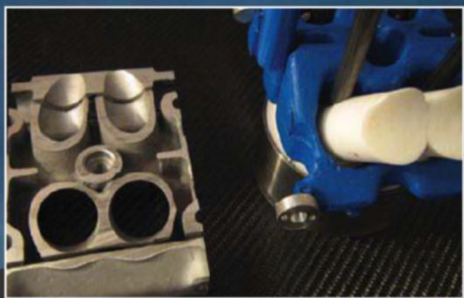
Leading-Edge Motorsport Technology Since 1990

Racecar engineering™

June 2013 • Vol23 No6 • www.racecar-engineering.com • UK £5.50 • US $13.50

Pikes Peak monster

875bhp for Peugeot's 208 T16



Audi R18 TDI
Exhaust flow management key to Le Mans success

Engine study
We dissect an Arrows V10 cylinder head

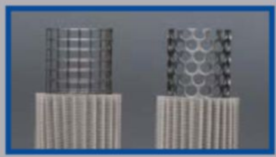
Lotus LMP2
Formula 1 meets Le Mans as new design makes debut

06

Xtraordinary All-Fluid Filters

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

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



Standard Core vs. High Pressure Core

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

71 SERIES MULTI-STACK - FAILSAFE STAGED FILTRATION

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

Stack and Stage
for Maximum Protection
On Race Day

SPACE SAVER SERIES - OUR MOST COMPACT FILTERS

3 Body Styles - 7 Choices of Screens

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

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

INTRODUCING THE NEW 70 SERIES

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

70 SERIES Pleated Stainless Steel or Cellulose Elements

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

XRP®

THE XTREME IN RACECAR PLUMBING

UNITED STATES XRP, Inc. sales@xrp.com tel 562 861 4765 fax 562 861 5503
EUROPE JLS Motorsport motorsport@lister.co.uk tel 44 (0) 121 525 5800 fax 44 (0) 121 525 4833

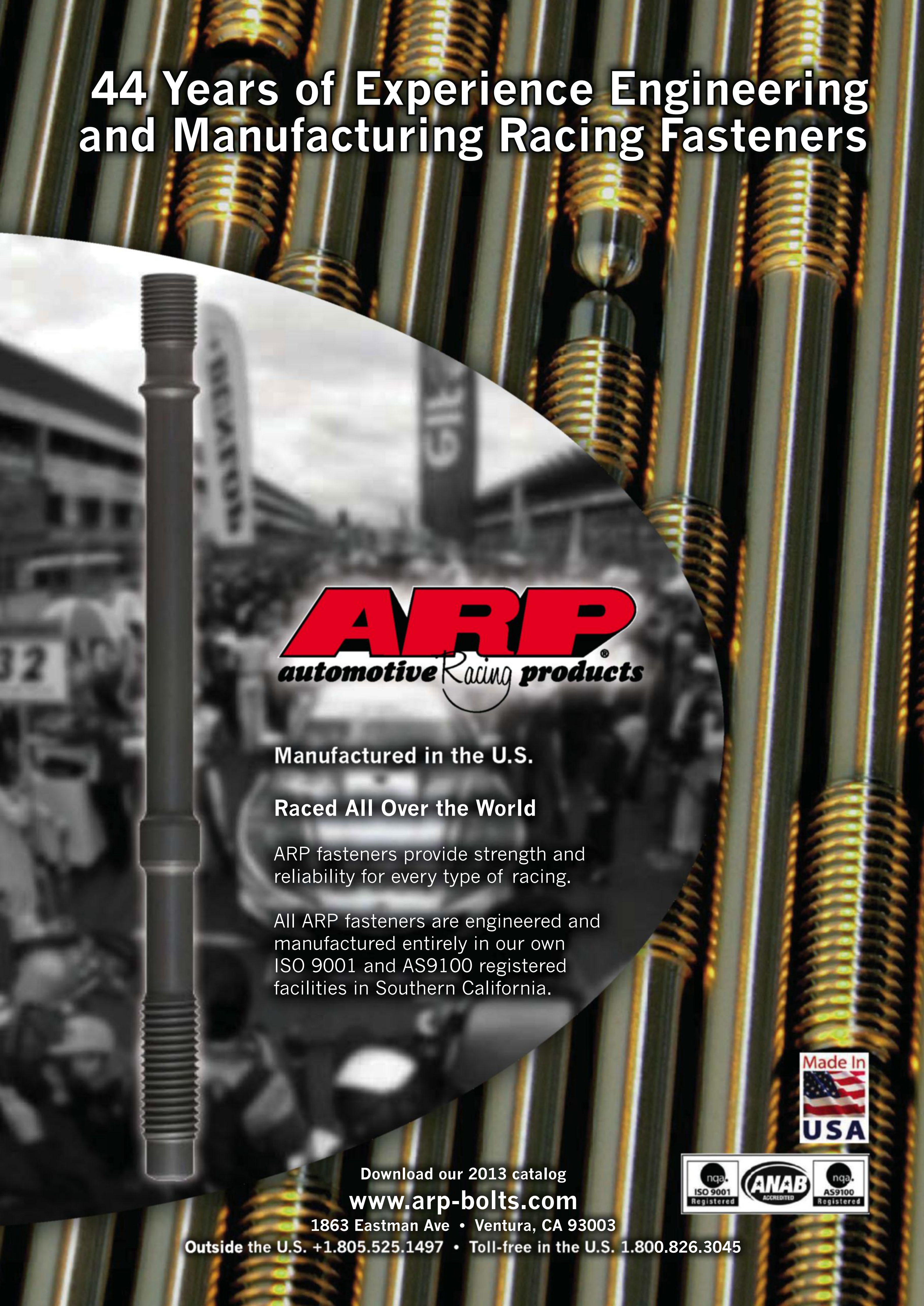
COVER STORY

COLUMNS

FEATURES

TECHNICAL

BUSINESS NEWS


44 Years of Experience Engineering
and Manufacturing Racing Fasteners
ARP
automotive Racing products
Manufactured in the U.S.
Raced All Over the World
ARP fasteners provide strength and reliability for every type of racing.
All ARP fasteners are engineered and manufactured entirely in our own ISO 9001 and AS9100 registered facilities in Southern California.
Made In USA
nqa. ISO 9001 Registered
ANAB ACCREDITED
nqa. AS9100 Registered
Download our 2013 catalog
www.arp-bolts.com
1863 Eastman Ave • Ventura, CA 93003
Outside the U.S. +1.805.525.1497 • Toll-free in the U.S. 1.800.826.3045

Byte-sized motorsport

Data has come a long way in recent times. If only programming had too...

From the multi-discipline Cambrian explosion of different car designs at the start of motor racing, things settled down in the 1920s, and it seemed that we had would continue keeping the old ways, artisans (*garagistes*) toiling away but with a fixed paradigm of cars. The DOHC four cylinder Peugeot engine taken to Indianapolis in 1912 was the base parameter for racing engines for decades afterwards. Granted, there was a world war and a world depression, a period where the only evolution came from major manufacturers being used to flex nationalistic muscles or technical breakthroughs trickling down from aviation, bridled by limited finance and a tradition of handicapping derived from horse racing via Brooklands. A pastoral scene, which would have made you worry about the threat of Morris dancing in the paddock if the information technology revolution hadn't arrived.

From Vaucanson's first automata, the most notable being the Digesting Duck, to Jacquard and his descendants, Ada Lovelace and Babbage to today has been a long trip, the urgency of war prompting the first electric computers to realise Alan Turing's vision of a Universal Machine.

The programming used within that primitive, 5kb universe – less memory than is allocated to displaying a single icon on a computer screen today – broke the distinction between numbers that mean things and numbers that do things. Since then, computers have been in an Alice in Wonderland mode, growing on the inside and shrinking on the outside. Neumann and Shannon expanded the operation principles and hardware into a redoubtable tool.

Professor Eberan-Eberhorst helped to develop a special on-board recording instrument that plotted parameters such as car speed, engine speed, shifting and breaking points. These techniques were not used again until the 1960s by Chaparral and Ford, engine manufacturers that brought computers to racing in Europe.

The first computer I used at university filled a whole room, and my allotted time was 15 minutes a week, presenting my programs on a Hollerith punched card for input of program and data, direct descendant of the Jacquard loom card. The myriad vacuum valves were a welcome heating source in winter night runs, although we didn't have as many as the celebrated 1946 ENIAC – the first fully Turing-complete computer that used 17,468 vacuum tubes and consumed 150kw of power. It had a speed of one thousand times that of electro-mechanical machines, which was unmatched by mechanical computers.

Alan Turing, indirectly responsible for any PC problem you're having today

Punch it wrong, have a hanging 'goto' or have an infinite loop in it, and it meant waiting till the following week. This encouraged tight programming, clean flowcharts and a maniacal dedication to machine code, akin to religion. Parsimony with commands reached a Scots level, which made for elegant programming, something absent from today's bloatware. Architects draw detailed plans before a brick is laid or a nail is hammered. Programmers and software engineers often don't. Can this be why houses seldom collapse and programs often crash?

The ability of today's computers to do something due to its enormous capabilities does not mean you have to resort to crude Frankensteinian monster patched programming. Leonardo Pisano Bigollo – aka Fibonacci – responsible for bringing the Hindu–Arabic numeral system in Europe through the publication in 1202 of his Liber Abaci, is probably spinning in his grave at high RPMs, having rid Europe of having to do calculations in Roman numbers, only to have all that work undone through sloppy programming. Never mind, rant over.

My first F1 car was partly designed on a computer, a HP-9825, with a mammoth 24kb of RAM, with the 12kb expansion pack, a 16 character LED readout, and the programs were stored on several cassettes, 'chained' for running. On it I could calculate a 3D geometry program in roughly nine minutes. I had to write my own programmes, as it didn't come with any, and there were no programmes to be bought.

With its accompanying daisy wheel printer and A4-sized mechanical plotter it cost £23,000, or roughly the price of a new, fully equipped Mercedes Benz SLC roadster. Today you can buy something several orders of magnitude more powerful for the equivalent of 60 packs of cigarettes or 180 cups of espresso coffee – in my case one month's consumption. You can even buy dedicated motorsports programs, which together with CAD, stress analysis, CFD and FEA programs can be run concurrently with MP3 and MPEG files so you can multitask to the sound of Boccherini, Led Zep or Billie Holiday.

My first F1 car was partly designed on a computer with a mammoth 24kb of RAM

The first time I was working with CFD, Nissan's Technical Centre had a liquid-cooled Cray-2 capable of 1.9 GFLOPS. With four central processors and 256 million 64-bit words of random access memory, a clock period – the time needed for one computational cycle – of 4.1 nanoseconds to do the calcs, and a Hitachi S800 for post-processing. Put an aerofoil profile in it at 6pm and it would chug along Navier-Stokering it till the next day, rendering voxel by voxel. But first you had to hand-mesh the grid in 3D, which would take considerably more time.

In 1992 Benetton was a pioneer user of CFD in F1, using FLUENT to analyse a front wing, for example, with a mesh of 100,000. Today 1 billion cell meshes or more are possible. Sauber's custom-built Albert2 supercomputer, with 512 Intel Xeon 5160 dual core processors, was able to do 12,288,000,000,000 calculations per second. Given Moore's law, it will accelerate as Chronos doles out time on the hardware side, and the FIA limitation of CFD in F1 will do the same for the software.

It is much better to be uninformed than ill-informed as Keith Duckworth said, so all this morass of data is only pertinent if the calibration and range of sensors are correct.

With the amount of hype around Big Data it's easy to forget that we're just in the first inning. More than three exabytes of new data are created each day, and market research firm IDC estimates that 1,200 exabytes of data will be generated this year alone.

I expect the world will end not with a sigh or a whimper, but with an algorithm, but before that I expect to participate in the WTC, World (Alan) Turing Car Championship.

Hierachy malarkey

Why are today's team management structures such a confusing mess?

Not so long ago a typical top management structure in a team constructing its own racing cars would consist of team owner/managing director, team manager, engineering director, chief designer, financial director – and not much more. Alongside would be someone charged with the complicated business of manufacturing the racecars – mostly known as manufacturing or production manager – and a person or agency whose task was raising the money. Those named as directors by the shareholders of the company – sometimes one and the same – had the prime responsibility of running the business in a proper fashion and according to the objectives of the shareholders.

So a nice, tight and manageable team with clear briefs concerning their responsibilities and reporting route.

Technology – primarily the advent of the microchip and enormous accessible computing power – together with budgets, has moved on apace, and now there are many necessary functions within motorsport companies that did not exist previously. The whole enterprise of designing, building, developing and racing of cars has expanded enormously in complexity. This has, I'm sure, introduced new challenges in formulating management structures. However, I do not believe that it justifies the proliferation of new titles that have crept into being.

The point of being given a title is surely to make clear the responsibilities and roles with which the individual has been charged. Chief designer is a good example – this is the person in charge of the design of the car. He or she may not actually draw much or indeed any of it, but they are where the design lead comes from. Clear and straightforward, yes? However, hedge it around with other people holding titles such as senior vehicle engineer, head of vehicle dynamics and the like, and it begins to get a little hazy. Similarly with technical director and director of development within the same organisation – who has the real authority here? What does sporting director imply, viewed alongside team manager and chief operating officer? An intriguing new one is performance engineer. A general assumption would be that all engineers worth their salt in the motorsport environment are always seeking performance and are motivated to do so – why then the need to invent this title and role? What does it mean and how are colleagues, staff and others supposed to understand where this individual and their work really fits in?

Proliferation of job titles can lead to a convoluted chain of command

The title of director in particular seems to be dished out liberally these days. Reasons for this vary, but typically it is to confer status upon somebody that the company doesn't want to lose, or to assist in recruiting someone whom it wishes to gain. But this devalues the position of director and goes against the principle of tight senior management, and can create a structure that is too hierarchical. Being a 'proper' director carries with it certain legal implications as well as responsibility to the shareholders. A major part of the job is to attend the regular board meetings in which the state of the company financially and operationally is assessed and discussed and relevant decisions made. In some examples I have come across, if all those individuals named as a director followed this long-established model, the organisations concerned must have very lengthy board meetings.

Common business wisdom is that horizontal rather than vertical structures are more efficient, keeping layers of management to the minimum and among other benefits reducing response times and promoting quicker decision-making and implementation. The larger the operation and the wider the areas of activity essential to the operation of the business, the harder this becomes. So it is essential to identify the really key roles that require representation at board (director) level and keep these to a manageable number. Delegation to them is essential while keeping a close eye on empire-building – the term director can easily encourage this. Whoever is in ultimate charge of the whole operation can only cope with a certain number of direct reports, and must leave time and energy free for forward thinking and planning. Some 'blue-sky' investigation and evaluation is a very good thing for someone at the helm of any enterprise, even if only to see the potential grey storm clouds lying ahead.

With a technical director and director of development in the same team, who has authority?

I am a firm believer in job titles that describe the responsibility and function of the position accurately. Titles that are not a true reflection of the role and responsibility of the holder risk creating confusion within the organisation and also outside with technical and business partners as well as the media. Therefore 'head of' or 'chief' are perfectly adequate titles for describing those who have the responsibility and capability of leading a department, but are not board members. By the nature of the job, these senior people attend frequent management meetings, which may or may not have any directors present. This is where, as well as ensuring good communication and understanding between them, decisions get made that do not directly affect the overall company strategy, although they may be very important to the company's success. Therefore a summary of the meeting, together with the outcomes, will generally be fed up to the relevant directors, keeping them well-informed.

Are so many positions necessary? Could they lead to some vagueness around the edges which allows vital actions to fall between them? An excess of individual inputs may lead to a committee culture, creating the opposite of the tight and manageable team of people with clear briefs previously mentioned. I can think of one current F1 machine that has at least some of the hallmarks of being a 'committee car', where the key elements of efficient and useable race performance appear to have been subjugated to the desire to be seen, for whatever reason, to be aggressive in its design philosophy.

Pug gets BULLISH

The French marque has gone all-out in its effort to win the Pikes Peak challenge

BY ANDREW COTTON

It has been 18 months since Peugeot pulled the plug on its sportscar programme, but since then the engineers at Velizy, Paris, have been hard at work developing rally cars for customers, including the R2 and the R5 208, but in September last year the button was pushed on the ultimate rally challenge, the Pikes Peak hill climb, held in Colorado.

For many months there were rumours that Peugeot would return to Le Mans with an experimental Garage 56 car, probably using the air hybrid system that the company unveiled at the Geneva Motorshow earlier this year. However, that rumour was firmly quashed by Peugeot Sport, probably because the team already had its rally programme sorted and the Pikes Peak hillclimb is a headline event.

The draw was obvious – with a short lead time the 'unlimited' class at Pikes Peak offered Peugeot's engineers the opportunity to run wild, and more importantly, raid the parts bin from previous high-profile racing programmes, principally that from Le Mans.

