range of the new PUs, so providing a range of options from eight ratios. Additionally, because the engine is generating almost constant power above the peak fuel flow RPM of 10,500, the RPM can be extended upwards to allow DRS or slip-streaming top speed increases.

OVERALL IMPRESSIONS FROM JEREZ

- The new regulations are great and offer a real challenge for F1, to which it will rise. They should be given a chance to prove themselves capable of delivering exciting racing before being criticised. The fuel consumption reduction is guaranteed to be achieved; but whether the speed will be up to the mark without more variable aero than DRS provides remains to be seen.
- The nose shapes are not really noticeable on the circuit – their perceived ugliness only shows up in close-up photographs. Nice of Ann Summers to comment on F1, though!
- From the rear, the cars look great, with their purposeful exhaust outlet giving them the look of a small fighter trainer.
- The cars sound great too. No need for earplugs or ear-defenders in the pit lane or stands, where one can hold a conversation while cars are running. On TV, who will really notice the difference?
- McLaren has set a new ball rolling with their rear suspension shapes. We should expect all sorts of developments in this area above the diffuser.
- When cars stop on the track with smoke rising from the rear of the car, the smell is that of overheated or burning electrical insulation, instead of the usual hot oil. Different!

WEIGHT

The weight limit of 690kg is providing a real challenge, denying race engineers ballast to adjust the handling of the car. Two examples that illustrate the lengths to which designers have to go is the replacement of aluminium oil and water pipes with carbon fibre ones, and the dispute over turbine failure containment. All the PU manufacturers have conscientiously ensured that their turbos are safe, but an argument over the wording of the regulation on the subject is really about the difference of over 3kg in the interpretation, hence the intensity of the discussion.

BRAKING

With engine braking from the MGU-K increasing from 60kW of KERS in 2013 to 120kW, brake balance becomes critical, and the FIA has permitted a level of brake-by-wire to adjust brake pressure distribution. Two other issues have emerged. Firstly, the teams have reduced the size of the rear brakes, and a loss of MGU-K braking will lead to an under-braked, but fortunately stable car. Secondly, as the zero-shift transmission changes down during braking, the torque pulses to the rear wheels have become larger with a destabilising effect. Smoothing the shifts becomes important. There were plenty of signs at Jerez that the teams had to work hard on rear braking.

So roll on Melbourne – I for one can't wait.

Mercedes has split the compressor from the turbine, locating the former at the front of the engine and the latter at the rear

Teething troubles

The opening two tests have demonstrated the challenges that lie ahead this year, with cooling and the brake-by-wire system proving particularly problematic for some teams

BY SAM COLLINS

The arrival of F1's new power units has provided a significant challenge teams over the winter. This was made abundantly clear at the opening two tests, where a number of cars struggled to accumulate adequate mileage. The trouble seems to stem from the installation and on-track operation of the systems, especially when it comes to the two hybrid systems and their cooling.

Teams using the Renault RS34 have had the biggest issues, initially due to a failing in the battery management system in the French firm's energy store.

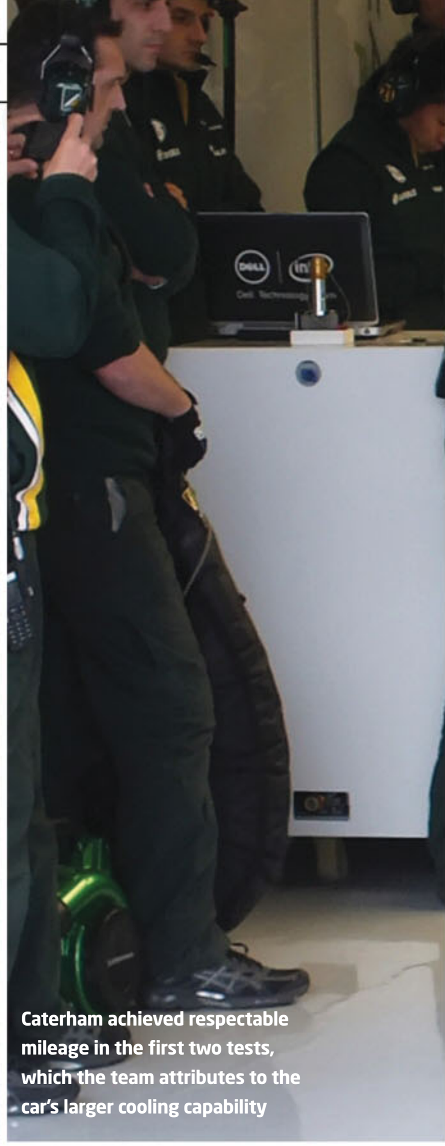
'The underlying causes of our problems are not straightforward: there isn't a single component or system that has caused particular trouble,' said Renault Sport F1 technical boss Rob White. 'A number of related things have been troublesome, principally concerning the control and operation of the various sub-systems of the power unit within the car. We subsequently had problems with the turbocharger and boost control systems, with knock-on effects on the associated engine management systems in turn provoking mechanical failures.'

It is clear that the cooling requirements of the three units to be used in the coming season vary greatly, with the Ferrari having the lowest demand and the Renault the highest. This has to an extent caught out some of the car designers, including Red Bull, which only started to get in significant mileage on the second day of the second test in Bahrain.

'It was, you could argue, a result of aggressive packaging,' said Adrian Newey, 'but we felt that we needed to take a few risks to try to get a good package that would minimise the aerodynamic damage of this very large cooling requirement.

'The Renault seems to have a particularly large cooling requirement. Each of the three engine manufacturers will have a different target for how hot their charge air is going back into the plenum, and Renault have given us a fairly challenging target. It has all sorts of advantages if we can get there, but it is not easy to achieve.'

The Renault-engined cars all have noticeably different cooling



Caterham achieved respectable mileage in the first two tests, which the team attributes to the car's larger cooling capability

IS MCLAREN'S REAR SUSPENSION ILLEGAL?

Confusion surrounds both the purpose and legality of the rear suspension on the McLaren MP4-29. At the car's launch at the team's factory in Woking, England, the only notable feature of the rear suspension was the length of the rear wishbone arms. When the car appeared at the Jerez test, however, the rear end was fitted with four unusual elements fitted to the wishbones. The exact purpose of the so-called 'mushrooms' (as McLaren has dubbed them) is not clear, but their purpose is almost certainly aerodynamic rather than mechanical.

'I would imagine that they are trying to make the diffuser work better,' said Rod Nelson, chief test engineer of Williams. 'One of the major functions of the lower rear wing [beam wing] was not to generate downforce on its own, but it helps you to be more aggressive with the diffuser, and stops it stalling at lower ride heights – so I would imagine that they are doing that.'

If that is the case, then it is hard to understand how the design complies with the 2014 F1 technical regulations relating to the suspension components. The seemingly clearly written article 10.3.4 states that non-structural parts of suspension members are considered bodywork:

'With the exception of minimal local changes of section for the passage of hydraulic brake lines, electrical wiring and wheel tethers or the attachment of flexures, rod ends and spherical bearings, the cross-sections of each member of every suspension component, when taken normal to a straight line between the inner and outer attachment points, must:

a) Intersect the straight line between the inner and outer attachment points.

b) Have a major axis no greater than 100mm.

c) Have an aspect ratio no greater than 3.5:1.

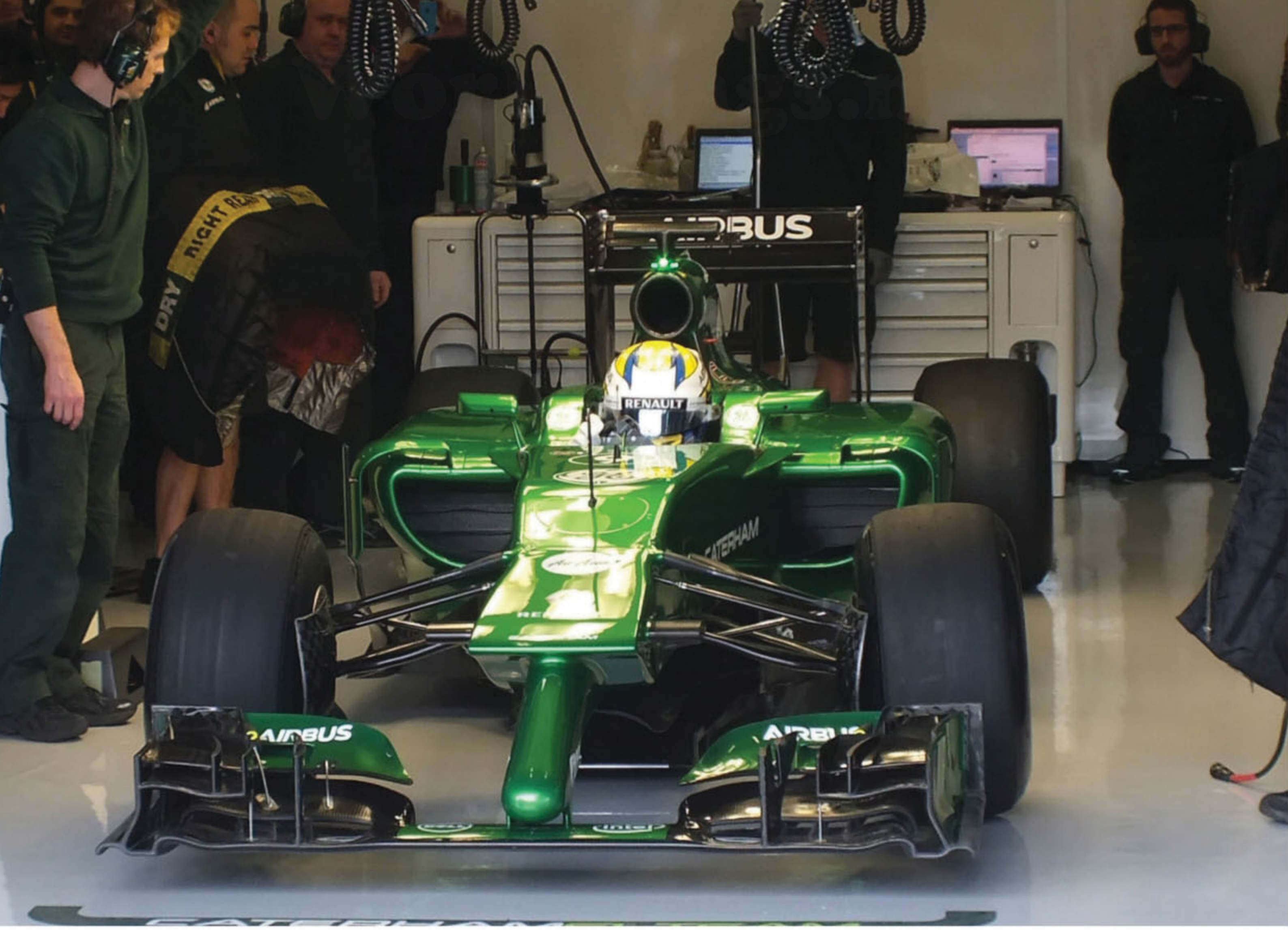
d) Have no dimension which exceeds 100mm.

The major axis will be defined as the largest axis of symmetry of any such cross-section. The length of the intersection of this axis with the cross-section must not be less than 95 per cent of the maximum dimension of the section.'

If, however, the mushrooms are considered to be bodywork, then article 3.15 would come into force, which states that:

'With the exception of the driver adjustable bodywork (DRS) and the brake ducts, any specific part of the car influencing its aerodynamic performance, must be rigidly secured to the entirely sprung part of the car (rigidly secured means not having any degree of freedom) and must remain immobile in relation to the sprung part of the car.'

Nelson was one of a number of engineers that have voiced



both curiosity and the assertion that they do not believe that the mushrooms are structural in any way. 'They have been quite cute with the regulations,' he added. 'The rear part of the wishbones have a kind of dog-leg in them, so they can kind of get these surfaces on the trailing edges. It's quite clear that the primary purpose of them is not mechanical. You do not design a tension or compressive member with a dog-leg in it on purpose, unless you want to make something heavy and flexible.'

The mushrooms being mounted to the wishbones are clearly unsprung and clearly move. However, there is talk in the paddock that somehow McLaren has found a loophole in the regulations that mean that the devices are not bodywork, and so article 3.15 does not apply. If the mushrooms are considered part of the suspension rather than as bodywork, then they must comply with article 10.3.1.

Some engineers in the paddock have described it as a head-scratcher quite how it can be considered legal and comply with either 3.15 or 10.3.1, but many are already beginning to think about implementing their own version. 'If the FIA deem it to be legal, we would be remiss not to try it in the tunnel,' admitted Nelson.

Perhaps McLaren has managed to push the regulations to the limit with the dimensions of the mushrooms, just staying inside the limits defined in 10.3.1. It will then be a case of having to prove that the primary purpose of the design is not aerodynamic, and instead is structural. It may be that the only way that teams will be able to find out how the McLaren design is legal and does not constitute a moveable aerodynamic device will be to protest the car, something that may happen at the Australian Grand Prix in March.

"A number of things have been troublesome, principally concerning the control and operation of the power unit sub-systems"

packages, unlike those using either Ferrari or Mercedes power which are all quite similar. This may suggest that the cooling requirements supplied by Renault to the teams were not ideal, and the company admits that some of its data was not as good as it should have been.

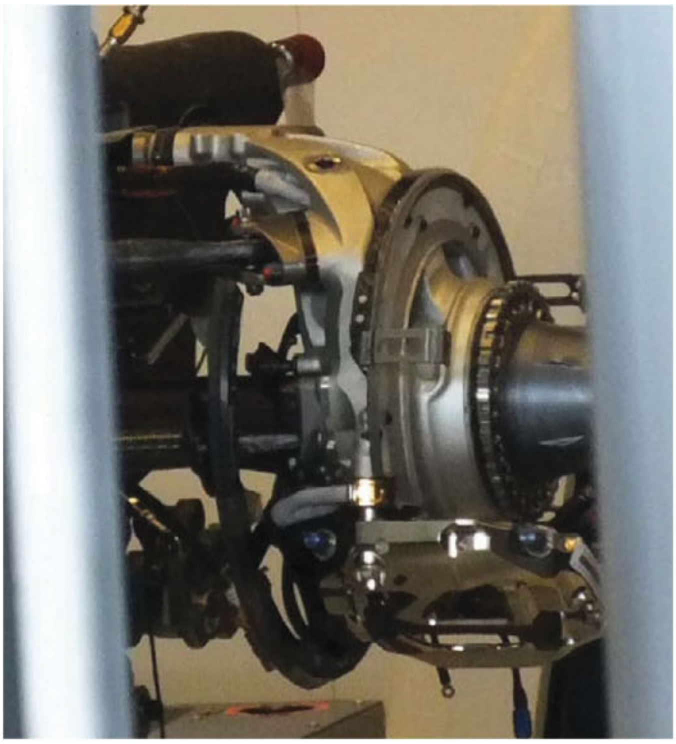
'We believed our initial configuration was a robust start point for track use but it has not proved to be the case,' said White. 'We have done substantial dyno running in a similar configuration with few issues. We now know that the differences between dyno and car are bigger than we expected, with the consequence that our initial impressions were incomplete and imperfect.'

One Renault customer with very few problems is the Caterham team, which managed to get respectable mileage in at both of the opening tests, which the team puts down to its obviously larger cooling capability.

'My brief was that we should not be in a position where the cooling was marginal at these first four races,' said technical director Mark Smith. 'Obviously there are different demands at different circuits, but we do not want to be cutting holes in the bodywork when we get to Bahrain. We are conservative by intent, and with the data we have got in terms of heat rejection from Renault, and analysis in CFD and wind tunnel in terms of mass flow rate through the ducts, we believe that we should be able to cool and have a little bit of a margin.'

This suggests that at least some of the problems suffered by other Renault teams are not down to the power unit, but rather its installation and packaging being rather too tight.

Once teams have overcome the installation issues with the power units, they then have to master the brake-by-wire (BBW) systems which come with them. To allow teams flexibility on energy harvesting strategies during braking, the 2014 rules allow for a semi-active electronic control of the rear braking pressure line. This BBW system allows the braking load to fluctuate between the engine braking effect of the KERS harvesting and pure friction braking – and indeed any combination of the two.



A first look at the brake-by-wire rear caliper on the McLaren. Japanese company Akebono specially developed the electro-hydraulic controls for the 2014 car

This is not a first for motor racing – the GT300-specification Toyota Prius was fitted with two brake calipers on each of its rear wheels: one a conventional AP Racing hydraulic design, the other an electronically controlled unit from Project Mu. 'When you brake, the motor recovers energy from the rear wheels and that feels to the driver like engine braking,' explains Hiroto Kaneso, who designed the GT300 Prius. 'But when that KERS braking phase ends due to the battery being full, you lose that retardation.

'For the driver it is important to retain the brake feeling, and that's why we have the second caliper, so when the battery is full, the second caliper maintains that feeling and retardation. The second brake caliper is fully electronically controlled and operated with no master cylinder.'

BRAKING POINT

Getting the feel right for drivers is a major headache for some teams, as well as making the systems reliable. At the first test at least two teams struggled to get BBW fully operational, leading to a few off-track moments. The F1 layout involves only a single caliper on each rear wheel, and has more complex inputs as can be expected.

'You just take the hydraulic inputs that the FIA specify, and work with an electronically-controlled hydraulic link to the caliper,' said Toro Rosso technical director James Key. 'At the same time you have some redundancy in there, so if you have a failure it should revert to a manual brake circuit. You have to account for any failure mode you can think of both mechanically

POWER STRUGGLES LEAD TO REGS CHANGE

The complexity of the new F1 power units was always likely to leave one of the engine builders behind, but as discussed in *V23N11*, strict homologation rules mean that anyone left behind would not be able to catch up until 2015.

'I can't imagine a situation in which you could just allow someone to have a bit of a leg up,' Rob White of Renault Sport F1 told *Racecar* back in 2013. 'I see no circumstance that would be acceptable to the broader community. There is going to be a car on pole position and a car at the back, and I don't think anyone would seriously suggest that the one at the back deserves a more powerful engine to catch the one at the front.'

However, ongoing reliability issues suffered by teams in the first two winter tests have made it clear that some – notably, in fact Renault Sport – may not be able to get their power units fully reliable by the 28 February homologation deadline. This has led to a subtle but important change being added to the F1 Sporting Regulations.

Now the engine manufacturers will be allowed to modify and re-homologate after the deadline if the changes are for reliability, safety or cost-saving reasons. Additionally, the updated power units can only be used if the FIA is satisfied – after full consultation with all other suppliers of power units for the championship – that it could fairly and equitably be allowed to compete with other homologated power units.

The manufacturer wanting to change the power units would have to show clear evidence of failures – something that Renault Sport would not struggle with.

That evidence would then be circulated to all parties to see if there are objections. A similar rule was in place under the V8 engine freeze, but did not always have the intended result – often manufacturers made changes with the headline purpose of improving reliability, but just happened to bring sizeable performance gains.


Grand Prix Racewear
WWW.GPRDIRECT.COM - 08435 070 858
"A PROFESSIONAL SERVICE FOR PROFESSIONAL DRIVERS"
BESPOKE RACEWEAR by:
OAKLEY
Grand Prix Racewear are pleased to announce a new partnership that see's us being appointed as the Exclusive UK Retail Partner for Oakley Racewear. Please contact us for more information
As worn by UK OAKLEY Ambassadors Rob Huff (WTCC Champion) & Robb Holland (25hrs of Thunderhill Winner)

"Brake-by-wire is massive for us in 2014. The driver needs to have a good feeling of retardation vs pressure that does not move around"

and in software. It's a bit like a differential or a clutch, but the tricky bit is mapping it well.'

Mapping the systems is an area where some teams, notably Renault runners who lost track time at the Jerez and Bahrain tests, will be struggling. 'Brake-by-wire is massive for us in 2014,' says Williams chief test engineer Rod Nelson. 'You have control system mapping, driver mapping to get him comfortable, state of charge control, making sure the battery is topped up at the right time, and temperature and vibration – and that's just one system.

'The driver needs to have a good feeling of retardation vs pressure that is not steppy or moves around – it has to stay the same. He can adjust the bias forwards or rearwards as in the past, but we are also balancing how much energy he uses from the rears with how much we are trying to recover.

'It's key to the mapping and the brake setup that when you come off the brakes, there is no residual force that may give a little bit of instability or a lock up. Some drivers are very, very sensitive to this. We can model the brakes on the simulator, and we have done, but they are not straightforward as there is a thermal effect. The amount of stopping power the brakes have depends on the temperature of the brake, so that's an input we need to understand. We set a recovery target for each lap, so whatever a driver does not put in, the MGU does.

'We have had issues with losing brake-by-wire, and the driver ends up on his own. The pedal has a very different feel when that happens – it is much softer than you expect it to be. More significantly, the brake bias shifts substantially. If you come into a corner with a BBW failure, you'll get a wake-up call.'

It also creates a challenge for the caliper manufacturers such as AP, Brembo and Akebono, who have to develop control systems to aid the braking effort at the rear, negating the need for the driver to constantly alter the brake bias, and also contributing in preventing rear lock-up.

The arrival of BBW in F1 means that now the only things the driver controls mechanically are the steering angle of the front wheels, and the pressure applied to the front brakes. Every other system on the car is now drive-by-wire. This is something some say reduces the challenge for drivers, but increases it for engineers.

However, the drivers themselves say that driving with underdeveloped BBW systems and dealing with the huge torque from the ERS is a big enough challenge in itself. It is certain that the Australian Grand Prix will be quite unlike any other F1 race, and here at *Racecar* we cannot wait!

COMPOUND FRACTURES

There is an old university lecturer's trick that gets rolled out from time to time: 'What is the most important part of a racing car?' he would ask. Predictable answers come back: 'the engine', 'the wings' and even 'the driver'.

But The correct answer is the tyres. Little has been said about the 2014 F1 tyres, which is a surprise considering quite how much of a role rubber played in the 2012 and 2013 seasons.

With so much focus on just getting the new power units to work, many teams have had very little time to understand the new Pirelli compounds and construction. At the first test, the Italian company brought along special 'winter' tyres to cope with the highly abrasive surface at Jerez, as well as the cold conditions expected at the Spanish circuit. It also had some of the proper 2014-spec tyres on offer, although most teams were not interested at that point.

'The 2014 tyres are just as different to their predecessors as the 2014 cars, with the majority of our preparation work having been carried out by using advanced data simulation, as well as real on-track testing,' said a Pirelli spokesman. However, the on-track testing was conducted using the previous generation of car, which could not replicate the torque characteristics of the 2014 power units.

The new 2014 tyres have a new construction and new compounds, with slightly increased weight. The wet tyre has also a new tread pattern and a different compound, and it is this that could catch some teams out during the season.

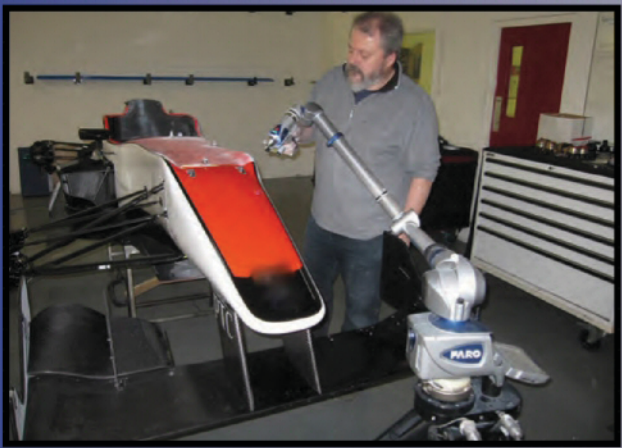
The 2014 regs state that one of the 12 pre-season test days will be dedicated to wet-weather tyre testing, with Pirelli arranging for the track at Jerez to be watered on one of the days. This was scheduled to take place of the final day of the test, but in fact happened earlier as some light rain fell on the track on the second day. However, the weather improved and despite a rather half-hearted attempt to wet the track further, the sun soon dried it out. At the same time, several teams were stuck in their garages with power unit problems, and did not get to try out the wet tyres.

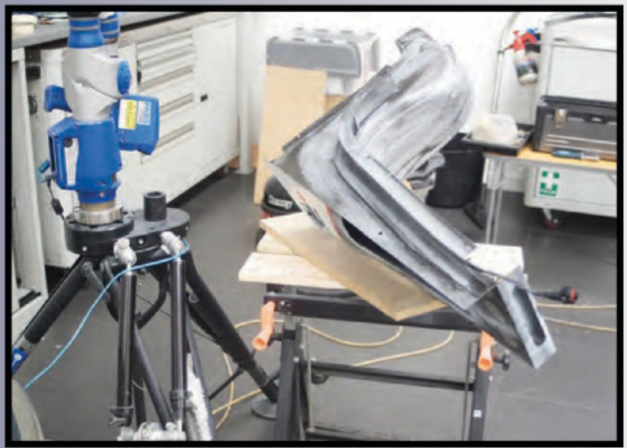
This will mean that when it rains at a race this year, it could be the first time some teams and drivers have ever tried out the wet tyres, and they will have no real data at all, which should be fascinating. Other teams have had very little running on any tyre at all and will have a steep learning curve through the first part of the season. It should be very interesting indeed.

Pirelli also brought a new design of tyre to the Bahrain tests, with 2014 construction and compound. However, these are actually considered to be 'prototypes', as their purpose is to test tyre behaviour without warming blankets, which will be banned from 2015 onwards

Portable Measurement Solutions

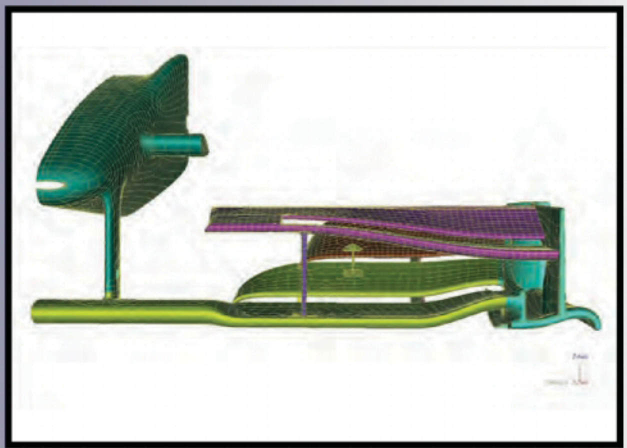
ONSITE INSPECTION AND NON CONTACT LASER SCANNING SERVICES





FARO ARM INSPECTION

HIRE AND LEASING OF FARO ARMS, GAGES, LASER TRACKERS AND LASER SCANNERS. ACCESSORIES, PROBES, MAGMOUNTS, LEAPFROG CONES AND MUCH MORE.



WWW.MANCHESTER-METROLOGY.COM

Manchester Metrology Ltd, Unit 12 Greenside Lane Industrial Estate
Greenside Lane, Droylsden, Manchester M43 7AJ
Tel: 0161 637 8744 • Fax: 0161 425 0944
info@manchester-metrology.com

The new generation

It's all change for the 2014 season, and a host of different solutions to problems posed by the new regulations can be found among the latest batch of cars

BY SAM COLLINS

Lotus E22
Power unit: Renault RS34

The Lotus E22 was the last of the 2014 Formula 1 cars to appear. Its roll-out is thought to have been delayed by the car lacking its wiring loom and its radiators. Much has already been discussed about its nose with the twin front impact structures, but beyond that the car is fairly conventional at face value. Its design – according to the team – is all-new, but many of the concepts such as the suspension have been carried over from the E21 of 2013.

But if you put the E21 next to the E22, and stripped off the bodywork, you'd see a lot of major differences. For example, the radiators on the E21 are significantly smaller than those on the E22 due to the far greater cooling requirements this year.

One area that the team has apparently excelled in is the transmission of drive from the power unit to the gearbox. It is believed that the car has a highly innovative solution in this area.

Mercedes-Benz W05
Power unit: Mercedes PU106A

The 'Silver Arrow', one of only two cars on the grid with a fully integrated engine/chassis package (the other being the Ferrari). According to the team, the new PU106A has been designed for optimum installation in the F1 W05, and the chassis designed specifically around this power unit.

Mercedes was the only team to arrive fully prepared for the test at Jerez, having run a shakedown at Silverstone a few days earlier.

The Mercedes nose is perhaps the most conventional looking in the field, but in fact it is one of the most interesting. Instead of the pointed anatomical noses seen on many other cars, the Mercedes crash structure is entirely contained in the main part of the nose. Interestingly, that crash structure is U-shaped and blended into the front wing supports, a neat and perhaps controversial layout. A front wing failure reportedly caused by a failed bond in the nose structure stopped the car from getting even more mileage at Jerez, but it still accumulated the most miles of any 2014 design.

Williams FW36
Power unit: Mercedes PU106A

The Williams FW36 is one of the most technologically advanced Formula 1 cars produced by the British team, and it is hoped to be capable of putting the team back into the points on a regular basis.

After years of Cosworth and Renault power, Williams has switched to Mercedes. Despite having a highly capable department in-house specialising in energy recovery systems, the homologation regulations have forced Williams to use the Mercedes HPP solution. Overall, the car seems to be a relatively conventional 2014 design, although the transmission does again appear to be lower than other cars.

Toro Rosso STR9 (below)
Power unit: Renault RS34

Once known as Minardi, the junior Red Bull team is keen to kick its reputation as simply being a customer team and has grown under the leadership of James Key. 'The aero side was by far our biggest priority,' he says. 'We wanted to put that department into a much more current and competitive shape.

'Over the past 12 months, we've been working on increasing the size of the aerodynamics department. It's grown significantly, and we now have many new people with very relevant F1 experience. We have more people joining us this year too, so I would describe it as a work-in-progress, but the group is developing very well and becoming increasingly close to the blueprint that we have in mind of what an aero department of a team of this size and budget needs to be. It's been a big project, helped by the arrival of a new head of aerodynamics – Brendan Gilhome – in Bicester, last June, while we worked on 2014 without neglecting the task of making the most of the 2013 car as well.'

The STR9 shares some components with the Red Bull RB10, not least the Renault RS34 power unit as well as its gearbox internals, though the casing is bespoke.

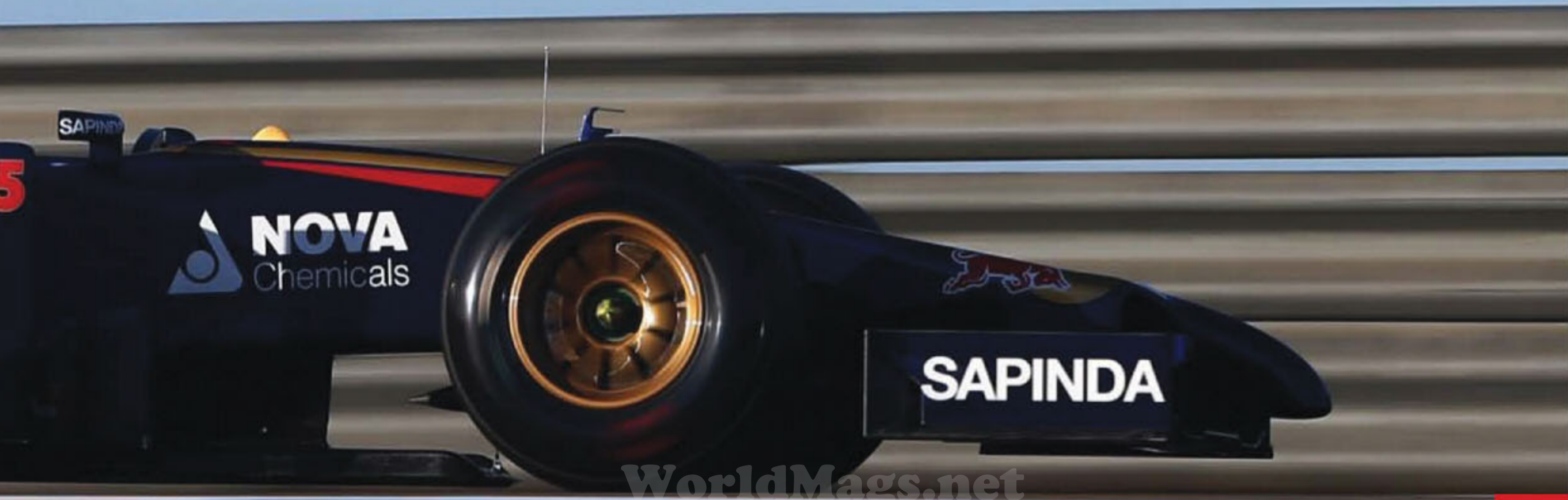
Key denies that Red Bull and Toro Rosso share design data, and this rings true when you look at the larger amount of cooling on the STR9 compared to the RB10, perhaps one of the reasons that the car built in Italy went further at Jerez and Bahrain than the car built in Milton Keynes, England.

Caterham CT05
Power unit: Renault RS34

Caterham turned up to the first test with what was undoubtedly the most eye-catching 2014 design, and it has been seized upon by the social networks. Even the team's owner branded it ugly. However, the odd-looking nose is not likely to remain in place for long with the team working on a Lotus-style twin-tusk solution. The real interest on the CT05 is its very large cooling package, and this could be the reason it was able to continue running when the other Renault-based teams had continual issues at the Jerez test.

'My brief was that we should not be in a position where the cooling was marginal at these first four races,' says technical director Mark Smith. 'Obviously there are different demands at different circuits. But we do not want to be cutting holes in the bodywork when we get to Bahrain. We are conservative by intent, with the data we have got in terms of heat rejection from Renault and analysis in CFD and wind tunnel in terms of mass flow rate through the ducts. We believe we should be able to cool and have a little bit of a margin left.'

Interestingly, the CT05 features pull-rod front suspension which Smith claims is almost neutral in aerodynamic terms, but has some mechanical benefits. 'Oddly, the layout has a slightly better motion ratio as well compared to the old pushrod design,' he says, 'and there is a small improvement in terms of getting a lower centre of gravity as we can mount the inboard parts lower in the chassis.'



Force India VJM07
Power unit: Mercedes PU106A

Force India's new design has a lot in common with the 2013 design, and the team appears to have played it safe overall. At least that seems to be the case with the car in its testing trim. 'Apart from the obvious, it doesn't look hugely different, but it is,' says technical director Andy Green. 'Almost every single part is a new design, from the front wing right back to the diffuser.

'Its genetics still lie in the 2013 car, but we've had to achieve the same results in a slightly different way. The nose is a stand-out, but from the nose backwards it looks quite similar. It's a little bit "fatter" for the increased cooling requirements, but we hope to trim that out during the early part of the season. To be competitive we have to develop, and because there are so many areas that need significantly refining, optimising the performance of this car is going to be a big challenge.

'Our nose is a launch spec, and later we will have an updated front end of the car, which potentially is quite different. We had to take quite a pragmatic view of it and say we've got to go testing, so we've got to get a car out of the door. As much as we want to push the boundaries of the impact structure, because we know how important they are for the whole car, we don't have the resources to push it to the limit in our first iteration, so we need a banker.'

Interestingly, to aid integration of the PU106A into the various customer chassis, Mercedes HPP has employed a number of highly experienced engineers to embed into the teams. Julian Cooper, who has designed a number of cars himself, including various Lolas and Subaru WRCs, is responsible for the integration of the Mercedes power unit into the Force India.

Marussia MR03
Power unit: Ferrari 059/3

Marussia arrived late to the first test and only managed a few laps, but still went faster than the Red Bull RB10. The Russian-owned, England-based team is still by far the smallest on the grid, but it has a sense of optimism about it. A recent recruitment drive has seen a group of promising young engineers join the team in this, its fifth season.

The MR03 uses the Ferrari power unit and transmission, which means that the rear end shares some similarity with both the works F14-T and the Sauber C33 including the inboard suspension pickup points. Overall, the car has a fairly clean uncomplicated design with some concepts carrying over from the 2013 design, but also some new approaches taken in other areas.

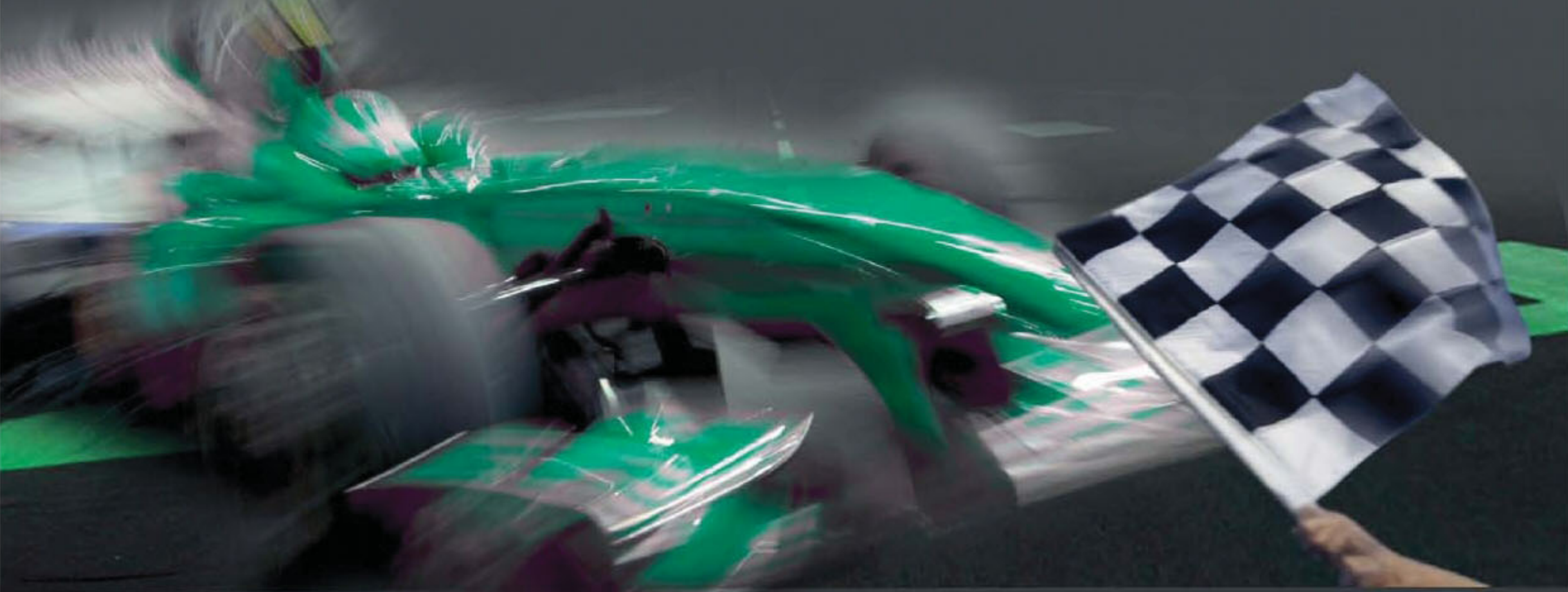
The rear wing support is similar in concept to that fitted to the McLaren (though chief engineer Dave Greenwood says the McLaren concept is similar to the Marussia), but one unique feature is the air box and roll hoop design which is fully enclosed.

