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New GR8 coupe aims to re-establish legendary marque

F1 DESIGNER SERGIO RINLAND
Brabham, Benetton and Sauber man on the route to innovation

F1 TYRE CHANGE
HOW PIRELLI PREPARED FOR ITS GRAND PRIX RETURN

Hispania F110
Dallara gives its take on 2010 Formula 1 involvement

DJ Firestorm
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The Autosport Engineering show and the larger Autosport International exhibition traditionally represent the unofficial start to the new motorsport season, and the February issue of *Racecar Engineering* is therefore always one of the most important of the year. And never more so than in 2011, as the magazine is now the official media partner of the MIA's Cleaner Racing Conference, forming part of the newly created International Motorsport Business Week initiative. The publication's involvement with the Conference represents a clear indication of the importance we attach to this subject, as the topics discussed provide a clear marker as to the future technical direction motorsport is likely to follow.

Reflecting the forward-looking aspect of this time of year, this month's exclusive cover story reveals how Pirelli has prepared for its return to Formula 1 as the sport's official tyre supplier. Quite apart from Pirelli's desire to produce competitive, durable products to showcase its expertise at the sport's top level, the teams' chassis engineers will be attempting to work out, with the brief amount of testing available these days, how best to optimise their 2011 cars to work with the new rubber. It's a fascinating story that will play out as the new season unfolds.

Also this month, we examine DJ Engineering's Firestorm single seater, which looks set to shake up the British Hillclimb scene, examine lessons to be learned in the final part of our series on recent motorsport business failures, investigate the new coupé that heralds the return of the much-missed Chevron marque to motorsport and hear from US inventor, Winthrop Dada, about a potentially revolutionary new suspension system.

There's always a certain excitement and anticipation in the air at this time of the motorsport year. We hope we've captured and distilled a little of it for you in this month's *Racecar Engineering*.

EDITOR
Graham Jones

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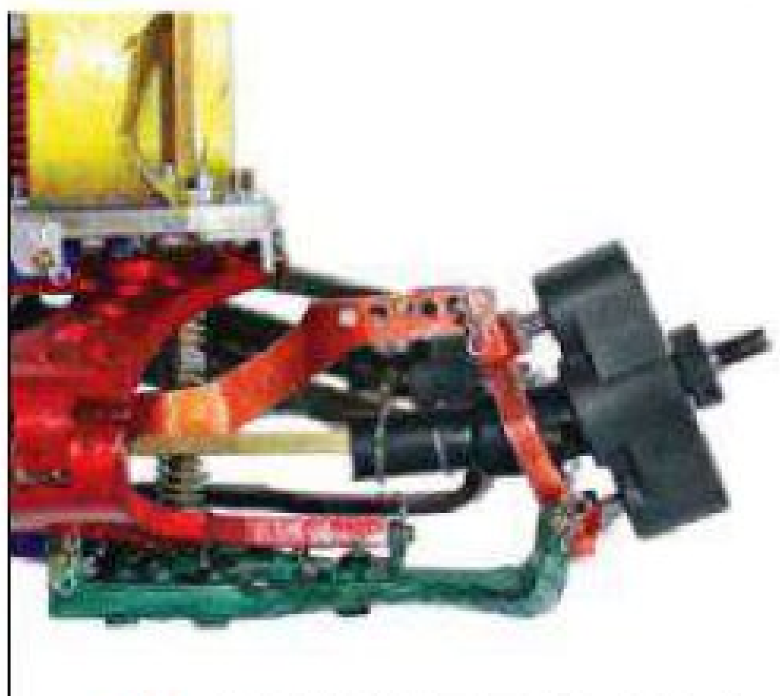
How Pirelli approached the challenge of making Formula 1 tyres



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The International Journal of Motorsport Technology
Racecar engineering

FORMULA 1

F1 agrees new engine regulations for 2013

1.6-litre turbos and 12,000rpm as F1 goes green

THE FIA HAS rubber stamped sweeping changes to the Formula 1 engine regulations to come into force in 2013, with a move to 'greener' engines, which are felt to be more relevant to the motor industry.

F1's new engine formula is to feature four cylinder, 1.6-litre, turbocharged units. They will have a power level similar to the current output, thanks to a planned extended use of KERS.

The FIA hopes fuel consumption will be cut by some 35 per cent thanks to the changes, while for 2013 each driver will be limited to just five engines a season, with that limit dropped to four the following season.

The FIA said: 'The WMSC [World Motor Sport Council] approved the introduction of a new specification engine from 2013, underlining the FIA's commitment to improving sustainability and addressing the needs of the automotive industry. Following dialogue with the engine manufacturers and experts in this field, the power units will be four cylinders, 1.6-litre with high-pressure petrol injection up to 500bar with a maximum of 12,000rpm.'

The changes follow drawn-out discussions between the FIA, the teams and the engine manufacturers, and it is widely thought that some teams and manufacturers were arguing to keep the current 2.4-litre V8 formula. However, it is believed that FIA president, Jean Todt, pushed for the changes.

More 'industry-relevant' engines are the way ahead

Some of the other new regulations for this coming season have also now been set in stone, chiefly the movable rear wing flap idea, which has been designed to aid overtaking. It was also announced that gearboxes will now have to last five races, rather than four.

Additionally, the FIA has moved to tighten up the bodywork regulations, in the wake of protests in 2010 regarding the front wings on the Red Bull and the Ferrari - which some claimed were flexing - and, as a result of this, the rules relating to the reference plane are to become much stricter, while much tougher deflection tests are planned for F1 scrutineering this year.

RACECAR SAYS...

To be honest, the prospect of 1.6-litre four pots doesn't sound very exciting (and probably won't 'sound' very exciting), but F1 must move with the times - and let's not forget, as the 1980s showed us, small capacity turbo engines don't necessarily mean boring cars

FORMULA 1

Group Lotus buys into Renault F1

GROUP LOTUS HAS become a major shareholder and title sponsor of the Renault Formula 1 team which, from the beginning of this season, will be known as Lotus Renault GP.

The deal comes after Renault sold its stake in the team to co-owner Genii Capital who, in turn, sold that stake on to Group Lotus.

Lotus Renault GP launched the car in its 2011 livery, which is the iconic black and gold that adorned Lotus F1 cars in the '70s and '80s. This raised some eyebrows as the other Lotus Team had recently announced its intention to use the same colour scheme. It has now announced it will race in green and yellow, as it did in 2010.

The title sponsorship with Group Lotus is due to run until the end of 2017, but Group Lotus CEO, Dany Bahar, has hinted he would like to take over the team completely within the next couple of years. He also said he considers this team to be the 'real' Lotus.

Bahar said of the new deal with Renault: 'I can think of no better platform for automotive brand communications than motorsport and F1. We're well aware that there has been a lot of controversy around the usage of our brand in F1 and I'm delighted to be able to formally clarify our position: we are Lotus, and we are back.'

Carlos Ghosn, chairman and CEO of Renault, welcomed the new deal: 'This multi-partner alliance will bring a new dynamic to the team and enable it to compete with the sport's best from next season.'

Tony Fernandes, owner of Team Lotus - the team that is independent of Group Lotus - has said he intends to carry on with his team, and to call it Lotus, while Team Lotus technical director, Mike Gascoyne, responded to the Group Lotus announcement via Twitter, saying: 'Rest assured, we are Team Lotus and we are here to stay and we at Team Lotus are in F1 to design, build and race F1 cars from our home in Norfolk, and in the future to win as a team. Bring it on.'

ENDURANCE

Audi puts a lid on it

AUDI HAS UNVEILED its striking new R18 LMP1 challenger, the car with which it intends to take the fight to arch rival Peugeot and, for the first time since 1999, its Le Mans car is a fully enclosed Sports Prototype.

In recent years the German company has resisted opting for a coupé, the route taken by Peugeot, and as recently as last summer its head of motorsport, Wolfgang Ullrich, told *Racecar Engineering* he was not sure if it would ever go the closed-car route, although he did add: 'One thing is clear. If you look into the rule books in the last three years, it was more or less impossible to make an open car with the same speed as a closed car.'

But now Ullrich says the aerodynamic benefits mean that the closed car philosophy simply could not be ignored: 'In the future, aerodynamic efficiency will be even more important at Le Mans than it was in the past. A closed car has clear advantages in this respect. Our computer simulations have been confirmed in the wind tunnel and during initial track tests.'

Significantly smaller engines will be used at Le Mans in 2011, as the rule makers (the ACO) aim to achieve a substantial reduction in engine power. With this in mind, Audi has opted for a 3.7-litre V6 TDI unit, staying with the diesel concept. 'From our point of view, the TDI continues to be the most efficient technology,' says Ulrich Baretzky, head of engine development at Audi Sport. 'There are good reasons why the share of TDI units among Audi's production models is as high as it is.'

Another new development, Audi tells us, is the six-speed transmission in the R18, which has been specifically modified for use with the smaller engine.

As far as the chassis is concerned, the carbon fibre monocoque of the R18 does not consist of two halves, but features a single-component design, which Audi says saves weight and increases stiffness.

Audi says it was able to draw on the experiences gained in 1999, with the R8C, and in 2003, with the Le Mans-winning LMP1 of its sister brand Bentley when it came to developing the R18, while head of engineering at Audi Sport, Martin Muhlmeier, says its experience in the DTM also helped: 'The Audi A4 DTM, which, for example, features a heated windshield, allowed us to shorten the development cycle with respect to the ventilation of the cockpit, the doors and the heating of the windshield.'

KERS looks sure to feature on the new car in the future too, but Audi is in no rush to fit it. 'Efficiency is always the crucial factor for us,' says Ullrich.

Development of the new Audi R18 started in mid-2009 and it completed its first track test at the end of November.

BRIEFLY...BRIEFLY...BR

LAW ON ORDERS

Formula 1's ban on team orders has been dropped, but there will still be an article in the rules that will enable the FIA to punish teams they feel bring the sport into disrepute. The ban was brought in after Ferrari rigged the finish of the 2002 Austrian Grand Prix, and this was brought starkly into focus again when the team asked Felipe Massa to move aside to allow Fernando Alonso to win last year's German Grand Prix. For that, the FIA fined the team $100,000.

TOYOTA BACK ON TRACK

Toyota Motorsport has announced its first direct involvement in racing since it pulled the plug on its Formula 1 effort at the end of 2009. The German-based motorsport arm of the company is to supply LMP1 engines to the Lola coupé-equipped Rebellion Racing team. Toyota Motorsport has an impressive pedigree in Sportscars, making a splash at Le Mans with its GT-One in 1998, when it set fastest lap, and then coming second with the same car after starting on pole in 1999.

INDY EXPANSION

IndyCar boss, Randy Bernard, has made it known he wishes to expand the championship's calendar so that it includes at least 22 races, some of which will be outside the USA. This year the IndyCar circus travelled to just 17 events, but Bernard is now aiming to introduce at least two new international events and intends to schedule between 22 and 24 races by 2015. Meanwhile, IndyCar has also announced that its TEAM funding system will be limited to the top 22 finishers, rather than the top 24, as has previously been the case. The move is designed to boost the quality of the field.

Despite years of resisting, Audi boffins have finally conceded that roadsters simply cannot compete at Le Mans with coupés in terms of efficiency and aerodynamics

The new R18 will be powered by a 3.7-litre V6 TDI and features a one-piece carbon monocoque. It uses technology and knowledge gleaned from Audi Sport's experiences in other prestigious motor racing series, such as the DTM

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ENDURANCE

KERS you're worth it

Zytek energy recovery system exceeds targets in tests

Zytek recently completed a successful track test of its KERS system at Suzuka. The system was fitted in Honda R&D's HEV Super GT car (pictured) and the 40kw system is said to have run for some 2000kms without a hitch. Zytek says it proved capable of up to 1.5 second improvements in lap times, or an eight per cent reduction in fuel consumption, while its push-to-pass option provided a very useful extra 10km/h boost by the end of the straight. Operating duty cycles for the system were said to have reached and even exceeded target performance at over 1200kJ of energy per lap (three times higher than the systems used in Formula 1 during 2009). The combined mass of the transaxle integrated motor and monocoque mounted inverter and lithium-ion battery was 38.5kg, with liquid cooling systems and high voltage wiring adding a further 6kg.

FORMULA 1

Cinderella curfew for F1 teams

FORMULA 1 PERSONNEL will have to stop working on the stroke of midnight during some race weekends this season after a strict limit on working hours was imposed by the FIA.

The aim of the curfew is to cut down on the working hours of mechanics and others in F1, and it is believed to have come about after there were concerns voiced over the number of hours worked by the personnel of the three new teams during the early races of the 2010 season.

Details of the curfew were announced in the 2011 F1 regulations, which were ratified by the FIA just before Christmas. The curfew itself will be in force from midnight to 6am when practice starts at 10am and from 1am to 7am if practice starts at 11am.

The FIA said: 'No team personnel who are associated in any way with the operation of the cars are permitted within the confines of the circuit during two six hour periods, which commence 10 hours before the scheduled start times of P1 and P3.' It did add, however, that each team will be permitted four individual exceptions to the above regulation during a championship season.

BRIEFLY...BRIEFLY...BR

AUSTIN A4

Rob Austin Racing is to join the BTCC fray next year with a brace of Audi A4s, now being built by GPR Motorsport to the new-for-2011 NGTC rules. The team has previously run cars in Ginetta racing and the GT4 class of the British GT Championship, and its boss, Rob Austin, is a former F3 race winner as a driver. A works Audi won the BTCC in 1996, while the marque's last appearance in Britain's premier tin top category was in 1998.

BASE JUMP

BTCC team, Motorbase Performance, is to switch from BMWs to Fords for this season's championship. Motorbase, which has run BMWs since 2008, has now bought three Focus STs from Arena Motorsport, which itself this year switches to the newer model Focus, and intends to run at least two of them. Mountune Racing has been entrusted with the work on the NGTC-spec petrol engines the team intends to use. Meanwhile, the two BMWs Motorbase has successfully campaigned in recent seasons have been put up for sale.

FORMULA 3

Super F3 announced

A BRAND NEW Formula 3 series that cherry picks the very best of classic F3 races worldwide is to feature in the international calendar this year.

The FIA announced its new Formula 3 International Trophy before Christmas, and any driver registered for the various national Formula 3 championships will be eligible to score points in this new super series.

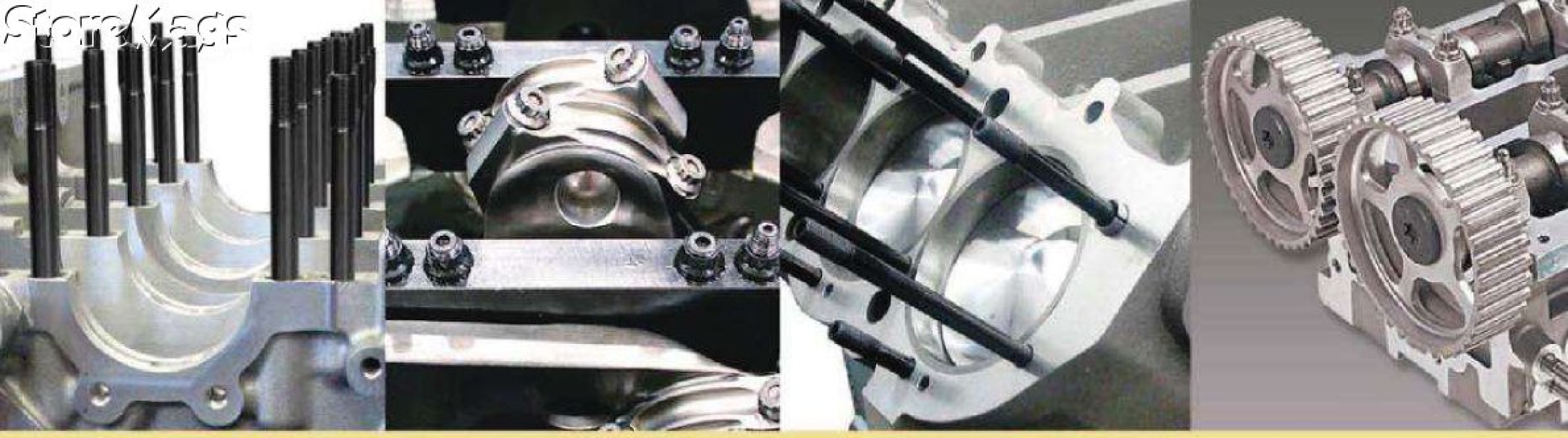
The six-round championship will include the revived Pau Grand Prix, a race at Hockenheim, the British F3 event that supports the Spa 24 Hours, the Zandvoort Masters, plus Macau and its new end-of-season partner event at the Korean Grand Prix venue, Yeongam.

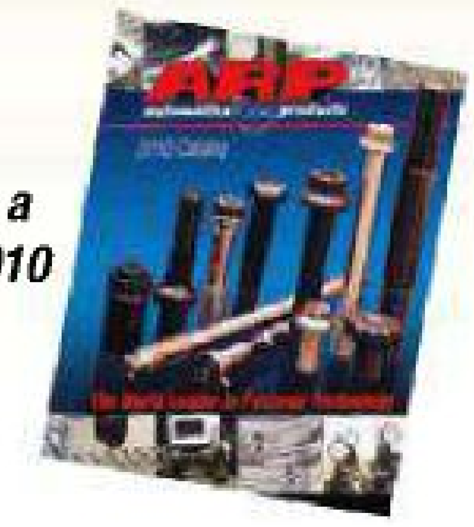
An FIA statement said: '[this] is in order to further increase the appeal of Formula 3 and to help develop the careers of young aspirant racing drivers and engineers.'

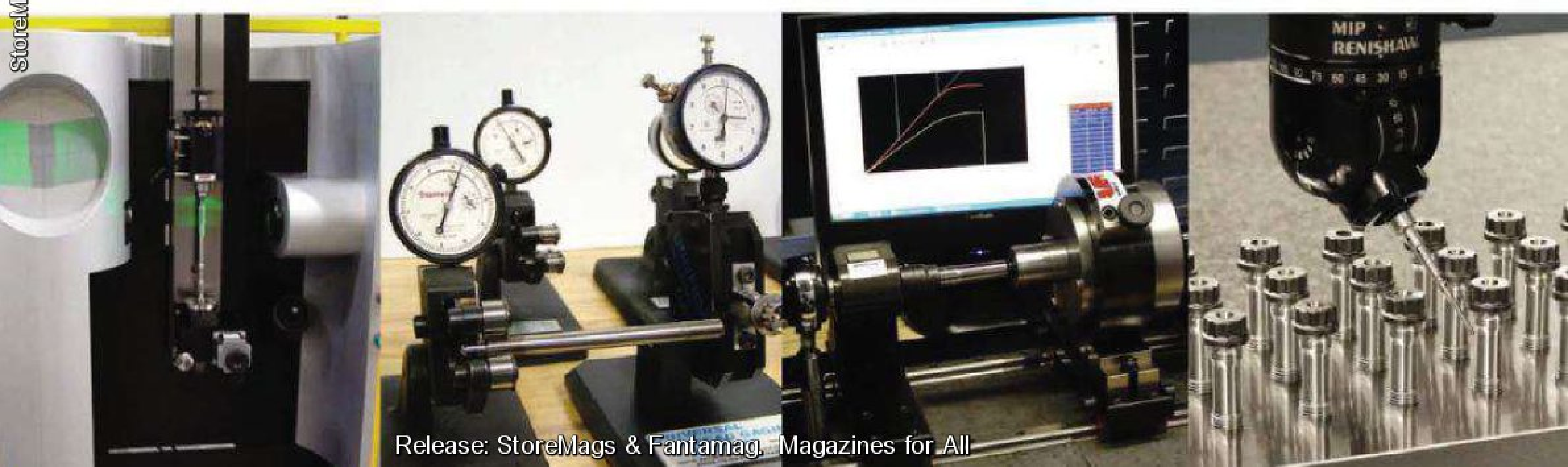
The F3 International Trophy will use the current F1 scoring system of 25-18-15 etc points for the top 10 finishers and the top three drivers in the series will qualify for an F1 super licence.

This announcement comes hot on the heels of the FIA's new lower cost rules package for F3 and is seen as a reaction to the competition from the new for 2010 GP3 series, which hit the F3 Euro Series in particular last year.

Meanwhile, the Euro Series has reported an upturn in interest, with two new squads signing up and expectations of at least 16 cars on the grid for races this season.







MIP
RENISHAW

HARDWARE

WATERMAN ELECTRIC PUMP

FUEL PUMP SPECIALIST, Waterman Racing Components Inc has developed a new, NASCAR-specific electric fuel pump. Designed with the proposed EFI systems in mind, the pump's main benefit is it utilises a brushless motor, so draws just over six Amps during use – considerably less than comparable units. It also has a digital controller with a six-mode emergency shut off, which will be required by NASCAR for all electric pumps once they are introduced. The pump will also operate with the existing carburettor set ups, requiring only 2.5 Amps when used in that configuration. The motor can also be purchased separately to convert existing Waterman Racing cable-driven fuel pumps.
For more information see www.watermanracing.com

HARDWARE

STAGE 8 FASTENERS

US COMPANY STAGE 8 has enlarged its range of locking fasteners to include more motorsport applications. Vibration, intense heat or cold and shock account for most fastener failures in the high stress motorsport environment and Stage 8's patented mechanical GrooveLock bolts can help prevent such occurrences. All bolts are made from aircraft grade 4130 steel and have a Duplex nickel finish, while the retainers are 5052-H32 aluminium. Both metric and imperial fitments are catered for, while the company also offers a selection of application-specific kits for a range of engines.
For more information see www.stage8.com

DATA ACQUISITION

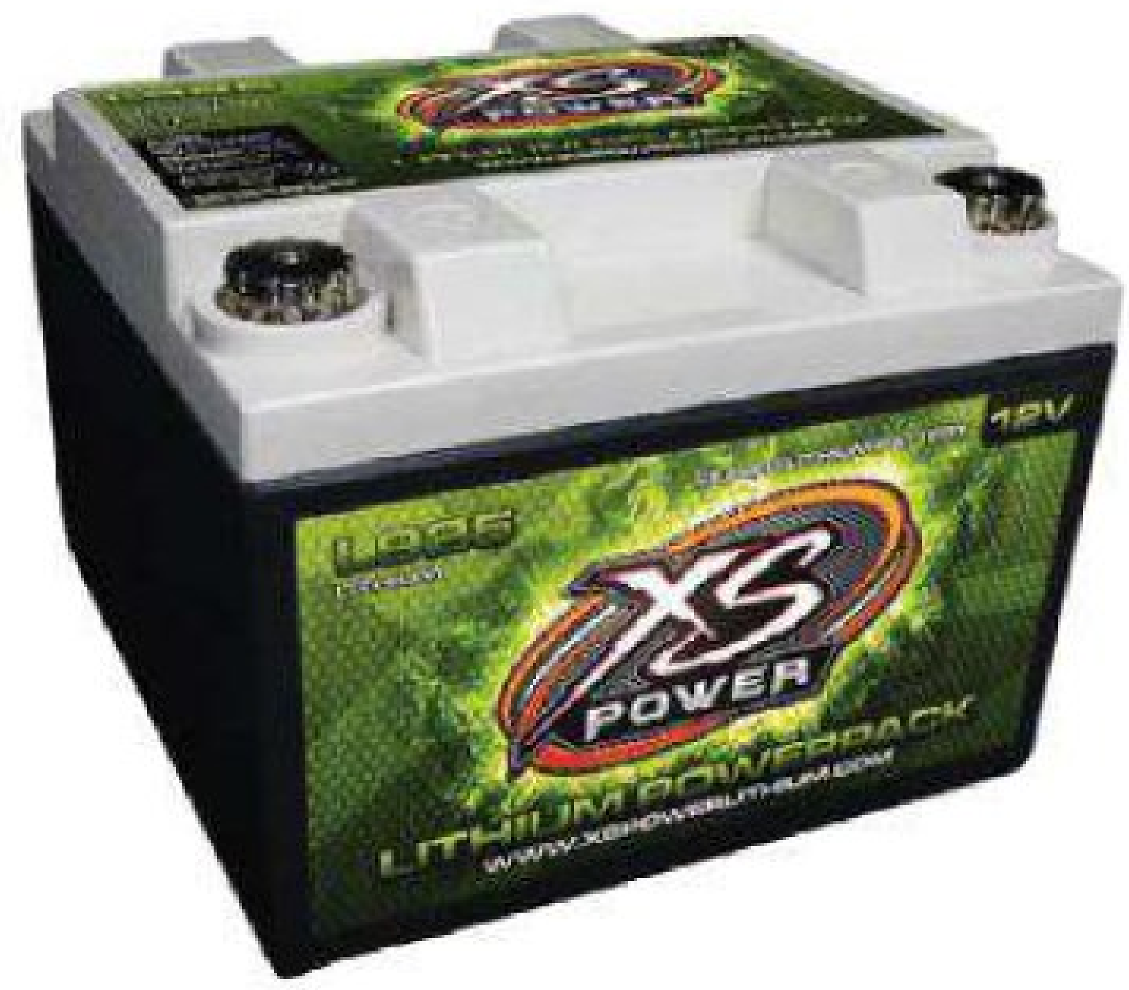
GET MD3-EVO LOGGER

THE MARKET FOR dashboard logger systems is constantly expanding, with units like this GET MD3-Evo Pro slowly but surely replacing conventional analogue gauges completely. The MD3 is capable of displaying all key vehicle data, as well as lap and split times, thanks to its in-built GPS based data logger, which features eight 0-5V analogue inputs, four 0-12V analogue inputs and five digital inputs. The dash unit is housed in a hard anodised aluminium case with a back lit LED screen and additional warning / shift lights around the periphery. All sensor and power wiring is routed through a Deutsch AS connector, except for the GPS antenna, which has its own dedicated cable.
For more information see www.getdata.it

HARDWARE

XS POWER BATTERIES

OVER THE LAST couple of years, lithium batteries have proven to be one of the most cost-effective ways to save weight in racing applications. The latest player to enter the market is XS Power, a US-based company that has so far focussed its efforts on the drag racing market. However, the company's new L and C series of batteries target all racing markets, from single seaters to rally cars. The L series feature a built-in microprocessor to monitor battery condition, including low and high voltage and overloading, while the more budget-conscious C series batteries do without the independent protection, but have a lower level of protection built into the cells. XS Power claim its lithium batteries provide a 40 per cent weight saving over lead acid equivalents.
More information see www.4xspower.com



TRANSMISSION

MANTIC CLUTCHES

AUSTRALIAN MANUFACTURER, MANTIC, is a relative newcomer to the motorsport industry, but its increasingly wide range of clutches is proving popular for high-power applications. Part of the reason for this is the company's unique grooved pressure plate design that the company says increases the mean effective radius of the cover plate, providing up to eight per cent more torque capacity. Single, dual and triple-plate systems are available for a wide range of vehicle applications, and Mantic also produces corresponding billet flywheels and hydraulic actuators for some applications.
For more information see www.mantic.com.au

DATA ACQUISITION

INNOVATE OT-2

IF YOU THOUGHT IPhone apps were simply for having fun, think again. US-based Innovate Motorsport recently unveiled the OT-2, a device that allows data to be collected from a vehicle's OBD socket and analysed wirelessly using an IPhone app. The OT-2 simply plugs into a vehicle's diagnostics port and, using its built-in wireless transmitter, sends it to your IPhone, where it can be viewed using the free LogWorks app. This software allows users to scan for vehicle faults, view key engine data and undertake performance calculations based on the vehicle's onboard data systems. The OT-2 can also be used in conjunction with Innovate's LC1 wideband lambda controller for accurate measurement of air / fuel ratios.
For more information see www.innovatemotorsports.com

ELECTRONICS

RACE PAK PCM

PCMS (POWER CONTROL MODULES) are becoming increasingly important as racecar electronics become more and more complex, and CAN Bus systems can now be found in cars competing at all levels of motorsport, right down to grass roots level.

The latest company to join the market is US-based RacePak, with its new, fully programmable SmartWire module. The unit features a total of 30 output channels, made up of eight 20 Amp channels and 22 rated at 10 Amps. All of the channels can be user-defined for function, output voltage and maximum current limit using the in-built USB interface. The SmartWire package also includes a dedicated switch panel to cater for basic vehicle functions, while additional panels can easily be added with the use of jumper cables.
For more information see www.racepak.com

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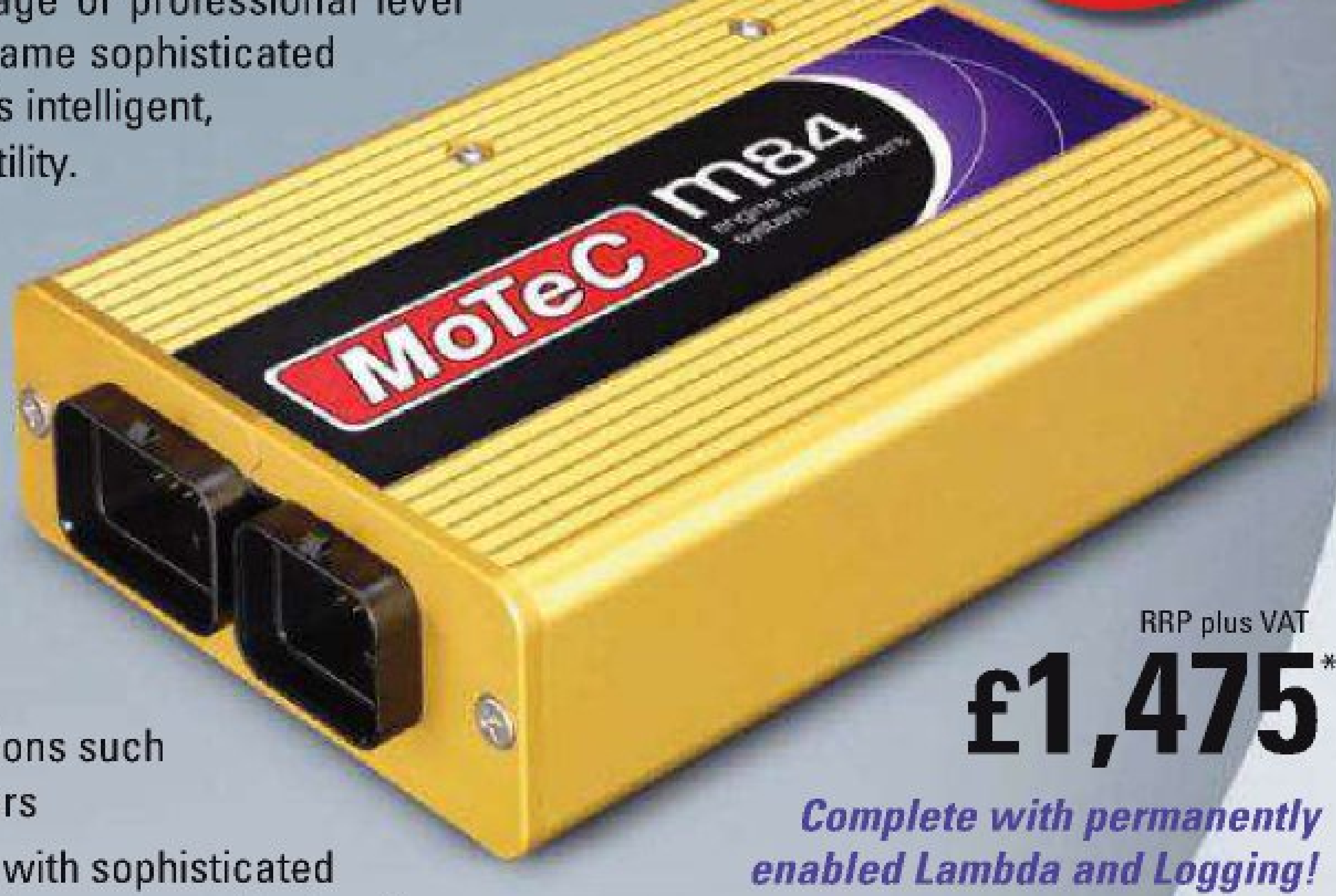

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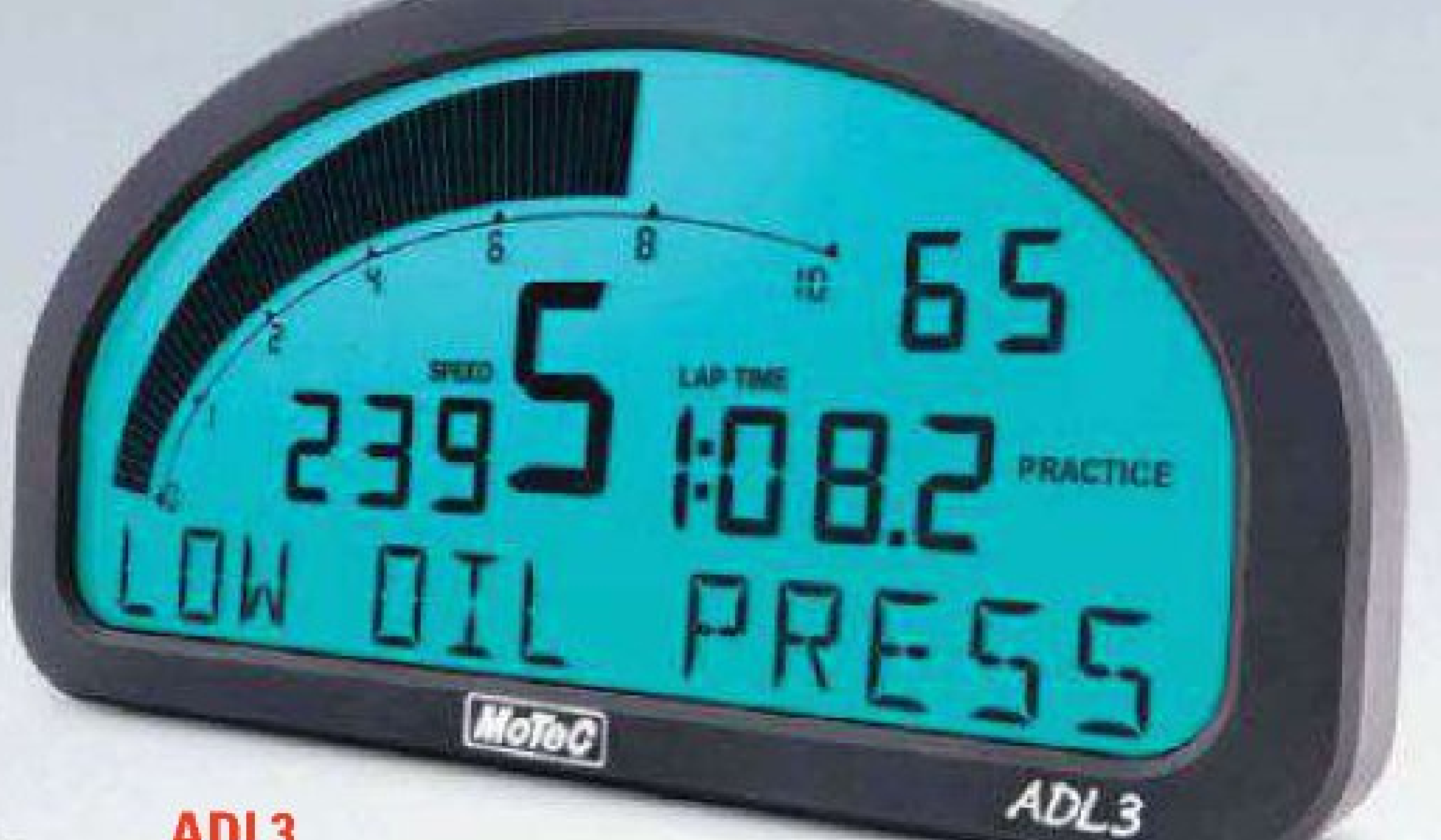

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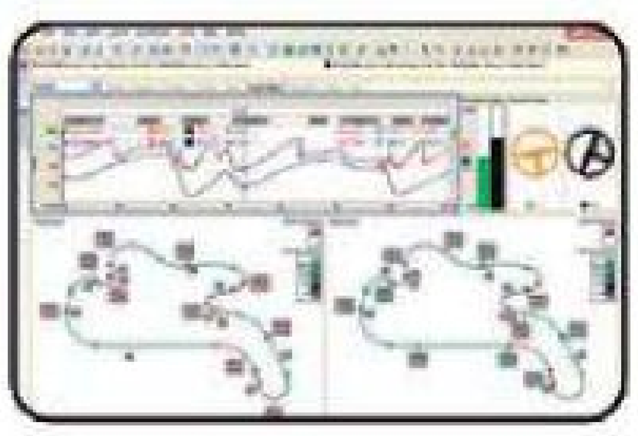

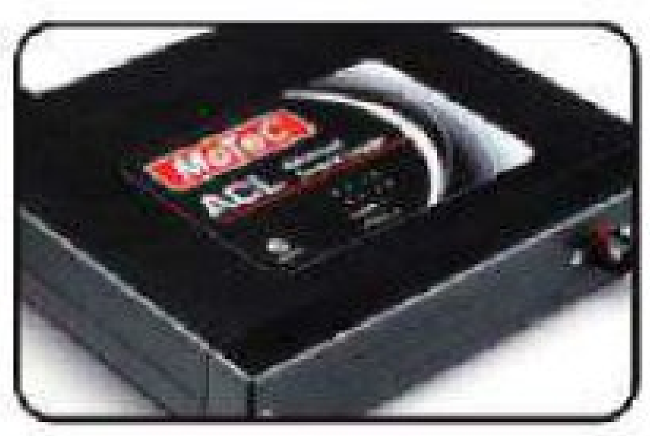

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MoTeC

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Tread carefully

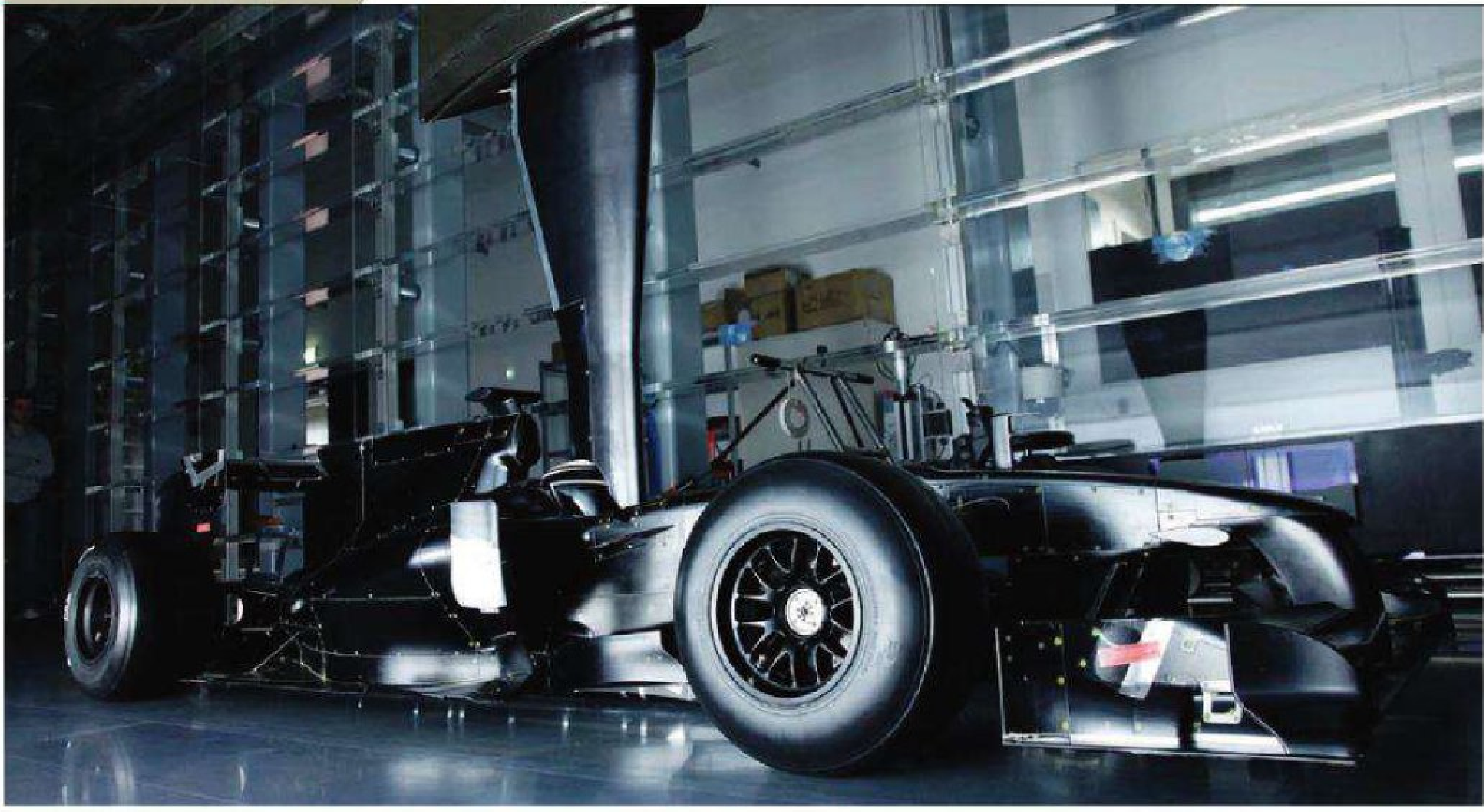
Formula 1's switch to Pirelli tyres represents the most significant technological change for 2011. *Racecar Engineering* asks the Italian tyre manufacturer how it has prepared for the task ahead

BY SAM COLLINS

This year's Formula 1 cars look fairly similar to those of 2010. They are dimensionally identical and, aside from the return of kinetic energy recovery systems, they have no major mechanical changes. But one thing that will be common to all of the cars is the removal of Bridgestone branding from the sidewall of the tyres, replaced by bright yellow Pirelli P-Zero logos. To the casual observer, it might seem that these visually similar tyres have just undergone a re-brand but, in reality, it is the most significant technical change this season.

Pirelli was only announced as Formula 1's sole tyre supplier in June last year after Bridgestone announced its withdrawal in 2009. It gave the Italian firm just a few short months to design and construct a tyre capable of withstanding the extreme demands of modern grand prix racing.

'I had spoken with Bernie [Ecclestone] over the years just to keep in contact,' reveals Paul



Pirelli has also tooled up to provide rubber scale model wind tunnel tyres, which accurately replicate dynamic deflection, to the aerodynamics engineers

Hembrey, Pirelli's motorsport director. 'We spoke in March, and he asked if we would consider Formula 1, so we had some internal discussions and, at the same time, there had been some internal discussions with our company owner and we decided to go for it. It was a case of an opportunity arising and we went for it. In an ideal situation, we would have done GP3, followed by GP2, then F1, and essentially scale up over time, but we didn't have that opportunity.'

Pirelli already had an established motorsport production facility in Izmit, Turkey, which was orginally opened to supply World Rally Car tyres, and it was decided to upgrade it to construct the Formula 1 tyres, although a lot of R and D work would have to be done before the Turkish staff could turn out any grand prix rubber. 'Certain work we had to commence in parallel with the ongoing negotiations before the deal was done, but in terms of physically making tyres it was a very tight thing,' Hembrey explains. 'We are lucky in the sense that we are a high performance tyre manufacturer already, so we have a lot of technology in house and a lot of simulation tools, which enabled us to prepare rapidly for the challenges of Formula 1. That's where we are at now.'

DESIGN CRITERIA

A number of design criteria were given to Hembrey's team by the Formula One Teams Association and the FIA, but the Pirelli engineers also had input into the specification. 'There are a number of elements at play when you design tyres. Obviously, there is the profile of the tyre and the materials used to construct it, but you also have external factors, such as the range of different chassis and circuits the series visits,' explains Hembrey. 'The first thing we were trying to fix was the profiles, so we did a lot of FEM to derive the best solution. That was step one. We had a number of meetings with the teams and there was a FOTA working group for the F1 tyres, and they gave us some broad design desirables for the tyre characteristics, which we used to an extent. We managed to sort the profile very rapidly and, since then, have been perfecting the internal structures and the compound choice for the different circuits.'

'The profile is critical as it defines the contact patch and, as a tyre maker, you want that to be nice and even,' adds Maurizio Boiocchi, Pirelli's R and D director. 'It is about preventing temperature build up and not overheating the compound. It's a work of art but, at the same time, it is a work of science.'

There are many similarities with the development of a modern car and the tyres it runs on, not least in the use of simulation technology. 'Our modelling is really very advanced. We have been developing it over the last 10 years, and now we are able to simulate a lot of tyre characteristics, the contact patch, the friction coefficient, the cornering forces, high-speed rigidity, rolling resistance and all of the items connected with fatigue in any part of the structure,' reveals Boiocchi. 'We did a huge amount of this before building up a prototype tyre. It is very similar to what happens with simulation on a grand prix car where they model every characteristic. A few days ago, I had the opportunity to evaluate the tyres on a car that doesn't yet exist with one of the teams. That helps us with the trade off between the different characteristics.'

> "the wear rate has been engineered to be higher than in 2010"

One of the key areas the Pirelli engineers focussed on was the stiffness of the tyre, both static and dynamic, not so much for the tyre's actual performance, rather its shape. 'This is not so important in the road cars, but is critical in racing. It would have a dramatic impact on the aero if the tyres were changing too much with the speed and load. A lot of things were given to us by FOTA, making sure we are careful about certain details around that, so we studied it in the simulation.

'The teams also supplied us with a large amount of dynamic data – the general dynamics of the vehicles and what was expected from the tyres, including cornering rigidity and vertical rigidity, because the biggest single stress is aero induced. And 1mm change in the tyre shape is a huge amount for them. With the vertical load changing so much with the speed and chassis to chassis it was a key point of attention,' continues Boiocchi.

SCALE AERO PROGRAMME

Formula 1 teams place unique demands on a tyre manufacturer due to their reliance on aerodynamics, and for many years the rubber suppliers have supplied them with scale tyres to use in their wind tunnel programmes. However, in the

The proven Toyota TF109 was chosen as the test car to develop the tyres. It was modified by Toyota engineers to replicate the dynamics of the 2010 models

past these were always metal, which meant they were not to the precision the teams' aero engineers demanded. What was wanted was a supply of scale rubber tyres, which accurately replicate the shape of the real thing (including the bulge) when running in the tunnel. Understandably, this was a major task for the Pirelli engineers, as Hembrey explains: 'We have to provide 50 and 60 per cent scale tyres, which have to replicate the rigidity exactly. It is a bit of a challenge because it's a product you just don't make for anything else. And because the inside of the tyre is nothing like the real thing - it runs at basically no inflation pressure - what you focus on is trying to replicate that dynamic deflection. That has probably been our biggest challenge in many ways, but we are now very close. We are working with the teams on it and they are giving great feedback. We have done a number of iterations, and each time we are perfecting it, but it has such an impact on aero performance it just has to be right. We are trying to do in three or four months what others spent three or four years doing.'

> The profile is critical as it defines the contact patch

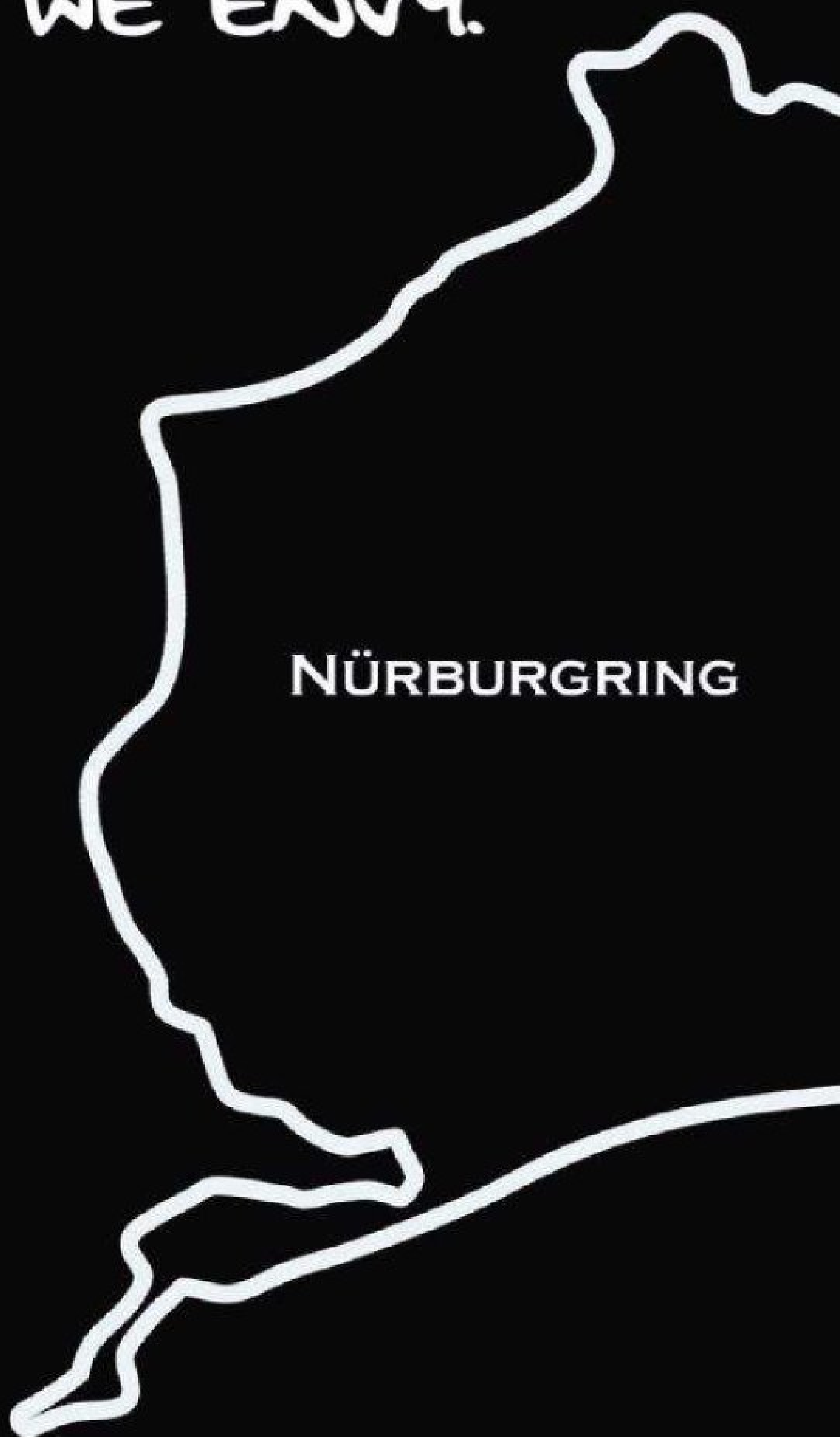
The teams also placed demands on the tyres' characteristics on track, while the FIA made requests regarding the tyres' durability.

'We have done a lot of work on the front tyre, as we were asked for a more robust and aggressive front tyre in terms of turn-in feel, and that was something we had as a focus. We provided that, so we now have to balance the rear tyre so the cars are not too strong on the front end. We were also asked that it perhaps not be as durable as the 2010 tyre after one car did nearly a full race distance without changing,' reveals Hembrey. Sebastian Vettel's run at the Italian Grand Prix saw the Red Bull driver stop at the start of the final lap for his mandatory pit stop, something that raised eyebrows in the paddock, and something we are unlikely to see this season, as Hembrey explains: 'I'm guessing we will have a number of races where two tyre changes will be required, as the wear rate has been engineered to be higher than in 2010. The engineers are different, though. They would like one set of tyres, then concentrate on the car, but the team principals think differently! It is a different design input. We could make them last the whole season, but we also want entertaining races!'