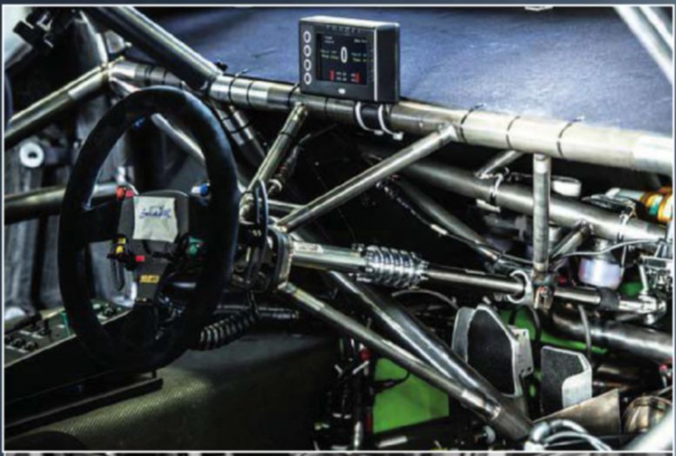
Peugeot has a rich history at Pikes Peak – Ari Vatanen's drive up the hill in 1988 in the 405 T16 has more than 2 million views on YouTube, and remains one of the iconic motorsport videos. This year, Peugeot has the opportunity to repeat history with another legend of the rallying world, Sebastien Loeb.

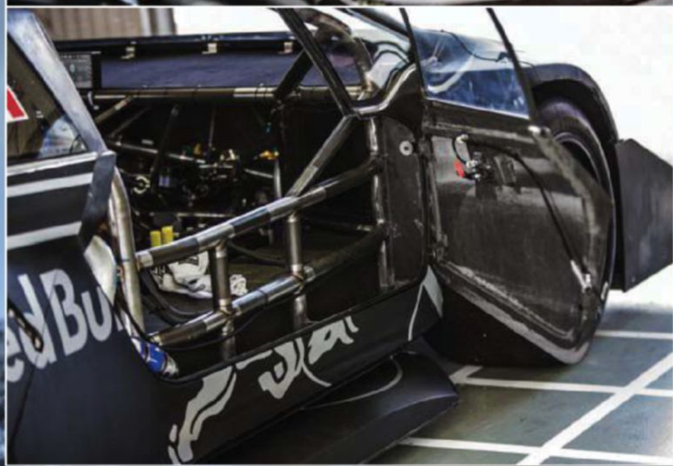
LIMITED REGULATION

The safety regulations are set in stone, and cannot be altered for anyone, even if your Indycar already has a roll hoop, as French driver Romain Dumas discovered when scrutineers insisted that there was a roll cage around the cockpit. However, for the unlimited class, the rule book is pretty free. For example, wings that are installed must be no wider than the outside edge of the tyres front or rear when the tyres are pointed straight ahead, the front or rear wing cannot extend more than 12 inches beyond the body, and the rear wing can be no higher than 18 inches above the cab.

'Your imagination is the limit when you set out to design a car for Pikes Peak,' says Jean Christophe Pallier, the Peugeot Sport engineer tasked with the development of the 208 T16 Pikes Peak car. 'Designing this car was a tremendously rewarding experience, even though we still had to take the time factor into account.'

The new 208 T16 features carbon bodywork on a tubular steel frame. Torsion bar front suspension and the 2m-wide rear wing are carried over from the original 908 Le Mans car - as the Pikes Peak course is now fully paved, cars are now able to run racing tech in place of rally variants. Speeds reached during the ascension should range from around 31-150mph, the latter being the T16's top speed. It can go from 0-150mph in seven seconds





Peugeot has also paid close attention to weight, achieving a 1:1 balance of power to weight with the engine sat in the middle of the chassis, like the Group B rally cars of the 1980s.

The 208 T16 Pikes Peak effectively shares its genes with those of the Le Mans 24 hours-winning 908 in several areas. Last year's Pikes Peak took place for the first time on an entirely asphalted course, so the machine conceived by Peugeot Sport is practically an out-and-out endurance racing prototype. The 208 T16 programme is Le Mans-meets-hillclimbing.

DEVELOPMENT PROGRAMME

With the button pushed late to prepare the car for the 2013 event, time was short, and so decisions needed to be taken in a hurry in order to hit the track at Peugeot's test facility at Mortefontaine early in 2013. The first of these was to decide the drivetrain, and the team opted for a Peugeot ES9 J4S 3.2 litre V6 twin turbo that ran in the Pescarolo-run C60 at Le Mans in 2003. Breathing through two 30.7mm air restrictors, the power for the Le Mans car was limited to 510bhp. In the Pikes Peak car, unrestricted, power is 875bhp, delivering 1bhp/kg in the lightweight car.

"With a normally aspirated engine, you lose 1% of available power every 100m you climb"

'We did consider using a diesel engine from the 908, but time was just too short,' said Pallier. 'It was the first intention to do this, but for the reasons of weight and dimensions, it was not possible.'

The hybrid system from the 908 was also planned, and the team reckoned that it would be a worthwhile addition, but there was neither the time, nor the spare parts, to put one together, despite the fact that Peugeot Sport builds its own batteries. 'It is a good idea,' admits Pallier.

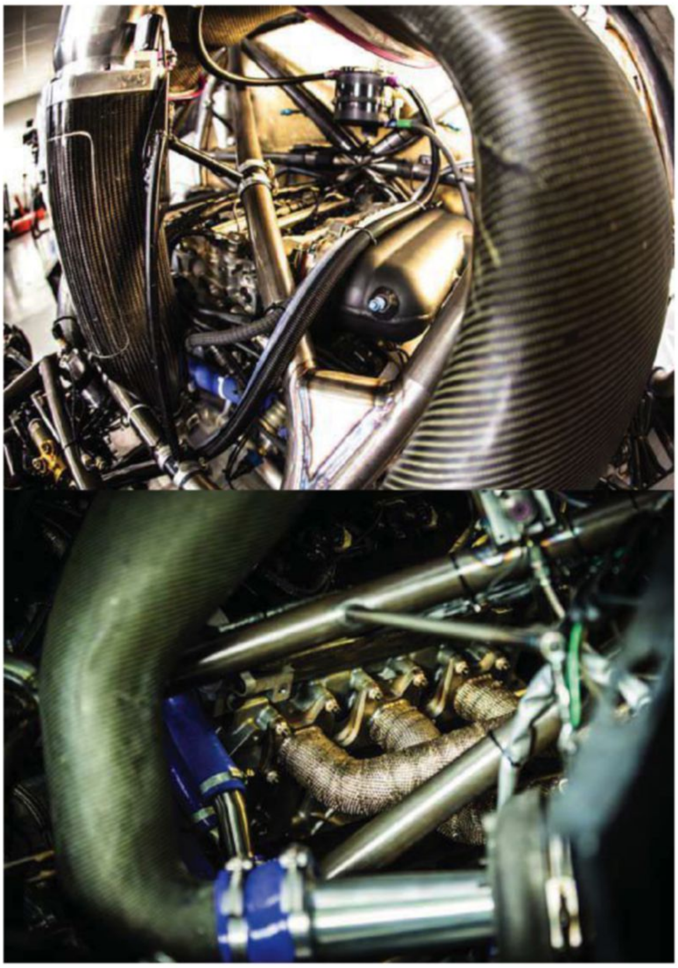
In unrestricted form, the car can shift from 0-100km/h in 1.8s, takes 4.8s to reach 200km/h and seven seconds to hit 150mph, its claimed maximum speed. Turbo manufacturer Garrett developed new turbos to work with the engine at low speeds, although the engine does rev to 7800rpm.

The hill climb presents a unique technical challenge, requiring teams to ensure that the engines are able to breathe at high altitudes. This is why the electric cars are so competitive – their power delivery is unaffected by the atmospheric pressure, and they are actually as fast at the top of the hill as at the bottom. Pallier reckons on a loss of around 15 per cent of power at the top of the hill compared to the bottom.

'In the case of a normally aspirated engine, you basically lose one per cent of the available power every 100m that you climb,' says Peugeot's sport director Bruno Famin. The race starts at 2865m above sea level and rises to 4301m, a rise of 1500m.

While the brakes, air intake to the engine, and running gear were taken from the 908, the gearbox was entirely new for the car, the team moving away from the Xtrac used at Le Mans a decade ago, due to the need for it to cope with four-wheel drive, and the power output of the car. It is a longitudinally mounted six-speed gearbox, with paddle shift mechanism.

Next on the tick box list was deciding on the chassis, and the team again had to make



Compared to the 510bhp that the restricted ES9 J4S V6 twin turbo achieved at Le Mans in 2003, the unrestricted version being prepared for Pikes Peak will be hitting 875bhp, delivering 1bhp/kg

snap decisions based on time, rather than performance. Due to packaging issues, the R5 chassis couldn't be used, and there was no time to put together a carbon tub. Instead, Peugeot welded a tube frame chassis together and built composite bodywork around it.

That bodywork was developed in CFD and, again due to the shortage of time, the car did not run in a wind tunnel. The team had to map out the course of Pikes Peak, and sent out a recce team, but they were thwarted near the top of the hill as it was covered in snow. The team will therefore see the hill for the first time at the beginning of June and has a mammoth test programme planned for the month leading up to the competition.

Carried over from the 908 Le Mans car is the 2m wide rear wing from the original 908, which sits high above the roofline of the car, and the torsion bar front suspension. The team has taken full advantage of the fact that the entire course is now paved to be able to run racing technology in place of rally variants. Downforce of the car is similar to the Le Mans car, a target set and achieved by the team.

'We used the experience that we had in prototypes to run the CFD simulation,' said Pallier. 'There is a team of aerodynamicists here and we set them the target of achieving prototype levels of downforce in Le Mans configuration.

'The speeds reached during the ascension range from 50 to 240kph, and aerodynamics play a key role from 100kph. Although hidden, the design of the car's under-tray is responsible for generating almost half the car's downforce.

While much of the car relies on the LMP experience gained between 2007 and 2012, there is some far-reaching future technology on the car, and that is primarily around the tyres. Audi has entered a fourth car at the Le Mans test weekend to gain experience with the Michelin tyres, and has a new bodykit designed to generate the anticipated levels of downforce. Peugeot, with its Pikes Peak levels of downforce, will also run the wheels and tyres that will be on the Le Mans cars in 2014.

'There was a discussion about the wheels in general and by Michelin for next year,' says Pallier. 'The tyres are for LMP1 and Michelin has developed a specific compound for the race. Also, with the four-wheel-drive we needed the same size fronts as for the rears, so that's why we did our own wheels.'

With the aero, drivetrain and rubber all sorted, the final decision concerned the driver. Porsche factory driver Romain Dumas was originally tasked with the job of piloting Peugeot's monster up the hill, but then Red Bull became involved, and the decision was taken to put nine-time World Rally Champion Sebastien Loeb behind the wheel instead. 'We couldn't ask for a better driver,' says Pallier.

'Since I was young I saw the video of Pikes Peak with Ari Vatanen, so it was in my head to do it, with a nice project,' says Loeb. 'This year, I had the chance to do it with Peugeot. We have Red Bull as a main partner, which is my main partner. It is a professional team, and I am convinced that it will be a good car. Testing has only just started, and my first contact with the car was used to adapt my position, work on the shifting. It was just to see if everything is OK, test the steering. I need to learn the track and the car, and I don't know how long that will take. I have to learn it by track – a car like this, the corners will arrive very quickly. I think it will be good.'

"We set the target of achieving prototype levels of downforce in Le Mans configuration"

The test programme in Paris concerns setting the car up so that it is a comfortable drive for Loeb, but there is a huge development programme planned for the month of June, when the true cooling and atmospheric conditions will become apparent. The team will travel to Colorado at the beginning of June. The race is scheduled to take place on 30 June.

TECH SPEC

Peugeot 208 T16

Engine
Type: V6 bi-turbo
Cubic capacity: 3.2 litres
Number of valves: 24
Position: mid-rear
Number of cylinders: V6 (60-degree)
Maximum power: 875hp
Torque: 90mkg
Maximum revs: 7800rpm
Top speed: 240kph/150mph
0-100kph/0-62mph: 1.8s
0-200kph/125mph: 4.8s
0-240kph/150mph: 7.0s

Transmission
Type: four-wheel drive
Gearbox: longitudinally-mounted six-speed sequential gearbox with steering wheel-mounted paddle-shift

Chassis
Frame: tubular steel
Bodywork: carbon

Suspension/brakes/steering
Suspension: double wishbones and pushrod/rocker arm actuation at all corners
Springs: torsion bars
Dampers: pressurised dampers
Anti-roll bars: front and rear
Steering: hydraulic power steering
Brakes: hydraulic double circuit brake system with one-piece light alloy calipers
Brake discs: vented carbon discs front and rear
Diameter (front): 380mm
Diameter (rear): 355mm
Wheels: Specific 18x13 magnesium alloy wheels derived from F1 technology
Tyres: Michelin (31/71x18)

Dimensions
Length: 4500mm
Width: 2000mm
Height: 1300mm
Front/rear overhang: 1690mm
Wheelbase: 2695mm
Wing: 2000mm (based on the rear wing of the Peugeot 908)
Fuel tank: 40 litres
Weight: 875kg

The opposition

Peugeot won't have things all to themselves in Colorado, as some extremely stiff competition will also be lining up...

The Unlimited class at Pikes Peak in 2013 will be no walkover. Peugeot Sport will have to take on teams with both good budgets and experience, and on paper the 208 T16 is far from the most potent entry.

Last year second in class was newcomer Cody Loveland with his heavily modified Honda NSX. This year he will be back with an all new car dubbed the Lovefab Enviate. Nominally based on the old NSX, the new car features a twin turbocharged, dry-sumped LS1 engine, a chromoly steel tubular chassis and a carbon fibre body. The only original NSX components are the subframes and suspension – everything else has been replaced by LoveFab-built components.

'In the first week of March, I made the decision to step it up a notch and build a tubular chassis to replace the caged NSX tub,' explains Loveland. 'The 180kg weight reduction will put the car in a competitive power-to-weight zone, which many of the other Unlimited Cars will be running within.'

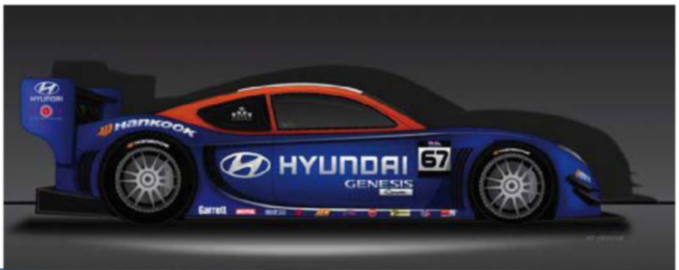
The new car has a bluff front end, is substantially smaller than the NSX and has only a single centrally mounted seat. It also sits much lower than the Honda lowering the centre of gravity. 'One of the other issues was that in 2012 the NSX had a lot of aero and with it a lot of drag, as we did not have the torque we expected it did not perform,' says Loveland. 'This year we are going to re-do things a bit – we have shortened the overall length by about 4 feet, the front end of the car is drastically different and with what we have designed, the airflow around the car should be a lot more predictable compared to running a large front wing.'

The engine selection was a key aspect of the new car and Loveland decided to replace his Honda engine with a big American V8 shortly after the 2012 event. 'One of the biggest complaints I had with the car last year was that it did not have enough response at altitude,' says Loveland. 'Down at sea level it was great, but high up it just wasn't there. So we have taken a six-litre Chevy LS1 V8, fitted a Kent Racing dry sump system and a pair of Garrett turbochargers and I think we will have a very potent car. Even with a stock LS1 we are expecting to have 700bhp, but we will build a spare motor for raceday and really turn it up and aim for near 1,000bhp. Our goal is to fall somewhere in the 1100Nm torque range, while still tipping the scales at around 900kg. With the low weight the car has and the torque it will have, I think it will be pretty lethal. To the opposition that is, not to us!'

The Peugeot will also face some opposition from cars that went toe-to-toe with its predecessor – the 405 T16 of 1988. A brace of British Group B Ford RS200's will run, one of which produces over 900bhp. On top of that there is a range of buggy-type specials purpose-built for the the hillclimb, some fitted with engines producing in excess of 1,400bhp.

Red Bull has hedged its bets and has also funded another manufacturers works Pikes Peak car, and this one has the outright course record holder Rhys Millen at the wheel. The Hyundai Genesis Coupe RMR PM580T is a heavily reworked version of the sports prototype that the Kiwi debuted in 2010. The purpose-built tubular steel car is fitted with a 4.1-litre turbocharged Hyundai V6 producing in excess of 900bhp.

The full entry list has yet to be announced, and with Honda announcing that it is entering 10 cars, it is likely that 2013 will be the hardest fought Pikes Peak hill climb in history.



(Main pic) The LoveFab Enviate, heavily modified from the Honda NSX; (above) the Hyundai Genesis Coupe RMR PM580T

"With the low weight the car has and the torque it will have, I think it will be pretty lethal. To the opposition that is, not to us!"


LifeRacing
Professional Electronics for Automotive and Motorsport
INTRODUCING...
..THE NEW F90RX
Designed for 12 cylinder engines with 24 injectors
..THE NEW X10
For CAN expansion of any Life Racing ECU.
10 Inputs, 10 Outputs plus 2 Full Bridge Outputs
..THE NEW F88GDI-4
Perfect control of all 4 cylinder GDI engines
AND THE F90
For advanced engine programmes with extensive I/O needs
LifeRacing
Tel: +44 (0) 1268 274 421
E-mail: info@liferacing.com
6 Repton Close, Basildon, Essex SS13 1LE

New strategy

The debut of Audi's latest R18 turned heads for the team's new thinking on fuel management as much as for the raft of tech and aero updates

BY ANDREW COTTON

The battle for the Le Mans 24 hours, 2013, started at Sebring, the opening round of the American Le Mans Series, where Audi ran one 2012 version of its R18, and one 2013 version. As it turned out, the race was a false dawn – the 2013 car was hardly quicker than the 2012 version and overall there was a lot of head-scratching as to how good it would be this year.