Sauber C33
Power unit: Ferrari 059/3

Sauber's 2014 design appeared in testing in an interim specification – according to the team 'it is missing some performance parts'. Its performance was average, and the team seemed to lack spare parts, with damaged bodywork being used throughout the test.

The car uses the Ferrari engine and carbon fibre transmission, so has some similarity with the design of the factory car. 'We know what kind of package we've put together, and we are happy with what we achieved, but it is difficult to foresee what shape our rivals are in,' explains Eric Gandelin, chief designer.

'The earliest opportunity to gain an impression of where the teams are in relation to one another will come later during testing. The path we have followed with the design of the C33 allows us maximum flexibility, so that we can react quickly. It is also clear that reliability will be an important factor in the first few races in particular, so this is an area which we have given very high priority to.'



SOLUTIONS MADE OF PASSION

At Kaiser we manufacture the Racecarchassis, -engine and -gearbox components our customers require within the shortest possible and agreed production time. We manufacture prototypes and small batches for the top end of motorsport, aerospace and the automotive industry.

F1 RACE PARTS

- suspensionwishbones and rods (incl. carbon)
- torsion bars incl. scragging and antiroll bars
- rockers, hubs, spacers, nuts
- shockabsorbers (incl. rotary-dampers)
- steeringhousings
- steeringracks and pinions
- steeringcolumns, quick releases and paddles
- hydraulics
- brakecalipers and -cylinders
- chassis parts in metal and carbon
- engine valvetrain
- conrods
- crankcases
- cylinderheads
- pumpbodies, gears and shafts
- clutch components
- gearbox-cases
- gearbox-internals
- gearbox-hydraulics
- turbo components
- energy recovery system and e-motor components
- and many more ...

Kaiser Werkzeugbau GmbH
Gewerbegebiet Helferskirchen
56244 Helferskirchen · Germany
Tel. +49 2626 9243-0 · Fax +49 2626 9243-20
www.kaiser-wzb.de · kontakt@kaiser-wzb.de

KAISER®
WERKZEUGBAU
TEAM

Ferrari F14-T (665)
Power unit: Ferrari 059/3

The new Ferrari is something of a make or break project for team management of the famous Italian constructor. It has little in common with past cars, other than the front and rear pull-rod suspension. While little has been revealed regarding the technical information about the car – named F14-T by fans online – an overall look shows how little cooling it has, something that technical director James Allison is clearly proud.

'Our car has quite a neat bodywork package and the radiators are quite small,' he says. 'That's a result of what the engine guys have done– they have bent over backwards for the chassis guys. The engines are incredibly busy compared to the V8s, and the Ferrari has been rather exquisitely packaged – it's very neat and small.'

The most striking visual design feature of the F14-T is the nose shape. Like all teams, Ferrari has had to develop a low nose design for the car while keeping the chassis as high as possible for aerodynamic reasons. Ferrari's solution is curious, however, in that it seems to restrict airflow under the nose rather than allow it.

McLaren MP4-29
Power unit: Mercedes PU106A

McLaren revealed images of its 2014 car just before the start of the Jerez pre-season test. In a statement, the team said: 'We have responded to the disappointment of our 2013 season by pragmatically framing our approach to the technical challenge. The new MP4-29 is a sensible and calculated response to the new regulations.

'But it is very much a frozen snapshot of the design team's steep development curve, and – as such – a machine that will potentially undergo more technical change throughout a single season than any other car in McLaren's long and illustrious history.'

While much attention has been paid to the MP4-29's rear suspension (see Tech Update, p16) the overall package looks to be an all-new concept for the team.

For example, the pull rod front suspension of 2013 has been abandoned in favour of a neat conventional push rod layout, while the car also features a Marussia-style Y-lon rear wing support.

Red Bull RB10
Power unit: Renault RS34

Adrian Newey's latest design was meant to be the first in a new family line of designs, but the car features many design cues from the dominant RB9 of 2013. However, this may be to the detriment of its performance. At the official launch Newey admitted that Red Bull may be a bit behind Mercedes, and by the end of the test the team were behind everyone – apart from Lotus who did not turn up.

Many of the troubles of the RB10 are linked to the Renault RS34, which suffered from battery management failures and – later – turbocharger issues.

The car seems to feature less cooling than either the Toro Rosso or the Caterham (both of which also use the RS34) and in the latter stages of the Jerez test, additional cooling openings were cut into the RB10's bodywork, suggesting that the packaging may be too tight in places and that there may be insufficient cooling. This is something the team is expected to fix before the first race.

The best of both worlds

A combination of Australian race team talent and Swedish performance know-how has combined for Volvo's attack on V8 Supercars

BY STEFAN BARTHOLOMAEUS

One of the icons of the V8 Supercars Championship, the Melbourne-based Garry Rogers Motorsport is about as Australian as a racing team gets.

Rogers, an off-the-wall former car salesman now in his late 60s, leads the team which has traditionally been a no-frills, underdog outfit that every fan has a place in their heart for. Its crew is an eclectic mix of youth and experience, and each member has their own quirky nickname.

It was therefore a shock to many when news broke that the privateer Holden squad would link with Volvo's performance offshoot Polestar – forming Volvo Polestar Racing – for a Swedish attack on the V8 Supercars Championship from 2014.

Looking to give a sporty, sedan edge to its sedate and SUV-focused public image, Volvo Australia's investment into the category comes in the second year of V8 Supercars' Car of the Future programme that, in 2013, saw Nissan and Mercedes-Benz join the traditional Ford-Holden contest.

Like Nissan, Volvo has significant pedigree in Australian motorsport, finding success in the Australian Touring Car Championship with its 240 Turbo during the Group A era, and later in the Bathurst 1000 through its S40 Super Tourer.

Despite the contrast between the ocker Aussies and the stern Swedes, the two parties appear to have put together a formidable partnership since the deal was inked last May. GRM has used its local know-how for the S60 body and aero development in Australia, with Polestar leaning on its state-of-the-art resources to undertake the engine programme from its base in Gothenburg, Sweden.

BODY MATTERS

As previously discussed in *Racecar*, V8 Supercars 'opened the shop front' to manufacturers with the CotF rule package, but its desire to maintain as much technical parity as possible between the marques ensures that homologation of new cars is a substantial undertaking.

The first part of the process is to fit the chosen model's bodyshell over the common steel chassis and roll-cage structure. The S60 racecar's wheelbase is stretched 44mm from its road-going configuration to fit the platform.

As is the case with Nissan's Altima (which was stretched 46mm), the growth comes by moving the front wheel cut-outs forward in the (composite) guards. This ensures that – unlike the downsized Ford, Holden and Mercedes – no cutting of the Volvo's doors or roof is required.

The composite rear door skins are, however, flared to blend with the widened rear wheel arches.

Additionally, the entire body sits 55mm further back on the wheelbase than it does on the standard car. The move is primarily made inline with V8 Supercars' mandate to align the greenhouse of each car as closely as possible for aerodynamic parity, although there are also other benefits.

'For us it's better from an aero point of view and it better

"It's not impossible to convert a Commodore into an S60, but you wouldn't exactly end up with a clean chassis"

The S60 of Scott McLaughlin, who combined a successful rookie year with his apprenticeship as part of the team's fabrication department

IMAGES BY DARIN MANDY

suited the clearance for the engine as well,' explains the team's senior engineer Richard 'Patches' Hollway. 'The plenum area is very tight with the back of the engine, so the further back you can move the plenum, the more clearance you get.

'In the end we shifted the greenhouse as far back as possible. We really couldn't go any further because the rear tyres started to impinge on the back of the rear door. But unlike some of the others, we haven't shortened or lengthened the end profile. The front overhang is less and the rear overhang is more, but the bodyshell is the bodyshell.'

Although the CofF concept allows teams to convert a V8 Supercar chassis into that of another marque with a change in body panels, introducing a new manufacturer requires significant design and fabrication work on the interface between the two.

The team elected to build two brand-new chassis for its 2014 campaign and says it won't be converting its Commodores, even for use as spares.

'We were surprised at how wide the Volvo is,' continues Hollway. 'From the outer of the doors it's wider to the inner mountings on the chassis than the Commodore, which means we've had to modify the interface with new welded sheet metal quite a bit. It wouldn't be impossible to convert a Commodore into an S60 – you could put it on the jig, cut it and weld the new bits on in a day or so – but what you'd end up with wouldn't exactly be a clean chassis.'

Erebus Motorsport is so far the only team to convert a chassis, with its first car having started life as a Stone Brothers Racing Ford Falcon before a team takeover led to the current AMG customer arrangement. The car is the team's second spare, unlikely to be raced.

GRM, meanwhile, had been campaigning its two Holdens through until the 2013 season finale in December – just days before the first Volvo hit the track for initial aero testing. The parallel programmes needed to be balanced during the year, most notably when a major accident for Alexandre Prémat at Phillip Island's penultimate round required the second Volvo chassis to be taken off the jig partway through construction.

'A chassis pops a little bit when it comes off the jig, which makes it tricky to put back on, so that was painful,' says Hollway. 'But obviously with that accident we had to cut the rear of Alex's car out so we had no choice. Stuff like that is just a timewaster in the end, but you just do it and get on with it.'

Uniquely, the team's six-strong fabrication department last year included 20-year-old driver Scott McLaughlin, who continued his apprenticeship while winning two races during a sensational rookie season. This year will see McLaughlin joined on-track by long-time Polestar man Robert Dahlgren, with Prémat reduced to endurance co-driver duties.

Completing the bodywork is the car's aerodynamic package, for which initial CAD and CFD work was undertaken in-house by team engineers Scott Campbell – who was previously involved in the Holden Commodore VE and Nissan Altima L33 V8 Supercars – and Scott Burch.

With the engines not arriving from Sweden until January, the maiden private aero test running took place in December, utilising one of the team's existing Holden engines. Several of the individual days were run – the last of which marked the debut of the Volvo powerplant – before the car headed to the category's homologation

The S60's boot is 150mm shorter than the Commodore, meaning that the rear wing protrudes quite a way off the back of the car

Volvo's Supercars engine programme consists of leftover stocks from the Yamaha-designed B844S previously seen in S80 and XC90 road cars

testing. There it was put up against the baseline Ford Falcon FG and a re-designed Altima.

Nissan's plea for re-homologation had seen plenty of headlines towards the end of 2013 as the manufacturer blamed V8 Supercars' open-air, coast-down testing process for a high-drag kit on its first Altima. Without a windtunnel in Australia that can calibrate the downforce and drag requirements, however, open-air testing doesn't look like going away any time soon.

'A lot of people are critical of the process, but in reality there's not a whole lot of alternatives in Australia,' explains Hollway. 'Obviously one of the biggest problems is the weather – you need calm conditions to get good numbers and bad weather puts pressure on the whole process. You've got a short window of days booked and if you go out and the wind picks up, it makes it very difficult. But if the weather is good the results are very accurate.'

The front bumpers/splitters, side skirts, front guards and rear quarterpanels were all made in-house by GRM's beefed-up five-man composite department. Once open-air testing of various splitter lengths, rear wing profiles, bumper 'cheek' inserts and endplates began, much of the work focused on the rear of the car, which has a boot a full 150mm shorter than the Commodore.

'We worked with V8 Supercars during our own private days to duplicate the homologation process, because we wanted to make sure we were following the right method,' says Hollway. 'The initial feedback from that group was that we had too much drag and that rear downforce was not enough – so basically we were chasing efficient rear downforce from there. In the end we had to trim down on the endplate and try to get the rear wing to work better.'

While the new Altima wing, which is the only centre-mounted spoiler in the championship, sits further back relative to the rear wheel centreline than the regulations had previously allowed, the Volvo is 50mm inside the guideline. 'The structural integrity of it played a role in that,' says Hollway. 'Because the wing is hanging out so far from the structure due to the short boot, we were conscious that we didn't want the wing loads too far away from the boot. That was part of the decision to bring it forward.'

POWER SUPPLIES

Although the 'generic' Chevrolet-based engine offered by V8 Supercars could slash the costs for a manufacturer entering the series, Volvo joined Nissan and Mercedes-AMG in emphatically rejecting the concept of racing without its own powerplant.

Where the VK56DE and M159 were obvious solutions for Nissan and AMG respectively, Volvo's V8 cupboard has been bare for several years. Its V8 Supercars engine programme is therefore utilising leftover stocks of blocks and heads from the Yamaha-designed B8444S, previously seen in S80 and XC90 road cars.

"Because the wing hangs out so far due to the boot, we didn't want the wing loads too far away"

With a 60-degree bank layout – which was designed for a transverse mounting in the road cars – and a standard capacity of just 4.4 litres, turning the B8444S into a 5-litre V8 Supercars engine has been no easy task.

The introduction of the four-valve Nissan and Mercedes engines alongside the two-valve Ford and Holden units was the biggest technical talking point of the 2013 season, with the regulations themselves somewhat of a work-in-progress.

The Nissan and Mercedes were built to match the existing engines as closely as possible, right down to the bore and stroke (102.7x75.3mm). The Mercedes, for which development started less than six months before the season-opener, did however enjoy the somewhat contentious concession of a flat-plane crankshaft.

Although also sticking to the fundamental category-wide guidelines of 5 litres, 10:1 compression and 7500rpm, Volvo's specification is somewhat further removed again. Bore and stroke in the Swedish unit sits at 95.5x87.1, up 1.5mm and 7.6mm from the standard B8444S respectively. Like the Mercedes, the Volvo too enjoys a flat-plane in order to curb vibrations.

'Bringing it up from 4.4 litres was quite a challenge,' explains Polestar engine development engineer Mattias Evensson. 'The cylinders themselves are not that big, so you can't bore it out very much – and the deck height is not that high either. We actually asked Yamaha if they have the tools (to recast modified versions of the cylinder heads) but they had scrapped it, so we only had the spare parts to work with.'

While the four-man Polestar engine department may lack the people-power of a Nismo or AMG, Evensson says that simulation techniques are a real strength. 'We try and work with that early in the project to make sure we're going in the right direction. Like gas exchange simulation and valve train simulation, I think that's a key to get in the ballpark right away.'

Evensson joined Polestar in 2007 and has since worked on the development of both of the company's 2-litre, naturally aspirated five-cylinder World Touring Car Championship engine and the 1.6-litre turbo that replaced it. 'To be honest the 1.6 for the WTCC was a bit more challenging than the V8 because of the technology on it – the direct injection, turbocharger with anti-lag on it and stuff like that,' he says when asked to compare the programmes. 'But with a naturally aspirated V8, it's so critical to get all the parts right to get a competitive engine. You can't be behind in any area because you won't be competitive.'

Like V8 Supercars, the 2-litre project had included the use of E85 fuel, giving Polestar a head-start on the combustion and intake evaporation qualities of the ethanol blend. 'The old five-cylinder engine has quite a bit in common with the V8 actually,' he continues. 'It's a similar RPM range and is naturally aspirated. That

The S60 V8 features AP Racing four piston caliper brakes

one was 2 litres so a bit smaller displacement in each cylinder, but quite similar in the design. We carried a lot of knowledge from that engine over to the V8.'

The 60-degree layout of the B8444S meanwhile provided two major challenges – those of packaging and vibrations. 'We had to work very hard on the packaging of the (eight-butterfly) intake, the runners, the throttle bodies and everything because it's so close between the two intake flanges with the 60-degree layout. That was a big deal and so important to get it right to get the performance out of it. We spent a lot of time there with simulations and gas exchange analysis.

'To control vibration, we had to use a flat-plane crank. If we would have gone for a 90-degree it would have been difficult. We'd probably have to use offset pins for the conrods, which the standard engine has, and there would be no way we could design a crankshaft strong enough with the offset pins. That would also be vibrating a bit more. With the flat-plane, when the drivers got in from the first testing they were happy with it. It vibrates a bit more than the Holden engine, but it's actually not too bad. It seems to work well.'

Polestar worked with its existing, trusted suppliers in the development of items such as the crankshaft, conrods, pistons and valves. The roller-chain operated valvetrain, meanwhile, is closely based on the standard B844S system and is, according to Evensson, 'very strong'.

Like Erebus Motorsport's AMG engine programme last year, minor maintenance tasks on the Volvo engines will be undertaken in Australia, with major rebuilds occurring back at base. The team plans to have eight engines in its pool for the two-car operation. One week of shipping time is required in each direction.

Having started as a clean sheet of paper in May, the engine ran on Polestar's dynos for the first time in November before enjoying its maiden outing in Australia during a straight-line aero test in January. Its one and only track test before the public, full-field Sydney Motorsport Park hit-out in February was aborted due to engine problems, although Evensson stresses that the move to pack up early was largely a precaution due to the limited engine stock.

The motors ran without fault in Sydney, where power steering issues proved the only major bugbear. Although reliability will still be a major challenge on the gruelling Adelaide streets that open the championship proper, the solid first-up test performance drew admiration from opposition teams.

Evensson though, isn't making any bold predictions for the beginning of the season. 'I have full respect for the competition because I know how long the guys have been developing the two-valve engines. I saw last year how much Nissan and Mercedes were struggling, so I think they put the regulations on the four-valves quite tight so they didn't blow the two-valves away.

'Where will we be at the start of the year? It's difficult to say, really. I think we might be competitive with the torque and the power, but with the economy we haven't really got a clue yet having only run one test day.'

The team will get its first real indication of where its engine sits when it undergoes homologation testing on V8 Supercars' own dyno in the week before Adelaide. If the engine performance is found to be below the category's power and torque curve 'ceilings', Polestar will be able to develop and resubmit parts for homologation until it reaches the targets.

'If we are a bit behind after the initial homologation we will need to work on upgrades to catch up,' says Evensson of the year ahead. 'But if we're OK I don't think they'll let us do much more development. If so, the focus will be on maintenance and reliability.'

SUSPENSION WORK

Despite the engine change, GRM has been able to carry-over the front-end that it used in its Holdens last year. The uprights and arms are identical, while the crossmember features minor revisions, and they are only to accommodate the category-wide move from block to sump engine mountings.

Although highly adjustable, the independent rear suspension is a control specification under the CotF rules, ensuring it is also carried over. Hollway is hoping that debuting a new marque with a year of running the CotF package under its belt will be a benefit through the season.

'Workload-wise it's probably not great because we tooled up for Commodore and did a lot of work there,' he says of the challenge compared to that faced by the Nissan and Mercedes teams last year. 'But in terms of being able to understand the CotF and then be able to put the new aero kit over the top, absolutely there's an advantage compared to Nissan and Mercedes. Even though VF was different, it gave us a year to understand the car – and now we'll see the differences more plainly.'

Whether the GRM-Polestar package will prove a winning formula at any point during 2014 remains to be seen. For Volvo, however, simply having these sleek-looking, sweet-sounding S60 V8 Supercars on track in front of a packed Adelaide house could be considered a victory in itself.

"The old five cylinder engine has quite a lot in common with the V8 – we carried knowledge over there"

TECH SPEC

Volvo S60 R Design

Engine
Block: modified Volvo B8444S, 60- degree aluminium cylinder block
Heads: modified Volvo B8444S, aluminium
Bore x stroke: 95.5 x 87.1
Capacity: 4989cc
Compression ratio: 10:1
Max revs: 7500rpm
Induction: naturally-aspirated, eight throttle bodies
Fuel: E85
Valve train: double overhead camshafts, direct acting tappets, chain drive
Ignition: Volvo B8444S coil on plug
Injection: port injection, one injector per cylinder, injection pressure: 5.5 bar

Top speed: 298+km/h
0-100km/h: 3.2 seconds

Suspension
Front: double wishbone suspension, adjustable damper and cockpit adjustable front anti-roll bar
Rear: control independent rear suspension, adjustable damper; cockpit adjustable anti-roll bar AP Racing six piston caliper, 395mm ventilated discs

Transmission: control Albins ST6 six-speed sequential transaxle with integrated spool differential

Steering: custom rack and pinion power assisted steering

Brakes: AP Racing four piston caliper, 355mm ventilated discs

Wheels: control Rimstock 18x11in forged aluminium

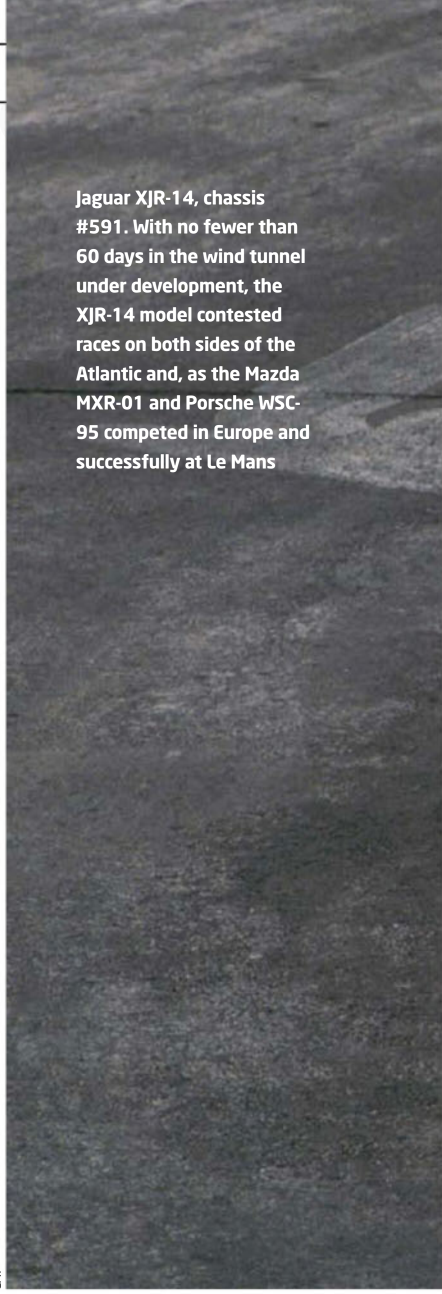
Tyres: Dunlop control tyre

Weight: 1410kg (includes driver)

Shocks: Ohlins TTX Dampers

Electronics: MoTec ECU and data logging system


What's the
secret
about the new 911 GT3 Cup's
new brakes?
Mobil 1
GT3
adidas
It's Quicker.
PFC
PORSCHE
OFFICIAL PARTNER
PORSCHE
MOTORSPORT
PFC
BREMSE
www.pfcbrakes.com
1.800.521.8874



Jaguar XJR-14, chassis #591. With no fewer than 60 days in the wind tunnel under development, the XJR-14 model contested races on both sides of the Atlantic and, as the Mazda MXR-01 and Porsche WSC-95 competed in Europe and successfully at Le Mans

LAT

Reviving a broken legend

Deciphering the repair history on a classic sportscar has enabled XJR-14 chassis No 591 to ride – and win – again

BY MIKE FULLER

With advanced composite racecars finding their way into historic racing series, the need to verify their structural provenance, especially cars that have been crashed in-period, has become prominent.

Now, as the perceived potential value of the car increases, the level of documentation of crash repair seems to follows suit. Naturally, it's assumed that Formula 1 cars will typically have high post-racing career value, and therefore it requires any manufacturer tasked with repairing a monocoque in-period to document exactly what was done in order to maximise the car's value once it ends up on the private market.

The issues occur when the car in question is more than 20 years old, dating back when there was a lack of awareness of what the car's value would be decades down the road. The challenge then becomes identifying methods and materials used to repair a composite monocoque and then to verify how exactly the repair was carried out.

Which leads us to a case in point, one of my all-time favourites: the Jaguar XJR-14, and specifically chassis No 591. Back in September 2012, I received an interesting email from Bob Berridge, principal of Chamberlain-Synergy Motorsports, the team that oversees the Gareth Evans-owned Jaguar XJR-14, No 591. Chassis 591 is the only original Jaguar XJR-14 in existence. Berridge understandably took issue with a categorisation I once made of the No 591's 1992 repair as being, 'cosmetic only'. He said: 'I would be grateful if you could change your otherwise excellent piece on the XJR-14s to reflect the actuality of the car's current race-fit state, as the existing unfounded assertions are potentially quite damaging.'

But the rub was this: my assertion of 591's 1992 repair status came from none other than Tom Walkinshaw Racing-USA's team manager at the time, Tony Dowe. An 25 April, 2005 email noted:

'The first car we had was 591. This was involved in the Lime Rock accident. We sent it back to England to see if it could be repaired. Well, they did a repair on it, but we were told that the tub should only be used to build up a show car as it was not a very good area to repair (Left front tip corner, where the torsion bar bellcrank was located).'

But a little history first.

Jaguar XJR-14 chassis No 591 first debuted at Round 1, Suzuka, of the World Sportscar Championship in April, 1991. With Derek Warwick behind the wheel, 591 qualified on pole, absolutely dominating the rest of the field in the process. Warwick would lead from the start and up until the first fuel stop. His race would stumble, however, with the need to change the starter motor after 591 refused to restart, and 591 ended up 10 laps down to the winner at the finish as a result. A disappointing debut given the start, but it confirmed how completely superior the XJR-14 was compared to its competition at that early part of the season. 591 would go on to win at Round 2 in Monza, with a third place and a second place at Silverstone and Autopolis respectively, to round out its WSC season.

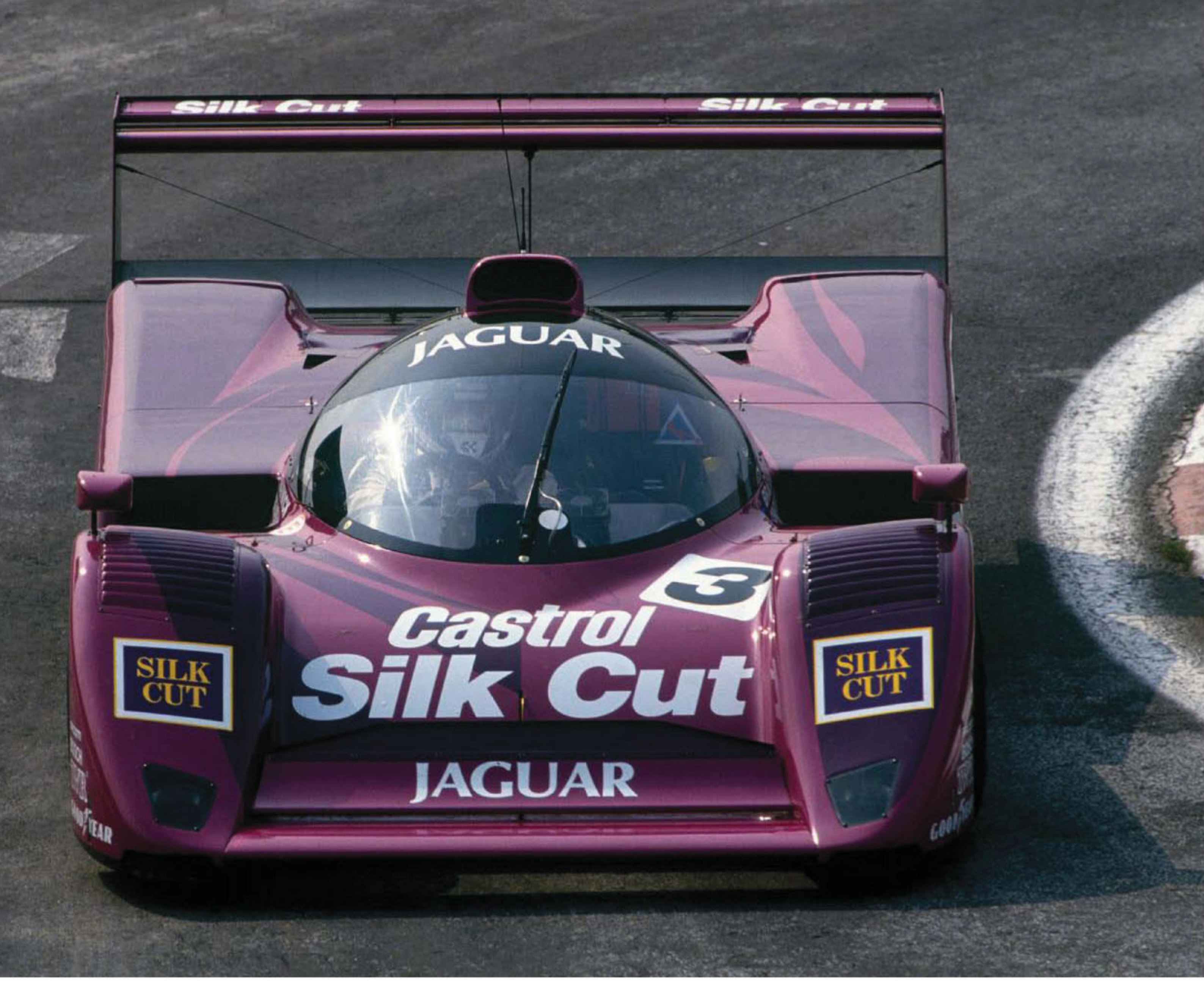
Jaguar Silk Cut/Tom Walkinshaw Racing (TWR) would go on win and both the Team and Drivers' Championship (Teo Fabi) for 1991.

With the subsequent shutdown of the TWR/Silk Cut Jaguar Group C program, 591 was then shipped to the United States for the 1992 IMSA GTP Championship. 591 would debut in the US at the Miami (Round 3, Rounds 1 & 2 being the Daytona and Sebring endurance races) street circuit. TWR driver Davy Jones subsequently put the car on Pole, though only finished sixth after a late race spin. This was followed by near domination at Round 4, Road Atlanta - pole, fastest race lap, led every race lap, and took the race win.

Next came Lime Rock. But issues cropped up for 591 when Jones speared off the track, following a wheel failure (this would be reoccurring issue during the 1992 IMSA season), at the high speed and flat out downhill section while leading the race. The damage to 591 was extensive and consisted of the front and approximately two-thirds the length of the left side of the tub, where the front suspension pickup points, torsion bar, and rocker arms are all located; in the area of primary suspension loading. The XJR-14s had a internal longitudinal bulkhead off set from the primary monocoque wall and damage was transferred to this structure as well.

Given the frantic nature of the IMSA GTP season, the team set 591 aside and TWR-Kidlington shipped chassis 691 to the US. Chassis 691 was race-prepped in less than a week, and the team then headed off to Mid-Ohio and reaped the rewards - a race win (even after missing Friday practice). 691 – and eventually 791 – would see out TWR's IMSA GTP season (though with 691 crashing at Road America, again a victim of wheel failure).

After a wheel failure at Lime Rock, damage was extensive to the front and some two-thirds of the left side of 591's tub



Chassis 591 was sent back to England and repaired, but it sat out the rest of the 1992 season as a show car. Perhaps more interestingly, 591 was over looked for the TWR-Porsche WSC 95 program a few years later - Chassis 791 was preferred. 591 never raced competitively again, and that was very telling.

Questions lingered over the viability of the repair to 591 as the car passed into private ownership. Over the years the details were forgotten. The repair looked OK after all. Looks being one thing, ultrasound testing apparently showed a void-free repair.

But void-free and viable could be two different things after all, as it said nothing at all about what that repair entailed, for example, what materials were used. And, given that the corner was so highly loaded, it was of particular importance to verify the provenence of the repair, if possible. Says Robert Tetrault, Operation Manager at Astec, Advanced Structural Technologies, Ltd, from 1992-1996, '...from memory the laminating specification in that corner would be up to 15-20mm thick with unidirectional and woven carbon fabric lay up in a very specific way to take account of the loads in racing conditions.' Hence slapping some carbon on the corner and calling it good wasn't going to suffice at all.

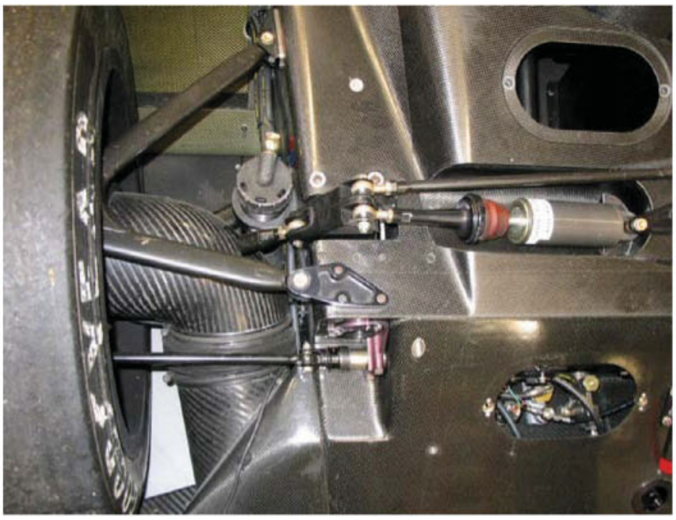
And with these question marks making their way into the public domain, Berridge and Evans were concerned that they could tarnish the car's marketability given 591's very high potential value; it is the only original XJR-14 in existence. So more research was needed.

Heading up that research was Dave Benbow, director of Composites Technologies, the firm ultimately entrusted with executing the contemporary repair on 591, but more interestingly, an engineer with TWR during the XJR-14 time period, 'At the time, when the car was originally crashed, two repair schemes were offered to TWR from Astec. One to make the car complete, and the second to make the car raceable again.'

"When the car was originally crashed, two repair schemes were offered: one to make it complete, and another to make it raceable"

Scheme One entailed removing the damaged section and manufacturing new replacement sections, laid up out of the original mould and from the correct layup schedule. Given the location and nature of the repair, multiple new sections would have to be manufactured. To start, all the damaged sections would be removed as neatly as possible. Then the entire perimeter of the damaged area would then be offset by relieving the honeycomb back 25-30mm, in order to create lap joint for bonding. The replacement panels would then be dry fitted to the tub, to insure a precise fit, and then cold bonded with 3M 9323 structural adhesive, and riveted into place. After full adhesive cure the rivets would be drilled out and black-pigmented adhesive put into the resulting holes.

Scheme Two consisted of Scheme One, but with additional



As you can see, any damage occurring to this highly loaded corner would be a real headache

The high downforce nature of the US circuits in 1992 highlighted the Jaguar's weakness - wheel failure at Lime Rock led to a large accident

Three monocoques were manufactured for the original XJR-14 World Sportscar 1991 programme; chassis 591, 691 and 791

layups, the 'belts and braces,' on the outside and inside of the monocoque across the seam of the replacement sections, in order to tie everything together structurally. The work required on the inside of the tub meant abrading the surfaces to be laid up, laying up, and vacuum bagging around the off-set longitudinal bulkheads, in the very confined space of the foot well; a claustrophobic's nightmare. And in the end, all of this would have added substantially to the cost of the repair.

And as such, Tom Walkinshaw opted for the less expensive of the two repair schemes (roughly £3500 v £5000-£6000 in 1992 costs). It was said, according to Benbow, that even Walkinshaw did not expect the car to race again, inasmuch as there wasn't any place in Europe for the XJR-14 to race any longer and the US IMSA GTP series effectively imploded at the end of the 1992 season. But what came out of Composite Technologies' research into the work done to 591 back in 1992 was tacit admission that Scheme One was considered, 'non-raceworthy.'

With it confirmed that the original 1992 Scheme One repair wasn't raceworthy, the hard decision was made to carry out Scheme 2. But really there was little choice, the completion of the entire 1992 repair would make the car whole once again and eliminate any questions regarding its provenience.

Naturally there would be challenges. For instance, the use of 3M's 9323 structural adhesive in the 1992 Scheme One repair would mean that a low temperature pre-preg composite would have to be used for the 2013 Scheme Two repair. The reason for this was 9323 lost substantial strength at temperatures above 180degF. So this limitation had to be taken in to consideration in order not to affect the strength of the original 1992 repair. Composite Technologies was able to source suitable low-temperature pre-preg from PRF Composite Materials out of Poole, Dorset, UK; a 2x2, 200g/sq m (gsm–denotes fabric weight and more importantly, relative ply thickness), twill fabric for the inner ply and a period-correct five-harness satin, 280gsm, outer ply.