Front tyre compound is more robust and aggressive for more turn-in feel

AVAILABLE COMPOUNDS

Eventually, four compounds of slick tyre were decided on, split up in the same way the 2010 tyres were: super soft, soft, medium and hard. During each race, two compounds will be available to the teams, which Pirelli will select from the four available. These are officially known as the prime (harder) and option (softer). 'Chemically, the compounds are quite different in terms of recipe, though mechanically they are quite similar in terms of basic concept and construction. What is common to the F1 compounds is the balance between the polymer and the filler, and the difference is in the sticky components, but the basic processs is the same and is very sophisticated and unique [to Pirelli]. Some of the tyre relies on technology we have used in other competition, parts of it are totally innovative for F1, but derived from some other technologies we have been developing in recent years. But we can't go into much detail on that,' adds Hembrey inriguingly. 'The compounds may change during the season as we learn. The teams have suggested doing some running on Fridays or doing young driver testing on the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THE WET CHALLENGE

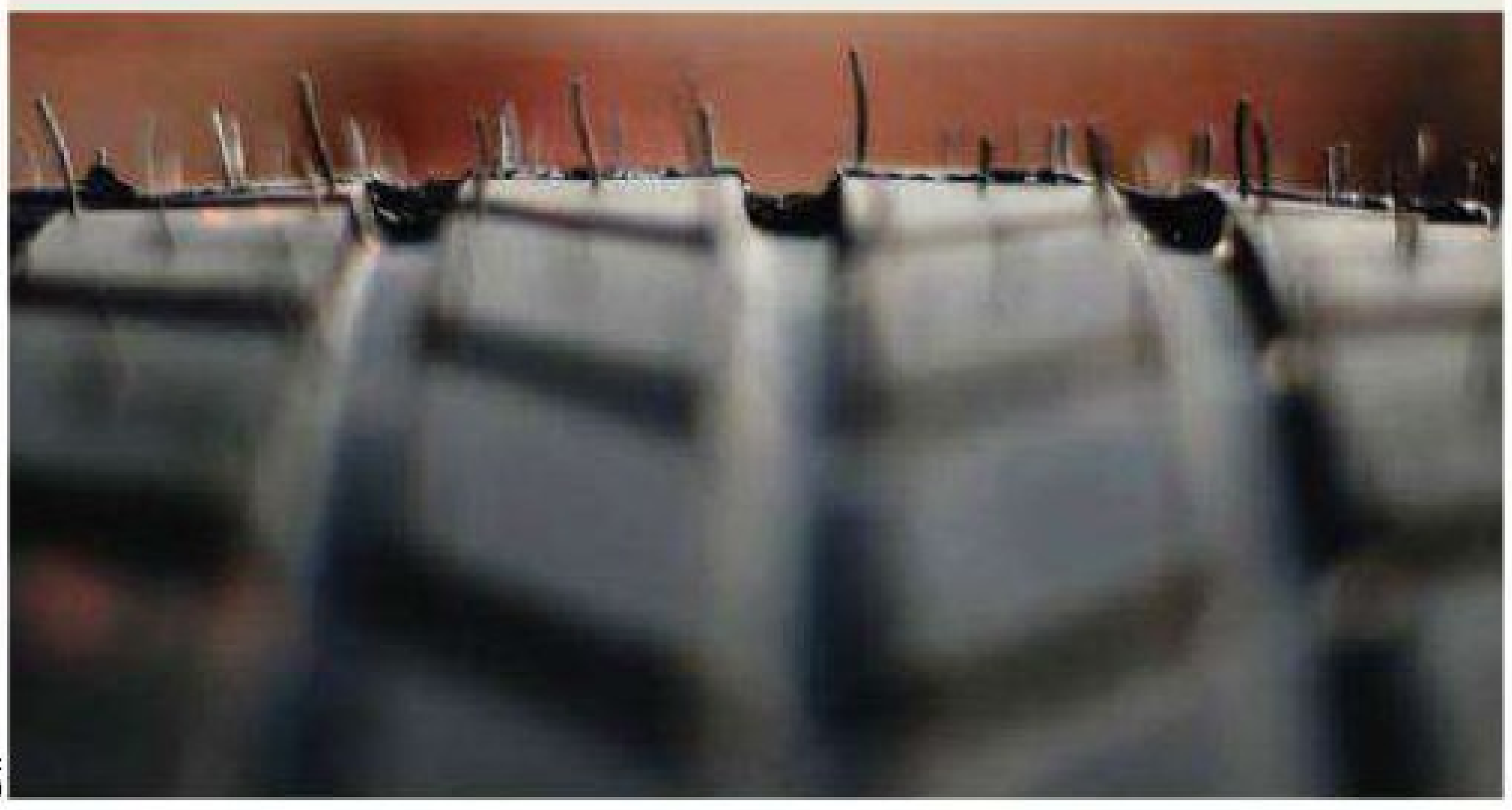
LAT

In 2010, wet weather played a critical part in a number of races, notably in Korea, and it is something Pirelli has had to tackle, with both a full wet tyre and an intermediate. Pirelli R and D director, Maurizio Bolocchi, explains the development of these treaded racing tyres.

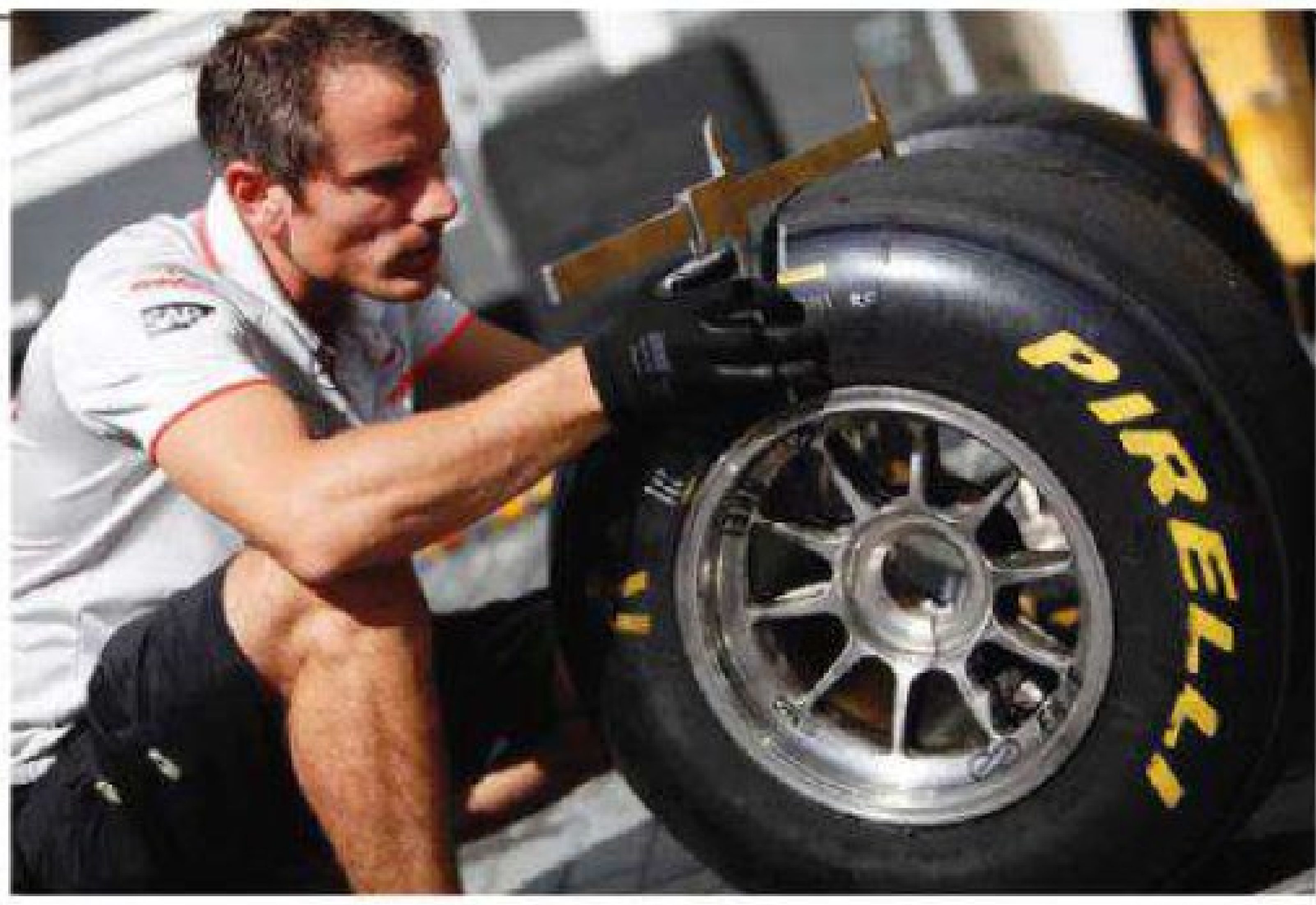
'The big challenge with a wet tyre is that Formula 1 is unique in having two wet scenarios – hot wet in somewhere like Singapore, where the ambient temperature is around 25-30degC, and cold wet somewhere like Silverstone, where it can be just 10degC, so you have to have compounds that resist very high temperatures, yet still work at the very low ones. To understand changeable climatic behaviour, we are having a wet test in Abu Dhabi, under the floodlights, which is a first. That is designed to simulate a 25 degree ambient temperature, and we have to do it at night so the water we spray on the circuit doesn't evaporate!

'With the tread patterns, you have to manage the deformation of the blocks. We measure that, we simulate the deformations and we have to balance between water displacement and stiffness, otherwise you have not got any good feeling. The best [compromise] is to have enough cornering force, while having enough wet drainers for these speeds.

'To get the shape, we have modelling tools similar to those used in aerodynamic programmes but, in this case, the fluid is not air but water, and you can simulate many different design iterations. To see at the rear what effect running more camber may have, you look at the footprint, so you balance the water dispersion characteristics with cornering force.'



LAT



Working in conjunction with Toyota Motorsport also gave Pirelli access to one of, if not *the* best, research and development facilities in motorsport

Mondays following races at some circuits if we decide we want to do some developments.

'It would be arrogant or naïve of us to expect to get it perfectly right when there are some tracks we have never been to, either because they are new [India] or because they are street circuits. There may be some circuits where we have quite agressive tyre wear, but the teams will just have to modify their strategies to manage that.'

By August, the tyre specification had been finalised enough for the Izmit factory to start producing the first prototype sets and, by the middle of the month, the tyres were run on track for the first time. To remain neutral, Pirelli opted to work on its test programme with Toyota Motorsport, which gave it access to arguably the best R and D facility in the world, as well as a number of modern, reliable and available F1 cars. However, rather than using the potent yet unproven TF110, Pirelli decided to utilise an older type.

'We were not sure about the reliability or performance of the 2010 car as the team had not run it at all,' explained Hembrey. 'The TF109, on the other hand, was a known and reliable product, so it was an ideal test bed.'

Toyota's Cologne, Germany-based engineers modified the TF109 to replicate 2010 characteristics, which involved increasing and re-distributing the weight to replicate the longer wheelbases and full fuel tanks of the 2010 designs.

As you might expect with a test platform, the Pirelli TF109 is heavily instrumented, as Hembrey explains: 'During testing, we have been studying the combinations of things like temperature, pressure and wear. If you look at the test car, it is loaded with sensors, thermal scans and as many data channels as you could imagine. In terms of load cells, we know everything that is going on with the chassis, and everything that is going on with the tyre. But the race teams are reluctant to do it as it adds to the weight, so the Toyota and GP2 test cars have essentially become dynamic cornering force machines. It gives us all the data of how the tyre is performing in a real world dynamic situation. In a race situation, the data is not as comprehensive, but it's just as important because you need to understand if a given chassis is using the tyre in a different way to another, and in a certain circuit or certain corner the differences can be quite remarkable. With Toyota Motorsport we were able to use a lot of the technologies they developed in house, and the best facility there is. We were very lucky from that point of view.

> **"It is about preventing temperature build up and not overheating the compound"**

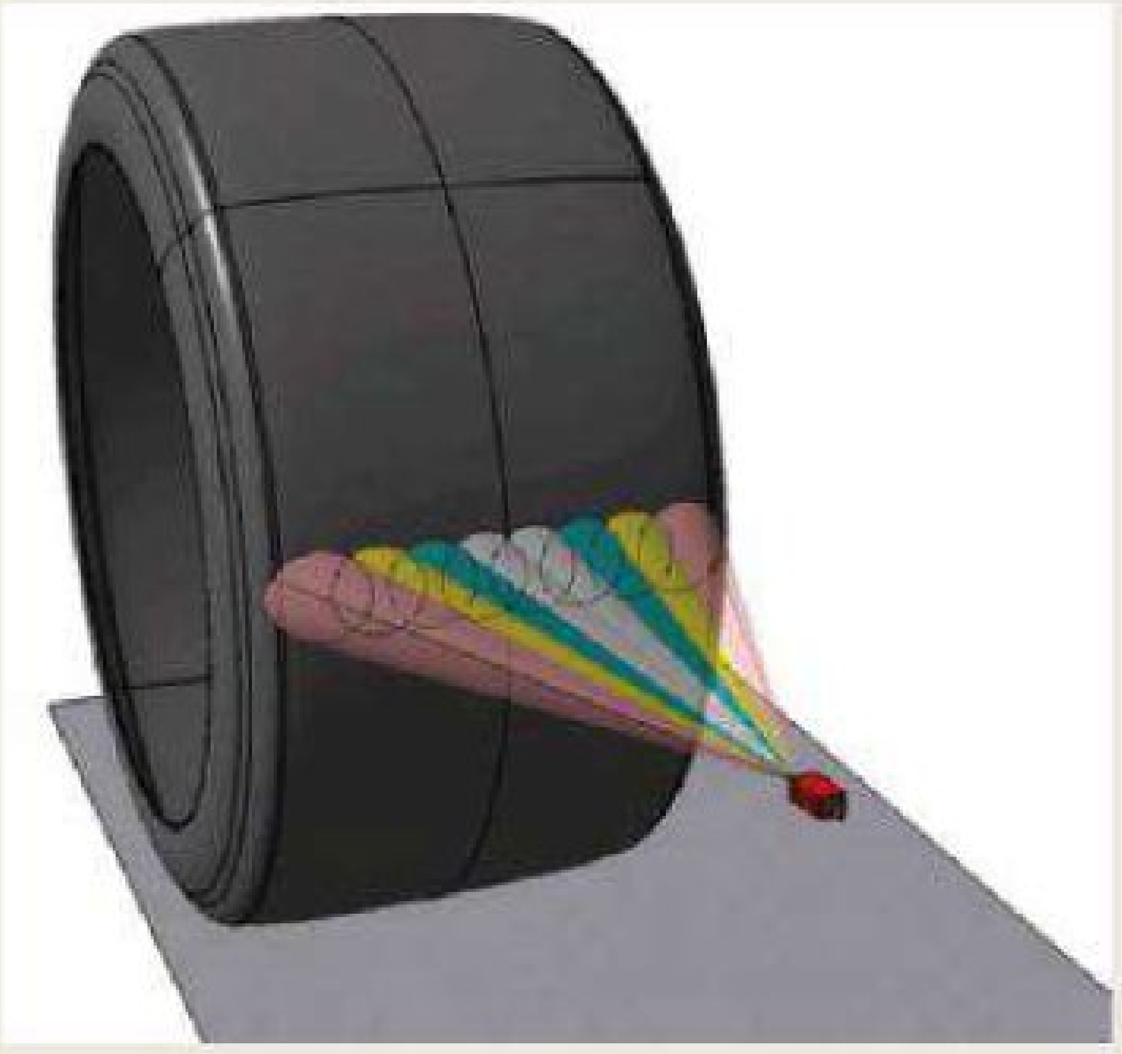
There is no substitute for

TYRE DEVELOPMENT TOOLS

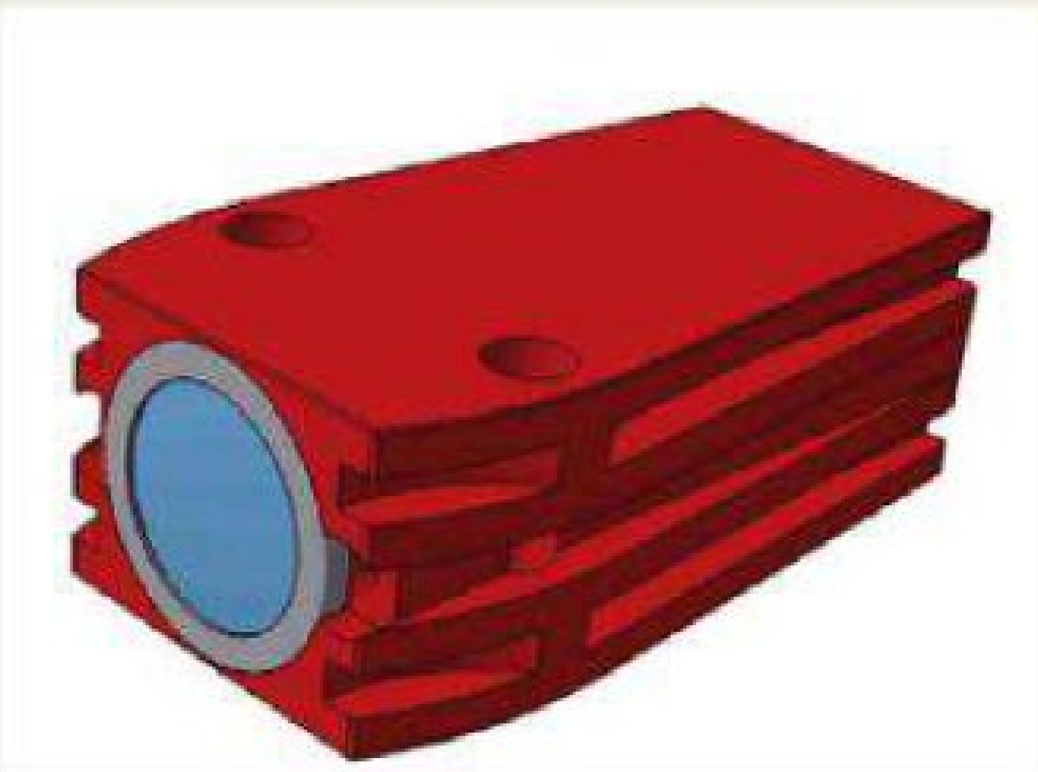
The teams will be using all available equipment and technology to help understand how the new tyres are behaving. One such device that will undoubtedly be seeing some pit lane use is the new, eight-channel tyre surface temperature sensor from Texys. The IRN8 was developed specifically for Formula 1 application and measures a line of eight spots across the tyre surface, showing temperature distribution right across the contact patch.

It is most accurate at 180degC (+/-one per cent FS), and is very small indeed, measuring just 31 x 11 x 17mm and weighing 15g with cable. With a mounting distance between 200 and 700mm (ie on the car floor facing the rear tyre),the IRN8 can give a reading across a total width of between 152 and 532mm in 260 milliseconds at 200degC.

The Texys IRN8 is available with a -20 to +200degC range and with a supply voltage from six to 16V.



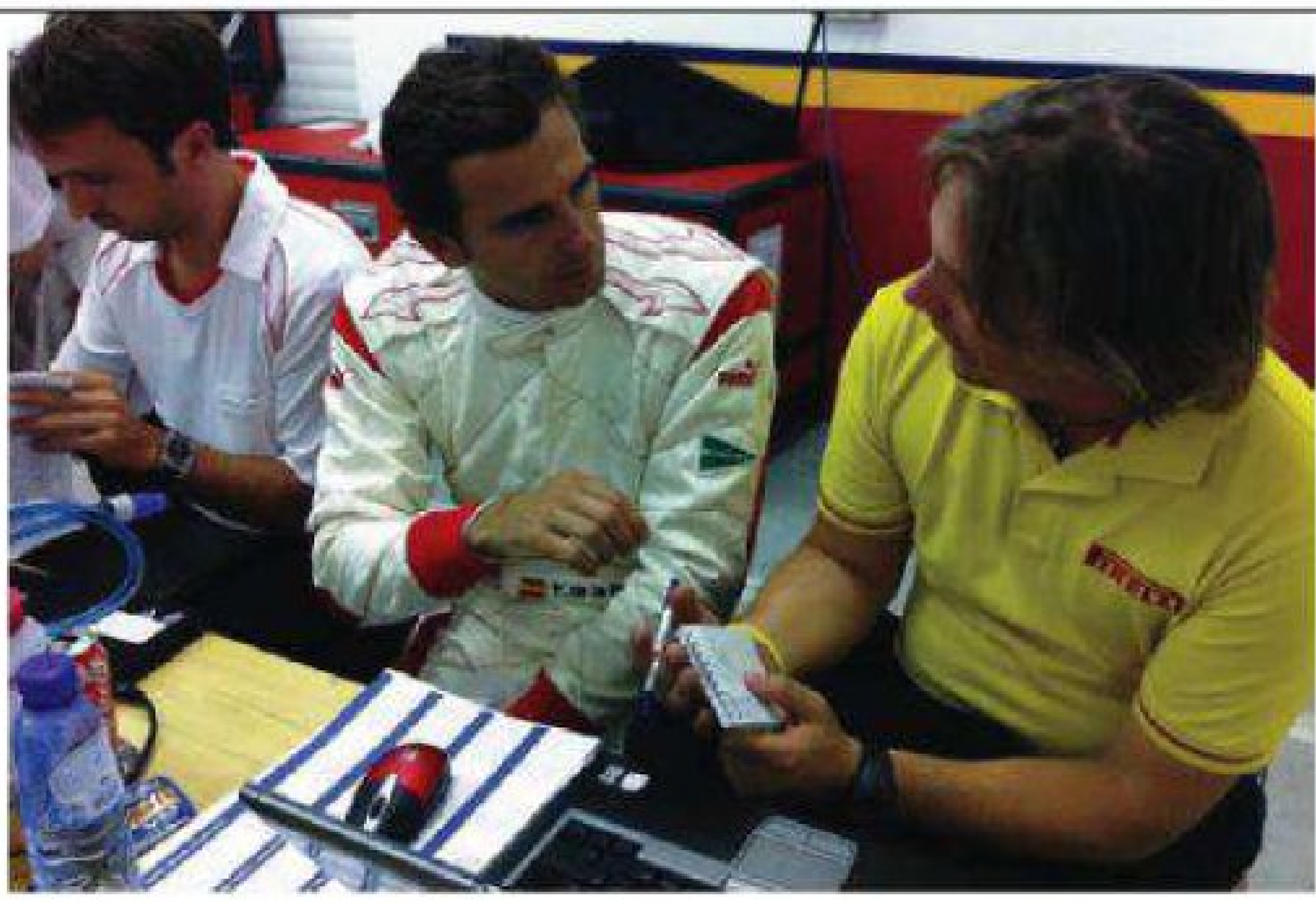
The Texys tyre surface temperature monitor measures eight points at once across a tyre's surface



At just 31 × 11 × 17mm and 15g, the sensor is easy to integrate into a car's electrical system

Another thing some teams have been doing is feeding the tyre model supplied by Pirelli into their simulators, among them McLaren, which has already been testing its 2011 MP4-26 with Pirelli tyres, despite the fact it has not actually built the car yet.

Teams will take data from devices like Texys' IRN8 (above), combined with information from the seven-post rig and real-world testing conducted in Abu Dhabi, together with the data supplied by Pirelli, to try to build the most accurate model possible of the tyres they will be racing on. With two tyre stops likely in some races this year, it's probable the team that creates the closest simulation is the one that will be at the front of the field.



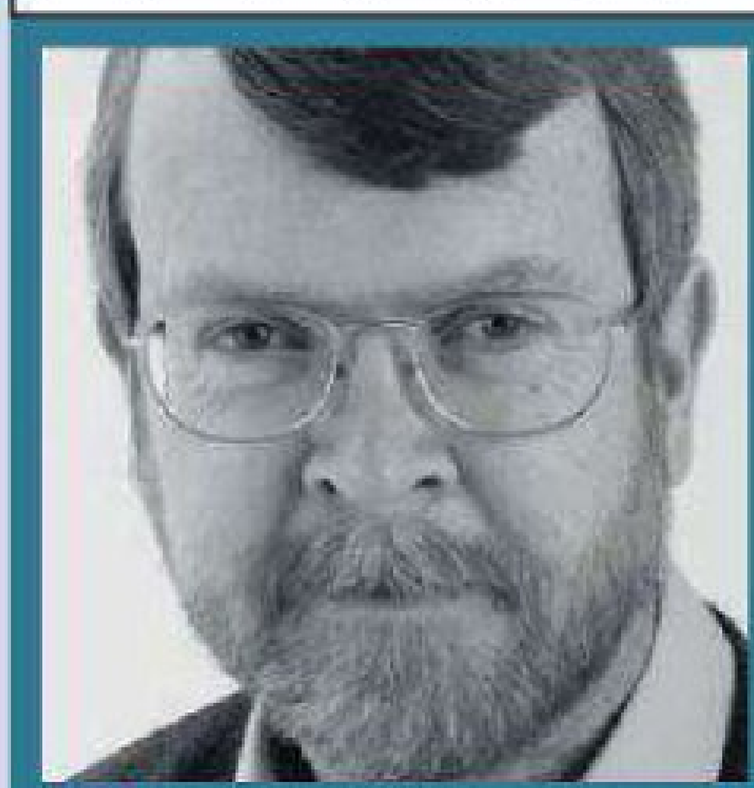
Driver feedback was also a critical component in the tyres' development

testing. You can simulate all you want, but the fine tuning requires an experienced driver like Pedro De La Rosa or Nick Heidfeld, plus a younger driver like Romain Grosjean, and those three drivers have given us great feedback. It was very similar, if not identical, between them, so that has given us confidence in our simulation. You do need to go out and try things, especially with the compounds, and some of the circuits are very abrasive, so it lets us be sure of the structures and the wear. Without the dedicated test vehicle, it would not have been possible to get the tyres ready.'

As well as running the ongoing two-car programme with the Dallara and Toyota, a two-day test was organised following the Abu Dhabi Grand Prix at the Yas Marina circuit. It was the first time the teams had a chance to run the new tyres, just three months after rubber first ran on a car. 'The teams' engineers were very complimentary about what they saw on track, and how it compared with the data we supplied them,' Hembrey enthuses. 'For us, it was also great information as it validated our simulations. The data the teams ran was not as comprehensive as that from the Toyota, but it let us look at what loadings have been put into the tyres so we can understand better if there are areas of commonality between the chassis. In some ways the cars are similar, but in other ways very dissimilar. Formula 1 is very good at copying, though – if teams have gained an advantage, the others are very good at adapting the technology and catching up. So we have to be aware of any design trend that may help with our product design and devlopment. If we saw one thing after the Abu Dhabi group test, it was that the cars were running quite high camber compared to what we had been used to, but equally, different products have different camber and pressure sensitivity. Perhaps we went beyond what the teams expected, so we are now just doing a bit of fine tuning to get the rear slightly changed in terms of balance. The cars at Abu Dhabi were designed around a totally different tyre, so this year the chassis will be developed to suit the P Zero characteristics. We are not planning to introduce any changes, but we will take note of the tyre performance in the first few races and we will have an ongoing development programme with the Toyota.'

> **"We could make them last the whole season, but we also want entertaining races!"**

So when the flag drops at the end of the Bahrain Grand Prix on 13 March, just how much of a result does Hembrey think the change of tyres will have played? 'The teams that will start well will be the teams that have understood how to get the maximum out of our product the quickest,' he concludes.



FIRST PRINCIPLES

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

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Regaining balance

Refining the balance on a modified ALMS GT2 Porsche 997 GT3RSR

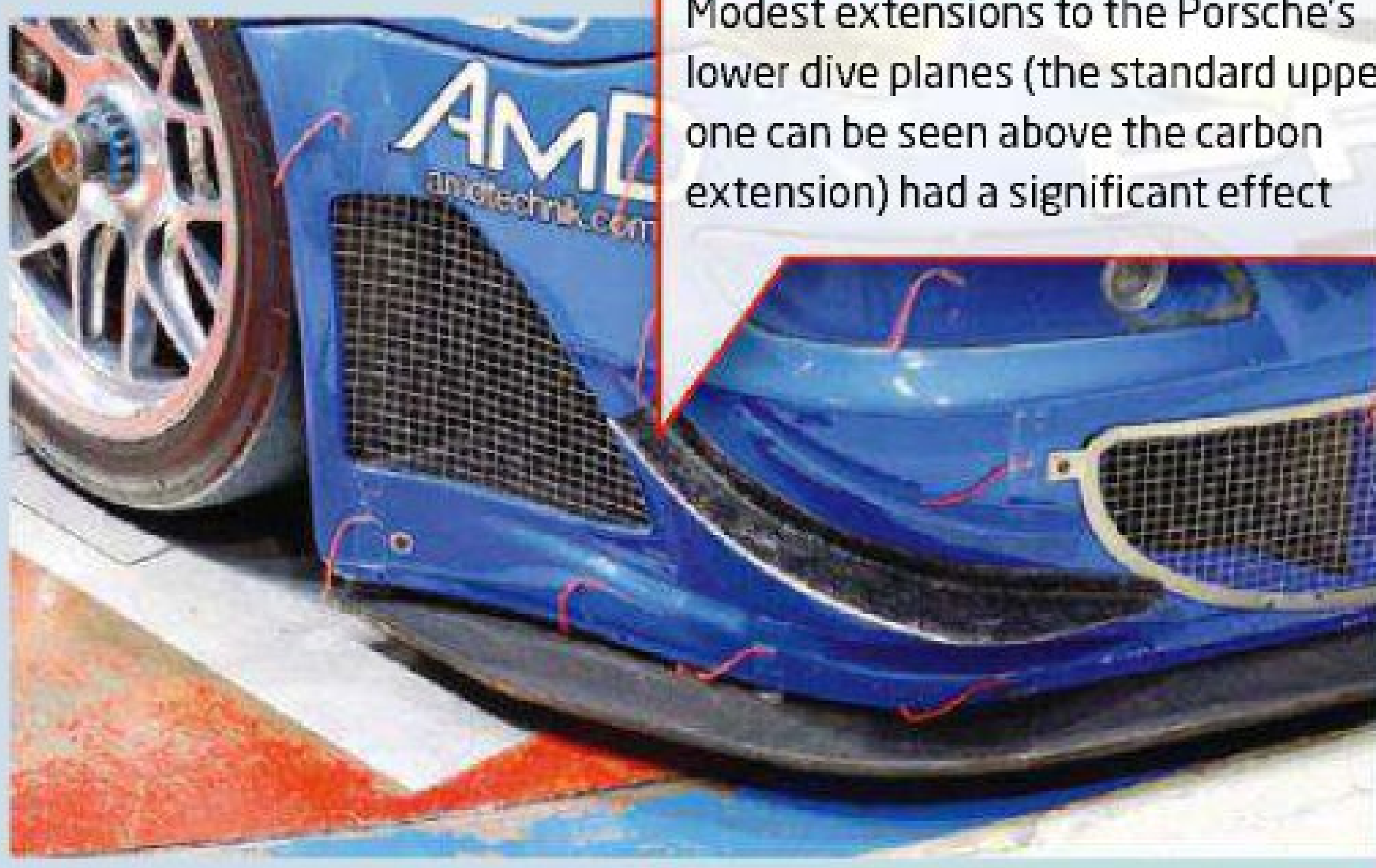
Continuing our insight into a session in the MIRA full-scale wind tunnel on the former ALMS GT2-class Porsche belonging to the Paragon Racing Team, this month we examine some measures taken to re-establish an aerodynamic balance with high-downforce settings as the car was modified even further from its GT2 class restrictions.

As regular readers will recall from our previous two issues, it was found that the initial aerodynamic balance was quite rear biased, and total downforce and efficiency were also lower than expected. Trials with various length front splitters brought front downforce up to a level that would balance the car better. But then swapping to a wider span rear wing that was located higher and further back on the car than GT2 regulations permitted added rear downforce, reduced drag and increased overall efficiency. Unsurprisingly, it also took downforce off the front wheels. Given the potential this replacement rear wing showed in attaining an overall higher downforce level at a higher efficiency level, attention was switched again to the front end to see what further modifications would bring the front downforce up again to balance the more potent rear end.

Clearly, the most efficient way of regaining the balance in this circumstance would be to fit a slightly longer splitter. At this point in the session, the team had tried three splitter variants, and the longest (75mm) was installed at this point. Had one another 20mm or 25mm longer been available, this might have done the job, as we had seen that longer splitters added front downforce with no extra drag. However, this option was not available on the day, so the next simplest available fix was to add dive planes. Although we have seen previously in Aerobytes that dive planes invariably shift aerodynamic balance to the front, they are not always the most efficient devices, so Paragon had brought along two variants to try – one relatively small extension to the standard items, and one rather extreme extension. The results are shown in table 1.

> "the most efficient way of regaining the balance... would be to fit a slightly longer splitter"

The first observation on these results is that the small dive planes had a marked effect, but the much larger ones had very little *extra* effect. So focussing on the smaller dive plane results,



DIVE PLANES 1
Modest extensions to the Porsche's lower dive planes (the standard upper one can be seen above the carbon extension) had a significant effect

DIVE PLANES 2
More extreme dive plane extensions had little additional effect over the more modest ones

Photos: S McBeath

these certainly shifted the balance significantly more onto the front wheels, adding over 24 per cent to front downforce, while knocking just two per cent off rear downforce. Drag increased by 4.8 per cent but, with overall downforce increasing by 5.7 per cent, there was a small increase in efficiency (-L/D). The balance was also almost in the target range of 35-38 per cent front and, compared with the configuration at the start of the session, which produced a balance value of 21 per cent front, the drag was almost identical, though downforce and efficiency were markedly up.

TABLE 1

The effects of adding dive planes

	CD	-CL	-CLfront	-CLrear	% front	-L/D
No dive planes	0.413	0.627	0.182	0.446	29.08%	1.516
Small dive planes	0.433	0.663	0.226	0.437	34.11%	1.530
Large dive planes	0.439	0.667	0.233	0.433	35.01%	1.520

TABLE 2

The final results compared with the starting configuration

	CD	-CL	-CLfront	-CLrear	% front	-L/D
Starting numbers	0.435	0.523	0.110	0.413	21.11%	1.203
Final numbers	0.439	0.705	0.245	0.460	34.79%	1.606
Change	+0.92%	+34.8%	+122.7%	+11.4%	+13.68	+33.5%

INCREASED EFFICIENCY

Some additional modifications were then made that all combined to add further modest amounts of downforce and increase overall efficiency. Adding side fences and a pair of intermediate vertical fences to the flat plane that constituted the GT2-restricted diffuser panel added a small amount of rear downforce and efficiency, but dropped the front per cent to 32.93 per cent.

Next, two variants of running boards were tried - shorts ones as shown and longer ones that extended to the rear of the front wheel wells. These added a small amount of downforce and efficiency, but barely altered the balance. And then a modified rear bumper was fitted that featured cutaway rear wheelarches and, somewhat perversely, this added very slightly to drag and generated a modest increase in rear downforce, together with a slight reduction in front per cent to 32.86 per cent!

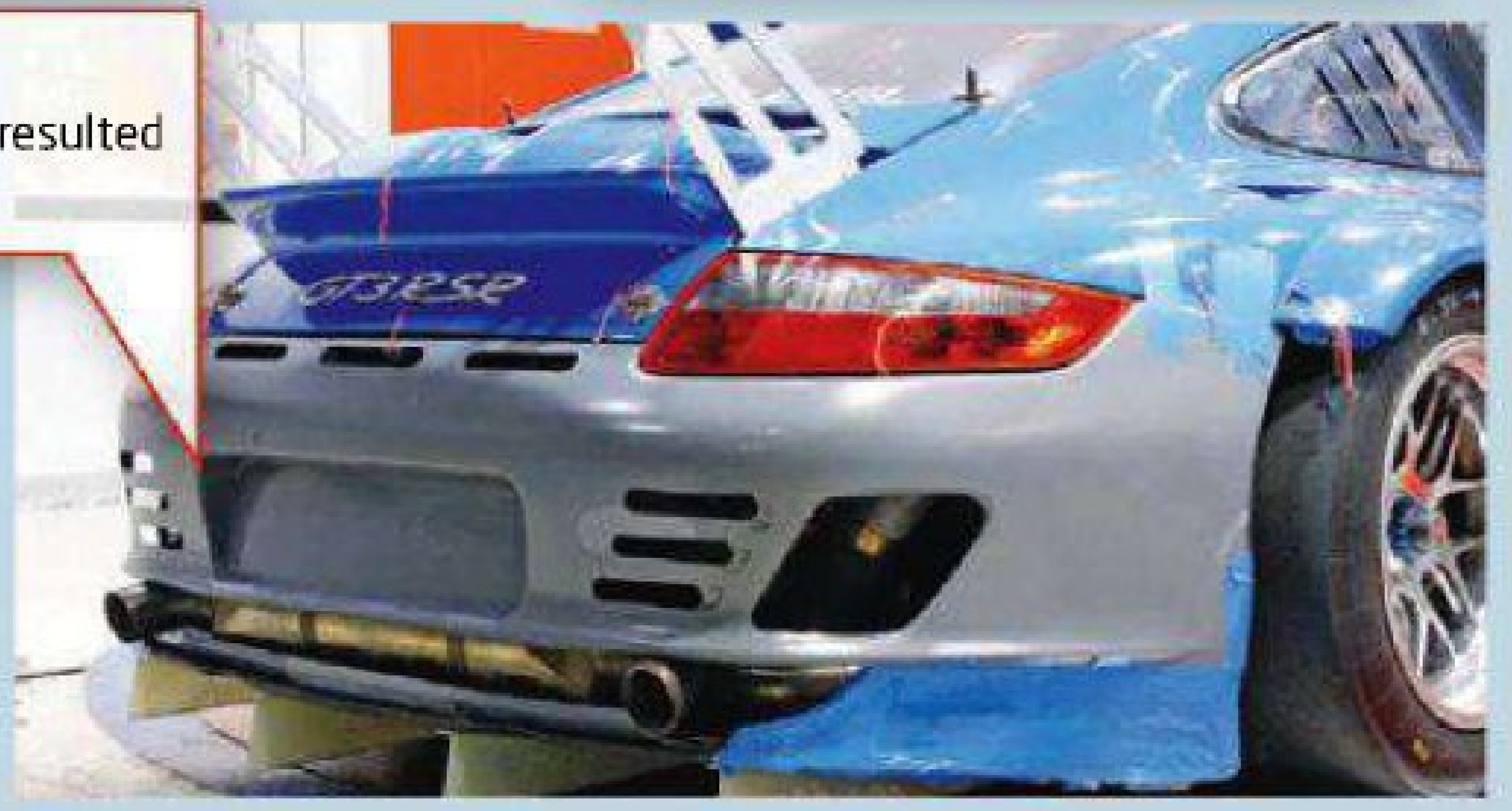
The important thing was downforce and efficiency both continued to climb as the result of all of these modifications, but one final change involved some rather crude attacks on the Porsche's bodywork with an angle grinder. Holes were opened up in the rear of the front wheelarches (inner and outer) to try and win a little more front downforce to achieve a reasonable balance. The modification, rough though it was, actually yielded another seven per cent front downforce. The final set of results is shown in table 2, compared with the configuration at the start of the wind tunnel session.

So, although most of the major modifications to add downforce were simple and obvious, given the additional freedoms allowed by the relevant regulations, and produced pretty much the expected effects, the final results were very satisfying for the Paragon team. Not only did the final configuration offer markedly increased downforce for a very small increase in drag, and an aerodynamic balance that was certainly in the right ballpark, but also some of the trends discovered along the way will allow still more downforce to be added in the future.

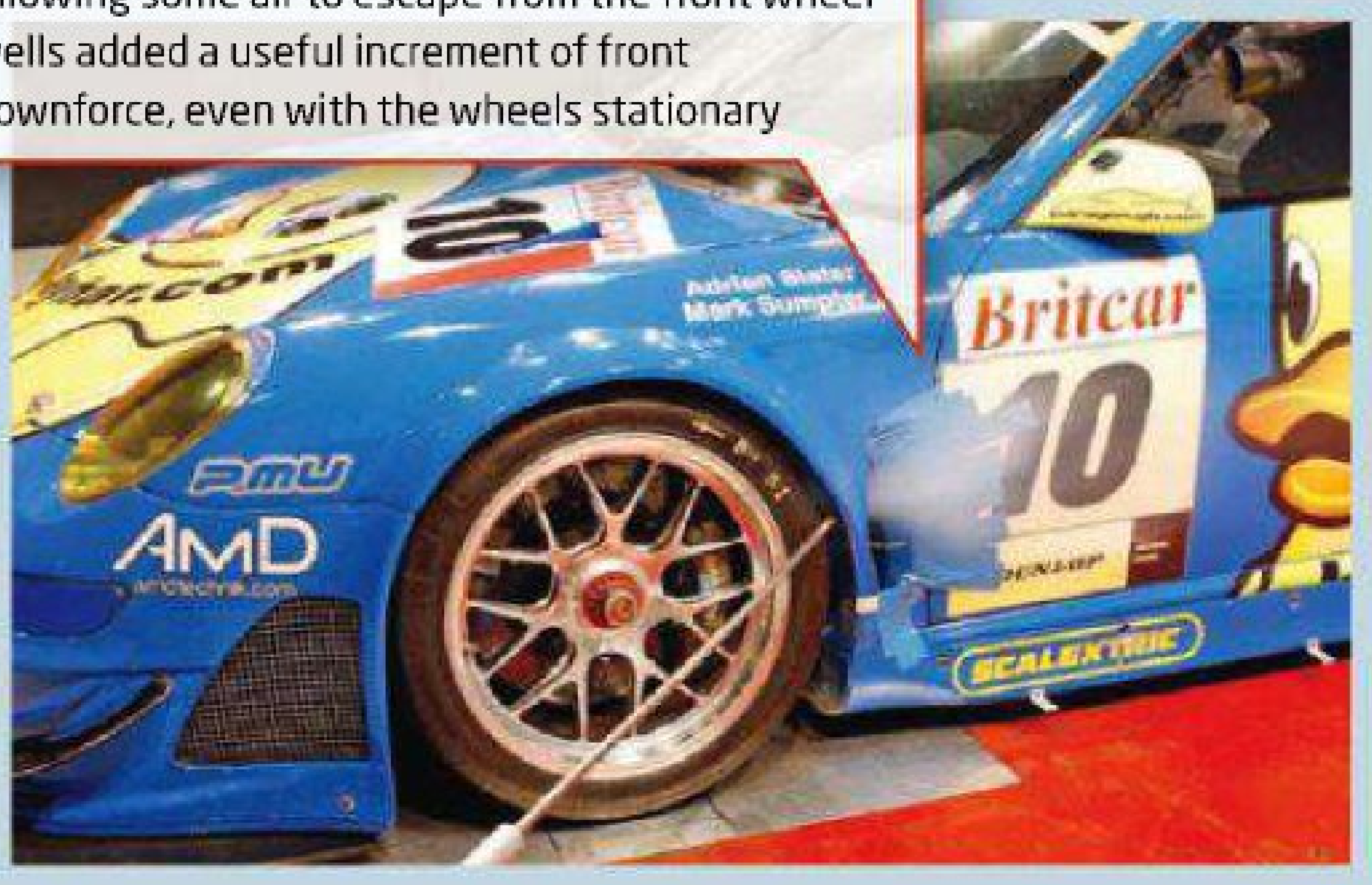
Thanks to Mark Sumpter and Phil Jose at Paragon Porsche.

DIFFUSER FENCES
Side and intermediate vertical diffuser fences produced a modest gain in rear downforce

RUNNING BOARDS
Short and long running boards were tested. These short ones were almost as effective as the full length ones



REAR BUMPER
This modified rear bumper resulted in more rear downforce



WHEEL WELLS
Allowing some air to escape from the front wheel wells added a useful increment of front downforce, even with the wheels stationary

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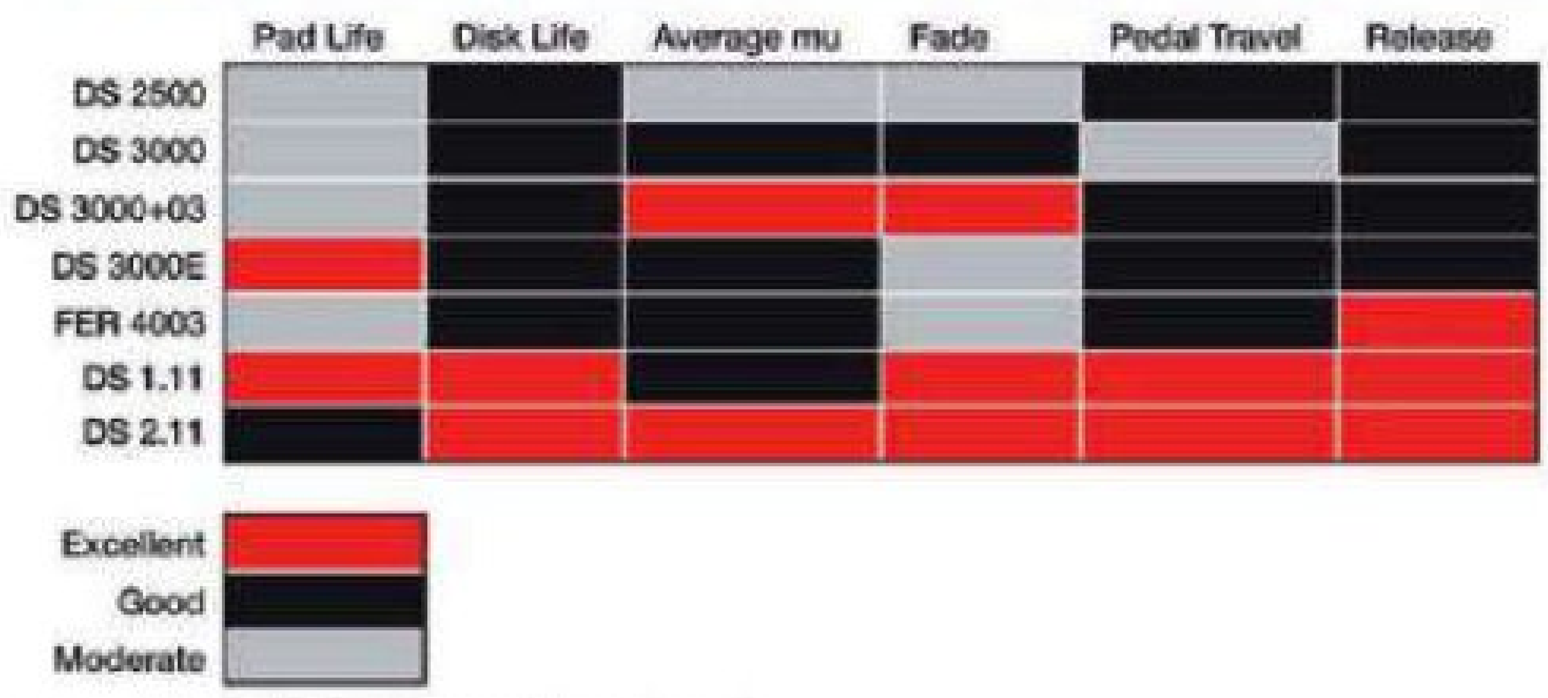

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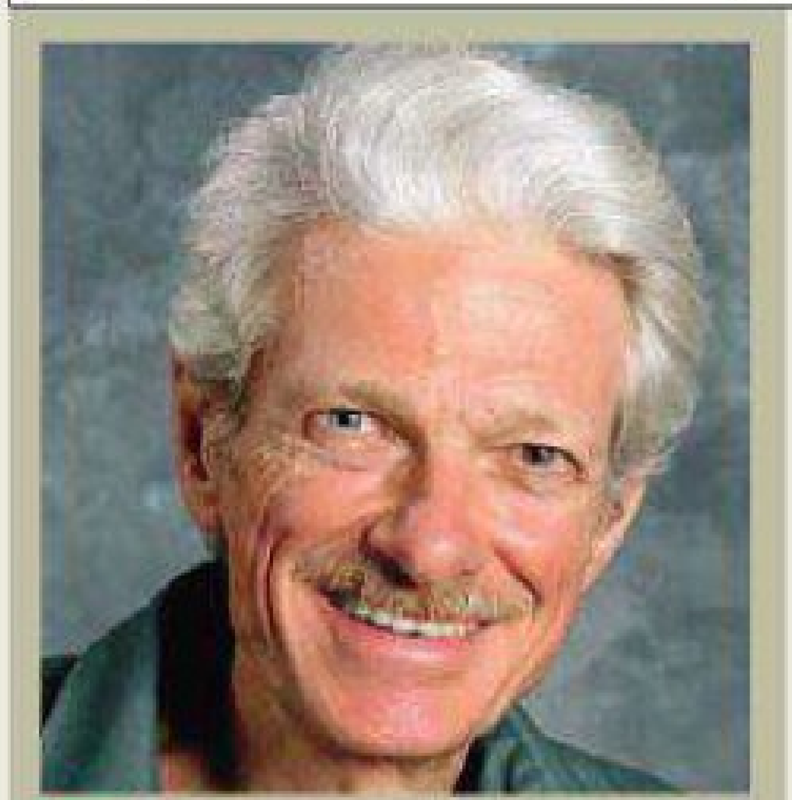

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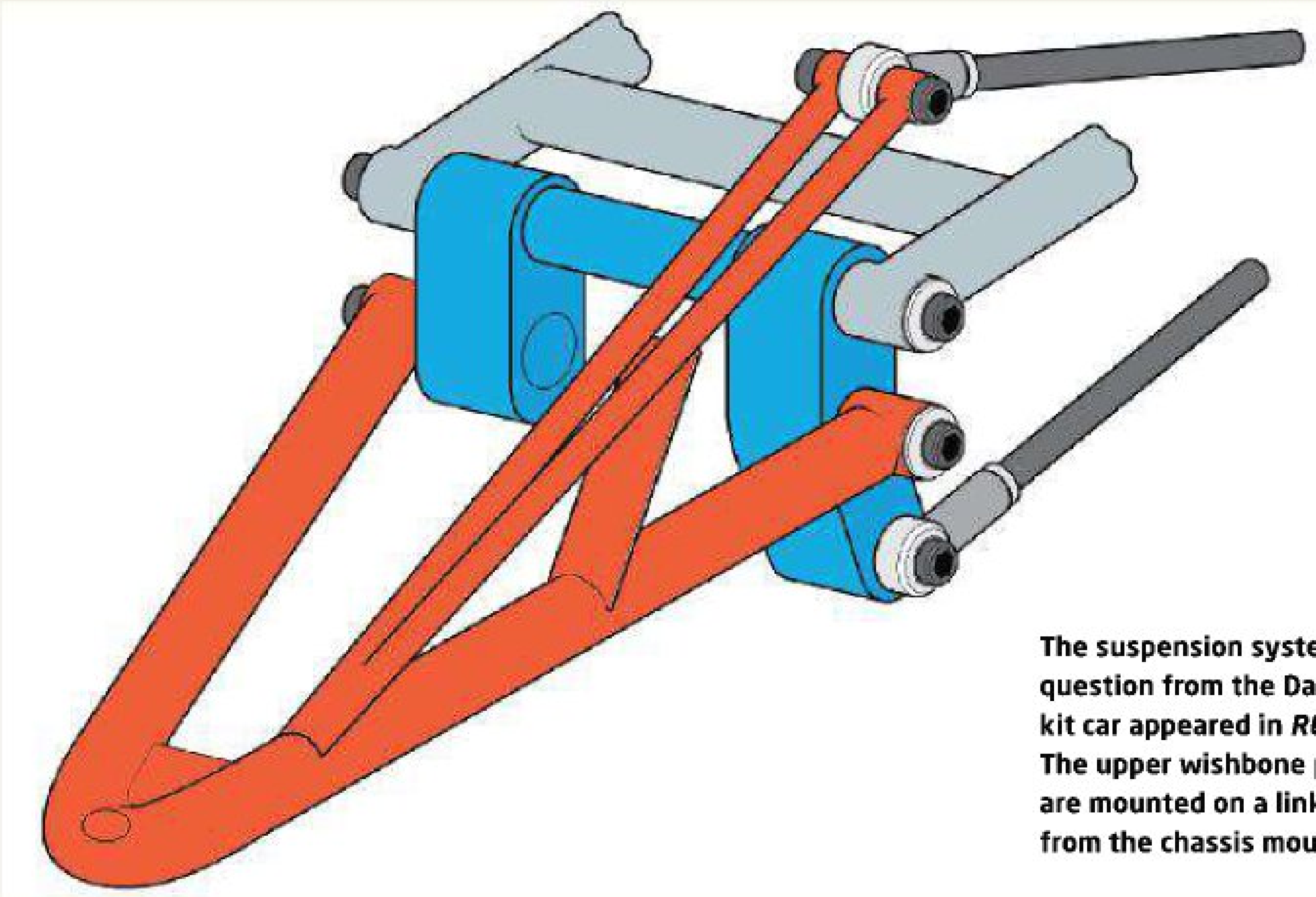


The suspension system in question from the Dax Rush kit car appeared in *RE* V11N6. The upper wishbone pivots are mounted on a link hanging from the chassis mounts

Jim Bamber

THIS MONTH:
Q Is it possible to have a suspension with zero camber change in both ride and roll?

A Many semi-independent designs can be configured to have a little camber change and scrub in both ride and roll, and lower roll centres than are commonplace with pure beam axles.

Semi-independent suspension

Q In your June 2008 Chassis Newsletter, you stated, 'With a passive independent suspension, it is impossible to have zero camber change in both ride and roll,' but I recently ran across an interesting article on a camber compensating suspension that was first published in *Racecar Engineering* in 2001 (http://www.locost7.info/files/suspension/dax/) that shows a system that looks like it does a good job of keeping camber very constant in both modes. I was therefore interested to hear your take on it.

I've started looking into ideas for building a car for the track. I basically want an FSAE car, stretched for the higher speeds of a road course, with more power. My target is 800lb, 175bhp with a Hayabusa engine. I'm looking to keep it simple and easy to fabricate and repair, and am leaning towards a monoshock on the front, with a torsion bar for anti-roll, but I'm not sure if that will be up to the task on the rear. I look forward to hearing your feedback.

A As may be seen from the linked article, this system superficially resembles a conventional short-long-arm (SLA) suspension. Unlike the SLA system, however, it mechanically interconnects the upper control arms in a manner that, in cornering, pulls the top of the outside wheel inboard and pushes the top of the inside wheel outboard, providing more camber recovery than the SLA. Indeed, it can have 100 per cent camber recovery in roll, just like a beam axle does (ignoring the component of roll due to tyre deflection), or even more than that if desired. It can, at the same time, also have no camber change at all in ride - again like a beam axle - or some moderate amount of camber change in ride.

This suspension is one of a family of layouts that look like what we traditionally call independent suspensions, but are not independent in the usual sense. That is, they share two characteristics we associate with beam axles, and not with independent suspensions.

First, they do not have the same camber properties with respect to the sprung mass in both ride and roll. Second, when there is vertical displacement of only one wheel of the pair, and not the sprung mass, the wheel not displaced vertically undergoes camber change, and usually some lateral displacement or scrub at the contact patch.