Then Audi arrived at the opening round of the World Endurance Championship at Silverstone with a completely different fuel strategy, found two seconds per lap – estimated to be worth five seconds per lap at Le Mans – and Toyota suspected trick new aero at the rear designed to reduce drag.

The cost of the extra speed was an increase in overall fuel used; the R18 used 21 per cent more fuel to go 1.5 per cent further than last year. Yet despite the extra speed, the R18 managed its tyres considerably better than last season. For all concerned it was an impressive step forward, and was certainly a strategy that few anticipated. That this year's car was faster is to be expected. That the strategy is so different was not.

AERO DEVELOPMENTS

Audi arrived at Sebring with what effectively amounts to a full width rear wing. The extensions on either side of the wing are fashionably labelled as rear wheel arch extensions, similar to those debuted by Toyota last year – the Rebellion team featured similar extensions as designed by Multimatic.

The aerodynamic effect of the extensions allow the engineers to balance the car better than last year, rather than to provide more downforce, although that option is clearly available. The ACO reduced the size of the rear wing in 2009, and stipulated that it had to have a single plane, forcing the teams to compensate by also reducing downforce

"This is an evolutionary car. We're not aiming for more downforce or less drag – we had a successful layout last year"

on the nose. By increasing the potential for downforce at the rear, balancing it out with more downforce at the nose is relatively simple.

'With regular aero development you try to gain efficiency, and that is the key factor,' says Christopher Reinke, overall project leader for the LMP programme. 'This is an evolutionary car. You are not going for more downforce or less drag, because we had quite a successful layout last year. The balance will be in a similar range, so through those parts of the bodywork you can gain the same downforce, but more efficiently. In theory you could reach a higher downforce level, but I can reach the same downforce levels putting the rear wing down.' The team carried over the monocoque, crash structure and headlights, but otherwise pretty much reworked the car from nose to tail.

'Where we feed the air in and where it escapes, it is similar. It is just ongoing development,' said Reinke. Will Audi be able to use the wheel arch extensions at Le Mans? 'I would expect that the efficient tool might be used at Le Mans by us as well.'

AERO EFFICIENCY

At Silverstone, however, the car underwent a significant change, and it is understood that the exhaust gases are channelled through the wheel arches, leading to rumours of a blown rear diffuser.

However, a blown diffuser in the traditional sense of the word is not possible with a turbocharged engine, as the gases emerging from the exhaust would be a little flaccid. What Audi is believed to be doing is playing with the air pressure behind the rear wheel in an effort to reduce drag.

Audi has confirmed that it has switched from a single to a twin exhaust layout, and Toyota says that there is enough mass to be able to change the pressure.

"Last year's hybrid system was purely laid out for Le Mans. With the solution we had, we would harvest only a third of what the rules allow"

Audi is believed to be playing with the air pressure behind the rear wheel to reduce drag (see separate feature).

Interestingly, Toyota also says that it has evaluated this concept and could introduce it to the 2013 version of the TS030. Toyota has experimented with blown diffusers before, notably in the TS010.

The suspension, chassis, dampers and gearbox are direct carry-overs from the 2012 car, but the traction control system is new, and was not optimised for cold tyre running. That partly explained why Allan McNish crashed on cold tyres at Sebring, the only place that the cars run without the aid of tyre warmers.

Audi launched a long-tail version of the R18 and raced it at Spa in May. 'Fielding the Le Mans aero variant on the third vehicle that hasn't been optimised for the lap times at Spa is an important element of preparation,' said Dr Wolfgang Ullrich, the Head of Audi Motorsport

At the opening WEC race of the season at Silverstone in March, Audi ran a new fuel strategy which could be worth five seconds per lap at Le Mans

HYBRID HALF-MEASURES

The principal gain in performance is expected to come from the mechanical flywheel hybrid system. Audi says that it has improved the efficiency of the flywheel system, and explained that it set up the Motor Generator Unit (MGU) for Le Mans in 2012. It has now built in the capability to adapt it to slower circuits, although this wasn't fully exploited at Sebring.

'Last year's hybrid system was purely laid out for Le Mans,' said Joest's technical director Ralf Jüttner. 'You go 330km/h four times a lap, and the MGU was laid out with the ratios and revs to charge the flywheel so that it fits to that speed. With these ratios, we went to the other circuits, where maybe we were at 290 or something, but we never fully charge the flywheel because we never reached the revs for it. There was never a solution prepared, but now we can change the ratios on the MGU and adapt to the drag similar to what you can do with the gearbox. We go to 285 at Sebring and we have a ratio that allows us to close-up to the optimum of charging the flywheel in the braking zones. With the solution that we had here last year, we would harvest maybe only a third of what the rules give us, so this year will be better.'

The issue of braking zones appeared to have the makings of a proper fight between the two manufacturers, but has since fizzled out. Audi claimed that the definition of a braking zone has been cut from 2g/second to 1g/second, which would help Toyota, which, through its super capacitors, can generate the full 500kJ of energy at each braking event. In practice, however, although the regulations stated 2g/1s minimum braking, in practice the 1g/s minimum was applied on the slower circuits as 2g force did not occur often enough on the slower tracks.

One of the improvements in performance comes from the decision as to who would run the

CONNECTING INTELLIGENCE

Interpreting the system requirements of top level motorsport designers takes more than simply applying tried and tested formulae, it takes years of experience and intuitive thinking. Blending this with an unrivalled engineering pedigree helps us produce innovative solutions for customers in F1, endurance and WRC – in fact, every form of motorsport.

Flexible Hose and Fittings

Rigid Lines and Swagetite

Filtration

SERVICES:

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

PRODUCTS:

- **Titeflex smoothbore and convoluted hose products and fittings**
- **Swagetite fittings and hard-line system solutions**
- **Pall Filtration systems**
- **Industria Solenoid valves**

FHS

M O T O R R A C I N G

Maintaining system integrity, saving weight and cutting costs. **Make the connection now.**

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

+44 (0) 1753 513080

FHS Motor Racing Ltd | 656 Ajax Avenue | Slough, Berkshire | SL1 4BG UK Tel: +44 (0)1753 513080
Fax: +44 (0)1753 513099 Email: info@fhsracing.co.uk Web: www.fhsracing.co.uk

Audi has introduced screens to the cockpit linked to a roof-mounted camera to help with forward and rearward visibility

cars in 2013, and the approach to the setup of the cars is completely different according to whether or not it is Audi Sport or Team Joest race engineers who run the cars.

In 2012, Audi remained undecided which was the better option – the lightweight 'ultra' cars, or the hybrid 'quattro' models. At Spa, it seemed that the writing was on the wall as, in the wet, the quattros were significantly faster, but this was not entirely due to the four wheel drive with the hybrid activiated.

'This is a quattro only for a few seconds,' says Jüttner. 'There is a sort of a philosophy that we are a racing team, and the engineers say that we run too stiff. Talk to the drivers, and they say that we need to run stiff. Last year, one of the hybrid cars was engineered by the engineer from Audi Sport, and one from our engineer. The two hybrid cars were more under the Audi Sport control, and the two non-hybrid 'ultra' cars under our control. We had to split it up a bit. I cannot look after four cars.

'We set-up the cars according to how the drivers wanted and from data last year, and the cars were quick. Come the rain, the soft setup from the other cars worked. The quattro helped, but it doesn't make a difference of a few seconds. When it dried out, they were nowhere.'

ENGINE TWEAKS

Audi made few changes to the V6 engine for this year, although refinement is always the name of the game. The ACO reduced the air restrictor size for the 3.7-litre V6 engine in its balance of performance measures announced in January, meaning that the Audi will now run with a 45.1mm restrictor. 'We reduced the diameter of the air restrictor, by something like 10-12KW,' says head of engine technology Ulrich Baretzky. 'It was not necessary, but the ACO believed that it was. We had an increase on the injection pressure up to 2800bar, to improve efficiency and consumption and power. And the rest was working on next year's engine.'

COMING SOON...

The battle for 2014 is also high on the list of priorities of both Audi and Toyota. Both are eagerly awaiting the fuel flow sensor that is at the heart of the FIA regulations, but there is still no decision on who has been awarded the contract. The first incarnations of the Gill ultrasonic sensor were not a success, with a variation of more than 8 per cent and with no temperature control to accommodate fuel at different temperatures.

'If you have a deviation of 0.5 per cent on, say, 2000 litres, that is 50 litres, so you are dead,' says Ulrich Baretzky. 'They are testing it, but not in how you test a car with vibration, dynamic and heat. You have to take that into account. If it is going in the wrong direction you need time to change it. If it goes wrong at Le Mans, how do you explain to the press that this little chip has screwed you?'

Audi has tested its car using a front splitter that does not conform to any regulations, but which develops downforce similar to that expected of the 2014 car and will run it at the Le Mans test day to gather information. 'The tyre partner needs information, grip levels, tyre loads and so on,' says Baretzky. 'You cannot wait until such a car is ready and then start to build tyres. An interim splitter would not be according to any rules, but would give you some information. It produces your wheel loads and aero loads that give you what you expect on the new car already. We are working on that, and there are components which will be used later, but this is nothing special.'

Thomas Laudenbach, former head of drivetrain at Porsche, has been recruited to head up a new department designed to improve the efficiency of the hybrid and storage systems, as well as the internal combustion engine.

'You have to see that with the introduction of the hybrid system you have a new quality of interaction between the combustion engine and the electric motors,' said Baretzky. 'Call it strategy, functions, strategy on how to drive, more power or economic – it is a learning curve that takes a long time. This movement started slowly and went on, and then you see that it is another world. It is something new for a mechanical engineer like me.

'The complexity of the system in the car requires more networking between the systems and how to combine them, and this is a completely new area of development. This is part of the battleground for the next generation of racing cars. The car is becoming more an entity of different systems.

'Before you had a chassis, engine, gearbox, tyres and that was it, roughly. Now you have a hybrid system, energy storage system and one or two computers, they have to make decisions, and you have to enable them. You have to make a lot of simulations or reflections. With every element included, the complexity grows by a factor of 10, and the elements that you can tune is huge. Then you cannot be sure that these systems cover all the possibilities that you have in the car.

'It is good that Laudenbach has a deep understanding of engines to optimise or create the best possible interaction between the electric motors and the combustion engine.

'He is in a completely new department that he is building up. It is a link between engine, hybrid and energy storage systems, to make them work in a perfect way. His job is to optimise the electronic and hybrid side. The more he can contribute to the performance of the car, the better.

'If you look at Toyota and the progress that they made in the last 12 months, we are far behind and that is visible.'

TECH SPEC

Model Audi R18 e-tron quattro (2013)

Vehicle type: Le Mans Prototype (LMP1)
Monocoque: carbon fibre composite with aluminum honeycomb, tested according to the strict FIA crash and safety standards
Battery: lithium ion

Engine:
Type: turbocharged 120deg V6, four valves per cylinder, DOHC, one Garrett turbocharger, mandatory intake air restrictor of 1x45.1mm diameter and turbo boost pressure limited to 2.8 bar absolute, diesel direct injection TDI, fully stressed aluminum cylinder block
Engine management: Bosch MS24
Engine lubrication: dry sump, Castrol
Cubic capacity: 3,700cc
Power: over 360kW (490hp)
Torque: over 850Nm

Hybrid system: electric flywheel accumulator, max 500kJ, WHP motor generator unit (MGU) on the front axle, water cooled with integrated power electronics, over 2x80kW

Drivetrain/transmission
Transmission type: rear wheel drive, traction control (ASR), four-wheel drive e-tron quattro from 120km/h
Clutch: carbon clutch
Gearbox: sequential electrically activated six-speed racing gearbox
Differential: limited-slip rear differential
Gearbox housing: carbon fibre composite with titanium inserts
Driveshafts: constant velocity sliding tripod universal joints

Suspension/steering/brakes:
Steering: electrical assisted rack and pinion steering
Suspension: front and rear double wishbone independent suspension, front pushrod system and rear pullrod system with adjustable dampers
Brakes: hydraulic dual circuit brake system, monobloc light alloy brake calipers, ventilated carbon disc brakes front and rear, infinitely manually adjustable front and rear brake balance
Wheels: OZ magnesium forged
Tyres: Michelin radial
Front: 360/710-18
Rear: 370/710-18

Weight/dimensions:
Length: 4650mm
Width: 2000mm
Height: 1030mm
Minimum weight: 915kg
Fuel tank capacity: 58 litres

With the improved power from the hybrid system and the improvements to the engine, it was inconceivable that the R18 would lap slower than last year, and so it proved. At Silverstone, the cars were up to two seconds per lap quicker, but used significantly more fuel, nearly 21 per cent more to go 1.5 per cent further over the course of the race.

There was clearly an increase in fuel consumption, admitted Baretzky after the race, but 'we had higher fuel consumption, but for a number of reasons, and one of them is speed,' he said. One of these is the increase in minimum weight to 915kg this year.

LAT

For Toyota, the increase in fuel consumption is a mystery and Pascal Vasselon went on record to say that it was like 'blowing it into the air'.

GOOD WEAR

What was really encouraging for Audi was its tyre management. At Silverstone, the cars were easily able to run double stints on the 2012-spec Michelin tyres, which it ran throughout the six hours, while Toyota struggled to do so and only really worked on the 2013 car. Even in 2012, Audi was only just able to run double stints on these same tyres. This year, the wear was so good that the team considered attempting a third stint in race conditions.

Michelin has worked with both Toyota and Audi to develop a tyre that can cope with the cold conditions at Le Mans, meaning that – should the race run without safety cars – the pace at night should be higher. With the 2012 tyres being run so comfortably, the 2013-spec tyres should be a step forward.

'It was not the latest development spec, because we tested so much that it became impossible for Michelin to produce in numbers,' said Jüttner of the decision to run 2012 tyres at Silverstone. 'The weather is different, the ambient and track temperatures are not too different to last year, but yes, it was encouraging.'

At time of writing, the Audi has yet to be seen against the 2013 Toyota TS030.

BLOCKED AIRWAY

Audi was undoubtedly compromised by the ACO's decision to now allow it to run the 'air hybrid' system that was 15 months in development and was intended for use in 2014.

'For next year you are allowed to use two energy recovery systems and we are working on this,' says Audi's Ulrich Baretzky. 'We made something that was too clever for the sport authorities. It was a kind of air hybrid, what I call a clever version. It was nothing to do with electricity. I am not happy that it was banned, but it was proven that it really was working and from an engineering point of view it was really OK and it has road car relevant.'

So why ban it? 'A good question – why not? It was a comparatively simple system, there was nothing complicated, and it was efficient. It was just that in a race environment it would have been a help. A turbocharger is also an energy recovery, but this was something different. We spent 15 months developing it, but for us now it is dead. It was just one of the projects, we also improved the efficiency and power of the engine. Even if this is the last season of this engine, you try to keep it competitive.'

The system is believed to work in the similar way to the Peugeot system announced in Geneva. A compressed air reservoir is charged by the engine cylinders during braking/coasting and then released on acceleration, eliminating turbo lag. This eliminates the need for batteries. 'This year, you will not see it,' said Baretzky. 'The rule-book will develop and the more recuperation will be allowed.'

Exhaustive possibilities

An exhaust is conspicuous by its absence at the rear of the new Audi. We look at what is possible with the exhaust plume

BY SAM COLLINS

There was something that the fans at Sebring could not fail to notice – the two Audis sounded very different to one another. The German marque had brought two of its R18s to the Florida track for the famous 12 hours. One was in the 2012 World Endurance Championship trim, while the other was built to 2013 specification. Apart from a Toyota-inspired wheel arch wing, the cars looked outwardly similar.

Closer examination in the pits revealed that there was a big difference between the two. The 2013 car did not appear to have an exhaust pipe. When accelerating way from the pits, however, the tell-tale plume of smoke was ejected from the car's diffuser.

The idea of blown diffusers has been well explored by Formula 1 teams in recent times, and the management of exhaust flow continues to dominate the aerodynamics of the current breed of cars. Audi, it seems, has entered the fray with a new system on the 2013 R18, albeit with a twist.

Blown diffusers are not a new concept – they were used in F3000, and Toyota used an 'exhaust-driven' diffuser in its TS010, blowing the exhaust gas into the wheel well.

What is today referred to as an exhaust blown diffuser (EBD) in F1 circles uses the high energy flow from the exhaust to seal the sides of the cars diffuser, preventing dirty air from the base of the rear wheel from entering it, with a resultant increase in downforce.

Red Bull Racing was the first to do it, with the RB6 in 2010 relocating the exhausts to the car's floor. Its engine supplier, Renaultsport, developed technology that allowed the engine to continue to generate these gases even when the driver was off-throttle, maintaining the artificial downforce at low speeds, but that was effectively banned by the FIA at the end of 2011. But they did not effectively outlaw blown diffusers altogether. Now, the teams are using sculpted bodywork to channel the exhaust plume into the crucial area and, while it is not as effective, it is an area that still gives a significant increase in performance.

To make an F1-style blown diffuser effective, the exhaust plume needs to be fairly energetic, and a turbo diesel engine simply does not produce an adequate mass flow rate at the tailpipe. The mass flow/horsepower may not be that different, but the temperature, and hence velocity, will be lower due to diesel cycle and energy extracted by the turbo. As explained in *RCE V22N7*, the F1 solution is not the only way to utilise the exhaust gases. 'There are other ways to take advantage of the aerodynamic impact of the exhaust, other than working the diffuser,' said former Lola designer Julian Sole.