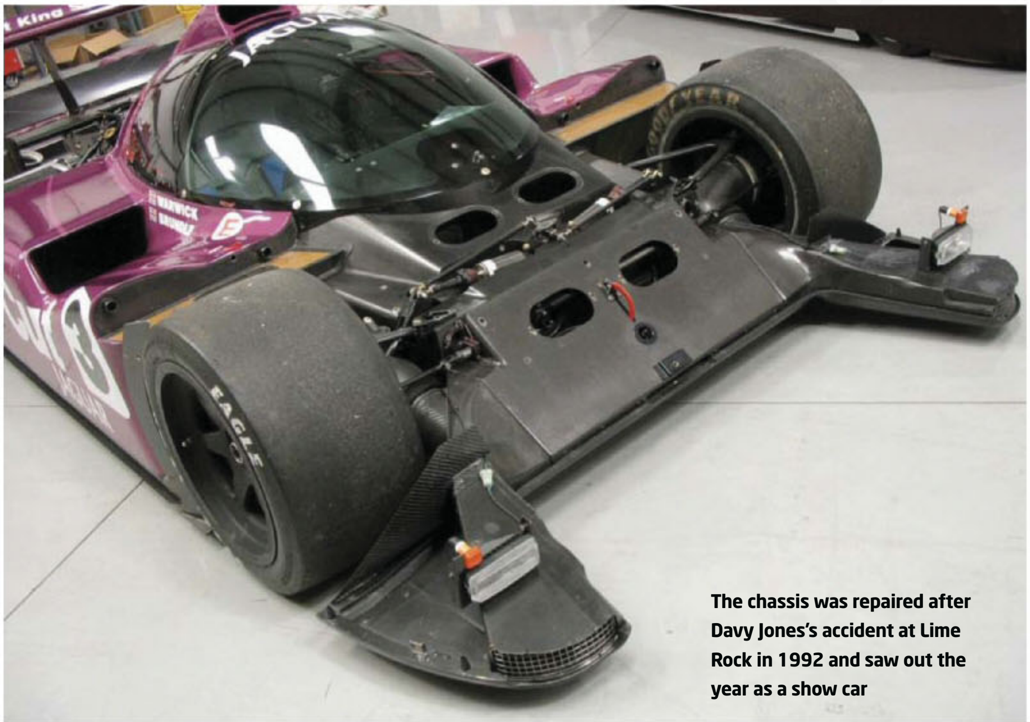
But before any layup could be done, Composites Technologies first had to establish a bagging method for the outer and inner repair work. Given the shape changes, awkward bagging locations, insert and through-holes all conspiring against, it took more than one test-try to achieve an inner and outer bag that held acceptable vacuum. After 45 accumulated hours of testing, acceptable leak-down results were achieved and the technicians had a method to complete the Scheme Two repair.

And most would have stopped there. But given the intrinsic value of the car, reputedly upwards of $3m, it was thought it would be prudent to 'prove' the effectiveness of the work. Delta Motorsport Ltd, an automotive and motorsports engineering consultancy (notably carrying out the FIA's yaw-blowover study for LMP sportscars), was contacted to devise and execute a series of tests to verify the suspension mounting point stiffness and monocoque integrity, and to ultimately validate 591's track suitability.

However, prior to any design work being executed, the XJR-14's suspension geometry needed to be defined. Let us harken back to the days in which the XJR-14 was designed; these were still the days of drafting boards, and the paper drawings that defined the XJR-14 are gone, or essentially so, and very difficult to acquire. And even if CAD was utilised to define elements of the XJR-14, data such as that is no easier to acquire than paper drawings given obsolete CAD programs and corrupted data. Therefore it was up to Delta Motorsport's technicians, using height gauges, linear calipers, and digital scanners, to inspect all the relevant suspension elements, mounting points, and monocoque surfaces, and then model these, using Catia, into 3D CAD space.

But additional information was needed. Lacking knowledge of representative static ride heights,

Given the intrinsic value of the car, reputedly upwards of $3m, it was thought it would be prudent to 'prove' the effectiveness of the repairs



The chassis was repaired after Davy Jones's accident at Lime Rock in 1992 and saw out the year as a show car

former TWR race engineer for the No 4 Jaguar XJR-14, Steve Farrell, joined the project as a consultant. Farrell had access to XJR-14 aero maps (loadings), engine power figures, weight distribution, and could confirm static ride height dimensions, as well as a multitude of other details, having engineered the cars during the championship-winning 1991 World Sportscar season.

Farrell confirmed an 880kg race weight (driver and fuel), 56mm static front ride height, 40 per cent front weight distribution, and a staggering 7845lbs of downforce at 200mph with 38 per cent front aero balance in high downforce configuration. Farrell indicated the XJR-14 could generate upwards of 4.8G of braking deceleration and 4.5G of lateral acceleration; clearly the XJR-14 had been a serious racecar in its day, hence the need to acquire actual loading data as opposed to best guesses.

With knowledge in hand, Delta Motorsport was able to couple this information with the CAD reconstruction of the XJR-14's monocoque and front suspension geometry, developing a load and suspension geometry analysis using kinematic geometry software.

IMAGES BY MICHAEL J FULLER

Chassis 591 has now been proven to be ready to race

With the downforce loading information provided by Farrell, static load (linear) figures could be generated for any single suspension component, and the concentration was on these four loading scenarios: maximum deceleration, end of straight, maximum cornering acceleration, and end of straight coupled with a 2G kerb strike (vertical impact).

Analysis of these four cases showed that the highest loads were achieved during the braking event and from the vertical strike. A test rig was then designed to individually load the front top wishbone for the braking event, the lower front wishbone for the same, in addition to a pushrod fixture to load for the vertical strike scenario.

These tests would be carried out first on the undamaged right-hand side and then on the repaired left-hand side, and so the fixtures had to take this requirement into account. Additionally, the fixturing needed to remove any compliance as well as constrain the monocoque during the testing.

With all the requirements laid out, Delta Motorsport set out designing and having the test rigs manufactured. They also sourced a suitable testing facility, with the Cranfield Impact Centre being chosen due to their experience in structural and non-destructive vehicle testing.

And the results? Analysing the upper wishbone on the left-hand side, the forward leg mounting point averaged 7 per cent stiffer, while the aft leg mounting point averaged 8.5 per cent stiffer. The lower wishbone showed similar (13.8 per cent and 29.1 per cent stiffer for the front and aft wishbone legs respectively) as compared to the right. So too the pushrod mounting point – 8.5 per cent stiffer. Given the results, Delta Motorsport concluded in their report: '...the monocoque and its suspension mounting points are fit for purpose and have an acceptable stiffness level to receive on track loads.'

The only thing left was to take 591 out on to the track at the Silverstone Classic. Driver Nic Minassian subsequently put the Jaguar on pole with a lap time five seconds ahead of the next competitor (Sauber C11) with a 1:46.425 lap. 'I've been smiling all week,' said Minassian. 'The car did exactly what I wanted and it feels like a proper race car. Easily one of the best cars I've ever driven.' 591 performed to expectations all weekend, and then some, with Minassian admitting he could have been faster, but that he 'didn't push it'. Minsassin nearly lapped the entire field in the main event, on his way to first place.

It's not often that a car owner does the right thing, but as Bob Berridge indicated: 'It was a case where being 99 per cent certain wasn't good enough, leaving 1 per cent provenance on the table left us no choice.'

Given the ultimate value of the car, it made little sense in not clearing up this part of the car's history once and for all – and that has now been done in spades. The transparent process, coupled with the testing procedure verifying the repair, will allow any questions about the car to be dispelled for future owners of 591.

"I've been smiling all week – the car did exactly what I wanted and it feels like a proper racecar. It's easily one of the best I've ever driven"


FERODO
RACING
DSUNO
ENGINEERED FOR
EQUILIBRIUM
RACE PROVEN
GT - TOURING CARS - FORMULA - RALLY
Circuit Supplies (UK) Ltd, Unit 8, Eden Court, Eden Way, Leighton Buzzard, Beds LU7 4FY
Tel: 01525 385 888 • Fax: 01525 385 898 • info@circuitsupplies.com • www.circuitsupplies.com
www.ferodoracing.com
FEDERAL MOGUL
SUFFIX TO ORDER THIS MATERIAL IS 'Z' (e.g. FRP3087Z)
WorldMags.net

The big switch

As recent Richard Childress Racing recruit Mike Coughlan explains, subtle changes in thinking between Europe and the US – particularly in terms of simulation – make the recruitment of F1 talent to Sprint Cup incredibly worthwhile

BY SAM COLLINS

When NASCAR introduced its Generation 5 concept into the Cup series, it heralded the widespread arrival of a new breed of engineer, coming directly from F1 teams in Europe. To the outsider, the differences between Formula 1 and NASCAR Sprint Cup are gigantic – one seems packed full of exotic technology and post-space age materials, and the other seems firmly stuck in the 1950s. But according to the latest arrival from the grand prix paddock, the two are not that far apart at all.

'People say it's a big change, but in reality the calibre of people is no different,' says Mike Coughlan. The Brit joined Richard Childress Racing (RCR) at the end of the 2013 Sprint Cup season, having left his previous role as chief technical officer at the Williams F1 team in the summer.

'The guys in NASCAR are as bright as those in F1 – and just as dedicated,' he says. 'They are just dealing with different tools and a different product. But I don't think the philosophy is any different – you are looking at what other people are doing, you are ensuring that you understand your vehicle, and you try to understand the weather too. While we don't deal with rain, we do have big variation in temperature with day and night races like Daytona. There are smaller margins in some areas and bigger ones in others, but overall the culture is very similar.'

Coughlan first dipped his toe in the water with Michael Waltrip Racing a few years ago, but was tempted back into Formula 1 in 2011 by the Williams team. It led to a strange legal dispute which saw a NASCAR team attempting to sue a Formula 1 team, but that was settled amicably and even saw Frank Williams attend his first Cup race. Coughlan has now returned to North Carolina as technical director of RCR.

'Eric Warren still oversees engineering and Mark McArdle oversees the production of the cars, so I guess my role is to develop the potential of the vehicle,' says Coughlan. 'Then the race team has to deliver that potential. I'm looking at all areas of the car – its aerodynamics, weight saving and all of the

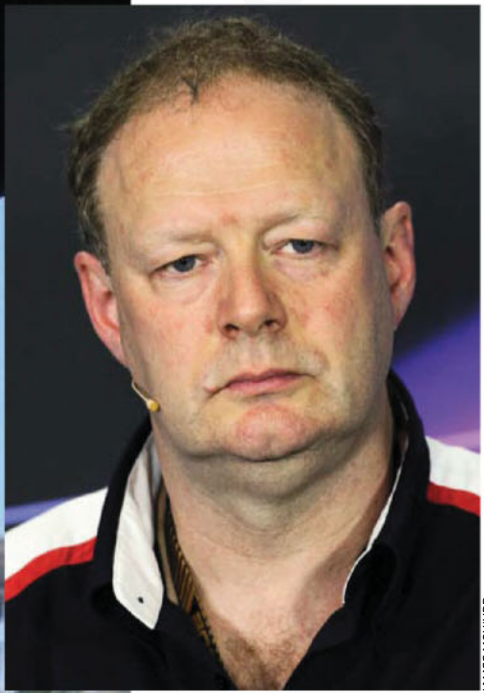
Driving simulators give good grounding, but many don't account for driver feel and familiarity with certain characteristics that are unique to particular circuits

other things that make your car have more speed. It's very similar to my job at Williams F1, although there I was technical director responsible for everything including the race team.'

The most noticeable difference between 2013-spec Formula 1 and Cup comes with the tyres, according to Coughlan. 'Here you do have the ability to change and tune the car during the race, whereas in Formula 1 essentially all you do is arrive and make sure you understand the tyre for that track. The two are very different.

'Here in NASCAR the tyre is safer in terms of the number of laps you can do, whereas Formula 1 is still trying to get a tyre that gives good racing and has a performance limit to reach, so it's hard to compare. In 2012, everyone thought the Pirelli tyre was great, but in 2013 – with only minor changes – it was perceived as a disaster.

'NASCAR does not sail so close to the limit, even though some of the circuits here are very abrasive and the lodgings are high with the weight, speeds and downforce.'



JAMES MOY/XPB

Engineer and designer Mike Coughlan

While Formula 1 is seen as cutting-edge in all areas of motorsport, the troubles the teams had with tyres in 2013 suggests that there are some areas where the Europeans could learn from their counterparts in North Carolina. The chat in Iron Thunder, Concord at one point was all about how the Lotus F1 Team (which was testing at Windshear) learned a few tyre management tricks from Hendrick engineers, which was how they managed to make them last so much better than other teams in 2012. Whether that tale is true or not, Coughlan believes that F1 could indeed learn from stockcar racing. 'F1 is very much aero-dominated these days, and NASCAR too is improving in that area,' he says. 'But the vehicle dynamics are understood much more in NASCAR, because in Cup the determining factors are grip and suspension travel.'

But that is not to say that there is nothing that NASCAR teams can learn from those racing in F1 and LMP1. In fact, for an organisation like RCR, the big benefit to having an engineer like Coughlan involved is the knowledge of techniques and methodologies that they can bring, knowledge that's in fact considered mainstream in Europe.

'Some of the simulation software in F1, and the tools they use, will be coming here,' says Coughlan. 'It's things like the design process – you can feed target parameters into a computer, tell it that you have an upright that has to weigh under 1kg, and take a certain loading via fixed points. Then it can design the perfect structure. The computers can tell you how to improve performance, and we are gradually moving away from guessing, educated or otherwise.'

Indeed, Coughlan highlights one area as something that will change NASCAR racing in Cup, Nationwide and even the Truck series.

'If I could take anything from F1 and drop it into RCR, it would be a simulator, because it is a very powerful tool – you can use it to answer lots of engineering questions. A simulator that is powerful for the driver will make a big difference.

'Driver-in-the-loop simulation is not big in Cup now, but it will be coming, as will hardware-in-the-loop. If you take a Formula 1 simulator now, it actually runs all the standard processors. The McLaren ECU is used in-the-loop, so if you want to develop code you can use the simulator. So, not only is the simulator used for driver education, it's also used to prove code.'

Every F1 team has its own simulator (at least one) these days, as do the works Porsche and Toyota LMP1 teams, but even some junior series outfits like Arden International – which runs in GP2 and GP3 – have them too. Most of these use motion platforms, which offer six degrees of freedom, but Coughlan is uncertain whether this is the best approach.

'Simulators are not hard to come by now, and they are also not unduly expensive any more,' he says. 'Even in F1 there are constant questions over whether to use a hexapod or a dart-type simulator, but in NASCAR I think you can get away with a dart-type.

'I want to get more scientific about things like that, but don't forget that a F1 car is a very transient thing – always braking and turning. Only for a very short period is it at full throttle for any amount of time. In NASCAR, almost the reverse is

Despite the different tech used, engineering expertise carries over between F1 (above) and NASCAR (below)

JAMES MOY/XPB

"Some of the simulation software in F1, and the tools they use, will be coming here"

true. Generally, the intermediate circuits are steady state. In some ways, that makes the simulation easier as you do not have to look at very many states, but in other ways it makes it harder.

'The car has a single yaw value and a single ride height, but in F1 it all changes with high yaw angles and steer angles. In NASCAR you may get 3deg, but in F1 it can be 11deg of yaw. You don't have those transient states in NASCAR, so you could probably get away with a McLaren-type simulator, or a fixed-floor type simulator, because you don't have the big braking or the big turning events that you have in F1 with things like chicanes. There are no kerbs – the tracks are relatively smooth and there are no big changes of direction.'

Putting the driver in-the-loop has changed Formula 1 in a subtle but important way. Today, with very strict testing limits, the driver needs to be able to make progress on the simulator to be consistently competitive in the races, and to get the best out of the car. This is something that requires a slightly different skill-set, from both driver and engineer. 'You do need cueing. If you did a simulator version of Charlotte Motor Speedway in a Cup car, there would not be a lot of movement, even on a six degrees of freedom machine. Here, the car is driven with a lot of feel, so perhaps you just need to get the cues correct.'

However, understanding the cues that a driver reacts to is more than just looking at G loading and corner shape. It seems to be an inexact or not fully understood science based on the smallest things that even the driver may not understand. '3D was a big step at McLaren – you can see this in the consistency of lap times from a driver on the simulator. The consistency can go from tenths to hundredths just from using 3D. You soon realise that the visual cueing is so important. When Fernando Alonso arrived at McLaren, there was a small lag in the simulator visually at the time. When he was driving at Barcelona, there is this house by the side of the track that flashes past, but it did it slightly at the wrong moment and it caused problems. He had driven so many laps of Barcelona over the years, he knew that house and when it flashed past he lifted, but now it passed after he turned – a matter of a fraction of a second – but it made a difference. You have to get the visual cues perfect or get rid of them all together and just do the track and not the big visual things. He was using this house on the horizon, some way off the track. Nobody had thought about that before, and why would they?'

For NASCAR teams, they will primarily be dealing with 1.5-mile oval tracks, like the ones in Charlotte, Atlanta and Las Vegas. These present very different challenges to the simulation experts in comparison to a road course like Barcelona, but it also challenges the drivers. Some cannot get the best out of the simulator, while others are exceptionally good on them. Famously, Michael Schumacher could not get the best out of the Mercedes facility as it made him feel sick.

CUEING UP

'You will start to see the same thing happening now – you get a phase as the teams start to understand the science and you will start to find drivers who can react to the cues properly,' says Coughlan. 'In NASCAR they will be different though, there will be no house flying by at Barcelona – there is just a wall. It's not going to have the big movement that the F1 drivers can react to either. I don't know enough about NASCAR yet to know the answer to what it is that the driver reacts to, and what he feels. I think sometimes it's a bump or a ripple on the track – that was the case in F1 too to some extent.'

Simulators clearly put human performance in the spotlight, in a way that is almost alien in motor racing, but perhaps fully understood in Olympic sports. It is something that F1 teams have started to understand and that may prove crucial in NASCAR, especially in 500- and 600-mile races. 'The joy of the simulator is that you can have 10 laps with a constant fuel load, atmospheric conditions and tyre wear, and flip between setups at a flick of

"If you did a simulator version of Charlotte Motor Speedway, there would not be a lot of movement. Here, the car is driven with a lot of feel"

a switch with the driver in the same conditions too. When you do simulation studies in F1, you find that when you track a driver with a baseline setup throughout a day, his performance is not the same – it varies. You see this kind of wave. They drop off after lunch, for example.'

The technology will also likely change some up-and-coming drivers' career paths, and you will find some highly paid drivers never taking to the track in races. Indeed, some will never even spend time in the real car. This is a common practice in F1, but totally alien in NASCAR. 'There are some who are perfect simulator drivers. Mercedes GP I think have a driver who can beat the race drivers. It changes careers. Pedro de la Rosa was really key at McLaren when I was there. He could drive in the styles of Kimi Raikkonen or Juan Pablo Montoya on demand. Montoya was always hard on the brakes, and wanted the aero balance forward and turned in late, while Kimi was smoother and carried more speed. He could just switch between them. That made de la Rosa very powerful as a development tool at McLaren – he understood what they saw and what they felt. He is a valuable commodity because of that.'

LAT

Honda opened the HPD Indy Tech Center and DIL Simulator in Indianapolis last year, initially made available to Honda-powered IndyCar and sportscar teams

It is likely to be something that makes a difference to the top Cup competitors in the coming years, but the substantial change that is on the horizon in Sprint Cup is really what has attracted Coughlan back to the NASCAR garage. 'One of the reasons I came back to stockcar racing is that there is a move from NASCAR to make the series more technically challenging to try to appeal to the audience. Also, there is more engineering input in NASCAR, perhaps because you are starting from a lower mark. Formula 1 is really totally aerodynamic. F1 will have a few years of challenging designs with the new rules this year, but I don't think that anyone will design a car that is hopelessly wrong, because the F1 simulation tools are that good. Everyone will get it about right, and that's what I want to see brought here.

'I'm really looking forward to learning lots and bringing some of what I have learned in Europe to help RCR move forward,' says Coughlan. 'Generation 7 I'm particularly looking forward to. The series is going to get more fuel-efficient engines, and there will be more science involved in the design and development. The product will be more aligned with where I have come from, and I think that is for the good of the sport.'

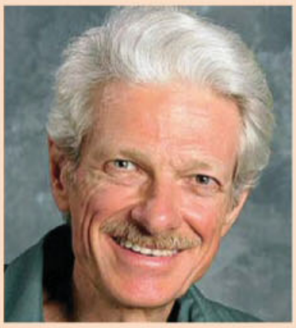
The question that has yet to be answered by NASCAR, is when Generation 7 will arrive. Only time will tell.


pankl
RACING SYSTEMS
High Tech | High Speed | High Quality
Pankl Engine Systems GmbH & Co KG
A member of Pankl Racing 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


CRANFIELD
MOTORSPORT SIMULATION
Whether you are a privateer racing driver or an entire race team, the Cranfield Motorsport Simulation (CMS) range of products and services offer you the most powerful off-track training aid in the market today.
CMS provides a complete range of personal training services and development tools or if you require it, provision of a complete training device tailored to meet your individual needs.
Contact us to book our dedicated simulation facility or to discuss the purchase of one of our off the shelf or bespoke product solutions.
+44 (0) 1234 754 099
graham@cranfieldmotorsportsimulation.com
www.cranfieldmotorsportsimulation.com
INNOVATION IN SIMULATION


Intelligent control and distribution of battery power in a modern racing car.
PCM / PDU
POWERBOX
CONTROLLING POWER
HP 8440 -V2
Used in championship winning cars:
- Le Mans winner LMP1, 2008-2013
- ALMS winning Porsche RS Spyder's
- Ferrari 458 GT2, BTTC and more...
Main Features:
- Maximum 200 Ampere continuous.
- 34 individually programmable output channels.
- Operated by 11 conventional, 32 CAN channels and by 20 virtual channels.
- Weight 710 gr.
1,399 €
Excl. VAT
Software included
Free upgrade
Analog to CAN converter
4 x Analog inputs to CAN.
Board size 24x24mm.
OEM board for your application.
8 x Tyre temperature to CAN in one small unit. Measure 8 points on your Tyre - Transmit CAN to Logger / Dashboard
OUR IDEA, DESIGN AND PRODUCTION
HP ELECTRONIK
Virkelyst 10 · Gjellerup
7400 Herning · Denmark
Tel. +45 9626 4333
Fax +45 9626 4233
info@hpelec.dk
www.hpelec.dk


Call us first...
Trident
Racing Supplies
MasterCard
VISA
Unit 31 Silverstone Circuit Towcester Northants NN12 8TN
T: 01327 857822 F: 01327 858096 www.tridentracing.co.uk



Mark Ortiz Automotive is a chassis consultancy service primarily serving oval track and road racers. Here Mark answers your chassis setup 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

Yaw velocity effects

Where do these factor in with low speed understeer and high speed oversteer, to help avoid making a car too loose for comfort?

QUESTION

In relation to the well-chronicled low speed understeer vs high speed oversteer argument – my thinking has been that the degrees of rotation required against distance covered (yaw rate?) to negotiate the tighter radius turn induces the understeer. If the car is adjusted to work well on tight radius turns (fairly unstable or highly responsive to input), then on large radius turns that car becomes too loose for comfort at the high speeds and low rotation/distance required.

I have to wonder if I am missing something.

I've been following your articles on torque wedge relative to beam axle cars with interest.

Not knowing any better, I have used three links with a centred third link with Watt's or Panhard lateral location. I have made big improvements on some Trans-Am-type cars' exit traction by replacing the upper two links in the four link. We have to add a fair amount of ARB to the rear, of course.

Now I see that I really should be mounting the third link offset to try to balance torque equally left and right (road race assumed).

Obviously, the torque applied depends on engine output and trans torque multiplication, so it is a pretty dynamic number.

I am trying to figure a way to calculate the effects. Torque is pretty easy to work out once I decide which trans gear I am going to use, along with an average of the engine torque.

The part that balls me up is the anti-squat. I have learned that I can have the same anti-squat % with two totally different side view swingarms. And with the rear axle torque reacting through the links, a short swingarm will make the car super-reactive to throttle position. I find that an IC somewhere near front axle seems pretty good with high power cars.

Now I am trying to figure out how to relate the third link offset and side view swing arm to the torque wedge.

THE CONSULTANT SAYS

In the past I have addressed the reasons that cars tend to understeer more in low-speed turns than high-speed ones.

The questioner here describes yaw velocity, and suggests that this adds understeer. It is true that the car will have greater yaw velocity (in degrees or radians per second) in a small-radius turn than in a large-radius one, for a given lateral acceleration.

However, I don't think that yaw velocity adds understeer, in and of itself. Yaw acceleration (rate and direction of change of yaw velocity, in degrees or radians per second squared) – or more precisely, the inertial reaction to that acceleration – does add understeer if its direction is into the turn, as during entry. If its direction is out of the turn, as during exit, it adds oversteer instead. In other words, due to yaw inertia, the car doesn't want to start rotating when it's going straight, and once it is rotating it wants to keep rotating. This effect tends to add understeer on entry and oversteer on exit.

The effect is more pronounced in cars that have larger polar moments of inertia in yaw (masses toward the ends) and less pronounced in cars with small polar moments of inertia in yaw (masses toward the middle, as with mid-engine cars). It is more pronounced in tight turns than in sweepers.

We could perhaps say that higher yaw velocity indirectly adds understeer, because the concomitant tighter turn radius implies that the front wheels will track further outside the rears, or not as far inside the rears, for a given set of slip angles at the tyres. That is, on a wet road, in a tight turn, the front tyres will generally make tracks outside of the rear tyre tracks, whereas in a sweeper the rear tyre tracks will be outside the front tyre tracks.

With rear drive, the front tyres are creating a drag force as they corner, and the rears are creating a thrust force. If the thrust force acts at a smaller radius than the drag force, as in a tight turn, a yaw couple results that tends to rotate the car out of the turn and therefore adds understeer. If the thrust force acts at a larger radius than the drag force, as in a sweeper, the effect acts the other way and adds oversteer.

For a given forward acceleration, higher speed requires more thrust from the rear tyres to overcome the increased aerodynamic drag

For a given forward acceleration, including zero (constant speed), higher speed requires more thrust from the rear tyres, to overcome the increased aero drag. That reduces the rear tyres' available lateral force capability, and adds oversteer.

If the car has a spool, or if the diff generates any locking torque in the conditions we are examining, that creates a yaw moment that adds understeer in any car that has to turn both ways and cannot use tyre stagger. Up to a point at least, this effect is greater in tight turns than in sweepers.

Does more anti-squat/anti-lift produce more throttle push and/or more drop-throttle oversteer? I doubt that it necessarily does, although there might be a very short-lived effect of that nature, due to the rear tyres loading and unloading a little more abruptly. I would be inclined to attribute any observation like that to changes in rear steer effects when the geometry is changed.

Now, to the question of what to do with a three-link to cancel torque roll. Assuming that the lower links are symmetrical, the side view instant centre isn't what we need to pay attention to, nor is the overall amount of anti-squat.

What we need to do is create a roll moment with the longitudinal links that is equal and opposite to the roll moment created by the driveshaft torque. If the lower links are symmetrical, any lift or squat force they generate is the same on both sides of the car, so these forces do not create any roll moment. What matters is the lift force created by the upper link, and how far to the right of centre this force acts.

The relative height of the lower links and the upper – at the axle centreline plane – determine the magnitude of the tension force on the upper link. That plus the slope of the upper link determine the lift force from the link. The magnitude of the lift force – plus how far off centre it acts – determine the roll moment countering the driveshaft torque.

The only gear ratio that matters is the ring and pinion ratio. This determines the ratio between the axle torque and the driveshaft torque. The equation for the inclination angle of the upper link, when the rest of the geometry is known, is shown in **Equation 1**.

EQUATION 1

$$\tan Ø_u = (R_t (H_u - H_l)) / (N_{rp} * H_l * L_{yu})$$

where:

$Ø_u$ = upper link angle from horizontal (nose down positive)
R_t = effective radius of tyre
H_u = height of upper link, at axle centreline plane
H_l = height of lower links, at axle centreline plane
N_{rp} = ring and pinion ratio
L_{yu} = lateral offset of top link from centre

This equation does not allow for friction in the ring and pinion. This friction will reduce the axle torque slightly and call for a slightly steeper upper link angle. However, since we are really only trying to get close to the correct value, this effect can be ignored.

A three-link with the top link offset is a very simple way to cancel driveshaft torque roll, but it causes roll and wedge change when we brake. Unless we use a transmission brake, the brakes don't act through the driveshaft, so there is no driveshaft torque from them. Yet the asymmetrical three-link is still reacting axle housing torque asymmetrically. The car rolls to the right, and the right rear and left front unload.

We can make the brake torque react through different linkages than drive torque, and get even rear wheel loading under both power and braking. The simplest way to do this is to use a birdcage or brake floater just on the left. Alternatively, we can have birdcages or brake floaters on both ends of the axle.

Obviously, this complicates the system. If we want to retain the simplicity of the basic three-link, we can compromise and accept having only partial cancellation of driveshaft torque, and a little wedge change and roll in braking.

Stagger effects on rear anti-lift

Could an over-staggered car be subject to brake-like forces?

QUESTION

I was reworking several of my Excel spreadsheets, specifically my calculations of anti-squat and longitudinal load transfer as defined by pitch centres and axis. I started to wonder what the implications would be for an over-staggered car on the forward longitudinal forces seen at the tyre contact patch, and then by definition in the longitudinal locating links on a solid rear axle car (torque arm and trailing links as per usual in my case).

At some point, would it not be true that the outside (larger) tyre would be driving with a positive longitudinal slip, and a forward accelerating force and the inside (smaller) tyre would be dragging with a negative longitudinal slip and a rearward longitudinal force?

And if the above statement is true, then is not the small tyre side longitudinal linkage seeing what is – in essence – a force similar to braking?

If all of the above is true, then there is really only one radius of curvature at which the car is stagger neutral, with both rear tyres providing forward force in proportion to their vertical loading. And at that time – and that time only – we are getting the total anti-squat forces we calculate from our left and right longitudinal link geometry.

THE CONSULTANT SAYS

It definitely is true that anti-squat/anti-lift forces depend on the actual ground plane forces at the contact patches, and these can be dramatically influenced by tyre stagger, with a locked axle or a limited-slip.

It is difficult to predict just what the ground plane forces will be. Their total magnitude, their distribution, and even their direction change depending on how close the tyres are to the limit of adhesion. As these things change, not only do the resulting yaw moments change, but any roll moments created in the rear suspension by anti-squat/anti-lift effects also alter.

With independent suspension, it is fairly simple to predict the jacking force at the wheel for a known or assumed ground plane force. With a live axle, it's more complex. The longitudinal locating linkages are inboard of the wheels, so a portion of the longitudinal force from each tyre reacts through the opposite side's links. Also, the linkages act on the sprung structure inboard of the tyres.

That's just the thrust forces. On top of that, we have the torque. That acts on the axle housing as a unit, and reacts through whatever mechanism controls housing torque. The roll moment from the torque does not depend on the distribution of the individual wheel torques – it only depends on their sum.

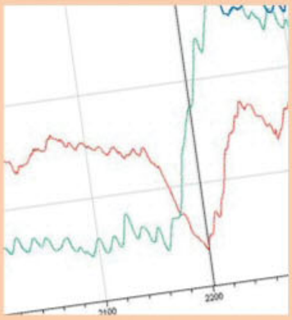
If we have the brake calipers on floaters or birdcages, and a locked axle, the torques of the two brakes react through their individual birdcages or floaters. If we have dissimilar brakes, that changes the distribution of the torques. However, with a locked axle, dissimilar brakes don't change the distribution of the thrust forces. Both rotors act on the axle as a whole. Longitudinal forces (which, in sum at least, will be negative thrust, or positive retardation forces) are highly sensitive to stagger effects.

On the other hand, if we have a locker or diff that unlocks on deceleration, dissimilar brakes will give us dissimilar ground plane forces. Stagger will affect the car, but in the same way that it does at the front in braking: a smaller tyre gives us more retardation force for a given brake torque.

DYNAMICMETALS
TITANIUM AND SPECIALIST METALS
The UK's Largest Independent Stockist of Titanium and Specialist Metals.
Aerospace metals for the most demanding of applications.
E: sales@dynamicmetalsltd.co.uk
T: +44(0) 1442 212 340
www.dynamicmetalsltd.co.uk


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
BMRS
Professional Race Hose & Fittings


Ferrea
RACING COMPONENTS
CUSTOM MANUFACTURED to your specifications
FASTEST TURNAROUND times in the industry
Maximize your race engine's potential with our
NEW Titanium Hollow Stem Valves
Ferrea's Titanium Hollow Stem Valves just got lighter and stronger with a complete new design. We have developed a proprietary manufacturing process that gun drills and micro polishes the bore of the valve stem. This proprietary process insures greater structural integrity than any other Titanium hollow valve on the market today. We have achieved a valve reduction in weight by approximately 10 percent compared to solid Titanium valve.
Hardened Tips & Radial Grooves
Super flo. & flo. designs
CrN coating throughout the entire valve
SEMA AWARD WINNING PRODUCT
FERREA RACING COMPONENTS
Tech Line: 954-733-2505 • Toll Free: 888-733-2505
www.ferrea.com
FOLLOW US ON:



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

To allow you to view the images at a larger size they can now be found at www.racecar-engineering.com/databytes

Monitoring pressure

A variety of techniques are available to gauge the temperatures and pressures that are so critical to smooth running in motorsport

With new regulations and new technologies emerging at the top level of motorsport, the issue of reliability has become an extremely hot topic.

Information systems on racecars are nowadays so powerful that in most cases all that's necessary is to dream up a method for calculating something, and the system can be programmed to do so. Saying that, even in today's extremely hi-tech world of motor racing, some simple methods can be employed to get a really good idea of what is going on in the racecar.

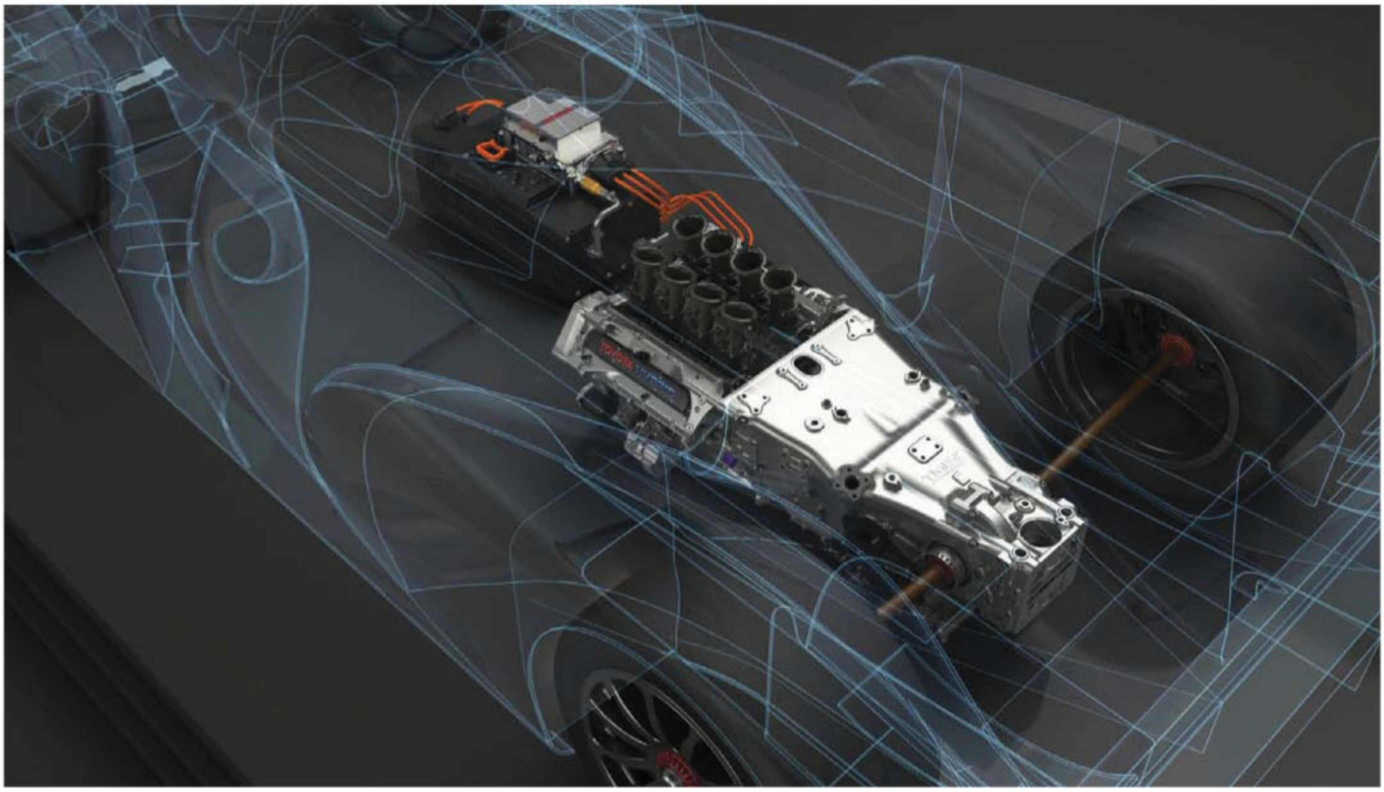
Looking at the engine itself first, no matter what formula the car is built to, there are always the same principal elements to look for: temperatures and pressures. The oil needs to be at the right pressure and temperature, the water for cooling needs to be at the right temperature and also have adequate pressure.

Creating automated check channels for these is relatively simple. The engine oil pressure pump is normally driven from the crank (or other rotating part) of the engine, so the pressure is influenced by the RPM. If this is taken into account, the automated check for whether oil pressure is good is shown in the box below.