There is no generally agreed convention regarding how such systems should be classified. I would term this class of systems either hybrid or semi-independent suspensions. I would therefore stand by my earlier statement about the limitations of passive independent systems.

LIMITATIONS

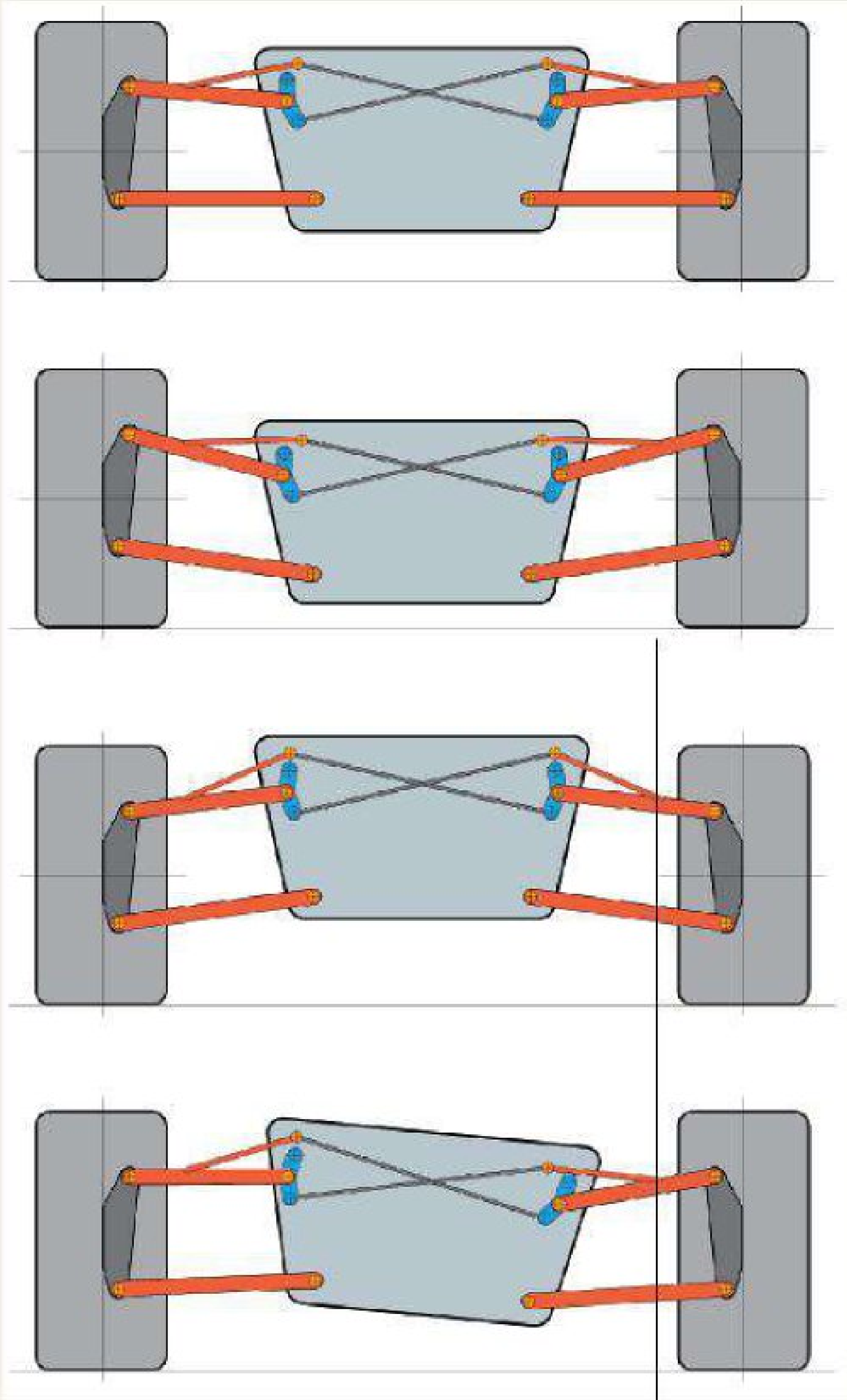
Semantics aside, what are the possibilities and limitations of these types of systems? Are they worth pursuing, or are they mere re-inventions of the beam axle? Or do they offer possibilities not available with a beam axle?

First of all, most semi-independent systems package more like independent systems than beam axles. Even a twist beam generally needs less space than a true beam axle. Some semi-independent designs connect the upper control arms using hydraulics rather than links. These offer the greatest packaging flexibility, at the expense of added complexity, vulnerability to leakage, cavitation and unintended damping effects.

Unfortunately, in one packaging-related respect, semi-independents with good camber recovery in roll resemble beam axles *more* than independents. They also need a big wheel well, assuming the car has wings (fenders). Depending on the combination of displacement at the two wheels, the top of the tyre can assume a fairly wide range of positions with respect to the body, and the wheel well must accommodate this. With an independent system, the spatial envelope needed to enclose the top of the tyre is generally smaller. For an open-wheeled car such as the questioner mentions, this is only a factor immediately inboard of the upper portion of the wheels, and it is usually easy to provide room there.

A beam axle generally provides zero scrub (zero track change) and zero camber change in ride, plus 100 per cent camber recovery in roll due to cornering (again, ignoring effects due to tyre deflection) and considerable camber change and scrub in roll due to bumps. Some variations may include an axially and / or torsionally compliant slip joint in the beam, and these may have some scrub in ride, and may also have more or less than 100 per cent camber recovery in cornering, but such designs are rare.

Many semi-independent designs can be configured to have a little camber change and scrub in both ride and roll, and lower roll centres than are commonplace with pure beam axles. Whether this actually makes the car faster or more pleasant to drive probably depends on road or track conditions, but the design flexibility can probably be regarded as an advantage.



This illustration shows the zero camber capability of the Dax layout and how the cross links govern the changing positions of the wishbone pivot points during suspension movement

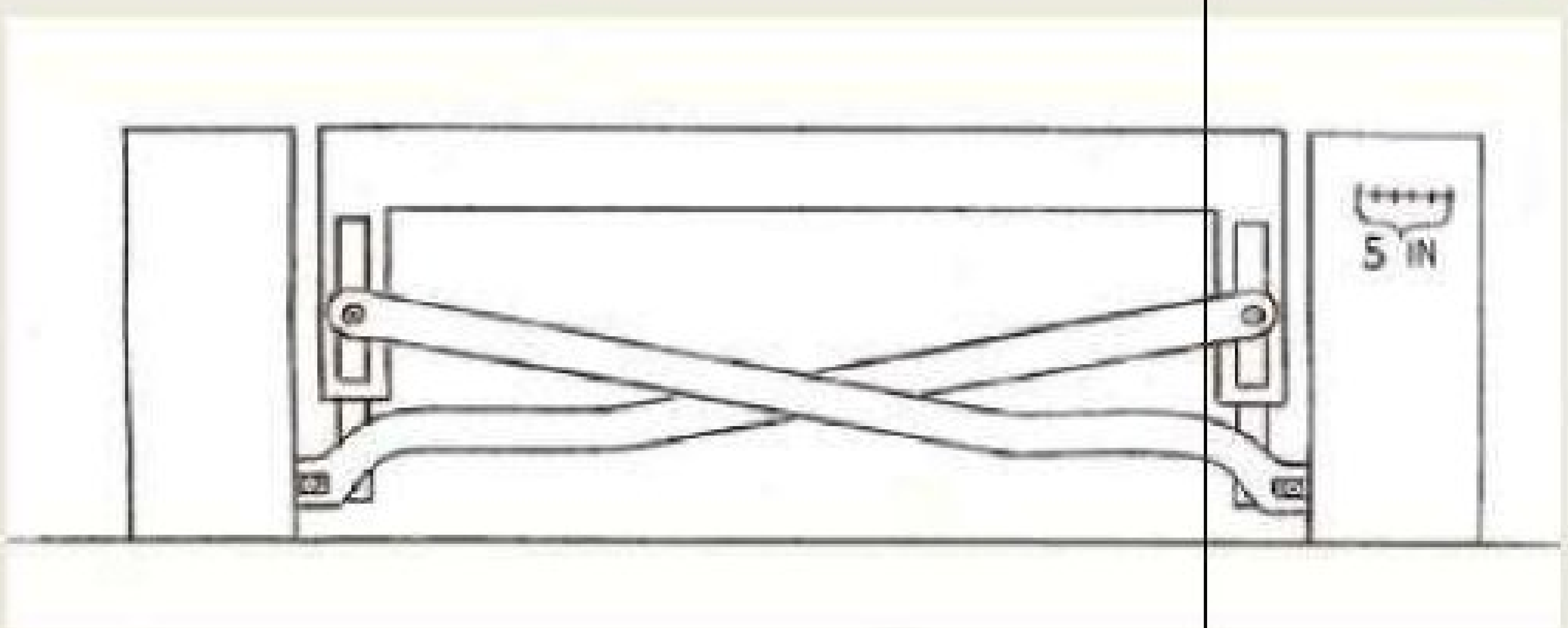
A SEMI-INDEPENDENT DESIGN USING SUPERIMPOSED SUSPENSION ELEMENTS

Inventor Gil Scigalski of Illinois sent us the following description of his concept for a semi-independent suspension:

'In its general layout the design resembles a Ford twin I-beam suspension, but with the characteristic long overlapping swing axles pivoting from unsprung rather than sprung parts of the vehicle. The unsprung parts consist of vertically aligned, chassis-mounted struts similar to the sliding pillars used on Morgan sports cars. In addition to transversely locating its associated swing axle, each strut also connects to and moves with its opposite axle via a slot formed therein. Each slotted connection accommodates the lateral difference between the vertical path of the strut and the arching path of the swing axle during jounce and rebound. Longitudinal location and springing / damping of the swing axles are not shown, but inferred and accomplished by means known to the art.'

Mark Ortiz responds: After pondering this layout for a while, I have concluded that it is roughly equivalent to a beam axle with a Panhard bar, or other lateral locating mechanism at the height of the swing-axle pivots. More precisely, it is equivalent to a slip-jointed beam axle, with its ends hung on sliding pillars or trailing arms, and a roll centre at the height of the swing arm pivots.

The inventor claims the suspension will eliminate roll, up to the point of tyre breakaway. Actually, tyre breakaway or not, it will generate geometric anti-roll, but not 100 per cent unless the roll centre is raised to unsprung mass c of g height. As with a beam axle, this will result in large amounts of scrub on one-wheel bumps. The inventor is correct that the system eliminates the jacking that would be encountered when trying to achieve anything like 100 per cent geometric anti-roll using pure swing axles or any other independent system, but again, this merely duplicates what a beam axle can do.



A semi-independent suspension concept using overlapping swing axles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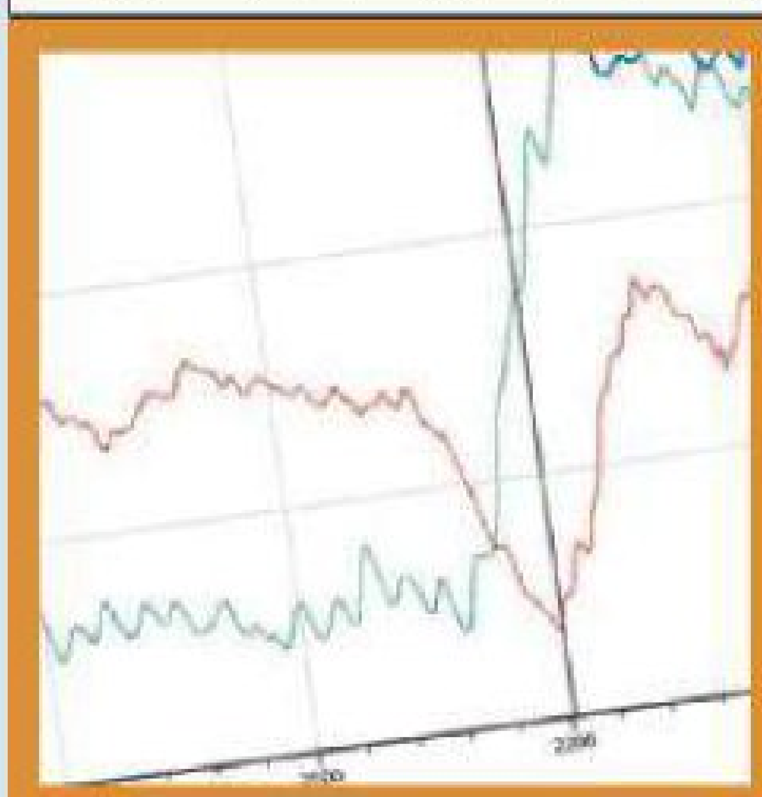


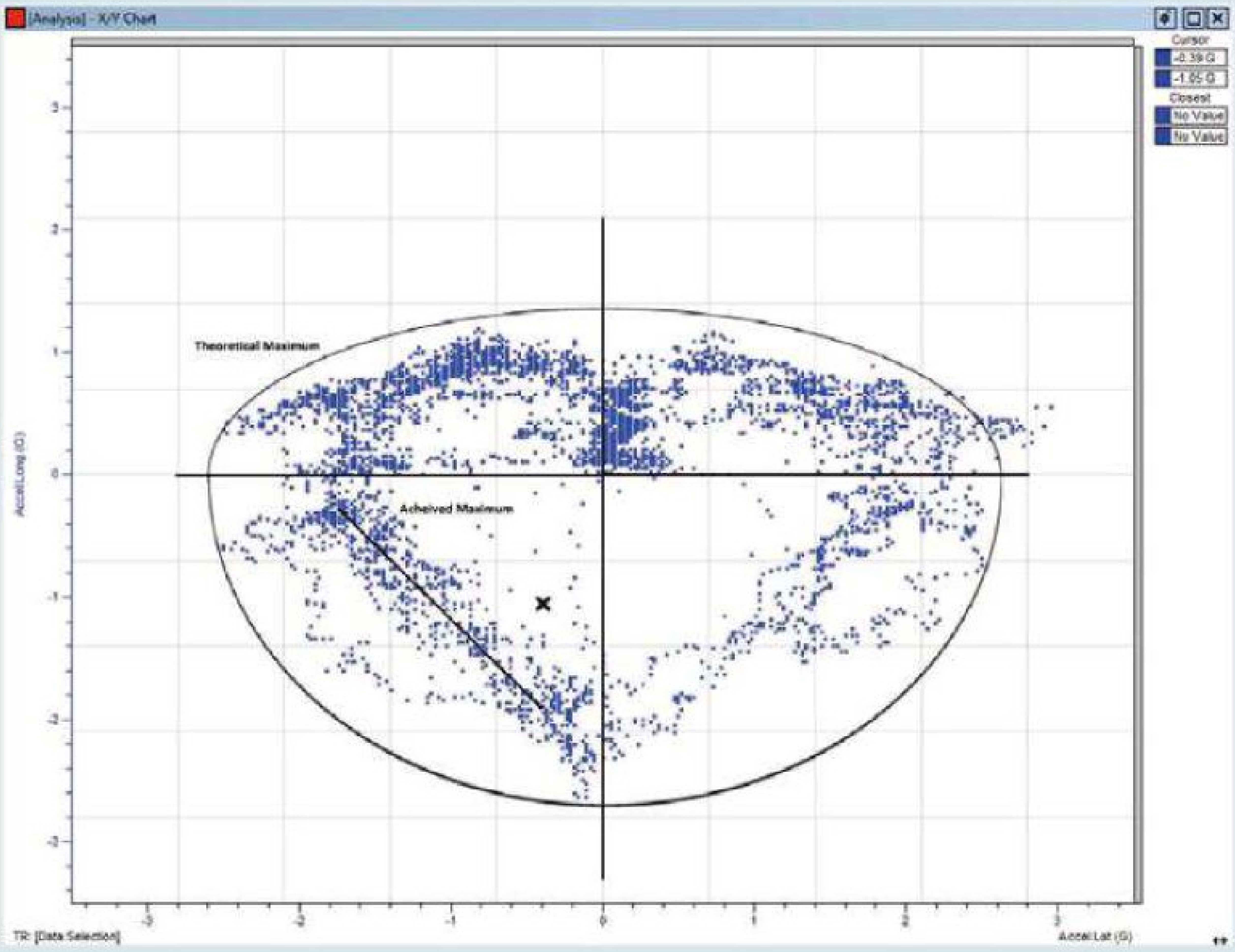
FIRST PRINCIPLES

Databytes gives insights to help you improve your data analysis skills each month as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems. Plus we test your skills with a teaser each month.

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

Traction circles

Whatever system you choose, the key is to transmit information quickly and efficiently



The ellipse encircling the plotted points should be shallower in the top section, as shown above

A well designed racing tyre should be capable of developing approximately equal power in acceleration, braking and cornering, and a traction circle is a simple and effective way of identifying the cornering power of a vehicle for a given tyre type or compound.

A traction circle, or 'G-G' diagram, can be created using the X-Y chart in a data acquisition software package and plotting lateral acceleration and longitudinal acceleration on the two axes. It is important that you have correctly calibrated your sensors and are aware of the sign convention for the acceleration traces. Positive values should represent right-hand turns and forward acceleration.

The shape of the G-G diagram will provide initial indications of driver performance. The traction circle should resemble an ellipse, shallower on the top than the bottom due to maximum deceleration being greater than maximum acceleration. The ellipse represents the theoretical maximum acceleration potential available and should encircle the plotted points, and the 'heart-shaped' trend shows how much of the potential acceleration the driver used during the period of one lap. Points between the axes represent the transient phases of cornering. Braking during turn in is revealed in the lower quadrant, as values of lateral acceleration increase, left or right, as longitudinal acceleration moves in the positive direction. Steady-state cornering is shown by the population of points close to zero values of longitudinal

> **"The ellipse represents the theoretical maximum acceleration potential available"**

acceleration and exit in the positive longitudinal transient phase of lateral acceleration.

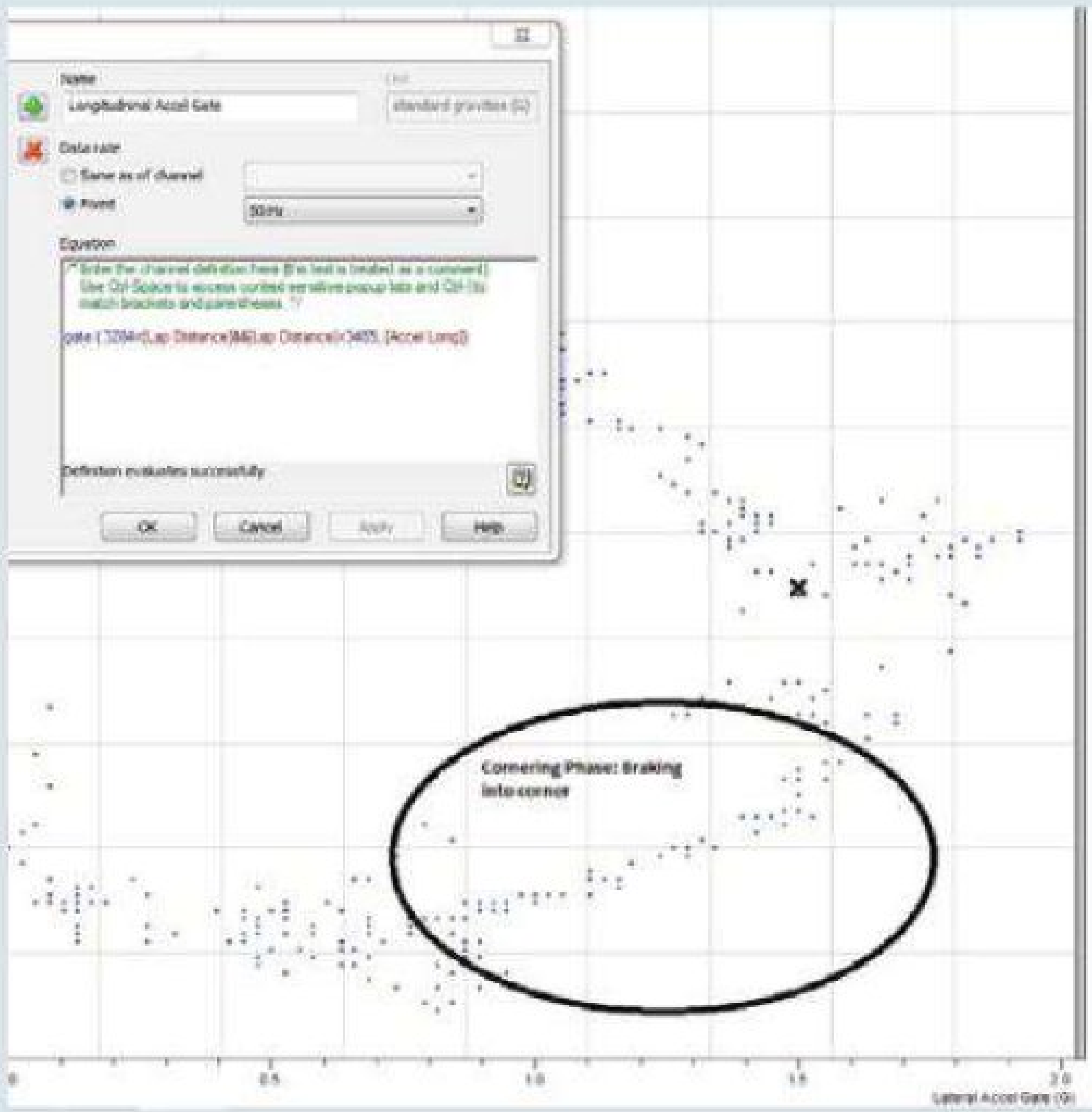
Maths channels can be created to calculate combined acceleration to analyse a car's cornering potential moving between phases of lateral and longitudinal acceleration. At any given point, the vector sum of lateral and longitudinal components forming the combined acceleration can be calculated as follows,

$$G_{Combined} = \sqrt{(G_{Lat}^{2} + G_{Long}^{2})}$$

When plotted in a time / distance graph, the output of such a channel would effectively show the achieved values of acceleration potential over a given lap. The generation of further maths channels can allow for driver and vehicle analysis at different corners and speeds. The outputs of 'choose' or 'gate' functions can then be used to filter out data points outside of a specified region.

The size and shape of the traction circle will vary with aerodynamic downforce, which in turn is dependent upon vehicle speed. Lateral grip potential will be much greater in high-speed corners than in low-speed corners and, of course, longitudinal potential decreases in high-speed corners due to aerodynamic drag.

Using additional channels, such as steering, throttle and brake inputs, a G-G plot will allow for detailed analysis of driver performance and give a clear indication of effective brake usage entering a corner and throttle application on exit. A set of G-G plots over a series of laps could also be used as a rudimentary approximation of tyre scrub in and degradation during an outing.



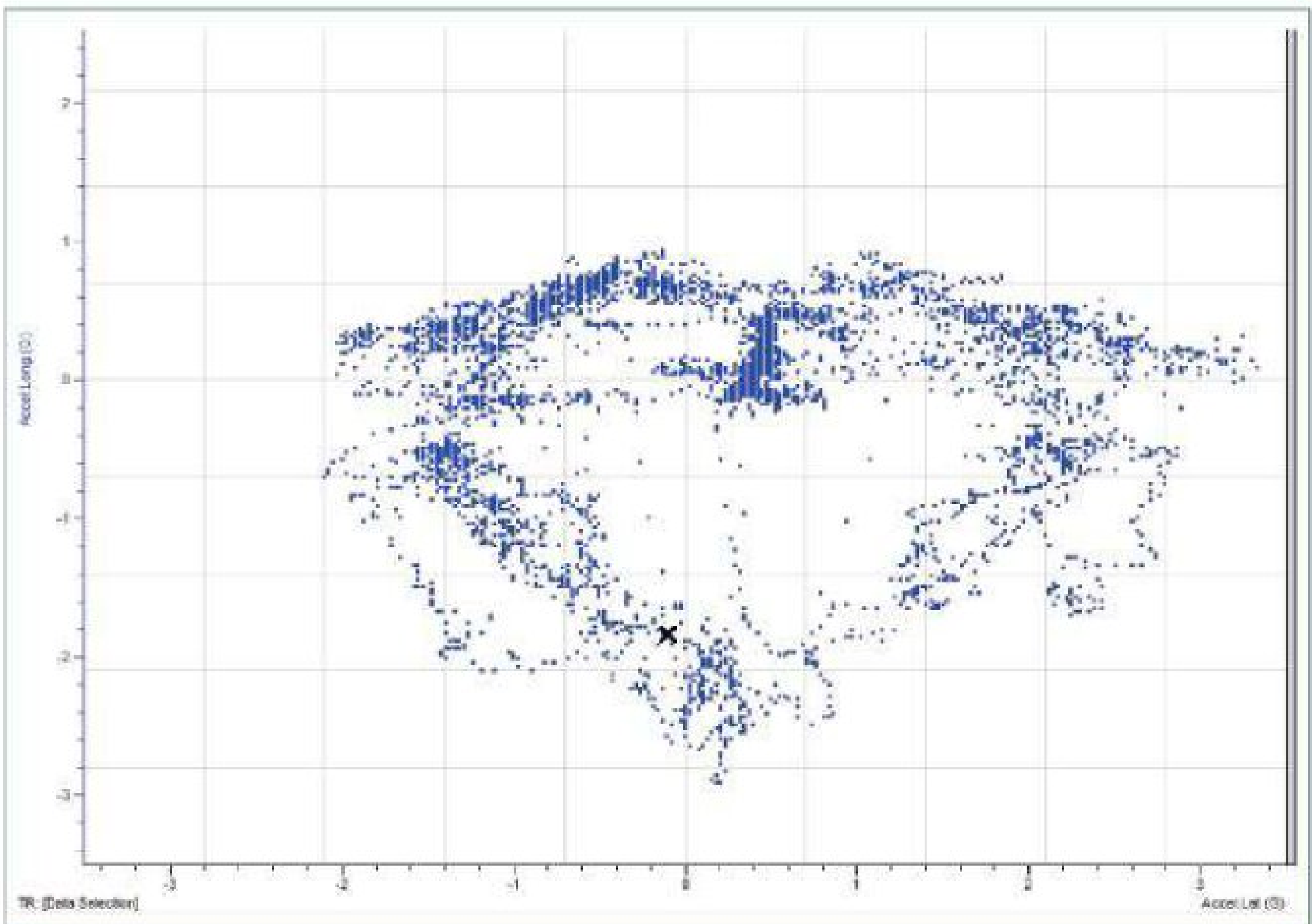
A G-G plot allows for detailed analysis of driver performance and how effectively the brake and throttle is being applied in corners

> "The size and shape of the traction circle will vary with aerodynamic downforce"

CHALLENGE

Test your own data analysis skills with this challenge set by the data engineers at Cosworth

Question:
Can you identify what is wrong with this G-G plot and what is the solution?



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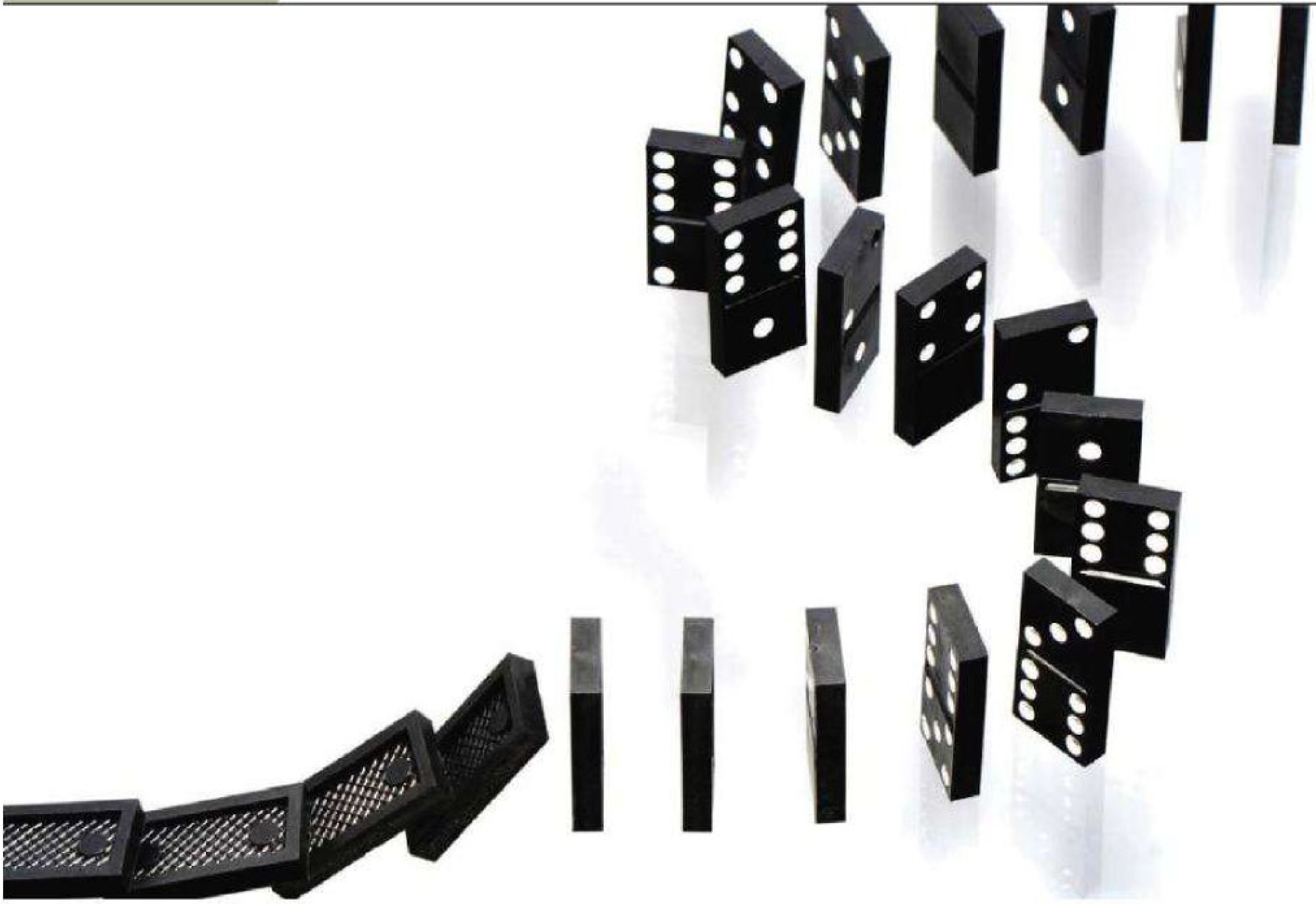


Supply or demand

In our concluding episode on motorsport business failures, we summarise the problems for suppliers and point to a number of avoidable common factors

BY PAUL J WEIGHELL

In the previous three issues of Racecar Engineering, we have examined the business failures of the A1GP series, DVLL Donington Grand Prix and the USF1 Formula One team. Although it is interesting to learn about successful businesses, it is perhaps more useful to learn about those that fail. If a business can avoid failure, then it may succeed one day but, if a business fails just once, then it can never succeed.

INITIAL CAPITAL

Both DVLL and USF1 failed before they got to market, which points strongly to lack of initial capital. Although some capital was available, the amount was insufficient for the size of the business envisaged. USF1 had perhaps $15m (£9.45m) via their main investor, Chad Hurley, and DVLL probably had a similar amount from its principals' previous businesses and private investment. Both companies, however, embarked on businesses costing in the

$100m strata. Therefore, the ratio of start-up capital to total capital sought was about eight to 1 against, and that alone should have warned prospective suppliers to take extreme care.

In all three cases examined so far, the principals consistently reported that they had funds in place, or that funding was not a problem. USF1: 'We are two guys who can say we are going to do a Formula 1 team because we have the capital to do it.' DVLL: 'Financially, we're in rude health.' A1GP: 'The group is forecast to break even, or even show a small profit in season four… and we are confident it will kick on from there.' All such statements were shown later to have been false hopes.

In addition to exaggerated media publicity, several binding legal contracts were entered into with the same over-positive spirit. DVLL was soon forced into the Derby County Court when its landlord sought £2.47m ($3.93m) in rent arrears: 'Despite receiving numerous reassurances over a number of months [DVLL] have consistently failed to meet their financial obligations under the terms of the lease.' The FIA checked USF1 documents, which confirmed it had committed sponsorship of just $8m rather than the $26m it claimed in written submissions. The FIA concluded from a timeline and cash flow analysis that USF1 would have been in debt before the end of its first season, a fact the team never publicised.

Instead of using the few million it had to secure sufficient start-up capital for the entire business plan, DVLL first committed to host an F1 race in 2010, then immediately embarked on rebuilding the Donington track to host it. At that point, however, DVLL accounts already showed it could not have met Formula One Management (FOM)'s contract.

USF1 acted similarly and, instead of using its relatively modest seed capital to trawl for adequate funding, instead committed to race in 2010 and embarked on building a car. At the point USF1 committed to the FIA and the Concorde Agreement, it was already too financially weak to fulfil it.

LOANS AND RISK PERCEPTION

It is of course unrealistic to expect that all new businesses use only their founders' seed capital and, if insufficient funds exist to maintain a start up until it makes profits, then principals may be forced to risk borrowing additional capital. In modern times with easy credit, this has become perfectly normal, but it carries inherent risk, not least for those supplying such credit-fuelled business, which are in effect accepting an involuntary role as a risk carrier for the client business.

The perception of the risk inherent in any business differs between the borrower and the lender. The perception mismatch at DVLL seems to have been its single point of failure, as it clearly thought it was a viable business when it approached Goldman-Sachs for £100m. The bank thought otherwise, refused the loan, and DVLL promptly collapsed – it really was as simple as that, despite months of surrounding packaging, cul-de-sacs and red herrings.

> **"The perception mismatch at DVLL seems to have been its single point of failure"**

Failed principals usually ascribe failure to factors other than their own judgment. DVLL might argue that the banking crisis had changed Goldman-Sachs, although the bank had proceeded with other new loans during the same period. Other sources of finance also existed, albeit fewer than before the banking crises, but, whichever way you look at it, a loan had not been finalised. DVLL never really had the cash, but proceeded to take on commitments as if it had. Even Bernie Ecclestone assumed something similar: '[DVLL] must have had finance in place or they would not have started.' (The only time the author has known Mr Ecclestone to make a mistaken financial judgment!).

If DVLL or USF1 had found funding parachutes after they jumped off their respective cliffs, then their bold pronouncements would in hindsight have been seen as justified.

It is perhaps luck that some companies gain sufficient capital where others do not, but pre-spending what one knows one does not have is a management strategy clearly more likely to fail than succeed.

VIABLE BUSINESS?

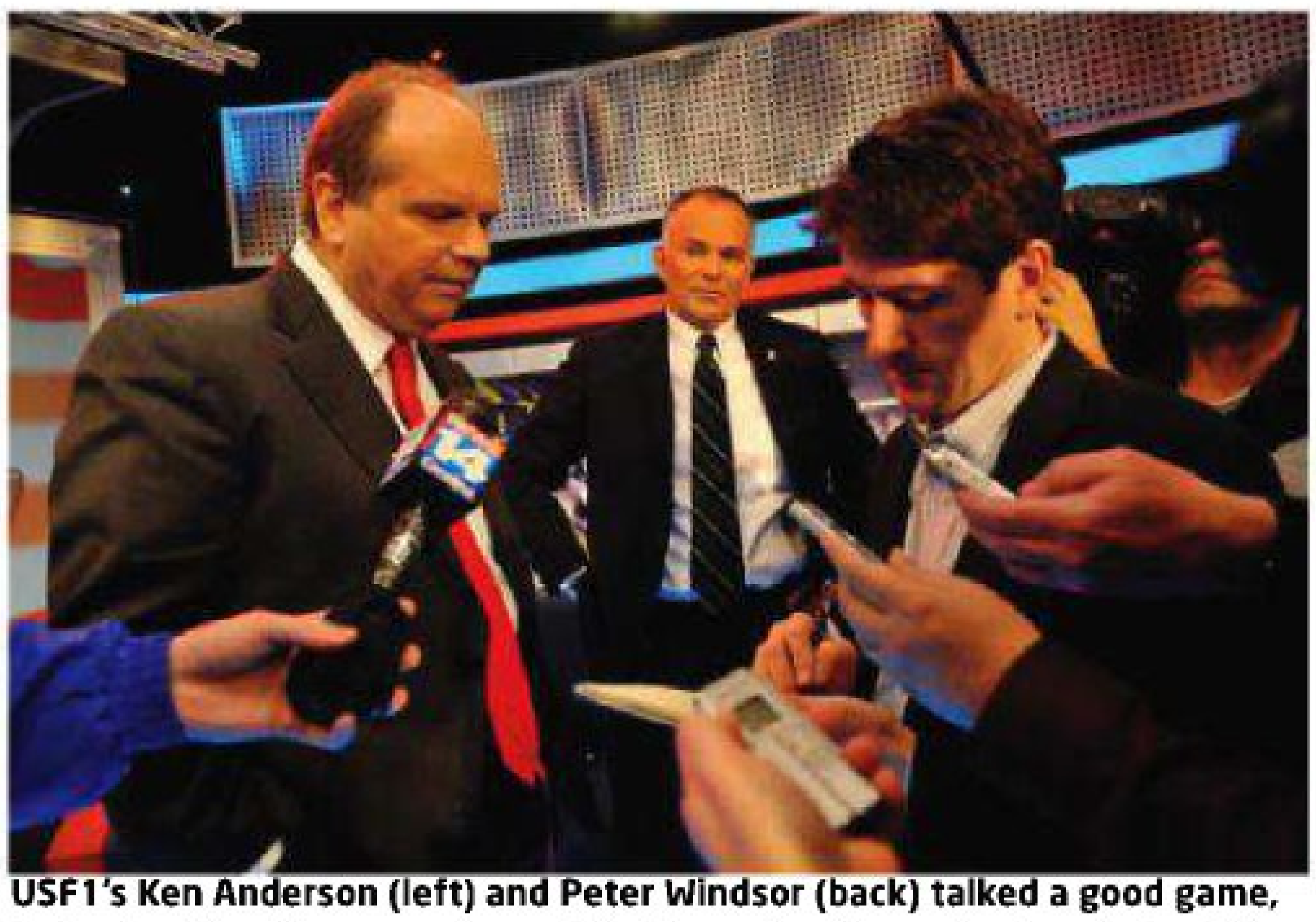
In contrast to the two start-up failures, A1GP not only had sufficient capital, but also had suitors waiting to snap it up after just one year. Some $240m had gone into creating A1GP, and more lavish investment followed as it was bought from its founder by the RAB Capital hedge fund.

A1GP ran for several years generating income, but it seems clear it was never a viable business, as in no single year did income exceed expenditure sufficiently to clear both start up and ongoing debts and costs.

A1GP was what engineers might aptly term a 'total-loss' system – it survived only by pouring new money into one end, only for it to emerge smartly out of the other, where it then disappeared for good. It always burned more cash than it generated, and so much so that A1GP was said by some to be a money laundering operation, pure and simple. Certainly the controversy surrounding its principals' previous careers helped fuel some bizarre stories.

To try and assess the situation accurately, Racecar Engineering assembled a selection of comments from A1GP teams and ex-management staff, necessarily anonymous due to ongoing litigation.

'The A1 organisation was completely uncommercial in its approach from day one –



USF1's Ken Anderson (left) and Peter Windsor (back) talked a good game, but, when the chips were down, didn't have the finance in place to back it up

The first rule of building anything in England is get planning permission first. DVLL didn't, nor did it own the land it started unlawfully developing

Though it appeared to make money, as a business proposition, A1GP was what engineers call a 'total loss' system

expenditure was utterly out of control whilst they had the RAB Capital cash available. This uncommerciality was due to the wrong people being in the wrong positions, senior and junior, with leadership having no idea at all about how to operate the series, deliver to the franchises or run a small international business.'

'From the outset, it's clear that some execs (TV for example) were brought in on the wrong deal, a deal that didn't actually serve the purposes of the series and its stakeholders. Most execs were dramatically overpaid in comparison to their last posts. All their Christmases at once...'

'After year one, it was clear that some of the franchises were stronger commercially than the series HQ itself. Failing to recognise why, [Tony Teixeira] was waylaid into thinking how to solve the commerciality errors of HQ in one big move, hence the Ferrari deal, a deal of complete insanity.'

The failure of A1GP seems a clear case of poor management control of expenditure, including on salaries, although what executive will cut his / her own income while the company is still able to borrow enough to pay it?

> **"alternate funding is all too often drawn from suppliers by way of delaying invoice payments"**

Of the three business failures examined in this series, two failed due to insufficient funding and the third due to excessive expenditure. To perhaps oversimplify that, we found that all three businesses failed because they spent more than they earned. When that dire state became apparent, they all then turned to the same solution...

SUPPLIERS AS 'BANKS'

The author has been told on more than one occasion in relation to Formula 1 teams and their business plans that to even discuss the true financial state is to be 'negative', an attitude likely to diminish the chances of raising money to fix the problems. The failing business tendency is often to maintain silence and carry on spending money it has not got in order to buy time during which principals seek alternate funding. Unfortunately, this alternate funding is all too often drawn from suppliers by way of delaying invoice payments. The final season of A1GP is thought to have been almost completely financed by suppliers' credit, the organisation leaving invoices unpaid for a year or more and eventually defaulting on them entirely. One UK-based engineering company finally had enough of such treatment and invoked the legal action that closed the whole A1GP edifice down. All unpaid suppliers then had their losses crystallised and there was some animosity about the legal action from those who still dreamed that A1GP might have turned around one day and eventually paid its bills. Run your profits and cut your losses is a hard discipline, but an essential one.

Failed businesses end with official administrators converting remaining assets into cash to pay off creditors. However, in motor racing, such assets are often bespoke and therefore difficult to sell. A1GP had a set of expensive racecars and associated parts, but these are not readily reusable in any other existing series. USF1, meanwhile, had not managed to build even a single car, and would it have been saleable to another F1 team anyway? DVLL did not even own its largest physical asset, the Donington race track, as it had been leased and was therefore unsaleable, as was much of the equipment and facilities used by all three businesses.

The liquidation downside in these cases is that the running business value was higher than the disposal value. While a business is growing successfully, such leverage between income and assets is a boon, but when the business is bankrupt, the same leverage works the other way around – against the creditors.

Even where assets can be disposed of, the cost of paying for the liquidation comes off the top of any income. One of these failed businesses accumulated an administration charge of £320,000 after selling just a

CREDIT INFORMATION

It is tempting to offer credit to gain business, especially if one is a small supplier, but one sure way to become an even smaller supplier is to offer more credit than one can afford to lose.

If it is unrealistic to avoid giving credit, then being armed with information on prospective customers may help, especially if the information comes from other suppliers.

The Motorsport Industry Association (www.the-mia.com) runs an Industry Credit Circle for its members to regularly exchange payment reliability information about customers, an invaluable assistance to be recommended to all motorsport suppliers.

Other sources of precautionary information include:

- internet searches
- credit agencies
- bank references
- trade references
- credit insurers
- company accounts
- Companies House

These should be used to check on all new customers.

few spare parts and the office furniture. Such levels of cost leave little for creditors.

There were more than 250 suppliers affected by the three failures, ranging from Ferrari to Donington Parish Council, and the principals of the failed ventures bear the responsibility. The buck, if indeed there ever was a buck, should rest with them.

In two of the cases, the principals had little or no motorsport industry experience. In the case of USF1, they had technical experience but no business experience at the level required to drive a Formula 1 project to reality. While there seems no realistic way of barring people from motorsport merely because they may seem unsound, there are practical ways of improving the chances of avoiding default when dealing with them.

TABLE 1

Common factors

	A1GP	DVLL	USF1
Principals had industry experience?	No	No	Yes
Organic growth from principal's existing business?	No	No	Partial
Grossly exaggerated PR announcements?	Yes	Yes	Yes
Unrealistic technical expectations?	Possibly	Yes	Yes
Sufficient initial funding to reach sustainability?	Yes	No	No
Accepted binding commitments without adequate funding?	Yes	Yes	Yes
External image projection contrary to internal reality?	Yes	Yes	Yes

AVOIDING DEFAULT

Before the FIA embarked on making Formula 1 racing more cost effective, it demanded up front but returnable deposits of about $45m from new teams, which were repaid in tranches throughout the season. Those deposits were a major hurdle to new teams, but ensured that those with insufficient capital were filtered out early. Such a system would have halted USF1 long before it entangled suppliers in its own debts.

A similarly large deposit requirement from FOM would have ensured that DVLL had sufficient money to complete all of the work required to prepare the Donington Park venue for the British GP *before* it was granted the license to host the race. DVLL would, of course, not have been able to make such a deposit, the FOM license would not have been granted and the costly mess at Donington avoided.

It is easy to make judgments after the event, but advance deposits upset customers' cash flow, and suppliers can gain extra business by avoiding such draconian requests of their customers. In doing so, though, the consequences of default are suddenly increased from being near zero to unpleasantly high.

In the current global circumstances, banks are no longer providing easy credit, and it is more likely than ever that companies will lean heavily on their supply chains for funding. Never mind *caveat emptor* or 'buyer beware', let suppliers now adopt the slogan 'seller beware'. Some already do.

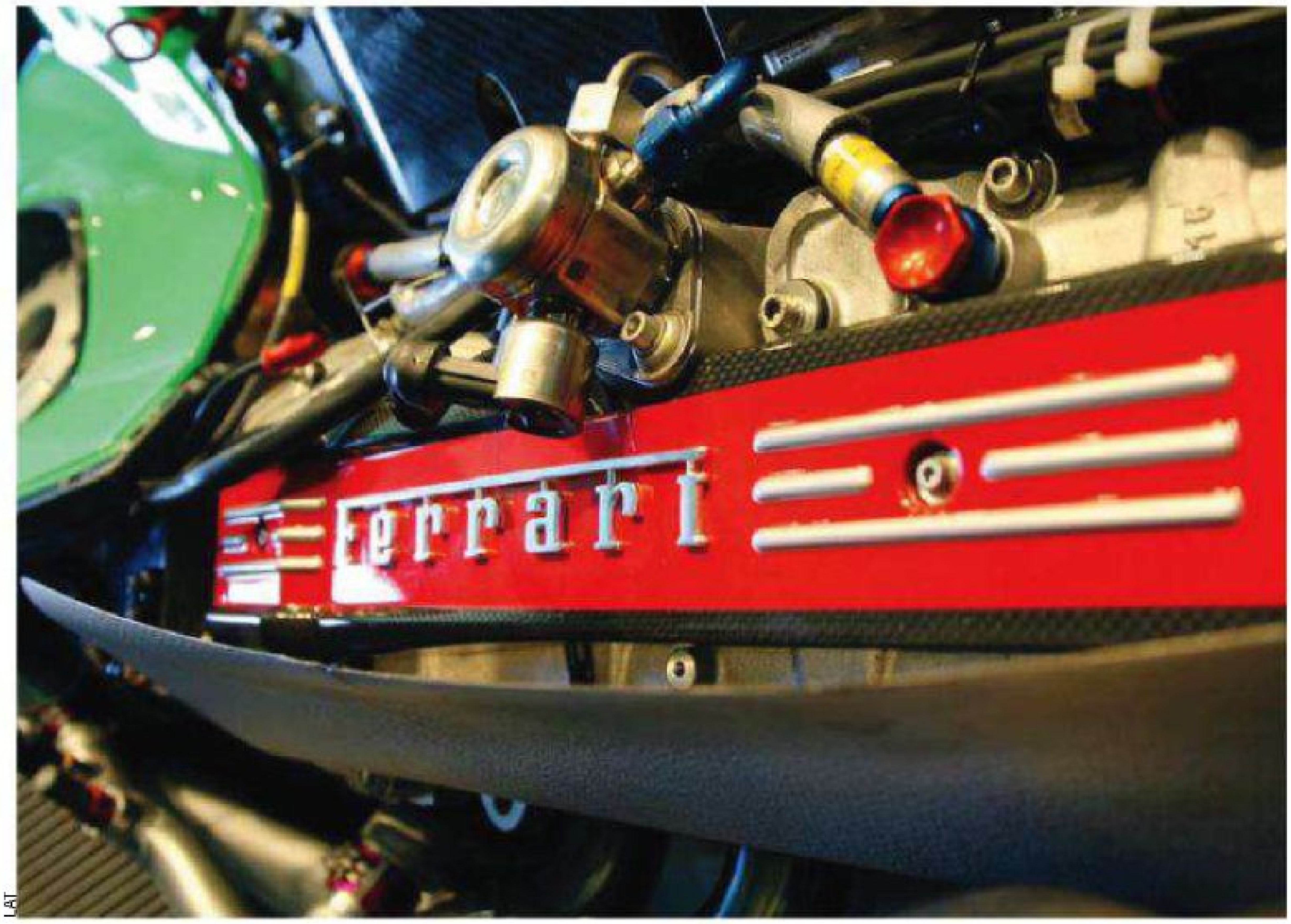
> **glossy images are, of course, no guide to reality**

MILITANT ACCOUNTS DEPT

Racecar Engineering spoke with a well known hose and fittings supplier to A1GP who suffered no financial loss when A1GP collapsed. The secret apparently was the supplier's 'militant accounts department'. Sales to A1GP were initially contracted via Lola, which built the first series car and had a good credit record. When the new Ferrari-engined car was launched, however, the customer changed to A1GP Operations Ltd. This was a new company for the supplier and was therefore required to pay in advance. This was poorly received and we are told that a senior executive of A1GP 'phoned the supplier to deliver much colourful abuse. The 'militant accounts department' stood firm and A1GP continued to be treated as an untried company. The result of such a sensible arrangement was that the hose and fittings company survived the collapse of A1GP without loss. There must be a number of other companies that adopted the same prudent approach, but they are unsung heroes as their names do not appear in the creditor lists.

The tendency perhaps is for some suppliers to the more glamorous ends of motorsport to be convinced of financial soundness by lavish press reports, impressive contracts from the FIA or FOM and smiling principals flying around in helicopters 'doing deals'. Such glossy images are, of course, no guide to reality. Neither the FIA nor FOM will guarantee any motorsport business has a level of credibility beyond the minimum required to gain and pay for the FIA or FOM contracts. Again, we stress that neither the FIA nor FOM extend credit – sound advice by example!

The president of the FIA at the time these businesses were being launched was Max Mosley, and he commented to us that: 'Most businesses in the racing world learn very quickly never to give credit. Ignoring that rule, which applies today just as much as it did 40 years ago in my March days, is the surest way to lose money.'



LAT

Unfortunately, it is the suppliers who all too often bear the brunt of the financial collapse. Seller beware. Wise words

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The top contenders in the British Hillclimb Championship are always spectacular and innovative racecars. DJ Engineering Service's new Firestorm is no exception

BY SIMON MCBEATH

DJ Engineering Services, or DJ for short (formerly known as DJ Racecars) has come a long way since its first hillclimb single seater in 1999. And while not the most prolific hillclimb constructor in the UK, DJ Engineering Services has nevertheless developed a reputation for creating finely engineered, extremely good looking, competitive racecars, as well as a range of beautifully finished metal and composite race parts. Notable under any circumstances, this becomes all the more remarkable when taking into account that the company principal / chief engineer and his co-designer (and closest friend) both have full-time jobs in addition to their racecar business. Del Quigley, a time-served engineer, works in the Fire and Rescue Service (hence the 'Fire' prefix to the car names), while Andy Smith (whose initials formed the ADS model number prefix on the early designs) is a design engineer for a product design and development company. But don't be tempted into thinking this is a part-time operation, for the nights are long, and then there are the weekends... and up to six full-time staff involved, too.

The company's first spaceframe single seater, the DJ ADS1 (see V9N5), was followed in 2000 by the Suzuki Hayabusa-powered, aluminium honeycomb chassis, ADS 3 Firecat Sports Racer (V10N6). Then, in 2002, the company's first full composite chassis single seater, the DJ Firehawk (V12N10), appeared, of which five have been built, all propelled by Hayabusa engines, normally aspirated and supercharged. In each case, the major components, whether fabricated, machined or moulded, were designed using Pro/Engineer 3D CAD and manufactured entirely in house.