F1 teams are now using sculpted bodywork to channel the exhaust plume into the crucial area

ENERGETIC DIVERSION

The reason the 2013 Audi sounded different to the 2012 car was that the exhaust system has been redesigned, and it seems that the exhaust gases are now channelled through the wheel arches. This could only be possible if the exhaust was changed from a single to a twin pipe, and the mono turbo V6 in the R18 only ran a single tailpipe in 2012.

It has been suggested that while the exhaust flow is rather flaccid, it is still sufficient to have an aerodynamic influence, though not sufficient to be used in the same way that Formula 1 teams use the higher energy flow from their high revving normally aspirated SI engines to increase downforce by sealing off the diffuser.

Indeed Audi has admitted that it has switched to a twin-pipe layout, and chief engineer Ralf Jüttner explained that the exhaust was influencing the airflow in a way that reduces overall drag. This suggests that the gases are being channelled into the low-pressure area behind the car itself.

'Filling a low-pressure area at the rear of the car with "energetic" exhaust will reduce drag,' says *Racecar*'s technical consultant Peter Wright. 'However, it must have an effect on downforce, as that low pressure will also act on the underside of horizontal surfaces. If the flow goes into the wheel arch, it will be too turbulent to perform a "blowing" function, which sets out to energise air to increase flow over a surface, such as the diffuser.'

The problem that Formula 1 has found with directing the airflow to the diffuser and the wheel well area is that, off

Audi have confirmed that the new R18 has switched to a twin-pipe exhaust layout – but where is it?

throttle, there is not adequate flow to seal the diffusers, meaning a loss of downforce at low engine speeds. This can make the cars very tricky to drive indeed.

But Audi is not looking for downforce in its Le Mans package. It is looking for a drag reduction to help it down the straights.

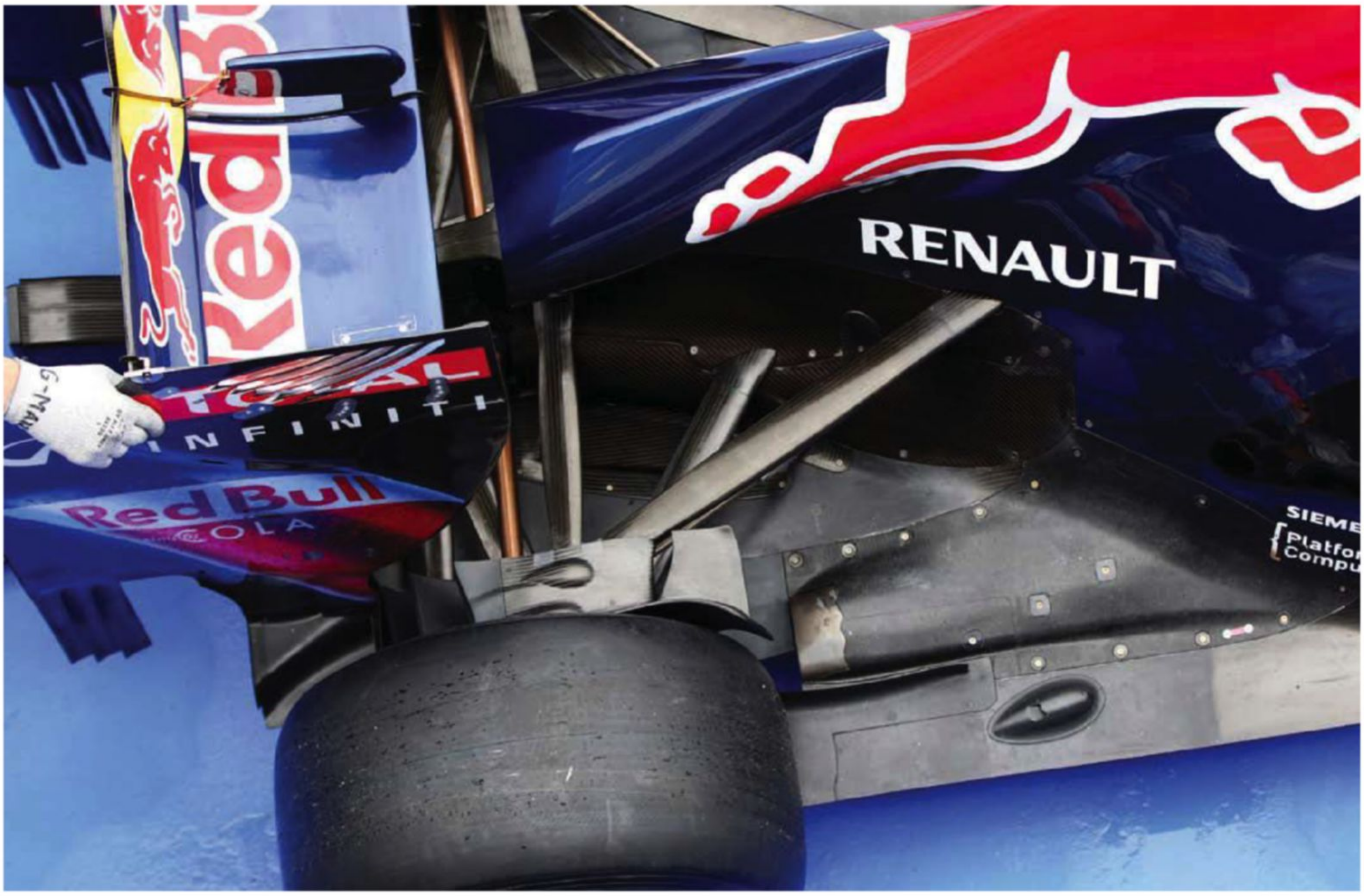
One other consideration is gear changing. An upshift means fewer revs, and a different flow rate, which would in turn impact the car's aerodynamic performance. This, says Wright, is not a problem. 'If it is only drag, then an interruption in a corner is not too serious, and is a good reason not to let it influence downforce too much. At 150kph, it takes about 0.125secs for the flow to change – one car length – and a gear change is less than that, so the full effect change will not necessarily be felt.

'This idea was pioneered on ballistic projectiles – ie artillery shells – to add significant range, but has been used on cars too as a drag reducer,' says says *Racecar*'s aerodynamic expert Simon McBeath. 'If mass flow is useful, despite the lack of energy, it is probably not creating low pressure to reduce drag. More low pressure at the rear increases drag, although it also drives the underbody harder to get more downforce. However, Audi could be using a modification of the "base bleed" principle, where adding mass flow at the rear sort of fills in the low pressure in the wake to increase base pressure and reduce drag.'

Racecar columnist Ricardo Divila designed exactly this system for the Copersucar FD01,

Channelling the exhaust for Wilson Fittipaldi's Copersucar FD01 during the 1975 Formula 1 season resulted in a significantly increased top speed

driven by Wilson Fittipaldi in 1975 Formula 1 season. Top speed increased significantly thanks to the system. The volume of air exiting the exhaust simply reduces drag if it is channelled into the right place. 'I think it is something that stands out,' says Divila. 'Look at aircraft cooling on a Mustang P51. You can make it go faster because you have the cold air coming into the



Red Bull F1 rear suspension and exhaust from 2011. An FIA clampdown on blown diffusers caused the team headaches mid-season

radiator matrix, heated up, expanded and then shot out through a nozzle, so your cooling is making the plane faster. You are just using expansion of air and the exhaust.'

The location of the radiators in the R18, just ahead of the rear wheels, suggests this could be an alternative solution to Audi's airflow intrigue. 'There is nothing obvious when you look at both cars,' says Jüttner of the difference between the old 2012 car and the 2013 model. 'The design is hiding it a bit, but with the front wheels and the rear wing, internal airflow is quite different to improve efficiency with the same drag.'

'In the front wheel arches, where you use the dustbin covers, you can flow air into the low-pressure area,' says Divila. 'The wheel centre is a low-pressure area. You fill in your vortex so you don't have the drag. The rear wheels are a bit more difficult – there is a lot to be played around in that area.

'You reduce the base pressure if you put it in the right place. You either blow it or it goes all over the place. In F1 they are really working it hard – this is aerodynamics gone mad.'

But why would Audi locate the exhaust exits in the wheel arches? Quite simply because they had no other option. The 2013 LMP1 regulations are very rigid on the shape of the car's floor, restricting openings and essentially preventing the exhaust from being placed under the car or in the diffuser itself, as Toyota did with the TS010. According to the regulations, the only openings permitted are the minimum gaps necessary for wheel and suspension part movements (suspension travel and steering), air jack holes, sensors for measuring the ground clearance (LMP1 only), closed hatches (maintenance operations) and the overflow fuel pipe.

The only exception to this is the front diffuser which is free, but it is highly unlikely that Audi has followed the lead of the Renault R30 in running the exhaust pipes forward through the car. Indeed the mandatory chamfered floor of Le Mans Prototypes would likely see the exhaust plume bleed out of the side of the car.

There is, however, a loophole in the regulations in that, while the underbody is regulated, vertical surfaces are not, so the forward – and indeed rear – edges of the wheel arch can have whatever openings the team desires. The sides of the car are similarly unregulated. The Peugeot 908 for example had its exhaust exit just ahead of the rear wheel on the car's flank, which makes a Copersucar FD01-style layout entirely possible too.

One notable concern with the wheel arch exit is the proximity the exhaust exit and its hot gases would have to the tyre and suspension components, but if the tail pipes were directed to the centre of the car and the diffuser then perhaps this would not be so much of an issue.

These layouts are likely to only be seen this year as for 2014 they are specifically banned, when a new rulebook comes into force. In it blown diffusers are outlawed and critically the exhaust location is tightly restricted with the rules stating that: 'Exhaust pipe outlets must not be inside the diffuser. No point of these outlets must be situated less than 300mm from the trailing edge of the rear diffuser. Any point of these outlets must be visible when seen from above or the side.'

Audi's LMP1 rival Toyota is reported to have tested its own blown diffuser and it is possible that with the higher mass flow rate from the Japanese spark ignition V8 engine, a F1-style blown diffuser could be used to increase downforce. Alternatively a similar approach to the Audi could be employed.

"There is a lot to be played around with in that area. In F1 they are really working it hard. This is aerodynamics gone mad"

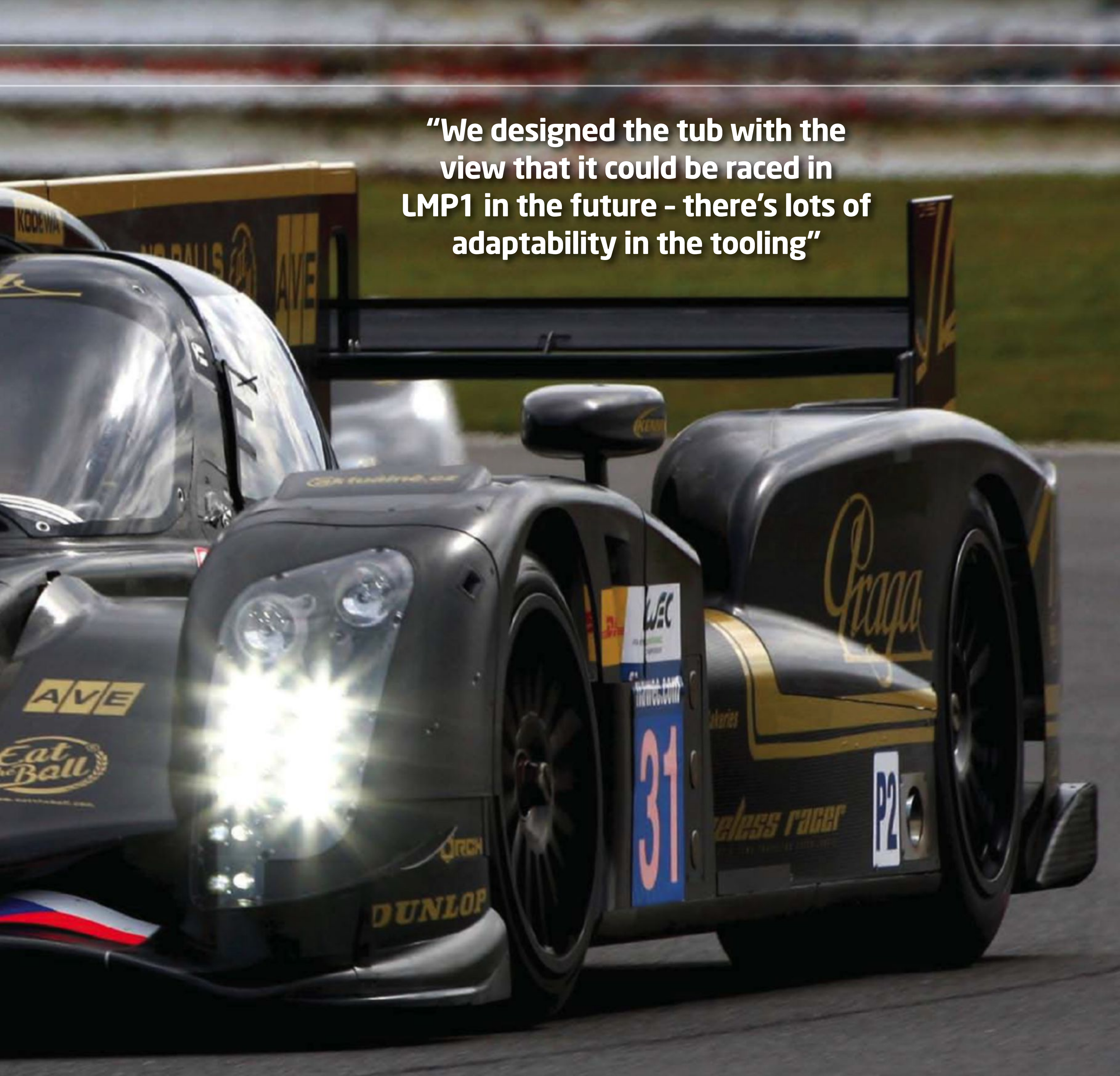

ARROW

Playing the name game

BY SAM COLLINS

It has more in common with last year's HRT F1 car than anything bearing the Lotus brand, but the new T128 is a LMP2 contender with potential

"We designed the tub with the view that it could be raced in LMP1 in the future - there's lots of adaptability in the tooling"



The new Lotus T128 has a somewhat confusing name. It was not built by Lotus - though it is officially endorsed by the English firm - and has no direct relationship with the Lotus T128 which contested the 2011 Formula 1 World Championship. However, this Le Mans Prototype can trace its roots directly back to a 2011 Formula 1 car, just not the Lotus…

When the project first began, it was just to prove the capabilities of the company that instigated it.

'It was started by SCE Solutions based in Munich, Germany,' explains the company's founder Stéphane Chosse. 'We decided that we wanted to develop a Le Mans Prototype as a demonstration for what SCE could do. The idea was that we would sell the design study, but we were not successful at first.'

However, Chosse was also working with the HRT F1 team as chief of aerodynamics at the time, which brought him into contact with team principal, Colin Kolles. 'SCE Solutions acted as the aerodynamic department for HRT, and as Colin is a big fan of sportscar racing I told him about the LMP project,' he says. 'We discussed it, and in the spring of 2012 we decided to go for it. As a direct result of that we decided to create a bigger company called Adess GmbH - short for Advanced Design & Engineering Systems Solutions - and Colin gave us the opportunity to build the LMP and compete in WEC with the Kodewa team. We had the target of having two cars on the grid for the first race of 2013 at Silverstone.'

The new company had to take a design concept and turn it into a running car in around 12 months. Adess and SCE had all the capability required to design and develop the car in-house, but much of the manufacturing work had to be outsourced - the same approach taken with the HRT F112 Grand Prix car. 'Adess is primarily a design and engineering office. Like the F112, the car is manufactured by a group of companies, including the Kodewa team who make parts. Holzer Group makes some parts too. So we have a good group of companies integrated in this project.'

Kodewa had secured backing from Lotus to compete in the LMP2 class of the World

The Lotus features torsion bar front suspension, not seen on an LMP2 design since the Porsche RS Spyder

Bodywork consists of carbon sandwich composite panels, with quick release nose, rear diffuser, wheel arches, rear end and rear wing

Endurance Championship – it ran a Lola-Judd in 2012 and has a licence to use the Lotus brand in 2013 and 2014. This is why the the new LMP2 is branded Lotus instead of Adess or similar.

Early in the car's development, Chosse decided that the car would have to be a coupe instead of a roadster. There was also an eye on the future with the design of the monocoque. 'We had a few targets with the car,' he said. 'One of the first things we decided was to build the monocoque to the 2014 LMP1 technical regulations. Firstly because we want the car to be sold all over the place in a few years, so the monocoque has to be state-of-the-art. From a performance point of view we absolutely wanted to go for a closed car because LMP1 in the future will only be closed, and we think that in the medium term LMP2 will be the same.' The 2014 LMP1 regulations place the driver higher and further forward in the car and give the drivers greater visibility. The T128 is the first car to be built with a new specification monocoque. 'We have designed the tub with the view that it could be raced in LMP1 in the future, so we have designed a lot of adaptability into the tooling to allow us to go for the top class in future.'

Aerodynamic development was another one of the priorities of the Adess engineers. 'Another driver for a closed car was the aero,' explains Chosse. 'We have done a full aero programme with this car. With our common work with HRT we have taken the same approach with an F1-style programme. We have a wind tunnel model and extensive CFD work has been conducted.'