Note that this check is not the oil pressure alarm condition, but a flag to indicate a low pressure, and that we need to keep an eye out for further developments there. The graph in

MATH

```
choose([RPM] > 3000, [Engine Oil Press] <= 4.0, 0) // Return a flag if oil pressure drops below 4.0 bar at Engine RPM over 3000.
```



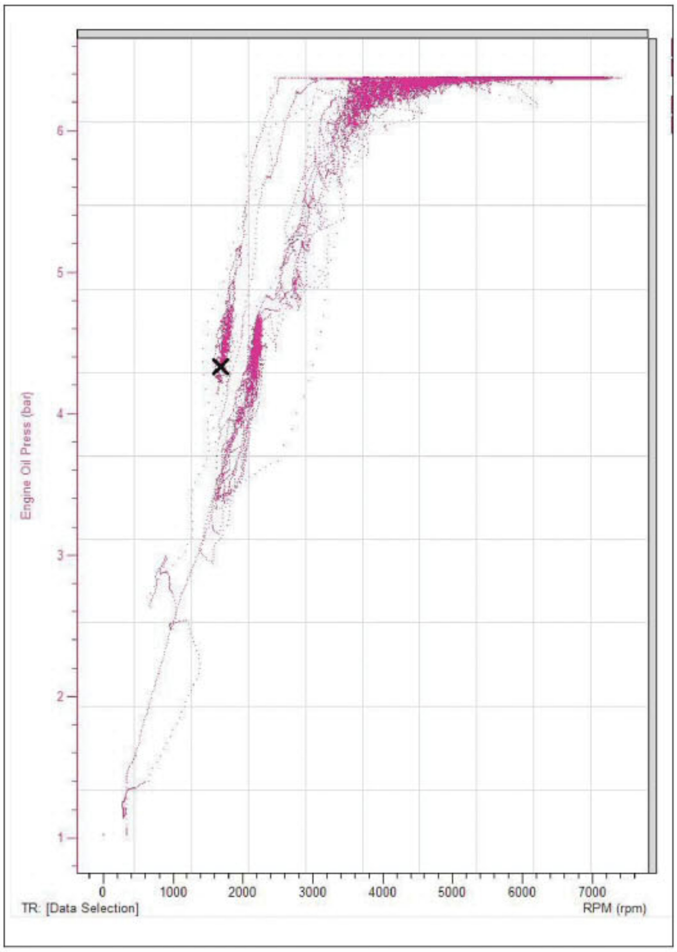


Figure 1: how oil pressure is influenced by the engine RPM

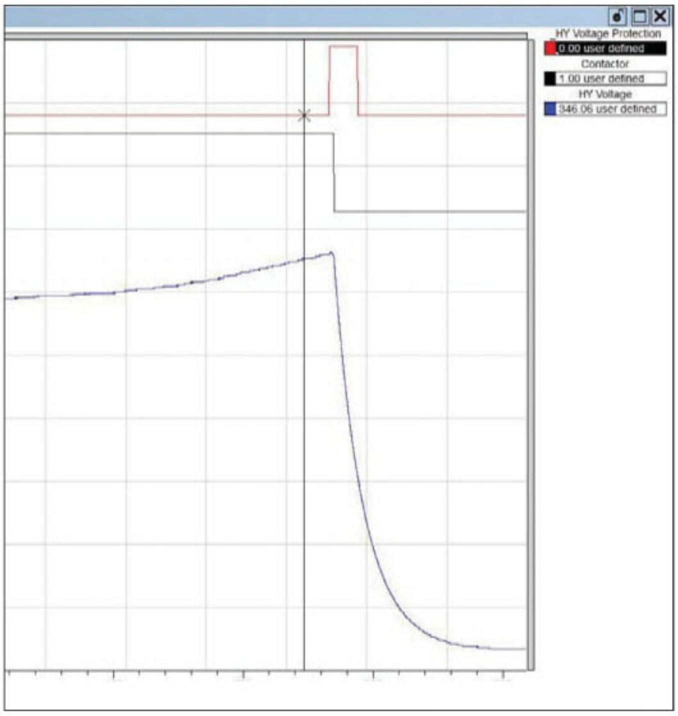


Figure 2: example of an over voltage protection strategy – when the voltage hits a certain limit, the contactor is set to off and voltage drops immediately

Figure 1 above shows clearly how the oil pressure is influenced by the engine RPM.

The oil temperature also needs to be maintained at optimal by oil cooler(s), and in order to make sure these are working properly temperature measurements before and after the cooler are necessary. This allows us to calculate a simple efficiency number which can be an indicator of the health of the oil cooling system and also the oil.

Water needs to be monitored in a similar way as the oil – the temperature and pressure are of interest. The effect of the temperature directly influences engine performance and the pressure value gives an indication of the integrity of the system.

If the water temperature rises but the pressure stays the same, it could indicate a leak in the system.

In this day and age, racecar powertrains are changing and the token popular medium for either replacing or boosting a fossil fuel power plant is electric. The electric or hybrid powertrain presents a different challenge to the more common powerplants in terms of maintaining reliability. Temperature is still a major issue and it is critical to control the temperature of both the energy storage and the motors.

The temperature directly influences the performance of both and if it goes too high, the internal protection will limit the amount of power available. Maintaining a good cooling system is therefore a key factor for the performance of the car. Most electric motors and energy storage solutions have built- in diagnostics systems and have options for external control as well. A good data system can therefore be configured to monitor any value and – if required – a control strategy can be implemented to make sure all systems are working well.

High voltage battery systems have an element of danger associated with them, so values like current, voltage and isolation are critical not just for performance but also for safety reasons.

Figure 2 is an example of an over voltage protection strategy – when the voltage hits a certain limit, the contactor is set to off and the voltage drops immediately.

If we are to single out one element that should be at the top of the list when it comes to reliability, it is temperature. The biggest contributing factor for cooling in a racecar is airflow, and in today's racecars aerodynamics have a major influence in lap times. The two are unfortunately at opposite ends, and a big advantage in one means a compromise in the other.

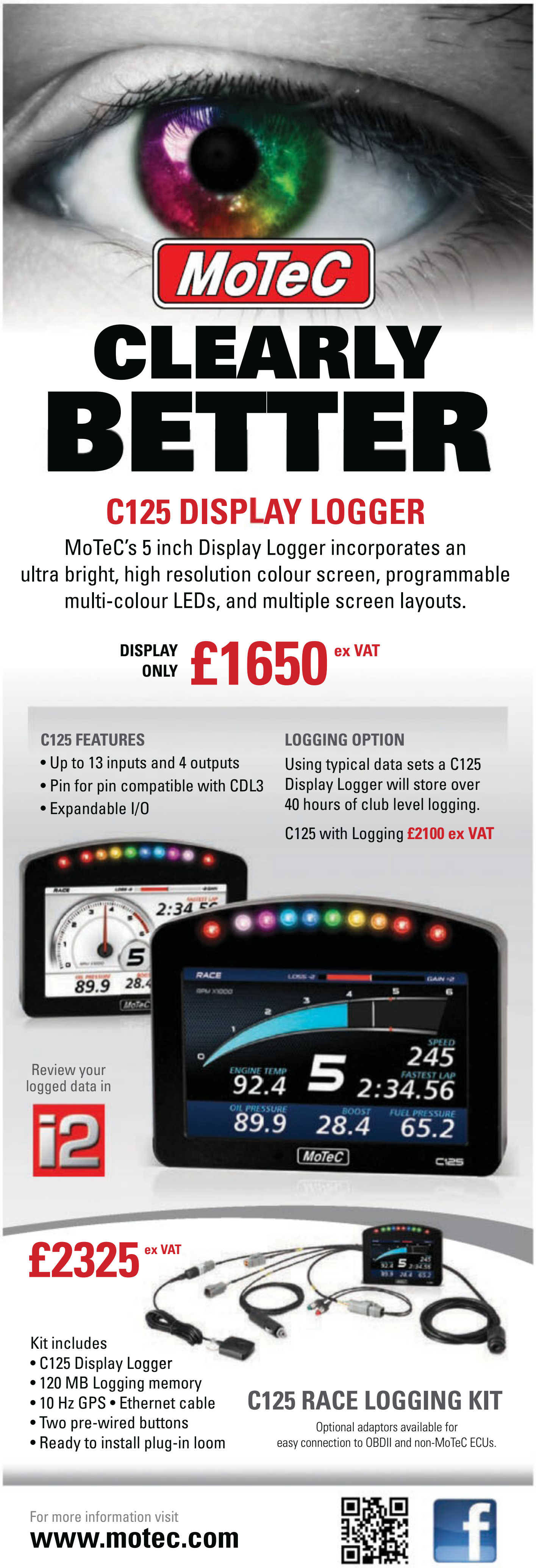
Aggressive aerodynamic designs therefore often demand that the powertrain systems work at higher temperatures, which is possible with a traditional powertrain, but is a much bigger challenge with the latest in hybrid technology.

COSWORTH

Produced in association with Cosworth
Tel: +44 (0)1954 253600
Email: ceenquiries@cosworth.com
Website: www.cosworth.com

A good data system can be configured to monitor any value and – if required – a control strategy can be implemented to ensure all systems are working well


FUEL SAFE Racing Cells
FIA CERTIFIED FUEL BLADDERS
Custom Rally Pro Cell
458 Ferrari
Viper GT3-R
• Shortest lead times in the industry
• CAD modeling = precision fitment
• Dual fuel / ethanol compatibility
• Lightweight / flexible
• Custom containers available
HIGH-PERFORMANCE ACCESSORIES
High Performance Pumps Available From Fuel Safe
Redhead Drybreaks
Swirl Pot
CONTACT OUR EXCLUSIVE AGENT IN THE U.K.
Classic World Racing, Tel +44 (0) 1527 521050
www.fuelsafe.com
MADE IN USA
FUEL SAFE Racing Cells


MoTeC
CLEARLY BETTER
C125 DISPLAY LOGGER
MoTeC's 5 inch Display Logger incorporates an ultra bright, high resolution colour screen, programmable multi-colour LEDs, and multiple screen layouts.
DISPLAY ONLY £1650 ex VAT
C125 FEATURES
• Up to 13 inputs and 4 outputs
• Pin for pin compatible with CDL3
• Expandable I/O
LOGGING OPTION
Using typical data sets a C125 Display Logger will store over 40 hours of club level logging.
C125 with Logging £2100 ex VAT
Review your logged data in
i2
£2325 ex VAT
Kit includes
• C125 Display Logger
• 120 MB Logging memory
• 10 Hz GPS • Ethernet cable
• Two pre-wired buttons
• Ready to install plug-in loom
C125 RACE LOGGING KIT
Optional adaptors available for easy connection to OBDII and non-MoTeC ECUs.
For more information visit
www.motec.com


-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.
Nº1
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
KENT CAMS
HIGH PERFORMANCE ENGINEERING
www.kentcams.com
Cams + Pulleys, Belts & Chains
Valves & Valve Springs
Performance Cam Kits & Valve Spring Kits
Followers & Tappets


VAC
MOTORSPORTS
Your #1 Source for BMW Stroker & De-Stroke kits
For BMW S65, S54, S50, S14
Billet Dry Sump Pans
Available for BMW S54, & S65
ARP automotive Racing products
CARRILLO
ARROW PRECISION
SCHRICK
COMETIC GASKET
www.vacmotorsports.com - 215.462.4666

Praga performance

We start a new project in the MIRA wind tunnel this month with the very desirable R1, a 'coupé CN' sports racer

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

MIRA

Tel: +44 (0) 24-7635 5000
Email: enquiries@mira.co.uk
Website: www.mira.co.uk

Featuring a pleasing blend of LMP1-like appearance but with significantly more compact dimensions than those sports racing leviathans, Praga's stunning R1 is – according to their spokesperson interviewed in our June 2013 (V23N6) issue – a compromise between styling and aerodynamics.

Market forces had dictated that the car would have a roof, to make customers feel safer. Beyond that, the car is the product of designer Juraj Mitro's obviously finely honed eye for aesthetics coupled with some well-proven aerodynamic concepts. How would it fare in the MIRA full-scale wind tunnel? The team very kindly hauled one of their racecars the 1800km from Bratislava, SK, to Nuneaton, GB, to put their work – and aerodynamic data – on public view.

BASELINE RUNS

As usual we started the session on the R1 with some runs at different speeds to see if there was any sensitivity across a speed range from approximately 65km/h (40mph) to approximately 125km/h (80mph, the tunnel's maximum speed). And as always we need to remind ourselves that MIRA's tunnel has a fixed floor but with a boundary layer control fence installed, and the car's wheels are stationary. So, as with any low ground clearance racecar that develops a significant proportion of its downforce from ground proximity devices, we knew there would be an underestimate in the downforce levels we recorded. The question is often asked 'how big is this underestimate?'

Table 1: baseline coefficients on the Praga R1 at different speeds

	CD	-CL	-CLfront	-CLrear	%front	-L/D
66km/h	0.599	1.365	0.501	0.864	36.7	2.277
97km/h	0.591	1.375	0.506	0.868	36.8	2.327
127km/h	0.583	1.380	0.508	0.871	36.9	2.367

Unfortunately we do not have any track-derived data to compare to. Every car type would be different depending on what proportion of total downforce came from ground proximity devices, and just how close to the ground those devices were. So we will have to content ourselves with comparisons to other cars tested in the same wind tunnel to give us a relative idea of the Praga's aerodynamic capabilities.

First though, **Table 1** shows the key aerodynamic coefficients and parameters on the Praga R1 at three different speeds.

So there were modest changes to each of the coefficients as speed was increased. The drag coefficient came down by eight counts (0.008) with each additional speed increment, but the overall negative lift coefficient went up by 10 counts with the first speed increase and by five counts with the second speed increase. Similarly, both the front and rear negative lift coefficients increased more with the initial speed increase.

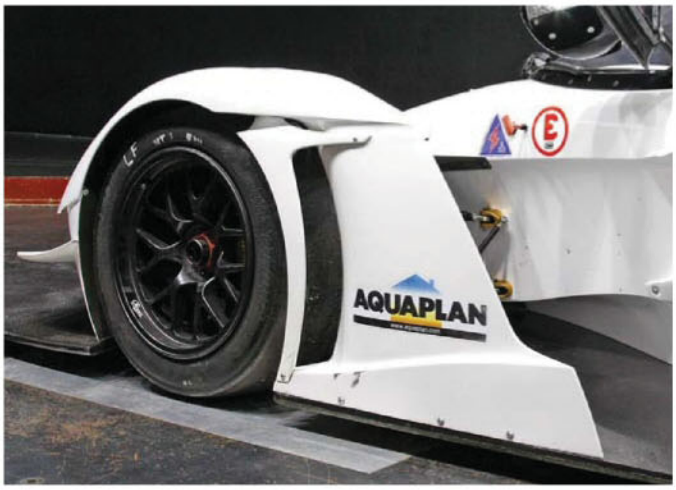
The small changes first of all imply that even at the lowest

The overall negative lift coefficient went up by 10 counts with the first speed increase and by five counts with the second speed increase

From any angle, the Praga R1 is stylish as well as being effective

Rear quarter view shows clear areas between the front wheels and the chassis

View of the nicely radiused, raised splitter leading edge and integrated devices between the wheel pods and chassis, and between wheel pods and splitter



Detailing around the front wheels is very interesting; note the undercut sidepods and chassis below the cooling inlets

Table 2: comparisons between the Praga R1 and the Ligier JS49

	CDA	-CLA	-L/D
Praga R1	0.845	2.001	2.367
Ligier JS49	0.790 to 0.839	1.978 to 2.198	2.470 to 2.620

speed used here, the flows on the downforce-inducing surfaces were fairly well developed, with little in the way of flow separations occurring. And secondly, the bigger changes from the slowest to the medium speed used here suggest that the flows were just about fully developed at 95km/h.

The R1 has a static weight distribution of 40 per cent front and 60 per cent rear with driver and fuel aboard. So, with the precept that an ideal aerodynamic balance for steady state cornering should see slightly less than 40 per cent of total downforce on the front axle, the baseline value for aerodynamic balance of around 37 per cent was close to being perfectly poised to deliver mild understeer at higher steady cornering speeds, assuming the chassis was mechanically balanced.

What was also noteworthy though is that the balance did not shift to any tangible extent with changing speed (at this zero yaw angle), again suggesting that flows were already well attached to the downforce inducing surfaces even at the lowest speed used here.

COMPARABLE CARS

In order to compare different cars, it is conventional to report CDA and -CLA numbers rather than CD and -CL values because multiplying the coefficients by the frontal area, A, gives values that are directly related to the forces that are actually measured. And as frontal area values are often just estimates, this approach also eliminates any errors in those values. It also makes sense to compare configurations that produced an aerodynamic balance on each vehicle.

The vehicle nearest in type and application that *Racecar* has tested in the MIRA wind tunnel was the Ligier JS49, reported on in this column between April and June 2009. Competing then in what was known as the VdeV Series – now the SPEED EuroSeries – the Ligier was, like its series competitors and like its current descendant the JS53, an open sports prototype. But in dimensions it was not too far different from the Praga, sharing an 1800mm overall width but being somewhat longer at 4600mm, including a well over-hung rear wing and

Clever shaping around the rear wheels allows airflow inboard of the wheels

a long rear diffuser as against 4144mm for the Praga.

With a similar static weight distribution to the Praga, the Ligier was also deemed to be balanced with around 37-38 per cent of its total downforce on the front axle, and in that condition the Ligier yielded a range of results depending on exact configuration. These ranges are given in **Table 2**, together with the well-balanced figures from the Praga's first baseline run, all runs being done at or near MIRA's maximum air speed.

So despite the fundamental difference of one being a closed coupé and the other being an open prototype, the Praga's principal parameters compared very well with those of the Ligier. Drag was slightly higher than the Ligier's upper value, and downforce was at the lower end of the Ligier's range. But considering that the Praga's roof would have been contributing aerodynamic lift and additional frontal area, its designer would seem to have done well to generate an aerodynamic package that performs similarly to the Ligier. Chief designer Mitro commented that the company developed the R1's aerodynamics with the aid of CFD (at the local university), which not only explains some of the adventurous-looking shaping, it also demonstrates what a useful tool CFD is in producing an effective aerodynamic package from the outset.

Next month we'll delve into more detail, and analyse the responses to various configuration changes.

Racecar Engineering's thanks to the team from Praga Cars

Despite one being a closed coupé and the other an open prototype, the Praga's principal parameters compared very well with those of the Ligier

Front wing fundamentals

Nowadays, the front wings on top single-seaters are festooned with intricate details – but there are numerous other crucial elements that have to be right first...

BY SIMON MCBEATH

In a sense, the aerodynamicists in F1 have it easy when it comes to front wing design. This is because a number of the basic parameters, such as maximum span, maximum chord, maximum depth, fore and aft location, minimum static ground clearance and – in the central part at least – the actual section profile, are stipulated in the technical regulations. Within those limits there is still an essentially infinite variety of possibilities of course, but consider the situation in a single-seater category where perhaps the only restriction, if any exist, is on maximum span and the rest is free. Where do you start?

In contemplation of this question, we have taken advantage of the use of ANSYS CFD software to investigate some of the basics. We'll see, among other things, why wings stall when they're too close to the ground and what happens when they do stall; why wider spans or wider flaps don't necessarily lead to more downforce; what happens when the wing is moved closer to the front wheels; why a more potent front wing doesn't necessarily create more drag, and what happens when the overall span is changed in the manner that F1 rules mandated in 2009, and again in 2014.

Where do you start with a front wing specification when there are few or no rules? This is the DJ Firehawk hillclimber, with a dual-element front wing

FRAME OF REFERENCE

The basis for this investigation is the single-seater concept design that underlies your writer's long-term hillclimb racecar project, the Vortex. Though currently firmly secured to the back burner, this project is still alive, but more importantly in the context of this feature it means a CAD model of a single-seater intended for UK hillclimbing already existed on which to try out a range of front wing variations. (The project itself morphed into a sports racing concept, but the single-seater at its core essentially hasn't changed). A front wing design also already existed. The model was also upgraded with improved wheel and suspension detail, although it remained a simplified representation.

In addition to the minimum static ground clearance of 40mm, UK hillclimb regulations only have two specific rules regarding front wings on 'racing cars':

- **Maximum width ahead of the front wheels is 1500mm**
- **Maximum height of any part wider than 1100mm ahead of the front wheels is not to exceed the top of the front wheel rim**

So there are far more degrees of freedom available in terms of the size and location of the wing than in more heavily regulated categories, and this situation also has relevance in other single-seater racing categories too, even though maximum span may be somewhat less. There are other categories and classes where there is no maximum span limit too, and we shall visit the situation where wingspan equals the car's width across the front wheels, analogous to F1 regulations from 2009 to 2013.

First, though, we are going to look at the effect of ground clearance. Although in UK Motorsports Association (MSA)-sanctioned events this parameter is covered by the 40mm minimum static ground clearance regulation, the dynamic situation can give rise to a fairly wide operating range, depending on mechanical setup. Furthermore, we need to examine a wider range than that to try and pick out a preferred static starting point.

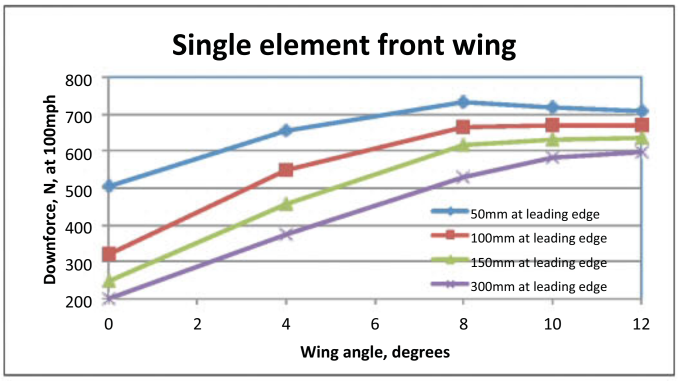


Figure 1: downforce vs angle on a single-element wing at different ground clearances

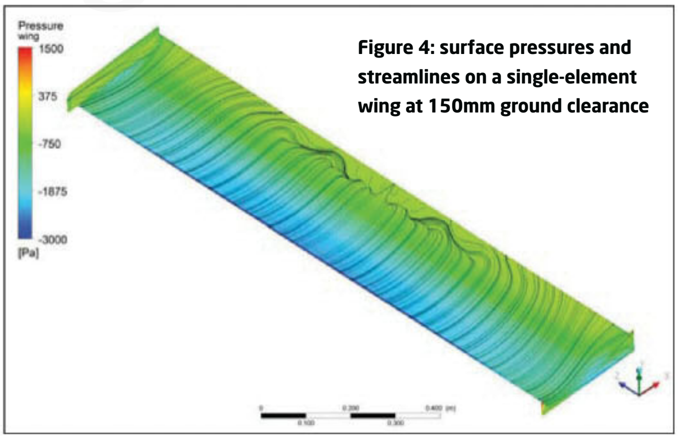


Figure 4: surface pressures and streamlines on a single-element wing at 150mm ground clearance

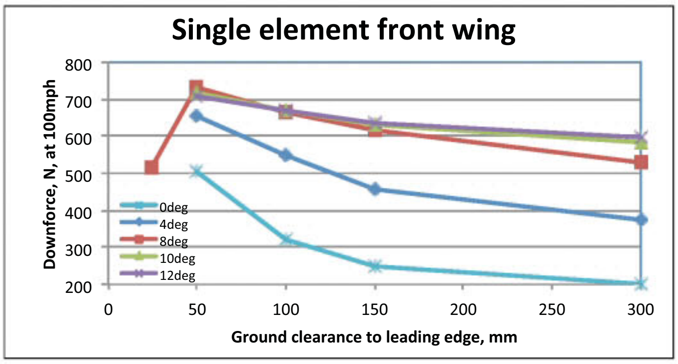


Figure 2: downforce vs ground clearance on a single-element wing at different angles

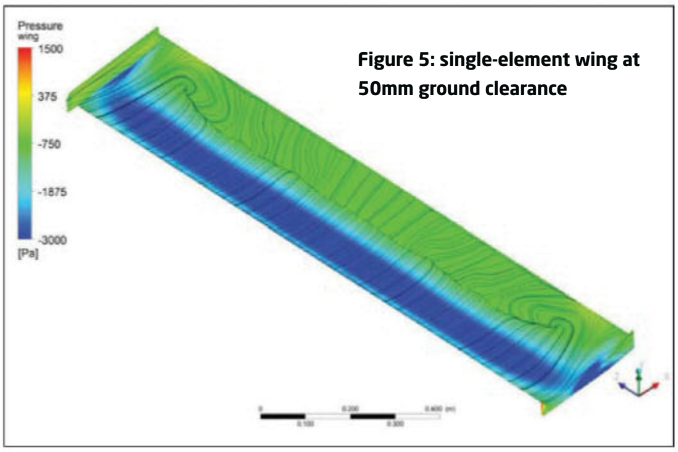


Figure 5: single-element wing at 50mm ground clearance

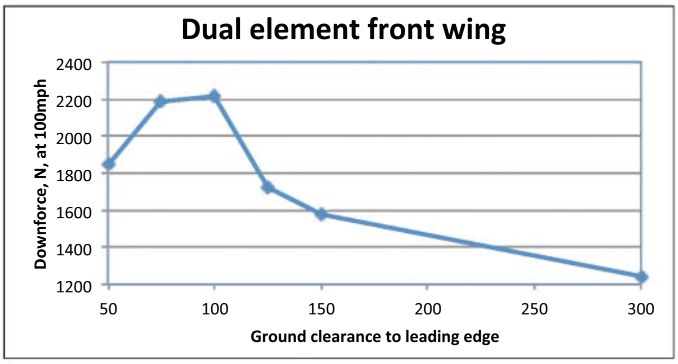


Figure 3: downforce vs ground clearance on a dual-element wing

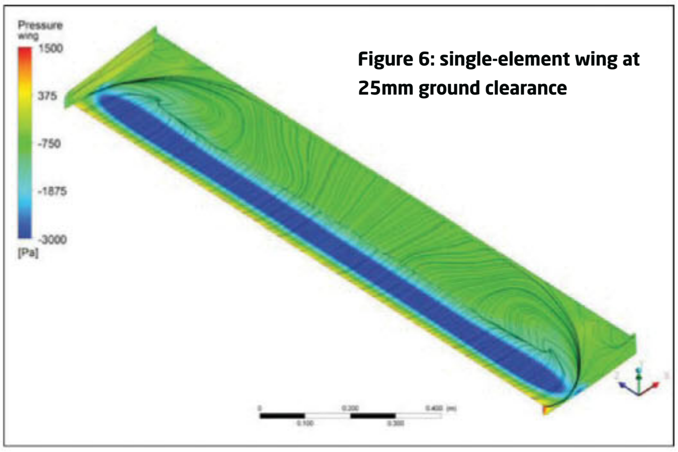


Figure 6: single-element wing at 25mm ground clearance

GLORIOUS ISOLATION

As a first step we'll look at the results on a single-element and a dual-element wing in isolation from the car, to highlight the behaviour of the wings themselves as ground clearance is changed. Span was 1500mm in each case, and end plates were simple, flat sheet devices. In the case of the single-element, 275mm chord wing, overall angle was adjusted across a range at various ground clearances from 300mm (measured from the ground to the tip of the leading edge) down to 50mm (and in one case, 25mm).

With the dual-element wing, the same main element angle was fixed and the 120mm chord flap angle was adjusted, and again the wing was mapped at a range of ground clearances from 50mm to 300mm. (The latter height was unfeasibly high for installation on the car model as a suspended wing, but was tested in isolation to give a more complete idea of how ground effect influences wing performance.) **Figure 1** illustrates.

The usual pattern of increasing downforce with increasing angle, up to a point, was evident, as was the increase in downforce brought about by reducing ground clearance. The wing peaked at between 10 degrees and 12 degrees at the greatest height, but at just 8 degrees at the lowest height, with something of a transition in between.

Figure 2 plots the same data in a different way, with an interesting additional sample point added, and shows clearly that reducing ground clearance below 50mm didn't look like a good idea with this wing at the angle tested.

Maximum downforce occurred at 50mm ground clearance for all the variations tested here, and this might seem to be the best height to select for that reason. However, it is also obvious that the lowest ground clearance would also be the most sensitive to dynamic fluctuations in ride height, so a decision always has to be made about just where on the downforce vs ground clearance curve you set your wing – at the 'peaky' maximum downforce height, or slightly higher on the more benign side of the peak? Either way, it looks like ride height fluctuations need to be controlled and that downforce levels will fluctuate dynamically.

Moving on to the dual-element wing, which featured a full span flap, first the flap angle at which peak downforce occurred was established at 100mm ground clearance (measured to the main element leading edge again), at which flap angle overall chord was 364mm, and this configuration was then adjusted to a range of ground clearances from 50mm to 300mm. **Figure 3** plots the results in similar fashion to **Figure 2**.

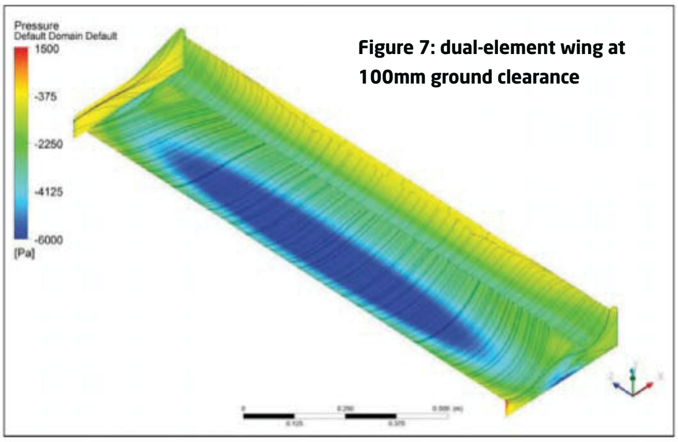


Figure 7: dual-element wing at 100mm ground clearance

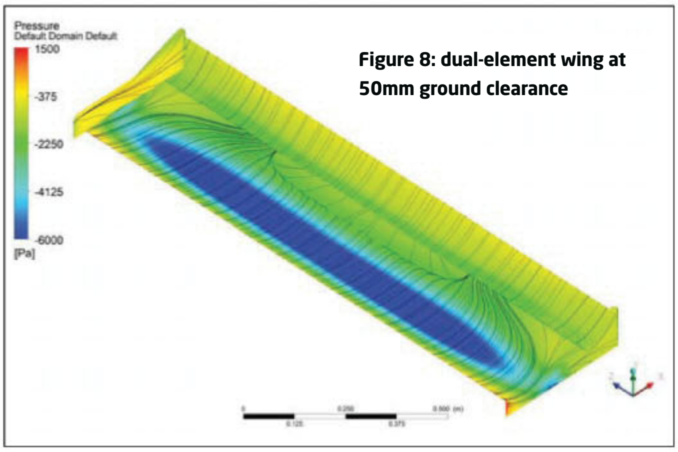


Figure 8: dual-element wing at 50mm ground clearance

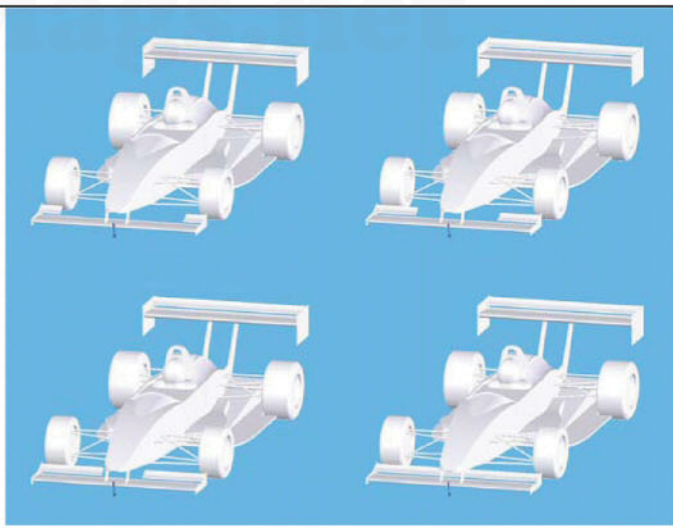


Figure 9: four flap span variations were tested

GROUND CLEARANCE CONVENTIONS

Engineering convention is to state front wing ground clearance as the ratio of ground clearance over chord, g/c. The table below enables conversion of the ground clearance dimensions used in this article to g/c for each wing

g/c for the single- and dual-element wings used in this article

Ground clearance, mm	Single-element, 275mm chord	Dual-element, 364mm chord
50	0.182	0.137
100	0.364	0.275
150	0.545	0.412
300	1.091	0.824

Table 1: aerodynamic data from variations in flap span

					Drag, N, 100mph					Downforce, N, 100mph				
Flap span	Drag, N	Total Df, N	-L/D	%front	Car body	Front wheel	Front wing	Rear wheel	Rear wing	Car body	Front wheel	Front wing	Rear wheel	Rear wing
0.25	930.3	2330.4	2.505	2.55%	429.0	138.4	38.8	158.3	165.8	763.9	-88.2	408.9	-93.4	1339.2
0.50	946.5	2812.6	2.972	21.12%	414.9	128.4	73.3	162.8	167.1	1032.8	-95.5	685.2	-88.3	1278.4
0.75	984.7	2820.2	2.864	34.21%	421.7	114.2	108.6	174.1	166.1	636.6	-81.5	1068.1	-50.5	1247.5
1.00	975.4	3099.5	3.178	45.04%	412.1	111.9	125.0	164.4	162.0	547.3	-59.6	1453.7	-79.8	1237.9

Here we see a similar pattern to the single-element wing, but peak downforce appeared to be at 100mm, with initially a gradual fall off at 75mm and a more rapid decline at 50mm. Above 100mm the decline appears to be more peaky too. Both wings would require more ground clearances to be tested at smaller increments in the regions of interest, but the general picture can be seen from the data points shown here.

STALL MECHANISMS

So what actually happens at these critical low ground clearances that causes the apparently sudden reduction in downforce? Looking at the single element wing first at 8 degrees angle of attack, **Figure 4** shows the surface pressures and streamlines on the wing's suction surface at 150mm ground clearance. And even though the wing was just below its peak downforce angle at this height there is already some flow separation occurring in the central area towards the trailing edge (the airflow coming from bottom left). Moving on to **Figure 5**, this was the pressure and streamline pattern at 8 degrees and 50mm, at which peak downforce occurred. Clearly the flow separation has spread, yet the region of lowest pressure under the wing has also spread, and the wing's downforce peaks because of this (although the downstream flows will be modified too).

Figure 6 shows the wing at 8 degrees and 25mm ground clearance where downforce had declined – the low pressure region has shrunk and flow separation is widespread. The wing has stalled.

As for the mechanisms at work here, there are two. Firstly, as the wing approaches the ground, the magnitude of the suction under it increases, which leads to an increasingly steep adverse pressure gradient from the region of lowest pressure to the wing's trailing edge. When this pressure gradient becomes too steep, the air can detach from the wing's surface – so-called flow separation. Then, as the wing gets really close to the ground, viscous effects start to cause blockage to the flow under the wing. This reduces the energy of the flow passing under the wing, and this makes it harder still for the air to remain attached in the now even more adverse pressure gradient towards the rear of the wing. Separation becomes stall.

We'll come back to look at what happens to the wing as it is deployed ever closer to the ground when fitted to the car later. Next though we'll take a brief tour of some other variables that might seem unrelated but which, it turns out, are highly relevant.

FLAP SPAN

The dual-element wing tested in isolation in the previous section featured a full span flap. But flaps are often only part-span, either because of technical regulations, such as in F1 with its 500mm mandatory single element neutral centre section, or perhaps because only part-span is required to achieve a balance with a mandated rear wing, such as in F3. **Table 1** below shows the CFD results of a flap span trial with the 1500mm dual-element wing now installed on the car (at 100mm ground clearance), and **Figure 9** illustrates the front flap chord variants, referred to as full span (1.00 in column 1) down to quarter span (0.25).

Having the ability in CFD to measure the aerodynamic forces on individual components enables tremendously valuable insights into the effects of changes. And perhaps the key point here is

Table 2: aerodynamic data from variations in fore and aft location of the front wing

					Drag, N, 100mph					Downforce, N, 100mph				
x-change, mm	Drag, N	Total Df, N	-L/D	%front	Car body	Front wheel	Front wing	Rear wheel	Rear wing	Car body	Front wheel	Front wing	Rear wheel	Rear wing
0	946.5	2812.6	2.972	21.12%	414.9	128.4	73.3	162.8	167.1	1032.8	-95.5	685.2	-88.3	1278.4
100	959.9	2907.6	3.029	18.21%	429.2	135.4	63.5	164.6	167.2	1180.0	-89.9	628.3	-88.7	1277.9
200	946.4	2782.6	2.940	15.08%	431.8	135.8	50.3	161.7	166.8	1110.9	-70.7	560.1	-88.9	1271.2

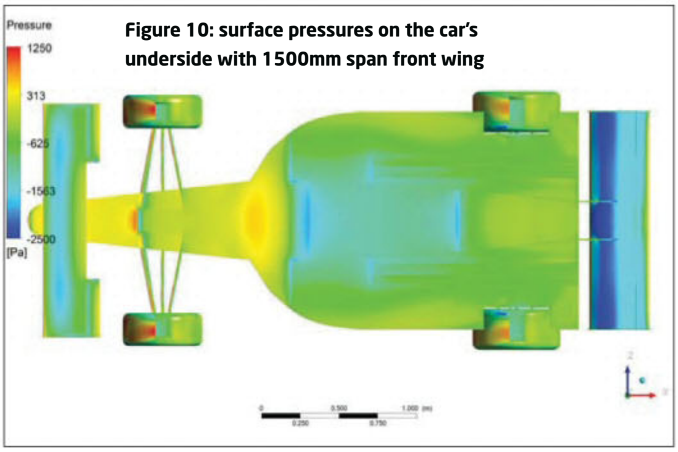


Figure 10: surface pressures on the car's underside with 1500mm span front wing

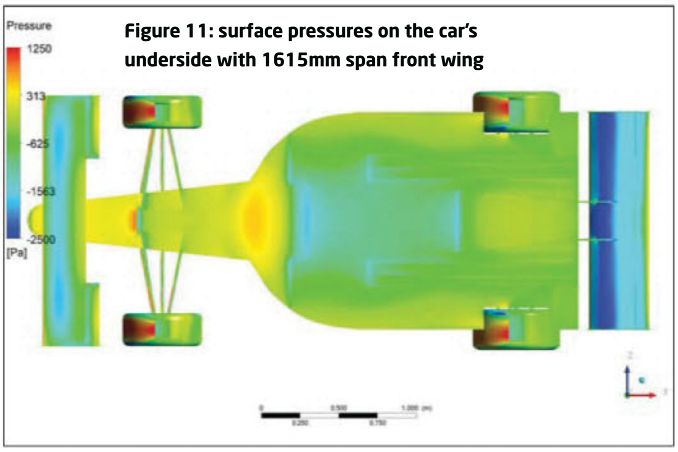
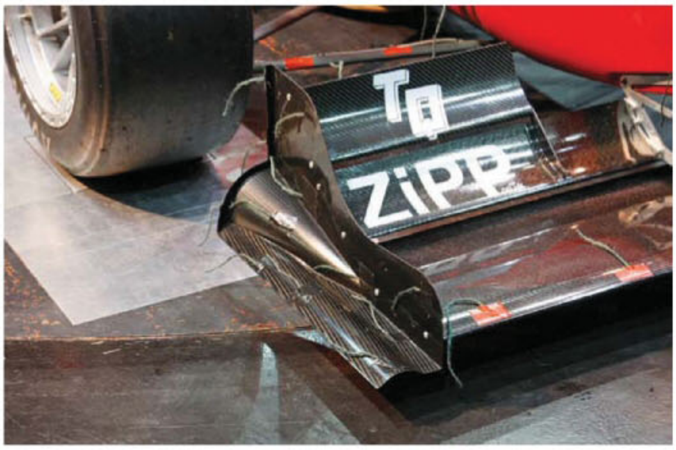


Figure 11: surface pressures on the car's underside with 1615mm span front wing

Table 3: aerodynamic data from variations in overall front wing span

					Drag, N, 100mph					Downforce, N, 100mph				
Overall span, mm	Drag, N	Total Df, N	-L/D	%front	Car body	Front wheel	Front wing	Rear wheel	Rear wing	Car body	Front wheel	Front wing	Rear wheel	Rear wing
1300	951.7	2309.4	2.427	7.36%	423.1	139.8	49.7	171.2	167.9	711.4	-70.1	467.3	-91.1	1291.9
1500	959.9	2907.6	3.029	18.21%	429.2	135.4	63.5	164.6	167.2	1180.0	-89.9	628.3	-88.7	1277.9
1615	968.6	2588.5	2.672	18.94%	416.9	139.6	67.3	178.7	166.1	827.5	-103.0	693.4	-115.6	1286.2


DJ Firestorm front wing at 1300mm span plus thin end plates


DJ Firestorm 1300mm front wing plus 100mm VEEPs

that maximum overall downforce, which comes with the half-span flap, does not coincide with maximum front wing downforce, which – not surprisingly – comes with the full span flap.