The Firehawk's chassis had provision for a range of different engine options, up to and including racing V8s, alluding to an underlying – dare one say burning – ambition to compete in the sport's top echelon. The British Hillclimb Championship has been won since 2003 by normally aspirated, petrol-fuelled variants of the ex-ChampCar Cosworth XB from Nicholson McLaren Engines, latterly badged as the NME V8 (see V14N10), running in Gould Engineering

TECH SPEC

DJ FIRESTORM

Class: British Hillclimb Championship, Racecars over 2000cc

Engine: Cosworth XD

Configuration: V8, 75 degree

Capacity: 2650cc, bore 92.0mm, stroke 49.8mm

Valves: 32

Power: 528bhp at 13,750rpm

Torque: 218lb.ft at 11,500rpm

Clutch: Tilton 4.5in, five plate

Transmission: Lola LT1B Formula Nippon B06/51/FN06

Chassis: carbon composite

Brakes: AP four-piston calipers and 227mm × 16mm ventilated, slotted discs

Suspension: double wishbones, pushrods, twin coilover units with Öhlins TTX40 dampers, third elements with bespoke Öhlins dampers, front and rear anti-roll devices

Dimensions:

Length: 4300mm

Width: 1718mm

Wheelbase: 2480mm

Track front: 1400mm

Track rear: 1370mm

Weight: 'comparable with opposition' (*Racecar Engineering* estimate: 425–475kg…)

Wheels:

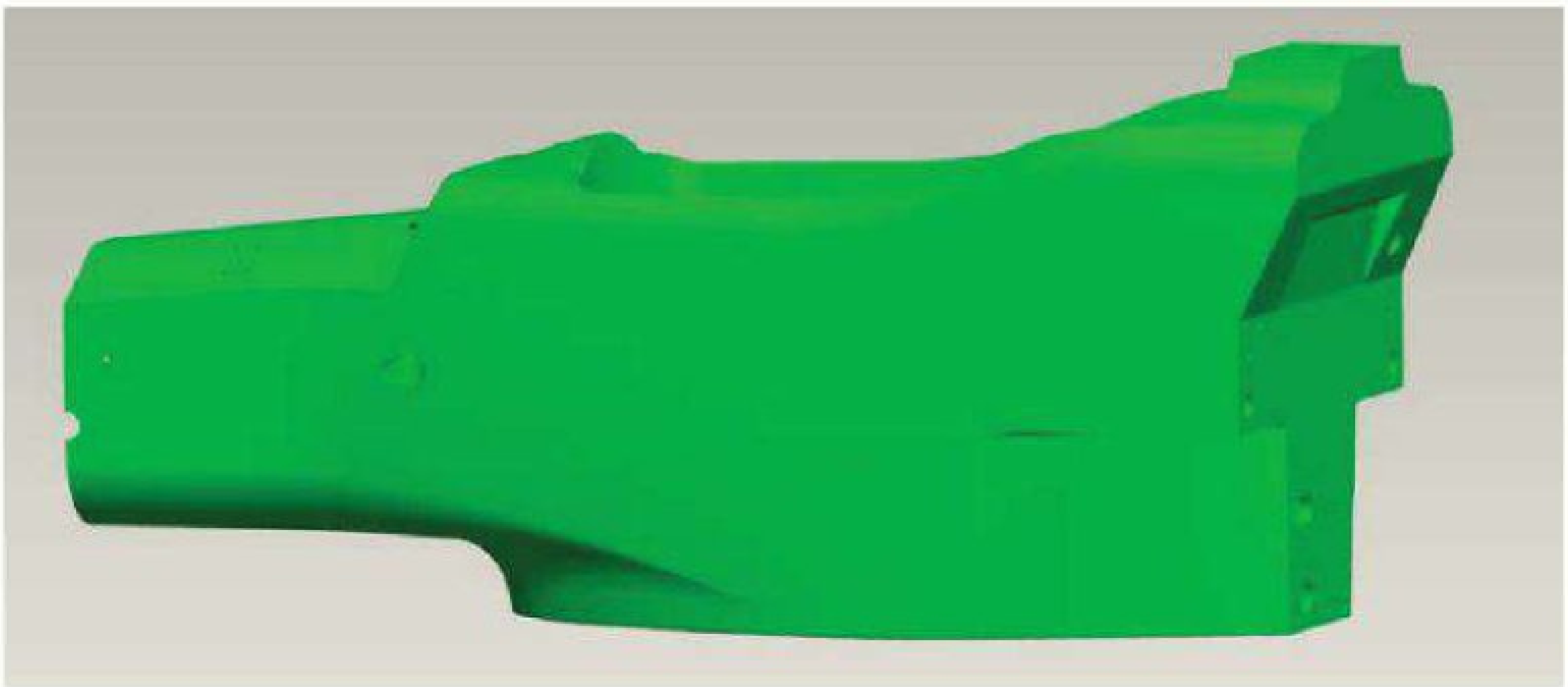
Front: ATS, 11 × 13in

Rear: ATS, 13.7 × 13in

Tyres:

Front: Avon, 230/550-13

Rear: Avon, 315/660-13



The Firestorm's chassis in CAD (courtesy: DJ Engineering Services)

chassis, the champion constructor since 1998. But ultimately it was decided that the Firehawk chassis involved too many compromises and, to compete against an established combination like the Gould NME, a fresh start was needed...

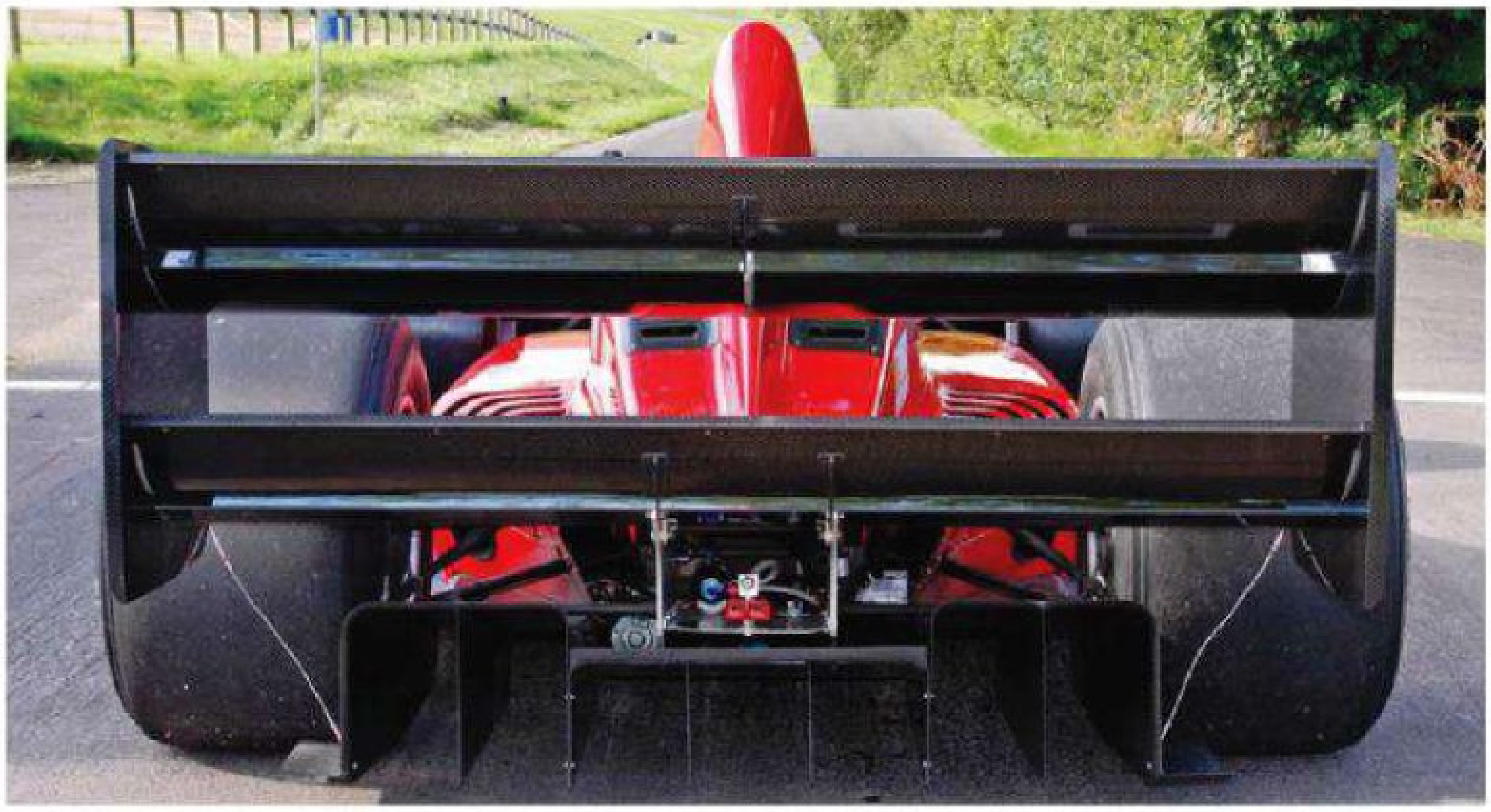
PROJECT RATIONALE

One of the customers to have purchased a supercharged 1300cc Firehawk was Scotsman Wallace Menzies, who drove the car to numerous class successes in his homeland and in England. But, with the car running in the up to 2.0-litre class, there was still that top echelon - the Unlimited Capacity Racecar class - to tackle. And Menzies shared the same ambition as DJ's principals, which was to challenge for the British Hillclimb Championship: 'We looked at everything else available, but after the Firehawk I didn't want anything else. The relationship with DJ was good, and we didn't want to follow everyone. We hoped to gain advantage by trying something different. But there were mutual risks in doing this. DJ hadn't built a 'big' car, and they didn't know how I would fare in one.'

So, with eyes wide open on all sides, DJ Engineering Services received the commission from Menzies, and the decision making on the key components for the Firestorm - chassis, engine and gearbox - began seriously in 2007. Menzies: 'We decided that Del, Andy and I all needed to be able to fit the chassis [none of them is what one would call 'small' - SMcB], so we quickly concluded a new tub was needed! Right away then, there was to be no compromise on this or anything else. This gave us a clean sheet of paper start.'

> "a blend of objective analysis and subjective opinion, coupled with the desire not to follow the crowd"

Quigley related that because this was the first time DJ had done anything at this level, they decided to seek as much expert help as possible. Martin Ogilvie, the ex-Team Lotus F1 chief designer who had been involved in other relatively recent hillclimb projects, including the PCD Saxon and the GWR Predator and Raptor, was hired as a design



A great deal of thought was put into airflow under the car, with the emphasis placed on making it less sensitive to dynamic ride height fluctuations and somewhat more benign, rather than chasing maximum downforce

THE COSWORTH XD

David Gudd, head of development at Cosworth, offered some recollections on the XD's genesis: 'The XD was designed in 1995 and introduced in 1996. It replaced the XB, the primary weakness of which was the timing drive. The XD's timing drive was re-located to the rear of the engine where, thanks to the inertia offered by the flywheel and clutch, the torsional amplitudes were considerably smaller. The timing chains on the XD were also significantly shorter, and the combination of these two changes allowed race engine speeds to be raised from 13,800rpm on the XB to 14,800rpm on the XD at the end of its development.

'The XD carried over many features of the XB. It retained the same bore size of 92mm, as extensive testing on the XB yielded no incentive to change. Port and valve sizes were also very similar, although the valve angles were reduced to make the combustion chamber more compact. And the inlet port was straighter, while each exhaust valve had its own port, rather than the siamese arrangement used on the XB. This was no advantage in terms of flow, but it allowed for more even load distribution on the head joint.

'The XD also had a significantly stiffer block and head structure, with larger diameter head studs. The extra material required for this meant the engine was about 5kg heavier than the XB. The XD's reduced v-angle of 75 degrees [80 degrees on the XB] also made it easier to keep the exhausts clear of the car's underbody.

'The DJ Engineering Services project has been very much led by them, and isn't an official Cosworth project by any means. But the quality of the work DJ has done is exceptionally high, and we are following the project with interest.'

The Cosworth XD former ChampCar engine has been exquisitely mated to the Lola LT Formula Nippon transverse transmission, keeping the gearbox weight ahead of the rear axle. Rear suspension features twin springs and dampers, a damped third element and a conventional anti-roll arrangement. Lola CVs inboard connect via ADS-manufactured driveshafts to DJ bespoke CVs, hubs and uprights. Suspension is again double wishbones and pushrods, with transverse toe links

consultant and 'wise head' for a few days. One of Ogilvie's ideas was the indent on the lower, rearward sides of the tub, to allow for improved cooling packaging, but also because the engine of choice featured wide front upper mounts but narrow lower ones, so a square rear bulkhead shape like the Firehawk's was not optimal. The tub was also subjected to lots of ergonomic work too, incorporating a HANS device, as well as provision for a foam cockpit surround (still to come at the time of writing).

As with the Firehawk, the main chassis pattern was CNC machined (from CAD generated by Smith) from epoxy tooling block, prior to wet lay up of the carbon-epoxy tooling. The tub itself comprises 13mm aluminium honeycomb encapsulated in 1.5mm pre-preg carbon skins, with local thickening in areas of high loads. The bare chassis weighed in at around 35kg.

DRIVETRAIN

The decision making on the drivetrain, however, was a more complex matter. A spreadsheet was created listing the cost, power, dimensions and weight of the known engine options, and discussions took place with Nicholson McLaren Engines, Engine Developments and Powertec, among others. The lightest option was the ex-DTM, 2.5-litre V6 that won the 2001 and 2002 BHC, but it was felt that this had been developed as far as it could be, and it also required a spaceframe around it because it could not be used as a stressed member. Also, subsequent to its last championship success, the 3.3-litre, then 3.5-litre Cosworth XB/NME V8 had usurped the little V6 on both power and torque.

The now almost ubiquitous NME V8 (see V14N10) would have been an understandable choice then, given its run of success since 2003, and the various Judd V8 options - 4.0-litre versions of which offer prodigious torque and power - were also considered, as was the possibility of an ex-F1 V10 (as used in the GWR Predator), though this was dismissed because of the physical length and servicing costs. Perhaps inevitably, the decision became a blend of objective analysis and subjective opinion, coupled with the aforementioned desire not to follow the crowd. Menzies: 'Some of the big V8s seem to have almost unusable levels of torque, whereas the Cosworth XD seemed to be more like a big motorbike engine, with lower torque and lots of revs,' to which he might have added, 'like I had become used to with the supercharged Hayabusa'. And sequential gearboxes with flat-shift systems mean that the fewer shifts required with a large capacity, high-torque engine are less of a benefit.

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The XD offered additional benefits too, as Menzies related: 'There were lots available in the USA and, when the dollar exchange rate was over two to the pound, the purchase cost was *very* favourable. The engines were built for long races and were very reliable, so servicing costs were going to be reasonable, too. And in race trim they pushed out 840bhp, so they were obviously strong. We also wanted an engine that was easy to fit and remove - the XD comes off with a few bolts and dry-break connections, so it came out tops all round.'

Having selected the base engine, it then needed converting to run without a turbocharger and on petrol (methanol is allowed, but was not the preferred option), and warm tribute is paid by Quigley here to David Gudd, head of engine development at Cosworth, 'who offered significant engine-related advice and was generally a great mentor for all things engine-related.

The in-house designed and CNC machined bellhousing weighs just 3.48kg

'But there was a heck of a lot of work to convert the engine,' continued Quigley, 'and we've ended up with a Formula 1-esque, twin overhead high pressure fuel rail system.' Menzies chose the Motec M800 EMS, a system he had some experience with, and which 'actually allowed the engine to be mapped' - a task performed by Engine Developments, who were supplied all the requisite information by Cosworth.

The transmission was the remaining key component to select, and initial research focussed on Xtrac, Hewland and Ricardo. For different reasons though, each of those was ruled out in favour of the LT1B six-speed transverse unit from Lola, as fitted to its B06/51, or FN06 Formula Nippon car. Crucially, this magnesium-cased unit features a drop gear set enabling it to be matched to a wide range of peak rpm inputs, and with the Cosworth XD running to a potential 15,000rpm in its initial 2.65-litre guise, this was a deciding factor. The Lola transmission was also already able to run with the well-regarded Geartronics pneumatic, closed-loop control, paddle-operated, flat-shift system.

The drop gear set inevitably brought a weight penalty with it, and at 57kg the gearbox was not the lightest option, but it was considered to be a strong transmission for a category where, historically, low-weight transmissions have been an Achilles Heel. DJ has since obtained a CAD model of the Lola transmission casing, and some judicious machining is planned for the 2010/'11 off season to shave off some surplus weight.

Connecting the engine and gearbox required a bespoke bellhousing, and with CAD of the XD created by Smith, and the available LT transmission CAD, this was another in-house task. It was CNC machined from a 58kg billet into a 3.48kg artwork that incorporates the mounting for the starter motor, as well as an idler gear that meshes with the flywheel ring gear. An on-board starter is optional under the regulations but, with the number of starts in a meeting (which after a competition run are often in holding paddocks remote from team equipment) it's a great convenience to have the on-board facility.

SUSPENSION SYSTEMS

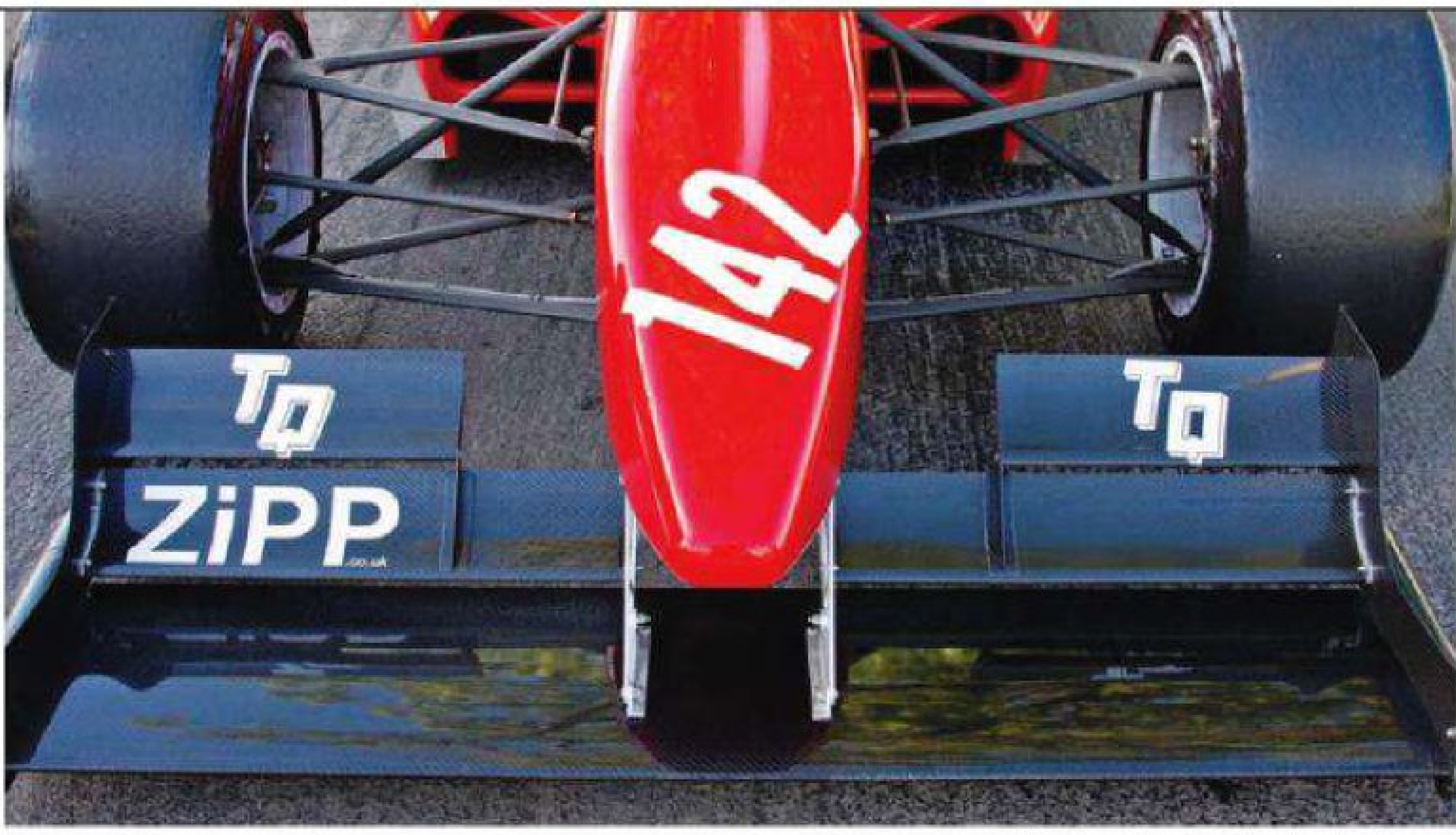
Suspension geometry tends to evolve from one car to the next, and so it was on the Firestorm, where the proven geometry from previous cars has been adapted to suit the demands of the larger car. However, the spring / damper / third-element layout is interesting, DJ electing to go with twin main springs and dampers, and third elements with bump stops and damping for controlling heave and pitch at the front and

ON TRACK

After minimal shakedown running at the Mintex test facility in Leeds, the Firestorm made its public debut in July 2009 at the nearby Harewood hillclimb in Yorkshire, observers exuding superlatives on the attention to detail of the engine and gearbox interface, as well as the generally harmonious integration of all the chassis components which, according to designer Del Quigley, was only possible because the car was designed entirely on CAD prior to manufacture. The car was soon snapping at the heels of the established runners, scoring its first BHC points in only its second ever event, at Bouley Bay on the Channel Island of Jersey. It went on to collect points in all bar one of the 14 BHC rounds (of 34 in total) entered, with a best fifth place finish at the local hill of owner / driver, Wallace Menzies' - Doune, in Scotland - in the final round.

The 2010 season saw a delayed start as Menzies' family gained an additional member. But the Firestorm blazed again at Doune in June, complete now with sidepods and underbody, scoring another fifth and a seventh. There followed a steady string of points-scoring places, with a best of third at Craigantlet in Northern Ireland, beating all bar the top two title protagonists. The season culminated in eighth overall in the championship, netting a coveted 'permanent number' (awarded to the top 10 finishers in the BHC) for 2011. Considering that quite a few of the venues had been entirely new to the driver, and only 24 of the 32 rounds were entered, securing 'number 8' was creditworthy indeed. And, apart from a sporadic camshaft sensor glitch that was soon rectified, the car has proved itself to be totally reliable, too.

The DJ Firestorm in action at the British Hillclimb Championship event at Gurston Down Hillclimb near Salisbury, Wiltshire, in southern England, August 2010



The Firestorm's aero package has been gradually developed throughout 2010. The potent triple element front wing (above) was balanced with a more potent upper tier on the double tier, dual element rear wing. Gills and louvres (bottom) aid heat rejection at the rear

rear. Twin springs were preferred because of previous experience, and expert advice suggested this would offer more control and adjustability, even though extra cost and a little extra weight were incurred compared with a front monoshock.

The benefits of a third element are perhaps especially suited to this sport, allowing softer suspension to be run at low speed for better mechanical grip, with the third element supporting the car at higher speed when under aerodynamic loads. The third element here is damped to soften the transition onto the bump stops.

The anti-roll device at the front features an essentially solid torsion box connecting across the car, with the link between this and the right side bell crank containing small, interchangeable springs that provide the adjustment. It is said to be highly tuneable. The rear anti-roll system uses a conventional pivoting 'H-bar on its side' that integrates with the third element.

Plenty of steering lock for the tight corners of UK hillclimbs was a prerequisite, so the steering arms have been located low down on the front uprights, the design of which benefited from Martin Ogilvie's input, necessitating a T-type steering rack to connect to the high-mounted column. Brakes are off-the-shelf four-piston calipers with ventilated and slotted discs all round.

Proprietary Formula 1 rear and Formula 3 front wheels were also selected, avoiding the need for rim modifications, and smaller section front tyres than are commonly used were chosen for their stiffer sidewalls.

AERODYNAMICS

With few rules defining this critical area, selecting the initial aerodynamics package was a finger-in-the-air exercise and DJ, who did the styling, sought guidance from a former Formula 1 aerodynamicist and also from Simon McBeath at SM AeRo Techniques. For the car's first few events in 2009, it ran without sidepods or undertray, and with the exhausts routed to silencers centrally mounted under the lower rear wing tier. But, for 2010, the Firestorm appeared with its full sidepod and underbody kit, with the re-configured exhausts now contained within the sidepods.

Apart from a minimum static ground clearance of 40mm and a maximum width behind the front wheel axle of 1400mm, the underbody is free, and the Firestorm's was based on the Firehawk's, re-worked to cater for the different rear wheel sizes. The slightly stepped bottom from the chassis to the 'tunnels' was also retained so the airflow could never be completely choked at low ground clearances, and the car should be less sensitive to dynamic ride height fluctuations than one with an entirely flat forward underbody. Ultimate downforce may have been compromised by this decision, but hopefully for a more benign aerodynamics set up.

Much thought was given to the wing packages and, although all involved consider drag not really to be an issue for these powerful cars on UK hills, as the Firestorm was going to start its life about 120bhp (18 per cent) down on the 3.5-litre NME V8-powered cars, this saw an initial slightly conservative rear wing package selected. However, it became clear during 2010 that the high-speed balance was forward biased and, rather than back off the front wing and lose total downforce, a more potent upper tier main element profile was fitted, along with 15mm Gurneys on both upper and lower flaps, which resulted in improved front-to-rear balance.

With a planned visit to the MIRA full-scale wind tunnel and a long list of development parts to be evaluated, plus the expectation of considerably more power on the way, the Firestorm's aerodynamics will continue to evolve throughout the 2011 season.

And development will continue apace on all fronts, perhaps the most important of which is enlarging the engine to 3.2-litres by increasing the bore and stroke. This will see a reduction in peak rpm from the screaming 15,000rpm currently employed but, with the potential to rev higher than the 3.5-litre NME V8, thanks to the XD's improved design, fully competitive power in excess of 600bhp should be attained.

The outlook for the Firestorm is exciting then. With more knowledge of the venues and car set up coming with time, plus more power and improved aerodynamics, Menzies and DJ Engineering Services will be aiming to see the Firestorm rising up the championship table in 2011.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Multiple choice

Re-thinking the multi-layer steel gasket

BY GRAHAM JONES

Multi-layer steel (MLS) technology has been at the heart of the high-performance gasket and sealing technology field for some years and is well established. It is therefore significant news that Cometic Gasket has re-thought the MLS concept as part of its process of designing a new head gasket. The new design of gasket will boast several features intended to tackle issues associated with MLS gaskets, specifically in the areas of combustion seal and clamp load. These include:

- A wider, lower profile embossment for increased contact area between the gasket and sealing surface, also resulting in decreased load requirements
- A centre, load-limiting layer, which allows for improved recovery during operation and prevents overloading of the combustion seal
- A narrower profile on the load-limiting embossment than on the two mating outer layers, allowing the sealing radii of each layer to seat against a solid flat area around the inner and outer perimeters of the centre, load-limiting layer
- Three active layers, which lend themselves to better repeatability between individual gaskets than some four or five-layer gaskets, as a result of there being less layer interaction and less friction between layers under load

Cometic Europe's Rob Barker points out that as the gasket is still under development, other design elements are also in the works. Specifically, the company's engineers are experimenting with embossment profile variations around single combustion beads ie profile changes in areas where more or less load is required, such as at the ends of the first and last bore; also, perimeter embossments around fasteners to even load distribution.

Less layers means less interaction and less friction, plus better repeatability

With more than 120 staff working in up to 24-hour shifts at the company's Concord, Ohio manufacturing facility, Cometic Gasket claims to have the fastest delivery / turnaround time in the gasket manufacturing industry and to be able to produce a prototype MLS gasket in just 24 hours. It also has a European operation based in Thetford, UK, and recently acquired Advanced Sleeve Corporation, so can now offer custom liners as part of its product expansion programme.

For more information see www.cometiceurope.com

Statistics

Image: 1 Pseudocolor Rep

Average Pressure	15729.45	PSI
Std. Dev	3919.06	PSI
Contact Area	24.53	sq.in
Total Area	180.45	sq.in
Force	385791.06	lbf
Minimum	7219.80	PSI
Maximum	18500.00	PSI

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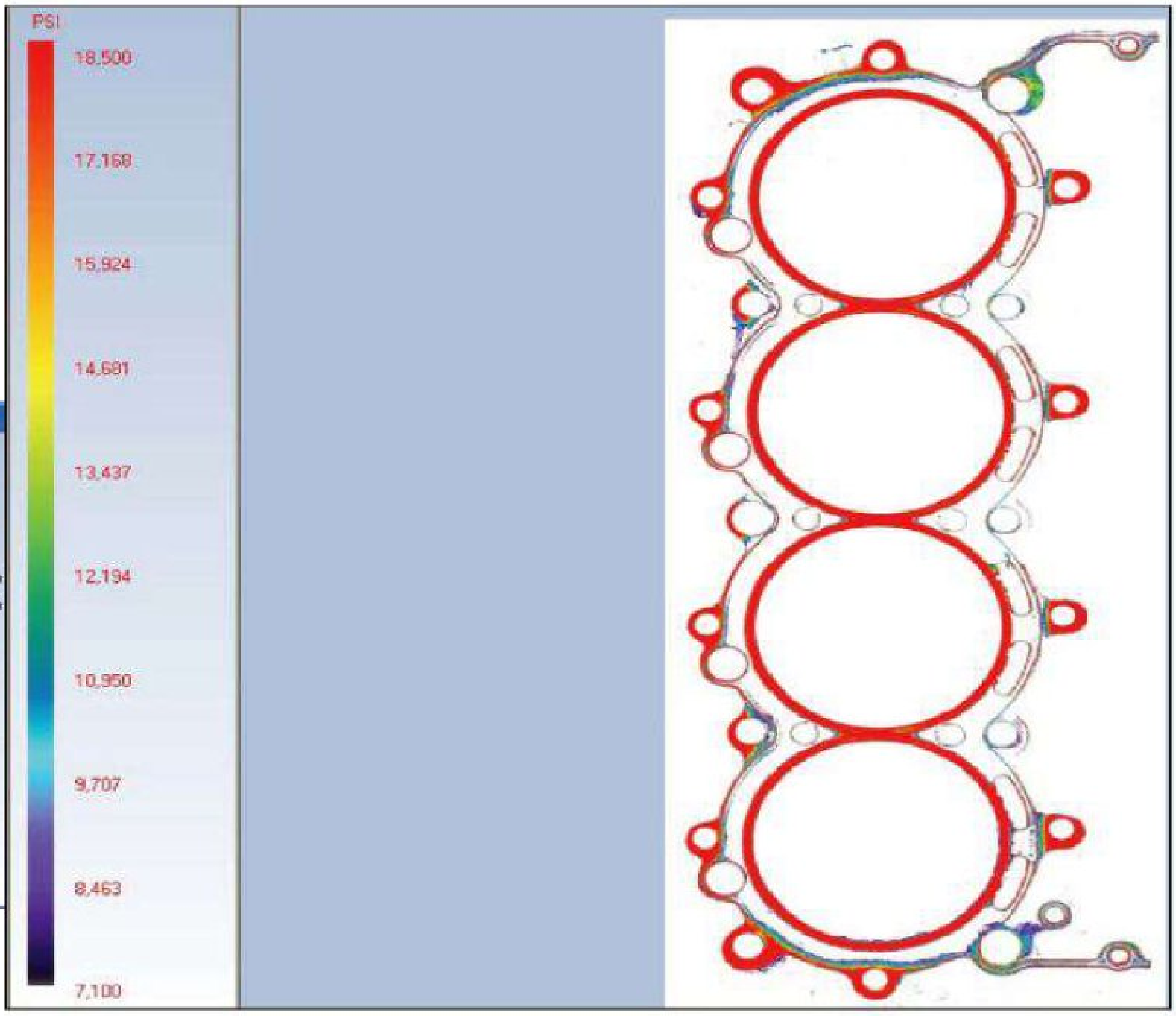

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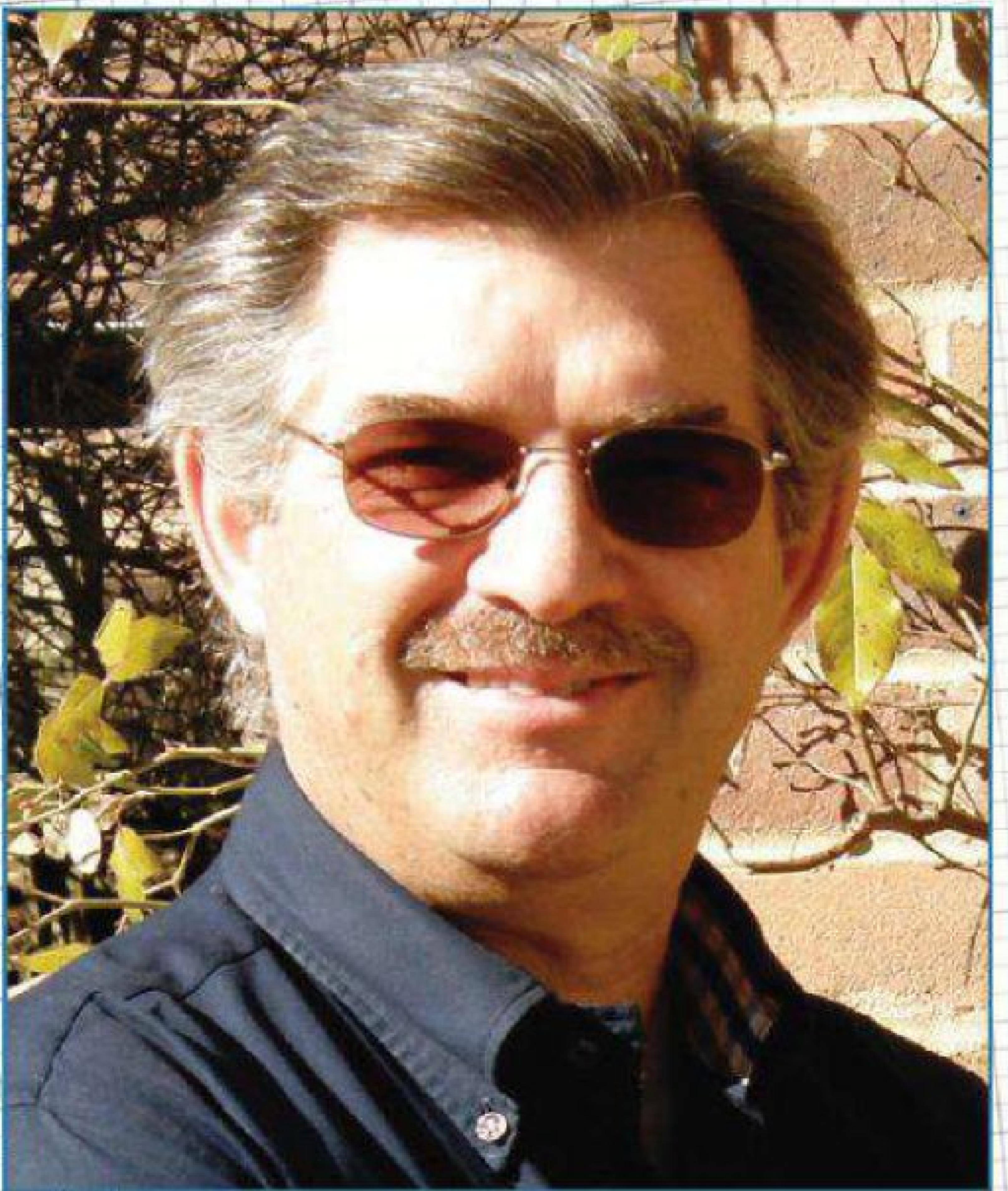
THE DESIGNERS

SERGIO RINLAND



"I don't profess to be an innovator. I'm more of a talent manager and innovations spotter"

He rates a car with limited success as his best design, yet the Argentinian designer has been a pivotal figure in motorsport for almost 30 years. So what makes Sergio Rinland special?

BY CHARLES ARMSTRONG-WILSON

'I've never worked with anyone who wakes up in the morning with a brilliant idea,' says Sergio Rinland, a designer with a notably pragmatic approach to designing and building racecars. 'Normally ideas evolve because you have a synergy between bright minds. One of them may be able to see the light, but it's because of the input and influence of other people.' This, he explains, was the case when he presided over probably his biggest contribution to Formula 1 racecar design – the famous twin keel front suspension.

In 2000, the FIA set out new rules for the following season that included a raised front wing, reducing the amount of ground effect it could generate, and consequently downforce. Rinland, chief designer at Sauber at the time, realised this was going to create a major challenge to good lap times, so distributed his limited aerodynamic resources accordingly. 'We put a lot more effort into the front,' he recalls. 'I don't profess to be an innovator. I'm more of a talent manager and innovations spotter. The twin keel was an evolution. It just came out of a discussion in a group, which is how great designs come about.' It proved to be a landmark innovation that gave the car an instant advantage and has been widely copied since.

This anecdote sums up the talent of this designer, which one might describe as more Ross Brawn than Adrian Newey, but very effective, as his CV illustrates.

Rinland was born in Buenos Aires, Argentina, the son of a civil engineer whose work took the family to Patagonia. From an early age, young Sergio opted to follow a technical career, much to his father's dismay, who wanted him to study in a business school. But Rinland was already focussed on motorsport. By the time he left school, the Fangio years were long past and Argentina's heyday in motorsport was over. But he still found opportunities to get involved, helping out friends in motorcycle racing, karting and Touring Cars.

Then, while studying mechanical engineering at university, he and a couple of classmates found a customer for a Formula Renault and spent their summer break designing and building the car. Powered by a Renault Dauphine 1.6-litre drivetrain, it was a typical Formula Ford-type car with no wings. Unusually, the trio opted to base it around a steel monocoque, spot welded and riveted together. This created a very robust structure, which was handy because many of the races were conducted on dirt.

On graduation, Rinland had built up a number of contacts in motorsport that helped him get a job in Formula 2, the top motorsport discipline in Argentina at the time. His first season was with one of the Chrysler satellite teams, and the following year he moved up to the works outfit, developing its cars to be the top of their class. Ultimately, he aspired to design his own racecar, but it was clear that was not going to be possible in Argentina, so he decided to make the move to the UK.

"As soon as they saw me working on the car, they realised I was not a mechanic"

'I used to go to the Argentine GP. The year I was moving to the UK, I told everyone in the F1 paddock,' says Rinland. 'They said, "okay, come and visit us" and I took it literally, knocking on everyone's door, making a nuisance of myself. Chrysler F2 driver, Enrique Benamo, said, "Why don't you stay with me and help in F3?", so I helped set up his team at Snetterton for half a year. After a while, though, I needed a proper job'. He had just £30 in his pocket and had to give up smoking – when it became a choice between that and eating. 'I then got a job with PRS in Formula Ford as a mechanic, the only job available. They thought it would be useful to have a Spanish-speaking mechanic as

Above: by 1986, the designer was working with Patrick Head at Williams, on the design team for the monocoque and front suspension of the FW11, driven by Nigel Mansell

Photos: LAT

Above: Rinland's first foray into Formula 1 was in 1984, as a designer for RAM. This gave him his first taste of composite work

Right: Yamaha-powered Brabham BT60 was one of the first F1 cars to be designed using CFD and one of the first high-nose cars

they had an Argentine and a Mexican as drivers, but didn't check on my skills. As soon as they saw me working on the car they realised I was not a mechanic.'

They did, however, find a use for his skills at PRS and, before long, Rinland was chief designer and penned the '82 and '83 cars. Toward the end of 1983, he had a call from Ron Tauranac, who had been impressed by the FF2000 that had shown well in Europe. 'I worked for Ron for a short while. You learn by serving him. I have been lucky to work for great people.' But then an opportunity to enter Formula 1 presented itself: 'Jeff Hazel put me in touch with John MacDonald, who was looking for someone who could hold a pencil for the F1 design office at RAM, doubling the design team. Against Ron's advice, I left him. A door in F1 opened and I went in head first without looking or thinking.'

The following year, they [RAM] hired Gustav Brunner to design the 1985 car and Tim Feast to help out. 'We used to work 24 hours a day in shifts. Gustav liked to work at nights, so I worked from eight or nine until 10pm and Gustav would come in about 7pm and work until four or five in the morning. He was doing the gearbox, Tim did wishbones and uprights and I was doing monocoque and bodywork. That's how I first got involved in composites.' Rinland recalls Brunner as very innovative and the experience as very valuable. 'It was a better opportunity than on a bigger team,' he says, highlighting the variety of tasks offered. 'Even then, people were starting to specialise.'

> **"A door in F1 opened and I went in head first without looking or thinking"**

Initially, the car showed promise, but ultimately the team was strapped by a lack of funds and things started to unwind. Unable to afford the rebuilds, the team was exceeding the life of the engines, causing unreliability. Eventually, the money ran out and the team had to stop.

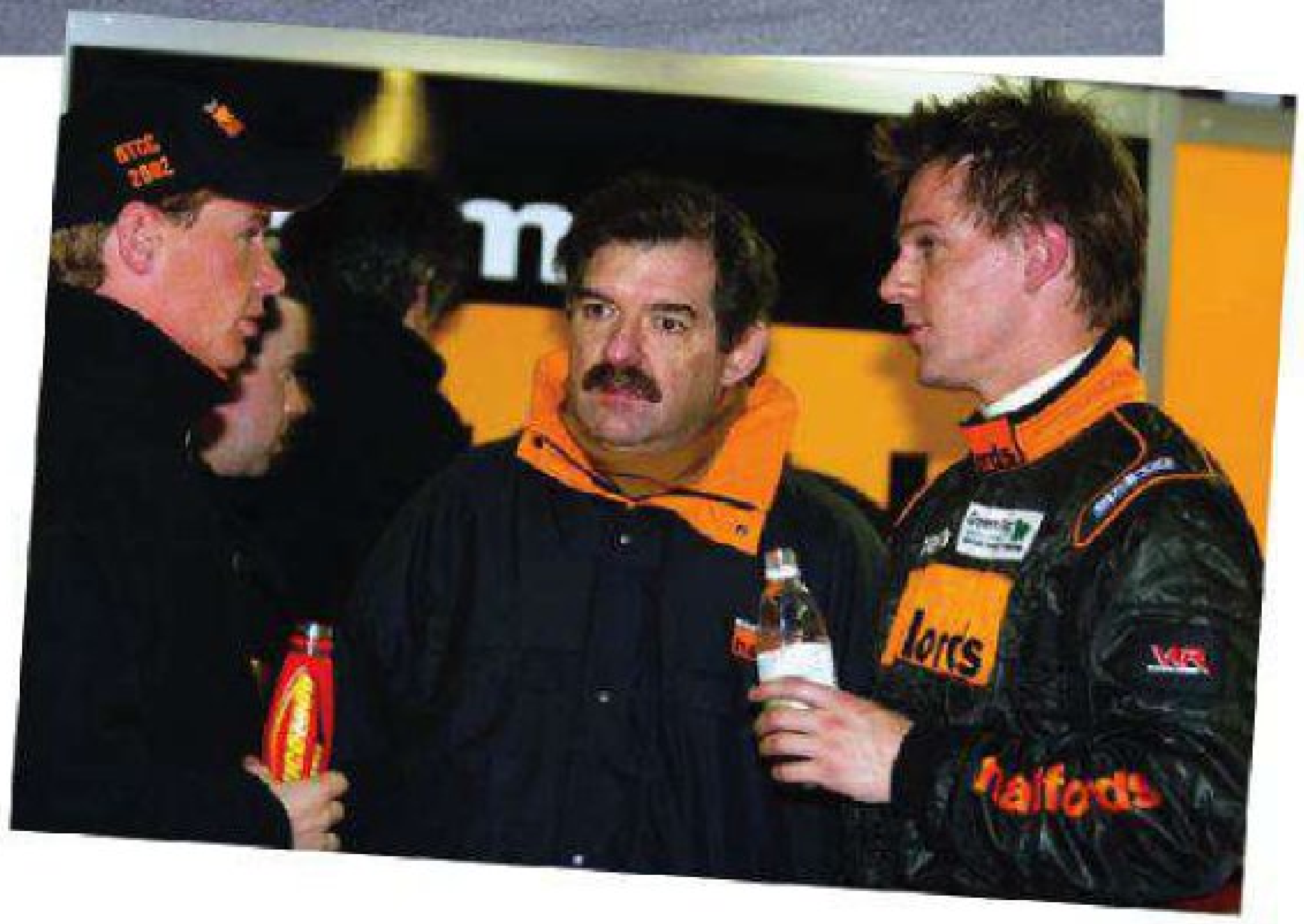
Around this time, Rinland went to collect a friend from Didcot railway station and bumped into Patrick Head of Williams. This chance meeting turned into a job offer and he spent a short time at the team working on the FW11, mainly on the monocoque and front suspension, and also race engineering for Nigel Mansell.

Rinland experienced at first hand the guiding influence of Head. 'On one occasion, he didn't like my front anti-roll bar design, so he re-drew it overnight and gave it to me in the morning. He is a very pragmatic engineer and I learned from him to think more as an engineer than a racer. Getting the right compromise is the most difficult thing on a racecar, and people sometimes get bogged down with pet ideas. They fall in love with a concept and compromise everything else for it. I also learned from Head what makes a car fast and win races.'

Within a year, Rinland was tempted to move to Brabham. However, soon after his arrival, Gordon Murray left in the wake of the disappointing BT55 and Rinland found himself responsible for delivering the car's successor with David North and John Baldwin. He believed the BT55's problems were in part due to insufficient torsional rigidity and installation stiffness, so he responded with a totally different design philosophy for the monocoque.

Initially, the team hoped to ditch the unloved, laid down BMW engine in favour of the proven upright version. But BMW held them to the terms of their contract and, at the last minute, the design had to be re-worked. 'We designed the car for the upright engine and were laying up the first monocoque when Bernie came into the drawing office from BMW saying, 'you are running the laid-down engine'. It was a good job we hadn't cooked the outer skin, but it was all laid up. We designed some inserts for the mould to take the BT55-type frame. With the upright engine we hoped to be competitive but, when we had to use the laid-down engine, we knew we were up against it!'

The car was dogged by unreliability, but managed a couple of podiums until, in 1988, Brabham pulled out of F1



Above: the BT58 was the result of Rinland's move back to Brabham when Ecclestone re-launched the team. It was a simple but effective racecar

Above right: when Brabham closed down for the second time, Rinland moved to Fondmetal, where he was commissioned to design a new car for the 1992 season, the GR02

Right: he always retained an interest in Touring Cars, too. Here, the designer of the VLR Peugeot 307 chats to BTTC racers Carl Breeze and Dan Eaves

altogether. 'Bernie's interest was starting to fade as he began to think beyond the team,' recalls Rinland. 'He told me he was under a lot of pressure from other teams to give up Brabham because of the conflict of interest with his role at FOCA.'

With Ecclestone's blessing, Rinland moved to Italy to work as chief designer for the new Dallara-Scuderia Italia F1 Team. 'Then Bernie told me he was getting Brabham back into F1, so it was a no-brainer to come back. I did the BT58 that [journalist] Jabby Crombac called "très jolie", which was nice, and Martin Brundle said it was one of the nicest cars he ever drove. It was a fairly simple car because Brabham was no longer a top team. We needed a manageable car, as we didn't have the resources of a top team, even though we finished third at Monaco with Stefano Modena and had a good number of points finishes.'

This success was followed by what Rinland describes as 'not a very good car', the BT59. 'This was the first car where we did all the wind tunnel work before we designed the car, and we went backwards. We made some wrong assumptions and the wind tunnel guys were coming up with big improvements that weren't there when we put the car on the track. We always had the wind tunnel, but with the BT56 and BT58 we built the model at the same time as the car. You couldn't say we designed the car in the wind tunnel. We used the wind tunnel to validate ideas and develop the car during the season.'

The BT60 was a different story. That was also studied in the wind tunnel for a year before we designed the car, but by then we had probably one of the best aerodynamicists of those days, Hans Fouche. He did a lot of research before we came up with the shape. He used CFD, which was in its infancy then, and he did pressure and velocity mapping around and through the car with Pitot tubes. It took ages, but it gave us so much information to design the front wing end plates, the sidepods, the nose, the front wing and the flaps. This was the first time we could see what air was doing. For me, it was an eye opener.'

Sadly, Fouche left motorsport in the early 1990s to return to South Africa. 'For me, that was a big loss. At the time I rated him alongside Adrian Newey,' says Rinland. 'He was brilliant.'

The BT60 was, Rinland believes, one of the first genuine high-nose cars. It had a full-width front wing with a low centre section suspended beneath a bullet-shaped nose, stabilised with guy ropes. Unfortunately, the car was hobbled by an early version of Yamaha's Formula 1 engine that was heavy, under-powered and had big cooling requirements necessitating huge radiators. It failed to show its chassis' true colours.

When Brabham closed down, the factory was sold to Yamaha and most of the staff laid off. However, Rinland got a contact with Fondmetal, the wheel manufacturer owned by Gabriele Rumi that had been venturing into F1. In December 1991, Rumi commissioned Rinland to design a new car for the following season. It was a tight schedule. He opened a design office in Tolworth, Surrey, near the old Brabham HQ, and pulled together most of the key people from the defunct team, right down to his old secretary. 'Brabham had the best people and a team is people. That team was fantastic, like a family. When it closed down we were in tears because it was the end of an era. Opening the office in Tolworth, I managed to attract most of those people.'

Renting the wind tunnel from Yamaha and outsourcing the manufacturing, they went from setting up the office to the car running in just four and a half months. It was the car the BT61 would have been, but simplified to suit the resources of the team. 'When you design a car, you need to consider who you are designing it for and what resources you have available. Fondmetal was a small team in Italy – it didn't have any

“This was the first time we could see what air was doing. For me it was an eye opener”

manufacturing facilities - so development was going to be complicated because everything was outsourced. Also, although the team of mechanics were good, they were not the Brabham guys! I decided that it was going to be a car where simplicity had to be a main feature. We would try and innovate in aerodynamic concepts, but keep it simple. There was no semi-active front suspension and we went from a complicated three-shaft gearbox to a simple two-shaft design.

It worked. Aerodynamically, we had some innovations, like a sculptured front wing and flaps and undercuts on the sidepods that were copied 10 years later by Ferrari. But because the car wasn't winning, I guess people didn't notice. The car was very good and was the last car that I was actually still drawing. Up until now, it has been what I believe is my best design, if not the most successful - it qualified seventh after its first and only test at Silverstone.'

Again though, the car was limited by a lack of resources. 'Williams would get through maybe 60 or 65 floors, because it was a consumable in those days. We only had two floors and, after two or three races or repairs, they changed shape.' Eventually, the team ran out of money, and Rinland moved on.

Following a short spell at Scuderia Italia, he de-camped to the US to work for Dan Gurney on IMSA and ChampCars. 'People say, "Never meet your heroes because you will be disappointed." With Dan it wasn't true. I was blessed to work with him.' Then, via a couple of diversions, including working for Keke Rosberg in the development of his DTM Opels, he ended up at Benetton. 'I was there for four years working on composite design.'

Rinland describes the wind tunnel-designed Brabham BT59 as 'not a very good car'. The numbers simply didn't tally

Then came the offer to be chief designer at Sauber on the C20. 'My approach at Sauber was again to do a simple but effective car, to create the foundations for a more innovative one later as we grew the team. It needed to be light to be able to run as much ballast as possible, as forward weight distribution was starting to play a major role. From the team I found when I went there, I only changed two guys. All I did was physically re-arrange them in the design office and get them to work in small teams according to their tasks.'

"There is no magic, only constant learning and hard work does it"

The C20 gave Sauber its best season ever but, even before the season started, Rinland's efforts at the team were starting to unravel. 'When I went there it was an all-out war between the design office, race engineering and manufacturing. I managed for a short time to bring it all together but it was getting more and more difficult to hold it. When the 2001 season started and we needed to go into the next car, all those factions tried to break up what I was trying to keep together.' Realising the impossibility of the task, Rinland moved to Arrows but, before he was able to make a start on a new car, the team ran into problems and folded.

Since then, he has been an engineering consultant for several companies and teams in GP2, IRL, BTCC, GT1 and LMP1, completed an MBA, co-founded a CFD consultancy company, set up a gearbox division for Pankl and designed a Le Mans Prototype for Epsilon, which unfortunately didn't race.

Reflecting on his career, Rinland sees his greatest contribution as someone who makes things happen. 'That is the technical director's job today', he says. 'He is a talent manager who gets in and delivers, bringing the talent out of people.

'I disciplined myself from my early days to spend at least two hours a day studying new ideas and technologies, which keeps me abreast of what's coming. There is no magic, only constant learning and hard work does it.'

After more than 35 years working in the very heart of motorsport, Sergio Rinland is well placed to recognise a good idea when he sees one, but also has the ability to bring it to fruition, which is what ultimately makes teams successful.

At Sauber, Rinland battled to bring the design, engineering and manufacturing teams together, but left in 2001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Something old... something new

Photos: Ian Wagstaff

TECH SPEC

CHEVRON GR8

Class: GT / GTC

Engine: Cosworth 2.0-litre YD Duratec 255bhp

Transmission: Hewland JFR five-speed sequential

Suspension: Chevron, Proflex custom built, remote reservoir racing dampers

Brakes: AP Racing four-pot calipers with 'long wear' pads, vented brake discs - front: 330mm, rear: 304mm

Wheels: SL Corse Flow form one-piece wheel - front: 17in, rear: 18in

Chassis: Chevron Racing Cars

Electronics: Cosworth Electronics PiRQ4 ECU, Pi Omega LCD dash

Aeroquip

Goodridge

Fuel tank: Advanced Fuel Systems 80 litres

Body: glass fibre reinforced plastic

Length: 3900mm

Width: 1700mm

Wheelbase: 2360mm

Dry weight: 635kg

Making a modern version of an iconic racecar is never an easy task, but Chevron seems to have done it with the all-new GR8

BY IAN WAGSTAFF

It is easy just to resurrect a charismatic name that shares nothing with its predecessor, but director of operations at Chevron, Helen Bashford-Malkie, and the current team understand that indefinable something that is a Chevron, and have ensured it can be found in the GR8. Ask any aficionado of the marque and their favourite Chevron will almost certainly be either the B8 or B16 coupés. The GR8 is their spiritual successor. 'We started by thinking we would just make a B8 and update it a little bit,' explains Bashford-Malkie. That didn't work out, but you can still see the styling influences. Like the B8, the car is simple, with a spaceframe chassis, but uses considerably less, and modern-sized, tubing. 'We needed to be able to manufacture it quickly,' she says. 'Everything is made big as I wanted the car to be cost effective and driver friendly. Hence a big radiator, so a larger one does not have to be fitted when racing in a warm country.' This is a bespoke product manufactured by Radical. 'We have tried to use the suppliers that have been with us for many years. I also wanted to use known names and branded products, hence AP for the brakes, which are probably bigger than you think you might need - so much so that we have not had to use any air ducting, except for the entry for the Silverstone 24-hours.'