Wind tunnel development was conducted at 50 per cent scale using the commercially available wind tunnel at Mercedes GP in Brackley, England with a maximum air speed of 50m/s. The CFD development was conducted in-house using CD-adapco Star-CCM+.

The front end of the car is not dissimilar in concept to the Audi R18, with a high nose. 'We had a very close look at what the other manufacturers are doing. On these LMP cars you have basically two concepts with the splitter, a semi-open car like the Audi R18, or a closed car like the Oak Pescarolo. We did a lot of evaluation of this in the wind tunnel, but at some point in your development you have to take a route and decide what to do. We decided for a semi-open design,' says Chosse.

One of the main focuses for the car's design was making it useable for the amateur drivers, as it is hoped that the car will be sold to customers.

'One of the criteria during the programme was to make sure the car was safe and stable in high-speed corners, with a low ride height sensitivity,' Chosse continued. 'We took this approach because with gentleman drivers there is more time to gain than there is from a professional driver getting the ultimate pace. Our reference car was the Lola B08/80 coupe that the Kodewa team ran last year, but this car was a real blank sheet of paper. We have done very little comparison work with the Lola so far, but we plan to. At Le Mans we will have a real Le Mans aero kit on the car – the team takes that really seriously, but will show that there is a lot you can do within the cost cap.'

Under the 2014 rules, LMP2 cars must not sell for more than €440,000/$570,000 making it very difficult to make a profit from a highly developed car. Indeed Chosse explains that the priority with the T128 is initially not to

SOFTWARE SOLUTIONS

The engineers at Adess employed several HyperWorks tools in the T128 project, including HyperMesh, the meshing tool of the suite, to create finite element models; RADIOSS for linear and non-linear analysis, especially for crash test simulations of the front structure of the car; then HyperView to post-process the results.

'The bodywork panels of the car are made of lightweight carbon sandwich composites and it has a carbon composite monocoque as well,' said Stéphane Chosse, founder and CEO of Adess. 'Altair's HyperWorks suite is crucial in handling the crash event simulation of all safety-related parts to make sure that they meet all the crash and stiffness regulations, while keeping the car as light as possible. We are very satisfied with the results we get from HyperWorks and feel confident that it is the best solution to meet all of our engineering needs as well as external requirements. In addition we are also happy that we found a software provider who is an expert in the area of composite simulation.'

With the results achieved in the development of the T128 racing car, Adess is planning to continue working with Altair and HyperWorks on current and future projects including its 2014 F1 car design. It also intends to apply the optimisation tool OptiStruct to optimise composite parts to further improve the lightweight and stiffness characteristics of its racing cars.

PERFORMANCE PERFECTED

- Ultra-Lightweight for Reduced Unsprung Mass
- Maximum Travel in Combination with Smallest Block Heights
- Exceptional Block Resistance and Durability
- Precision Tolerances-The Tightest in the Industry
- Precision Parallelism and Squareness Tolerances, Maintained Under Loaded and Unloaded Conditions to +/- 1 Degree
- Lowest Side Loads and Load Centres Precisely Aligned to the Spring Axis
- Highest Linearity and Guaranteed Rate Consistency Within 2% of Advertised Rate
- Each Spring is Individually Tested and Rated

Eibach produces the finest race car springs in the world. Period. When other springs sag, or need frequent replacement, the top race teams inevitably turn to Eibach and wonder why they didn't choose us in the first place.

But don't just take our word for it, actions speak louder than words. Our springs have taken teams to 2011 championship victories and podium finishes at Le Mans, BTCC, CTCC, DTM and WRC.

Eibach: The Choice of Champions.

United Kingdom
Eibach UK | Phone: +44 14 55 - 28 58 51 | eMail: sales@eibach.co.uk

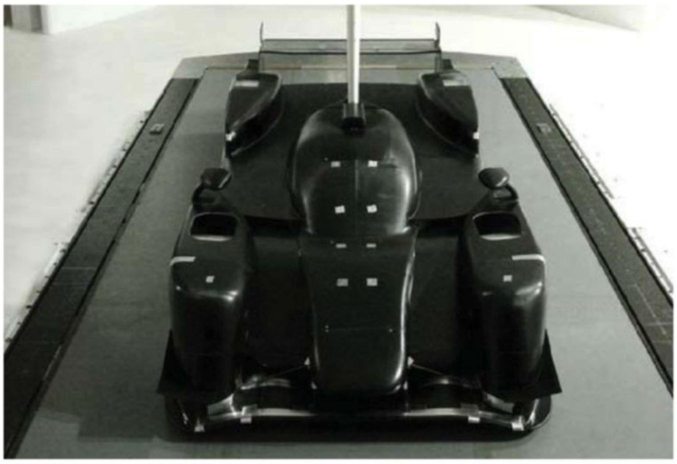
make a profit from selling cars, rather to show what it can do.

'The target of the project is to demonstrate the performance of the car,' he says. 'We are certain that the car will be competitive and this is a multi-year project. There is also the balance of performance, so we do not want to do anything stupid. So we are not developing the car for outright performance, but also to ensure that a gentleman driver feels comfortable in the car.'

The overall design of the T128 is a departure from what is normal in LMP2. Indeed, some in the WEC paddock have been overheard saying 'that is not a sportscar – it's a Formula 1 car', and they are not far from the truth. 'A lot of people working on the project have been involved with F1 very recently. I'm still involved personally,' says Chosse. 'On the Kodewa side of things, they've worked in F1 before too with HRT, Jordan, Spyker and Force India. When you have people like that, you end up with a lot of creativity and F1 inspiration. With the Toyota you will find the same approach.'

This F1 inspiration is immediately evident with the nose of the car removed. The tub has a raised nose with aerodynamic concepts that appear, visually at least, to come straight from the open wheel design textbook. Torsion bar front suspension, not seen on an LMP2 design since the Porsche RS Spyder, only adds to this.

'We went to torsion bar suspension at the front for reasons of performance,' says Chosse. 'Compared to our competitors our tub is much smaller and we have to package



Aerodynamic concepts appear to come from the open wheel design textbook. A full aero programme was undertaken, adopting an F1-style approach

everything, so a torsion bar was the right direction.' At the rear, torsion bars are not used but the suspension still has some single-seater design elements including a neat third element. 'It's not torsion bar suspension at the rear, though there is also clear F1 inspiration in this area,' he continues. 'We had great freedom at the rear as we did not use an off-the-shelf transmission. Instead we have a bespoke transmission from Hewland. It was very important to us that we did not just replicate what others had done – we wanted to go our own way. The car was developed in late 2012, so we wanted something more modern and we have made a big step in this area. It adds a lot of value to the car. A lot of attention went into keeping the weight down at the rear to achieve our target weight distribution. It is a magnesium case with an aluminium bell-housing. Although we have our own case, the off-the-shelf transmissions also have quite a range of pickup points, so it's not a great advantage in that respect, but with this transmission the pickup points are exactly where we want them.'

Powering the T128 is the Judd HK 3.6-litre V8, albeit wearing the branding of Czech firm Praga. 'The team last year had some difficulties with Judd last year, but decided to stand by them,' Chosse explains, 'We feel Judd is a very reliable partner and the team is very happy to have them with us. The regulations state that there must be two engine installations, so we integrated the NISMO engine as well as the Judd. The NISMO has very similar installation to the Judd HK.'

The two Kodewa-run T128s debuted at Silverstone for the opening round of the 2013 WEC. Things didn't run all that smoothly however, and neither car was classified, but the team is hopeful they'll be much stronger at Le Mans.

'Everything is new and that takes a lot of courage,' concludes Chosse. 'If you look at the rest of the LMP2 field, the cars are older with chassis dating back to 2006 and 2007 in some cases. This is a really nice product – I hope we can sell some. We want first to demonstrate its potential, then see a few customers next year.'

TECH SPEC

Lotus Type 128

Class: LMP2

Chassis: carbon fibre monocoque to LMP1 2014 regulations

Engine: Judd HK 3600cc N/A V8

Bodywork: carbon sandwich composite panels, quick release nose, rear diffuser, wheel arches, rear end and rear wing

Suspension: double wishbone front and rear with pushrod-actuated dampers

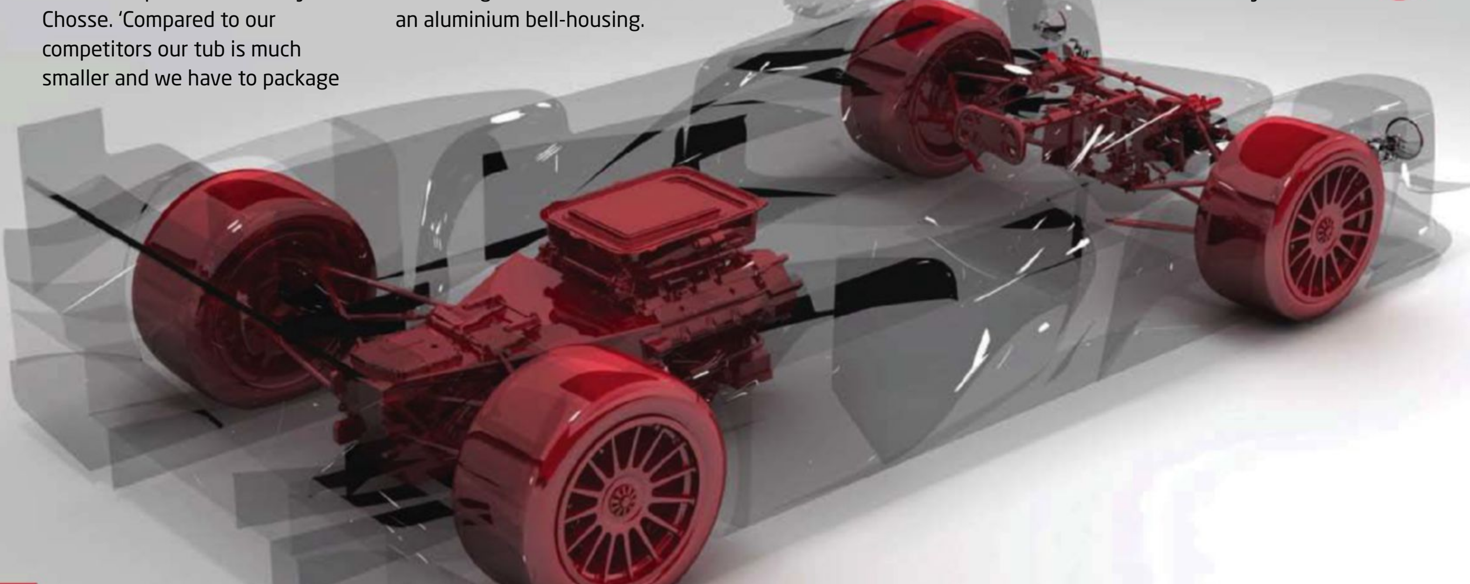
Transmission: Hewland TSLM 200 six-speed sequential

Brakes: Brembo carbon/carbon with aluminium caliper and in-cockpit quick balance adjuster

Steering: DC Electronics EPAS

Electronics: MoTeC EDL3, multifunction F1-style carbon fibre steering wheel with integrated LCD display

Fuel system: ATL tank with Stäubli refuelling valve, electronic lift pumps and catch tank



PFC
YEAH, OUR CUSTOMERS
ARE THAT LOYAL.
www.pfcbrakes.com
PFC
BRAKES


Ferrea
RACING COMPONENTS
Your Complete
Valvetrain Solution
Ferrea's USA based factory located in Fort Lauderdale, Florida, continues to expand manufacturing through state-of-the-art research, development and production capabilities. In 2012, we are looking to add new machinery and advanced software programs, to optimize designs, that will in turn, help meet the increasing demand for our valves, retainers and other valve train components. Pricing and lead times are available upon request for any valve train component not found in our catalog. Keep an eye out for our NEW website coming soon!
Titanium, Competition Plus, Hollow Stem, 6000 Series and 5000 Series valves:
• A variety of different series valves that should be selected and used for your specific engine build
• All of these valves are manufactured from premium materials in USA
Retainers:
• Fully heat treated US spec Military Titanium and Ultra-light Tool Steel retainers
• Engineered for optimum strength and weight savings
Valve Springs:
• Manufactured from Ultra-clean premium wire
• Featuring new technology that increases the accuracy of spring rates in extreme racing conditions
Valve Locks:
• Made from premium quality heat treated steel alloy
• Stronger than OEM. Available for most applications
Valve Guides:
• Precision machined from high quality manganese bronze material
• Excellent for both Intake and Exhaust applications
• Compatible with Stainless Steel and Titanium Valves
FERREA RACING COMPONENTS
Tech Line: 954-733-2505
Toll Free: 888-733-2505
www.ferrea.com
FOLLOW US ON:
Showtime


Lightweight Lithium Ion Starter Batteries
• Up to 80% weight saving over standard battery
• Incredibly compact, only 2/3 size or smaller
• Longer service life averaging 4000 cycles
• Recharges much faster
• Low discharge rate at only 10% per year
Super B is involved in all levels of motorsport including BTCC, WTCC, WEC, WRC, WSB, BSB, IDM, DTM, Historic and Classic, Dakar Series and many more…
SUPER B
Want to know more?
Visit us at www.super-b.com
or give us a call on +44 741 260 8539
Super B SB12V25P-SC
1500 Pulse Cranking Amps 4,2 KG

The new Radicals

A revived Slovakian brand is offering an eye-catching alternative to the UK firm

BY SAM COLLINS

Slovakia is not known for racecar production, but it is possible that it soon will be after the revival of the Praga marque. It is not a brand that many people know, yet it is one of the world's oldest car makers, founded in 1907 in Prague, then part of the Austro-Hungarian Empire. Over the years, Praga engineers have built everything from luxury cars to trucks, and even aircraft. A Praga-designed light tank – the Panzer 38t – was even used by Nazi Germany in the second world war after Hitler's forces captured the firm's facilities in 1939. After the war ended, communism was imposed on Czechoslovakia and the industries were nationalised. All Czech car production was undertaken by Skoda and Tatra, and Praga became focused on trucks and military vehicles. This continued until the turn of the century when production declined. Around 2007 Praga was limited to making gearboxes and hydraulic systems and the brand seemed to be slowly fading from memory. Its final car left the factory in 1947. Or so it seemed.

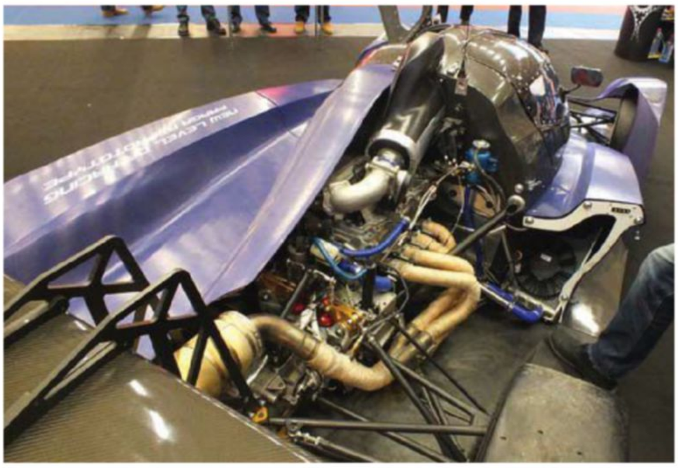
Praga is under new ownership and back in the automobile manufacturing business, initially with racing cars. The first car to wear a Praga badge in over 60 years was designed and built in Slovakia by K1 Engineering, originally dubbed the Attack R4. But although the firm has produced some very successful karts in recent years, the first proper new Praga made its public debut at the PMW trade show in late 2012.

The R1 attracted admiring glances at both the Cologne and Autosport International shows. Its looks, allied to a neat LMP1-style carbon fibre monocoque chassis make the car appear seem like it's aimed at a market higher than it really is, for the car has modest origins, as a Praga spokesperson explained.

'We had some Radicals we were running as part of a racing school at the Slovakia Ring, and we found that quite a few clients were scared of driving a car without a roof. They kept asking us if they could drive something like a Radical, which they really enjoyed but which had a roof. We realised that there was a market and that we had to fill it. But at the time the economic crisis was biting hard and it was important to keep the costs down.'

The Slovakians came up with a new body concept, and ran basic tests on a Radical SR8 chassis, but soon decided that the best thing was to go their own way. It built up a team of young engineers at its base in Orechová Potôň, Slovakia.

The bodywork of the R1 is something of a compromise between styling and pure aerodynamics according to the team behind it. 'We wanted it to look good,' said the Praga spokesperson. 'If we went totally down the aerodynamic route, you end up with a Le Mans Prototype and they are not as sexy as this, but they have much better aerodynamics than this so it is a compromise.' Although not wind tunnel-tested, the car's test driver, Martin Short, claims that it generates significant downforce at speed.



The R1 features a Renault Sport Formula 2.0 engine, capable of 210bhp, although Praga has a 532bhp Suzuki Hayabusa-based model in development

Quality-name components on the new Praga include Koni dampers, Cosworth ECU, a ZF Sachs clutch, Hewland JFR gearbox and AP Racing brakes

Praga's engineers decided that simply developing a new body to run on its Radicals was not enough – it would have to go the whole way and develop its own chassis. The resulting design was as neat as it was eye-catching, and unlike the car that inspired it, the R1 features a composite chassis. 'For us, safety is very important,' says Praga, 'so we have a composite monocoque chassis. It offers us much higher torsional rigidity. It was fully designed in-house but the composites were outsourced.' The chassis rigidity is increased with significant reinforcement and bulkheads, while safety is enhanced with front and rear crash structures.