Clearly the aerodynamic balance (%front) is different between those two cases too, and it's evident that the half-span flap enables more car body downforce to be generated. Examining the surface pressures on the car's ground effect underbody revealed lower pressures under here with the half flap, verifying the cause. Of special relevance in our current context though, this is evidence that the configuration of the front wing has a profound influence on the response of all the downstream components, something that will also be evident in each of the following cases.

LOCATION, LOCATION

Another fundamental variable in non-restricted categories is the fore and aft location of the wing; not only will this affect the leverage that the wing exerts on the car, but proximity to the front wheels must surely affect the front wing's performance? The 1500mm wing with the half span flap was moved rearwards in two 100mm increments from its initial position, with the results shown in **Table 2**.

Once more, peak overall downforce did not coincide with peak front wing downforce, the former occurring in this coarse trial when the wing had been moved aft by 100mm. And again, peak downforce was the result of the car body, and more specifically the underbody, producing more downforce. Much the same relationship with balance prevailed though, the %front value being highest in the most forward wing position tested here.

OVERALL SPAN

Although not always a variable in the sense that in most categories the technical regulations apply a maximum, it's nevertheless interesting to take a snapshot of overall span variation. The choices tested here – 1300mm, 1500mm and 1615mm – equate respectively to approximately the same relative span in relation to the overall width across the front tyres as in F1 prior to 2009; the maximum

Table 4: wind tunnel results on VEEPs on the DJ Firestorm

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Flat end plates	0.768	1.481	0.589	0.893	39.8	1.928
VEEPs	0.771	1.778	0.772	1.005	43.4	2.303
Change, counts	+4	+297	+183	+112	+3.64	+375
Change, %	+0.5%	+20.1%	+31.1%	+12.5%	+9.2%	+19.5%

Table 5: CFD results on VEEPs

	Drag, N	Total Df, N	Front Df	Rear Df	%front	-L/D
No VEEP	951.7	2309.4	170.0	2139.4	7.36%	2.427
VEEP	957.3	2806.0	484.5	2321.5	17.27%	2.931
Change, %	0.59%	21.50%	185.00%	8.51%	9.91% (Absolute)	20.79%

Table 6: full CFD results on VEEPs

					Drag, N, 100mph					Downforce, N, 100mph				
	Drag, N	Total Df, N	-L/D	%front	Car body	Front wheel	Front wing	Rear wheel	Rear wing	Car body	Front wheel	Front wing	Rear wheel	Rear wing
No VEEP	951.7	2309.4	2.427	7.36%	423.1	139.8	49.7	171.2	167.9	711.4	-70.1	467.3	-91.1	1291.9
VEEP	957.3	2806.0	2.931	17.27%	416.8	145.5	54.7	173.3	167.0	1071.5	-59.1	583.7	-93.5	1303.4

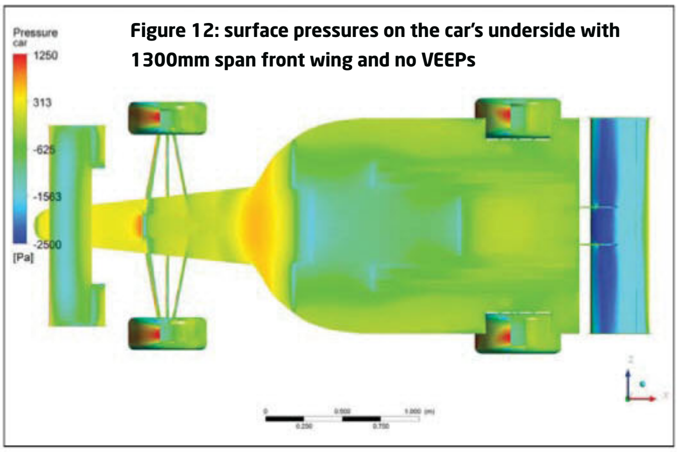


Figure 12: surface pressures on the car's underside with 1300mm span front wing and no VEEPs

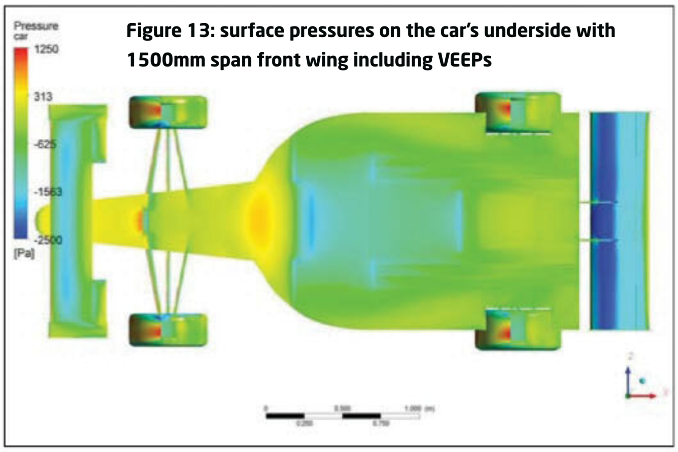


Figure 13: surface pressures on the car's underside with 1500mm span front wing including VEEPs

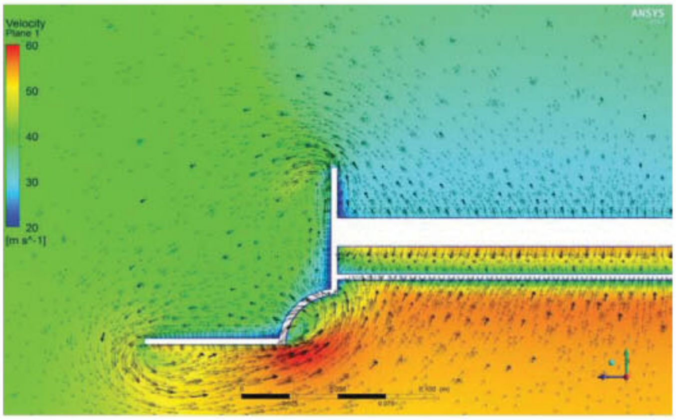


Figure 14: transverse section in line with the slot gap on the front wing (coloured by velocity), with vectors showing vortices under the footplate and within the 'vortex entrainment cone'

permitted in UK hillclimbing (and, relatively, roughly what F1 is using in 2014); and a span equal to the overall width across the front tyres, analogous to what F1 used from 2009 to 2013. The combined flap span was notionally half the total span in each case, the fore and aft location was x+100mm, and the results are shown in **Table 3**.

The range in total downforce was quite marked in this instance, reflecting not only the change in wing area from span to span, but also changes to the underbody downforce and the effect of where the flap terminated inboard, which we have already seen is influenced by the span of the flaps (although there may well be other mechanisms at work here). But visualisations (**Figures 10** and **11**) of the underbody pressures confirm that the 1500mm front wing span model did see lower pressures in the underbody.

END PLATE VARIATIONS

The trials so far have all featured simple flat end plates, but for 15-20 years now, designers in the top echelons and increasingly in other categories have been trading off wingspan for end plate details that, seemingly, more than make up for the loss of wing area. Of these, the simplest forms are the horizontal 'footplate', and a variation featuring a quarter cone scallop at the lower rear corner of the end plate. I had surmised that these quarter cones entrained the tip vortex that spills under the end plate to allow the wing to do its job better, and as such they are referred to here as 'vortex entraining end plates' or 'VEEPs'.

We first evaluated a VEEP design when we took the DJ Firestorm hillclimber into the MIRA wind tunnel in 2010 (featured in Aerobytes in May 2011), and the results were pretty astounding, although the comparison was between a 1300mm-span wing with flat sheet end plates and a 1300mm span with 100mm-wide VEEPs, making the latter 1500mm overall span. The results were as shown in **Table 4.**

Although a gain in front downforce had been expected, an extra 31 per cent was a lot more than expected, and a gain in rear downforce was not expected either. Would a similar trial on our CFD model reveal a similar state of affairs and perhaps throw some light on the mechanisms? **Table 5** shows the results, with the wing in the x+100mm fore/aft location, expressed in similar fashion to the wind tunnel results.

The comparisons between the changes in drag, total downforce and –L/D found in the wind tunnel (**Table 4**) and in the CFD trial (**Table 5**) are remarkable, although likely to be at least partially coincidental given the differences in wing designs and many other details. The gain in front downforce in the CFD trial seems huge in percentage terms but reflects the low initial value in this case, while the gain in rear downforce was of similar order to that found in the wind tunnel. So can we deduce the mechanisms? **Table 6** gives the full CFD results component by component.

Now we can see that not only did the VEEPs enhance the front wing's performance, but there was also a large increase in car body downforce too, and since the rear wing's downforce changed very little we can conclude that the increase in rear downforce came from the car body. **Figures 12** and **13** verify this, with the latter showing the wing with VEEPs generating greater suction, but also there are lower pressures within the underbody, and the magnitude of the positive pressure in the underbody inlet under the chassis has also been reduced.

Did the VEEPs fulfil their vortex entrainment function?

Table 7: trading wing area for VEEPS

					Drag, N, 100mph					Downforce, N, 100mph				
Span, end plate	Drag, N	Total Df, N	-L/D	%front	Car body	Front wheel	Front wing	Rear wheel	Rear wing	Car body	Front wheel	Front wing	Rear wheel	Rear wing
1500 incl. 3mm EP	959.9	2907.6	3.029	18.21%	429.2	135.4	63.5	164.6	167.2	1180.0	-89.9	628.3	-88.7	1277.9
1500 incl.100mm VEEPs	957.3	2806.0	2.931	17.27%	416.8	145.5	54.7	173.3	167.0	1071.5	-59.1	583.7	-93.5	1303.4
1615 incl. 3mm EPs	968.6	2588.5	2.672	18.94%	416.9	139.6	67.3	178.7	166.1	827.5	-103.0	693.4	-115.6	1286.2
1615 incl. 100mm VEEPs	933.0	2777.0	2.976	15.45%	436.1	120.3	53.6	159.9	163.1	994.6	-70.0	609.6	-94.7	1337.5

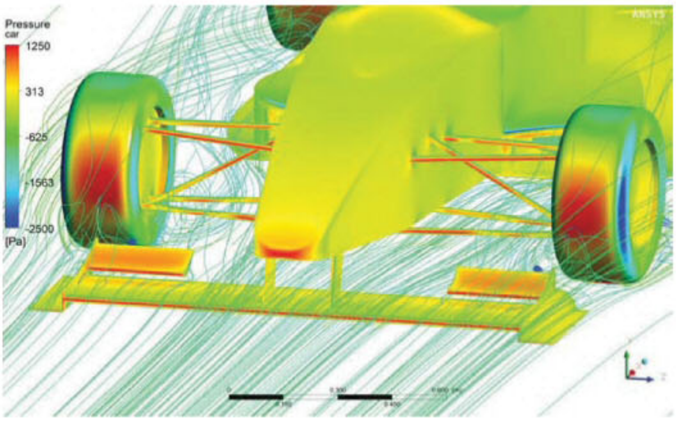


Figure 15: complex flows inboard and outboard of the front wheels with the 1500mm front wing including VEEPS at 50mm ground clearance

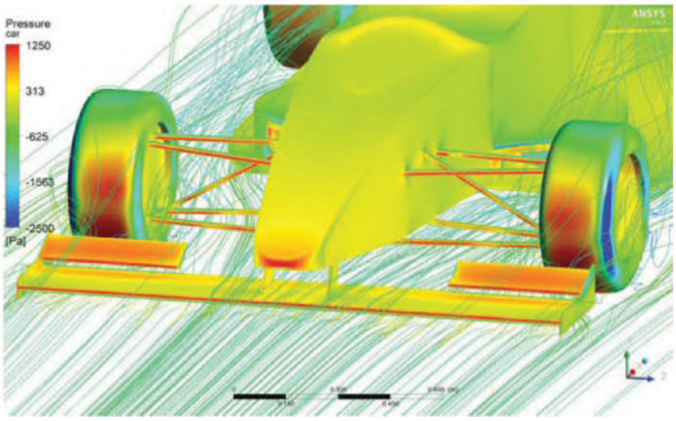


Figure 16: flow patterns (and the pressure distributions, eg on the front tyre) were different with the 1625mm span front wing, with no VEEPS at 100mm ground clearance

Table 8: varying wing ground clearance

					Drag, N, 100mph					Downforce, N, 100mph				
Ground clearance, mm	Drag, N	Total Df, N	-L/D	%front	Car body	Front wheel	Front wing	Rear wheel	Rear wing	Car body	Front wheel	Front wing	Rear wheel	Rear wing
50	962.5	2625.8	2.728	18.14%	406.2	135.0	69.5	183.7	168.1	784.8	-64.9	681.7	-98.7	1322.9
75	954.7	2763.4	2.895	21.34%	409.6	133.0	61.1	184.2	166.8	923.1	-58.8	698.1	-106.6	1307.6
100	942.7	2846.2	3.019	19.75%	419.2	122.3	61.4	171.9	167.9	1070.4	-55.1	627.3	-99.8	1303.4
125	952.2	2671.3	2.805	12.73%	433.0	132.8	49.7	169.1	167.6	1039.8	-66.4	495.0	-83.6	1286.5
150	945.1	2572.3	2.722	7.83%	432.0	142.8	45.8	156.9	167.6	997.0	-87.2	436.5	-72.6	1298.6

Figure 14 shows a transverse section in line with the slot gap on the front wing (coloured by velocity), with vectors showing two vortices, one just inboard of the outer edge of the footplate, the other within the quarter cone, verifying the entrainment mechanism at work.

VEEPS VS SPAN

A key question was 'would trading span for VEEPs yield overall benefit?' This was looked at for spans of 1500mm and 1615mm, using thin flat end plates and full wingspans in the one case, and 100mm wide VEEPS in place of 200mm narrower wing element spans in the other, with thought-provoking results, as **Table 7** demonstrates.

So, at 1500mm overall span the car produced more total downforce and slightly more %front with no VEEPS, but at 1615mm span the opposite was the case, with significantly more total downforce with VEEPs than not. And although the 1615mm front wing produced more downforce than the 1500mm wing in similar configuration, it also led to reduced car body downforce and increased wheel lift figures, giving less total downforce in both cases than the narrower wing. These results were not what were expected, but perhaps other combinations of variables (flap span, fore/aft location) might yield a different picture. **Figures 15** and **16** show some of the complexity of the flows from two of these front wings.

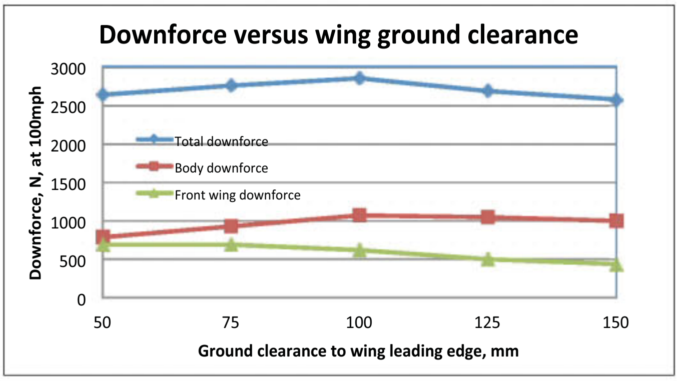


Figure 15: car body, front wing and total downforce vs wing ground clearance

WING HEIGHT REVISITED

For the finale in this brief study we'll return to looking at wing ground clearance as promised, this time on the car. The wing used was the 1500mm span including VEEPs in the x+100mm location, and the data is shown in **Table 8** and **Figure 17**.

As we have seen with almost every variable looked at in this study, maximum total downforce did not coincide with maximum front wing downforce. The latter occurred at 75mm ground clearance, with the wing's main element showing flow separation very similar to the isolated case in **Figure 8** below that. Peak total downforce occurred at 100mm wing ground clearance though, this leading to best car body downforce.

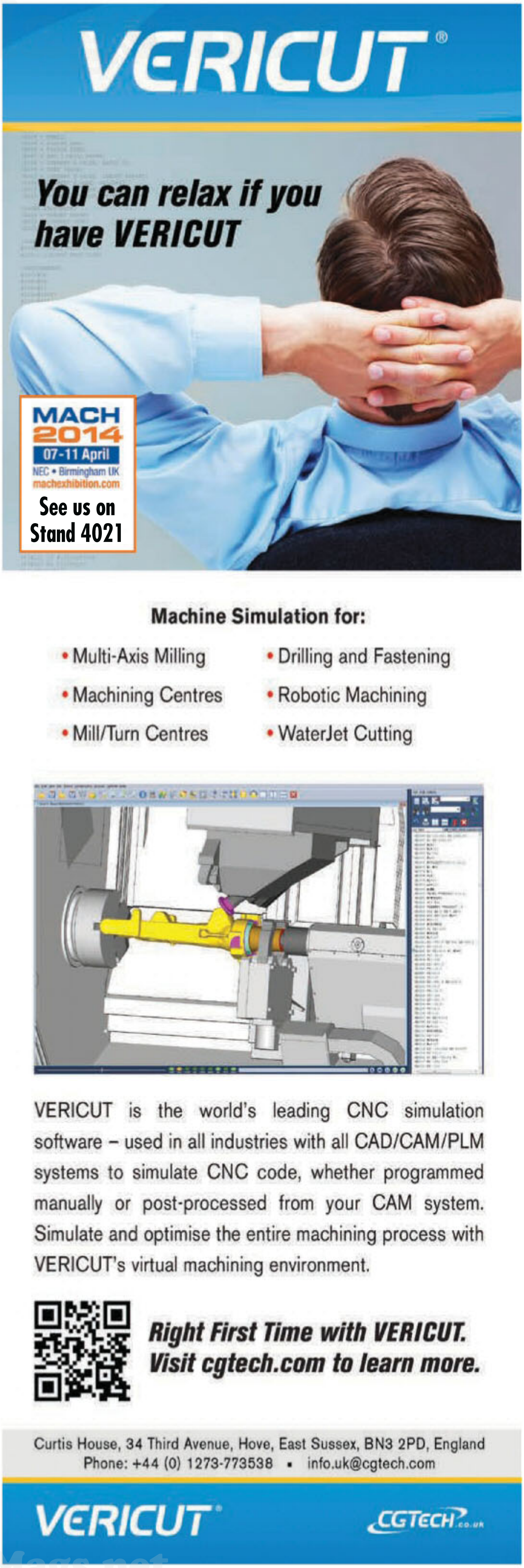
SUMMARY

We have seen that variations in wing configuration had a marked effect on the overall aerodynamic performance of the single-seater model used here. Above all, the interaction between the front wing and the underbody was very significant in these trials, even with the very coarse adjustments that have been made, and much finer mapping would be required to get a better understanding of these interactions before any design decisions could be taken.

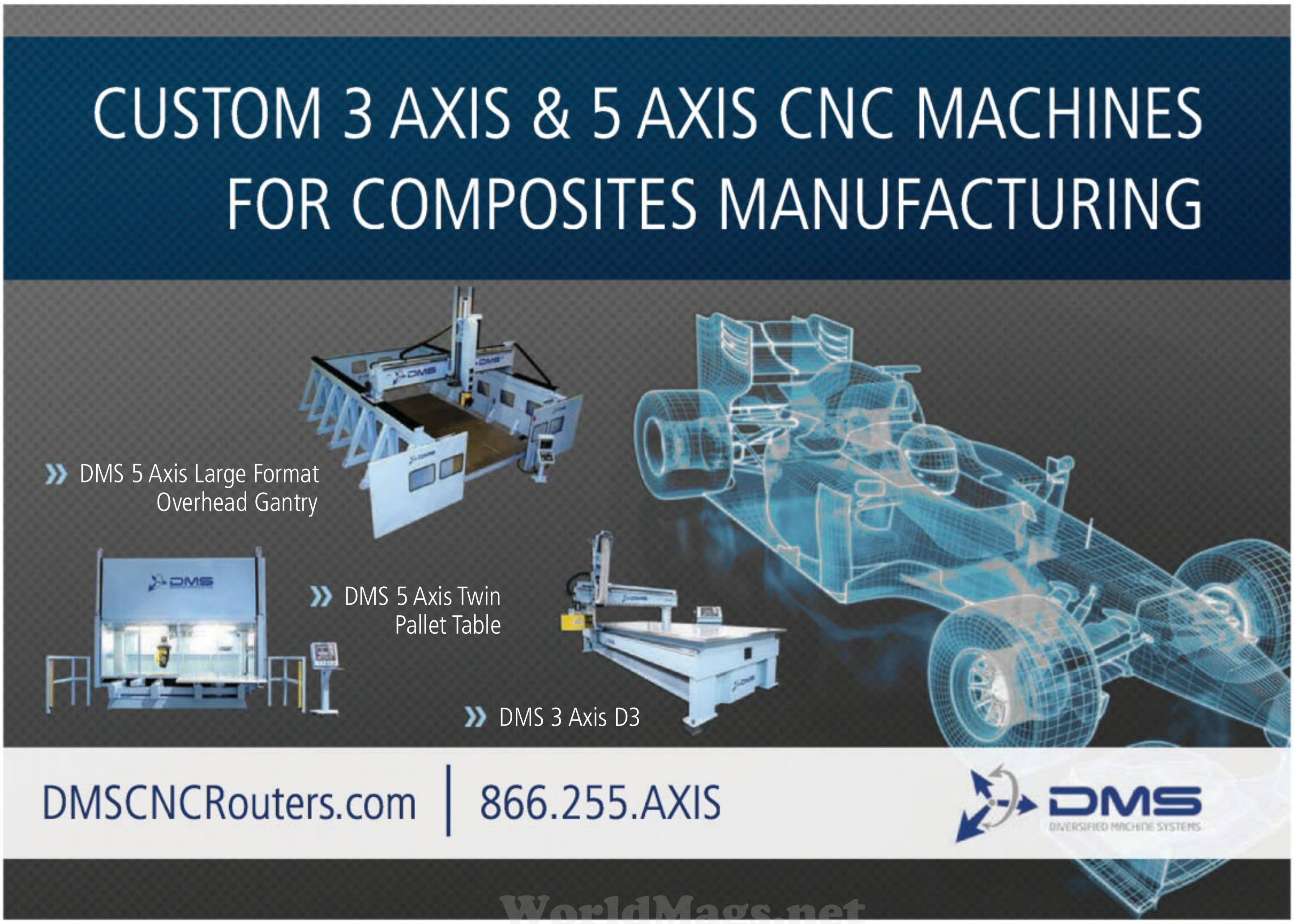
When the technical regulations allow an almost totally free hand, selecting the best front wing configuration is no easy feat – but a tool like CFD most certainly helps.

The writer's thanks go to ANSYS UK for software provision


MOCAL
OIL COOLERS
• THE MOST POPULAR COMPONENT IN MOTORSPORT
• COMPREHENSIVE RANGE OF COOLING ACCESSORIES
• BRITISH DESIGN & MANUFACTURE
FOR THE BEST IN OIL COOLING SYSTEMS...
...MAKE IT MOCAL!
MOCAL
WINNING RACES SINCE 1967
Worldwide enquiries go to:
www.mocal.co.uk
USA enquiries go to:
www.mocal.us
0208 232 3525
Like Us


VERICUT®
You can relax if you have VERICUT
MACH 2014
07-11 April
NEC • Birmingham UK
machexhibition.com
See us on Stand 4021
Machine Simulation for:
• Multi-Axis Milling
• Machining Centres
• Mill/Turn Centres
• Drilling and Fastening
• Robotic Machining
• WaterJet Cutting
VERICUT is the world's leading CNC simulation software – used in all industries with all CAD/CAM/PLM systems to simulate CNC code, whether programmed manually or post-processed from your CAM system. Simulate and optimise the entire machining process with VERICUT's virtual machining environment.
Right First Time with VERICUT.
Visit cgtech.com to learn more.
Curtis House, 34 Third Avenue, Hove, East Sussex, BN3 2PD, England
Phone: +44 (0) 1273-773538 • info.uk@cgtech.com
VERICUT®
CGTECH.co.uk


FORMAPLEX
WORLD-CLASS MANUFACTURING SOLUTIONS...
...for tooling and niche component production from advanced materials
Formaplex is a trusted manufacturing partner. We combine the best people with leading-edge technology to provide dynamic, expert-led design, tooling and advanced materials manufacturing solutions.
We deliver exceptional results for exceptional clients.
FORMAPLEX.COM
Vestas
Photo and copyright courtesy of Helena Darvelid/sailrocket

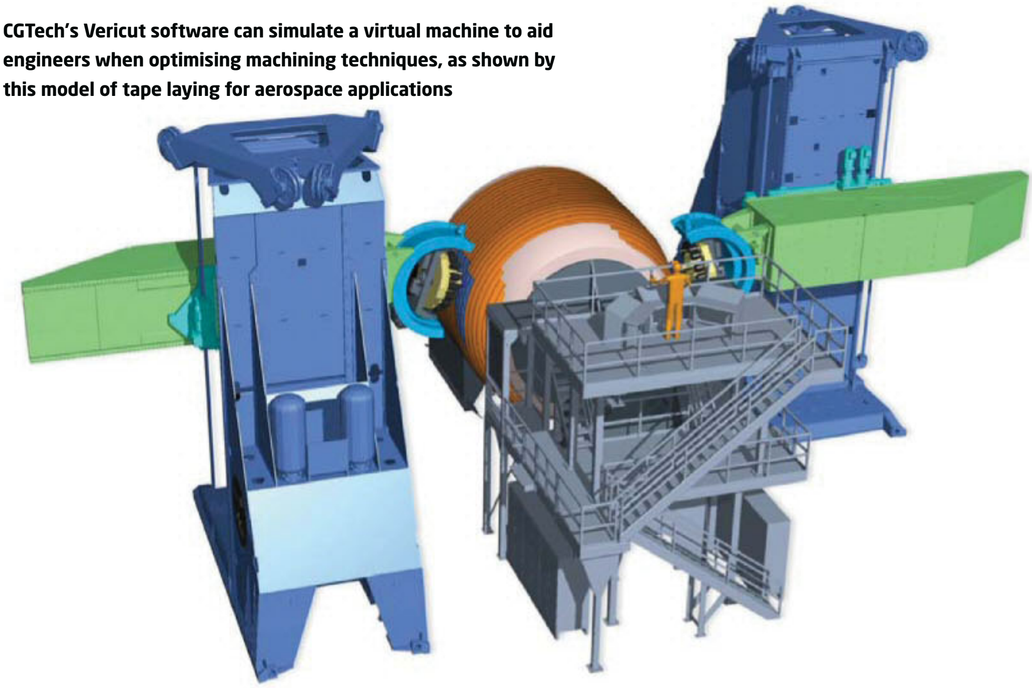

CUSTOM 3 AXIS & 5 AXIS CNC MACHINES FOR COMPOSITES MANUFACTURING
DMS 5 Axis Large Format Overhead Gantry
DMS 5 Axis Twin Pallet Table
DMS 3 Axis D3
DMSCNCRouters.com | 866.255.AXIS
DMS
DIVERSIFIED MACHINE SYSTEMS

Making progress

With so many components required by teams each season, racing is increasingly needing better machining solutions – and today's kit is more than up to the job

BY GEMMA HATTON

CGTech's Vericut software can simulate a virtual machine to aid engineers when optimising machining techniques, as shown by this model of tape laying for aerospace applications



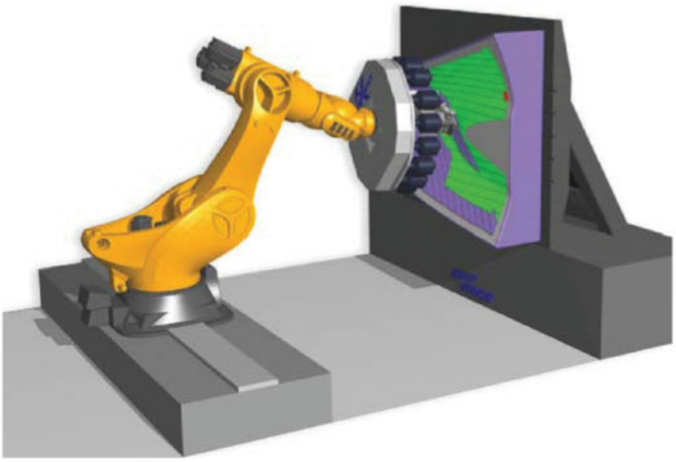
Last year's Red Bull Formula 1 car, the RB9, consisted of 6500 unique parts – a total of 100,000 components (70 per cent of which were made in-house), alongside 30,000 design changes throughout the season. It is no surprise, then, that 'the machine shop is the engine house of Red Bull Racing,' according to Christian Horner. 'It's phenomenal, what is being produced, whether it's a wheel nut or the machining of a chassis mould – they are pieces of art.'

Red Bull Racing has more than 20 large NC milling machines and mill turners to play with, providing the capability of machining 60 different types of metal, as well as composites. 'The job of the machine shop is to not only constantly improve the way we machine parts,' says Alan Peasland, technical partnership manager at Red Bull Racing, 'but also to machine parts quickly with the best quality and precision we can for reliability. It can sometimes be the case where we are machining parts up to the week of the race and that's the nature of this business – pushing the limits.'

To meet this demand, modern machining techniques are rapidly advancing; now, a single composite part can be manufactured in under three days.

CNC MACHINING

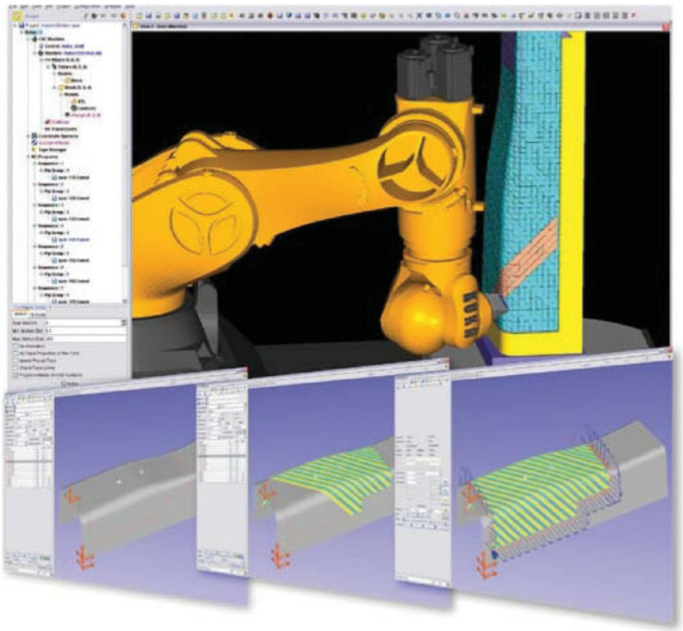
The cost of F1 continues to astonish. With Red Bull Racing's 2013 budget clocking in at £235.5m, you could be forgiven for assuming that reducing costs wouldn't be at top of their list. However, this is often underestimated, and the FIA are seeking to introduce a budget cap for 2015. Extracting the most out of every pound will become ever more important. This means that, when using thousands of pounds-worth of CNC machinery to manufacture highly expensive materials, there is simply no room for error. With such complex designs, processes and long run times, enforcing reliability from the machinery department is vital – if the machine were to collide with the part, the costs would be astronomical, and on tight schedules, missing a deadline in the factory could lead to a disaster on the track.

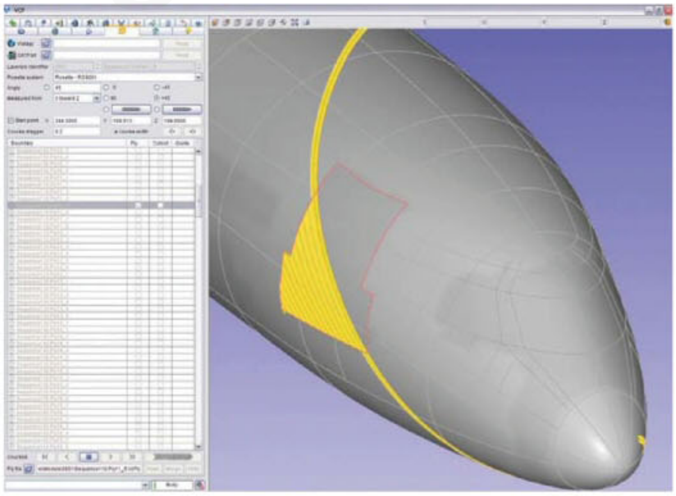


Vericut Composite Simulation reads the CAD models and NC code to simulate material being applied to the layup in a virtual CNC simulation environment

This is where Californian based CGTech comes into its own. The company specialises in numerical control simulation, verification, optimisation and analysis software for all types of CNC machining. In 1988, the company introduced the Vericut software, which was revolutionary and is now the industry standard. The software essentially models the CNC machining process for any desired part before it's physically made, therefore by detecting potential collisions, near-misses and over-travel zones between the tool and the part the accuracy of manufacture can be guaranteed.

Vericut can run independently and simulate the CNC process by post-processed NC code. However, to match the needs of industry, it can also be integrated with all leading CAM systems. Of course, to generate the most accurate simulation output, the data input to the software needs to be 100 per cent reliable. So, to obtain accurate models of cutting tools Vericut reads 3D model data provided by tool manufacturers, while interfacing with tool management systems so that the exact dimensions and offsets can be implemented into the simulation. Furthermore, CGTech has worked with end users, tool manufacturers and distributors to create effective Virtual Machine Tool configurations. The overall result is that any type of machine, from any brand, can be modelled, ranging from multi-axis machining centres to laser cutting.





Left and above: Vericut Composite Programming (VCP) reads CAD models of the layup tool and ply boundary information in order to create motion paths that add material

Unique to Vericut is the detail of the analysis. There is a review mode, which allows animations of the machine movements to be rewound or fast forwarded – removing and replacing material. Not only does this allow the production engineers to identify the precise time and position of potential problems, but it can also be shown to suppliers and customers.

As well as this, the Vericut verification process enables viewers to cross-section the part multiple times at any orientation for further checks and geometrical analysis which would be impossible to see in a solid model (for example, the intersection of two drilled holes).

'There is no point cutting a piece of material for three or four hours for it to be wrong because the cost of doing that is considerable,' says Simon Burchett, company director of Freeform Technology who use the Vericut software. 'It's not just the cost of remaking the part – it is the cost of not being able to do another job while you are waiting for that one to be finished. Our objective is to make sure what goes on the machine comes off right the first time. A five minute lapse of concentration can lead to a mistake which ruins your machine, affects the weeks work and damages the business – it becomes counter-productive.'

Freeform Technology specialises in machining composite patterns and moulds for the F1 and motorsport industries. Established in 2008, both the co-directors previously worked at Red Bull Racing and, having used Vericut there, they were keen to invest in the simulation and optimisation software. 'We always had Vericut at Red Bull as it was part of the process. As soon as we could afford it, we invested in the software because it is not just for big businesses. With only one machine you have to protect it, because if it goes down then you are effectively unable to work. We felt it was a false economy not to have the level of protection offered by Vericut. Other small companies see it as a massive overhead, but we see it as an essential tool of cost-cutting and survival in the long run.'

MACHINING COMPOSITES

It is predicted that the global composites industry will reach

"There is no point cutting a piece of material for three or four hours for it to be wrong – the cost of doing that is considerable"

THE FORMAPLEX FORMULA

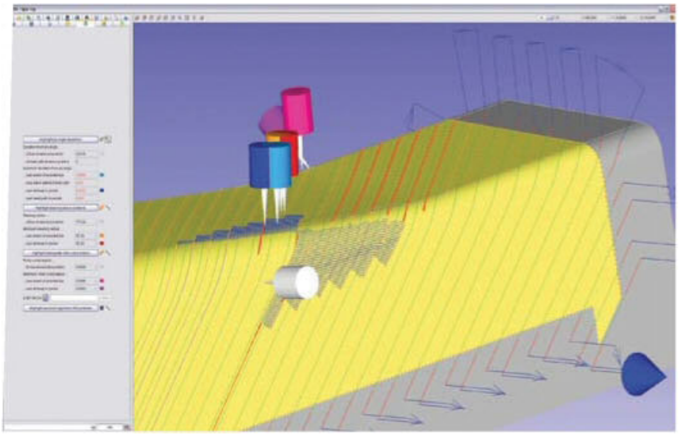
Last August, Formaplex expanded their business by a third by investing in several state-of-the-art CNC machines, one of which was the DMU 100 eVo – the first in Britain.