The GR8 features a centre section comprising a semi-monocoque aluminium sill and platform structure integrated with an MSA-compliant rollcage in 50mm diameter steel tube. The pre-fabricated steel panel inside the chassis is a reference to the B8, and the 50mm and 25mm box section steel spaceframe forward of the front bulkhead incorporates a removable nosebox. The sill design is claimed to make more effective use of material than a tubular structure and is seen as a preferable solution for side impact protection.

One area where a new supplier has been used is the suspension. Lancashire, UK-based Proflex supplies the dampers and springs and, reports Bashford-Malkie, has been particularly enthusiastic about the project. The front suspension incorporates an unequal length wishbone set up with outboard spring damper unit, while the rear consists of parallel links and radius rods. Chevron explains that while this may appear old fashioned, it is an effective method of feeding loads into the chassis. The track rod is angled, allowing considerable shortening of the rear chassis structure, which results in less weight and increased installation stiffness.

Such as the aluminium uprights and wishbones are manufactured in house or by Bolton-based Motorsport Components, the latter company's Dennis Aldred having been an engineer at Chevron with Vin Malkie.

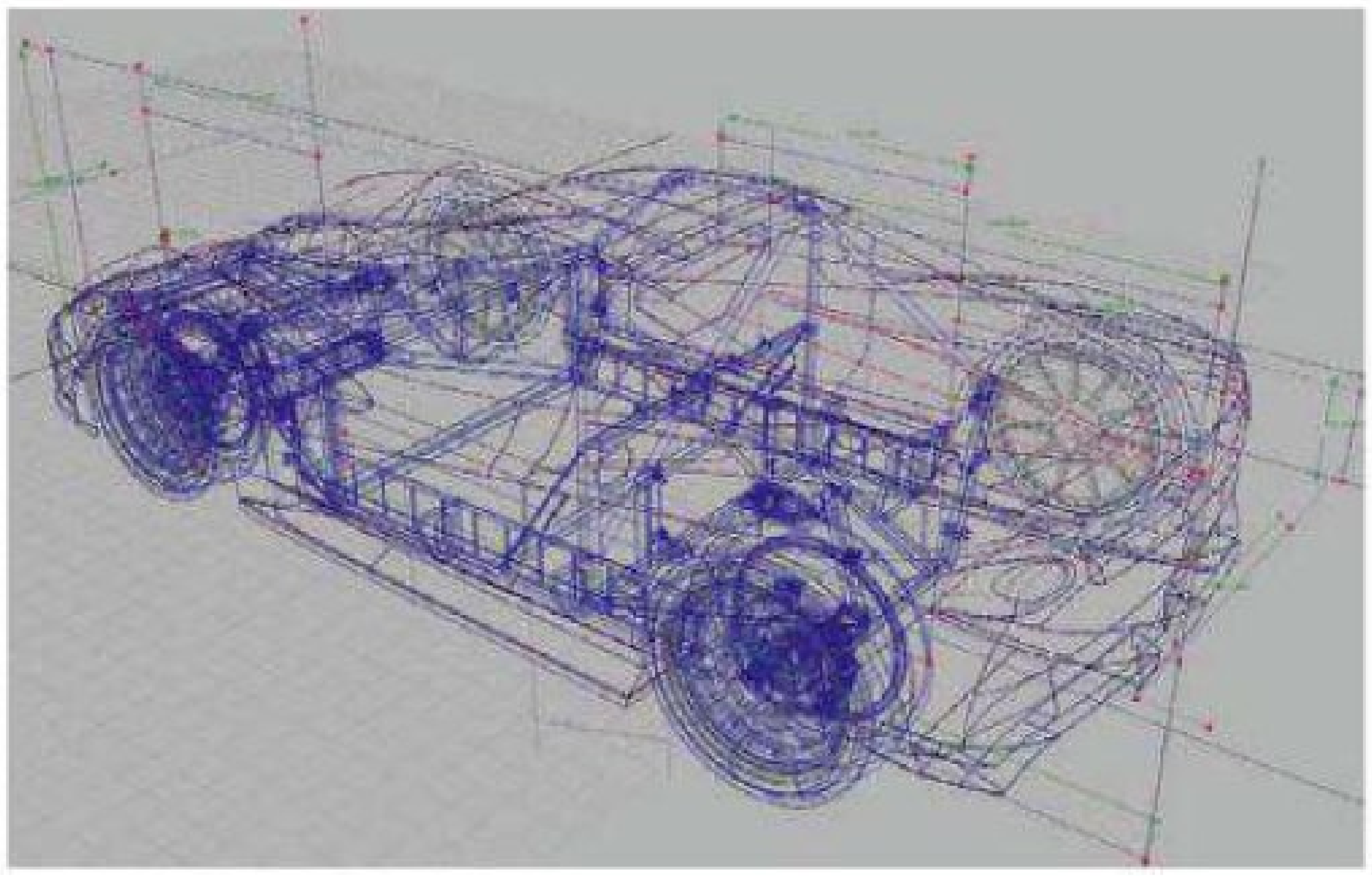
The engine, Cosworth's 2.0-litre YD, the Duratec update, produces 255-260bhp and engine rebuilds for the series are fixed at 30 hours, although Bashford-Malkie believes this could be longer. She confesses there had been thoughts of using a Chevrolet V8 engine, 'but with the recession I thought I ought to cut back. It has proved to be the right decision as the GR8 has proved economical to run.'

The transmission is a Hewland JFR five-speed sequential 'box. 'Five speeds seemed enough with the 2.0-litre engine,' observes Bashford-Malkie. 'I was thinking of having an H-pattern shift, but I'm glad that I didn't in the end, as modern drivers just aren't used to it. The Hewland 'box is fantastic. We have used just one dog ring all year in the Challenge cars.'

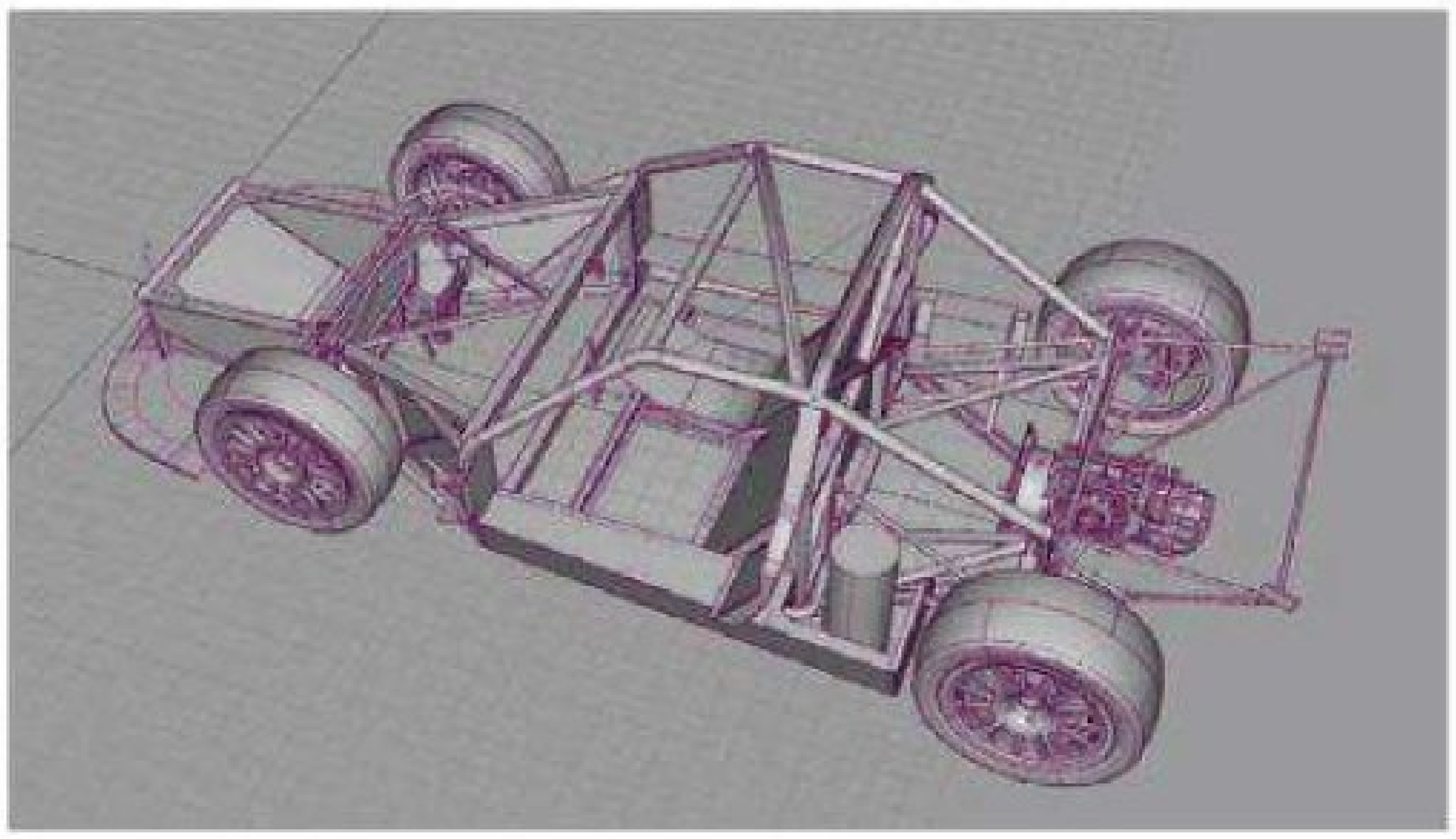
Electronics are obviously one major area where the GR8 differs from its predecessor and the supplier, Cosworth Electronics, was chosen mainly at the request of Cosworth Engines. Again, Bashford-Malkie says a higher spec has been used than is perhaps needed, but this means a paddle-shift system can be fitted if the car is used in GT racing.

AERODYNAMICS

The aerodynamic package is still being developed, but the team behind the car is adamant it will not radically change the appearance of the car. Expected are 'tweaks' to the underfloor and rear diffuser and the position of the rear spoiler. 'At the moment, we just have a plain, old fashioned Chevron splitter at the front,' says the car's stylist, Lester Allan.



Chassis uses a semi-monocoque aluminium sill and platform with box section steel spaceframes, an MSA-compliant 'cage and removable nosebox



Bodywork was styled by Lester Allan and made from a foam buck cut by Bakers Patterns. The GT-spec car was down to aerodynamicist Frank Doyen

A mid-mounted, 2.0-litre, four cylinder Cosworth YD engine provides the power, hooked up to a Hewland JFR five-speed sequential transmission

However, for the Challenge Series car to be converted to full GT specification, considerably more aero work will be required, Allan envisaging a bigger wing and perhaps a Gurney on the back of the bodywork.

The car run by TrackTorque in this year's Britcar 24-hours was basically the same as the Chevron GR8 Challenge Series contenders, although on Dunlop slicks, rather than Toyo road / race tyres, though Bashford-Malkie believes the series may change to slicks for 2011. Wear rate has already been proven to be good and, at a test on Chevron's 'local' track, Anglesey, a set of soft Dunlops lasted three hours. The slicks were proven to be worth around six seconds a lap over the standard tyres.

Prior to a rather disappointing showing in the Silverstone 24-hours, in which the car retired after two laps, possibly due to damage sustained during practice, the GR8s had only appeared at rounds of their own, BARC-organised series. However, it was never the intention to produce just a car to run its own championship. 'I am a manufacturer, not a race organiser,' says Bashford-Malkie. 'We were initially not sure how the car would be received, so running the series was a bit of a banker. Having said that, it is great to have the standard car being driven by 35-55-year olds coming off club racing. It's a car that can grow with them perhaps for four or five years and even up into Europe.'

Following the Silverstone race, the car was entered for a Donington Park round of the British GT championship, successfully finishing seventh overall, beaten only by GT3 contenders, and Bashford-Malkie reports a high level of interest in the GR8 amongst GT championship organisers throughout Europe, the expectation being that such expansion could see customers fitting larger engines. Now Bashford-Malkie has her eyes set on a return to Le Mans for the marque and would like to see the car homologated over the winter. Quite how it would fit into the ACO's GT regulations, however, remains to be seen.

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A suspension revolution?

Wheel camber control is always imperfect and involves compromises and limitations, right? Not according to one inventor...

In this technological age, genuinely new ideas are as common as hens' teeth. So naturally, when an idea is announced and touted as totally new, revolutionary even, it attracts scepticism. But then - hopefully - minds will be opened sufficiently to allow objective analysis. In that spirit of constructive scepticism then, let's take a closer look at the 'VXI' suspension system of inventor, Winthrop 'Win' Dada of Ojai, near Santa Barbara in Southern California, for which he recently filed a United States patent as a 'totally new type of vehicle suspension... like no other ever devised or built. It's called the VXI because the suspension arms are arranged in a V or X shape, and it's fully independent, hence the 'I' in VXI'.

BY SIMON McBEATH

THE INVENTOR'S CLAIMS

Having read this introductory assertion, probably the first question to come to mind is: what is there left that could be designed into a suspension linkage system that warrants a patent? Well, who to put it better than the inventor himself? 'The list of features and benefits includes the following:

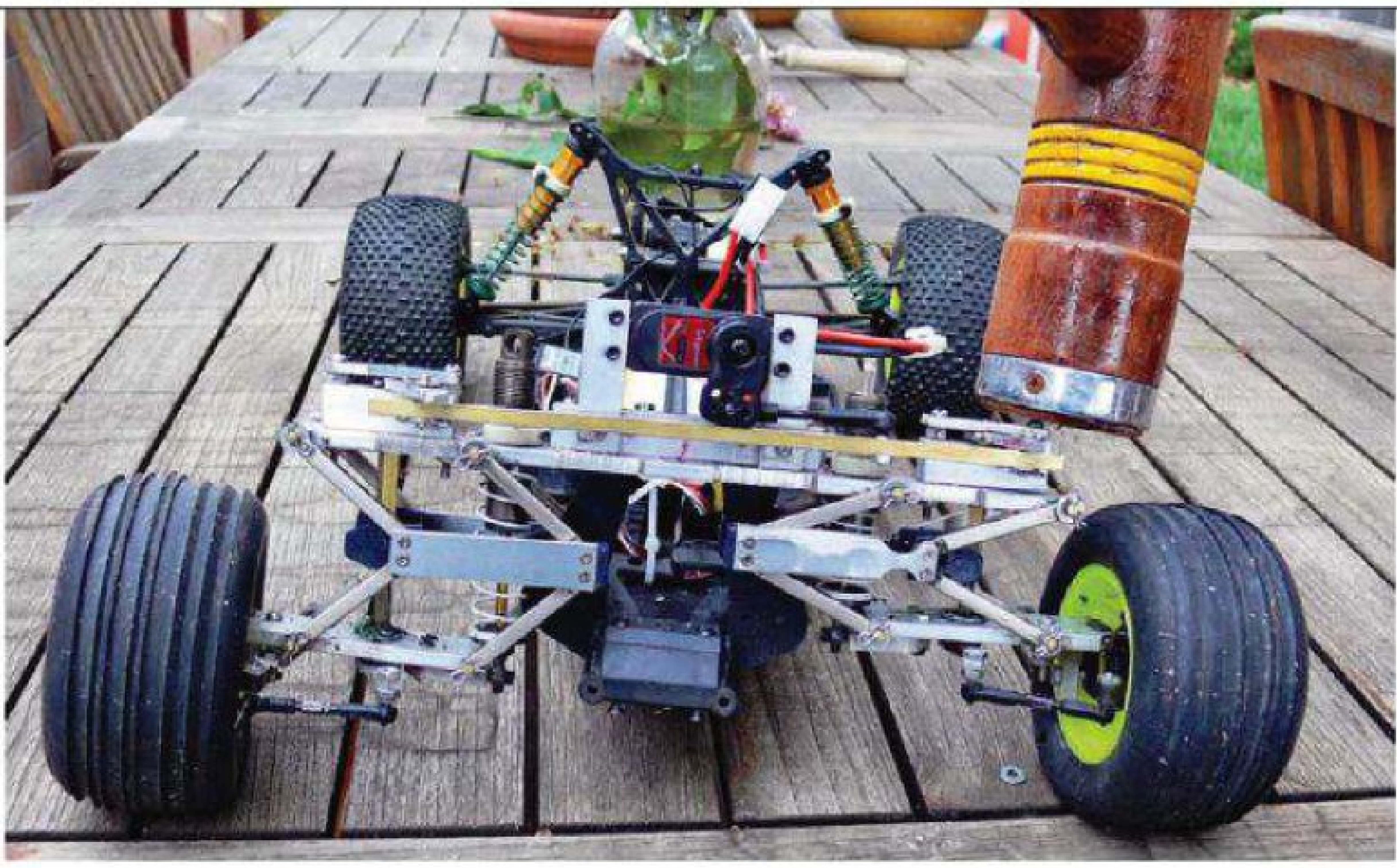
1. Absolutely zero track width change (zero wheel scrub) during suspension deflection.
2. The ability to set absolutely zero camber change, or to have the camber vary according to pre-set parameters. Using simple links, the VXI suspension can be set at zero degrees camber [or whatever optimal camber might be] at neutral compression, and can then go into negative

All photos: Winthrop Dada

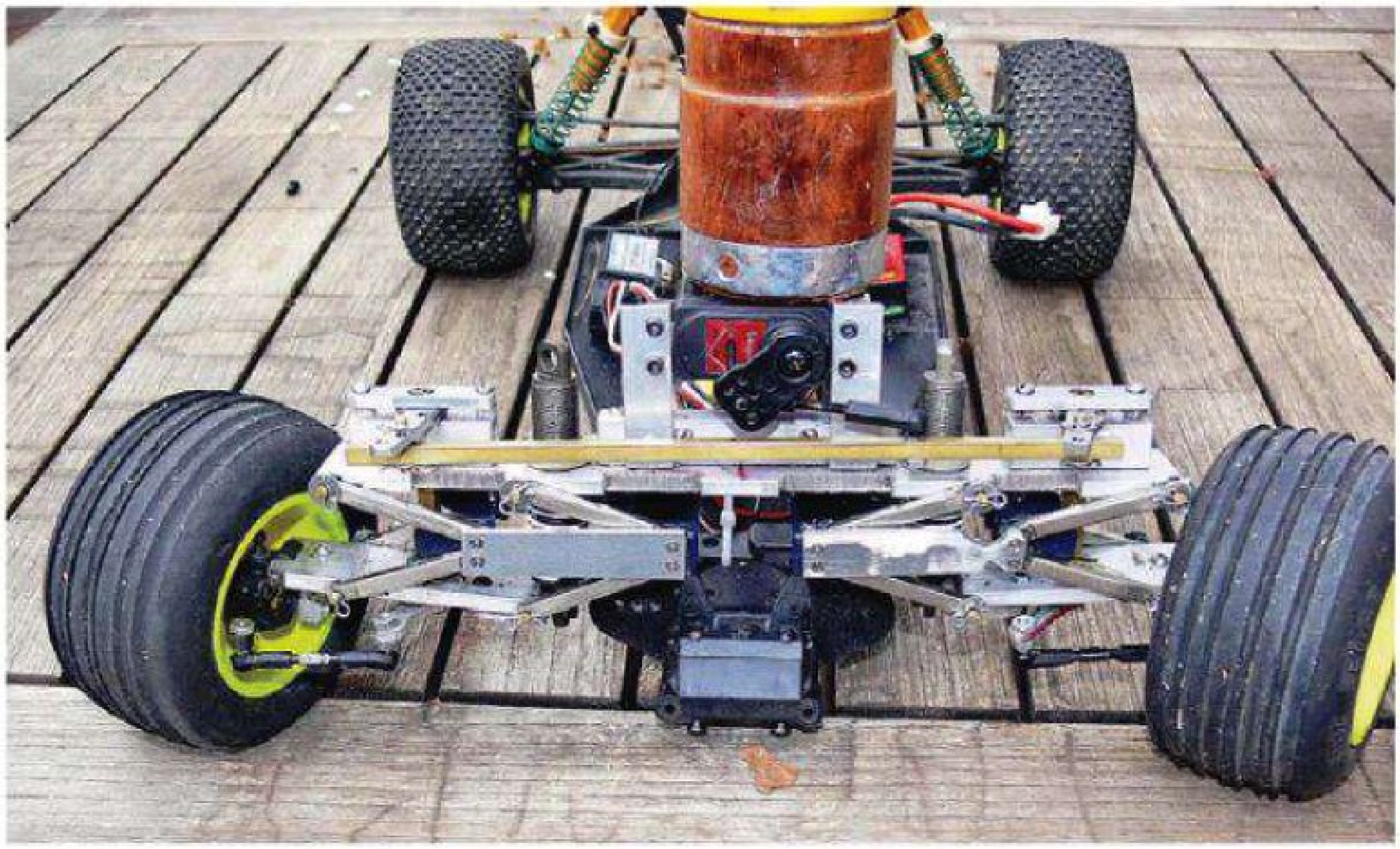
Winthrop Dada's Suzuki Sidekick in its natural rock-crawling environment, the source of the inventor's inspiration for a new suspension system

camber in compression and positive camber in droop. This, in essence, keeps the tyres at optimal camber at all times and negates the effect of body roll.

3. The roll centre is moved far outboard and higher than other designs, leading to an inherent resistance to body roll.
4. The patented steering system completely eliminates bump steer and deflection steer.
5. If desired, extremely high levels of wheel travel can be designed in. 40in (100+cm) of travel and more are possible.
6. It's extremely compact for a given amount of wheel travel.



Prototype no 1 with load applied to the left side suspension



Prototype no 1 with load applied centrally, and steering lock applied

The inventor continues: 'One key point is that the "roll centre" and "instant centre" on the VXI is just about as good as it can be. The instant centre of the VXI is off to infinity, just like a live axle. In a way, the VXI produces a "virtual independent live axle". As I see it, the VXI combines the best aspects of a live axle with the best aspects of an independent design, while also eliminating most of their combined shortcomings. That is, it's got the instant centre and lack of track width change and wide, outboard-mounted pivot points of a live axle, yet also has the fully independent operation, low unsprung mass and compact packaging of double wishbones. In addition, the VXI controls camber like no prior system I'm aware of.'

Dada asserted that VXI is the first suspension ever devised that uses 'floating' pivot points and also that it is the first suspension devised where the wheel does not travel through an arc of motion. 'The wheel travels up and down in a perfectly linear plane, not an arc.' (Author's note: the sliding pillar system has not been wilfully omitted here; it has simply never seemed a practical system for a racecar). 'In essence, the VXI suspension approaches the theoretical ideal. And all of this is done using simple links and simple geometry based largely upon existing bushings and links. Furthermore, there are endless means of springing and damping the suspension, as well as many ways to arrange the suspension arms, all of which are covered in the patent application. The upshot here is that the VXI suspension keeps more rubber on the road and will improve tyre wear, yielding more grip and fewer pit stops.'

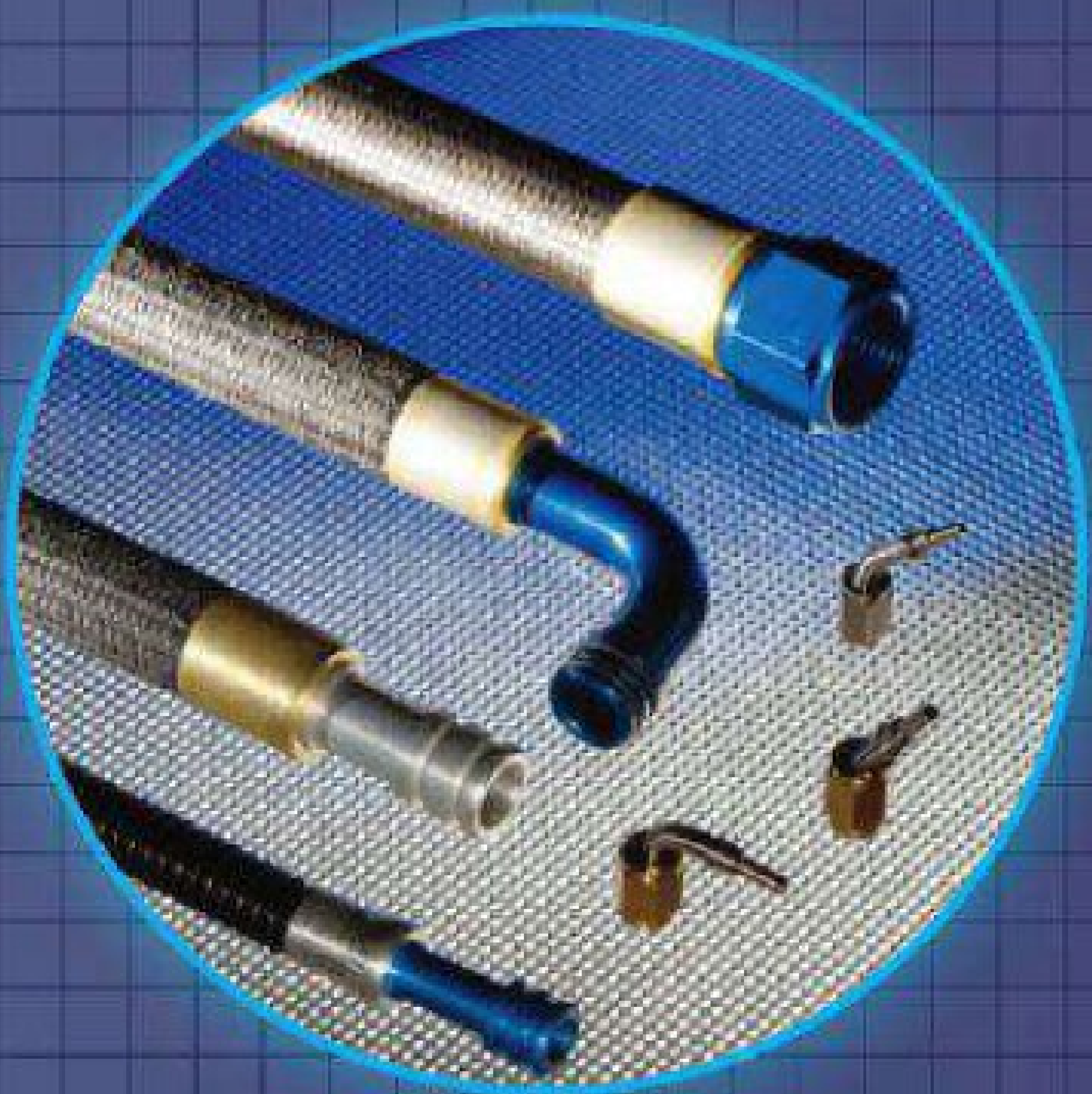
The reference to extreme suspension travel hints at the source of Win Dada's inspiration. A database programmer by profession, Dada also describes himself as 'an off-road, rock-crawling enthusiast... and a closet recreational automotive engineer. My original intention was to invent an independent suspension with high-travel characteristics for use in rock crawling. In doing so, I almost unintentionally stumbled upon inventing a suspension that has zero scrub and zero camber change, the Holy Grail of suspension design as I've heard it. At that point, I realised I had come up with something that was truly revolutionary and represented a quantum leap in suspension design.'

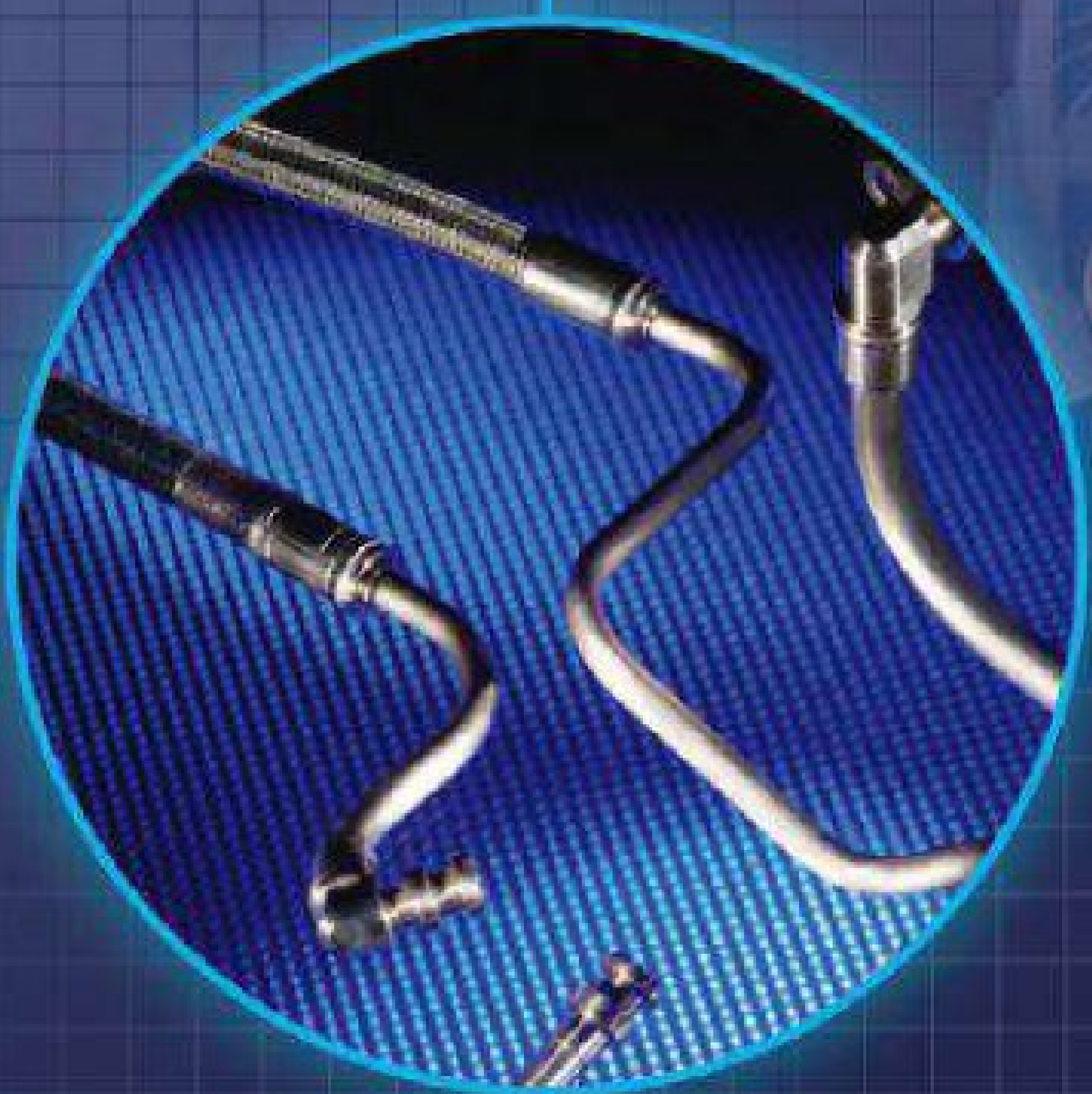
> **"the best aspects of a live axle with the best aspects of an independent design"**

So the claims sound both bold and interesting. And despite what you might be thinking, Dada is actually a modest man, keen to not be perceived as over-confident in his assertions – hence the notion of showcasing his ideas in this journal was greeted with a mixture of excitement and not a little trepidation. Nevertheless, Dada is prepared to argue his case: 'I know that many people are sceptical when I tell them about the design, but I am ready, willing and able to disprove them.'

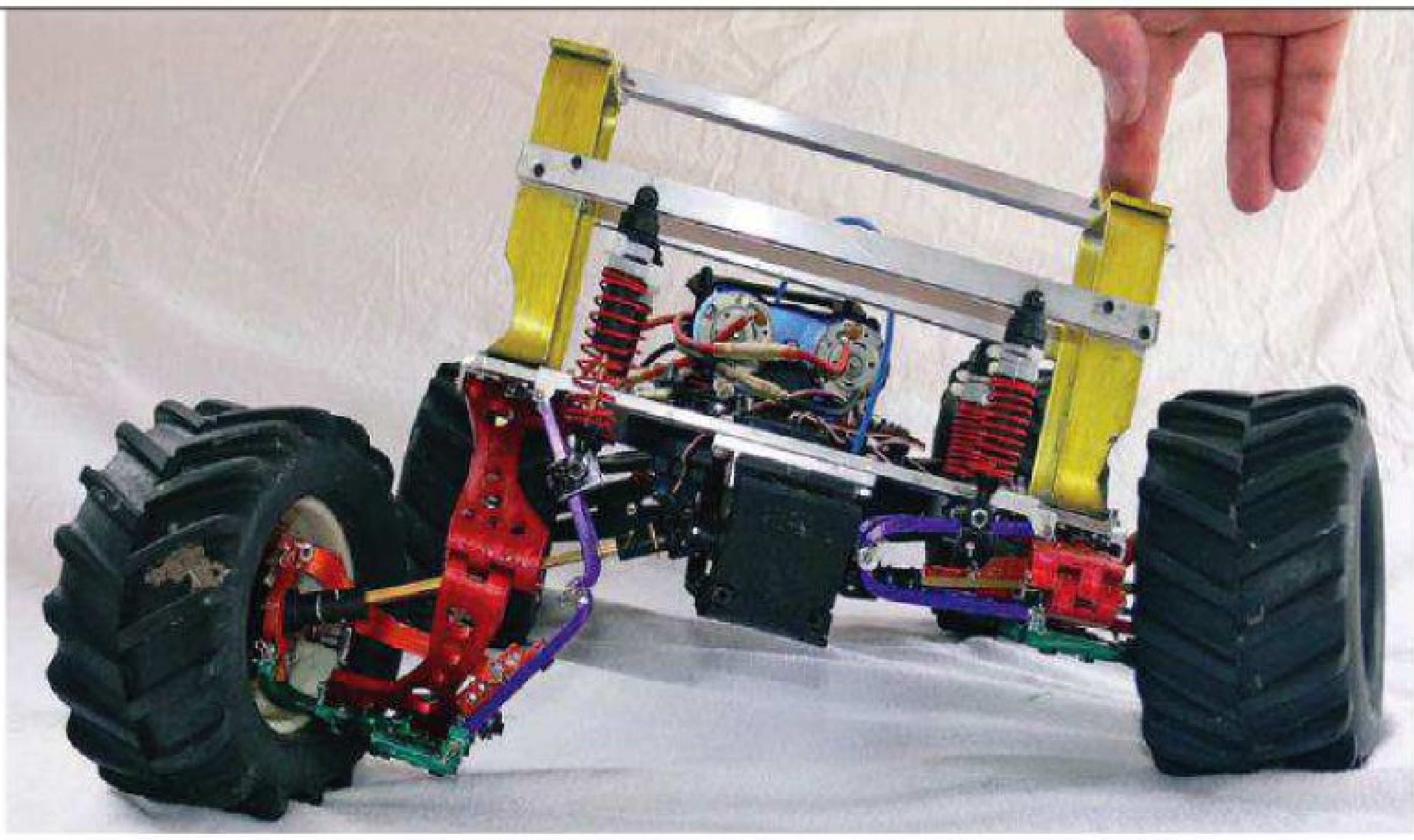
PROJECT GENESIS

'My modified Suzuki Sidekick (aka Vitara in Europe) was the vehicle that inspired the invention, as it has a live axle





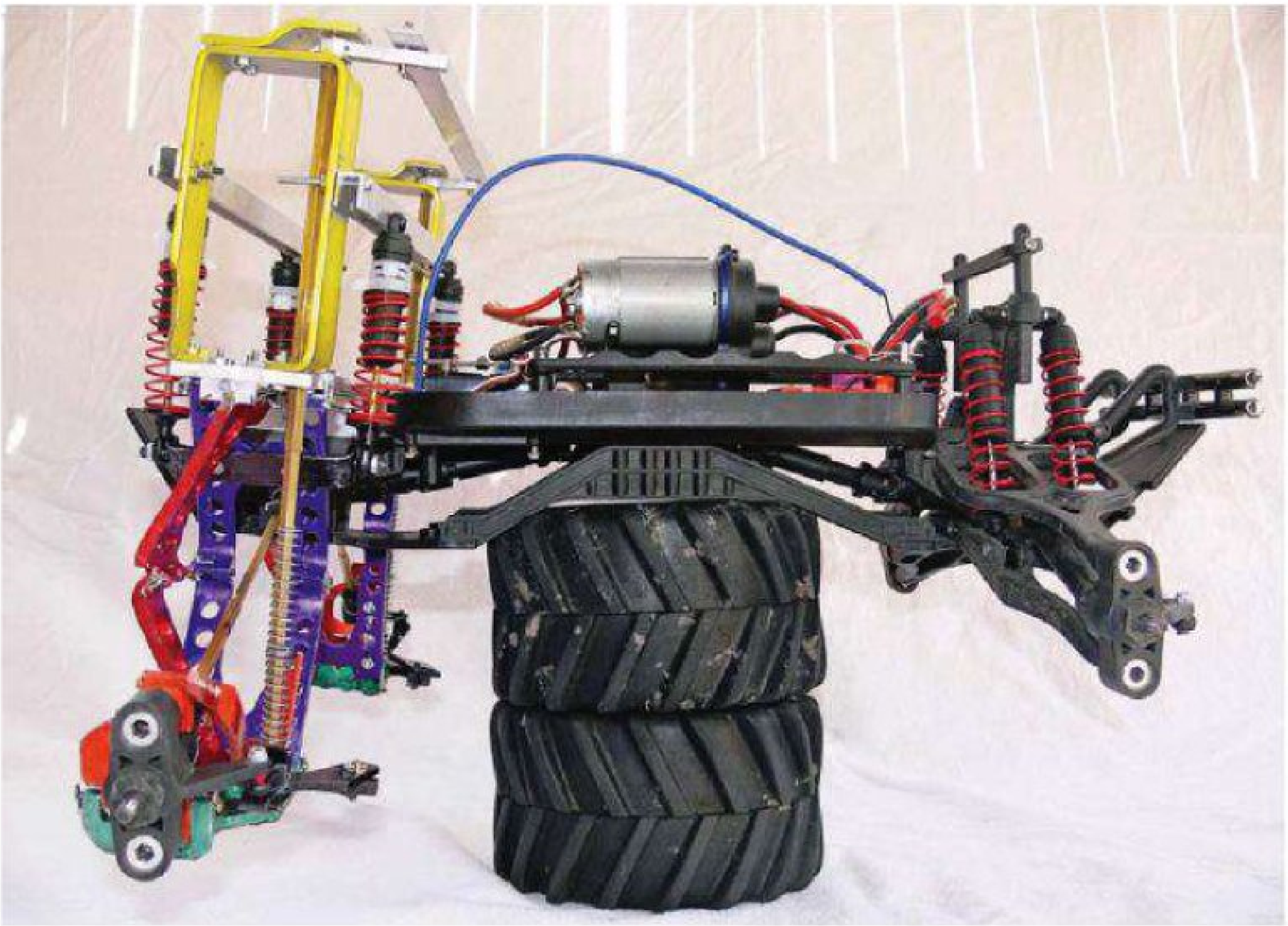
rear suspension and a strut-type independent front suspension. Initially, my motivation for creating the VXI was to solve the lack of wheel travel inherent in an independently suspended off-roader. Shortly after my son, Evan, was born, I was in the hospital waiting for him and his mother to recover, filling the time by doing sketches of the suspension, when the concept for the VXI came to me like a flash. It was the last of several prior but impractical iterations of the suspension I had been playing with in my mind. I immediately realised what I had created and said to myself "that's it".'



Prototype no 2, complete with colour-coded components, seen here with load and steering lock applied as if in a right turn. Note, the VXI-suspended front wheels are upright, in spite of the substantial suspension deflection, unlike the wheels with stock double wishbone suspension at the rear

SPARKLE IN THE EYE

Dada is keen to pay tribute to two individuals whose input was crucial in the next stages of the VXI's genesis: 'my co-worker, Jorge Villarruel, is an off-roader like me, and he was the first person I showed my sketches to who actually saw the light. He immediately had a sparkle in his eye and said, "I think you've got something there." When creating something totally new, you always have self-doubt and wonder if you're crazy, but Jorge gave me the confidence to seek a patent attorney, and that attorney, Patrick Avakian, gave me even more confidence after he also told me that I had something with the VXI. Given that Patrick is also a well-known racer of a BMW Z3 coupé in Southern California, I thought, "Well, if he thinks it will work, then I guess it really will." But I'm sure I looked ridiculous walking into Patrick's swanky office with my wooden mock-up of the suspension wrapped up in a beach-blanket...' However, Avakian generously remarked that 'I believe the benefits offered by the VXI system can be revolutionary for tyre management and tyre control. The zero scrub, zero camber change results are both realistic and challenge conventional multi-link and MacPherson designs. With lightweight materials, such as carbon and alloys, readily available and somewhat more affordable these days, Win's system is immediately plausible in racing applications, including rally, off-road and Touring Cars.'



From the side, it is possible to see just how much suspension travel the VXI system has allowed on prototype no 2. Compare the travel of the front VXI set up with the standard SLA double wishbone suspension at the rear

WORKING PROTOTYPES

So, with newfound confidence, Dada's next step was to construct a working prototype with which to demonstrate how the linkages functioned, and a scale model radio controlled car chassis was used as the basis for 'prototype no 1'. It is plain to see here that in jounce, with no roll applied, the linkages saw the wheels move in a single plane, but that when the chassis rolled, the wheels adopted a similar camber angle to the chassis, much as they would with equal length, parallel wishbone suspension, for example. However, the inventor had in mind from the start that what he calls a 'camber link' would need to be added, and that this would enable the wheel camber change during suspension deflection to be tuned to whatever was required. Dada: 'the plan was to allow the suspension to "dial out" body roll and keep the wheels at optimal camber at virtually all times.

'Picture this: the steering knuckle / spindle is mounted on a pivot point (in fact, this is the case with prototype no 1, but camber is fixed in place by the 'L'-shaped brace under the wheel carriage and just outboard of the steering mechanism). Now envisage a simple link that runs from the top of the steering knuckle (such a ball joint exists on prototype no 1, but is unused) to a point part way up one or both of the lower and outermost suspension arms. Let's say this link attaches to the arm a quarter of the way up towards the cross link. This link will now pull the wheel into negative camber in compression and push it into positive camber in droop. This effectively negates [the effects of] body roll. This, in turn, would allow racecars to have softer springs and more wheel travel, which, in turn, would allow the tyres to remain in contact with the road more of the time.

'The fact that both the inboard and outboard wheels are at zero degrees camber [or whatever the chosen camber might be] to the road and can accommodate more travel will yield more grip and reduced tyre wear in corners. This is especially true in the case of the inside wheel, which is often seen lifting entirely off the road due to lack of travel and / or is at a highly negative camber after body roll has set in. Get those inside wheels to give some additional traction and, all of a sudden, the VXI has a real advantage over other suspension designs in road racing applications.'

Prototype no 2 came along late in 2010, a refined 'long suspension travel' version to demonstrate all the above virtues, but also featuring reduced parts count, improved rigidity and less friction than no 1. Dada again: 'Number 2 was built on a Traxxas 1:8 scale 4x4 monster truck chassis. The different suspension components were coloured with the following code: green = wheel carriage; blue = longitudinal arms; red = lateral arms; orange = camber link apparatus; black = steering arms.

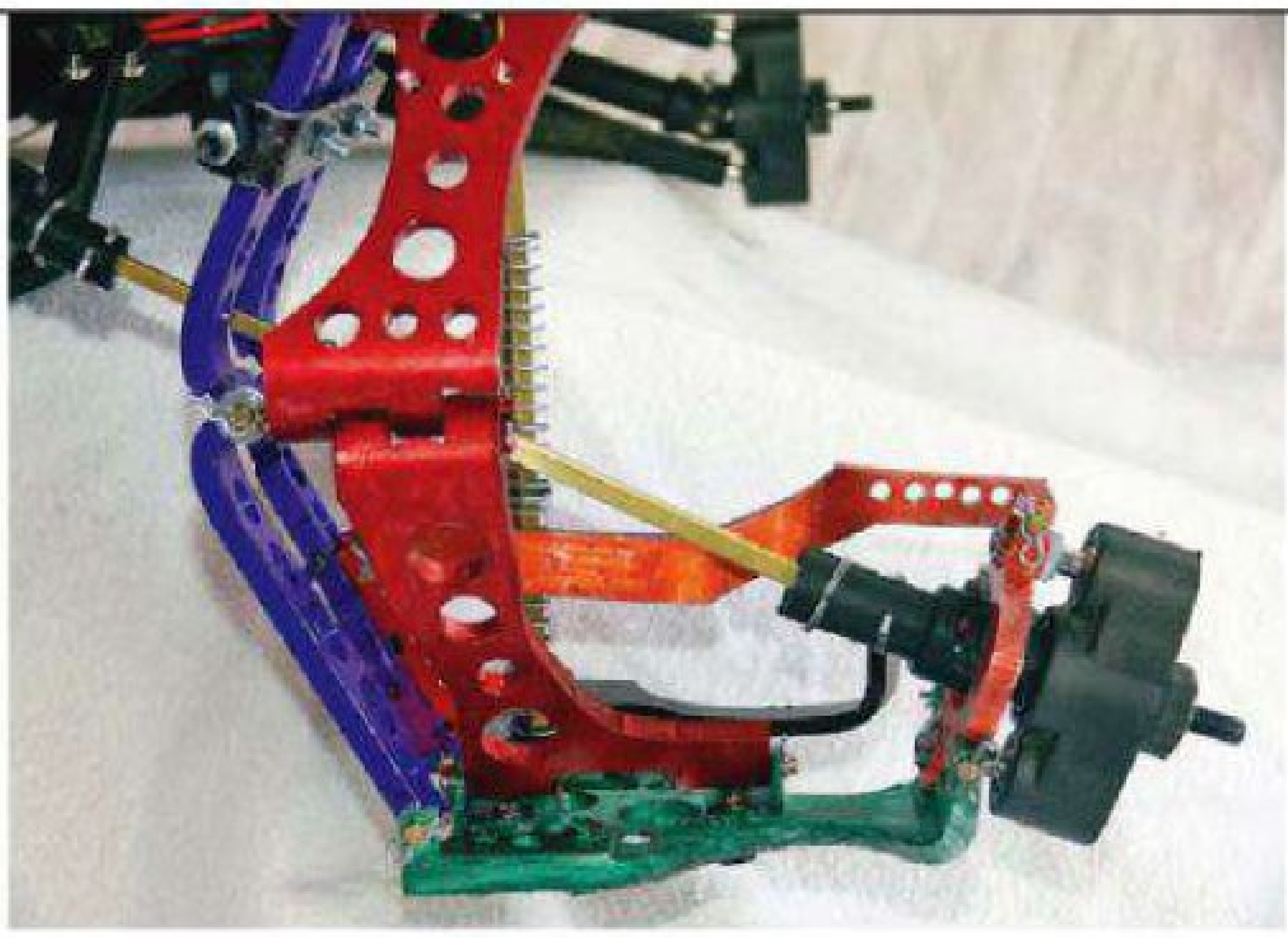
The square section brass tube replaced the mid-sections of the stock, slip-yoke driveshafts to enable full suspension travel to be obtained. 'The suspension has 4.5in (114mm) of travel,' continued Dada, 'and this means that even at this tiny scale there's already enough travel for many full-sized track racers! And the VXI easily out-travels the original short long arm (SLA) double wishbone suspension (3in / 76mm) and has far better track and camber characteristics. To scale, 4.5in of travel is equivalent to a real world 36in (914mm).'

Dada also pointed out that the separate sliding pillar steering and spring / damper unit could be combined so the sliding pillar becomes a 'steerable damper', theoretically reducing mass and parts count further still. He also stated that a pair of electric steering servos would negate the need for the steering tower / sliding pillar entirely, although perhaps with an increase in unsprung mass.

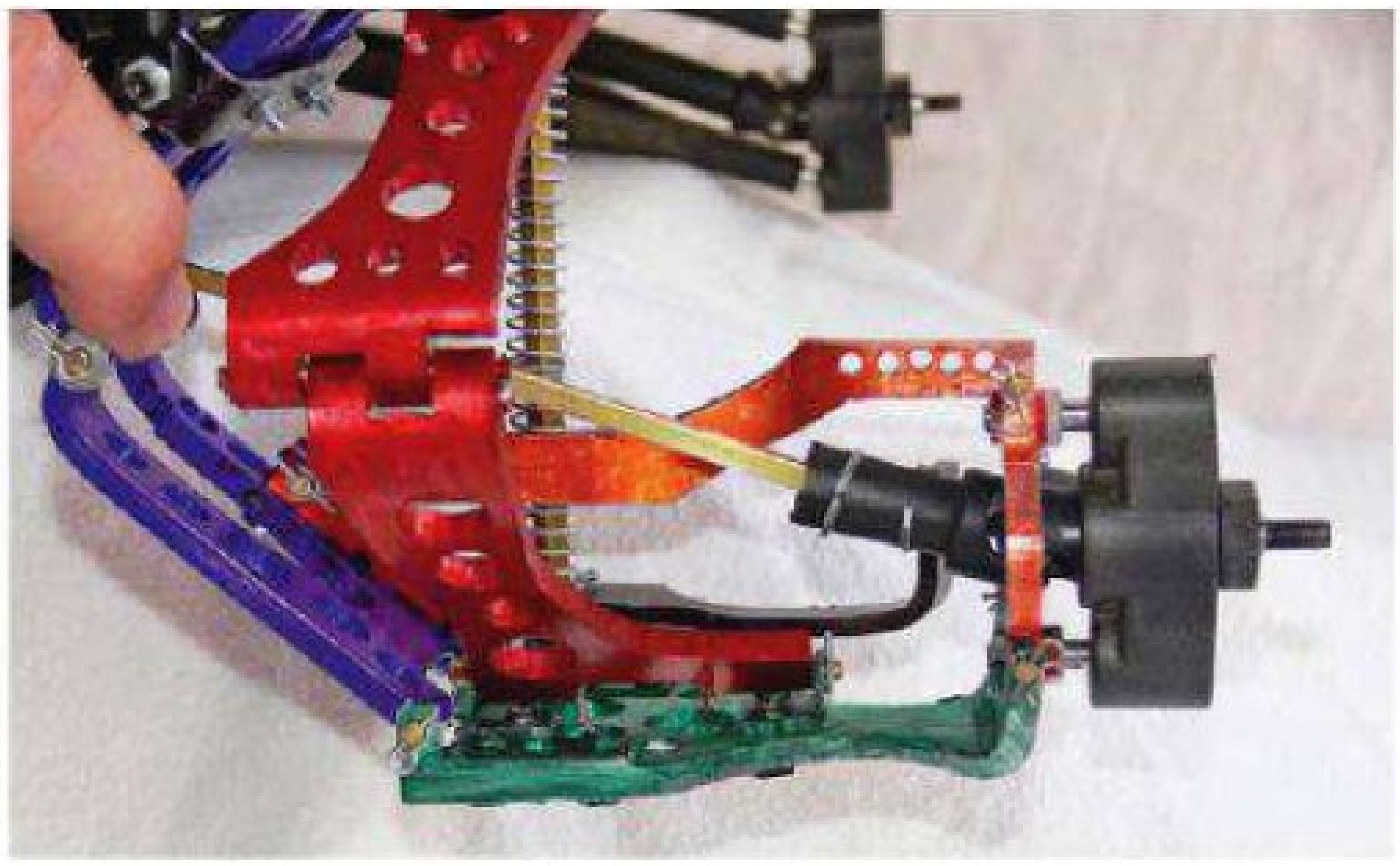
Going on to describe what can be seen with prototype no 2, Dada remarked, 'you will notice the camber either not changing at all or changing from highly positive to highly negative as the suspension goes from topped-out to bottomed-out, thanks to the action of the camber link and variable-angle knuckle. The rates of camber gain / loss can be varied from zero to as much as you'd like by changing where the orange camber link connects inboard to the blue longitudinal arms. The point at which the camber zeros out can also be varied by changing the length of the camber link by altering the outboard pick-up hole.

'Overall, the prototype is performing beyond expectations so far, I think, showing what the VXI suspension system can do. I purposefully chose the most difficult suspension type there is - a 4×4 monster truck - in order to demonstrate the capabilities of the VXI. I reckoned it's always easy to take parts and travel out of the suspension, but hard to add them back in. A monster truck suspension requires extreme amounts of travel and requires both drivetrain and steering mechanisms. Prototype no 2 demonstrates that the VXI can be used in any FWD, RWD or 4x4 application, and that it radically out-performs the original SLA suspension that came on the chassis. In short, for racers, the VXI should yield extra laps, both on the same tank of fuel and the same set of tyres.'