However, the reason that many new racecar constructors opt for a tubular steel chassis is that they are easy to manufacture, modify and maintain. This approach has served Radical very well indeed over the years, with over 1,600 cars sold to date. There is a well-reasoned perception that cars with composite chassis are more expensive, but in the case of the R1, Praga claims that it is not true. 'If you compare it to the Radical, we are not that much more expensive,' they say. 'The R1 costs €95,000, not a lot more at all. And that is not to say that the car uses low-grade components. We only want to use very high-quality components from the best brands in the industry so that we can build up a good reputation. We have dampers from Koni which we think are the best in racing, the clutch is Sachs and we have parts from ATL, Titan and Cosworth.'

The car is assembled and built in Slovakia, and not all of the parts are outsourced. Most of the aluminium parts, such as the bell cranks in the suspension, are all CNC machined in-house to a very high standard.

"We only want to use very high-quality components so we can build up a good reputation"

While most Radicals are equipped with a tuned motorcycle engine, the Praga engine is derived from a production car. It is the 2-litre normally aspirated in-line four used in Formula Renault, while the output is a fairly modest 210bhp – more than adequate in a car that only weighs in at 592kg. The engine features a Cosworth ECU with traction control and transmits its power to the rear wheels via a Hewland six-speed sequential gearbox placed in the rear in a transaxle configuration, with pneumatic paddle shifts and a ZF Sachs twin-plate clutch.

'We used the Renault because it is cost-effective and reliable,' says the Praga spokesperson, 'but in future we will fit other engines.' Praga has recently opened its own engine department and has a 532bhp Suzuki Hayabusa-based V8 in development, which tips the scales at 89kg, and would give the R1 more than 1bhp per kilo. A slightly less mad version will be fitted with a 1500cc motorcycle-derived four-cylinder engine which will produce 265bhp. Both will be available separately from the car. Praga also badges the Judd engines in the Lotus T128 LMP2 chassis, making its future ambitions clear.

'When we were designing the car we kept its cost in mind constantly so it can run for a lifetime for a normal hobby driver,' our source said. 'But there is a disadvantage of this engine, and that's its weight. It's a bit too heavy, but its durability is more important we think – it runs for 10,000km without any servicing required. The whole car has been designed for people who want to drive for fun. You only need one mechanic to run the car.' Much of the R1's design is aimed at making it easy to run for privateers and it features many small details aimed at improving its usability. Elements like bodywork that splits along the spine of the car, and suspension that allows for super-fast setup changes are great examples and are likely to be copied by the firm's rivals.

Right now the first run of 30 cars is under construction and examples are taking part in the new Superlight class of the Supercar Challenge, where they will go toe-to-toe with the Radical SR3 and SR8.

'The concept of our car is similar to Radical,' said the spokesperson, 'but we think it looks nicer and it has a roof. Intially we were a similar pace to the Radical, perhaps a little slower, but I think we are faster now.'

They will find out for sure when the Supercar Challenge comes to Slovakia Ring, where the Superlight class will run for the first time in mid-May.

TECH SPEC

Praga R1

Monocoque: single-seater carbon fibre (two seater optional)

Engine
Type: Renault Sport Formula 2010 2.0 engine, F4R 832, 16 valve, 4 cylinder
Location: mid, longitudinally mounted
Engine management: Cosworth
Bore/stroke: 82.7 x 93mm
Displacement: 1998cm^3
Power: 210bhp at 7250rpm
Torque: 220Nm at 4500rpm
Engine life: 10,000km before rebuild

Drivetrain/transmission
Clutch: lightweight steel flywheel/competition twin-plate ZF Sachs Racing
Gearbox: custom-made Hewland JFR – six-speed sequential semi-automatic transaxle gearbox, interchangeable gear sets. Pneumatic KMP paddleshift system with flat shifts and auto blip
ECU: Cosworth SQ6 with close loop lambda system, pit limiter speed control, traction control and full sequential shifting

Brakes: AP Racing with four-piston calipers

Wheelbase: 2527mm
Wheels: Praga
Tyres: Dunlop racing
Front: Centre locking 15x8, with 200/580R15
Rear: centre locking 16x10.5, with 265/605R16

Weight/dimensions
Length: 4144mm
Width: 1800mm
Height: 965mm
Minimum weight: 592kg


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


MOTORSPORT QUALITY ROD ENDS
AND SPHERICAL BEARINGS
INTERNATIONAL STOCKING DISTRIBUTORS
AURORA® · RODOBAL® · Seals-it®
broadest range
in Europe
metric and inch sizes
ACCESSORIES:
side seals
protection boots,
jam-nuts
bearing installation tools
Getecno srl
16141 GENOVA - Italy
fax +39 010 835.66.55
phone +39 010 835.60.16
contacts in English,
Deutsch, Français, Italiano
www.getecno.com - info@getecno.com


ENGINEERING THE ADVANTAGE
THROUGH QUALITY DESIGN
Our innovative design and precision performance engineering makes us your perfect Motorsport partner. Our world-class engineers are committed to delivering world class services where your exacting requirements will be mirrored by our exacting standards.
Contact us to see how we can engineer your competitive advantage.
T. +44 (0) 1480 474402
sales@titan.uk.net
www.titan.uk.net
TITAN MOTORSPORT
Dynamic Engineering

Change for the better?

When the British Touring Car Championship found itself looking for more excitement, it turned to Dunlop for help…

BY ANDREW COTTON

The net result of the BTCC confirming in November the need to switch tyres, combined with the extended winter in Britain, was that Dunlop had to quickly develop a tyre ahead of early testing at the end of January

The British Touring Car Championship felt that it needed something a little different for 2013, and so tasked Dunlop with creating an 'option' tyre, one that would shake up the order a little in one of the three races over the course of a race weekend.

The final decision was taken in November, and needed all of Dunlop's expertise to get something together for early testing at the end of January. Following its experience with endurance racing and touring cars, the new tyre is a combination of that developed for LMP2, and a compound developed from the BMW GTE, which Dunlop supported in the American Le Mans Series.

'The construction for the slick variants have stayed the same, which is a first for the touring car guys to have the same so the sidewall stiffness,' says Mickey Butler, Product Manager at Dunlop Motorsport Europe. 'The difference is the three different compounds – the soft, medium and hard tyre. The hard tyre is used at Thruxton, but at every other race the medium is used in two races, the soft in one. The soft is new and uses a well proven LMP tyre compound. We knew the family, we knew how our compounds and construction worked, but we don't have the right conditions at the moment to test extensively. It is too cold.'

Britain has experienced a long, cold winter and, given the timing of the decision to switch tyres, Dunlop had to develop a tyre in a hurry. 'People think that the soft tyre is better in the cold conditions, but with the new option tyre, the natural state is very stiff, very hard, so you need to get the heat into it to get it to work,' says Butler.

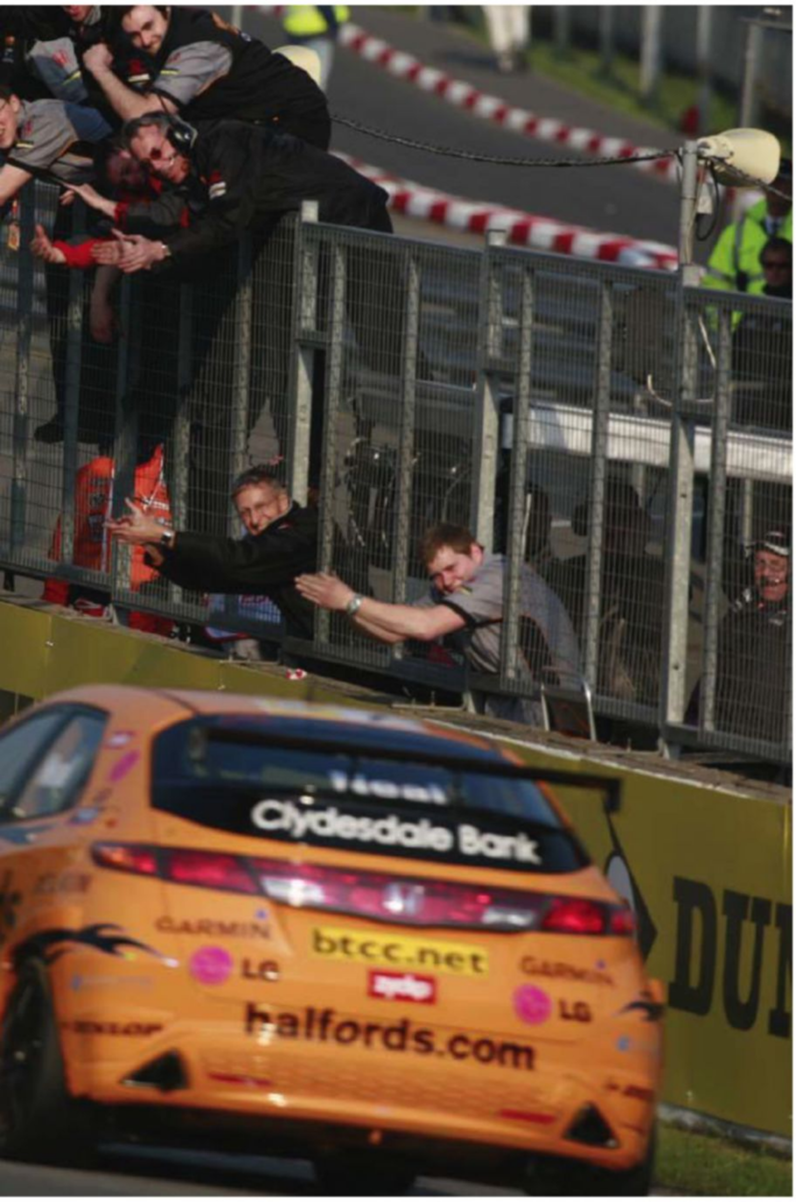
TESTING CONDITIONS

The first test was with Matt Neal in Rockingham, as the track is aggressive and Dunlop needed to be sure that the tyre lasted a race distance. Following that successful first test, they then moved to the company's traditional test at Portimão, Portugal, for some hot-weather testing in preparation for a hoped-for dry and warm summer.

With a track temperature of 18degC, the tyre lasted impressively, but there was a problem. The standard tyre has an operating window of 2-42degC. The new tyre, however, needs track conditions of upwards of 16degC to work properly, and tyre management in any other condition is going to be a factor in race wins.

'In extreme cold conditions, with the softer compound the heat drops out, it grains, the car slides and then they say that the tyre doesn't work,' says Butler. 'Drivers with a lot of experience will benefit more. If a driver is pushing too hard too soon, he has to back off and keep the tyre in the operating window. The first couple of races are going to be difficult. Once you get to the summer it should all go away.

'The medium tyre is so versatile, but there will still be some races where the soft is the



Experienced drivers will have fewer problems managing the new tyres, which need to be worked carefully before they reach optimum temperature

tyre to have. Look at Formula 1 – the soft tyre gets replaced with the medium, and that starts quick and gets quicker. We have the same with the touring car. They are different applications. For LMP it is a wide tyre – you don't need a stiffer compound. With the BMW the properties are slightly stronger, but there is a crossover point. It is a big enough step from the standard tyre.'

BALANCING ACT

'To get the grip you need to go softer to gain the time, but then you lose longevity,' continued Butler. 'With the current tyres, once you get the heat, the tyre is heat-resistant. So once it is there, it will stay the distance.

'A lot of people think it is a softer tyre, and will come in quicker. But it isn't. It's the hardest tyre they'll ever put on the car, but then when the heat comes it changes and the grip comes. At this point, drivers with better experience will manage the situation. For the first two laps they are going to have to build up to it. When you get it to optimum temperature it will be fine.

'This tyre is not seconds faster. If it was, the car would be in within five laps to change tyres. I reckon five 10ths but the tyres went away. Out at Portimão it was four 10ths, but it was warm and did the race distance.'

Ultimately, the short lead time has resulted in shortcuts. 'If we had three or four more tests before the season I'd be happier,' concluded Butler.

ELECTRONIC TAGGING

One of the big advantages that Dunlop has in a control tyre formula is its electronic tagging system. A microchip is installed in each tyre with data that can easily be scanned by the scrutineers to ensure that the right tyres are on the right car.

It is a system that was developed by parent company Goodyear for NASCAR, and Dunlop is now rolling it out across its motorsport and production products. Moto2 teams have started to test the system this year, alongside the BTCC which has now used it for three seasons, but Goodyear and Dunlop have discovered new applications.

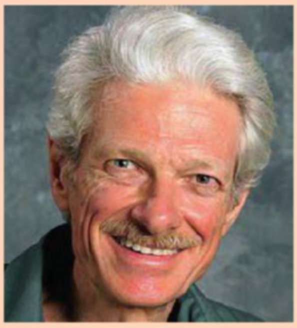
Trucks lease their tyres, and so keeping track of how many miles each tyre has done is a major advantage, particularly as they are regularly removed for regrooving and retreading. In the motorsport world, RFID provides control for organisers. The sale of GT tyres to one European championship may not be the end of the road for that tyre, and it may come back from another country into another championship, so RFID helps championship scrutineers to ensure they have the right specification tyre.

'It's a Goodyear technology,' says Mickey Butler. 'In the eco-friendly world we have full trace on the tyre from the moment it was made to the day it is scrapped. It leaves the factory, you zap it, when it comes back you zap it again, and you have full traceability. The team can see that a tyre has done 300km or whatever. It is vast, what you can do.

'Every tyre has a tag built into a sidewall. With TOCA we have a barcoding system in the sidewall. There's a serial number, and that is downloaded into the master computer. It is like a tracking system. Every time it goes through it picks up the serial number of the tyre. So, for example, Colin Turkington has these four tyres, they are his tyres, so that's OK. If there is a mistake and he picks up a tyre from a different car, you'll be able to find out.'


VAC
MOTORSPORTS
VAC ENGINEERED SOLUTIONS
DRY SUMP KITS - S65, S54 & MORE
RACING CRANK DAMPERS
COMPLETE ENGINE AND CYLINDER HEAD PROGRAMS AVAILABLE
ARP automotive Racing products
CP PISTONS
ARROW precision
SCHRICK MEMBER OF THE AVL GROUP
COMETIC GASKET
SAMSONAS MOTORSPORT TRANSMISSION
You Tube
VISIT WWW.VACMOTORSPORTS.COM FOR 3,000+ PRODUCTS


-35mm
Worlds apart
Our technology centre is the most advanced in Europe.
That is how we can achieve a negative radius of up to -35mm. Extreme engineering and precision that other performance cam manufacturers in Europe cannot match. All our camshafts and ancillaries have been developed by the best to be the best.
No1
Kent Cams – the best in Europe:
No.1 for product development expertise
The greatest performance increase of any single modification
The widest range of camshaft ancillaries produced on site
The most advanced technology:
Negative radius to -35mm
CBN wheels with constant surface speed
Multi-angle lobes with CNC dressing
Marposs 3D C and Z axis position probe
Microphonic wheel dressing
Lotus Concept Valve Train software
KENT CAMS
HIGH PERFORMANCE ENGINEERING
www.kentcams.com
Cams + Pulleys, Belts & Chains
Valves & Valve Springs
Performance Cam Kits & Valve Spring Kits
Followers & Tappets



Mark Ortiz Automotive is a chassis consultancy service primarily serving oval track and road racers. Here Mark answers your chassis setup and handling queries. If you have a question for him, get in touch.
E: markortizauto@windstream.net
T: +1 704-933-8876
A: Mark Ortiz, 155 Wankel Drive, Kannapolis NC 28083-8200, USA

Unusual angular roll stiffness

Finding the right formula to take in different eventualities

Q I understand the formula relating angular roll stiffness Kϕ to linear wheel rate in the roll mode K_{roll}, and I agree, but I have some questions that I think could potentially be interesting for a lot of readers.

1. This formula works when spring stiffness is the same for both wheels. In other words, if on the outer side there is bump stop contact, then this formula does not work unless you can split inner and outer wheels. Am I right?

2. In the case that the inner wheel is not in contact with the ground, typical in saloon cars or even in some formula vehicles that have very low suspension travel, then I think the formula has to take into account only one wheel stiffness. Again am I right?

3. If the suspension has some preload, then it has to be included in this formula.

4. If monotube or even double tube shock absorbers are used with high gas pressure, it is not completely clear how to take that into account. I suppose as the vehicle is in equilibrium that there is no need to take that into account. Is this correct?

For those that missed the original article, here is the equation in question:

$K_\phi = ½ * K_{roll} * t2 * \pi/180$ (1a)
$Kroll = (2 * K_\phi) / (t2 * \pi/180) = 360K_\phi / \pi t2$ (1b)

Or, approximating 180/π to three significant figures:

$K_\phi = ½ * K_{roll} * t2 / 57.3$ (1c)
$Kroll = 2 * 57.3 * K_\phi / t2$ (1d)

...where:

K_ϕ = angular roll resistance, lb-in/deg
K_{roll} = linear wheel rate in the roll mode, lb/in
t = track width, inches

Taking the last question first, I have addressed the question of gas spring forces in shocks in the past. It is vital not to confuse force with rate. Typically, shock builders or dyno service providers will tell you the gas spring force at one point in the displacement interval used in the dyno test. This will typically be one endpoint of the dyno stroke or the midpoint.