For the first six months, this machine was used specifically to supply F1 teams and with five-sided machining, five-axis positioning and five axes of simultaneous contouring, it provides the accuracy and flexibility necessary for the motorsport industry. 'Our machining is perfect for the F1 industry, as we specialise in bespoke one-offs for 60 per cent wind tunnel models. With the ability to turn a drawing into a component ready for testing in just five days, Formaplex is at the top of the market for F1 teams,' says Ben Yule, Formaplex's operations manager. 'In total the company has 33 machines that produce aero and wind tunnel components for Force India, Marussia, Mercedes and Red Bull as well as several batches of front wing end plate tweeks, manufacturing eight to nine pairs at a time for wind tunnel tests.

'We looked at various machines before proceeding. In my opinion DMG are the leader – the back-up and support aftersales is brilliant. With many of our clients in F1, we run our machines 24 hours a day, seven days a week, and to ensure maximum efficiency we use Seiki Systems to monitor the performance.'

One of the main features is the swivel rotary table, which is a precision machined disc that rotates freely while the work piece is clamped on to it, and offers numerous benefits over a Trunnion-style machine. For example, it can machine heavier parts. On a Trunnion design, the part is always rotating and twisting within the working envelope which usually generates a limit to the weight capacity that that axis can withstand. The swivel rotary table moves more like a standard three-axis machine, and once the part is placed on the table, the weight is distributed directly down to the base on the floor.

'The 100 eVo offers large capacity tooling, with the ability to manufacture pieces up to 800mm sq and up to 1000kg. The 100 eVo holds the machined component lower than other machines, allowing the tool to reach around the component without having to change workpiece. This allows a component to be manufactured in just two stages, where less capable machines take three of four.'



Vericut Composites Path for Engineering (VCPe) allows engineers to experiment with various AFP path options, and to evaluate the effects on the part's required design

Formaplex uses 33 machines to turn drawings into test components in under five days for their Formula 1 clients

approximately $34.1bn in 2018. Therefore, automation of composite manufacture is quickly becoming a crucial area of development. CGTech have recognised this and adapted the Vericut simulation software for Automated Fibre Placement (AFP) and Automated Tape Laying (ATL) machinery. The software consists of three components: Vericut Composite Paths for Engineering (VCPe), Vericut Composite Programming (VCP) and Vericut Composite Simulation (VCS).

VCPe allows the engineer to experiment with various AFP path options to analyse the effects of AFP path trajectory, material steering, surface curvature and other process constraints. It also allows the produceability analysis of the fibre angle based on the curvature of the part and overlaps required for structural analysis. VCP reads the surface models and then adds material to fill the plies according to the requirements. Finally, VCS reads the CAD models and NC code to simulate the virtual machine. 'Manufacturers of AFP and ATL machinery typically supply in-house developed offline NC programming software with their machine, forcing companies to inconveniently adopt multiple software applications for multiple brands of machines,' explains CGTech Ltd Managing Director, John Reed. 'But to survive in this industry, a company must be able to select the best solutions for the job, without the cost and risk associated with being locked to a single machine supplier.'

Automated fibre placement has advanced hugely over the last few years, and it may not be long before it makes its debut in the motorsport world. The process uses robotic arms to place individual fibres automatically, rather than placing sheets of pre-preg material by hand. A machine head keeps the resin-impregnated fibres cold, and then heats them up as they are laid to ensure that they stick to the other fibres in the structure. Once laid, a roller system compacts the fibres together – removing the need for an autoclave. Although, this technology is yet to be seen in Formula 1, due to the short production runs, several companies are investigating this machinery for parts that remain unchanged throughout the season.

'In terms of current automated pre-preg layup, it doesn't really lend itself to motorsport applications for a few reasons,' says Matt Charlton, sales manager from URT. 'Firstly, parts are generally one-off or very low volume, and so higher setup costs are prohibitive. Also, timescales rarely allow for the long setup times required for automated layup. Parts for the aerospace industry are less complex and so more easily automated, as opposed to motorsport parts which require the dexterity of a skilled laminator to position and "tailor" the pre-preg material correctly. We have looked at automated processes, but I would say it is more for niche and low-to-mid volume automotive projects than motorsport.'

FIVE STAR FORMING AND FABRICATING

Five Star Race Car Bodies – a division of Five Star Fabricating, Inc – is an advanced manufacturer specialising in forming/fabricating of polycarbonate windows, advanced composites, thermoformed plastics, and metal forming. Stemming from the high-performance automotive racing industry over 35 years ago, their work in manufacturing large, complex composite body panels and windshields led them to take on an extensive machining infrastructure.

In November 2012, Five Star acquired a DMS five-axis twin table CNC Router with dual 5 foot x 5 foot aluminium shuttle tables, 16 HP HSD quick-change spindle, a Fagor 8055 power CNC controller, with Fagor high-speed Sercos drives with absolute encoders on linear and C axes.

'I found major benefits with our DMS CNC router,' says Bill Maricle, Five Star Fabricating's operations manager – plastics. 'The most important is the ability to machine complex shapes in a single setup, saving time and cost. Going from three-axis to five-axis allowed us to do things we couldn't have done before – bringing us work that we couldn't even quote on previously. The head rotation allows us to get closer to the work, plus our customers' 3D drawings can be directly imported into our CAD system. Then it's relatively quick and easy to develop code for our DMS CNC Router. Without that DMS, we couldn't do anything that we're doing now.

'One project was a heavy equipment hatch cover for an operator cab – a 30 foot x 30 foot x .375 piece of formed polycarbonate, with multiple pockets and steps. The cover was tapered, so much of the machining had to be performed perpendicular to the angle, even the outside edge treatment. Before we got the DMS, we cut this item with a spindle mounted on an industrial robot. The DMS is very rigid and powerful – we were able to cut our cycle time by 40 per cent and produce a much nicer part.'

With over 30 years of industry experience, Diversified Machine Systems (DMS) is a leading designer and manufacturer of three- and five-axis CNC routers and machine centres based in Colorado Springs, CO.

Fuelling revolution

Among the huge raft of new regulation changes this year, the FIA-ACO has come up an interesting method of regulating fuel consumption

BY RICARDO DIVILA

This year has brought a series of changes to LMP1 regulations, be it in chassis dimensions and specification of permitted aero, but the most interesting one changes the engine specs and – most interestingly – consumption. Not by limiting fuel available, as in F1, by having a fixed total for the whole race (it ultimately does this), but rather by litres used each lap, and also using the F1 method of limiting maximum fuel flow.

The stated intention of the FIA-ACO was to maintain the spectacle, performance, safety, relevance to road use, sustainable development and also to keep privateer teams competitive.

Having a goal of 30 per cent reduction in fuel consumption this year without materially changing performance pushes all the manufacturers to work on something pertinent to the road car. And this is a big challenge, considering the gain over the last 20 years was a 20 per cent reduction.

It is a welcome move, levelling the playing field between different fuel types, but most importantly providing a set of rules that spurs development in alternate propulsion systems, plus making efficiency in fuel consumption primordial.

This has two related effects: one, encouraging manufacturers to have a pertinent reason to engage in competition to develop these technologies, directly relevant to their production models; and two: being able to showcase it in a very public environment.

Concisely, the air restrictor that limited power by controlling the amount of oxidiser the engine had available, and as a corollary spawned the huge table giving sizes for different engine configurations, induction systems (turbo/NA) and cubic capacity... that's now gone, the flow meter now being the limiting factor.

Previous attempts at reducing fuel consumption by giving a fixed amount of fuel for the whole race in the Group C days were not satisfactory. Going flat out at the start of the race would bring

THE FUEL TECHNOLOGY FACTOR (FTF)

1 Definition

FTF balances gasoline and fuel engine efficiencies. FTF is computed in two different ways, whether it is used for allocated energy computation (FTF average) or maximum flow computation (FTF max):

$$FTF_{average} = \frac{BSFC_{Gasoline\ Average}}{BSFC_{Diesel\ Average}} * \frac{ED_{Gasoline}}{ED_{Diesel}}$$

$$FTF_{max} = \frac{BSFC_{Gasoline\ @Pmax}}{BSFC_{Diesel\ @Pmax}} * \frac{ED_{Gasoline}}{ED_{Diesel}}$$

With:

- $BSFC_{Average}$ is the 'Best-in-Class' average brake specific fuel consumption on one single lap [g/kWh].
  'Best-in-Class' average BSFC is the best average BSFC on one lap whatever the appendix B column considered.
- $BSFC_{@Pmax}$ is the brake-specific fuel consumption at maximum power [g/kwh]
- ED is the energy density [MJ/kg]

$BSFC_{Average}$ is computed this way:

- P Corr(t) is the corrected power [kW]

$$BSFC_{Average} = \frac{\int_0^{LT} C(t)dt}{\int_0^{LT} P_{Corr}(t)dt}$$

- C(t) is the instantaneous fuel consumption given by the fuel flow meter [g/s]
- Both integrals will be computed when P Corr(t) is positive and outside braking zones
- LT is lap time(s)

2 Measurement

To check and compare average power and average consumption during events, the FIA uses:

- Fuel flow meter delivering the "C(t)" signal (instantaneous fuel flow)
- Torque meter delivering the T(t) signal (instantaneous ICE torque)
- Engine rotational speed w(t)
- Corrected torque $T_{corr}(t)$. Torque meter signal is corrected by the effect of EGERS

Instantaneous corrected power is computed this way:

$$P_{corr}(t) = T_{corr}(t) * \omega(t)$$

3 Effect of exhaust gas recovery system

Measurement of average true BSFC can be altered by exhaust gas recovery systems which increase counter pressure at exhaust and therefore decrease the efficiency of the engine. This phenomenon is taken into account by FIA by computing an instantaneous corrected torque.

$$T_{corr}(t) = T(t) + T_{loss}(t)$$

With :

- $T_{corr}(t)$ = corrected instantaneous torque
- T(t) = torque meter signal
- $T_{loss}(t)$ = estimated torque loss from recovery. Torque loss model to be defined

strategists to their knees when the teams realised that the fuel left in their budget mid-race would not bring the car to the end at that pace, hobbling the spectacle.

One can not carp as that gave me my first win – albeit in C2 class – at Le Mans in 1985, when the paleo computer program I was using doled out a strict consumption/lap time strategy that left us behind during the opening hours, but when reality struck, the competing teams let us romp away to a five-lap lead by the end.

Use whatever air intake method and engine layout you want. You only get so much fuel per lap, and it cannot exceed a given rate for both petrol and diesel respectively and – more interestingly – by the hybrid power level used.

Such intricacies may be a long way from the reasons the fans follow racing – being there to see drivers competing – but the good thing about the way it is being presented to the public is by the clear presentation of the goals, in the statement that the cars will be 30 per cent more fuel efficient with the same performance, and that this goalpost will be moved each year.

Differently from other championships where the Balance of Performance (BoP) is used to equalise disparate production cars to provide a level field in the interest of competition, the FIA-ACO rules have introduced the concept of Equivalence of Technology (EoT) that provides

The aim is to maintain the spectacle, the safety, relevance to road use and sustainable development

incentives to introduce or use a large diversity of technologies, but at the same time maintain an equilibrium in the case of faster or slower development cycles.

The challenge for the teams is to develop their cars inside the rules. And this must be monitored by the FIA-ACO, giving them an equally interesting challenge.

I have spoken before about the unintended consequences of regulations for road cars, including the bizarre old French equation that specified final drive ratio for taxation purposes. The French CV (in its fiscal power incarnation) was originally specified in 1956 as a tax to top up the retirees fund, and was calculated by using the bore, stroke, number of cylinders, RPM and a coefficient V (respectively for diesel and petrol). It could be defined by the cubic capacity multiplied by the fuel type, acknowledging different energetic capacities. Interestingly, the V coefficient at the time was 5.7294 for petrol and 4.0106 for diesel, giving a ratio of 1.4285643.

The input of gear ratios and final drive came in 1977, when using the cubic capacity, with the coefficient for petrol at 1 and diesel 0.7, and the factor K derived from the averaged mean speed at 1000rpm at each ratio expressed in kph that the car could theoretically achieve. So if you ever wondered why the ratios of French cars of that period were a bit strange, it did have a reason.

By 1998, sanity (of sorts) prevailed and the calculation was simply expressed by taking the maximum power of the engine in kW divided by 40, then having this value raised to the power of 1.6 and adding the emission of $CO2$ in g/km divided by 45, giving the fiscal power, rounded off to the nearest integer.

This approach seems to have inspired the equations that will control the cars this year, and will be a bit of a headache to enforce, both in the design and the race strategies to use, but it does allow engine designers to concentrate on energy efficiency rather than the continual and expensive evolutionary war between the regulation makers and engineers.

As the engines can now be designed for the configuration preferred by each manufacturer in line with their production priorities, this will bring in a wide variety of methods that will depend on additional instrumentation that is now enforced on the cars to normalise the performance.

Torque sensors on the lay shaft – a known and validated technology – will measure the horsepower delivered to the gearbox. Secondly is the measurement of the engine RPM, easily obtained from the ECU, both together then giving the power in kW; thirdly, the fuel flow meter in g/s. All of these factors are the parameters entered to calculate the Brake Specific Fuel Consumption (BSFC).

The fuel flow meter is a new system in endurance racing and poses several demands on the race teams, one being the necessity of having a receptacle in the chassis to lodge the two sensors in the case of no return to the tank, and three if there is a return line there.

They are configured much as the F1 fuel flow sensors and in fact use the same suppliers (which measures ultrasonically at 2kHz nominally with an accuracy of max +/- 0.25 per cent error, theoretically well within the specified 2 per cent margin of error demanded by the regulations).

The EOT is defined as an equivalence of BSFC, controlled by three factors. These are: the Fuel Technology Factor (FTF), K Technology Factor (KTF) and the ERS Incentive.

So the average BSFC is the ratio of two integrals. These will be computed when P Corr (t) is positive and outside braking zones, not otherwise. Braking zones are defined as the longitudinal

THE K TECHNOLOGY FACTOR (KTF)

KTF balances fuel and gasoline engine weights. The heaviest technology is handicapped because it does not allow embedding the same amount of ERS as the lightest technology

$$KTF = \frac{E_{Gasoline}/FTF}{E_{Gasoline}/FTF + E_{Additional}}$$

$$E_{Additional} = (W_{Best\ Diesel} - W_{Best\ Gasoline}) * \frac{\rho_{ERS-Diesel}}{x_{Diesel\ on\ lap\ time}} \quad \text{if } W_{Best\ Diesel} > W_{Best\ Gasoline}$$

$$E_{Additional} = (W_{Best\ Diesel} - W_{Best\ Gasoline}) * \frac{\rho_{ERS-Gasoline}}{x_{Diesel\ on\ lap\ time}} \quad \text{if } W_{Best\ Gasoline} > W_{Best\ Diesel}$$

- $E_{Gasoline}$ is the allocated gasoline energy in Appendix B [MJ]
- *FTF* the fuel technology factor defined in paragraph 1
- $E_{Additional}$ is the additional allocated Diesel Energy due to technology differences. It can be negative [MJ]
- $W_{Best\ Diesel}$ is the weight of the Diesel ICE with the best average BSFC whatever the appendix B column considered [kg]
- $W_{Best\ Gasoline}$ is the weight of the Gasoline ICE with the best average BSFC whatever the appendix B column considered [kg]
- $\rho_{ERS-Diesel}$ is the best-in-class ERS density among diesel cars only [s/kg]
- $\rho_{ERS-Gasoline}$ is the best-in-class ERS density among gasoline cars only [s/kg]
- $X_{Fuel\ on\ lap\ time}$ is the effect of additional Fuel on lap time [s/MJ]

THE ERS INCENTIVE

Appendix B has been computed based on the Endurance Committee recommendations, in order to conserve an incentive for big ERS system. Simulated theoretical incentive in Appendix B is:

~-0.5s/lap/MJ hybrid

Appendix B is currently based on Manufacturers data given in 2012, but theoretical hierarchy between columns could be wrong in case of discrepancies between 2012 and 2014 data (eg significant increase of chassis weight without ICE). In 2014, after having weighed every car, system and component, Commission will decide or not to change the Appendix B in order to conserve the hierarchy.

The Committee decision will be based on comparison of the optimum Hybrid LMP1 car weight and the minimum regulatory LMP1-H weight (870kg).
The optimum Hybrid LMP1 car weight will be estimated by FIA this way:

$$W_{Optimum} = W_{Best\ Chassis} + W_{Best\ ICE} + W_{Best\ 8MJ\ ERS}$$

Where:

- $W_{Optimum}$ is the optimum Hybrid LMP1 car weight
- $W_{Best\ Chassis}$ is the weight of the lightest chassis whatever the column or the technology (Diesel or Gasoline) considered[kg]
- $W_{Best\ ICE}$ is the weight of the lightest ICE whatever the column or the technology (Diesel or Gasoline) considered [kg]
- $W_{8\ Best\ MJ\ ERS}$ is the weight of 8MJ system computed with the best ERS density [MJ/kg] whatever the column or the technology (Diesel or Gasoline) considered [kg]

acceleration being lower than -1.0g and last until the acceleration becomes positive and greater than +0.1g (these factors being by vehicle speed calibrated on GPS system). Pcorr uses the approved torque meter, and is considered negative as soon as it becomes lower than 0kW. It lasts until Pcorr becomes positive and greater than +10kW.

The frequency of all of the acquisition channels used for this computation is 100Hz.

The Exhaust Gas Recovery Systems can increase counter pressure at the exhaust, decreasing the efficiency of the engine, so altering the measure of the true average BSFC, and then the FIA corrects the computation of the instantaneous torque by using the formula shown on p72.

Furthermore, KTF balances fuel and gasoline engine weights. The heaviest technology is handicapped because it does not allow the same amount of ERS as the lightest technology. The balance equation is also on p72.

The use of energy recuperation systems will be essential in extending the range of the fuel allotted, and the amount harvested can be used in various options. These range from none, the probable case for privateers as it would reduce development costs but allow 150.8 MJ/lap of petrol energy or 142.1MJ/lap of diesel at a max petrol flow of 95.6kg/h, 83.4kg/h for diesels, and for the manufacturers, who must run hybrids from two all the way to 8MJ/lap with accordingly reduced petrol (134.9MJ/lap) or diesel energy (127.1MJ/lap) and flow. An additional 20kg reduction in car mass is given to a no ERS car, down from the 870kg for ERS, 30kg less than the previous rules.

The use of energy recuperation systems will be essential to extend the range of the fuel allotted

The energy values of the ERS is detailed in two tables, one for Le Mans, and a correction factor for the other circuits, the amount of releasable energy being limited by the proportion of the length of the circuit relative to the length of the Le Mans circuit multiplied by a factor of 1.55, and the amount of fuel likewise, but multiplied by a factor of 1.11, as detailed in the Annexe B of the LMP1 Technical Regulations.

There will be an increase in lap time, and the cars will still be fast, but now the engines will not be run on a maximum power mode. Instead of developing engines that run in a maximum power state, they will be run in a state that has much more relevance for our daily driving. Reducing drag will still be important, but the narrower body width will reduce frontal area, despite having to raise the driver for the new visibility template. The emphasis will shift from aero development to fuel efficiency, but downforce will be affected. We should expect to see L/Ds touching 5, compared to the 4.2 to 4.3 today in LM trim.

There will be an increased interest in how this will be used in the race strategy and qualifying tactics, and raises several interesting scenarios. This is also controlled by the rules, and specifically by the fuel flow monitoring. Sandbagging in the initial data supplied or in running the two races before Le Mans was pre-empted for the first year of application of new LMP1 regulations (ie two first races of 2014 plus Le Mans 2014), for the EoT was defined as based on data delivered to FIA by manufacturers last December, reviewed in January, and then the final set of data was sent by manufacturers to FIA in February.

The values of BSFC (and weights necessary for KTF and ERS) were confidential but disclosed to the other manufacturers, and a dissuasive penalty is to be applied at Le Mans in case one of the manufacturers has declared data too far from reality.

The temptation to run a higher power for a qualifying lap is now deterred by the penalties defined in the regulations, and likewise in the race, as cross-checking of the FIA's data against that of the manufacturers will be carried out during the first two events and official testing sessions before Le Mans 2014.

If the results are considered to be correct, they will be maintained until Le Mans. In the event of abnormal results from data measurement or expertise of FIA, an emergency meeting can be held with the manufacturers concerned.

The good point in this approach will be that the EoT will be a transparent process. This is described by the rules:

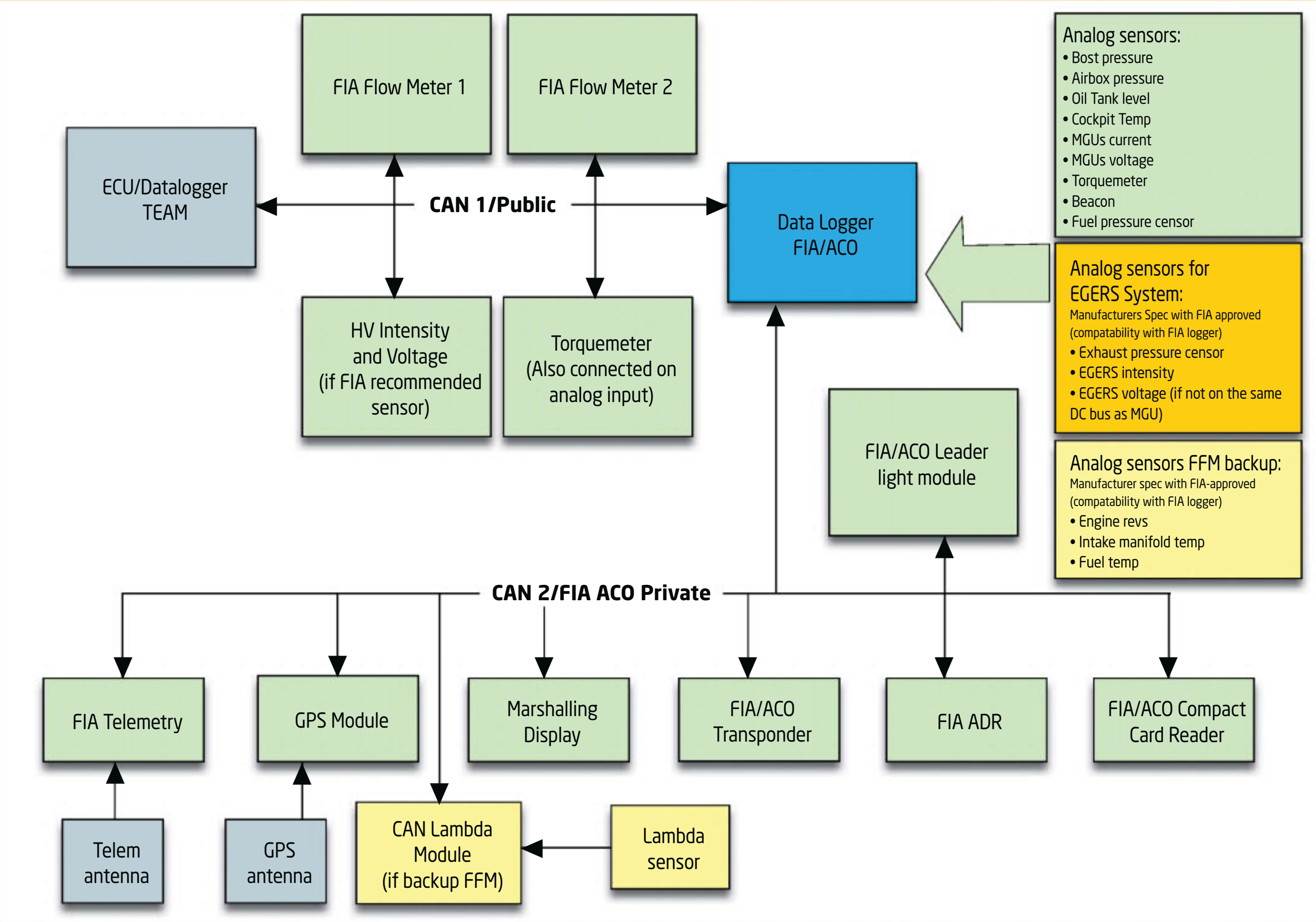
'Models used [are] described with disclosed formulas. Accelerations sectors information [will be] made officially available for competitors.

A list of engine, ERS and chassis parameters are asked to manufacturers in order to:
- Compute FTF and KTF
- Rescale torque meter
- Post-process race data'

There are, however, a lot of clever people out there juggling the what-ifs, and to close the loopholes there will be 'dissuasive penalties':

'If the FIA notices during the race that a car has an average or instantaneous (P max) BSFC exceeding what was announced in February by more than 2 per cent (estimation of the maximum error of the sensors), and to the advantage of this car, the technical delegate shall inform the stewards, after which there will be an open debate with the competitor in order to propose to him a minimum stop and go penalty of 60 seconds (which can be extended at the discretion of the stewards according to the duration of the infringement noted, ie the time during which the competitor ran while exceeding the authorised values). The duration will be

ARCHITECTURE OF WEC 2014



recorded on the basis of the on-board sensors (fuel flow meter and torque meter), information which will be available to the competitor.

'If the competitor accepts the penalty, official notification will be issued to the competitor and penalty will be applied. If the competitor then returns, until the end of the race, to the BSFC/KTF that he had announced, there will be no exclusion penalty; however, a fine could be imposed after the race on a manufacturer who has intentionally provided incorrect values in order to bias the EoT process.'

Furthermore, 'the detailed post-race analysis could involve tests and inspections with the competitor or elsewhere (calibration sensor check), and will include an analysis of the other data at the disposal of the FIA (reverse engineering).'

One interesting inclusion is the following:

'For the first two races of the season and the preliminary tests at Le Mans, we propose to monitor the BSFC and to "streamline" our methods, but without applying penalties (except in the case of a significant breach of the values established beforehand). Our results will be communicated to the competitors for joint recalibration.'

If this hints at 'We'll make it up as we go along', as an engineer I applaud the facing up to the reality of continuously changing technical knowledge and that it will attain the main objective of pushing development in fuel efficiency without losing the spectacle. The con, however, is that spectators might end up being a bit confused if not kept informed as to the breach of limitations. Good communication could also spice up the perceived competition.

The backup plan of changing precision to 3 per cent on fuel metering for instantaneous BSFC computation gives a logical plan B, and acknowledges that the sensor might not be up to speed yet.

As an executive brief we can say exciting times are ahead and heading in the right direction.

THE ACO PERSPECTIVE

'We don't care if you have turbo, or normally aspirated, KERS, whatever,' says the ACO's sporting director, Vincent Beaumesnil. 'We just want to make sure that fuel and diesel have the same chance to win. For that, the figure we are considering is the Brake Specific Fuel Consumption, the ratio between fuel consumption and performance. The manufacturers have declared their figures, and from there we define how much fuel they will have.

'If we see at Le Mans that their BSFC is not the one that they have declared, they will have a sanction. If they lie they will have no chance to win the race because we will stop them.

'We have a first set of figures received at the end of January, and a second set of figures adjusted just before the first race, and that will be the final figure. Equivalence of Technology is only this year to balance fuel and diesel. After Le Mans, every year, we will look at what has been the BSFC. If we have to adjust we will do so.

'You are allowed to use a certain amount of fuel per lap. If you exceed this amount, there are two possibilities. If the excess is within 2 per cent, then you have the two following laps to make an average. As long as you make an average on three laps that is OK, you will have no stop and go. We monitor this live.

'There is no way for a manufacturer to hide anything. No sandbagging, we will just have the truth and balance it correctly.'

THE NEW EVOLUTION IN TE'S MOTORSPORT MICRO CONNECTORS
DEUTSCH
AS Micro XtraLITE HE Connector
Ultra lightweight
• Compact size 2 shell
• No need for backshells for boot termination
• 6 x AWG24 contacts
Fast, easy installation
• Suitable for blind mating
• Positive locking coupling mechanism
• 6 keyway orientations
TAKE THE LEAD WITH THE DEUTSCH AS MICRO XTRALITE HE CONNECTOR WITH 6 CONTACTS
TE Connectivity (TE) introduces its DEUTSCH AS Micro XtraLite HE connector – one of the market's smallest diameter, lightest AS connectors for when space is at its most restrictive. Able to complement the ASX-3 and -5 options, this high performance interconnect helps to give you the edge in an environment where even the smallest component can be a true game changer.
Learn more at www.te.com/deutsch
TE connectivity
DEUTSCH
©2014 TE Connectivity Ltd. All Rights Reserved. DEUTSCH, TE Connectivity and the TE connectivity (logo) are trademarks.

Uprated Road Clutch Kits
HELIX
AUTOSPORT
CLUTCH & FLYWHEEL KITS
Lightweight
Steel & Alloy
Flywheels
www.helix-autosport.com
Email: sales@helix-autosport.com
Tel: +44 (0)1295 701076
Racing Multiplate Kits

Inerters revisited

How to simulate and evaluate their effectiveness in suspension systems

BY DANNY NOWLAN

A number of years ago when the inerter/J-Damper started to come on to the market, I did an initial analysis on the inerter and some preliminary simulation work on how to evaluate its effectiveness. That was nearly five years ago and a lot of things have passed since then. In particular, a lot of users in the ChassisSim community have been modelling inerters, both on the third and main springs. Given all this, I figured that now would be a really good time to revisit this feature.

What we'll be discussing in this article is a quick review of what inerters are and how they affect the racecar. We'll then discuss some techniques you can use in ChassisSim to help dial in the inerter settings.

To kick things off, it would probably be very wise to review exactly what an inerter is, and what it actually does.

It is a suspension element that acts on acceleration of a suspension element. As we all know, the spring acts on position to hold the car up, and the damper works on velocity to smooth the car out. The inerter it takes this to the next level. Put simply, it acts on acceleration to reduce body oscillation before it happens.

To get a better handle on this, let's review the quarter car model of equations of motion and how inerters affect them. Consider the idealised quarter car model as shown in **Figure 1**.

The quarter car model is characterised by the following:

- K_B = spring rate of the body in N/m
- C_B = damping rate of the body in N/m/s
- b = inertance of the body in kg
- K_T = spring rate of the tyre in N/m
- x_b = displacement of the body (m)
- x_t = displacement of the tyre

Taking a free body diagram of the system, we can derive the equations of motion of the system. The informed reader is probably well familiar with these, but I'm going to do a bit of work to put them in a form that includes the inerter.

Without the inerter (ie b = 0), **Equation 1** degenerates to the equations of motion for the quarter car model we all know and love. The reason I have done this will become clear very shortly.

To make our lives easier let us define the following, as seen below.

Providing all the terms in **Equation 1** are linear, we can express it in matrix form. This will look like **Equation 2**.

The astute reader will quickly realise that if we define the inertance matrix I_inert as **Equation 3**, then we can quickly define the characteristic equation of our quarter car model as **Equation 4**.

What this means is, if we already have our equations of motion of the quarter car model then all we need to is construct the inertance matrix, inverse it and we can start applying state space analysis techniques to figure out what effects the inerter will have. Recall that state space analysis techniques give us the ability to define the frequency and damping ratio response of the system.

Let's see the rubber hit the road on this idea. Consider the

The inerter is a suspension element, that acts on acceleration to reduce body oscillation

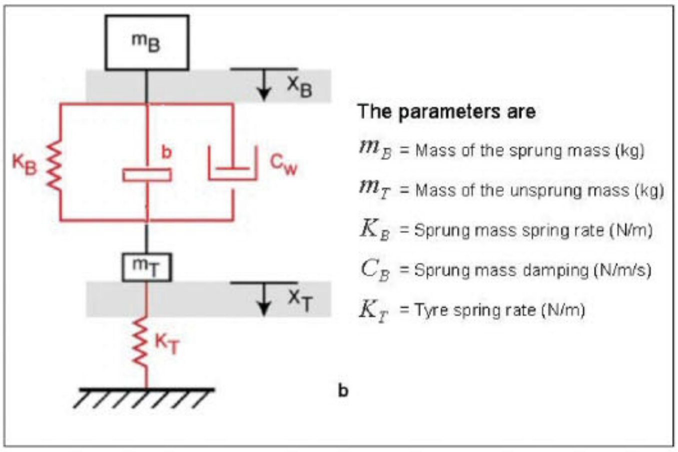


Figure 1: quarter car model with the inerter

Table 1: typical F3 quarter car values

Parameter	Value
K_b	120, 000 N/m
C_b	5000 N/m
K_t	200 000 N/m
M_b	120kg
m_t	15

Equation 1

$$(m_b + b)\cdot x_b'' - b\cdot x_T'' = -K_B\cdot(x_b - x_t) - C_B(x_b' - x_t')$$
$$(m_t + b)\cdot x_t'' - b\cdot x_B'' = K_B\cdot(x_b - x_t) + C_B(x_b' - x_t') + K_T\cdot x_T$$

Equation 2

$$\tilde{m}_b = m_b + b$$
$$\tilde{m}_t = m_t + b$$
$$x = \begin{bmatrix} x_b' & x_b & x_t' & x_t \end{bmatrix}^T$$
$$\begin{bmatrix} \tilde{m}_b & 0 & -b & 0 \\ 0 & 1 & 0 & 0 \\ -b & 0 & \tilde{m}_t & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\cdot\dot{x} = \begin{bmatrix} -C_b & -K_b & C_b & K_b \\ 1 & 0 & 0 & 0 \\ C_b & K_b & -C_b & -(K_t + K_b) \\ 0 & 0 & 1 & 0 \end{bmatrix}\cdot x$$
$$= A\cdot x$$

Equation 3

$$I\_inert = \begin{bmatrix} \tilde{m}_b & 0 & -b & 0 \\ 0 & 1 & 0 & 0 \\ -b & 0 & \tilde{m}_t & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Equation 4

$$\dot{x} = (I\_inert)^{-1} A\cdot x$$

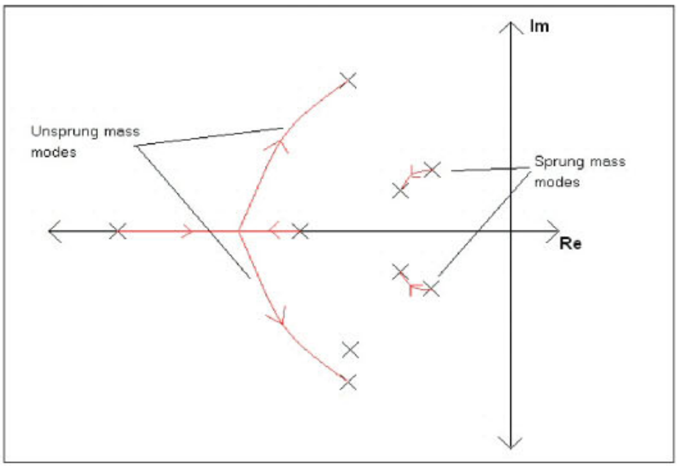


Figure 2: pole zero diagram of the inerter on the quarter car model

Equation 5

$$\tilde{m}_s = m_s + b_f + b_r$$
$$\tilde{I}_y = I_y + a^2 \cdot b_f + b^2 \cdot b_r$$
$$\tilde{m}_{tf} = m_{tf} + b_f$$
$$\tilde{m}_{tr} = m_{tr} + b_r$$
$$c_1 = b \cdot b_r - a \cdot b_f$$

Equation 6

$$I\_inert = \begin{bmatrix} \tilde{m}_s & 0 & c_1 & 0 & -b_f & 0 & -b_r & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_1 & 0 & \tilde{I}_y & 0 & a \cdot b_f & 0 & -b \cdot b_r & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ -b_f & 0 & a \cdot b_f & 0 & \tilde{m}_{tf} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ -b_r & 0 & -b \cdot b_r & 0 & 0 & 0 & \tilde{m}_{tr} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

following numbers that closely resemble some typical numbers from an F3 front suspension, which is shown in **Table 1**.

Evaluating **Equation 4** for a range of inertance values, we find some very interesting properties of the pole-zero diagram. This is a very useful tool in state space analysis to describe what the system is doing. Let's consider what it is doing in our case – **Figure 2**.

When we start from standard, the unsprung mass modes have quite high eigenvalues. These are typically in the order of 50 to 500. What this means in practice is that the unsprung mass modes quickly dissipate. This leaves the sprung mass modes, which are quite lightly damped. However, this is to be expected as the tyre and body spring rates are quite close.

As the inertance increases, some very interesting things start to happen. Firstly the sprung mass modes exhibit more damping. This is a good thing as it stabilises the sprung mass. However we don't get something for nothing. As the inertance increases, our unsprung mass modes start to decrease in frequency and eventually they split off into two complex modes. This is not a good thing, because it disconnects the sprung and unsprung mass modes from each other.

This pole zero diagram indicates why the F1/high downforce car formulas fell in love with the inerter. The reason it is so important is that these cars run very high downforce and are razor-sensitive to ride height changes. Anything that can aid improving ride height control is invaluable. Also, with motorsport regulatory bodies still insisting on banning active suspension, these cars need all the help they can get, so the inerter is a very valuable tool.

Also, as a matter of final reference, it would be wise to review what the inerter matrix looks like for the bicycle model of the racecar. Let us define the following terms:

M_s = total mass of the sprung mass in kg
m_{tf} = total unsprung mass at the front in kg
m_{tr} = total unsprung mass at the rear in kg
I_y = pitch rotational moment of inertia (kgm^2)
K_{Bf} = front combined spring rate of the body in N/m
C_{Bf} = front combined damping rate of the body in N/m/s
B_f = combined inertance of the front body in kg
K_{Br} = rear combined spring rate of the body in N/m
C_{Br} = rear combined damping rate of the body in N/m/s
B_r = combined inertance of the rear body in kg
k_{tf} = combined front spring rate of the tyre in N/m
k_{tr} = combined front spring rate of the tyre in N/m
a = distance of the centre of gravity to the front axle
b = distance of the centre of gravity to the rear axle

Before we define the inertance matrix, we need to define the following definitions – see **Equation 5**.