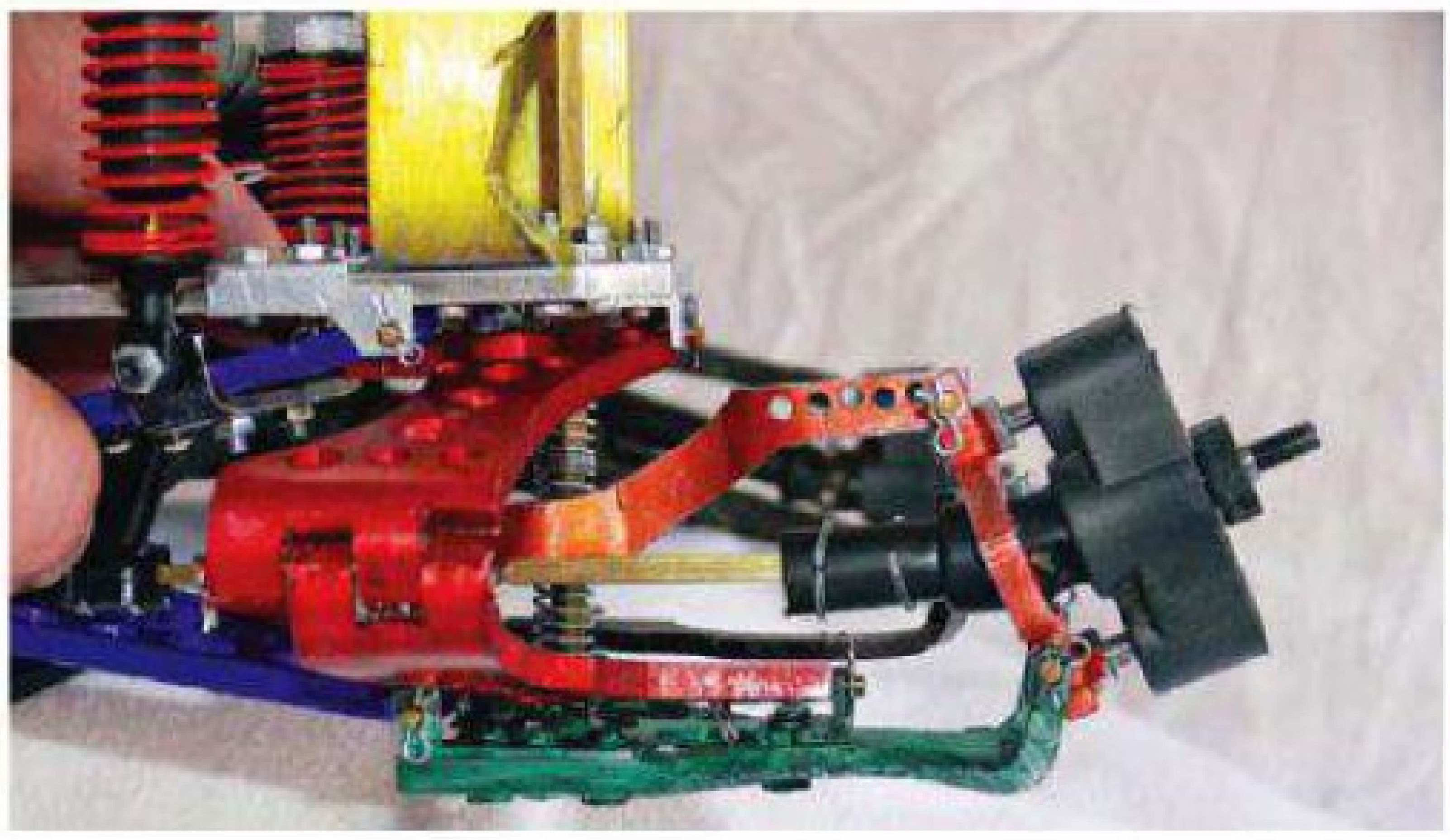
"the VXI should yield extra laps, both on the same tank of fuel and the same set of tyres"



In straight compression and droop, the camber link can be set to achieve whatever camber change might be required. Here it is in full droop...



...here in mid-travel...

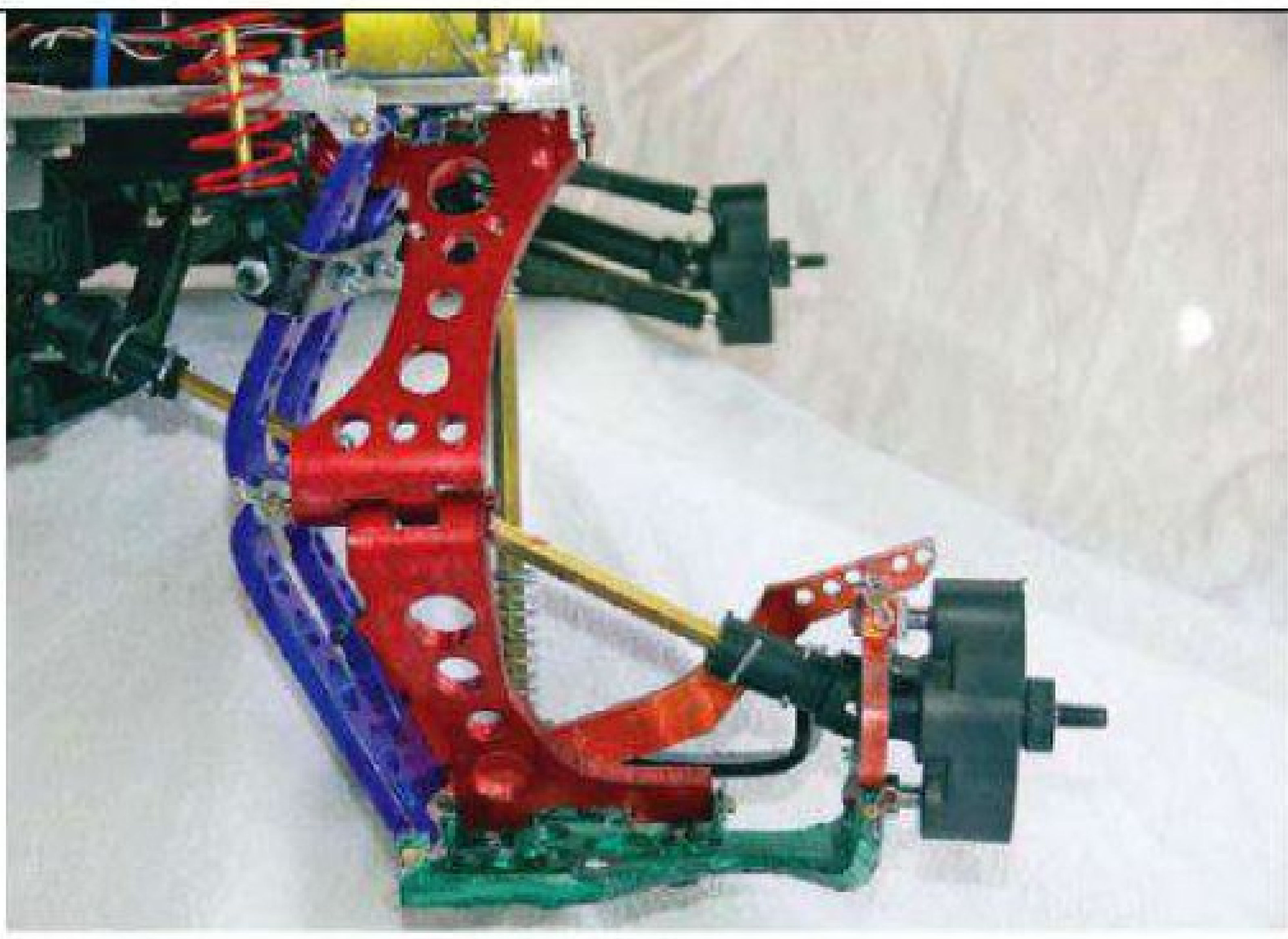


...and here in full compression

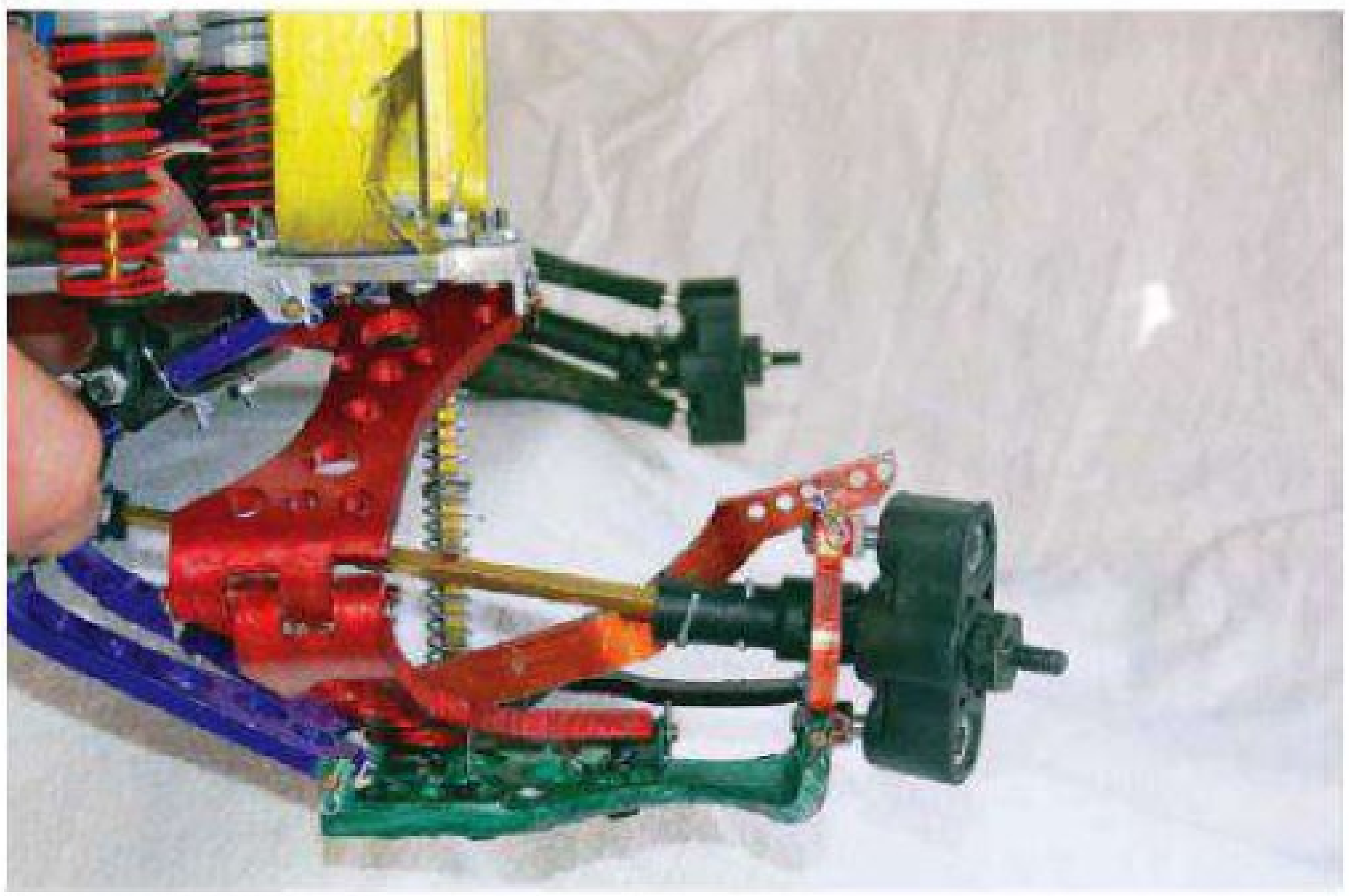
GOING ACTIVE...

So how well does the system deal with bump, jounce and roll? Dada was very open about the current system's compromises, stating that he was concentrating on setting it up to act in an optimal manner for corners. But also that he is aware of the problem of camber change in bump and jounce and is currently working on a third generation system where this is eliminated by incorporating a camber link that attaches to the steering pillar, yet which also maintains full control of camber in roll.

Apparently then, the VXI system will allow a wide range of camber control options to be utilised, depending on the needs of the particular application. But each application would presumably require a specific configuration to be derived and set up. However, for applications where it is permitted, the prospect of active control sees the inventor's enthusiasm elevate to another level: 'Think of the camber-changing link and pivot point being made "active".



Alternatively, the camber link can be set for zero camber change, as seen here in full droop...



...in mid-travel...

...and in full compression

In this case, the pivot point on the suspension arm can be made to move up and down on the suspension arm actively. If that pivot point is lowered to be in line with the pivot points on the wheel carriage then the camber change is eliminated. As the pivot point of the camber-changing link moves up the suspension arm, the rate of camber change increases. Now, if the system can be made to read either the steering angle and / or body roll, the VXI can keep the tyres at optimal camber at virtually all [ital] times. If the steering wheel is pointed straight ahead and the wheel encounters a bump, there will be no [ital] camber change, the wheel just goes up and down over the bump. If the steering wheel is turned left or right and the VXI can read that input, then the VXI system can dial out that body roll and keep the tyres at fixed camber.

'Taking this concept one step further, the camber-changing link itself could also be made of actively variable length. This would be of use in vehicles where the driver wants to vary the ride height – say, a 4WD or a rally car, for instance. When on a paved road, the suspension can be set to a low ride height and the system can keep the wheels at fixed camber by increasing the length of the link. If the 4WD or rally car then goes off road and the driver wants to increase the ride height, the wheels can again be set to optimal camber by shortening the length of the camber link. Then we'd have a system that could keep the wheels at optimal camber at all times and at all ride heights!'

POSSIBLE IMPROVEMENTS

The aforementioned third generation prototype will not only incorporate a camber link that attaches to the steering to overcome the problem of camber change in bump and jounce, but also other possible improvements include designs for a three-link spring / steering system that will enable the steering tower height, if used, to be cut by around 40 per cent. Also, the steering 'rack' will likely be lowered, there being no particular reason for its current high mounting position. And the (green) wheel carriage will be shorter so that it doesn't get so close to the ground in extreme roll situations. This is expected to make it stiffer too, yet offer the same wheel travel.

"early adopters will be rewarded for their risk-taking..."

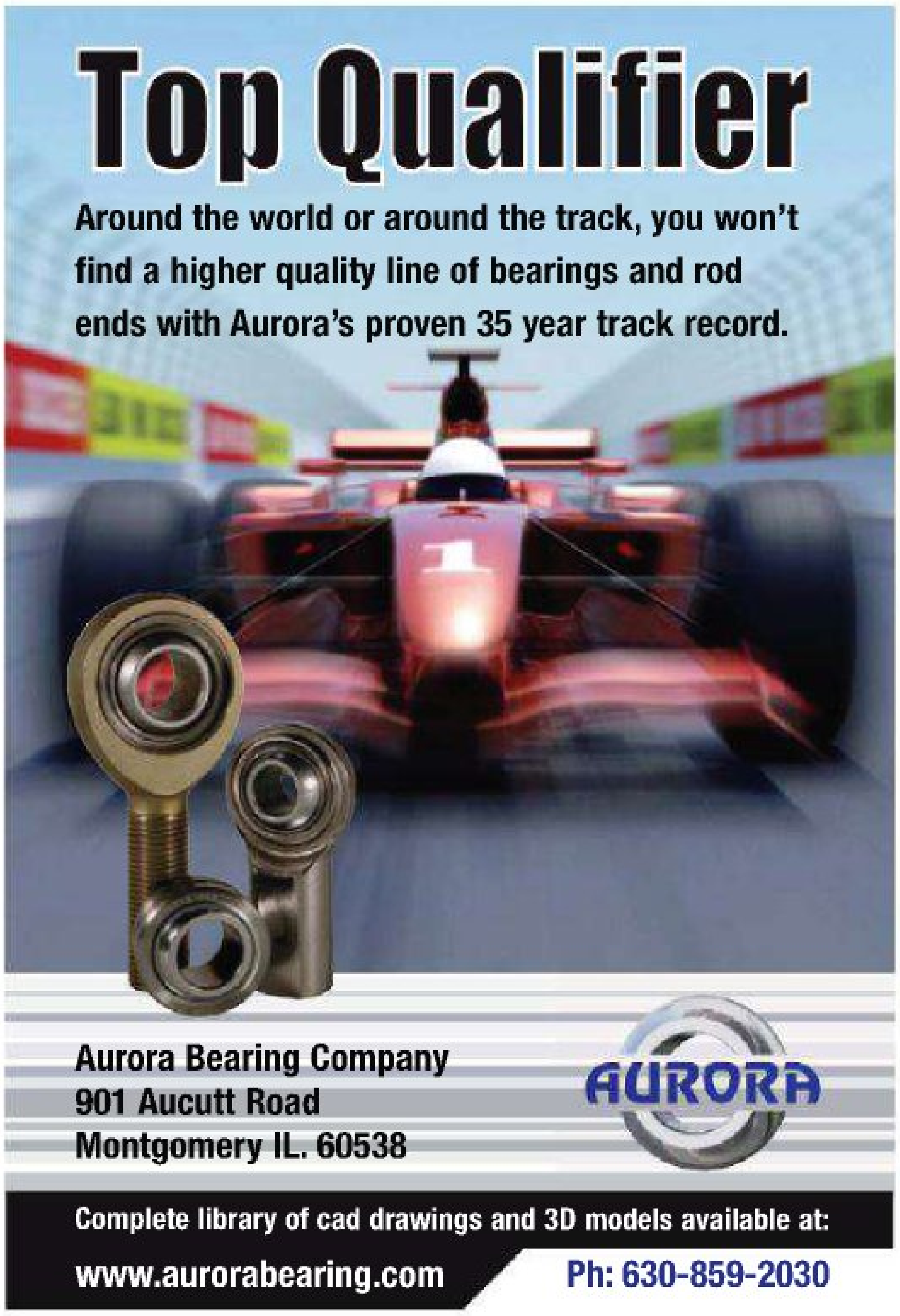
So does Dada's VXI suspension offer motorsport suspension engineers some, or even all, of the benefits they've been searching for? And which competition applications could benefit from the VXI's combination of long wheel travel together with new, possibly unrivalled methods of controlling camber change? In the case of most open-wheel applications, where chassis and suspension movement are generally restricted to maintain a controlled chassis-to-ground gap for aerodynamic reasons, and suspension kinematics is usually well down the priority list, there may be minimal benefit to be had from the VXI system, although the inventor asserted otherwise: 'More travel is good for virtually any vehicle, all else being equal. Also it's worth noting that lots of suspension travel is not equal to high ride heights. It seems to me that when F1 cars cut corners, as they do, they could use more travel. Even at low ride heights, as a driver / engineer, more suspension droop is your friend, especially when it doesn't come at the expense of track width and camber control.'

But what about the more complex and bulky physical form it takes, compared with the slender links of a conventional double wishbone layout? Superficially at least, there must be a considerable aerodynamic disadvantage just in terms of its frontal area, assuming the prototypes are at least reasonably realistic. Dada counters this by asking a question: 'Can the VXI with [scaled] 4.5in (114mm) of travel as depicted be made to fit into a racing wheel? I'm not sure, but it might be possible to make it compact enough to hide much of the suspension out of the wind in the actual wheels themselves.' In fairness, Dada always saw his system being more applicable to closed wheel and 'non-aero' categories anyway.

But if VXI's claimed benefits successfully scale to fit full-size vehicles, there would appear to be potential 'tyre management' and grip benefits to be had, which could be applicable to various forms of racing, possibly rallying, too. And the extended range of suspension travel that was the inventor's original target will likely see off-road events such as Baja and Dakar as potential applications, too.

Readers' views on the VXI suspension system are cordially invited. Meanwhile, the inventor is 'willing to grant rights use to interested race teams fully *gratis*, that is until such time as it's begun winning races. In other words, early adopters will be rewarded for their risk taking...'

Contact: Winthrop Dada, email: vxisuspension@gmail.com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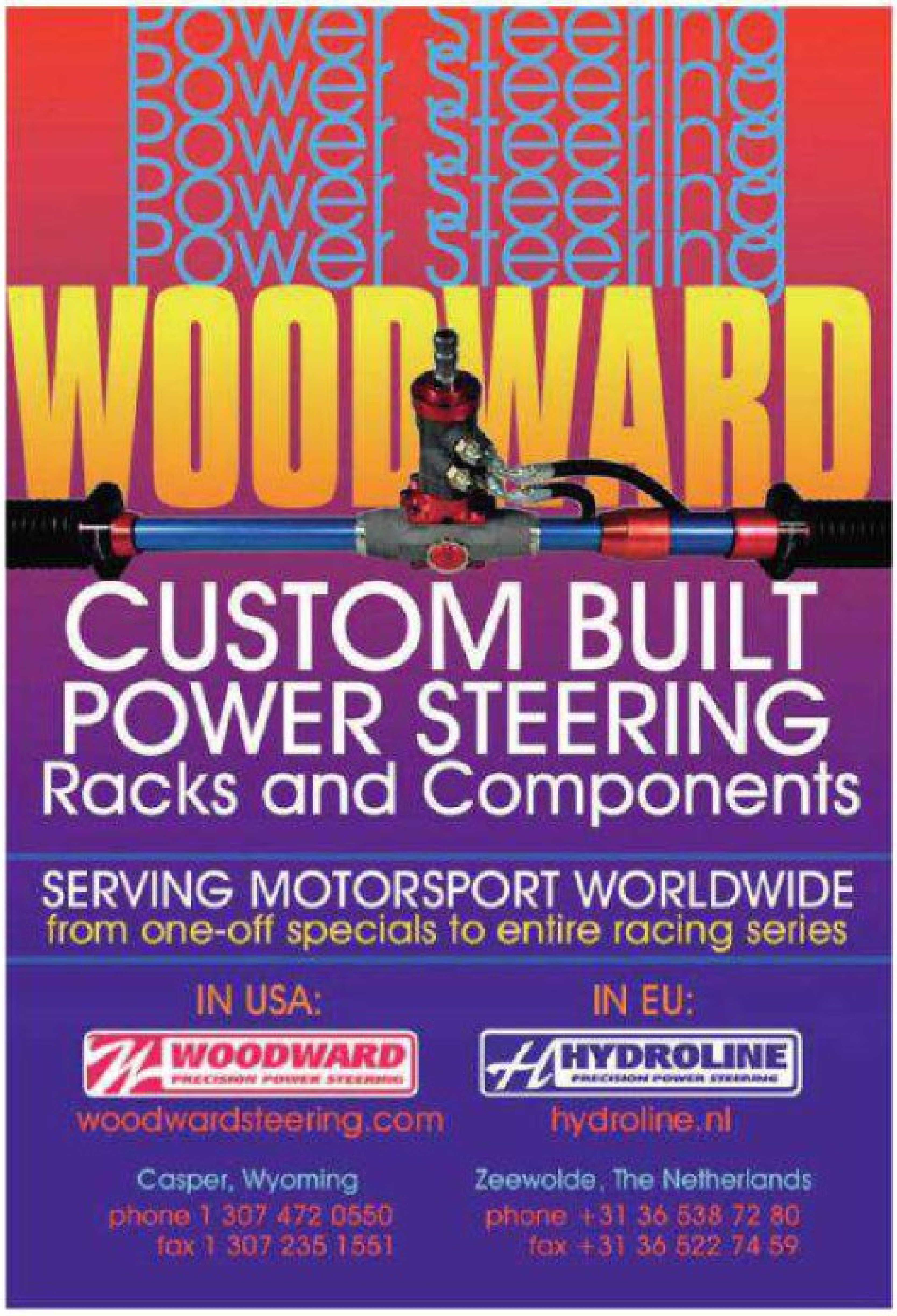
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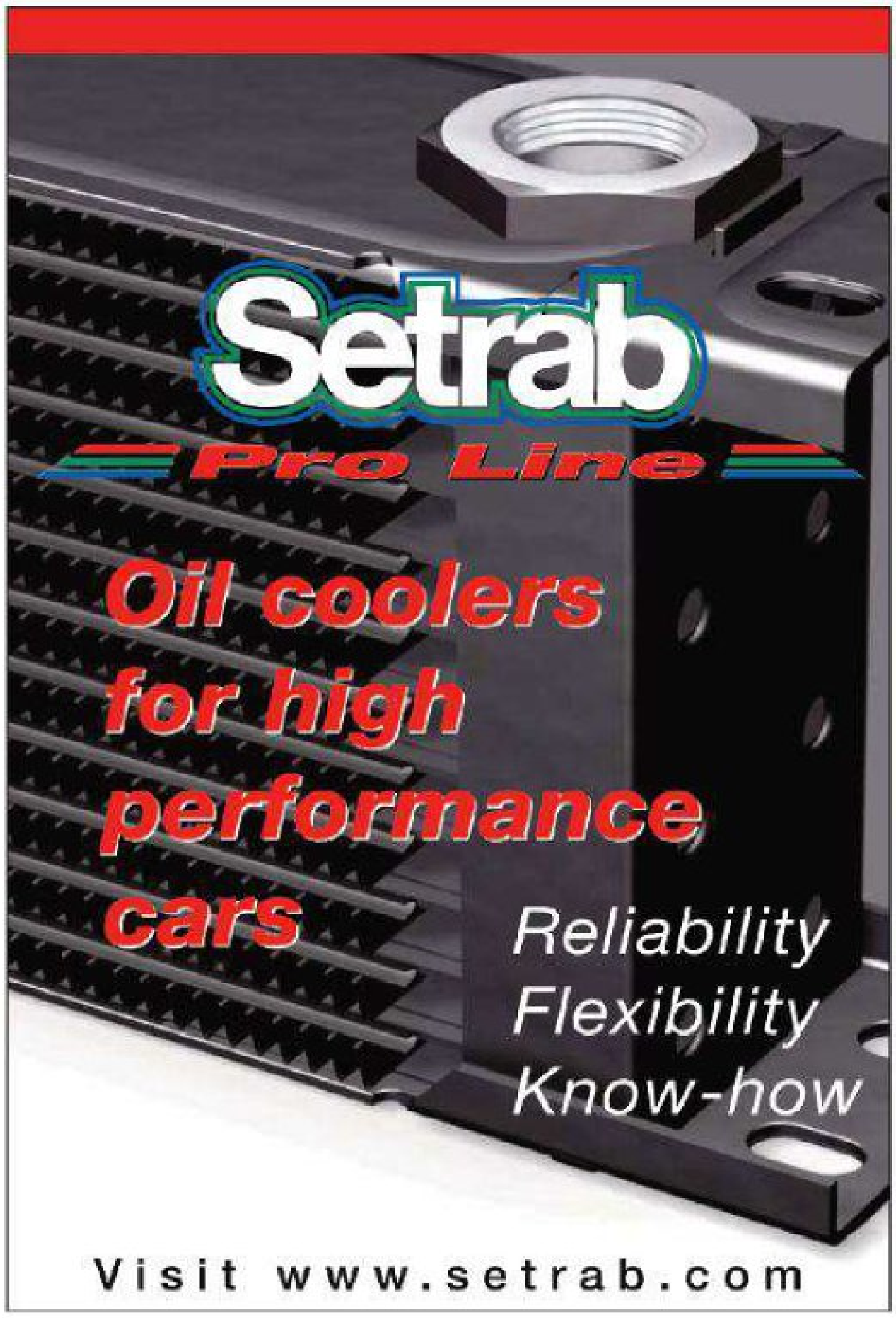
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Unfulfilled potential

Racecar Engineering uncovers the real story behind the development of the much-maligned Hispania F110

LAT

BY SAM COLLINS

Dallara was the first organisation to homologate a 2010 Formula 1 car, in November 2009. But that fact has largely been overshadowed by the events which followed. None of the new teams selected in the initial entry phase for the 2010 season made it onto the grid in unmolested form, and none of the teams selected had existing in-house car construction capability. USF1, Manor Motorsport and Campos-Meta 1 had the look of GP2, according to some of the established teams, and questions were raised about the ability of Manor and USF1 to even produce a modern grand prix car. But no questions were asked of Campos-Meta 1, which had made a deal with Dallara to design and construct its car – to be known as the F110 – and early signs looked promising.

'We were the first to homologate the chassis with the FIA, though not the whole car, as the rear impact test could only be done after the Xtrac gearbox arrived in January,' admits Luca Pignacca, Dallara's chief designer. 'All the rest of the car, which was under our control, was homologated in November. I think this explains the approach we took. We wanted to build something that would be the base of a long-term development. As it was our first Formula 1 project for some time, we wanted to make sure the car was ready for the first race. We wanted to have enough time to go testing at all the scheduled tests because we knew there would be some teething problems – be they reliability or performance-related – so that's why we got the car homologated as early as possible.'

"We wanted to build something that would be the base of a long-term development"

However, the Campos-Meta project then collapsed that same month, not long after the first chassis was completed.

But after much wrangling, a new team was put together at the 11th hour, this time called the Hispania Racing Team (HRT).

'We stopped work when Campos stopped but, with not long to go, we started work again to finish the cars off. We had the first monocoque, which we used for homologation, and that was covered in dust. Then, by mid-January, we had two monocoques in house, because after the first one was homologated we built the second. So the tubs were not a problem, it was everything else. What happened in the Formula 1 workshop [built at the back of the Dallara factory] was crazy. It was very exciting, to be honest, but it was the beginning of the end, unfortunately,' Pignacca continues with resignation.

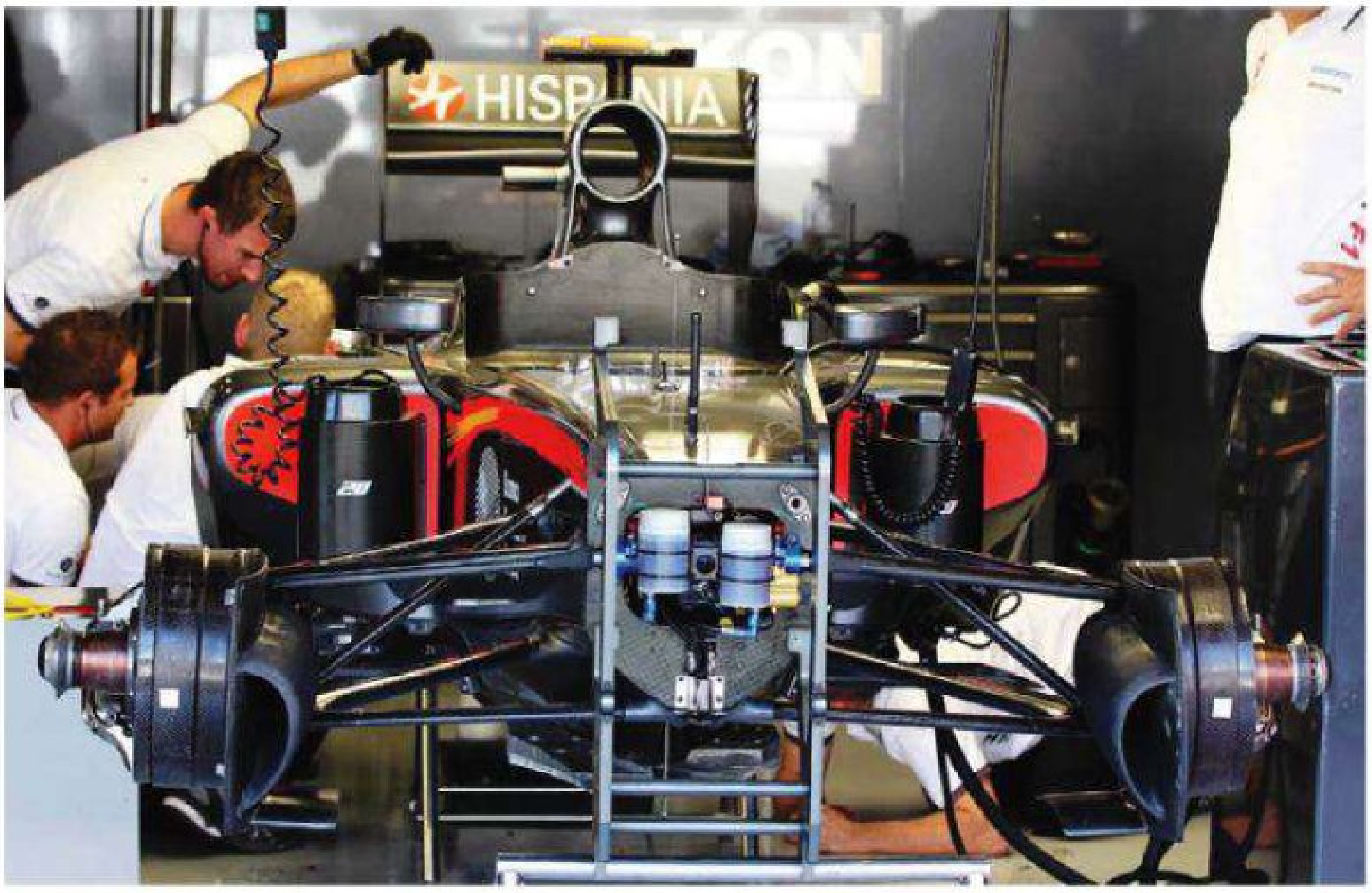
The relationship between HRT and Dallara did not survive for long and, as a result, the development of the F110 stalled. 'Basically, our involvement stopped after the first race. I went there with Ben Agathangelou and our chief mechanic. Ben was chief aerodynamicist on the project, and that was basically it. From then, the only development on the car from Dallara was a set of rear view mirrors, as the outboard ones the car originally had were outlawed. That was done in a very quick way – we had a 'phone call during a grand prix weekend and, in less than two weeks, the new parts had to be on the car. But we knew exactly the developments to do.'

> **"the tubs were not a problem, it was everything else"**

Dallara had already planned out a major development strategy for the F110, which could have seen it match both Lotus and Virgin for pace. 'If everything went as we had first envisaged, we would have gone testing and would have found a couple of issues. One of those issues was with the fuel tank, which suffered pick-up problems. We spotted that in Bahrain but, with the first four races being fly-aways, it was impossible to fix. We tried to "Band-Aid" it, but to no avail.' Eventually, the team fixed it with a new fuel tank.

'We also would have seen that aerodynamically the car was good, but there probably was not enough downforce. But that was going to be easy, as the pace of aero development was good. We were always quick in a straight line but very slow in the corners, but it would not have been too difficult to get the downforce to compete with the other two teams. The idea was to start pre-season testing with basic bodywork – a mk0 – which was completed in the wind tunnel in November, and start off in testing with that. At the first race we would then introduce a mk1 body, which was going to be completely different after testing. After having understood the mk0 performance, and how we compared to other designs, we would have a better idea of the direction to go in. Also we would have had another three months in the wind tunnel, a third of the car's development. That was the plan, but it didn't happen.'

The F110 ran for the whole season in the Mk0 aerodynamic configuration, frozen by Dallara in November 2009. No further work was conducted (other than the wing mirrors – see right), and the Mk1 parts were never made



Dallara says it is proud of the F110's power steering system, which was developed in house and proved a success

TECH SPEC

HISPANIA F110

Class: Formula 1 (2010)

Engine: Cosworth CA2010, 2.4-litre, naturally aspirated

Transmission: Xtrac 1044, ZF Sachs clutch

Suspension: wishbones, pushrod-actuated torsion bars. ZF Sachs dampers

Brakes: Brembo carbon / carbon

Wheels: OZ

Chassis: Dallara carbon fibre monocoque

Electronics: McLaren Electronics / Microsoft

Fuel tank: Premier

Radiators: Marston

Battery: Yuasha

Fuel: BP

Dimensions:
Track: 1800mm
Wheelbase: 3200mm
Height: 950mm
Length: 4800mm
Weight: 620kg (min)

In reality, the F110, as it appeared in the 2010 season, was always in mk0 configuration, running the same wing package at all circuits, Monaco and Monza included. Dallara's engineers had focused on creating a strong basic package for testing, but that was what was run on the car all season.

'When you go back to F1, you don't know where the others are, but we knew we were lacking in downforce initially. That is quite normal, though, as doing aero developments is exactly what F1 teams do. We put a lot of emphasis on creating a good base, then did a lot of work to try to optimise the front wing, so as not to lose downforce with the car steering and yawing. I think it was a very good base to start adding downforce to. A lot of the mk1 aero parts were already designed and tested, but they needed to be finalised in the tunnel in order to be used on the car,' Pignacca continues.

PRIDE IN THE DETAIL

Despite the turmoil surrounding the car's creation, and the poor pace it showed during the season, Pignacca is proud of many elements of the car. 'Something we spent a lot of time on were the uprights. Aluminium uprights were not new for us, as GP2 has had them for a long time, but the GP2 uprights feature steel ball bearings, whereas F1 has ceramic ball bearings. The GP2 version also features a steel sleeve, which is a bearing housing pressed into the aluminium, but on the F1 design the bearings were pressed directly into the aluminium. We spent a lot of time optimising this.

'If we designed a 2011 car, we wouldn't need to put so much effort into this as the big engineering work has been done. It's easy to see what would be good going forwards. For example, I'm very proud of the steering rack system because it was the first time we designed a power steering system for F1. Apart from a seal leaking in Bahrain, the system worked well. This was a big project I did with Gabriele Tredozi, and I'm very proud of it. It's the dream for any engineer to design a Formula 1 car, but it turned sour.

F110 – CHASSIS BY CHASSIS

Chassis 1 (F110-01)
Built: 28/10/09
Races: eight

Chassis 2 (F110-02)
Built: 28/12/09
Races: 19

Chassis 3 (F110-03)
Built: 27/01/10
Races: 11

One of the few aerodynamic updates on the F110 was forced by a regulation change. Outboard wing mirrors (left) were banned, forcing Dallara to design, manufacture and ship the revised parts (right) in less than a fortnight

XTRAC PERSPECTIVE

Xtrac designed its 1044 gearbox for use in all the Cosworth-powered F1 cars, but achieved the most success with the development programme run with HRT

Following the FIA tender process in 2009, it was clear there could be as many as four new teams using the Cosworth engine in 2010. It was felt that this presented a great opportunity to share design, development and tooling costs, and to save valuable time, if Xtrac put together a gearbox package that the new teams were all able to use. And so the 1044 gearbox was conceived. The longitudinal gearbox had instantaneous gearshift, a contemporary hydraulic differential and a pretty competitive weight – although some of the core components were designed for a six-race target, rather than the four that was eventually specified, adding a little extra cost.

The casing was made from precision cast aluminium, using a technology in current F1 use. However, Virgin Racing / Wirth elected to use its own main case design, while Dallara / Campos, which went on to become Hispania Racing Team (HRT), provided all the casing suspension design input that Lotus Racing also later adopted. The gearbox progressed rapidly, and two prototype gearboxes were finished at the end of November 2009. But as the project proceeded, it was clear some of the teams did not have the time or resources available to put together the all-important hydraulic and control system that would look after the engine throttles, gearchange, clutch and differential adjustment. Xtrac's Peter Digby: 'It was a real dilemma. If we didn't offer to help them, I strongly believe one or two of the teams may not have got to the first race. So ignoring the worldly advice "never to volunteer", we offered to facilitate the detail design and manufacture of a hydraulic and control system, the specification of which could be provided by the teams, and to provide testing input and detailed operation parameters.'

Testing at Xtrac and Cosworth on the dyno over the Christmas and New Year period went well and Xtrac was kept busy producing the inventory and supporting the two teams that were testing, as well as helping to finish the build of the HRT car. That carried on all the way up to the Bahrain race weekend. 'It really was extremely hard for the new teams at the start of the season. Four tests, only a few weeks apart, followed by four back-to-back, fly-away races stretched the existing teams, let alone the new teams, who were still learning how to work together. And with no further testing, each race was really a test and development exercise.'

Initially, and not surprisingly, there were some unreliability issues with the cars, particularly with the hydraulic systems, but race by race these improved. All three new teams worked differently. With Virgin Racing, Xtrac took the internals only, so the team ran its own programme, with assistance when required. Lotus Racing, on the other hand, used the complete Xtrac gearbox and the common hydraulic system, but again managed the programme itself. However, with HRT, Xtrac provided engineers and technicians embedded into the team, not only to oversee the programme and ensure product lifing, but also to carry out all new builds and overhauls of the gearbox and hydraulic system. 'Looking after the complete system was by far the best approach,' says Digby. 'Although HRT never really got the chance to make up for lost time at the start of the season, it did have a very good finishing record from mid-season onwards. HRT achieved more classified finishes than some of the existing F1 teams, and Kovalainen in the Lotus clocked up more racing miles than the likes of Kobayashi in the Sauber and Liuzzi in the Force India. If there was a major lesson learned for 2010, it was that we should have put embedded engineers and technicians with all our 1044 customers.'

> "Looking after the complete system was by far the best approach"

'It was very difficult at the beginning, watching the races on TV and knowing it's not a good representation of what we did, but towards the end you accept it is not yours any more.'

MISSED OPPORTUNITY

The frustration is obvious all around Dallara, and there is a clear feeling that the firm simply did not get to fully show off what it could do. 'I think that if we went on, the level of effort was going to be much higher, because we care. Mr Dallara does not like being last. We are a company that must make profit, like any company, so we do things only if we get paid for them normally. But in this case, we would have made extra effort. If we were to be paid 100, we would have given 150 worth with no discussion. Everybody here would push like hell to show that we could do a good job, but the problem was we did not have the opportunity,' Pignacca says.

To outsiders, it is obvious that Dallara's F1 car was never given the chance to show what it could do. The F110 came in under weight, while the rival Lotus T127, for example, was only just on the weight limit at the start of the season. It also met all of its stiffness targets, and Pignacca clearly believes the car could have beaten the Virgin VR-01 and Lotus T127 on sheer pace. 'I think going faster than them was possible. If you look at the gap between HRT and the other cars at the end of the season, it is more or less what we had at the start of the season, which is very strange. Lotus and Virgin did a lot of development too, so being ahead of them would have been an achievable target. This was a car that could have been much better, and it was quite obvious that we didn't have any significant reliability issues through the year.'

In the end, it was that reliability that ensured the Dallara F110 run by HRT was not at the bottom of the Constructors' Championship at the end of the season (that somewhat dubious honour fell to the Virgin VR-01). One can therefore only wonder what the F110 could have done with proper investment and development.

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Priced to succeed

An LMP2 for 325,000 Euros? *Racecar Engineering* talks with Oreca to see what challenges the French manufacturer faced

BY LAWRENCE BUTCHER

When the Automobile Club de l'Ouest (ACO) announced revised rules for its LMP2 Sportscar class in June 2010, one of the key tenets was a cost cap on new chassis of 325,000 Euros. At the time of the announcement, several manufacturers expressed the opinion that this would be a very hard target to meet and still remain profitable, but French manufacturer Oreca was not among them and, in August 2010, revealed it would be producing a new car for 2011, dubbed the Oreca 03.

The car would be based around the core tub of the existing Oreca 01 LMP1 car, itself an evolution of the venerable Courage LC70, a design that was also utilised for the company's successful Formula Le Mans (FLM) class. The benefit of going this route was that the company would be working with a proven chassis package, and therefore able to make considerable savings on development and tooling costs.

'[Building a car to the cost cap] was not easy, but a few years ago we did all of the development for the Megane Trophy car for Renault, which again is a low-cost formula, and we did Formula Le Mans. With LMP2 it is a bit different, though, because you still have a difference between the cars, and it is a matter of how fast you can go for the price. So the key factor was producing a car that was as good as it could be, given the price constraints,' explains Oreca technical director, David Floury. In his opinion, the Oreca 01 is one of the best Prototype chassis around in terms of speed and reliability, but he is keen to point out that the new car is not simply a budget version of the

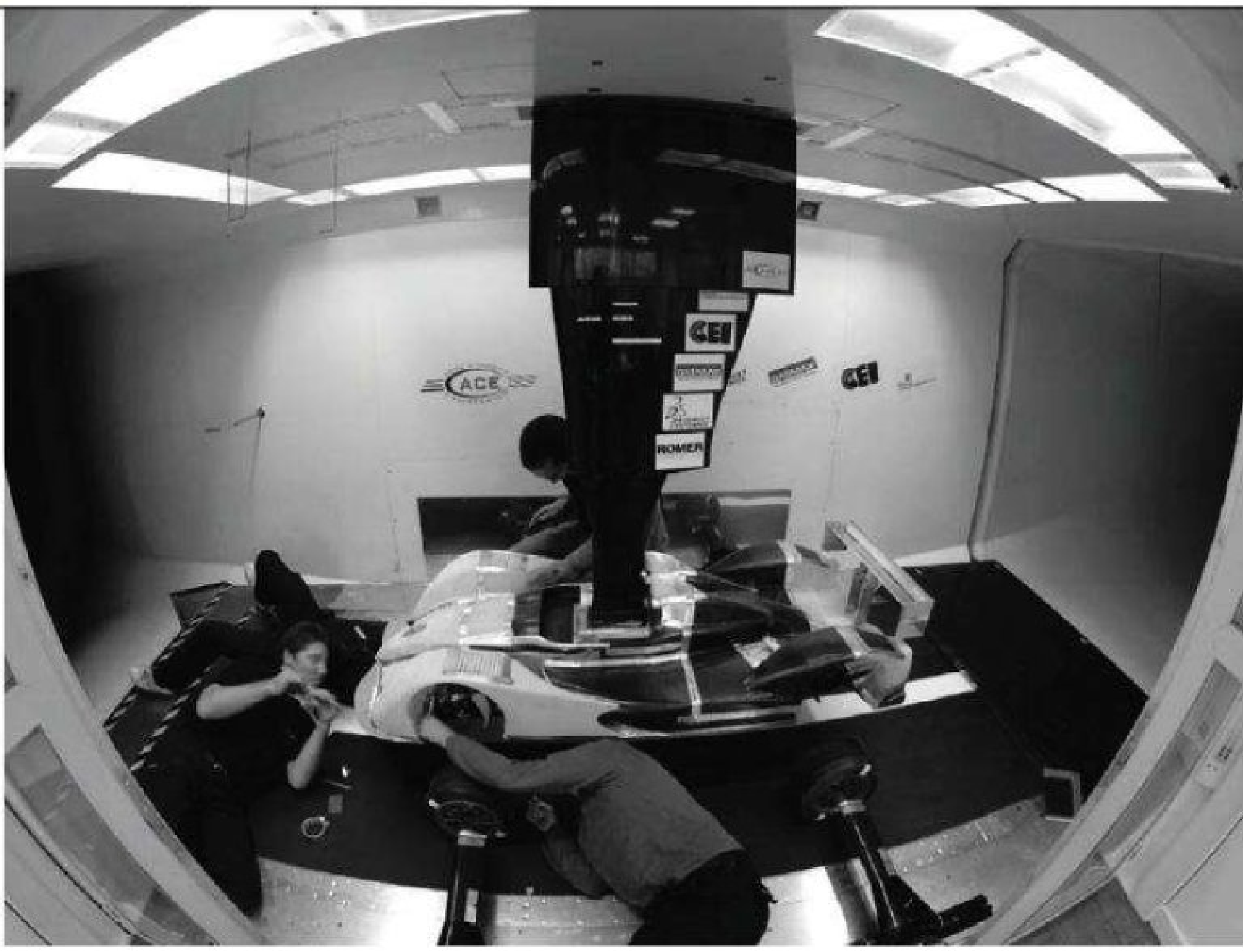
> "it is a matter of how fast you can go for the price"

TECH SPEC

ORECA 03

Class: LMP2
Chassis: carbon fibre and honeycomb monocoque
Length: 4600mm
Width: 1990mm
Height: 1025mm
Front track: 1670mm
Rear track: 1650mm
Wheelbase: 2870mm
Weight: about 900kg
Engine: free choice, producing about 460bhp
Suspension: pushrod with double steel wishbones
Gearbox: Xtrac six-speed sequential
Brakes: Brembo
Front discs: 380mm × 37mm
Rear discs: 355mm × 37mm

LMP1 contender. While the 03 retains the basic carbon tub and some elements of the baseline aero package, everything else is new. The main area that differs is in the requirements for the new generation of production-based LMP2 engines, several of which have appeared on the market. Floury also acknowledges that this is one area that could incur significant costs if they are required to accommodate too wide a range of powerplants: 'At the moment, we are developing it to run with different engines, but obviously we would like all of the customers to use the same one because it makes it easier to develop the car and make sure any issues are avoided. We have looked at different engine installations – the Nissan, HPD and Judd. Ultimately, though, it is still up to the customer to decide which engine to use.'



The revised bodywork was developed in the Aero Concept Engineering scale wind tunnel at Magny Cours, France

AERODYNAMIC DEVELOPMENT

The aero package has also been the subject of considerable development, mainly to accommodate the new 'fin' that will be mandatory for 2011. Additionally, the use of narrower front and rear wheels has necessitated a re-assessment of the underbody aerodynamics and wheelarch areas.

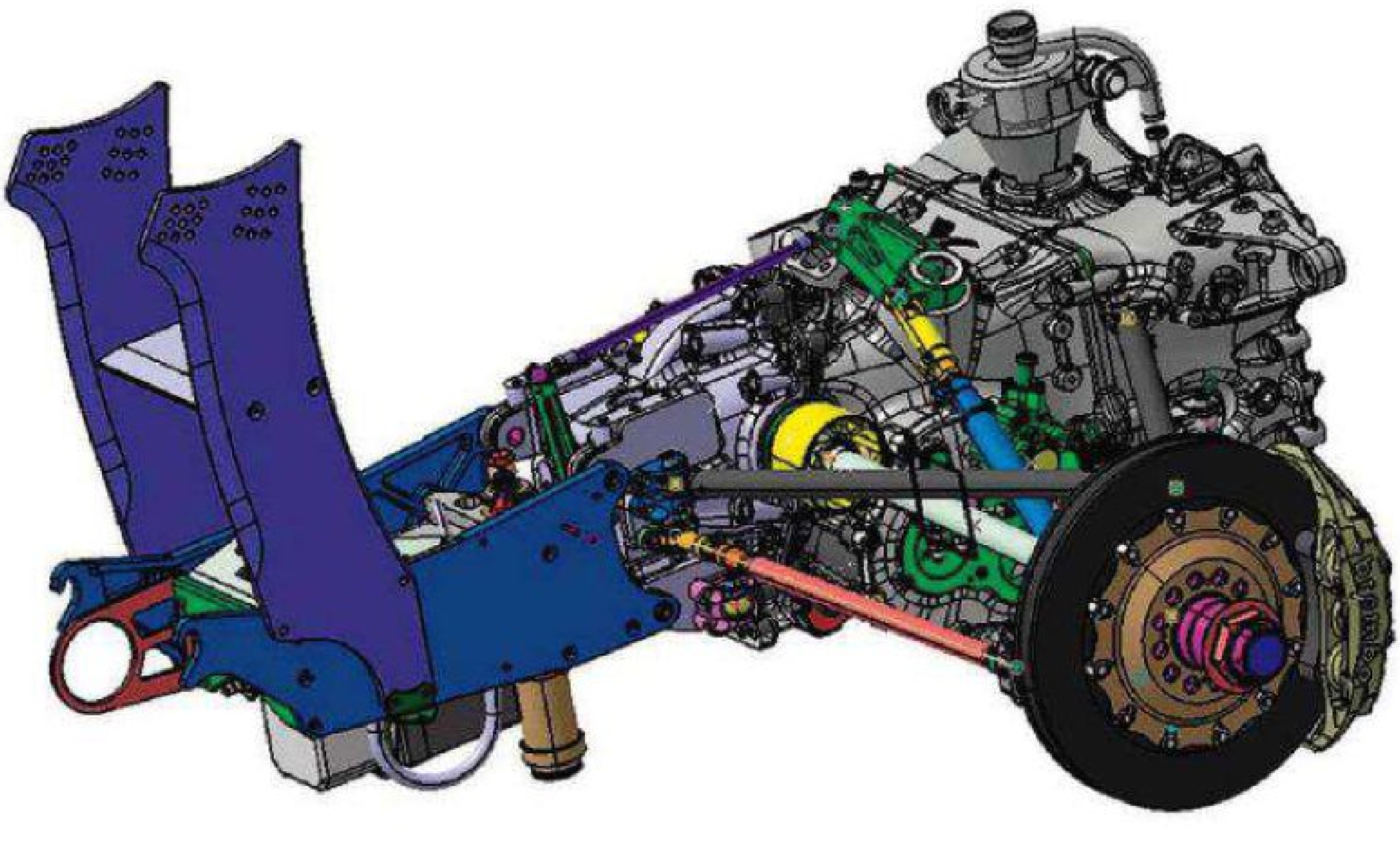
Ironically, one factor that has worked in the company's favour is its close tie up with Peugeot Sport and the use of the 908 Prototype in 2010. Oreca had finished the design of its own LMP1 contender, the Oreca 02, but the availability of the blisteringly fast, if sometimes unreliable, 908 meant it chose not to produce the 02, which freed up resources for other projects, notably the new LMP2 car. Floury: 'You will probably never see the Oreca 02, which is a shame, but this drew all of the resources. I think it could have been a very good car, and Tit would have been our first car built from scratch, which we have not yet had a chance to do. However, now we have a lot more resources available to work on our other projects.'

> an excellent balance of value and performance

The fact that the basic chassis has been used for a number of years and produced in considerable volume has allowed the company to develop production methods that give some economies of scale. Nevertheless, Floury is prepared for the possibility of not turning an immediate profit on the 03. 'We know that the first year of production will be difficult and we will not immediately make our money back. But, if we do a good car, we will sell more the second year and things will start to balance out. There are many negotiations going on with different teams but, as they say, talk is cheap and we will have to see who commits.'

There is also the possibility of teams currently running in FLM converting their current chassis to the new LMP2 spec – something Floury says is possible, but not preferable to buying a new car: 'We did not want to compromise too much trying to make it so we could convert an FLM easily. The chassis and components differ considerably between the two cars. We want to keep FLM as it is and make a lot of parts, so it is even cheaper to run, and keep the costs down.'

The new car is due to test in early 2011 and, if Oreca's track record is anything to go by, the 03 should provide an excellent balance of value and performance, exactly the qualities the ACO was hoping to achieve.