That is not the rate of the gas spring. The rate of the gas spring is the rate of change of that force with respect to displacement, not the value of the force at a single point. To get a measure of that, we need to know the force at a minimum of two points. Gas springs are non-linear, so the measured rate will vary depending on the points chosen. However, the rate in pounds per inch will generally be much smaller than the instantaneous force in pounds.

That is, the gas spring in a shock is a soft spring with a lot of preload. In general, its rate is much less than that of the tyres. Therefore, if we are seeking to improve accuracy by including rates other than that of ride springs and interconnective springs (eg anti-roll bars), the first thing we need to take into account is tyre compliance. If we are treating the tyres as rigid, we can safely ignore the rate of the gas springs in the shocks – we have bigger modelling inaccuracies to worry about.

Suspension having preload can mean various things:

1. **It could merely mean having static wedge in the car. This is common in oval track cars, but fairly uncommon in road racing.**
2. **It could mean having some preload on the ride spring(s) at full droop. That is common in road cars. If a spring compressor has to be used to assemble the suspension, the system has preload at full droop.**
3. **It could mean having a 'zero droop' setup, in which the suspension is at the droop stop in static condition and so cannot extend, but will compress further with any addition of load. In other words, the suspension is exactly topped out at static.**
4. **Or, it could mean that at static condition, the suspension is compressed so much that it will not move with a slight additional load, but will if the load gets beyond some threshold. At static condition, the suspension is topped out, and then some.**

There can be various reasons why the inside wheel would be off the ground. The suspension at that corner may be topped out, but it doesn't necessarily have to be in all cases. With independent suspension, it is possible for a stiff anti-roll bar to hold the inside wheel up.

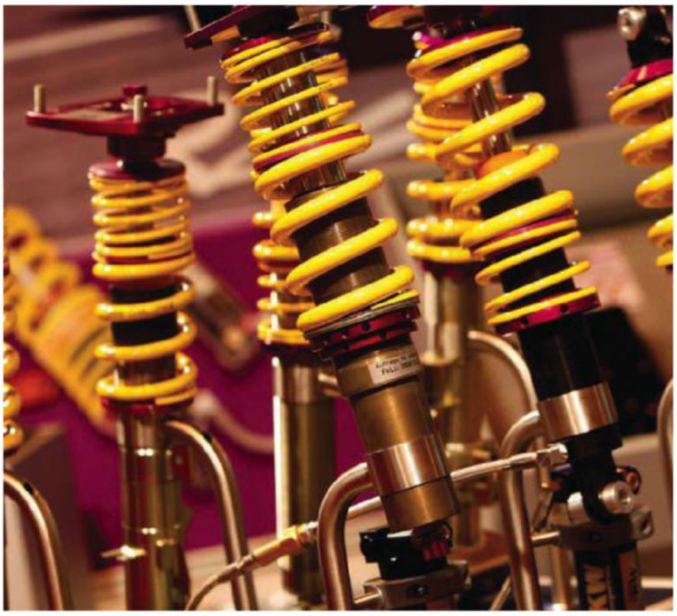
With a beam axle, it is possible for geometric anti-roll to hold the inside wheel up. In some cases, the suspension may even have a negative or inward roll displacement, even with the car rolled outward. The body is tilted out of the turn, and the axle is tilted out of the turn more, so the displacement at the suspension amounts to inward roll – inside shock compressed more than outside.

The inside wheel may be off the ground because there is vertical acceleration in combination with lateral acceleration, due to the car negotiating a bump, a kerb or a crest.

Whatever the reason may be, we know that if the inside wheel is airborne, all the available tyre loading at that end of the car is on the outside wheel.

Let's consider a relatively simple case, where the road surface is smooth and level, there is no aero loading, the cg is laterally centred, the only acceleration is lateral (y axis), and the car has no static wedge. If the inside front tyre is off the ground, that means the front end is exerting all the roll resisting moment on the car that it can. The front suspension may still have the ability to displace in the roll mode, and have a calculable angular rate in that mode of displacement, but it can't exert any additional roll resisting moment on the sprung mass, and it can't increase front load transfer or reduce rear load transfer.

In this condition, if we add further lateral acceleration, the resulting added roll moment must be resisted entirely by the rear suspension. Beyond the point of inside front wheel lift, the body's rate of roll angle change with respect to lateral force change is greater than it is short of the point of wheel



lift; the rate of rear lateral load transfer change with respect to lateral force change is greater; the rate of front lateral load transfer change with respect to lateral force change is zero.

Front load transfer is then 50 per cent of the total front wheel pair load. At static, 50 per cent was on each front tyre, and now 100 per cent is on the outside one. Rear load transfer is the total for the car, minus the front. Front anti-roll moment is 50 per cent of the front sprung weight times the track width. The rear anti-roll moment is whatever additional amount is needed to react the total sprung mass overturning moment.

Now let's consider a condition similar to the one above, except the inside front wheel is on the ground and the setup is zero-droop – just barely at the droop stop at static. Let's also suppose, for simplicity, that the suspension is independent and has no geometric anti-roll, so it doesn't jack up at all in response to lateral force.

Assuming that everything but the springing devices is rigid, the suspension cannot displace in pure roll. The wheels cannot move equal amounts in opposite directions, because the inside suspension cannot extend. The suspension can displace in roll, but only by displacing an equal amount in ride at the same time. To have an inch per wheel of roll displacement, we have to have two inches of compression at the outside wheel, since we cannot have any extension at the inside wheel. The ride and roll components are additive on the outside wheel.

If the inside wheel is airborne, all the tyre loading at that end of the car is on the outside wheel

On the inside wheel, they are subtractive and exactly cancel each other.

The load increase required at the outside wheel to produce this condition is then the force required to create an inch of roll displacement and an inch of ride displacement. The equation for K_ϕ is then:

K_ϕ = ½ * (Kroll + 2Kride) * t2 * π/180 (2a)

Or, approximating 180/π to three significant figures:

K_ϕ = ½* (Kroll + 2Kride)* t2/57.3(2b)

It will be apparent that the system has much greater angular roll stiffness than it would if the inside wheel's suspension could extend. This squares with common sense, or intuition – if half of the system can't give, the system as a whole is stiffer. What if, instead of being topped out at static, the suspension is bottomed out? What if we create a 'zero bump' suspension, instead of 'zero droop'?

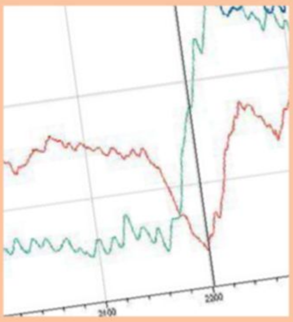
The situation is very similar to the previous case, except that the suspension needs to extend in ride in order to displace in roll, rather than compress. We have one side that is up against a stop and can't displace, while the other side can move. K_ϕ is calculated the same way. The sprung structure has to rise in order to roll rather than drop, but otherwise the dynamics are similar.

Very often, we have a situation where the suspension comes up against a bump or droop stop at some point in its travel that we are likely to encounter, but it is not at that point at static. In the case of a suspension that has preload against its droop stops at static, we can have a situation where the suspension is immobilised until forces reach a threshold, and then it can move. All of these are cases of what we might call two-stage behaviour. The system behaves one way up to some force or acceleration threshold, and at that point its characteristics change.

Assuming roughly linear behaviour both below threshold and beyond, we approach analysis by calculating what lateral acceleration gets us to threshold in the particular situation we're examining. If we are modelling an acceleration that is beyond threshold, we then know by what increment it is beyond threshold. We calculate the displacements and load changes at threshold, based on the system's properties short of threshold, and then the additional displacements and load changes for the increment beyond threshold, based on the properties in that range.


www.mussett.co.uk
Mussett composites
Moulding the future... and the past
Sub-contract manufacturers of pre-preg composite components and structures.
Autoclave processing and out of autoclave techniques.
Repair, re-design and re-manufacturing of historic motorsport composites.
F1 and other single seat formulae.
Le Mans Prototypes and Group C.
Crash structures, wings, floors and bodywork.
CFRP and Aluminium skinned honeycomb structures.
Experience with 1980's to current composites technology.
2D and 3D CAD motorsport design service.
CNC facilities for machining CFRP and metals.
Please contact Graham Muff for more details.
Tel: 01508 522500 | Fax: 01508 528769 | Email: enquiries@mussett.co.uk


ALL METAL SERVICES MOTORSPORT
We stock and supply
ALUMINIUM, TITANIUM, STEELS AND YELLOW METALS
for the Motorsport Industry
www.allmetalmotorsport.co.uk
motorsport@allmetal.co.uk
tel: +44 (0) 1675 430307
LONDON BIRMINGHAM BOLTON BRISTOL BELFAST FRANCE PR CHINA INDIA MALAYSIA



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

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

Wheel speed data

There are several options for gathering accurate figures

Knowing how fast you are going has always been, and will always be, critical to motorsport and road vehicles alike. The method of measuring speed has not changed much in principle throughout the years. A trigger wheel is mounted on a driven wheel and a sensor detects the proximity of each tooth and sends a pulse to a measurement device. Using the circumference of the tyre and the time between pulses, it is possible to calculate the speed at which the wheel is rotating. This is a proven and valid method and produces reliable and accurate results. It goes without saying that the number of teeth influences the accuracy of the speed measurement as well as the circumference of the tyre. The larger number of teeth, the more accurate the speed is. This can clearly be seen on modern road cars where the number of teeth is often close to 50 or even more.

However, as with anything to do with racing, more accuracy is always needed. Using GPS speed is all well and good, but also has drawbacks, and more importantly is hardly of any use for measuring the individual speeds. The individual wheel speed channels hold keys to unleash the performance of any racecars. The ability to detect wheel slip and lockups is a big factor, and the ability to calculate this in real-time and use it for control strategies such as traction control and anti-lock brakes is worth huge amounts of time. High calibre professional drivers have even been known to admit that they are unable to outperform a well calibrated high-end anti-lock brake system. Another drawback of conventional wheel speed sensors is the inaccuracy at low speeds. Standard wheel speed sensors, regardless of tooth count, are unable to detect speeds under 3km/h. It goes without saying that the ability to control wheel slip at very low speeds gets the car off the line quicker.

The solution to the increased demand for wheel speed data comes in this case from production cars. ABS and traction control are now standard on nearly all production cars, and the automotive manufacturers have

Added precision in the technology allows the wheel speed signal to be used for lockup detections

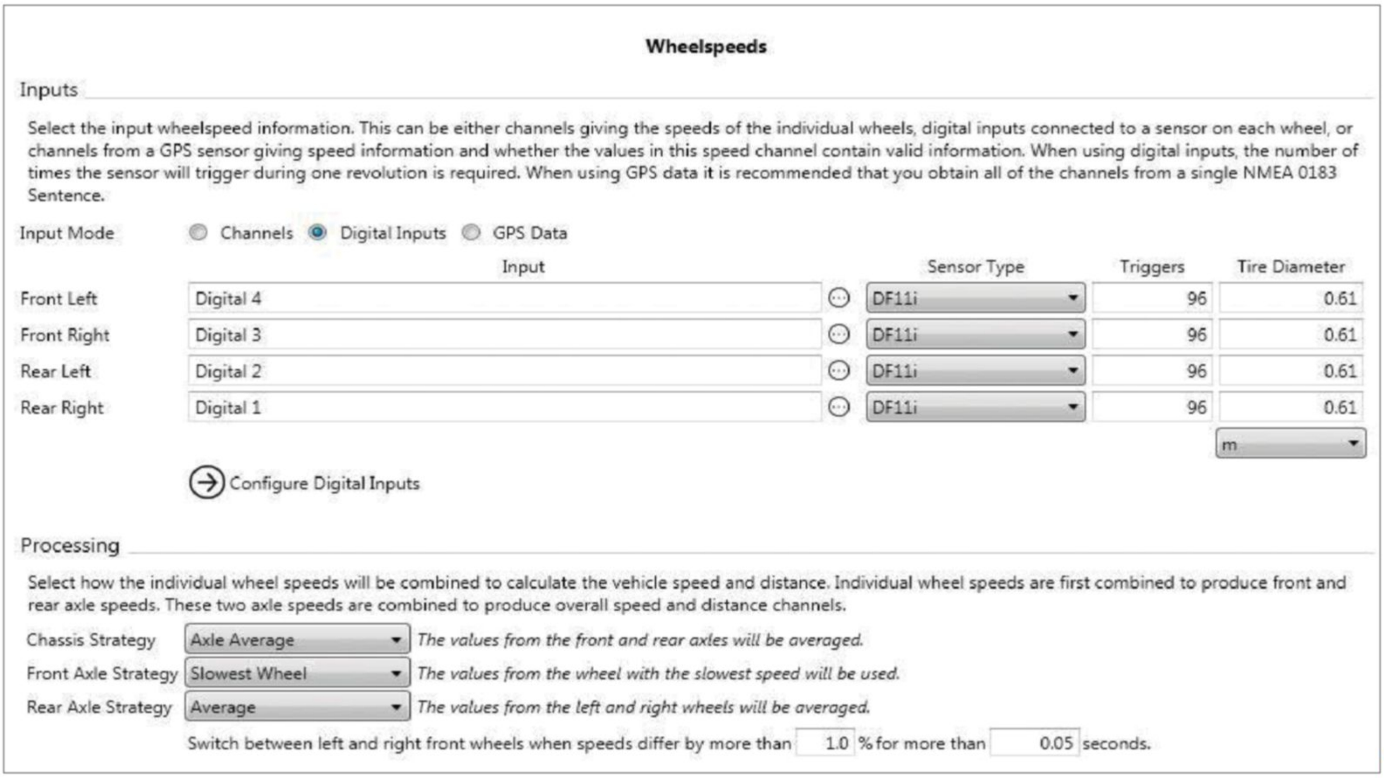


Figure 1: configuration of high definition wheel speed sensors. Note that 96 triggers are used for higher accuracy. High-end data systems also allow for various strategies in order to generate a highly accurate overall speed channel

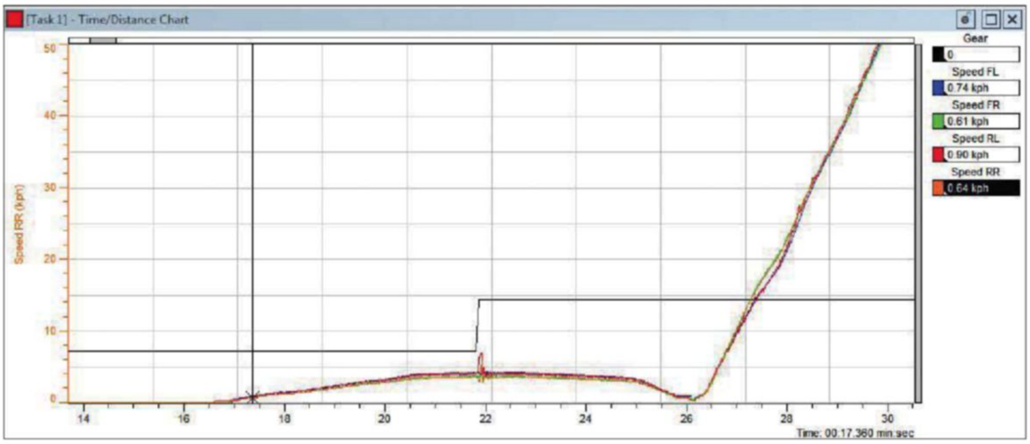


Figure 2: example of the type of slow speed precision possible with HD wheel speed sensors. The car is initially being pushed down the pit lane, the driver then engages 1st gear which is seen in the two rear wheel speed channels

```
register @a0;
register @a1;
register @a2;
@a0 = choose ( [Brake Press Front] > 10 , 1, 0 ) ;
//checks to see if the front brake pressure is more than 10 bar and if so a0 is 1
@a1 = choose ( ( [Speed RL] - [Speed FL] ) > 20 , 1 , 0 ) ;
//checks to see if the FL is slower than the RL by 20 kph and if so a1 is 1
@a2 = choose ( ( @a0==1 && @a1==1 ) , @a2 + 0.01 , 0 ) ;
// if Both a0 and a1 are true then start counting in 0.01 steps. Then as the channel is running at a rate of 100Hz the output is the amount of time the wheel is locked
@a2
//return calculated value
```

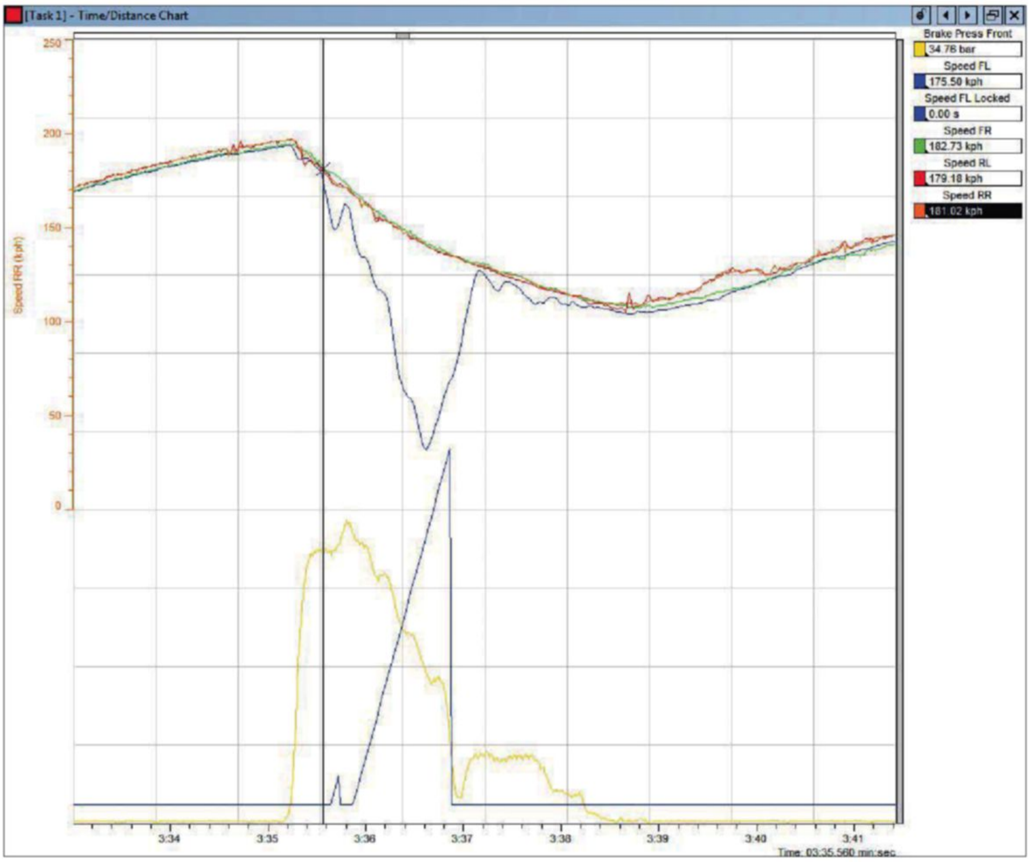


Figure 3: lockups detected by calculating the difference in wheel speed. This channel could also be used live on the racecar to display a lockup light to assist the driver

really pushed the development of those systems in the last few years. The latest development in this area is the high definition encoder wheel speed sensor. These sensors are active digital magneto resistive sensors. Using high precision manufacturing techniques to make a magnetised encoded trigger ring gives this sensor the ability to detect speed from 0, and also the direction of travel. This is a feature used in road cars for assisted hill starts. For motorsport applications, the 0 speed function is really the important feature and also the higher precision speed traces allowing for more accurate slip and lockup control.