Now we have all this information to hand, we can define the inertance matrix for the half car model as **Equation 6**.

I now have an exercise for those of you who are interested. Junior Data Engineers, engineering students doing FSAE – that means you. Take the bicycle equations of motion and then apply the inertance matrix to it. The results will be very enlightening. Also, invert the matrix and manually calculate what it does for a given acceleration vector.

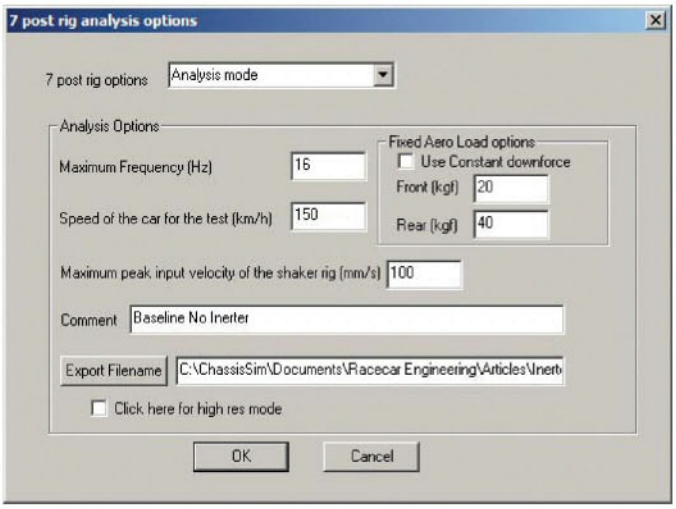


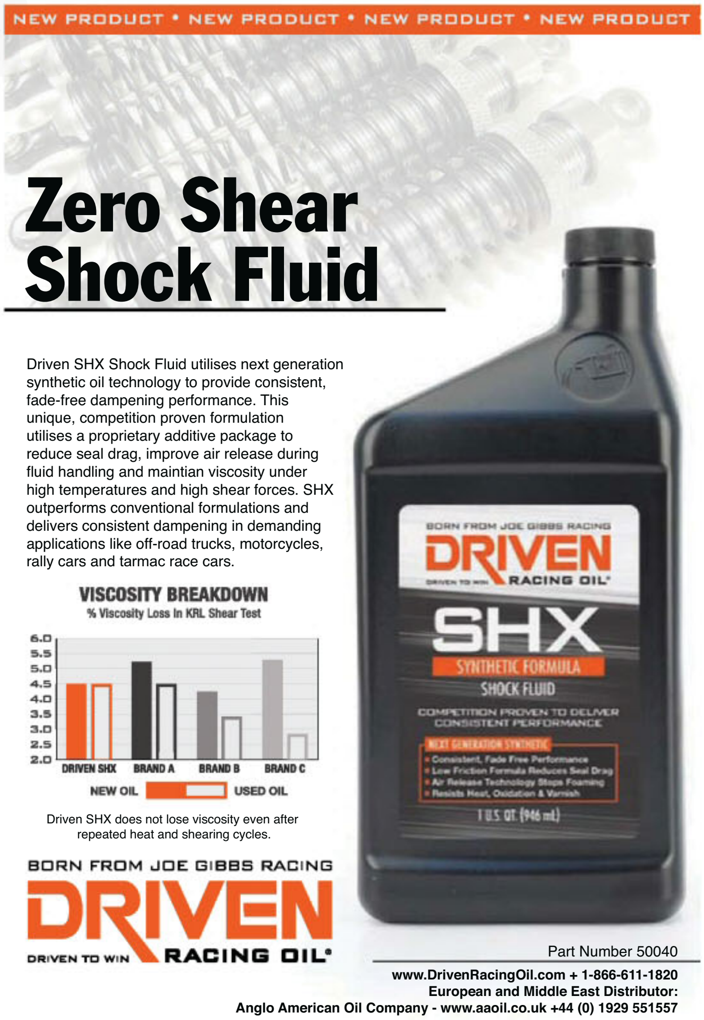
Figure 3: suggested baseline startup for inerter testing

Anyway, enough with the theory – it is now time to put this into practice. As I mentioned in the beginning of the article, ChassisSim has had inerters enabled for a while, which has been used in multiple formula. Since I last covered this subject, this experience base has been used to refine the inerter modelling and valuable lessons have been learned. What we are about to discuss is a technique to dial the inerter values in.

We are going to be using the ChassisSim shaker rig toolbox to dial in the front and rear ineter values. For our example, we'll use an F3 car. The reason we'll be using the shaker rig toolbox as opposed to the lap time simulation component is that we want a clear read on what this will do to tyre loads and the frequency behaviour. The shaker rig toolbox in ChassisSim replays swept sine constant velocity tests at different frequencies. This is

As the inertance increases, our unsprung mass modes start to decrease in frequency, and eventually they split off into two complex modes


Peterson
FLUID SYSTEMS
MADE IN THE USA
Peterson Fluid Systems manufactures top level quality oiling and fuel system components for motorsports. We have been the choice for top teams and auto makers for the last 30 years. Contact us today to see how we can help you with your project!
1-800-926-7867 petersonfluidsys.com


NEW PRODUCT • NEW PRODUCT • NEW PRODUCT • NEW PRODUCT
Zero Shear Shock Fluid
Driven SHX Shock Fluid utilises next generation synthetic oil technology to provide consistent, fade-free dampening performance. This unique, competition proven formulation utilises a proprietary additive package to reduce seal drag, improve air release during fluid handling and maintian viscosity under high temperatures and high shear forces. SHX outperforms conventional formulations and delivers consistent dampening in demanding applications like off-road trucks, motorcycles, rally cars and tarmac race cars.
VISCOSITY BREAKDOWN
% Viscosity Loss In KRL Shear Test
DRIVEN SHX
BRAND A
BRAND B
BRAND C
NEW OIL
USED OIL
Driven SHX does not lose viscosity even after repeated heat and shearing cycles.
BORN FROM JOE GIBBS RACING
DRIVEN
DRIVEN TO WIN RACING OIL
SHX
SYNTHETIC FORMULA
SHOCK FLUID
Part Number 50040
www.DrivenRacingOil.com + 1-866-611-1820
European and Middle East Distributor:
Anglo American Oil Company - www.aaoil.co.uk +44 (0) 1929 551557


kmp motorsport products
PADDLESHIFT
SERVICE & REBUILD
GEARS
DIFFERENTIALS
LIGHTWEIGHT PADDLESHIFT
SYSTEMS & COMPONENTS
www.k-m-p.nl


3Force Combined Sensor
G-Force, Gyroscopic, Magnetic
• Simultaneous full triple-axis measurement
• Anodised CNC machined 6016 grade Aluminium enclosure
• Lightweight (<55g) but sturdy
• CAN bus interface with a high level of configurability
• Upgradeable allowing for enhanced functionality
• Spare processing capability for custom firmware
Jacobs Design has been invovled in the Australian motor racing industry for the past 18 years and is a highly trusted supplier of sensors to V8 Supercars and Formula Ford.
3Force
cost effective
versatile
resilient
www.jacobsdesign.com.au
M +61 0413 442 734
E support@JacobsDesign.com.au

Table 2: inerter value sweep results

Fnt inerter (kg)	Rear inerter (kg)	Resonant freq (Hz)	Peak heave resp	Front CPL (kg)	Rear CPL (kg)
0	0	4	2.32	156.9	200.6
10	15	4	2.29	157	200.8
20	30	4	2.26	157	201.0
30	43	4	2.24	157.1	201.1

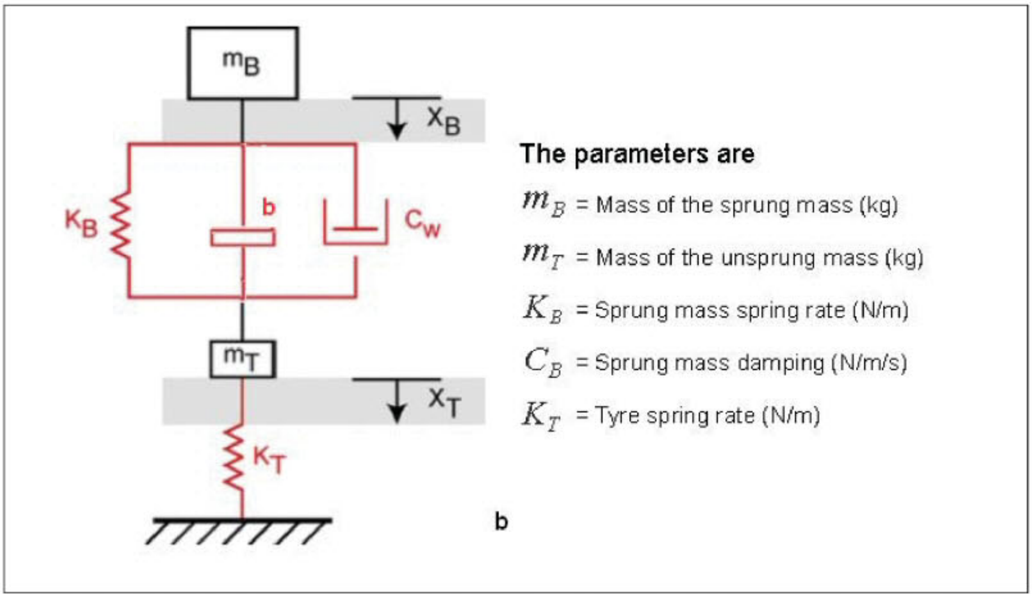


Figure 4: results of heave and pitch mode from F3 inerter sweep

not to say we can't do the same thing in the lap time simulation. Quite to the contrary, we can do it in the lap time simulation – but it's a bit more efficient to do it in the shaker rig toolbox.

To kick things off we are going to sweep the inerter values in proportion to the weight distribution of the car. We are doing this to get ourselves into the ballpark and then we can refine the results later. We will also focus on the third springs alone. For those of you on main springs, don't worry – the techniques will be identical.

The second thing that I want to talk about is the setup for the shaker rig toolbox. This is illustrated in **Figure 3**.

The pertinent figures to note here are a number of key parameters. Firstly, set the speed to the same speed as you would be experiencing mid-corner of the turns you wish to model. For an open-wheeler, I typically set this to 150km/h, but this will vary depending on which corner you are at. Also a good start point for the input velocity is 100mm/s. This you can dial in with experience, but is a good start point. Also if you have good pitch sensitivity aeromaps do not use the fixed downforce option.

The results on the F3 car make for very interesting reading. These are summarised in **Table 2**.

A plot of the sprung mass modes and in pitch make for very interesting reading as well. This is shown in **Figure 4**.

Please note that this used a pitch heave input mode. That is the front and rear road inputs moving up and down together.

The first thing that becomes immediately obvious from the results is how much the sprung mass mode loves the inerter. Not only is this obvious from the peak heave response, but if you examine the cross response in pitch, the higher the inerter values the less the cross response drops down. For example, compared to the baseline at 4.3Hz the cross pitch response drops from 1.4 to 1.3 for our max inerter configuration. This is manna from heaven for a high downforce open-wheeler car.

But this has not come without its cost. As we have added our inerters, the CPL values have increased. CPL is a measure of tyre load variation and the idea is the lower this number is the better the mechanical grip is. As we can see, as we add the inerters the numbers do get worse, albeit not by much. We are looking at a 0.1-0.2kg per every increase of the inerter. This is certainly not the end of the world, but it is something to be mindful of.

Looking at the results, you have two forks in the road. If you are after nothing but managing the aero platform go as high as you want. The results from **Table 2** and **Figure 4** strongly indicate this. However, if you need to manage mechanical grip then case 2 or 3 is the best compromise.

This brings me to the technique that you should be using to determine inerter values using the shaker rig toolbox. The procedure is:

- **Sweep through the inerter values**
- **Keep going as the peak heave and cross modes reduce**
- **Stop when this either flatlines or the CPLs go up**

I am not claiming that this procedure is perfect. There is a lot of stuff that we haven't covered here, like varying the inerter values away from the weight distribution or adjusting the damper values and other associated items. However, as a start point this will get you going.

Also, I want to add that this does not replace time on the shaker rig. For me to claim the shaker rig toolbox replaces the real shaker rig would be a fantastic act of stupidity. But what it does is to prepare you for your time on the rig, and it allows you to shadow what you do on the rig, so you know what you are doing. The two of these tools used together give you a really valuable 1-2 punch, so you'd be crazy not to use both.

The other thing that would be prudent to add here is that you still need to use the lap time simulation component. Always double-check this, because you don't want any nasty surprises when the car hits the track. What we have discussed should short circuit this process anyway.

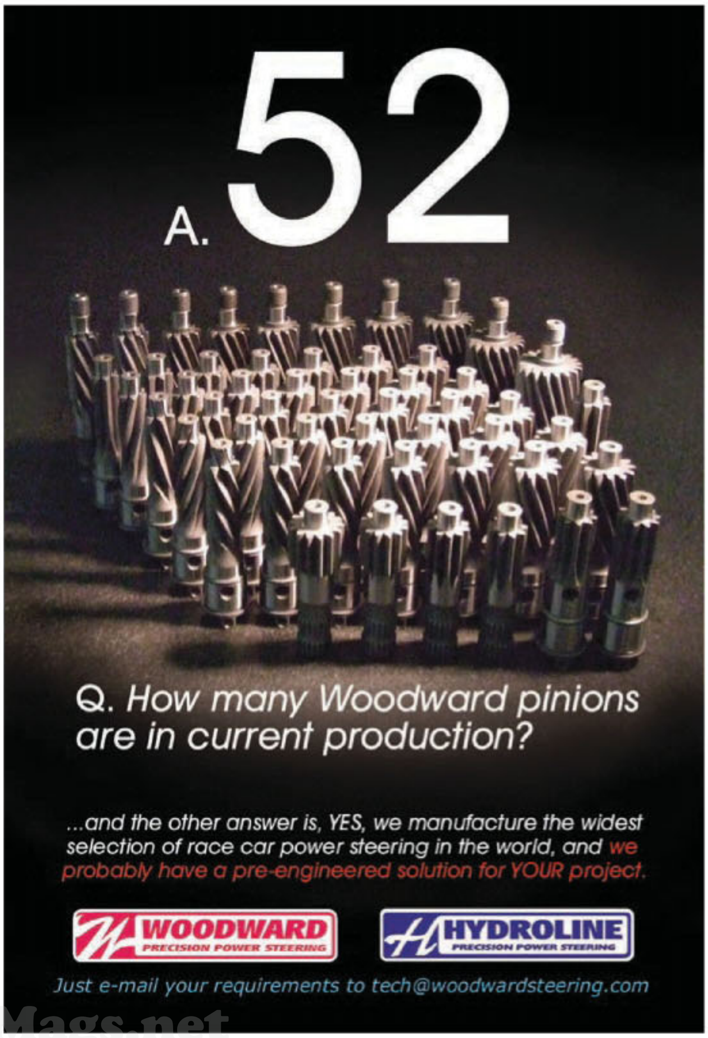
So, the inerter is a valuable addition to modern racecar suspension systems. The big thing it brings to the party is controlling the sprung mass modes which is invaluable when you are dealing with highly pitch-sensitive racecars running high values of downforce. We also discussed a technique for determining inerter values and illustrated some results to get you under way. While not perfect, it will get you going and you can use your experience and savvy and time on the shaker rig to help fill in the blanks.

The inerter is a valuable addition to racecar suspension systems. The big thing it brings is controlling the sprung mass modes, which is invaluable


CARTEK
MOTORSPORT ELECTRONICS
NEW
Power Control Panels
Innovative products:
- Solid State Battery Isolators
- Power Distribution Modules
- Wireless Steering Wheel Controls
- Coolant Sensors
- FiA Rain Lights
- Shift Lights
www.CARTEKMOTORSPORT.com
CARTEK AUTOMOTIVE ELECTRONICS Ltd
44 (0)2380 637600
info@cartekmotorsport.com


JLS MOTORSPORT
Air Jacks
• Designed & manufactured by JLS Motorsport, bespoke strokes are available.
• Manufactured with forged alloys & high tensile steels
• Lightweight & compact in design
• Delivering maximum performance & optimum safety
• All Air Jacks are supplied with 3 location rings for positioning & alignment
Air Jack Lance
Air Jack Probe
Made in the UK
European Sales
JLS Motorsport
email : motorsport@lister.co.uk
tel : +44 (0)121 525 5800
fax : +44 (0)121 525 4833
USA
Sales
XRP
THE XTREME IN RACECAR PLUMBING
XRP Inc. email : sales@xrp.com
tel : 562 861 4765 fax : 562 861 5503
lister


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 35 year track record.
Aurora Bearing Company
901 Aucutt Road
Montgomery IL. 60538
AURORA
Complete library of cad drawings and 3D models available at:
www.aurorabearing.com
Ph: 630-859-2030


A. 52
Q. How many Woodward pinions are in current production?
...and the other answer is, YES, we manufacture the widest selection of race car power steering in the world, and we probably have a pre-engineered solution for YOUR project.
WOODWARD
PRECISION POWER STEERING
HYDROLINE
PRECISION POWER STEERING
Just e-mail your requirements to tech@woodwardsteering.com

Ecclestone blames Vettel dominance for fall in F1 TV viewing figures

Formula 1 boss Bernie Ecclestone has said that Sebastian Vettel's dominance at the end of the 2013 season was a major factor in a 10 per cent drop in the amount of people watching the sport on TV last year.

The fall in viewing figures came to light in the 2013 edition of the Global Media Report, which is published annually by FOM (Formula One Management). Data in the report shows there were 450m viewers last season – a drop of 50m compared to 2012.


LAT

Ecclestone says Vettel's dominance explains a 50m drop in global TV audience

Ecclestone has said the drop from 2012 to 2013 was partly due to Vettel's dominance during the second half of the season, but the figures have actually been on the decline – though to a lesser extent – since 2011. There were 515m viewers in 2011, and 527m in 2010.

Ecclestone said: 'Last season our global audience was 450m viewers, a decrease compared to 2012, although not an unexpected one. The less-than-competitive nature of the final few rounds, culminating in the championship being decided ahead of the races in the USA and Brazil – events which often bring substantial audiences – had a predictable impact on reach.'

But while Ecclestone blames his own show, a breakdown of the figures actually reveals that changes in TV deals also had a significant impact. For instance, in China a move away from state broadcaster CCTV to regional broadcasters led to a dramatic plunge in audience figures, with just 19m viewers tuning in last year – around 30m fewer than 2012. In France the audience also dropped sharply from around 27m viewers to 10m, after a switch to pay TV network Canal+.

Yet there were also some increases in audience figures in territories such as the UK, the USA (up by nearly 10m) and Italy. Brazil still has the largest audience for Formula 1 with 77m viewers tuning in during 2013.

Ecclestone believes this year's new formula will go some way to boosting TV ratings. 'One thing I am sure of is that this coming season will not only offer a heightened level of unpredictability, but renewed excitement and fierce competition,' he said.

It has been suggested that the plunge in viewing figures may well have been the catalyst for the introduction of the controversial double points rule, which aims to keep the championship battle alive until the end by doubling the points awarded in the final race of the season.

Red Bull sponsorship worth a billion dollars to Infiniti

Red Bull sponsor Infiniti has become the first motorsport backer to generate over $1bn worth of TV exposure through its sponsorship of the world champion team in 2013.

The luxury arm of Nissan, which came into Formula 1 with Red Bull in 2011, is now the most exposed sponsor in the sport, according to data from global sports research expert Repucom.

Repucom's data was derived from measuring the amount of on-screen branding that was seen during races and qualifying broadcasts, a figure that surpassed $1bn for Infiniti in 2013.

Nigel Geach, a well-known motorsport sponsorship expert and Repucom's senior vice president, motorsport, said that Infiniti's billion-dollar exposure was down to a combination of the positioning of the signage on the cars, and Red Bull's strong performance throughout 2013. 'Excellent positioning of clear branding on both the Infiniti Red Bull Racing car, team and drivers, in addition to significant airtime thanks to the team's strong on-track performance throughout the year, gave Infiniti advertising equivalency value of over $1bn from global TV coverage – an amazing achievement,' he said.

LAT

Geech added that despite a fall in TV audiences in F1 in 2013, the viewing figures are still substantial and the sport offers good bang for buck for sponsors: 'Formula 1 is still proving to be one of the biggest value returns in global sport.'

Andreas Sigl, global director for Infiniti Formula 1, said: 'One of our key objectives for the programme is to build global brand awareness for Infiniti, so these results really showcase the power of harnessing the global pull of F1 with a modern marketing approach. These figures only tell part of the story, however, as they do not account for the significant additional exposure we get from an intensive schedule of F1 marketing and PR activations away from the track.'

It's estimated that Infiniti contributed $31m to Red Bull's coffers in 2013, which was thought to be a big increase on its spending in 2011 and 2012. This was rewarded with a bigger presence, in the shape of purple-backed branding on the car's flanks. In its first season with Red Bull, data showed that Infiniti amassed $250m in TV exposure value, going up to $339m in its second season.

UK prime minister to look into planned Dunlop closure

British Prime Minister David Cameron has promised to personally look into the planned closure of the Dunlop Motorsport plant in Erdington, Birmingham.

Goodyear Dunlop, the parent company, has said its been forced to announce the closure of the plant – and the loss of 241 jobs – because the lease of the factory comes to an end in September, with Jaguar Land Rover earmarked to take over the site.

Local news outlets have reported that Dunlop has been offered other sites in Birmingham, but despite this it has still decided to pull the plug on its West Midlands operation, which produces a quarter of a million tyres a year. It now intends to shift production to Hanau in Germany and Montlucon in France.

Speaking during Prime Minister's Questions, Cameron said he would examine the matter after it was raised by local politician Jack Dromey, the Labour MP for Birmingham Erdington.

Dromey also told the House of Commons that the UK Government's business secretary, Vince Cable, has already met with Dunlop urging it to take up an alternative site in the area. 'The business secretary and Birmingham City Council have identified three sites and a financial package to relocate,' Dromey said in the House of Commons. 'Will the prime minister join with the business secretary and I in urging Goodyear Dunlop to look at those alternatives and not walk away from 125 years of manufacturing history?'

LAT

In reply, the prime minister said: 'I was briefed on this issue just before coming to the chamber and I'm very happy to look carefully at it and see what can be done. The recovery of the automotive industry – particularly in the West Midlands – has been hugely welcome for our country. Dunlop is a historic name and I'll certainly do all I can to work with the business secretary and Mr Dromey to get a good outcome.'

However, despite Cameron's promise of intervention, it seems highly unlikely that Dunlop will change its mind.

In a statement, it said: 'No other appropriate site was available locally which would have provided continuity of supply to our key customers.'

Formula E constructing headquarters at Donington Park

Formula E has started to build an all-new base at the historic Donington Park circuit in Leicestershire in the UK.

The 44,000sq.ft bespoke headquarters for the FIA electric racecar championship will provide state-of-the-art facilities for each of the 10 Formula E teams, together with offices, stores and workshops for Formula E's own operational staff – totalling more than 150 people.

Formula E (FE) teams – all of which have now been announced – will also use Donington for testing and development work on the fully-electric Spark-Renault SRT_01E racecar.

The new facility, which is said to be a 'multi-million pound' investment, will be sited just 100 metres from the circuit itself, near the Melbourne Hairpin. In keeping with the green ethos of Formula E, the build will comply with recognised sustainable construction standards and with the UK Government's Low Carbon Economy and the National Planning Policy Framework requirements. All work will be completed by the end of April with the first teams moving in at the beginning of May. On a commercial level, FE will continue to operate out of its London offices.

Alejandro Agag, CEO of FE, said: 'We looked at a number of locations around Europe but the British motorsport industry is regarded as the best in the world, so it was an easy decision for us to be based in the UK and our new facilities at Donington Park provide the perfect central location for operating the FIA Formula E Championship. Being in the Motorsport Valley also means we can take advantage of the technology and skills all around us.

'All 10 teams will soon have top facilities at their disposal in a modern, sustainable building, as well as direct access to the circuit to develop their cars. We are also just a stone's throw from East Midlands Airport and the hub of our logistics partner DHL, meaning we will make substantial cost and emission savings.'

Agag added: 'It's also great for such an innovative and global racing series to be based at a historic racetrack like Donington Park and we're looking forward to welcoming the teams.'

The new 44,000sq ft facility will provide state-of-the-art facilities for each of the 10 Formula E teams

Fernandes threatens to quit F1 if Caterham fail to progress

Caterham boss Tony Fernandes has given his team a stark warning – raise its game, or he will pull out of Formula 1 at the end of the 2014 season.

The team, which is now heading into its fifth season in Formula 1, has failed to score points in 77 grands prix, and now Fernandes – a man with other business interests including the remainder of the Caterham Group, Queens Park Rangers football team and AirAsia – has made it clear he is losing patience with the lack of results.

Speaking at a pre-season event held at Caterham's Leafield, UK base, Fernandes said: 'My message to the 250 people here [the factory] is we have to go for it this year. This is it, the final chance. We've given you the best infrastructure, and the best potential drivers – but it is now down to all of you to go and do it.

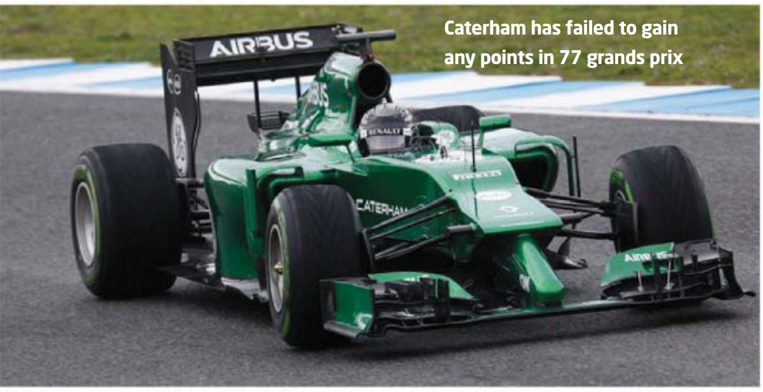
'If we're at the back I don't think I'm going to carry on. Nothing is set in stone, but after five years with no points there is a limit to one's patience, money, motivation, etc – so it's an important year.

'I need to feel like we're going somewhere. If I feel we can compete, then great, but if we're not competing then we have to seriously examine ourselves and ask "does this make sense?" If we're not competing, two seconds behind everybody else, then we haven't made any progress.'

Fernandes also hit out at F1 as a sporting spectacle, contrasting it with football. 'The sport has to examine itself,' he said. 'I'm in a fantastic position to see two sports – football and Formula 1. Every week I go to a game [as QPR boss] nervous as hell – whether we're playing Yeovil, Doncaster or Leicester – because football is unpredictable.

'It's no secret that people are paying more money to watch football, TV rights are growing, global audiences are growing – so what are they doing right that we're not doing right in Formula 1?

'We spend all our time looking at how long a piece of pipe is, KERS etc, but the racing stays the same, with the same three or four teams winning.'



Caterham has failed to gain any points in 77 grands prix

LAT

NASCAR could see electric cars in the future, says new COO

NASCAR's new chief operating officer, Brent Dewar, has not ruled out the use of electric cars in the premier US race series in the future.

Dewar, who took up the position of COO at the end of last year, has also said that he believes that NASCAR is now leading the way when it comes to green initiatives in sport in the USA.

Responding to a question on whether NASCAR could ever go electric, Dewar said he would not rule anything out: 'It's a great question. I think if you had gone back 20, 25 years ago, you wouldn't have been thinking about renewable fuels like ethanol.

'We pride ourselves on being the best venue for racing. We look to continue to innovate, so whatever the propulsions systems are, you start to look at it, and if you see our IMSA racing series and sportcar series [United SportsCars], you're seeing a number of different green initiatives and different fuel strategies, so we'll try to match the right fuel strategy, and the right propulsion system as the sport evolves and innovates over time.'

The former GM executive also said that he believes NASCAR is showing other sports the way ahead when it comes to embracing green initiatives: 'It's one of the things we're very proud of. We need to be a leader in all areas, not just in racing. We think we have the ability to lessen our footprint on the environment, we're already one of the leaders in recycling, and the fact that we have a green fuel, an ethanol-based fuel, renewable fuel, is a great storyline.

'We're working with our partners in recycling bottles, recycling tyres, recycling our oil, so we've gone from a position where it's not us just being a leader in environmental practices for motorsports, but all sports.'

Dewar added that its green initiatives are also attractive to NASCAR's sponsors: 'We have the finest partners in the Fortune 50 and Fortune 500, and that's important to their social responsibility programmes,' he said. 'They want to partner with companies like ourselves that are thoughtful about the environment.'

NASCAR has also recently announced a partnership with the American Council On Renewable Energy (ACORE), a Washington-based non-profit organisation which promotes renewable energy in the US.

NASCAR without the thunder? The future could be electric

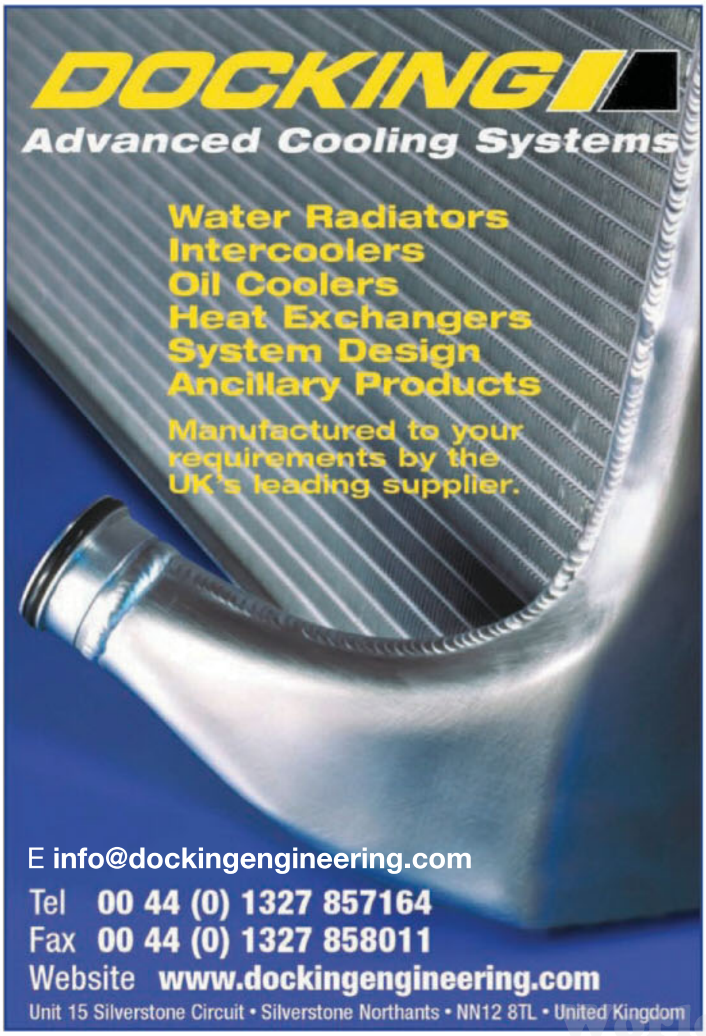
LAT

SEEN: VOLKSWAGEN GRC BEETLE

Volkswagen is to enter the US-based Global Rallycross championship with this four-wheel-drive Beetle. The aggressive-looking bug packs a TSI engine, which VW says will deliver in excess of 560bhp. A pair of the cars will be run in conjunction with Andretti Autosport in an operation which is to be called Volkswagen Andretti Rallycross, but the team will initially compete this season with modified Polo rally cars. The Polos will be based on the car that won the 2013 World Rally Championship for drivers and manufacturers – and at the time of writing leads this year's WRC, too. The team will switch to the GRC Beetle in August.


D.A.T.A.S. LTD.
Data Analysis Tools And Simulation
RaceSim version 2.7
• Expert: Steady state, transient, 4 post, optimisation, strategy, etc
• Standard: Low cost lap simulation
• NasCar: Stock cars with live axle
• F3 Lite: Incl. Dallara F3 car model
• RaceAlyzer: Race strategy tool
• ManagePart: Parts management tool
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. THE OLD CHAPEL NORFOLK IP21 4XP
TEL: +44 (0)1603 506526 +44 (0)7802 770345
http:// www. datas-ltd.com e-mail: info@datas-ltd.com


EARL'S
PERFORMANCE PRODUCTS
CUSTOM BRAKE LINES | OIL COOLERS | HOSE | FITTINGS
ADAPTERS | FILTERS | NOS | FUEL PUMPS & REGULATORS
FUELAB
NOS
Holley
EARL'S
STÄUBLI
Visit www.earls.co.uk for the full range
Online Shop now Available
QUOTE "RCE10" WHEN ORDERING TO RECEIVE 5% DISCOUNT
Earl's Performance Products UK Ltd
Units 15-16 Silverstone Circuit, Northants, United Kingdom NN12 8TL
+44(0)1803 869850 | sales@earls.co.uk


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


Snapdragon
ENGINEERING, LLC
Contract manufacturing of high value, high performance components to an international clientele in formula, sports car and rally competition.
Authorized sales, service and testing of Ohlins racing dampers.
Exclusive North American agents for Farringdon data acquisition systems.
413.256.0861 Amherst, Massachusetts, USA www.snapdragonms.com

Peugeot commits to World Rallycross with 208

French car giant Peugeot has announced it's to enter the new-for-2014 FIA World Rallycross Championship.

Peugeot, which now joins Ford in the championship, will link up with veteran rallycross operator Hansen Motorsport. The team will be known as Peugeot-Hansen and it will campaign a T16 silhouette version of Peugeot's 208 model in the Supercar class in all 12 rounds of the 'World RX' championship.

The news will be a further fillip for the inaugural championship's promotor IMG Motorsport, which already has Ford on-board – the blue oval tying up with Olsbergs MSE.

Martin Anayi, managing director of IMG Motorsport, said: 'We are delighted that Peugeot Sport has joined Ford Racing in committing to officially supporting professional race teams entering the FIA World Rallycross Championship in its inaugural year. To have a second major manufacturer involved in this way is another significant coup for our fast-growing series.'

Peugeot Sport director Bruno Famin explained that the discipline's burgeoning popularity with a new generation of motorsport fans – and the exciting nature of the action – made World RX a perfect match for the brand's international ambitions. 'At Peugeot Sport, we are constantly looking to explore different forms of motorsport,' he said. 'Rallycross is a discipline that is expanding quickly, and that includes the

LAT

Famin says Peugeot was attracted by big crowds and spectacular racing

introduction of an FIA-sanctioned world championship from this year. We were attracted to the sport by a long list of factors, including its spectacular side, the big crowds it draws and the cars that are involved. They are very close to our target.

'We naturally sought to strike up a relationship with one of the best teams in the business, namely Hansen Motorsport. Team Peugeot-Hansen is starting from scratch for this new championship, and we face a fascinating challenge with a calendar of 12 rounds across the world in some of the most strategically important markets for the brand.'

The World Rallycross Championship kicks off in Montalegre in Portugal on 3 May, and goes on to visit the UK, Norway, Finland, Sweden, Belgium, Canada, France, Germany, Italy, Turkey and Argentina.

Toyota signs 11-year Daytona deal with ISC

The $400m Daytona Rising redevelopment project has struck a long-term deal with Toyota.

Daytona's redevelopment project started eight months ago but this deal is its first significant commercial tie-up. The 11-year agreement gives Toyota the naming rights to one of the track's five 'fan injector' entrances from 2015.

The Toyota brand will also have a presence in the new 'World Center of Racing' zone, the central 'neighbourhood' overlooking Daytona's start/finish line inside the new front stretch facility, which is roughly the area of two football fields and is where race fans will be able to socialise and enjoy themselves prior to, during and after a race.

International Speedway Corporation's (ISC) massive redevelopment of the fabled superspeedway involves a complete reimagining of the venue

ISC chief executive officer Lesa France Kennedy said of the deal: 'When we started drafting the designs of Daytona Rising, we envisioned partnering with equally forward-thinking organisations like Toyota to bring forth the very best experience for our fans and guests.'

Meanwhile, ISC has released its financial results for 2013, which show the publically owned track-operating arm of NASCAR has had a stable year, with figures for the year ending last November showing total revenues of $612.6m, up $0.2m from 2012.

France Kennedy said she thought the results were encouraging: 'We are seeing encouraging signs of stabilisation in our core business, driven by slowly improving economic conditions and solid consumer and corporate marketing strategies.'

BRIEFLY

Honda move

In preparation for its re-entry into Formula 1, as an engine supplier to McLaren from 2015, the motorsport development team at Honda Research and Development has moved to a new facility in Sakura City, Tochigi, close to its previous base. Engineers started work at the new premises in January and Honda says the new F1 powerplant is making 'encouraging progress'. Meanwhile, Honda has also announced that its Milton Keynes European 'frontline operation facility' for the F1 engine programme will be active from June this year.

Motorsport electronics experts win US award

Well-known motorsport company DC Electronics (DCE) has scooped a prestigious prize at the eighth annual North Carolina Motorsports Association awards.

The NCMA awarded DCE, which has its US base in North Carolina, for its outstanding contribution to the racing industry in the USA since opening its first US production facility in Mooresville two years ago.

David Cunliffe, managing director of DCE, said: 'We are thrilled to have been honoured by the North Carolina Motorsports Association in their annual awards and the recognition is testament to our continued success in the US. Since opening our first US facility in Mooresville in 2012, DCE has gone from strength to strength, supplying high quality electrical systems and wiring harnesses to customers across the USA.

'We'd like to take this opportunity to thank all those who have welcomed us into the community, including the NCMA, the Charlotte Regional Partnership and the Mooresville Economic Development Corporation, along with our team here in the US for the fantastic support they are providing to our customers. We are looking forward to continuing to grow DCE in 2014 and will further build on our success in the US over the next 12 months.'