Xtrac six-speed transmission forms a key part of the LMP2 rear end. The bellhousing adapts to various engines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Moment, signal, manoeuvre

LAT

Danny Nowlan discusses the racecar manoeuvring conundrum

One of the nice things about what I do is from time to time to have discussions with my customers and colleagues that really make me think. This particular discussion originated in what makes a racecar so hard to drive at the limit. This arises because drivers typically drive through two conflicting inputs: what the steering wheel is telling them and what they feel in the back of the seat. The problem is, at the limit these two inputs are telling the driver different things. This conundrum is what we are going to explore here.

BY DANNY NOWLAN

Firstly, though, let me apologise in advance if what follows is an example of explaining the perfectly obvious but, in my experience, you take nothing for granted in this business and it's amazing what you can learn from pondering the perfectly obvious.

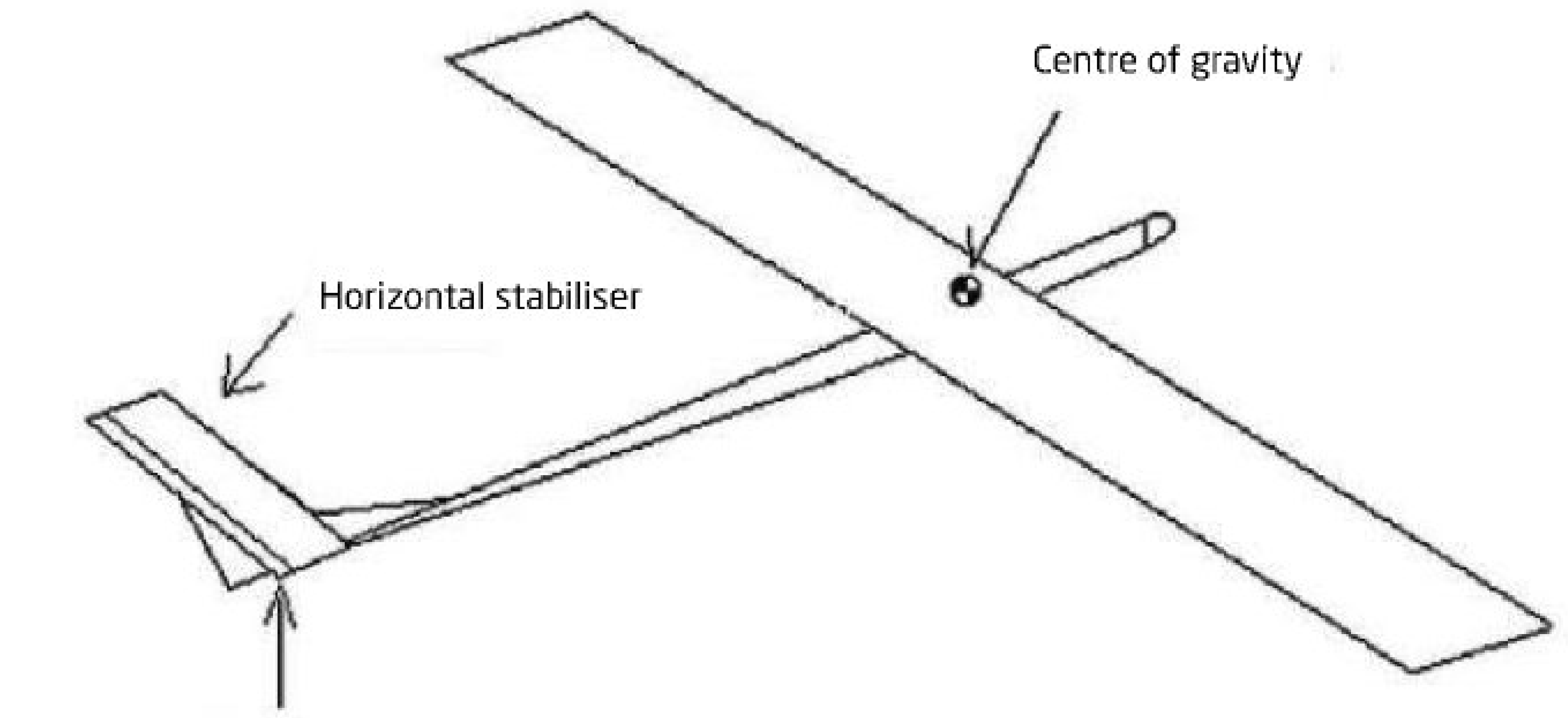
To kick off, let's consider manoeuvring an aircraft on the limit when we are pitching and looping. Bear with me, as there is method to this madness. To illustrate what we are looking at, consider the rather simplified illustration of an aircraft shown overleaf in figure 1.

Typically, what we have is a wing with the elevator offset from the c of g. For a conventional aircraft, the horizontal stabiliser / elevator is designed with a stall angle higher than the wing. This is due to the fact the aspect ratio of the horizontal stabiliser elevator is much less than the main wing, which is just as well, as otherwise the aircraft would become uncontrollable at the limit. Not a good thing.

When the pilot pushes back on the stick, this induces a pitching moment, which increases the angle of attack. A typical plot of

THE AIRCRAFT ANALOGY

Figure 1
Pitch controls for an aircraft



Lift or C_L vs angle of attack is shown in figure 2.

As we can see, things are pretty linear as we get near the stall. This is also going to affect the elevator / horizontal stabiliser but, as we commented before, the aspect ratio is significantly lower for the elevator horizontal stabiliser, so the stall angle is much greater. What this means is the horizontal moment or control power of the elevator will drop off, but not significantly.

As the aircraft approaches the stall, if the aeroplane is well designed, the pilot gets a very clear read on what his machine is doing. This is due to the fact that the slope of moment vs elevator angle or control power stays relatively consistent, allowing the pilot to concentrate on feeling what the wing is doing. This is just as well because, given that an aircraft is a 3D object, anything else would make a manually controlled aircraft un-flyable.

Unfortunately, the situation with a car isn't so straightforward, due to the way a tyre generates its lateral force. This is illustrated in figure 3.

As we can see, as we apply slip angle (directly analogous to angle of attack for an aircraft) lateral force increases linearly and then drops off. However, the joker in the pack is the self-aligning torque. As we approach the optimum grip, the self-aligning torque goes to zero, due to the fact that as we get close to the limit, the tyre is producing its grip primarily by sliding friction. The self-aligning torque is a major part of the steering moment the driver is going to feel. Mathematically, we can express this as equation (1).

$$M_{ZT} = F_y \cdot r_T \cdot \sin(\delta_{CASTOR}) + M_{Z\_self\_aligning} \quad (1)$$

Here, F_y is the lateral force of the tyre, r_t is the rolling tyre radius and $M_{Z\_self\_aligning}$ is the self-aligning torque of the tyre. M_{ZT} is the torque the driver is feeling through the steering wheel and δ_{castor} is the caster angle of the tyre. So, as we approach the traction limit of the tyre, the steering moment being applied to the driver drops off, particularly at low caster values.

> **the joker in the pack is the self-aligning torque**

This is all well and good, but what is going on with what the driver is feeling in the seat? To calculate this, we need to use the stability index that is a direct measure of what the driver is feeling at the back of the seat. I have discussed this at length in a number of my previous articles but, to refresh the reader's memory, the stability index can be calculated at the apex by the following. Remember, the lateral tyre force can be represented by equation (2).

$$F_{yf} = fn(\alpha_f) \cdot (Fm_1(L_1) + Fm_2(L_2))$$
$$F_{yr} = fn(\alpha_r) \cdot (Fm_3(L_3) + Fm_4(L_4)) \quad (2)$$

F_{yf} = front lateral force
F_{yr} = rear lateral force
$fn(\alpha_f)$ = normalised slip angle function for the front tyre
$fn(\alpha_r)$ = normalised slip angle function for the rear tyre
$Fm(L_1)$ = traction circle radius for the left front (N)
$Fm(L_2)$ = traction circle radius for the right front (N)
$Fm(L_3)$ = traction circle radius for the left rear (N)
$Fm(L_4)$ = traction circle radius for the right rear (N)

To keep things simple, I'm using a 2D tyre model (traction circle as a function of load) as opposed to a 3D tyre model (traction circle as a function of load and temperature). Using this, the stability index can be calculated by,

$$C_f = \frac{\partial C_f}{\partial \alpha_f}\bigg|_{\alpha=\alpha_f} \cdot (F_{m1} + F_{m2})$$
$$C_r = \frac{\partial C_r}{\partial \alpha_r}\bigg|_{\alpha=\alpha_r} \cdot (F_{m3} + F_{m4})$$
$$C_T = C_f + C_r$$
$$stbi \approx \frac{a \cdot C_f - b \cdot C_r}{C_T \cdot wb} \quad (3)$$

Figure 2

Plot of C_L vs angle of attack

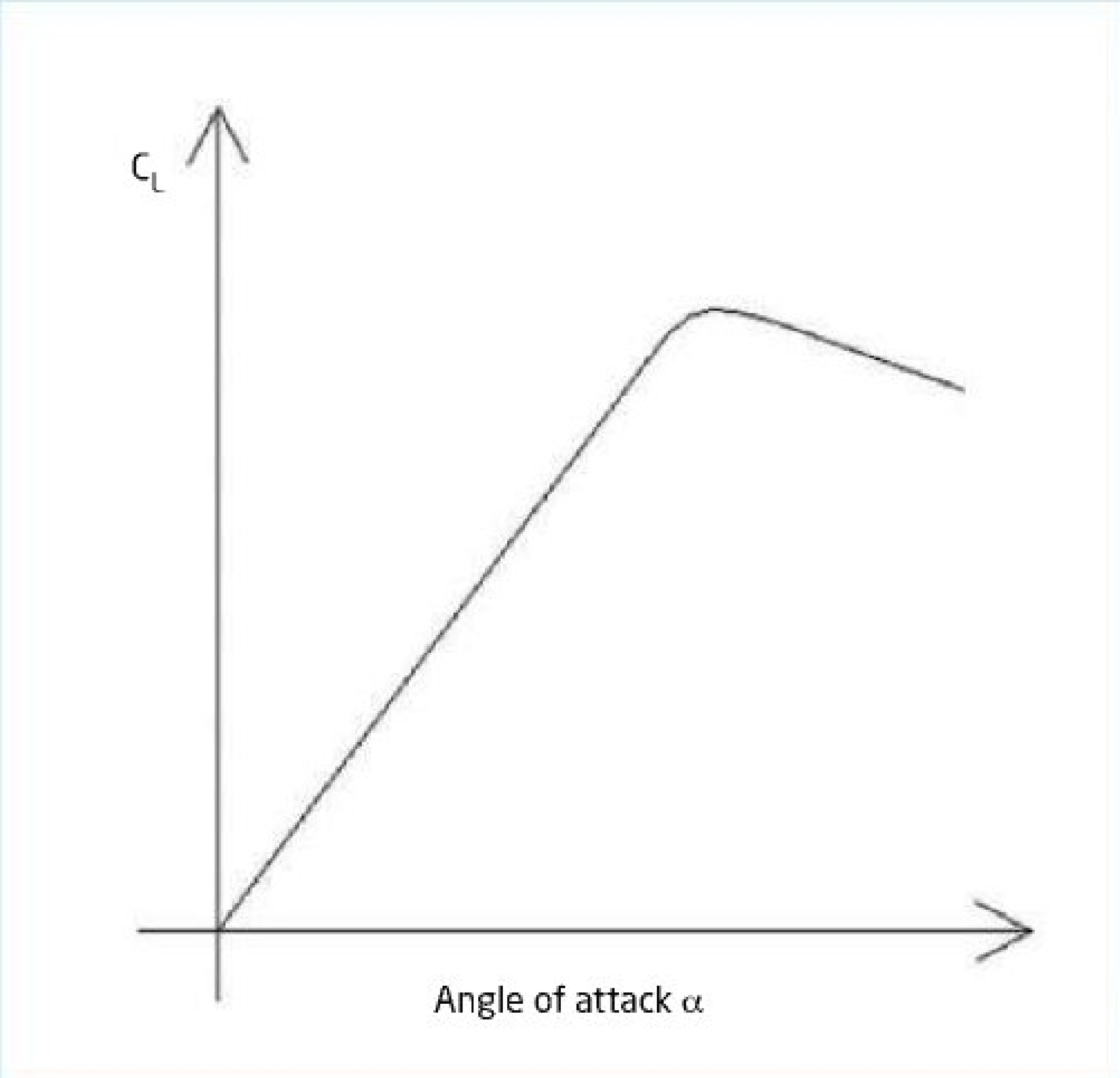


Figure 3

Plot of lateral force and self-aligning torque

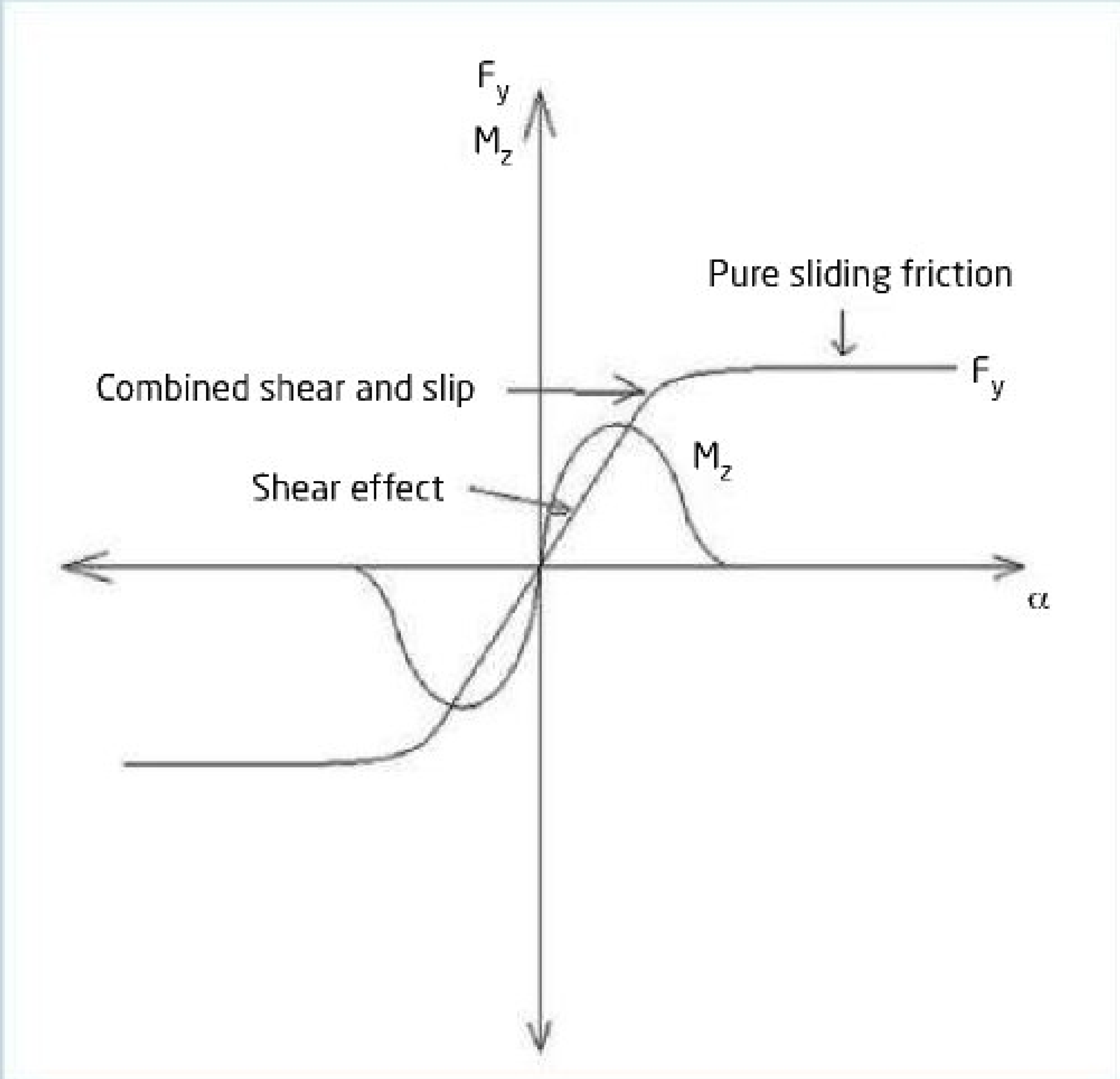
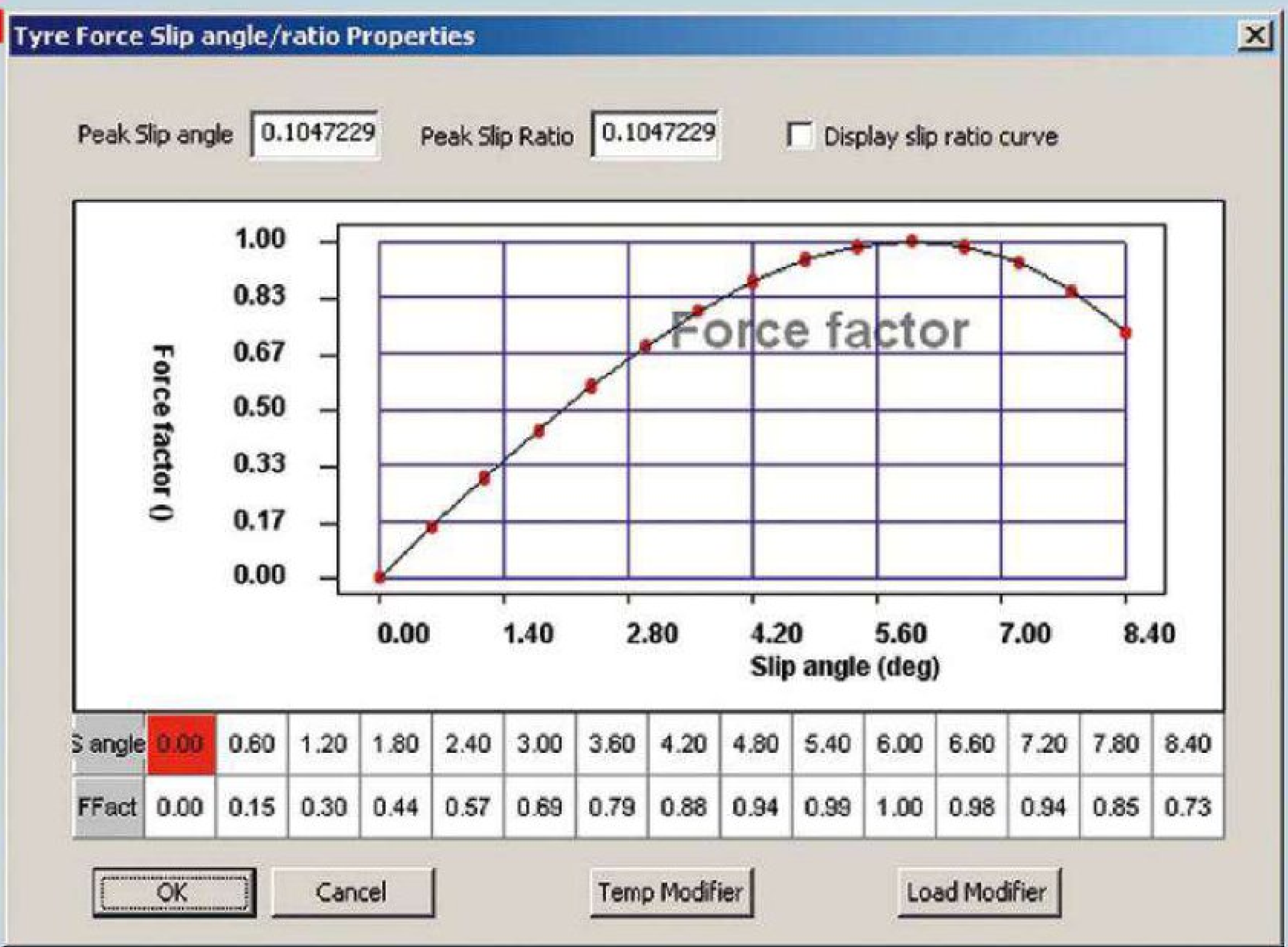


Figure 4

Normalised slip curve



Where a is this distance from the front axle to the c of g, b is the distance from the rear axle to the c of g and wb is the wheelbase.

Effectively, the stability index components are calculated by multiplying the traction circle radius by the slope of normalised force vs slip angle. With a good tyre model, the traction circle radius is relatively straightforward. However, what do we mean by the normalised force vs slip angle plot and slope? What we mean is the slope of the following curve.

The function fn(a), shown in fig 4, is what we multiply the traction circle radius by to get the current lateral force for a given slip angle. All we have to do is to calculate this slope and ensure we do it with slip angles being represented as radians.

My apologies for showing this in degrees but, in my experience, people relate better to degrees than radians. For those of you well versed with Pacjeka, all you need to do to construct the normalised slip curve is divide your force plot by the D_y term.

Figure 4 tells you a wealth of information about what the driver is feeling at the seat. If the car is understeering, the slope of the slip angle curve at the front of the tyre is significantly less than what is at the rear. Looking at equation (3), the first part of the stability index decreases and the rear component of the stability index increases. Consequently, the stability index will drop well below zero. The converse is the case for oversteer. Either way, the car will be telling you something.

To further explore this, let's evaluate some numbers. The first table I'm going to present has some typical F3 numbers that will show the combined traction circle radiuses front and rear. This is shown in table 1.

The next table we are going to discuss is a spread of normalised slip angle derivatives based on figure 4. This is shown in table 2.

The derivatives of table 2 can be found by evaluating the derivatives of a curve fit of the points in figure 4.

So let's first consider the case where the car is understeering. Let's say the front slip angle is five degrees and the rear slip angle is four degrees. Using equation (4) and the derivatives from table 2, the stability index is shown here (above right, top).

$$
\begin{aligned}
C_f &= \frac{\partial C_f}{\partial \alpha_f}\Big|_{\alpha=\alpha_f} \cdot (F_{m1}+F_{m2}) = 4.375\times 5000 = 21875 \\
C_r &= \frac{\partial C_r}{\partial \alpha_r}\Big|_{\alpha=\alpha_r} \cdot (F_{m3}+F_{m4}) = 7.9567\times 7000 = 55760 \\
C_T &= C_f + C_r = 77634 \\
stbi &= SM/wb \approx \frac{a\cdot C_f - b\cdot C_r}{C_T\cdot wb} \\
&= \frac{1.6\times 21875 - 1.1\times 55760}{77634\times 2.7} \\
&= -0.125
\end{aligned}
\tag{4}
$$

Let's now reverse the case and consider the oversteer case, where the front slip angle is four degrees and the rear slip angle five. Again, evaluating equation (4), the index is shown here (above right, bottom).

$$
\begin{aligned}
C_f &= \frac{\partial C_f}{\partial \alpha_f}\Big|_{\alpha=\alpha_f} \cdot (F_{m1}+F_{m2}) = 7.9567\times 5000 = 39783.5 \\
C_r &= \frac{\partial C_r}{\partial \alpha_r}\Big|_{\alpha=\alpha_r} \cdot (F_{m3}+F_{m4}) = 4.375\times 7000 = 30625 \\
C_T &= C_f + C_r = 70408.5 \\
stbi &= SM/wb \approx \frac{a\cdot C_f - b\cdot C_r}{C_T\cdot wb} \\
&= \frac{1.6\times 39783.5 - 1.1\times 30625}{70408.5\times 2.7} \\
&= -0.157
\end{aligned}
\tag{5}
$$

While this is a very simplified example, what these stability index numbers tells us is in the understeer case the total lateral force is acting at a moment arm of 0.335m behind the c of g, and in the oversteer case the total lateral force is acting 0.4239m in front of the c of g. In both cases, the self-aligning torque on the front tyres is starting to drop off significantly. We are now in a situation where the driver is feeling massive moments in his seat, just at the time the moment or torque in the steering wheel is starting to decline.

Here lies the innate nature of our conundrum. As we start manoeuvring the car at low slip angles, we have a very analogous situation to our aircraft. The steering wheel and the feeling in the seat are telling the driver the same thing. However, as we get close to the limit, the steering wheel and the feeling in the back of the seat are telling the driver two different things. This is the very nature of driving the car on the edge.

This can be readily evaluated by reviewing fig 3 and equation (1) to evaluate the self-aligning torque and using fig 4 and equation (3) to evaluate the stability index.

CONFLICTING INPUTS

Any serious driver worth his / her salt must be able to cope with this. Unfortunately, this is something that requires talent, experience and intelligence. When the car is on the edge of its performance envelope, the racecar driver must be able to mentally separate these two conflicting inputs.

There are ways of mitigating this. The first is to add lots of caster, which gives you a lot of trail and masks the self-aligning torque. However, it also adds significant cross weight. For some cars, this is a good thing, and V8 Supercars are a classic example of this. However, in some cars this is undesirable.

There is a silver lining to all this. As the self-aligning torque starts to decrease, it is telling the driver directly that he is right in the pocket of developing grip for the tyre. He just needs to have the mental ability to separate what is going on at the seat from what the steering wheel is telling him. The really good drivers are finely attuned to this and it is one of the telltale signs of which drivers you should be signing up.

The question that has to be asked is whether driving a racecar on the limit is more difficult than flying an aircraft on the limit. The answer is no, it's simply different, for reasons I'm not going to go into here.

In closing, being able to drive a car on the limit is a difficult activity. The thing that makes it so tricky is that you have the effects of self-aligning torque counteracting what the driver feels in the seat. The difficulty comes from the fact that as the forces and moments applied to the car reach their maximum torque in, the steering wheel drops off due to the self-aligning torque. Unfortunately, there are no ways easily to mitigate this, so it is something racecar drivers simply have to make their peace with. The silver lining to all this is that the good drivers can use the drop off in self-aligning torque to sense what the car is truly capable of.

TABLE 1

Typical values for stability index based around an F3 car

Item	Description	Value
Fm_1+Fm_2	Sum of traction circle radius for the front	5000N
Fm_1+Fm_2	Sum of traction circle radius for the rear	7000N
a	Distance of front axle to the c of g	1.6m
b	Distance of rear axle to the c of g	1.1m
wb	Wheelbase	2.7

TABLE 2

Plot of normalised slip angle derivatives based on figure 4

Slip angle (deg)	Slip angle (rad)	$\delta C/d\alpha$
0	0	14.323
1	0.0175	13.925
2	0.0349	12.731
3	0.0524	10.742
4	0.0698	7.9567
5	0.0872	4.375
6	0.1047	0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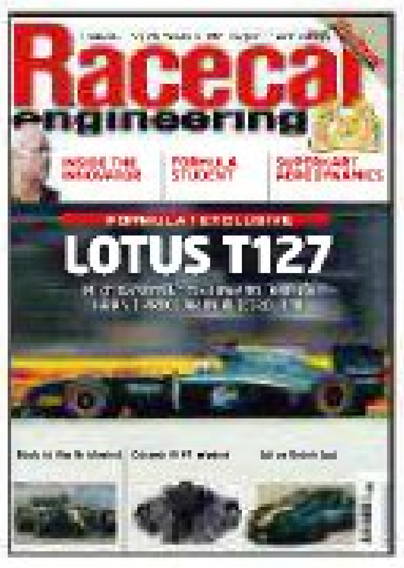
Toyota TF110 F1 car; Matech Ford GT; TOCA NGTC turbo engine; Mannic hillclimber; Formula 3 update; Ricardo Divila interviewed; keeping LMPs grounded; Ferrari F430GT aero; torque tubes; maths channels explained; deriving a vehicle model

AUGUST 2010
Nissan GT-R GT1; 2010 Le Mans technical report; Formula 1 clutches; Ferrari F430GT aero; how wings work; setting parameters for a tyre model; roll centres and their influence on anti effects; Panoz Abruzzi; Elleray single seater design; pros and cons of wide rear tyres



SEPTEMBER 2010
Lotus T127; Lotus returns to Indy; Lotus Evora Cup car; Cosworth CA2010; Lotus Survival Rules; Lotus innovations; Karl Ludvigsen on Colin Chapman; F1 simulator update; damper analysis; Formula SAE reports
+Stockcar Engineering VIII

OCTOBER 2010
Flexible wings; Superkart aero; power management systems; Frank Dernie interview; adjustable rear wing flap F1 2011; hydraulics behind movable wings; Blue Flame LSR car; Indycar head restraint system; F1 spark plugs; TKD V8s; damper analysis, part 2

NOVEMBER 2010
F1 pit stop evolution; Mazda RX-8 GT racer; Trevor Harris interviewed; drag racing safety developments; gear ratios; Business analysis- the demise of A1GP; Hindsight - the Wood brothers; welding technology advances; lap time simulation; Tech forum - how louvres work

DECEMBER 2010
BMW M3 GTR GT2; f-ducts update; Porsche 997 RSR GT2 aero; Business analysis - Donington Ventures; Prodrive Mini WRC development; TOCA Next Gen Touring Car; BTCC aero 2010; Chevrolet / RML Appendix engine; Tech forum - more on how wings work

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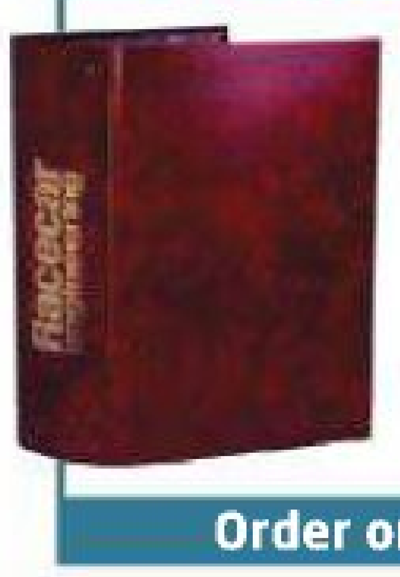

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BRIEFLY...

Oxeon Supergasell

Swedish company Oxeon has been acknowledged as the fastest growing company in Sweden 2010, and has been awarded the Gazelle prize 'Supergasell' by Swedish financial newspaper *Dagens Industri*. The Supergasell is an annual award that recognises a company that has shown exceptional growth and created new employment opportunities. Oxeon develops, produces and markets Spread Tow carbon reinforcements to composite manufacturers looking for ultra-light and optimised reinforcement solutions.

St Cross GET it

UK-based St Cross Electronics has announced a deal with Italian ECU and dashboard manufacturer, GET, to act as exclusive UK distributor for the company's MD60 GPS lap timing system. St Cross will also be able to supply bespoke wiring solutions to GET customers who wish to integrate the systems into their existing wiring looms. Additionally, GET will be displaying its wares on the St Cross stand at the upcoming Autosport Engineering show.

Noble achievement

The University of the West of England has awarded Richard Noble an honorary Doctorate in Technology in recongnition of his work with the Bloodhound SSC Land Speed Record project. The University felt that the aims of the project, in relation to providing inspiration and motivation to students in technological areas, aligned well with the university's own goals.

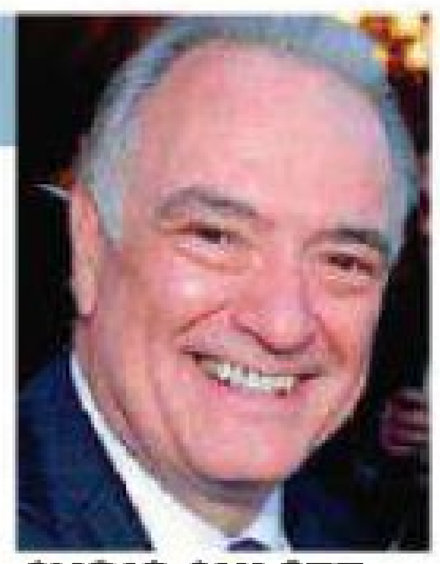
Dallara expands

Dignitaries representing the Town of Speedway, the State of Indiana, the Indianapolis Motor Speedway, IndyCar and Dallara officially broke ground

→

THE BUSINESS

USA calling



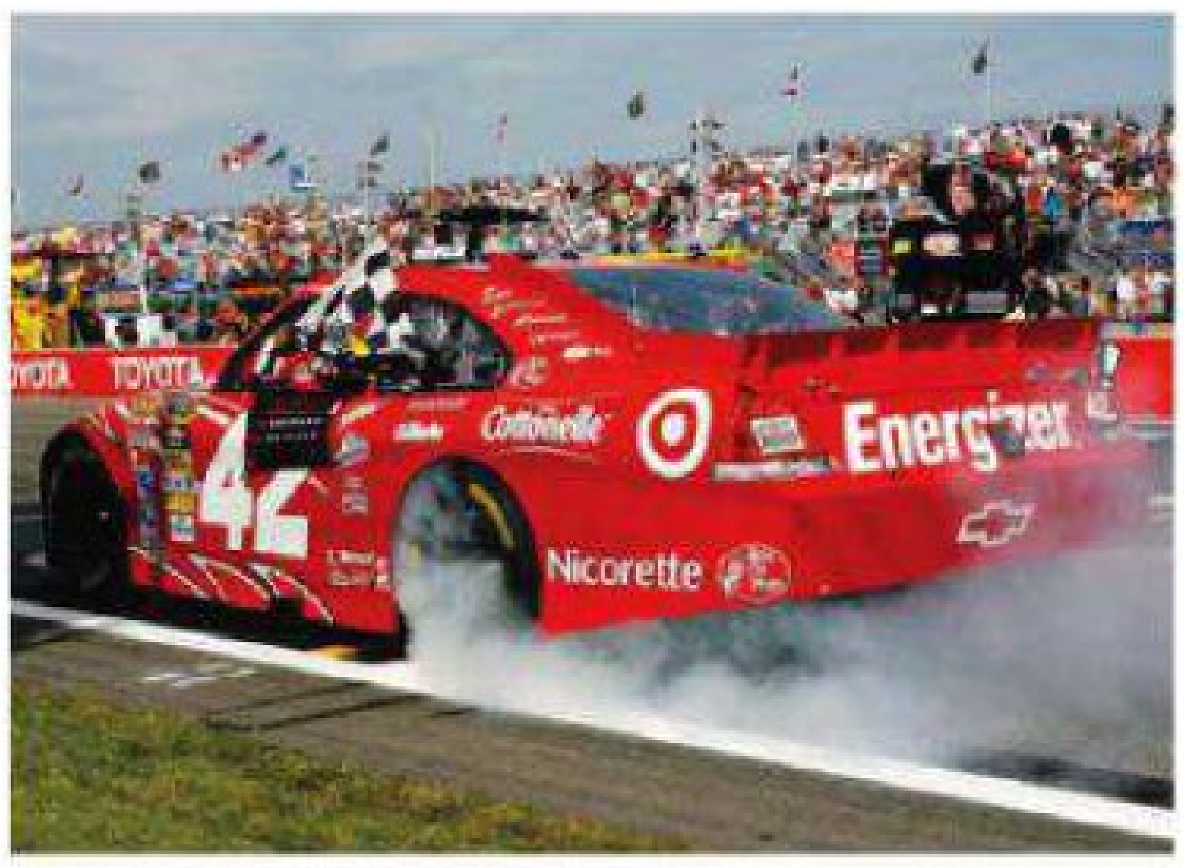
CHRIS AYLETT

There's business to be done during International Motorsport Business Week

With just a few days to go before you can make business happen during International Motorsport Business Week, check out www.internationalmotorsportbusinessweek.com and make sure you take full advantage of every possible business networking opportunity that presents itself. There is plenty of business still to be written in Europe, and many buyers and teams are leaving it to the last minute, which will stretch all their suppliers, but also means the Autosport International Show, and other events during that week, will be vital to kick the season off to a good start.

The MIA Clean Tech conference at Autosport International, supported by *Racecar Engineering*, is on Wednesday 12 January at the NEC. The focus is on how motorsport companies can engage with the automotive OEMs who are committed to spending millions on low-carbon solutions in the next few years. We have Porsche, Prodrive, Audi, Jaguar, plus many motorsport companies attending. This is your chance to meet mainstream automotive and get your share of this fast expanding opportunity. Check out www.the-mia.com events page for details.

Plan to come along to the Autosport International Business Lounge and meet the MIA and some of our international business visitors. Working with UKTI, we are offering a meeting service for UK companies to meet these international visitors - so don't hold back, go on the MIA website and register for the International Business Exchange now to expand your export business. And while you are about it, cast your vote for the Business Excellence Awards, which take place on Thursday 13 January.



The switch to fuel injection in NASCAR in 2012 will open up a whole new avenue of technology for US and European businesses to exploit. So start planning now

> "This is the year where you should make an effort to grow your business in the US market"

MAJOR MOTORSPORT MARKET

Having just returned from IMIS in Indy and PRI in Orlando, I am pleased to record the business written and the confidence that seems to be coming back into the major motorsport market that is the USA. IndyCar has now settled, and Dallara holds all the keys, plus the three engine suppliers - Honda (HPD), Chevrolet (Ilmor) and Lotus (Cosworth). I encourage all engine suppliers to chase that business right now.

It seems that fuel injection and NASCAR will not see the light of day until 2012, to give teams more chance to test, but this influential change in the top-ranked race series in the USA will have a significant effect on the use of carburettors in all other race series in the USA. This will have the likelihood of opening up opportunities for European engine companies to partner with leading US engine companies, but you need to start making those contacts now - and do use the MIA to help.

Likewise, the massive off road industry continues to grow fast, with many suppliers open to do business with specialists in Europe.

So make your plans to join the MIA visit to the USA now. We plan a three-market visit during one week in May - firstly, to the off road centre of business in California, then to the NASCAR centre in Charlotte to meet all the leading teams, and on to Indianapolis to meet the growing IndyCar programme, as well as drag racing. This is the year where you should make an effort to grow your business in the US market.

Whatever your particular area of interest, come and see the MIA during Autosport International, whether you are a member or not, to get some advice on conducting international business. We are here to help your business grow in 2011.

Chris Aylett is CEO of the Motorsport Industry Association www.the-mia.com

BRIEFLY...

at the site of Dallara's new $7 million US manufacturing facility. The site will be Dallara's first facility outside of Italy, and will be the production centre for the new Izod IndyCar chassis.

DC / Variohm tie up

UK wiring specialist, DC Electronics, recently announced a new partnership with Variohm EuroSensor, a market leading company in the area of sensor technology. The tie up will allow DC to provide its clients with a wide range of high quality and cost effective sensor solutions, designed specifically for motorsport applications. DC Electronics will be exhibiting on stand E252 at the upcoming Autosport Engineering show.

Charity case

The final day of the Indianapolis Motorsport Industry Show saw the announcement of the first ever motorsport-specific scholarship for students in the Indiana University - Purdue University Indianapolis Motorsports Engineering programme. Backed by CARA Charities, which was originally founded by the wives of IndyCar drivers, the scholarship is available for full-time students. Preference will be given to students who have demonstrated commitment by volunteering for a charitable organisation.

Carrera to Coyote

US performance shock absorber manufacturer, Carrera Shocks, has been acquired by Coyote Capital LLC. The takeover will see all of the company's operations moving to South Dakota. It is also expected that it will enable it to expand its product line, which includes shocks and springs for short track and drag racing.

SHOW REPORT

Good times

Buoyant year for Indy Show bodes well for the years ahead

**INTERNATIONAL MOTORSPORT INDUSTRY SHOW
INDIANAPOLIS, USA
1-3 DECEMBER 2010**

Short track and drag racing customers in particular were well represented

The Indianapolis Motorsport Industry Show has grown rapidly, with 570 exhibitors (some 225 more than last year), taking advantage of the increase in floor space available. 'It is a pleasant surprise to see how the show has grown in just a year,' said Jerry Thomas of Alcon.

Organiser Chris Paulsen pointed out that such is the location of the event that around 4000 visitors and exhibitors were able to sleep in their own beds each night, but said he has a five-year plan to make the show truly international, and is already planning a 60 per cent growth for 2011, which will be made possible by further expansion to the Indiana Conference Center.

An identity is developing that indicates the show is particularly important for the short track and drag racing fraternity, companies such as Penske Shocks, TCI and ATL all reporting that was where the main interest seemed to be. Crane Cams' Chase Knight agreed, but said all sectors seemed to be represented.

For example, workshop manager Phil Levett of Good Fabs, whose Inconel exhausts systems are probably too high end for short track, reported being visited by representatives of the leading NASCAR teams, while Alcon's Thomas said the show's first day had seen visits from top Sprint Cup customers – 'higher end engineers who seem to have been missing from the PRI show in recent years.' Visitors such as Paul Gentilozzi and Lee Dykstra indicated that there was also interest from the road racing fraternity, while Ganassi engineer Julian Robertson was among those from the IndyCar world.

The announcement by PRI that it had moved its 2012 show to exactly the same dates caused disquiet among some exhibitors, but Paulsen countered this by pointing out that the IMIS dates for the next five years were announced in 2009.

> **a five-year plan to make the show truly international**

IMIS has now expanded to three days, with two days this year devoted to safety and technical conferences, with a high level of speakers.The Thursday saw the launch of the Motorsport Supplier Advisory Group, an initiative that Superior Crankshaft's Cheryl Archer has copied from her time working in aerospace. Around 30 people attended the meeting to learn how such an association could exist to provide advice to the sanctioning bodies on a relatively informal level. 'It would be great to be a resource for them,' said Archer, predicting that it had a 50/50 chance of getting off the ground.

A major selling point for IMIS is the way in which it controls the level of its visitors. Following an exploratory visit last year, suspension specialist Eibach decided to exhibit with a view to meeting chassis manufacturers and, within less than an hour, the company's Adam Matthews reported that two had already been on the stand.

Randell Peters, associate professor at Indiana State University, had a different take that indicated the right people were present. 'We have got to be here. It's an absolute must. This is where the industry finds out that an education exists on its behalf.'

IMIS is certainly here to stay, and there would appear to be room for two US shows, even if holding them on the same dates is surely short sighted.

Ian Wagstaff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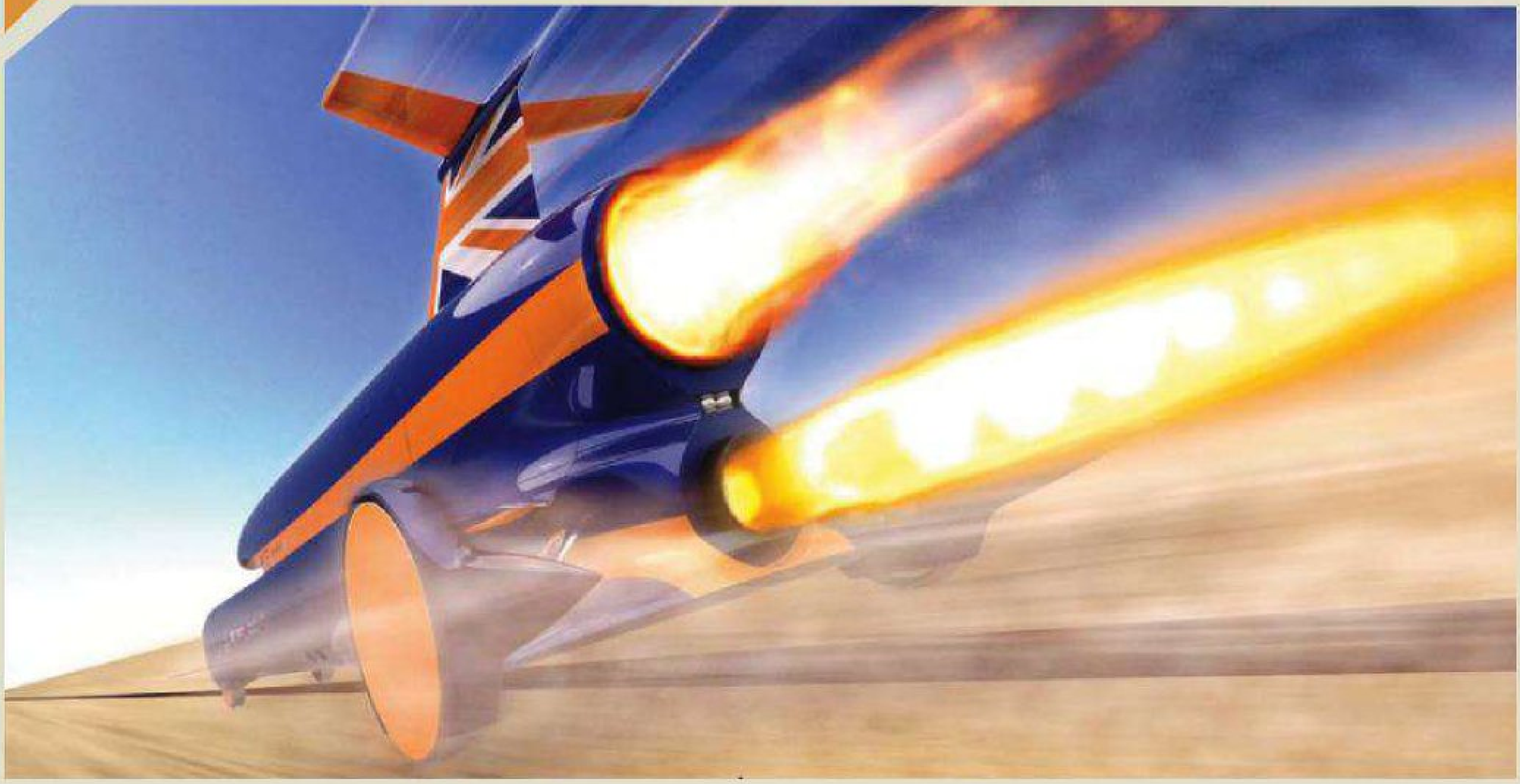
UNDER DISCUSSION: BLOODHOUND SSC



Scale modelling

Is Bloodhound SSC overweight, or is it not quite as simple as that?

The Wingfoot Express jet land speed car built by Walt Arfons and Tom Green weighed about 4000lb. The Bloodhound SSC has a projected empty weight of about 12,000lb.

At a weight of 2100lb, the EJ200 fanjet engine being used in Bloodhound SSC weighs exactly the same as the Westinghouse J-46 turbojet used in the Wingfoot Express. However, with a thrust of 20,000lb in afterburner, the EJ200 generates about three times the thrust of the J-46 and is even smaller in diameter (29in vs the 34in of the J-46).

If you put an EJ200 in a car that weighed 4000lb, instead of 12,000lb, it seems like you'd have a car where the jet engine all by itself could get the car to 1000mph.

If Walt Arfon's Wingfoot Express was fitted with Bloodhound's EJ200 fanjet engine, could it have gone 1000mph?

TYRE-LESS LSR WHEELS

According to John Ackroyd, designer of the Thrust 2 jet land speed car, a tyre-less wheel on dirt has about a .30 friction coefficient. As a comparison, a tyre on salt has about a .50 friction coefficient. My guess is Ackroyd arrived at the .30 friction coefficient by calculating from the rate of deceleration when the brakes were applied on Thrust 2.

I don't know what the friction coefficient is for a tyre-less wheel on salt or a tyre on dirt. However, obtaining answers to these questions might be a step toward solving the continuing issues of expense, complexity and reliability posed by conventional tyres in land speed racing.

Sincerely,
Franklin Ratliff

RIGHT TO REPLY

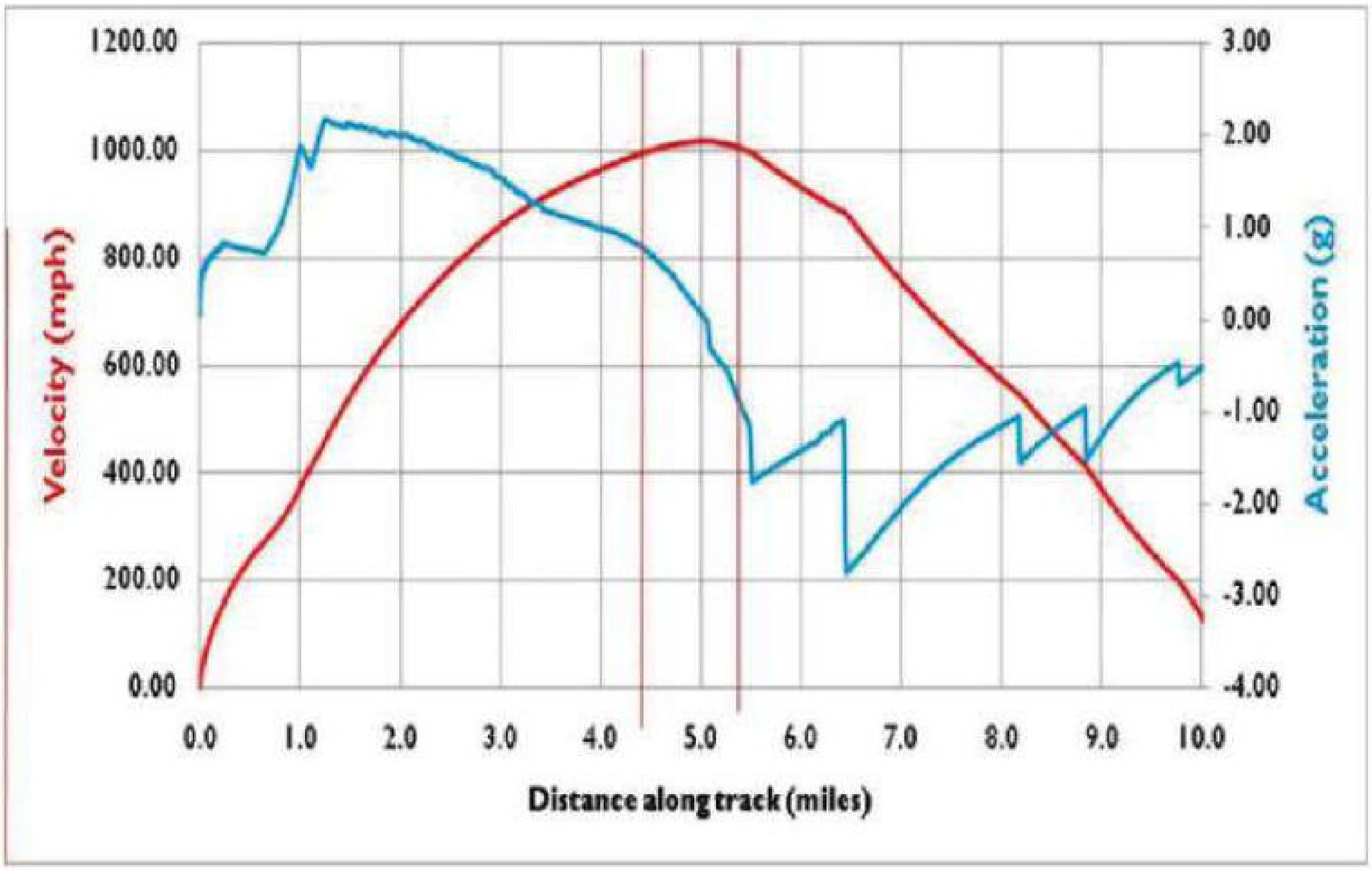
A few points to note...

Ron Ayres, chief aerodynamicist to the Bloodhound project replies

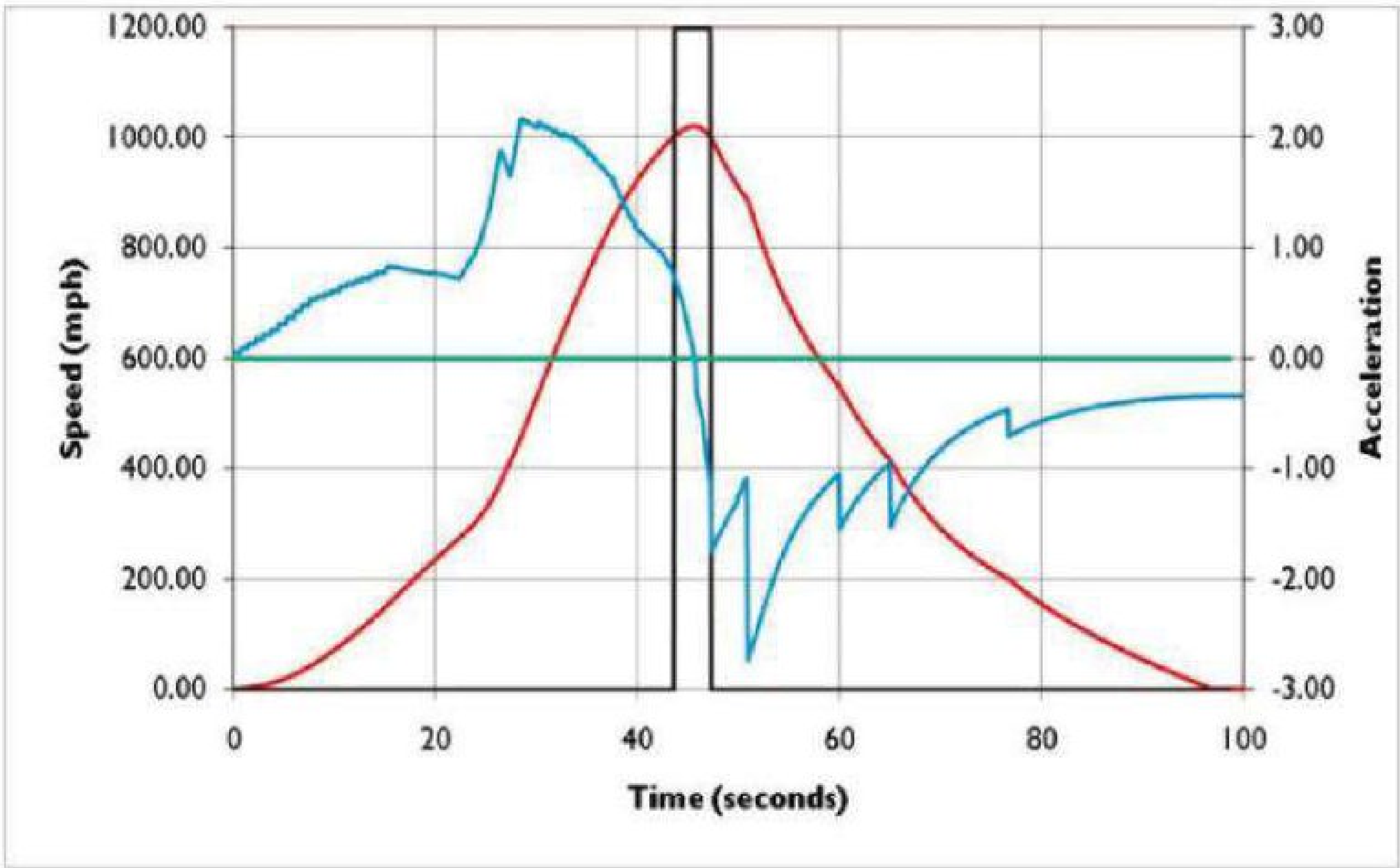
Franklin, your query has been passed to me, so I am happy to help.