Founded in 2002, the NCMA promotes the motorsport community in North Carolina. With members ranging from race teams and tracks, to attorneys and accountants, the association's mission includes legislative representation to ensure that the industry's best interests are served.

DCE also recently celebrated being named Small Business of the Year (with annual sales under £5m) at the Motorsport Industry Association Awards in the UK – the third MIA award in as many years for the company.

The company manufactures and supplies products for the motorsport, military and aviation markets globally.

On the motorsport side, products designed and built by DCE have been used in NASCAR, Formula 1, IndyCar and the World Rally Championship.

INTERVIEW – VICKY CHANDHOK

Indian dynasty

After nine years as head of Indian motorsport, Vicky Chandhok has stepped down. Before he departed he spoke to Racecar about the state of the sport in his country

Motor racing is not short of dynasties. In the United States there are the Andrettis, in Brazil the Fittipaldis, while in India you might count the Chandhoks. The family is best known for the exploits of ex-Formula 1 driver Karun, but his father Vicky is also a big name in Indian motorsport, a former race and rally driver of some repute, and the man that until very recently was the president of the country's motorsport federation.

The Chandhok name first came to the fore in Indian racing right at the very beginning, with Vicky's father, Indu, playing a part in organising the very first races on a disused WWII airfield in Madras (now Chennai). A successful racer in his own right Indu also set up the Madras Motor Sport Club in 1953 and the Federation of Motor Sports Clubs of India (FMSCI) in 1972, the year in which Vicky started competing. 'I've been in racing and rallying since 1972,' Vicky says. 'I did a lot of national rallying, a lot of national racing, and had 368 awards on my shelves, which sat for a while until I donated most of them to underprivileged schools to use in their sports days.'

Having followed his father on to the racetracks, it was perhaps no surprise when he chose to become more involved in the administrative side of the sport, too. 'It's been a tradition in our family for years. The Madras Motor Sport Club and the FMSCI used to function out of our office, until they got their own offices. I was a keen participant until the year 2000, when I competed in and won my last rally in a Mitsubishi Lancer, so I left on a high, and then moved into sport administration.'

LAT

"The kids in the slums can make a ball and go and play cricket. You cannot do that with motorsport"

During Chandhok's nine-year spell at the top of Indian motorsport, the big story has to be the Indian Grand Prix, which was added to the F1 calendar in 2011, only to lose its place for this year. 'It's not going to happen in 2014 – it's not on the calendar. The promoter, which is Jaypee Group, is trying very hard to get it on for 2015. It's still early days, but we are negotiating with Bernie Ecclestone and we are certainly hoping that it comes back in 2015.'

Many have said the reason for the loss of the race is because of import tax laws in India and in the state of Uttar Pradesh, but Chandhok believes that too much is made of this. 'The import taxes, to be honest, were only an admin fee. There are no real import taxes – it came duty free. But you had to pay a deposit, and – yes – it was a lot of money that they had to put out, but it was a deposit to which they would receive a refund. The customs just deducted an admin charge.'

Chandhok believes Jaypee, the Indian and local government and the federation are close to sorting this issue, which might help to smooth the way for the return of the grand prix. But even if the Indian Grand Prix finds its way back on to the F1 calendar, is there really the appetite for F1 in India? The attendance figures for its first three years were 105,000 in year one, 68,000 in year two, then 66,000 in 2013, according to Chandhok. That's a drop in the Indian Ocean when you're talking about a country with a population of over one billion souls.

Some have said that interest has fallen because the ticket prices were too high, but Chandhok believes there's more to it than that. 'I don't think it's just the ticket prices. I think Delhi has a very strange culture, and in year one everyone was there because it was something new. But in year two you can't go home and tell your buddies, "I've been to a grand prix," because they've already been there too. So I really think that at the end of the day that's what it is.'

LAT

Sebastian Vettel climbs the fence following victory at the Buddh International Circuit in New Delhi last October

And then there's cricket. The sport is a religion in India, and they take religion very seriously on the subcontinent, to the extent that heretical cults like F1 seldom get a look in. 'Motorsport is not a sport with a connection to the people here. They follow cricket. So what you're competing against is cricket, which is more accessible. The kids in the slums can go and play cricket – they cut something up like a cricket bat, and they'll make a ball out of something, and they will go out and play. You obviously cannot do that with motorsport.'

Perhaps the emergence of an Indian driver in a winning car might help fill those 110,000 seats at the Buddh International Circuit? 'Certainly. I think the presence of a winning Indian driver would make a big difference,' says Chandhok.

But it's not all about F1, and it's not all about drivers. India has slowly built up its own motorsport industry, which is largely based in clusters around Chennai – the traditional home of automotive engineering – and Coimbatore, both of which have their own circuits. The scene is vibrant, with well-supported single-seater and one-make racing categories. The top race championship is MRF Formula 2000, for which the cars are locally designed and built, but based on a Dallara carbon tub – Chandhok says it is somewhere between Formula ADAC and F3 spec. Meanwhile, the new FIA Formula 4 has also sparked interest, though there are questions over the cost of the chassis. 'I've had meetings with Gerhard Berger and the FIA, and I've seen the prototype. They are looking at it very seriously, to try and bring Formula 4 to India. But people here don't have the European budget of €45,000 [the cost-capped base price] to buy the cars – we cannot afford that.'

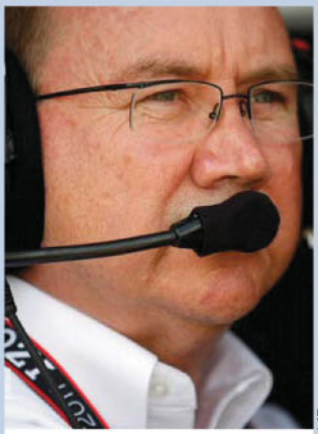
Finding the money to go racing is not a problem confined to India, of course, but where the country does differ from most is in its sheer size. In the USA they've always dealt with this with strong regional championships and national runoffs, something that Chandhok has tried to start in India. 'We have been trying to push for regional championships for years. We need these, so everyone can race in their regions rather than having the astronomical costs of travelling across a country as vast as India.

'But it's all just national championships at this stage. That's because we don't have strong enough regional centres of the ASN [the FMSCI] – when you have the regional offices and regional centres, that's the way to start regional racing and increase the footprint. Whether my successor [J Prithviraj] will agree and follow that path I don't know, but it would be an ideal one to follow.'

Chandhok says he's proud of his time as president – particularly for helping to get manufacturers like VW and Toyota involved in Indian motorsport – but he believes that it is now time to see to other business. But what does he think is the future for motorsport in India? 'I think the future for Indian motorsport is stable. I won't say bright, and I won't say it's bad.' After a pause he adds: 'And the hospitality will always make up for the lack of anything else!'

Mike Breslin

RACE MOVES



LAT

John Dick (above) has joined IndyCar outfit Rahal Letterman Lanigan Racing as its head of research and development. Dick, who comes to RLL from Dale Coyne Racing, worked at the team earlier in his career, when he was a race engineer for **Max Papis** when the organisation was known as Team Rahal.

Kirsty Andrew, the former head of commercial operations at Williams Advanced Engineering, has joined Cosworth as its sales director. Andrews, who started her career at Xtrac, has 15 years of experience in the motorsport and automotive industry.

Marcello Lotti has stepped down from his long-held post as general manager of the World Touring Car Championship. Lotti, who has been at the helm of the WTCC since it began in 2005, has said the reason for his decision was due to a clash of ideas with championship-owner Eurosport Events. At the time of writing Lotti was expected to be replaced by two people: **Francois Ribeiro**, director of motorsport business at Eurosport Events, and **Eric Neve**, the former motorsport director at Chevrolet Europe.

Igor Mazepa, the boss of the Russian Time GP2 team – which took over the iSport entry last year and subsequently won the teams' title – has died at the age of 40. Mazepa had made it known that he had plans to enter Formula 1 with the team at some time in the future. His death was due to thrombosis.

Craig Wilson is now managing director at Williams Advanced Engineering, the part of the group that commercialises Williams' Formula 1 technology and know-how for the automotive, transport and energy sectors. Wilson joins the company from engineering consultancy Oxford Applied Technologies, and before that he had worked at Walkinshaw Performance in Australia and the TWR Group in the UK.

Todd Parrott has been signed up to work as crew chief on one of the Tommy Baldwin Racing Chevrolets in this year's NASCAR Sprint Cup Series. Parrott, a NASCAR veteran, has recently finished a suspension for contravening the sport's strict substance abuse code, as a result of which he was released from his previous role as a crew chief at Richard Petty Motorsports.

Kevin Manion will tend the other Tommy Baldwin Racing car. With 283 Sprint Cup races under his belt, Manion was previously a crew chief at Earnhardt Ganassi Racing. Baldwin will now concentrate on the business and competitions side of the organisation.

NASCAR has reinstated **Ty Norris**, an executive at Michael Waltrip Racing who was suspended after the race manipulation scandal at Richmond last year. However, Norris, who is executive vice president of business development and general manager at MWR, remains on indefinite probation.

Tony Cotman, who recently worked as project manager for Andersen Promotions on the 2015 Indy Lights chassis and engine package, will return as race director for the series this season. Cotman was previously Lights race director from 2010 to 2012. He is also a former IndyCar vice president of competition.

Randy Hembrey is to be the race director for Pro Mazda and USF2000 in the USA. Hembrey has more than 30 years of racing experience, most recently as race director for the IMSA Porsche GT3 Cup Challenge, Porsche GT3 Cup Challenge Canada, and Lamborghini Blancpain Super Trofeo.

David Caswell has joined Andersen Promotions as its assistant technical director for Pro Mazda and USF2000. Caswell owns WesTrack Motor Racing and has more than 35 years of experience in racecar design, fabrication and preparation.

SPONSORSHIP

Unifin, a Mexican financial institution which deals in leasing and auto credit, has become a sponsor of the **Sauber** F1 team. Unifin's logos will be visible on the top of the nose of this year's Sauber C33, as well as on the drivers' overalls.

Motorsport tool and equipment manufacturer **Ingersoll Rand** is to be an associate sponsor on both of **Swan Racing**'s **Toyotas** in this year's **NASCAR Sprint Cup.** It will also provide the team with its cordless and compressed air tools for use in the pits.

The Skittles confectionary brand is to return to NASCAR sponsorship after a decade away from the track, with the candy's colourful paint scheme adorning the **Joe Gibbs Racing**-run Toyota of Kyle Busch in the Sprint Cup.

JGR already has a long-standing relationship with Skittles-maker **Mars**, with **M&M's**, **Snickers** and **Doublemint** brands regularly seen on its cars.

Alliance Truck Parts is to be the primary sponsor for **Team Penske**'s No 2 car – driven by Brad Keselowski – for eight NASCAR Sprint Cup races this year. Alliance will also serve as a secondary sponsor for the 24 races when Keselowski's familiar long-term sponsor **Miller Lite** takes precedence.

IndyCar team **Rahal Letterman Lanigan Racing** has signed a primary sponsorship agreement with the **US Army National Guard**, which will see the US reserve's logo on the No 15 car driven by Graham Rahal throughout the 2014 season.

BRIEFLY

Chassis switch

Chinese LMP squad KCMG is switching from Morgan to ORECA as it gears up for an LMP2 campaign in the World Endurance Championship this year. The Hong Kong-based team became the first Chinese team to race at the Le Mans 24 Hours last year, alongside its assault on the Asian Le Mans Series. KCMG will base itself at ORECA's Paul Ricard headquarters during the European part of the WEC. The team will also switch from Michelin to Dunlop tyres for this season.

A1GP reaccelerates

A series using the first incarnation of the A1GP car is set to hit the tracks as part of a new racing and music promotion later this year. The organisers of the 10-event Acceleration 2014 – mixing motorcycle and car racing plus a music festival – say they are confident of a 20-car grid, which will be similar to A1GP with teams representing countries. The fleet of Lola-built cars have been prepared by the Dutch MP Motorport squad while it's also been reported that Zytek has signed an engine lease deal for the season. Teams already signed up include: Linders Racing, Azerti Motorsport, Provily Racing, Performance Racing, GU Racing, Moma Racing and Team China.

Hyping hybrids

Toyota's presence in the WEC with its LMP1 TS030 Hybrid has not done its hybrid road car sales any harm, it seems, for the Japanese manufacturer has now sold over six million hybrid vehicles worldwide, this latest milestone being reached just nine months after its hybrid sales passed the five million mark. Toyota currently sells 24 hybrid passenger car models and one plug-in hybrid in 80 countries and regions around the world, while within the next two years it will launch 15 new hybrids. Toyota entered hybrid vehicle production in August 1997 with the Coast Hybrid EV bus in Japan.

Name change

NASCAR Sprint Cup outfit Phoenix Racing will now be known as HScott Motorsports, in deference to its owner Harry Scott Jr. The rebranding of the team comes five months after Scott purchased the team from James Finch. 'I am truly looking forward to the 2014 season,' said Scott. 'We have two great drivers in place with Justin Allgaier and Bobby Labonte, we've partnered with great sponsors and the team is ready and excited.' Finch, former owner of Phoenix Racing, has stayed on as an adviser to the team and is to be listed as the owner of Labonte's No 52 Chevrolet.

RACE MOVES

Butch Winkle is to return to the post of technical manager at the USF2000 championship. Winkle spent 2013 as assistant technical director for sister Anderson Promotions-run series Indy Lights. He is a past recipient of the Clint Brawner Award for Mechanical Excellence and a three-time winner of the Championship Association of Mechanics Outstanding Mechanic Award.

F1 exhaust supplier Good Fabs has appointed **Ross Allen** to the position of general manager. Allen comes to the company from Mercedes AMG High Performance Powertrains, where he worked in strategic and technical buying roles. Prior to that Allen worked in purchasing at McLaren Automotive, McLaren Racing and for Sunseeker, the luxury boat maker.

Graeme Hackland is the new IT director at Williams, where he will be responsible for the delivery of IT projects within the Williams Group. Hackland, who has now joined the group's executive committee, previously worked at the Lotus F1 team, where he was its IT director. He joined the Enstone team when it was known as Benetton back in 1997.

Ross Brawn has made it clear that he has definitely retired from Formula 1, despite rumours linking the former Ferrari, Brawn and Mercedes boss to McLaren or to a role with the FIA. Brawn told reporters he had no plans for the year ahead, other than to go fishing.

Well-known driver manager **David Robertson**, the man who along with his son Steve helped to get both **Jenson Button** and **Kimi Räikkönen** into Formula 1, has died at the age of 70. Robertson, who had been ill for some time, also played a part in setting up crack Formula 3 team Double R Racing.

J Prithviraj is the new president of the Federation of Motor Sports Clubs of India (FMSCI), replacing **Vicky Chandhok** (see interview, p90) in the position. Prithviraj is well-known in Indian rallying, both as a competitor and organiser. **Tutu Dhawan** is the new vice president.

MARIA W GRADY

Broadcaster and journalist **Chris Economaki**, who died in 2012 at the age of 91, has been posthumously awarded with the second ever Squier-Hall Award for NASCAR Media Excellence. Economaki was the editor, publisher and columnist for National Speed Sport News for more than 60 years. He began his television broadcast career with ABC in 1961.

NASCAR has inducted engine builder **Maurice Petty**, whose engines powered brother Richard Petty to most of his 200 wins, into its Hall of Fame. Fellow inductees were drivers **Fireball Roberts**, **Tim Flock**, **Dale Jarrett** and **Jack Ingram.**

Pierre de Coninck, who has been secretary general for sport at the FIA for the past 32 years, has now stepped down from the position. However, he will remain involved with the organisation, acting as an adviser to FIA president **Jean Todt**. **Jean-Louis Valentin** will now take on the role of secretary general for sport.

Jason Bargwanna is to be the Driving Standards Observer (DSO) for the Australian V8 Supercars championship this season. Bargwanna, who replaces **Cameron McConville** in the role, enjoyed a 15-year career as a driver, winning the prestigious Bathurst 1000 race in 2000.

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 send an email with all the relevant information to Mike Breslin at bresmedia@hotmail.com

CHRIS AYLETT

All roads lead to success

Use your voice to help influence how the Government supports motorsport

Our 20th anniversary year, 2014, started with a bang – and I hope yours did too. New business is appearing – new series, new regulations and new markets for those who want to chase them. Positive news on the economic front in the UK and the USA helps too. But how do we keep this going?

When UK business minister, Michael Fallon, attended the MIA Business Excellence Awards for the first time, I was reminded of the immortal line from Reg in The Life of Brian, and thought: 'what have the Government ever done for motorsport?'

The minister launched our Review of Motorsport Valley earlier by saying this was 'part of a stronger relationship developed with the MIA and the motorsport industry in the past year – an important element of which is dialogue with the industry. A truly collaborative approach between Government and industry can nurture what we have, and bring success and future growth to UK companies.'

You can read the review at www.the-mia.com. It explains that ours is now a £9bn industry that has grown fast over the past five years to become one of the great successes of UK engineering. This is not a dry, crusty report, but one written – with Government support – to help you to attract investors, financial backers, or even the bank manager if he wants to listen! We must tell our financial supporters how strong and successful this industry has become, and our closer relationship with the Government will make them feel even more positive.

The minister was sincere in that the Government wants to hear your views, and that dialogue is paramount to their industrial strategy. On Tuesday 11 March at Silverstone, we invite you to express your views as to how you want the Government to help your business grow. The MIA relies on information from our members – and also the wider industry, whether MIA members or not. This is your unique chance to influence future policy to make sure your business prospers.

So has the UK Government helped Motorsport Valley businesses? And what lessons can be learnt by other governments?

The UK has a general election in 2015, and a pre-election year is one of the most important in any government's lifetime. Let's assess their performance with our industry and agree where we should secure more support from the new government, when elected.

Substantial Government support built the Silverstone bypass in 2002, making access to the British Grand Prix much easier. Since then, Silverstone has virtually sold out every grand prix – the only host circuit in the world to achieve that. In The Life of Brian, Reg was forced to agree that the Romans had provided irrigation, central heating, medication, roads and sanitation – perhaps the UK government has helped Motorsport Valley more than you first realise.

In the past five years, R&D tax credits have pumped millions into the R&D supply chain of motorsport. The UK hosts more F1 teams than any country, which spend vast sums on R&D. They gain UK tax credits for doing so, which they invest with suppliers to meet new R&D demands, so these substantial sums reach a long way down the UK supply chain. The Technology Strategy Board spends millions on energy efficient, low carbon R&D, and in the past five years, more than 50 motorsport companies have received financial support for R&D – on a 50:50 basis – and helped to create networks of collaborative companies.

Over the past decade, UK Trade & Investment has provided millions to British motorsport exporters. As a result, nearly 90 per cent of UK motorsport companies export their products or services – a tremendous record which ensures that Motorsport Valley remains the global centre of motorsport engineering. Any day now, a consultation will commence to change the law in regard to closed public roads for motorsport events. Success here will open up motorsport to local communities, taking our sport to the heart of the population.

The MIA are hosting an Industry Forum at Silverstone on 11 March

The Government has asked the MIA to work with our members, and industry, to create and implement a Motorsport Business Growth Plan for the next five-to-10 years. Your ideas can feed into that, whether you attend Silverstone or not – if you can't make it, get in touch with us via info@the-mia.com.

Motorsport should take a lead from the automotive, aerospace and defence industries, all of which have recently developed their own Business Growth Strategies, partnering with the Government on a 50:50 investment basis, to make sure progress they need is made. The Government invests alongside industry to help deliver plans which the industry itself has identified is needed.

Where could motorsport companies grow with a little help? Many have outstanding capabilities in energy efficiency and low carbon engineering solutions, where the UK is determined to become a world leader. As the world car pool grows, so new motorsport markets will be created, and we need to win new business from this growth. We have unique, fast response R&D prototyping capabilities – in great demand from adjacent sectors – where the Government can help us secure new business. We can influence the number of young people studying engineering at schools by using the charisma of motorsport to increase our pool of talent.

Motorsport businesses must work together to make our one, substantial, voice heard by this and future governments.It's the perfect time to join in, so please help us to make this fantastic business of ours grow over the next decade.

I know many readers are based outside the UK, but perhaps this message will help them to better engage with their own national governments. We are all part of a small global family in motorsport – we need our sector to gain more respect and support, to our mutual benefit, so good luck.

I look forward to meeting you at Silverstone, and to welcoming your ideas for the future of our industry.

We must tell our financial supporters how strong this industry is, and our Government relationship will make them feel even more positive

CAMERAS

Dogcam Bullet HD 2 1080p Waterproof Sports Camera

The Dogcam Bullet HD 2 represents a revolution in high definition bullet cameras. Not only is it the smallest and lightest full HD 1080p bullet camera on the market, it is the only system to offer software configuration to produce optimal quality video and audio in any operating conditions.

Constructed from anodised aluminium, the camera is shockproof and waterproof down to 10 metres and contains the latest video processing tech, producing superb video and audio quality.

Track-tested and developed in association with F1 engineers, the Dogcam Bullet HD 2 is the perfect helmet and motorsport camera, and is proven to withstand extreme vibration and high temperature environments.
www.dogcamsport.co.uk

SHIELDING

DEI exhaust pipe shield

DEI's Titanium Pipe Shield has been developed with the company's Lava Rock Technology, which it claims provides maximum thermal protection and outperforms traditional Mylar-backed glass fibre shields.

Extreme direct or radiant heat can damage transmissions, brake lines, wiring and hoses. However, DEI's shield clamps directly to any size exhaust pipe to provide protection for sensitive electrical components, lines, cables, wires, transmissions or even occupants.

The shield combines a riveted 'stand-off' design using 3.5in (89mm) stainless steel clamps in order to provide a cooling air gap between the shield and the pipe. Combined with the heat dissipation benefits of the 2 ply material made with LR Fibre Technology, DEI claims the material combination provides heat protection up to 1350degF (732degC).
www.designengineering.com

SEATS

Schroth seats

The new line of Schroth Protec XLT products are on average 25 per cent lighter than the previous Pro Systems. The XLT (XtraLighT) devices have been optimised through extensive testing and advances in carbon fibre technology to reduce overall weight and to reduce driver fatigue. This allows for an increase in overall performance while maintaining the high level of comfort drivers worldwide have come to expect from the Schroth Protec FHR systems.
www.demon-tweeks.co.uk

LUBRICANTS

Driven SHX shock fluid

The new SHX Shock Fluid from Driven Racing Oil (DRO) uses revolutionary synthetic oil technology to create shock performance that – it claims – won't fade over time. The fluid is a synthetic, competition-proven formulation that utilises a proprietary additive package, said to reduce seal drag, improve air release during fluid handling and maintain viscosity under extreme heat and high loads.

In fact, the KRL Shear Test has proven it to have no viscosity loss. DRO claims that these tests show that SHX Shock Fluid outperforms conventional oils and delivers outstanding performance in extreme environments, such as those found in demanding racing applications.
www.drivenracingoil.com

TOOLS

Facom DF.80 and DF.100 brake bleeders

Tool manufacturer Facom has added new analogue and digital brake bleeders to its range.

Brake fluid, being hygroscopic, absorbs water from the atmosphere and needs replacing every two years, even if the car has had little use. If this important maintenance task is neglected, full braking performance will almost certainly be compromised.

To help facilitate fast, efficient brake fluid changes, Facom now offers its customers two new brake bleeder models: the analogue DF.80 and the digital DF.100. Both connect to the vehicle's battery and feature 10-litre storage tanks with adjustable and constantly regulated pressure from 0-4 bars. They will also stop automatically if the brake fluid drops below the minimum level. Robust housing equipped with wheels and handles means they are both tough and highly portable.

Additionally, the DF.100 digital model is ISO certified and offers more precise pressure adjustment via a digital screen. It also automatically de-pressurises when the process is stopped. A low level indicator and a cycle counter are also included. For convenience, space for a 12-volt vehicle battery is provided, eliminating the need to rely on the vehicle for power, making it a truly self-contained option that makes for even faster brake fluid bleeding.

Alison Howard, UK trade marketing manager, Stanley Black & Decker Industrial & Automotive Repair, says, 'There are a great number of vehicles on the road with degraded brake fluid. With our new brake bleeders on hand to make the brake fluid changing process so much easier, garages and workshops have the opportunity to tap into a potentially lucrative market.'
www.facom.com

SAFETY

Simpson Hybrid-series head and neck restraints

Simpson's Hybrid-series head and neck restraint has been given FIA approval, making it a viable alternative to other head and neck restraints, such as the HANS in series that require such certification. Simpson claims that it is the only FIA 8858-2010 approved head and neck restraint on the market that protects during front, offset and side impacts.

The system is available in three variations, the compact Hybrid Pro, the Hybrid and the more budget-conscious Pro Rage. Simpson claims that the Hybrid Pro series are the lowest profile devices in the industry, allowing for rapid exit from a vehicle in the event of an accident. The device sits on your back/shoulders, not over the chest or collarbone as with the HANS-type devices.
www.simpsonraceproducts.com

WEIGHING

Longacre Tablet scales

Wireless corner weight scales are nothing new, but Longacre has revamped the concept by removing the need for a bulky receiver unit. Instead it has incorporated the functionality in an easy-to-use-and-read tablet computer. Not only does this mean a more compact system, it also allows for extra functionality to be incorporated to increase the versatility of the scales system. The system allows for easy calculation of not only corner weights but front to rear and left to right weight distribution, with the ability to save multiple setups for future reference and comparison.
www.longacreracing.com

HELMETS

Bell HP7 helmet

The new Bell HP7, used by leading F1 and GP2 drivers, is a state-of-the art and innovative helmet conceived for open cockpit racing. The HP7 is the direct result of a intense and never-ending R&D programme by an international team of engineers and their close collaboration with F1 drivers and teams. Meeting or exceeding Snell SA2010 and FIA8860-2010, the HP7 benefits from the latest technological evolutions and innovations in the fields of aerospace and military grade composite materials and energy absorbing materials. The helmet retails for £2040+VAT.
www.bellhelmets.eu

TRANSMISSION

Crawford paddle shift

Crawford Composites, better known for designing and producing autoclaved composites for the US racing industry, has announced the creation of the Crawford Composites PaddleShift System (CCPS). It's a fully configurable pneumatic sequential paddle-shift system, designed to be adaptable to a range of various sequential gearboxes. The system can be tailored to each customers' specifications.

Crawford Composites has collaborated with UK-based ECU specialists GEMS Ltd to provide a powerful closed loop controller which is packaged in a compact and lightweight carbon fibre composite housing. The gearbox control unit features a high-speed processor, configurable analogue and digital inputs, CAN communications onboard logging, ratio learning and over-rev protection.

'The CCPS is a combination of our composite experience and motorsport prowess, and we are thrilled with the results,' says Max Crawford, founder and president of Crawford Composites. 'Our decision to involve drivers and end users in the engineering process has produced a very clever, yet user-friendly system.'
www.crawfordcomposites.com

SOFTWARE

CAEfatigue Vibration software from DTE

Engineering software solutions provider Desktop Engineering (DTE) has been appointed as the sole reseller of CAEfatigue Vibration, which is claimed to be a revolutionary new frequency domain fatigue solver.

It works with mixed random (power spectral density) and deterministic loading sources in a way not currently possible with other software solutions. CAEfatigue Vibration will deliver orders of magnitude improvements in solution speed and infrastructure needs.

The avoidance of fatigue failure is a design requirement for nearly all mechanical engineering systems. In fact, for most racing components, fatigue life (or durability) is the limiting design requirement.

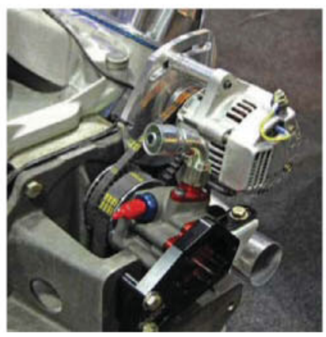
Testing plays an extremely important role in determining the required level of durability, but analysis is also vital at all stages of product development. Therefore, CAEfatigue Vibration is relevant to any stress or test solutions – for both chassis and powertrain applications – that uses FEA codes, such as MSC Nastran, to calculate fatigue in structures which vibrate.
www.dte.co.uk

STEERING

KRC rear mount power steering

KRC Power Steering's new rear mount alternator and power steering pump assembly for Ford Racing crate engines is designed for dirt track racing. By relocating the alternator and power steering pump to the rear of the engine, it moves these components out of harms way, while also helping weight distribution, placing mass nearer the centre of the car.

The mounting system mounts to the bellhousing and includes a single serpentine water pump drive with an idler tensioner, plus the necessary bolts and brackets.
www.krcpower.com



To Infiniti, and beyond!

Away from the hype surrounding Formula 1 noses, and Formula 1 reliability issues, the rest of the motorsport world is in something of a shadow at the moment. But there is a wealth of interesting things going on.

In this edition, for instance, we feature the new Volvo S60 V8 Supercar that will contest the Australian touring car series. It wasn't so long ago that Ford and Holden had a complete stranglehold on the series, building up a significant following. Both have seen their fortune in Australia dip, with significant job losses, which in turn has led to reduced involvement in the racing series. But, with Nissan and Volvo now joining – the former having apparently found a magic bullet and dramatically improved aerodynamics – the grid is still looking healthy.

Rallycross is another area of large growth, with Peugeot choosing to return to factory-backed racing in the FIA's world championship, alongside Ford. The return of the French manufacturer is a significant coup for the series. Peugeot clinched eight French drivers' championship titles between 1988 and 2012. 'Rallycross is a discipline that is expanding quickly, and that includes the introduction of an FIA-sanctioned world championship from this year,' said Peugeot Sport director Bruno Famin. 'We were attracted to the sport by a long list of factors, including its spectacular side, the big crowds it draws, and the cars that are involved.'

The arrival of Jacques Villeneuve, the 1997 Formula 1 World Champion and Indy 500 winner who raced twice at Le Mans for Peugeot, competed in the Andros Trophy ice-racing, NASCAR and Australian V8 Supercars, continues his diversification and has joined the Scottish team, Albatec Racing, with a 600bhp Peugeot 208. Whatever anyone thinks of Villeneuve, I take my hat off to him for giving everything a go. I am also far more excited by the prospect of a 560bhp all-wheel drive Volkswagen Beetle that will compete in the Global series with the Volkswagen Andretti Rallycross team, than Marco Andretti's association with the Formula E Drivers' Club. I have yet to figure out what the Drivers' Club means, but one new member confirmed that he didn't have a drive.

With so much to look forward to, this certainly looks like the start of a golden year of motor racing

What is interesting is the announcement of the Nissan ZEOD engine that will power a revolutionary new car at Le Mans this year. The little powerplant is a 1-5 litre three-cylinder engine that weighs 40kg and produces an astonishing 400bhp. The base engine is only 500mm tall, 400mm long and 200mm wide. It fits into a suitcase. It revs to 7,500rpm and produces 380Nm of torque. It also produces 10bhp per kg, giving it a better power-to-weight ratio than the modern F1 cars.

How successful the rest of the car will be is yet to be seen – and part of the fun is seeing whether or not this technology can be made to work in time – but the engine is a huge step in the right direction for the company in motor sport. 'Nissan will become the first major manufacturer to use a three-cylinder engine in major international motorsport,' says Nissan's global motorsport director Darren Cox. 'We are aiming to maintain our position as industry leaders in focusing on downsizing. Lessons learned from the development of the engine will be seen in Nissan road cars of the future.'

Also set for a return to the tracks is the historic Ligier name. This was treated with some scepticism as the trend to rebrand chassis as Morgans and Caterhams is becoming all-too common, but the Ligier brand returns with an all-new car, designed and built by Oak Racing. This LMP2 coupe is destined for global sports car racing in the second half of the year.

Moving on to Formula Student, organisers received entries from 178 teams, of which 114 have successfully claimed a place for the British competition at Silverstone on 9-13 July. Teams from China, Ecuador and Jordan will compete for the first time alongside teams from South Africa, Pakistan, Australia, Canada and India, as well as the European teams.

There is so much else that I haven't mentioned, but with so much to look forward to, this certainly looks like the start of a golden year of motor racing.

EDITOR
Andrew Cotton

Racecar engineering
The International Journal of Motorsport Technology

PIT CREW

Editor
Andrew Cotton
@RacecarEd

Deputy editor
Sam Collins
@RacecarEngineer

News editor
Mike Breslin

Design
Dave Oswald

Chief sub editor
Stuart Goodwin

Technical consultant
Peter Wright

Contributors
Stefan Bartholomaeus, Mike Blanchet, George Bolt jr, Lawrence Butcher, Ricardo Divila, Mike Fuller, Gemma Hatton, Simon McBeath, Danny Nowlan, Mark Ortiz

Photography
LAT, Darin Mandy, James Moy/XPB

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

Head of business development
Tony Tobias
Tel +44 (0) 20 7349 3743
Email tony.tobias@chelseamagazines.com

Advertisement manager Lauren Mills
Tel +44 (0) 20 7349 3740
Email lauren.mills@chelseamagazines.com

Advertisement sales executive
Stewart Mitchell
Tel +44 (0) 20 7349 3745
Email stewart.mitchell@chelseamagazines.com

Marketing manager
William Delmont
Tel +44 (0) 20 7349 3710
Email will.delmont@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
Subscriptions Department
800 Guillat Avenue, Kent Science Park
Sittingbourne, Kent ME9 8GU
Tel +44 (0) 1795 419837
Email racecar@servicehelpline.co.uk
http://racecar.subscribeonline.co.uk

Subscription rates
UK £66 (12 issues)
USA $162 (12 issues)
ROW £84 (12 issues)

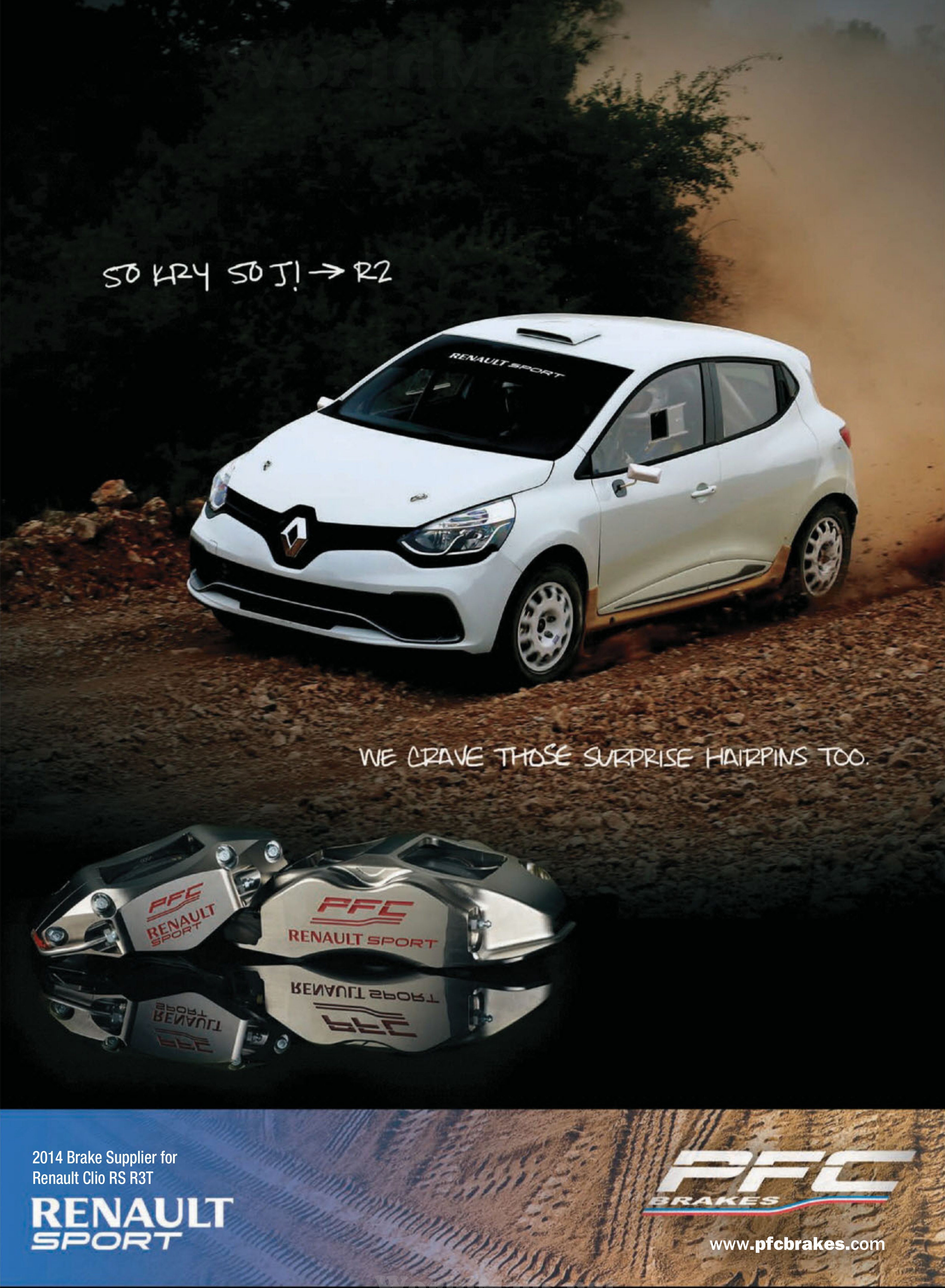
News distribution
Seymour International Ltd, 2 East Poultry Avenue, London EC1A 9PT
Tel +44 (0) 20 7429 4000
Fax +44 (0) 20 7429 4001
Email info@seymour.co.uk

Printed by Wyndeham Heron
Printed in England

ISSN No 0961-1096
USPS No 007-969

recycle

www.racecar-engineering.com


WE CRAVE THOSE SURPRISE HAIRPINS TOO.
RENAULT SPORT
PFC
RENAULT SPORT
2014 Brake Supplier for
Renault Clio RS R3T
RENAULT
SPORT
PFC
BRAKES
www.pfcbrakes.com