It would seem that you are doing a simple scaling exercise from Wingfoot express to the Bloodhound SuperSonic Car. If only! You do not mention drag, or the fact that drag coefficient increases significantly when going from sub-sonic to supersonic. That immediately throws out your scaling. You also make no mention of rolling resistance and spray drag. These can make a significant difference, and I am currently researching both of them, with the help of Swansea and Southampton Universities.

Of greater importance, however, is the fact that you cannot scale engine thrust to ever-higher Mach numbers. You can either optimise the engine / intake combination for low speed or for high speed, but not for both. If you are really wealthy (and that rules us out), you can go to the sophistication of a variable geometry intake. That ameliorates the problem to some extent, but certainly does not solve it completely.



Graph showing maximum speed, as well as maximum thrust for jet and rocket engines



Peak velocity = 1020mph, with rocket ignition at 22.4 seconds

A MATTER OF ACCELERATION

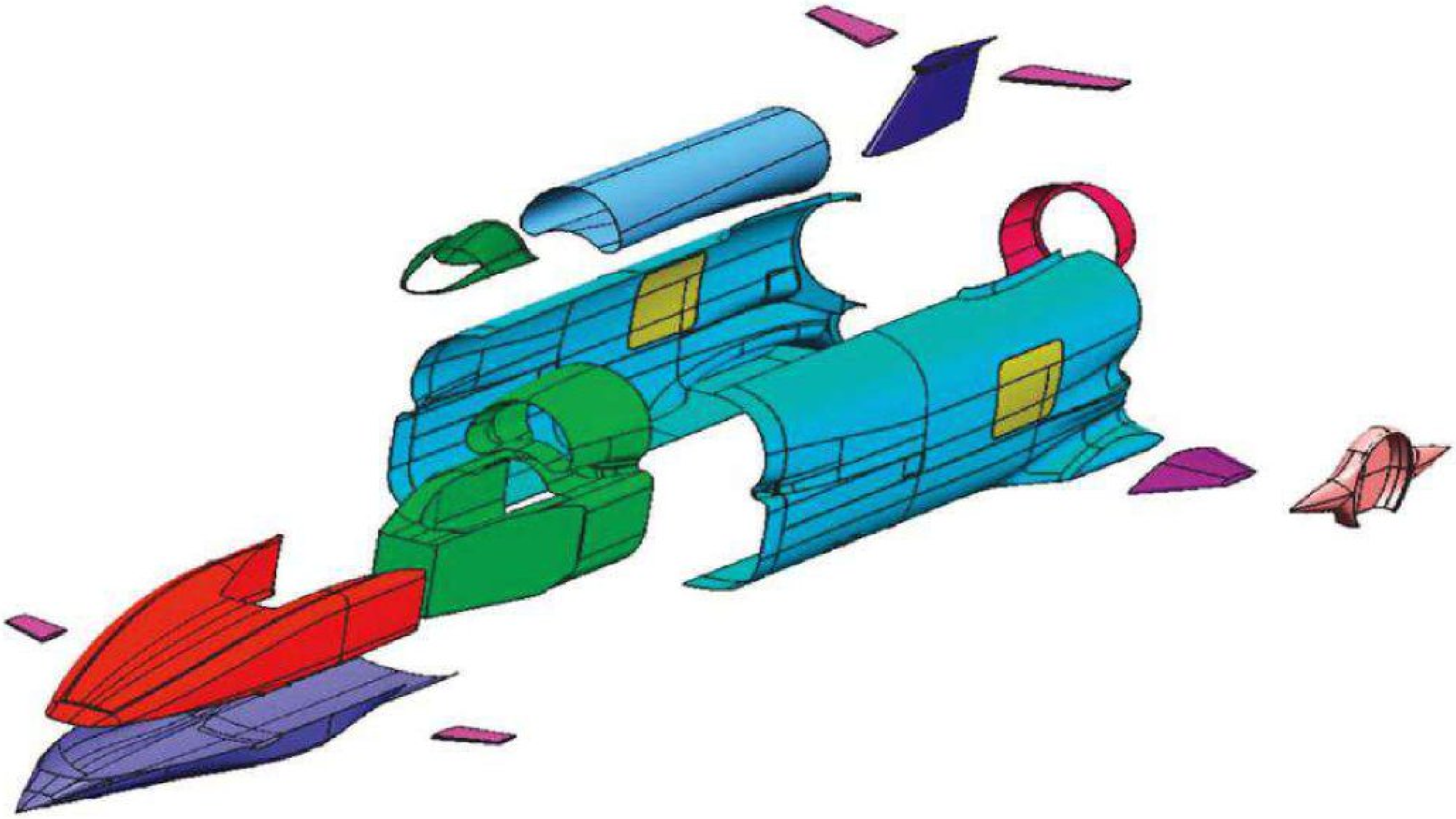
The most important factor you have ignored is the little matter of acceleration. Now we have lost the use of Black Rock Desert (to the ravages of sand dunes and the Burning Man festival), Andy Green has scanned literally every large flat, dry area on the globe, using satellite imaging, and the biggest he has found is Hakskeen Pan. The total length of this (from one pile of rocks to the other) is just 12 miles. Allowing one mile at each end for over-run / turnaround means we are choosing to run on just 10 miles. Subtracting a measured mile in the middle, this allows 4.5 miles in which to accelerate. That process takes nearly 44 seconds, which is an average acceleration of over 1*g*, all the way up to 1000mph. That really does scupper your thrust requirement, as it immediately adds another 12,000lb of thrust, just to provide the acceleration. Add in the extra fuel, the bigger tank, the extra weight – and hence the need for even more thrust. Hell,

> "You cannot scale engine thrust numbers to ever-higher Machs"

Franklin, you are an experienced engineer, so you will know all about the inflationary spiral you get every time you go round such a loop, so you already know this.

If we had more distance, would we accelerate more gradually? Definitely not. When Bloodhound SSC travels at

RIGHT TO REPLY



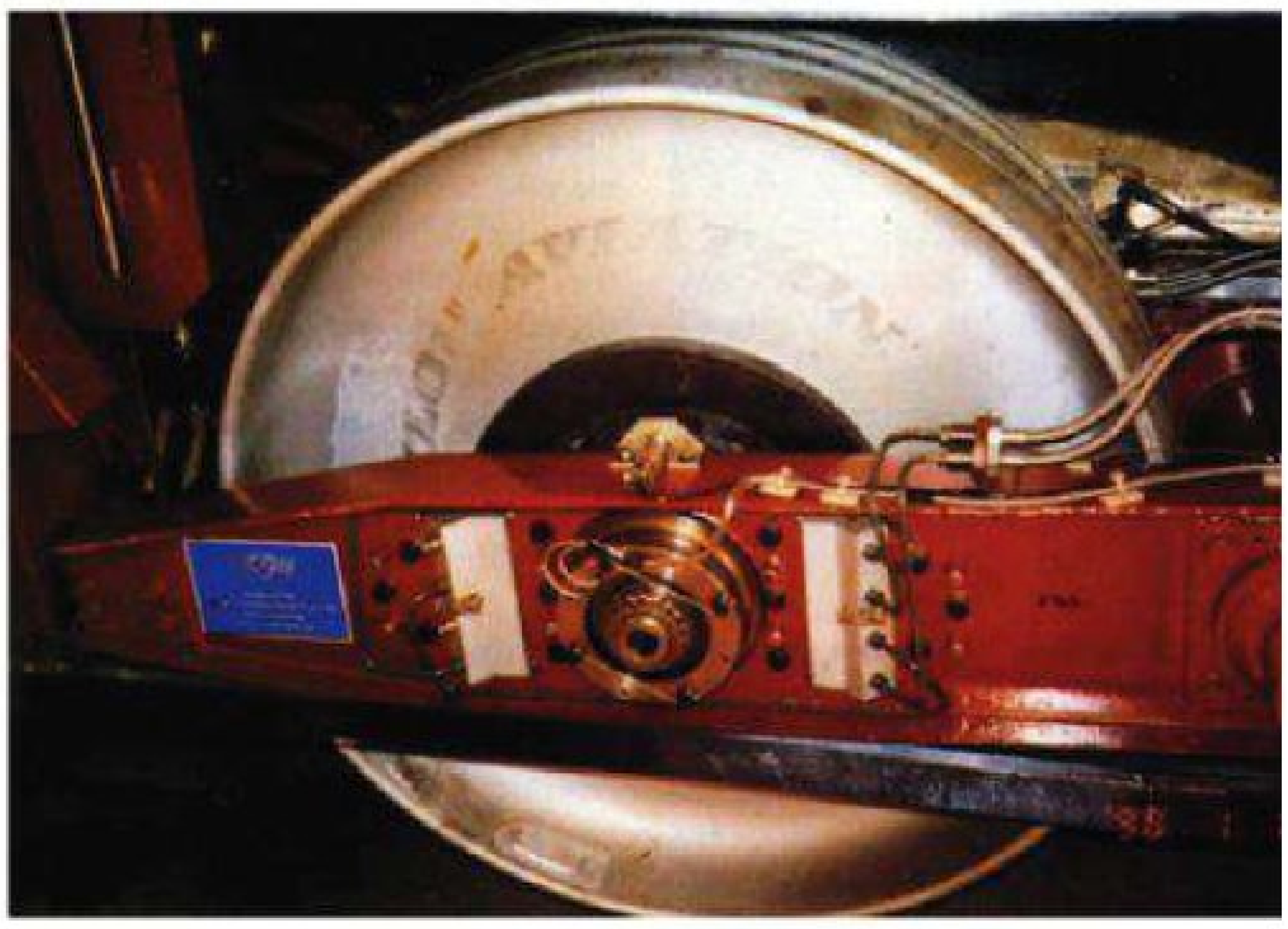
Despite extensive use of lightweight composite components, as shown above, Bloodhound is still much heavier than older cars like Bluebird CN7

Mach 1.35 at ground level, it is consuming more fuel in one second than an alcoholic party would consume in the whole Christmas holiday. To be more specific, at maximum speed, Bloodhound SSC is losing mass at the rate of more than one per cent every second. You cannot keep that up for many seconds. Another little matter that Andy Green will have thought of is that he will be consuming track at the alarming rate of one mile in less than 3.6 seconds. As he only started the run with a total of 12 miles, he will not be inclined to put his feet up at supersonic speeds and admire the scenery. At least, I hope he won't. Therefore, rapid acceleration, followed by rapid deceleration is the only option.

If we had more distance, could we make use of it? Definitely yes! More over-run would be comforting to have in the event of something like a 'chute failure.

Franklin, I have appended a couple of performance graphs (shown on previous page) for your interest. They are not totally up to date, but you will get the picture. You will see that Andy will be accelerating at more than 2*g*, pushing his blood into his head. He then promptly decelerates at 3*g*, pushing the blood into his feet. To combat this, he keeps his cardiovascular system tuned up by practicing aerobatics. That is when he is not on the Cresta run, competing in championships and often winning them. Personally, I am more at home with a laptop.

I started working on a forerunner of this project about 12 years ago. I looked at an all-jet solution and, trust me, you cannot even get near 1000mph. I also looked at several pure rocket solutions, but preferred the flexibility of the jet / rocket mix.



Thrust SSC used these tyre-less wheels during its record runs in 1998

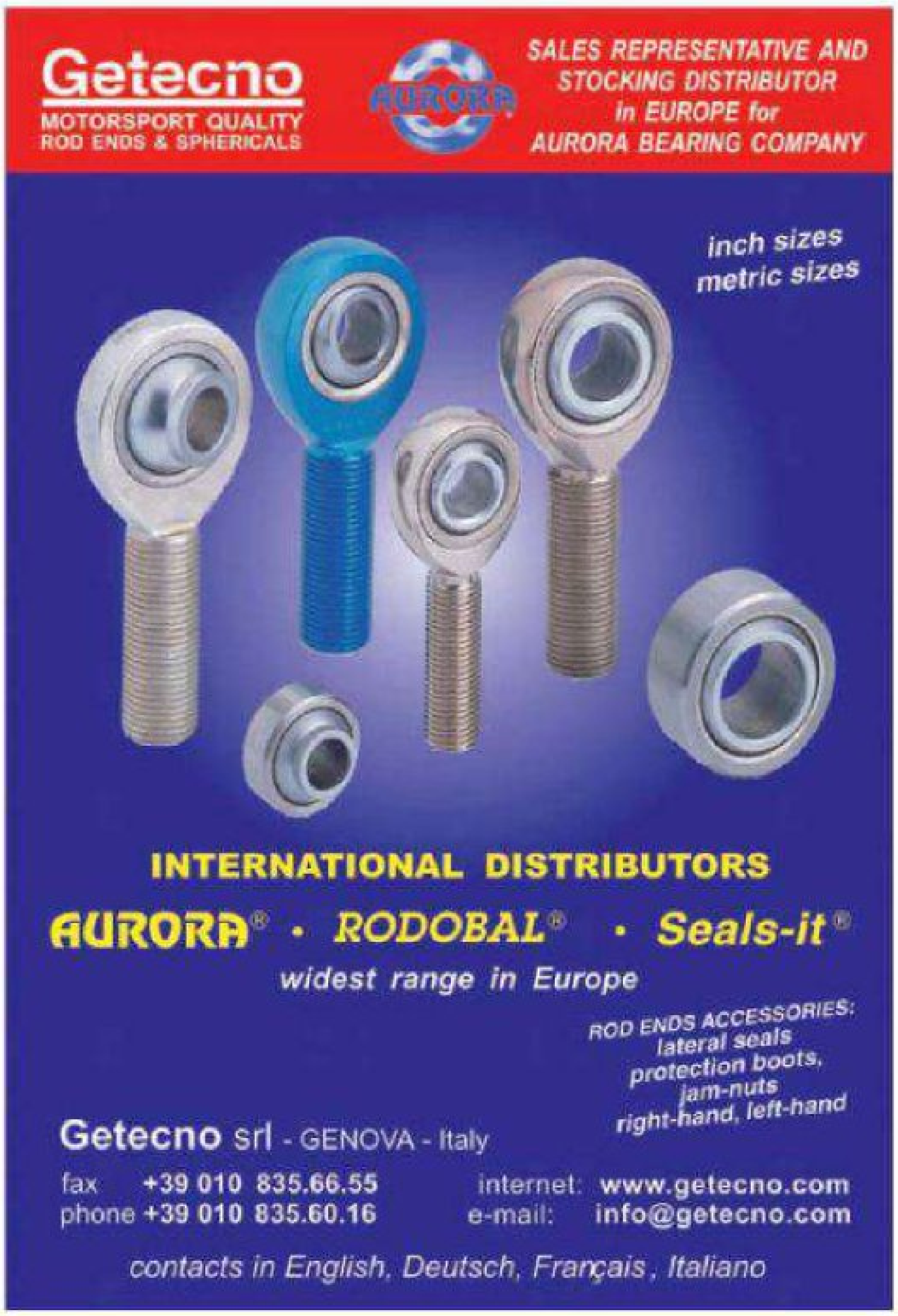
COEFFICIENTS OF FRICTION

I can also help you with your request for information concerning the coefficient of friction of a tyre on dirt.

In 1996 and 1997, I carried out limiting acceleration and limiting deceleration tests on the Al Jaffr desert in Jordan and on Black Rock desert. In every case, I got a limiting coefficient of close to 0.4. Any attempt at higher acceleration / deceleration simply caused the desert surface to sheer. These tests were carried out using normal road tyres on firm, dry, pristine desert. If the desert had been trammelled by previous vehicles, its mechanical strength was greatly impaired.

I hope I have answered your questions adequately. If not, ask again in the New Year. I must now go out before I get snowed in to do my Christmas shopping, or I will be in deep trouble over the festive season.

If you have an issue you want to discuss here, please email the editor at: **graham.jones@chelseamagazines.com** or write to: the editor, *Racecar Engineering*, Suite 19, 15 Lots Road, Chelsea, London SW10 0QJ, UK. Visit **www.racecar-engineering.com**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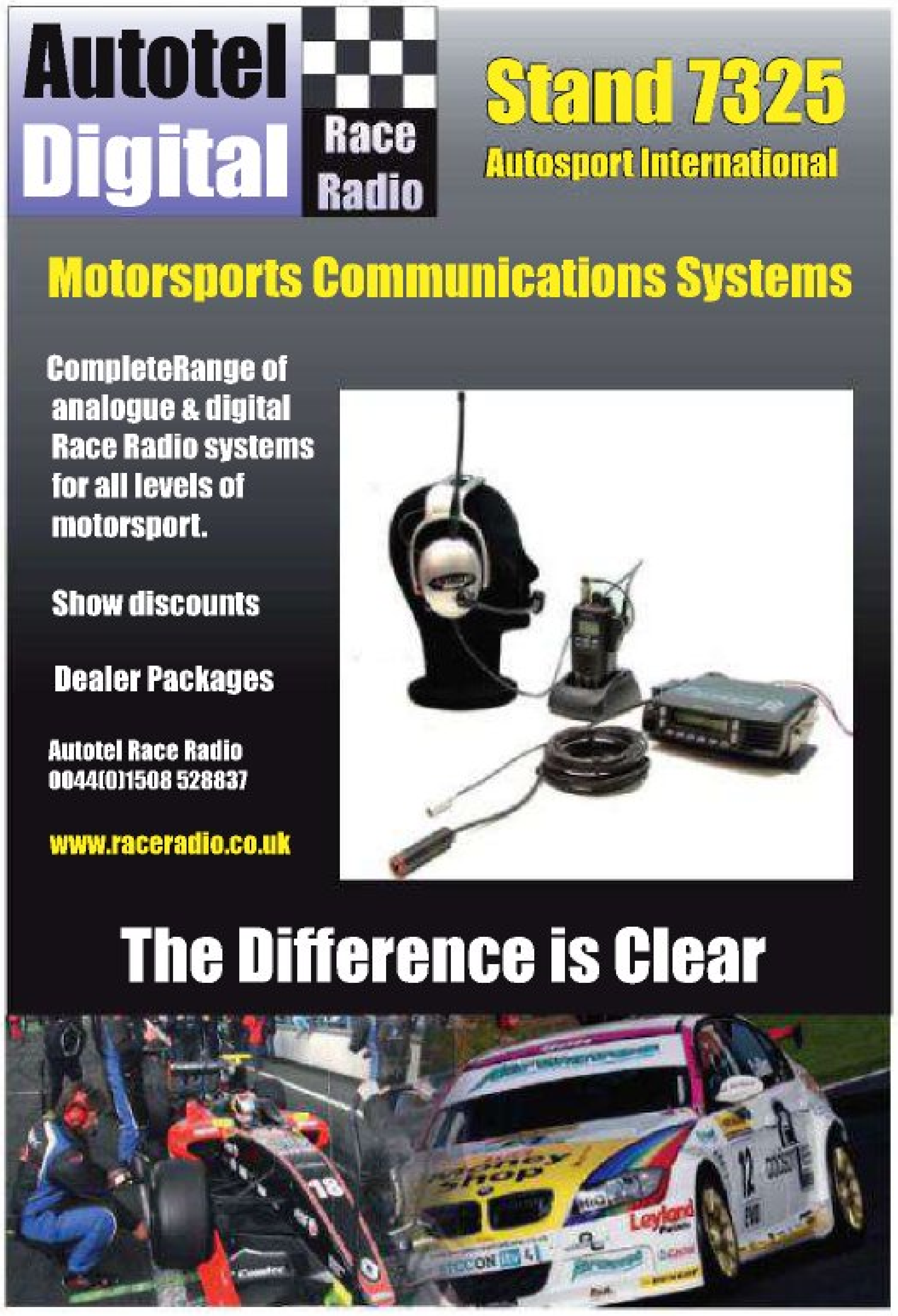
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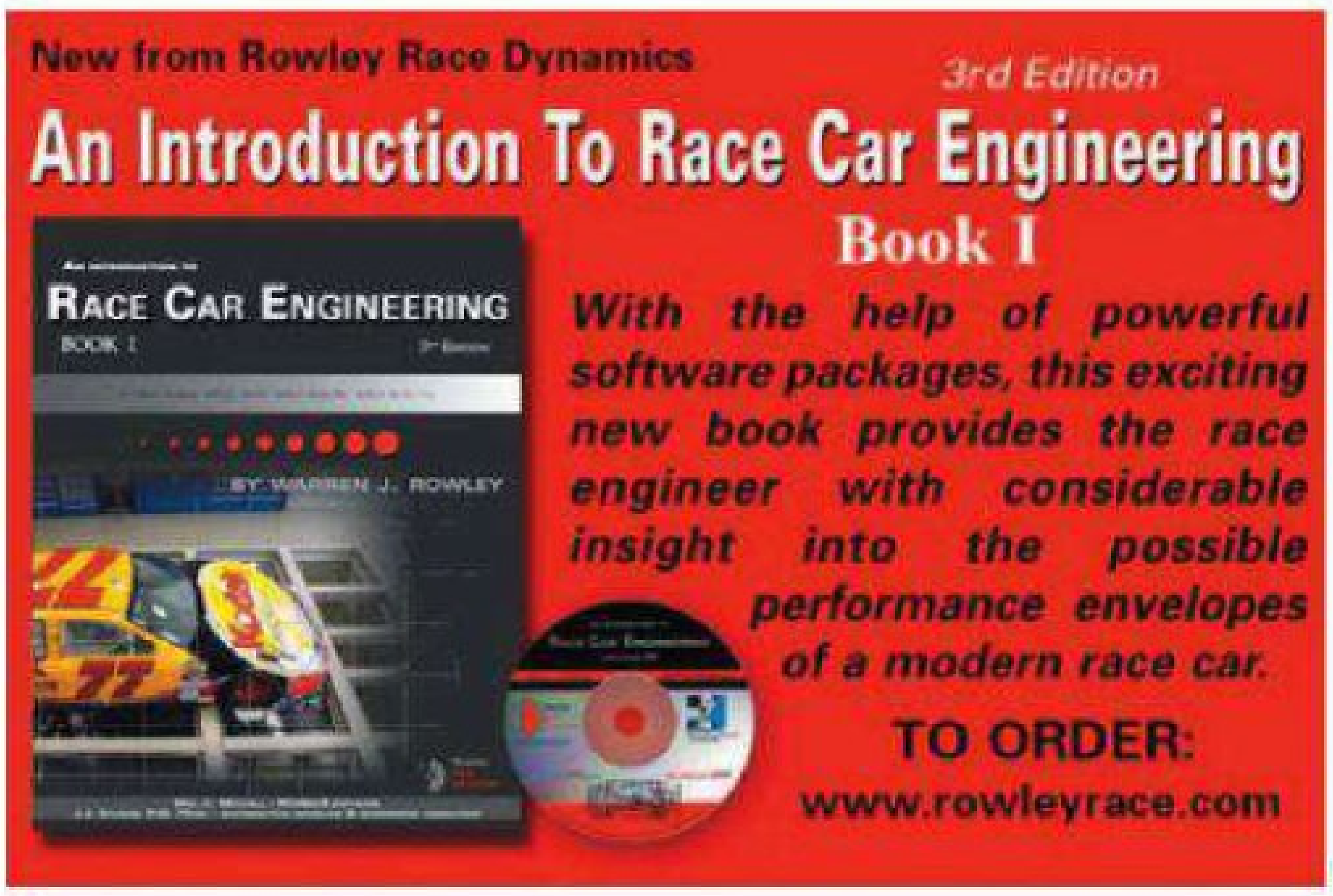
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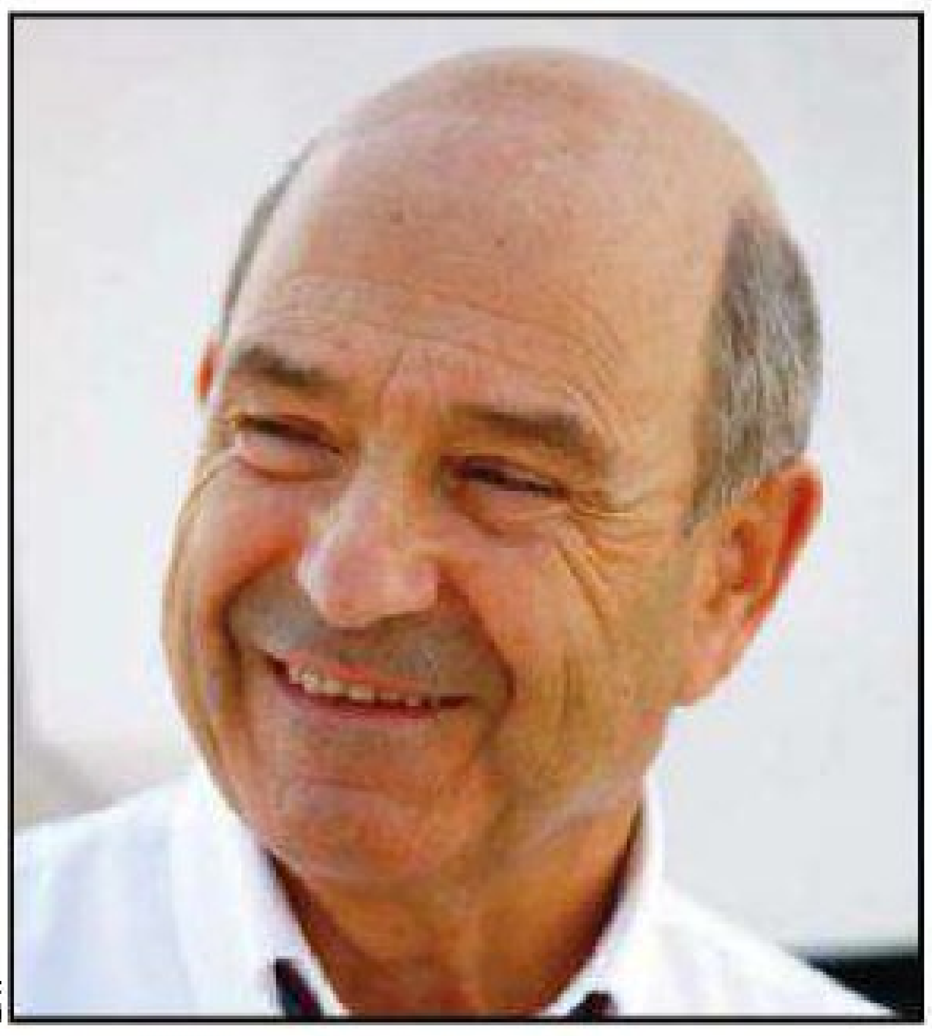
PETER SAUBER

THE INTERVIEW


LAT

identified the weaknesses of the C29 and laid down a clear road map for improvements. These ideas were quickly put into practice and had a positive effect. After collecting just a single World Championship point in the first eight races of the season, we added another 36 over the next eight GPs - plus seven in the final three races. Added to which, James also implemented a series of organisational changes. Our success in finding a way out of such a difficult situation over the course of the season represents a fine advertisement for the quality and spirit within the team.

Q Have you ever regretted the decision to buy the team back?
No, never. And I never will, although I knew that keeping the team alive would be a very difficult task. But if I hadn't taken the plunge, every day I'd have been asking myself why. We've cleared one obstacle after another from our path. When I compare the situation a year ago to where we are today, everybody in the team can be proud of what we've achieved.

Q The team's progress early in the season was very slow. What was going through your mind then?
That was tough, no question. The car was not only too slow, it was also unreliable, which is extremely unusual for this team. And then, as so often happens in sport, we also had a fair amount of bad luck. That wasn't just annoying, it also made negotiations with potential sponsors pretty much a non-starter.

Q But then, from Valencia onwards, things suddenly picked up. What was the catalyst?
In April, James Key took over as technical director and achieved a great deal in a short period of time. He and his team

Q How is the development of the new car progressing?
The development of the Sauber C30-Ferrari is running according to plan. We're setting our sights high, and things are looking good so far. James Key has proved in the past that he knows how to build fast cars. All the changes to the technical regulations – including the ban on double diffusers, the introduction of Pirelli tyres, adjustable rear wings and the option of using KERS - make this a particularly exacting challenge this year.

Q A lot has been written about the team being up for sale. What's the current situation?
I own 100 per cent of the team and there are at present no plans to sell the team or any part of it. Our partnership with Telmex, which will come into force on 1 January 2011, does not include any kind of stake holding and is purely a sponsoring agreement.

Q How long will you stay on as team boss?
A year ago, I said that I didn't want to remain on the pit wall when I turned 70. That's still the case, and I'm now 67. The critical thing for me is to ensure that we bring even greater stability to the team and

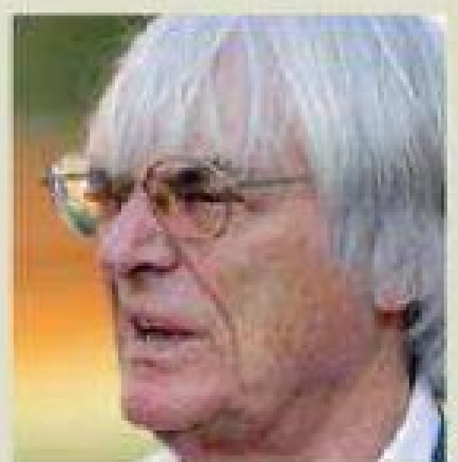
Peter Sauber, team principal, Sauber F1
- **1970-'76:** built Saubers for Swiss Hillclimb Championship and Sportscar racing
- **1976:** Most successful early Sauber, the C5, wins Interseries
- **1977-'78:** Le Mans with C5
- **1979:** F2 with Lolas
- **1980-'81:** developing and racing BMW M1
- **1982:** C6 Sportscar, first wind tunnel-developed Sauber
- **1985-'91:** working with Mercedes Benz in Sportscars
- **1993-'05:** Formula 1
- **2005-'09:** team is sold to BMW, Sauber takes on an advisory role within team
- **2009-'10:** BMW withdraws from F1 at end of '09. Sauber buys team back

RACE MOVES

Chip Ganassi was the recipient of the first ever International Motorsports Industry Show Achievement Award, presented at the IMIS welcome reception. Ganassi was recognised for his championship wins in IndyCar and Grand-Am and his Sprint Cup team's race victories in NASCAR.


LAT
Chip Ganassi

Gary Peterson has ended his AFS Racing team's tie up with Andretti Autosport, with which it joined forces three years ago – mainly to compete in Indy Lights, but also for sporadic IndyCar races. The AFS team still hopes to run its own IndyCar programme in the future, but for 2011 it will continue to run in Indy Lights.


LAT
Bernie Ecclestone

Formula 1 boss, **Bernie Ecclestone**, was mugged in central London in the lead up to Christmas. F1's commercial boss was with his girlfriend, Fabiana Flosi, when they were attacked by four men. Ecclestone, who is 80, was knocked unconscious during the attack and it was widely reported that the robbers got away with £200,000 worth of jewellery.

Adrian Campos is to take his Campos Racing squad into the Auto GP championship in 2011. The founder of the Hispania Formula 1 team, which was bought from Campos by **Jose Ramon Carabante** before the 2010 season started, has won several championships with his eponymous team, including the 2008 GP2 crown. Campos, a former F1 driver, set up his team in 1998.


LAT
Anthony Hieatt

Anthony 'Boyo' Hieatt has taken over the Raikkonen Robertson Formula 3 team he has managed since 2005, buying out **Steve** and **David Robertson** and former F1 world champ turned WRC driver, **Kimi Raikkonen**. The team will now be known as Double R Racing.

Motorsport writer, **Christopher Hilton**, the man who wrote the first biography of Ayrton Senna, has died. Hilton was a prolific and eclectic author, writing books on subjects ranging from 1930s' grand prix

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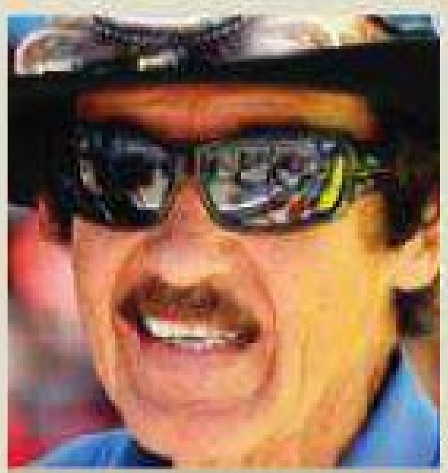
RACE MOVES

racing to present day Formula 1.

Richard Petty has retaken control of his NASCAR Sprint Cup team, by buying out **George Gillet's** share in the organisation. Petty, who is now 73, is to serve as chairman of the operation, which will remain at its Concord, North Carolina, base. The team will still source its chassis and engines from Roush.



LAT

Richard Petty

The crew of the no 11 Toyota driven by **Denny Hamlin** in the NASCAR Sprint Cup has scooped the 2010 Mechanix Wear Most Valuable Pit Crew Award. The Joe Gibbs Racing crew gained the award, which is voted for by the NASCAR crew chiefs, for its 'fast pit stops, flawless performance and incredible effort'. The crew was awarded a trophy and $100,000 prize money.

BMW motorsport boss, **Mario Theissen**, is to leave the company half way through 2011. Theissen, who has been the motorsport director at BMW since 1999, has chosen to leave at this time as it is a transitional period in the German car maker's motorsport history. BMW is set to return to the DTM in 2012 after pulling out of F1 in 2009.

LAT

Jens Marquardt

Jens Marquardt has left Toyota Motorsport to take up the position of BMW motorsport director. Marquardt has joined BMW to work alongside Mario Theissen (see previous entry) for six months as Theissen is to officially step down on 30 June. Before joining Toyota's F1 team in 2000, Marquardt worked for Ilmor.

LAT

Steve Letarte

NASCAR Sprint Cup outfit, Hendrick Motorsports, is to switch around the crew chiefs for three of its four drivers for the 2011 season. **Jeff Gordon** is to end his long-term partnership with **Steve Letarte**, who now moves on to **Dale Earnhardt's** car, while Gordon teams up with **Alan Gustafson**, who in turn moves from **Mark Martin's** car.

PETER SAUBER
THE INTERVIEW

CONTINUED

that we have a financial basis on which to move forward from a sporting point of view. When that is in place, the time will have come for me to step back.

Q You made a driver change ahead of the race in Singapore, replacing Pedro de la Rosa with Nick Heidfeld. With the benefit of hindsight, would you make the same decision again?

Yes, I would. We were in a situation where we didn't know how far we had come in terms of performance. Both drivers were new to the team, we didn't know them very well and we didn't know how good the car was. What we were missing was a reliable benchmark. We know Nick well after working with him for many years, and that allowed us to gauge the progress of various elements.

Q How happy are you with Kamui Kobayashi?

Kamui inspires us all within the team. His refreshing, attacking style really puts a smile on your face. You can tell from reactions in the stands that the Formula 1 fans love him, too. His overtaking moves are always great to watch. However, it would be doing him an injustice to only focus on this aspect of his driving. Kamui is also a very clever driver and understands how to put a pre-defined strategy into action. He's progressed wonderfully well this year and I'm certain there's more to come from him in the future. When I signed him a year ago, I had to put up with critical comments from some experts, but my gut feeling told me that Kamui was something special. And today I'm delighted to have him in the team.

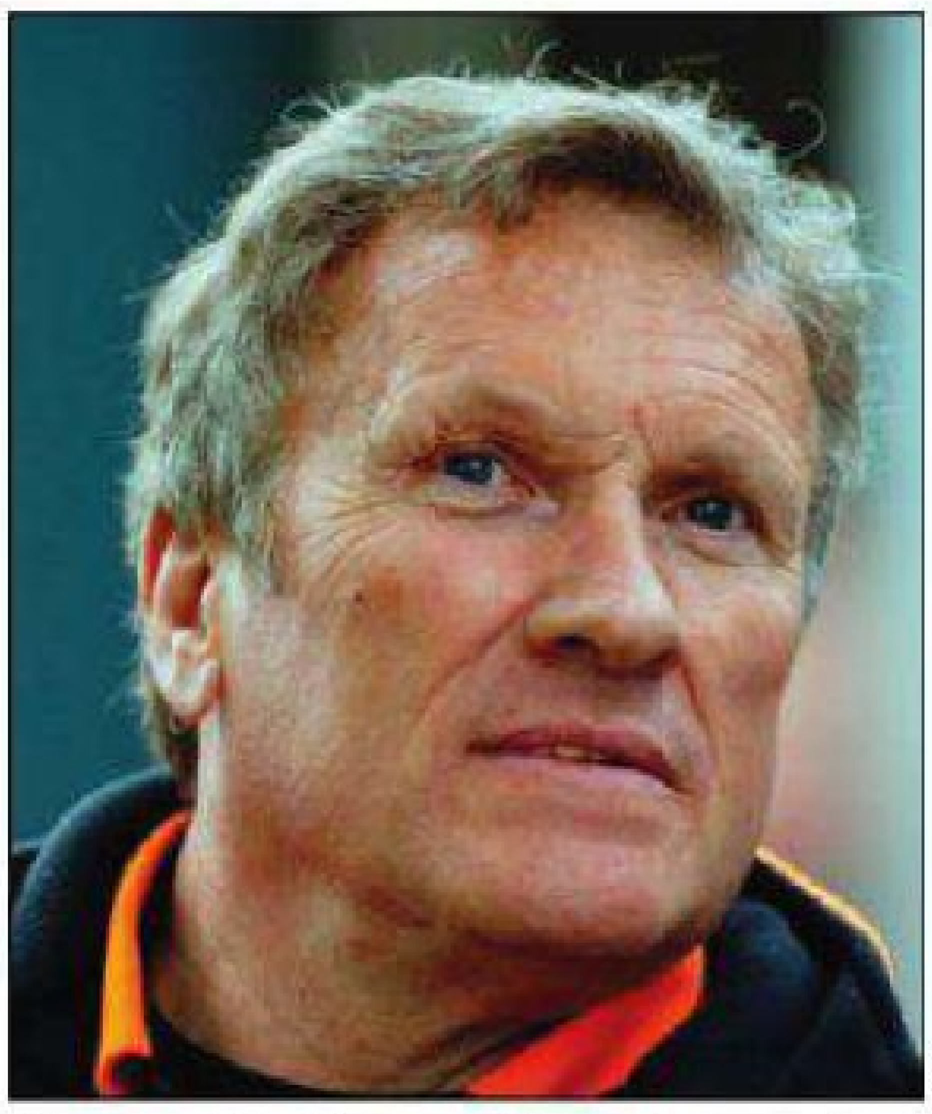
TOM WALKINSHAW
OBITUARY

Motor racing lost one of its great characters just before Christmas with the death of Tom Walkinshaw, a man who was as adventurous at the helm of a company or race team as he was at the wheel of a racecar.

Walkinshaw died at the age of 64, after losing a long battle with lung cancer. He was last seen in the Formula 1 paddock as recently as Monaco and Silverstone last year, where those who met him said he made light of his illness. But while he was at home in the grand prix environment, it is probably for his exploits at the head of the Le Mans-winning Jaguar team that he will forever be remembered.

Walkinshaw started his career in motorsport as a driver, winning the Scottish Formula Ford championship in 1969, before graduating to Formula 3. He even reached the heights of F5000 and Formula 2, but then chose to continue his career in tin tops.

It was while he was competing in the British Saloon Car Championship that Walkinshaw founded Tom Walkinshaw Racing, or TWR, as it became abbreviated - a three-letter brand that's up there with



LAT

BRM and ERA for race fans of a certain age and outlook.

But TWR was much more than just a race team, and over the years it grew to become a motorsport empire that included car dealerships and engineering companies. The racing was always central, though, and TWR was able to forge strong manufacturer partnerships with Mazda, Rover and then Jaguar in Touring Cars. Later, while Walkinshaw was involved in Formula 1, TWR continued to race in Touring Cars, famously bringing Volvo and its

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RACE MOVES

Martin's car will now be crew chiefed by **Lance McGrew**, who was formally on the Earnhardt car.

Gil Martin, the crew chief for the no 29 Chevrolet in the NASCAR Sprint Cup Series, has scooped the Wypall Wipers crew chief of the year for the 2010 season, picking up a cheque for $20,000. Martin's award was clinched after he won seven of the Wypall crew chief of the race awards, which was four more wins than his two closest rivals in the competition.

Ian Phillips, a former Formula 1 team director with March and Jordan, has formed a new motorsport management services company, with which he hopes to use the contacts he's made during 41 years in the sport to help drivers progress up the motor racing ladder. He also intends to help commercial companies maximise their investment in motorsport.

University of the West of England motorsport engineering student, **James Appleby**, has been called up for driving duties in a new official Aston Martin Racing junior team, Generation AMR, which is to compete in the 2011 GT4 European Cup.

James Appleby

LAT

Bernie Ecclestone has recruited **David Campbell**, once the boss of famous London venue, the O2 Arena, to work for his Geneva-based Allsport Management company – the organisation that runs Formula 1's Paddock Club corporate hospitality set up.

Group Lotus, which has recently made much of its intention to use motorsport to help market its range of road cars, has appointed former BMW executive, **Karl-Heinz Kalbfell**, to a position in which he is to 'support and advise' chief executive officer, **Dany Bahar**. Meanwhile, the Sportscar maker has also appointed **Guillaume Chabin**, who in the past has worked at Ferrari and Bentley, to the post of director of sales.

■ 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

TOM WALKINSHAW

OBITUARY

CONTINUED

previously 'moving chicane' estate cars to the forefront of the BTCC.

After its success with the XJS, winning the European title in 1984, TWR was asked to run Jaguar Prototypes in Sportscars, and the iconic Group C Jags went on to win three world titles and the Le Mans 24 Hours twice, in 1988 and 1990.

> **"he showed himself to be a shrewd hand at hiring people"**

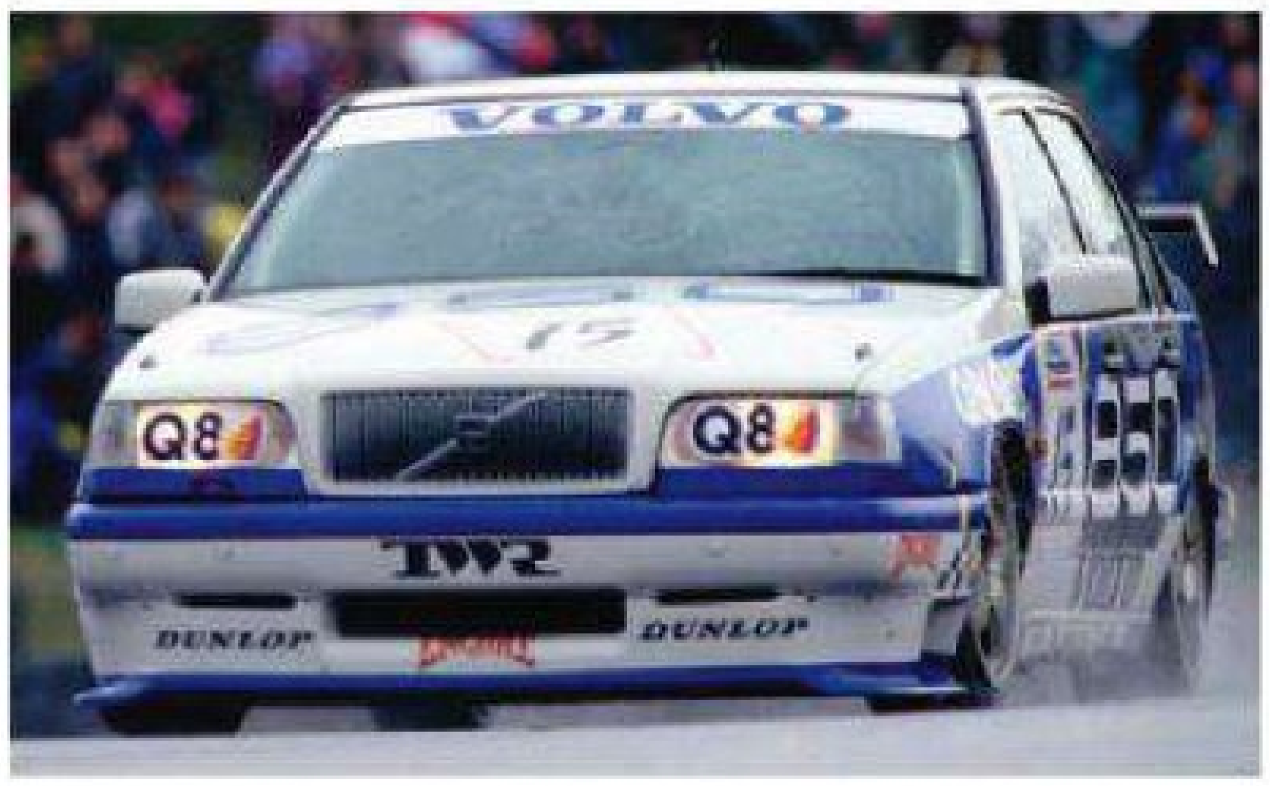
By now, Walkinshaw had hung up his helmet to concentrate on his businesses and race team management, and it was during this spell that he also showed himself to be a shrewd hand at hiring people, snapping up the then little known Ross Brawn from Arrows to design his Jaguars. And it was Brawn who was responsible for the phenomenal XJR-14.

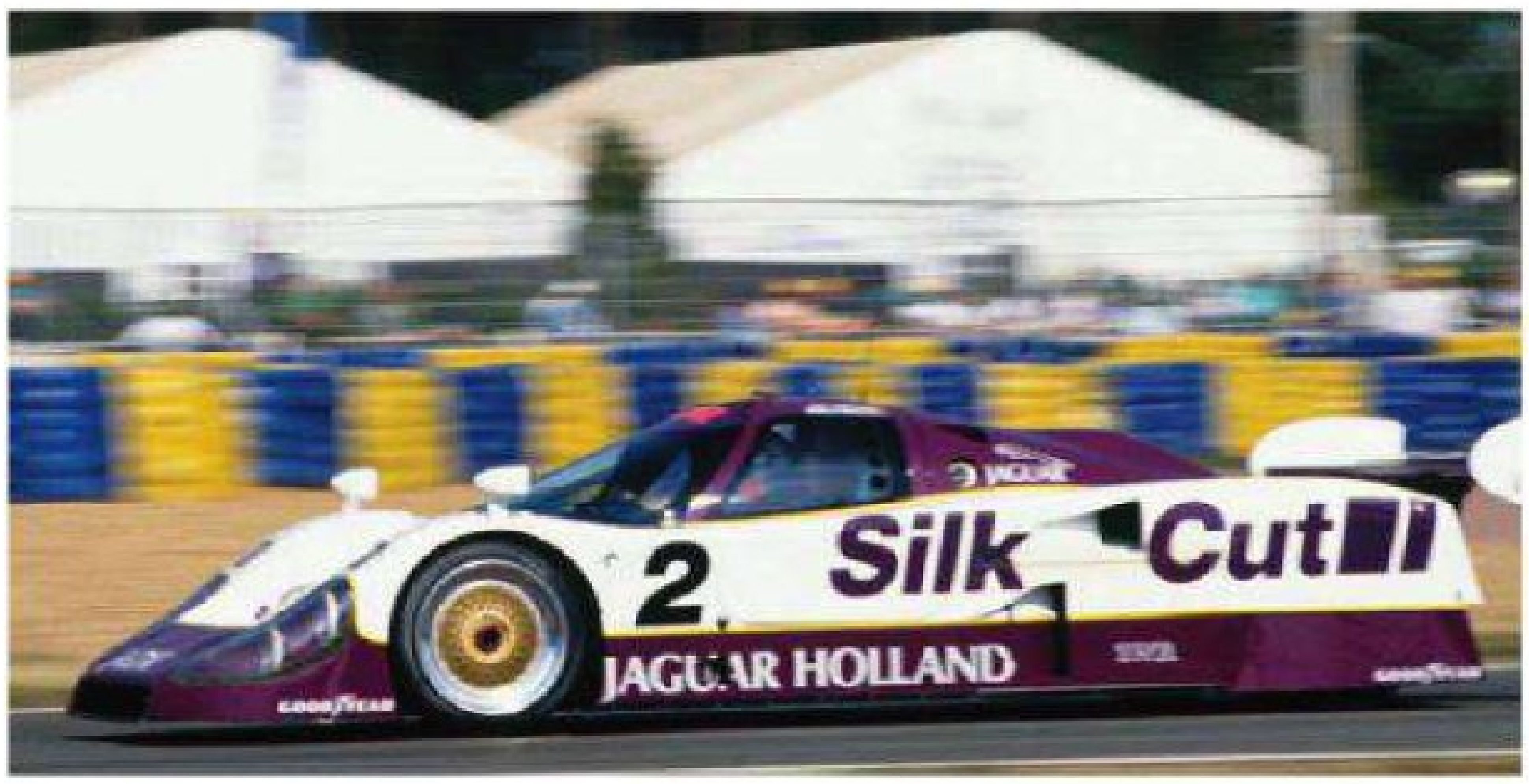
Talent spotting was a gift Walkinshaw then took to F1, when the pinnacle of the sport beckoned, and he was instrumental in getting Michael Schumacher into the Benetton at the end of 1991. Walkinshaw had arrived at Benetton as the team's 'engineering director' that same year, taking a big stake in the outfit before he moved to briefly head Ligier, finally taking that extra step to become a team owner in his own right at the end of 1996. The Arrows adventure promised much, but ultimately delivered little, although the decision to run the cars on Bridgestone tyres in 1997 - the first team to make the switch - nearly resulted in a shock win at the Hungarian Grand Prix that year. In the end, the team folded in 2002 and, with it, the entire TWR house of cards came tumbling down.

Walkinshaw was a controversial character, to say the least, and his competitive streak was such that he would push the regulations to the very limit in search of an advantage, while his business dealings could also be uncompromising. Whatever else Tom Walkinshaw might have been, he remained first and foremost a *racer*.

Tom Walkinshaw 1946-2010

Few believed the big Volvo 850s would be competitive when they first took to the BTCC grids in estate form in 1994, but their subsequent success in TWR's hands did more to improve the Swedish marque's image than anything before or since





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It was for the two times Le Mans-winning XJR Jags,though, that TWR will best be remembered

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LATE APEX

And the winners are...

It's that in-between time of the motorsport year when the action shifts away from the track for a brief spell before the new season's battles begin, and filling that gap are numerous gala prize dinners and awards ceremonies. It therefore seemed timely to nominate my personal winners in a group of categories entirely appropriate to *Racecar Engineering*. I should add that there has not been any assessment, nomination or voting process related to these awards, and the recipients will not be receiving any engraved hardware for their trophy cases – these are purely and simply the editor's personal choices. So without further ado, the categories and winners are:

● Rally Car of the Year
This is a bit of a misnomer, as this particular car can quite correctly be called the rally car of the decade, and probably deserves a place in the rally car hall of fame – if there was one. It established itself as a winner as soon as it was introduced, for the 2007 WRC season, and secured the Drivers' Championship that year, and for the next three years, as well as the Manufacturers' titles in 2008, 2009 and 2010. If new WRC technical regulations hadn't forced it into early retirement at the end of this season, it would probably have gone on winning. It is, of course, the Citroën C4 WRC.

● Racecar of the Year
The recipient here is another car that also dominated its branch of the sport in 2011, taking 15 pole positions, nine victories – it could have won more – a further 11 podium placings and six fastest laps in the course of 19 races. In the process, the Renault-powered Red Bull Racing RB6 delivered Austrian energy drink magnate, Dietrich Mateschitz, his first FIA Formula One World Constructors' and Drivers' Championships.

Designer of the Year
With such a dominant performance from the car in 2010, it follows that the man behind the Red Bull Racing RB6, Adrian Newey, receives our vote for this award. He has been a major contributing factor to F1 Constructors' Championships won by three different teams over the last 20 years – Williams, McLaren and now Red Bull – and, to my mind, is one of a very select group of designers who have proven they have an innate ability to get to grips quickly with new technical regulations and maximise the performance possibilities.

● Technical Innovation of the Year
In a Formula 1 season that had its share of technical interest, with the likes of blown diffusers, flexible wings and floors all hot topics at various points of the year, our vote goes to the f-duct, as introduced by McLaren, but copied by others during the season. The system allows a driver to manually alter the flow of air over the rear wing flap, causing it to stall. This leads to a worsening of the lift / drag ratio, but also to a significant drop in the coefficient of lift, resulting in a net reduction in drag and an increase in vehicle speed. It was clearly a clever idea, as it's been banned for next season.

> "it was clearly a clever idea, as it's been banned for next season"

Now it's on to the 2011 season, and what is certain to be another fascinating year for technical innovation and development. And that's the great thing about motorsport – it never stands still.

EDITOR
Graham Jones