This added precision in wheel speed technology now allows the wheel speed signal to be used more accurately for lockup detections, as well as various other things such as correlation with suspension data for kerbs and rumble strips and turn radius calculation.

Lockup detection is a good example of how the wheel speeds can be used as a driver aid or training tool. Using the syntax (left) it is possible to calculate the duration of a lockup and look at how the driver responds to its severity. This channel could also be used to calculate the total amount of time the tyre spends in a 'locked-up' state.

There are many areas of car control where wheel speeds are relevant, traction control and wheel locking being a key aspect. There are, however, other even more clever things that could be done – for example the high definition wheel speed sensors, using a sensor on each side of a driveshaft, could allow for the measurement of driveshaft torque.

COSWORTH

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

Attack philosophy

In the first of a new series, we analyse two very different UK Time Attack contenders in the Mira wind tunnel

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

Produced in association with MIRA Ltd

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

The still-growing worldwide phenomenon that is Time Attack imposes few constraints when it comes to aerodynamics, albeit with a few more restrictions creeping in year-on-year even in the 'open' classes. With often phenomenal power outputs, the general approach seems to be to aim for high downforce without worrying unduly about drag. Around the world, the successful cars appear to be the ones to which most aerodynamics attention has been paid. So *Racecar* decided to take a closer look at the aerodynamics of these enthralling machines by inviting two very different UK Time Attack cars, one already a frontrunner and one that certainly will be, to a session in the MIRA full-scale wind tunnel.

Jamie Willson's Lotus Exige is not the usual weighty power-belching four-wheel drive Japanese monster that has become associated with Time Attack in some quarters. Yet with limited resources and much do-it-yourself effort, Willson won the Club Pro class in 2012. With more power to come and a winter's aerodynamics development however, he's moving into the top Pro class for 2013.

The much-anticipated Roger Clark Motorsport Subaru Impreza – also known as Gobstopper II – follows on from the earlier Impreza-based RCM showcase project. The original Gobstopper won the UK Time Attack Pro class in 2008 and 2009 in the hands of Olly Clark, who along with his brother Matt, direct the company named after their late father, rallying legend Roger Clark. Not short of a few horsepower and with electronically controlled four-wheel drive, Gobstopper II features the kind of aerodynamics package its predecessor completely lacked.

So this month we shall look briefly at the philosophies applied to the aerodynamics of the two cars and start to examine the data generated in the usual all-too-brief half day wind tunnel session.

Table 1: baseline runs on the Lotus Exige

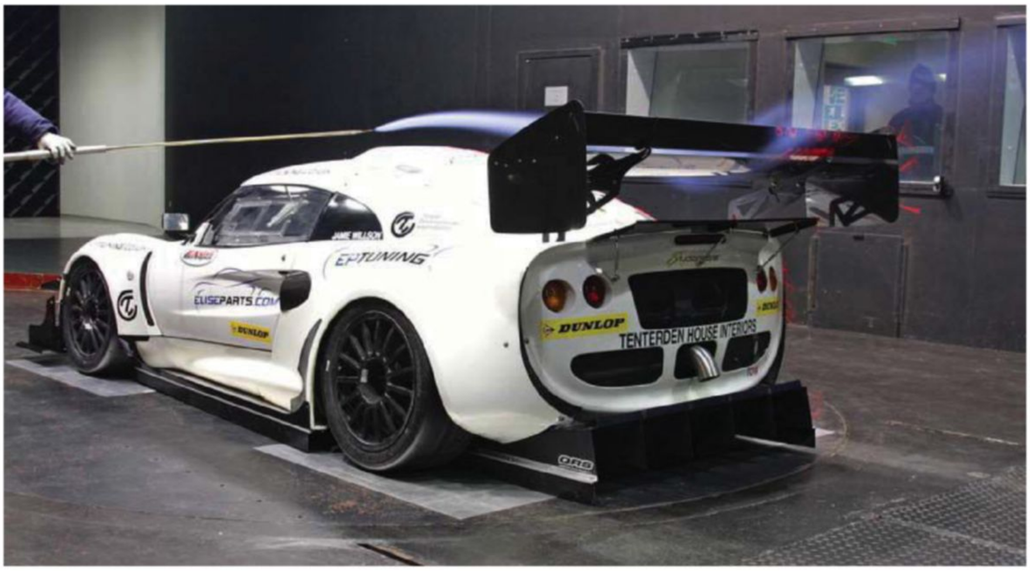
	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline	0.737	1.367	0.072	1.295	5.3	1.855

EXIGE EXAMINATION

The Willson Exige ran in 2012 with a medium camber dual element full-width rear wing but relatively modest front end modifications, plus flat floor and rear diffuser. The owner's aim was to generate useful downforce but without too much drag, the car having rather less power than some of its opposition. But with both the wing's main element and flap set to minimum angle, the car still understeered at 'aero speeds'. So additional devices were added during the close season to address the balance by generating more front downforce. Splitter end fences with 'footplates', dive planes and a small chord, part-width wing element were installed. An extension was also added at the rear to the 'duck's tail' to evaluate the interaction with the overhung rear wing. For its first baseline run, the rear wing was set with its main element in its middle position and the flap at its steepest setting, and as is often the case, that first run dictated the rest of the programme. **Table 1** shows the coefficients from the first run at 80mph.

A quick scan through the data in **Table 1** shows the downforce balance to have been – perhaps not surprisingly – heavily rear-biased with this setup, and focus thus shifted to addressing this. With few readily available options on the day for modifications to increase front downforce, the

The Willson Exige had undergone significant aerodynamic upgrades during the 2012/13 close season, especially at the front



Floor modifications were also apparent on the Willson Exige

most obvious way to address this imbalance was with rear wing angle decreases. Some rapid incremental changes to both flap and main element angle saw the data fairly drastically altered to that shown in **Table 2**.

So drag decreased by around 28 per cent and downforce decreased by some 34 per cent, leading to a drop in efficiency (-L/D) of about 8 per cent. However, balance had certainly headed in the right direction, with a target in the range 35-40 per cent of the total downforce on the front wheels. It's important to keep in mind that the car's splitter and underbody would generate more downforce out on track than on the MIRA wind tunnel's fixed floor, so 26 per cent of total downforce on the front was perhaps not so far away from being balanced, and the team's 'seat of the pants' track test plans will ultimately determine the balance. However, the car would need more front downforce to enable a balance at a higher downforce level.

We'll return to some other interesting modifications made to the Exige, some of which improved the balance still further, in the next issues. But let's switch our attention now to the aerodynamics philosophy and baseline runs on the RCM Subaru Impreza...

The Roger Clark Motorsport Subaru Impreza featured an aggressive aerodynamics package at the front...

...as well as at the rear

RESEARCHING THE RCM

The design thinking with the RCM car was quite different, and with good reason. Chassis dynamics analysis had determined that the car would naturally oversteer when under power and that it would need a significant proportion of its total downforce to be generated at the rear. So the car's aerodynamic package was devised with this in mind using CFD and a CAD model prepared from scan data. In essence the car featured a full width well cambered twin element rear wing, a moderately large front splitter with outboard diffuser sections, a small chord full-width front wing and large front end plates. The floor was flat through to the rear diffuser. The baseline and final data at 80mph are shown in **Table 3.**

Resisting comparisons between the two different cars, the Impreza's baseline data showed reasonable total downforce bearing in mind such a car's intrinsic lift, and despite the potent-looking front end, the balance was biased well to the rear. However, it was not too far from the balance target of 75-80 per cent rear (20-25 per cent front), and taking into account the wind tunnel's fixed floor may even have been in the right ballpark. Changes clearly altered that balance quite significantly. Instrumented straight line track testing is planned in order to correlate with the wind tunnel and CFD, and to fine-tune the balance.

Next month: more detail on the responses to configuration changes with both cars.

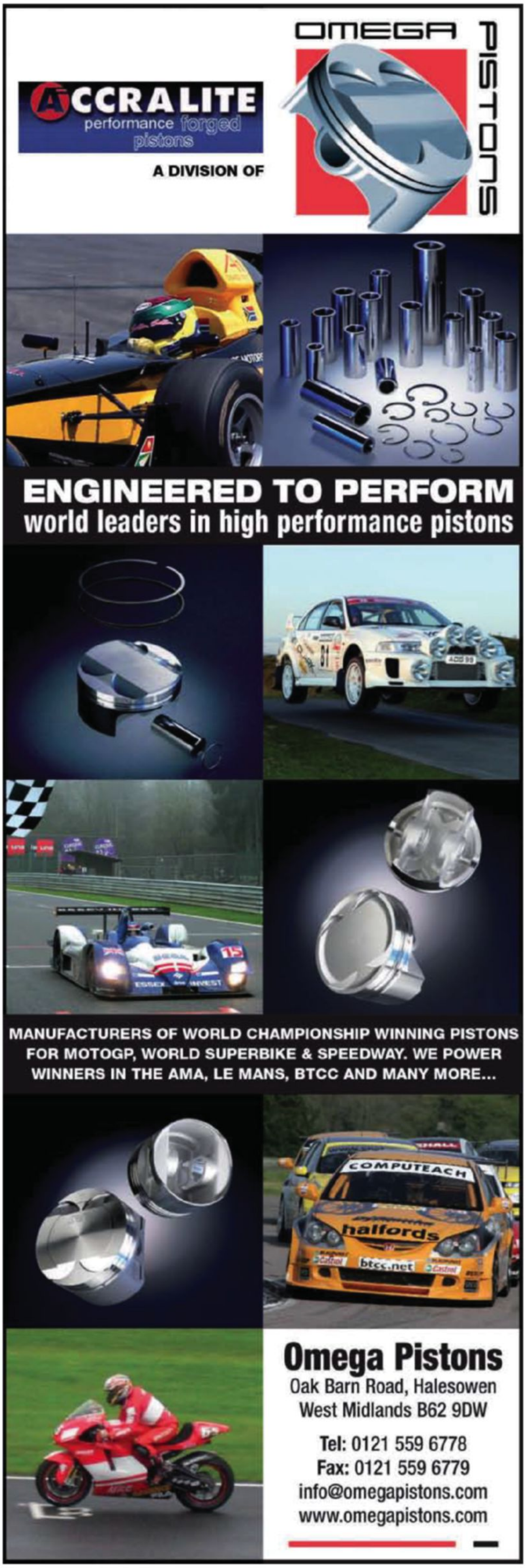
Racecar Engineering's thanks to Jamie Willson and team, and to Roger Clark Motorsport

Table 2 : Exige data after wing adjustments

	CD	-CL	-CLfront	-CLrear	%front	-L/D
After wing adjustments	0.528	0.902	0.238	0.664	26.4	1.708

Table 3: the Impreza's baseline and final configuration data

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline	0.584	0.663	0.123	0.540	18.6	1.135
Final	0.553	0.707	0.205	0.502	29.0	1.278


OMEGA PISTONS
ACCRALITE
performance forged pistons
A DIVISION OF
ENGINEERED TO PERFORM
world leaders in high performance pistons
MANUFACTURERS OF WORLD CHAMPIONSHIP WINNING PISTONS FOR MOTOGP, WORLD SUPERBIKE & SPEEDWAY. WE POWER WINNERS IN THE AMA, LE MANS, BTCC AND MANY MORE...
Omega Pistons
Oak Barn Road, Halesowen
West Midlands B62 9DW
Tel: 0121 559 6778
Fax: 0121 559 6779
info@omegapistons.com
www.omegapistons.com


NISSAN
SET THE BAR
MoTeC
RAISED IT
Introducing the powerful new
NISSAN R35 GT-R
ENGINE PLUG-IN ECU KIT
Next generation, intelligent engine control.
Quick installation.
Easy tuning.
Race smart.
www.motec.com

Go to Le Mans these days and you are going to get plenty of exercise: the most technically interesting cars reside at opposite ends of the pit lane. At the sharp end, the sophisticated and highly-honed LMP1 cars are to be found, with their state-of-the-art GDI and turbo diesel hybrid systems, tended by German and Japanese engineers and technicians. Far away at the other, a lone outlaw occupies Garage 56. Beyond the regulations but tolerated, in fact encouraged by the ACO because they are enlightened enough to want to know what might lie over the horizon.

The first to take up the challenge of Garage 56, offering a radical solution to competing at Le Mans in the most efficient and environmental way, was the DeltaWing. Startling to behold, daring in its concept, rubbished by many, this somewhat 'garagiste' effort ran long enough to prove its hypothesis: that by halving the weight one can half the downforce, halve drag, and so halve the power, thereby performing competitively at half the fuel consumption. In a logical world, all existing racing cars should have been scrapped, rules re-written, and motorsport would have rolled on into the future, twice as efficient as before. But motorsport doesn't work that way.

The ACO's chosen Garage 56 project in 2013 takes a different approach, using an alternative to carbon-based fossil fuels, such as hydrogen. Now I am not a big hydrogen fan, a fuel scientist having once told me that the best thing we can do with hydrogen is to hang a few carbon atoms on to it, preferably enough to turn it in to a liquid. I will be watching the GreenGT H2 Project with great interest to see what it can achieve, but if the DeltaWing cannot change motorsport, I doubt that a hydrogen fuel cell car can.

For 2014, when the new fuel efficiency WEC regulations come into force, Nissan has been granted Garage 56. Presumably enthused by their DeltaWing experience, their proposal to come with a 'novel electrical powertrain' convinced the ACO to allocate it to them. One must also presume that the ACO knows what they are planning and their promise to evolve it into an LMP1 entry fits well into the future rules, but for us on the outside it offers a wonderful opportunity to speculate.

Some commentators, most of whom should know better, have interpreted Nissan's announcement as meaning that they will come to Le Mans with an all-electric vehicle. They should do the maths.

Let's say they aim at LMP2 performance: 450cv and 900kg. At 70 per cent full throttle during a lap, something like 15kWhr of electrical energy would be consumed in a lap. If the car could be built to a weight of 650kg without batteries - just possible - you'd be allowing about 300kg for batteries to bring it up to a full fuel weight of an LMP2 car. At around 100kg of charged batteries for one lap, three-lap stints might just be possible. Changing batteries every three laps means that the car would have to lap some 10-20 seconds per lap faster than other LMP2 cars. This would need more power, more batteries, more weight. The maths do not work unless Nissan has a battery that is four to five times less energy-dense than existing batteries. Even going down the DeltaWing route of reduced weight, power and energy doesn't change the frequency of the stops.

The Le Mans 24-hours has encouraged new technology, from the introduction of TFSI and turbo diesels to lightweight and hydrogen. What's next?

Home of

innovation

BY PETER WRIGHT

Before we speculate on what Nissan might be developing, let us look more closely at what the ACO hopes to achieve with Garage 56. Part of the long-lasting attraction of the Le Mans 24-hour race is that it is and always has been a struggle to complete the race, let alone win it. When major manufacturers are involved, it becomes a titanic struggle and fans pour in to watch the action. So the ACO has gone out of its way to attract major manufacturers, and no manufacturer has been as committed to Le Mans as Audi have been over the past 14 years. Because Audi believes it can get something more out of endurance racing than just marketing, it has poured massive R&D funding into developing GDI technology and super-efficient turbo diesels through racing. It has gained both technically and in successfully convincing its customers of the benefits of these technologies.

Taking their cue from Audi's approach, the ACO has striven to make both its own - and now the FIA's WEC regulations - relevant to the technologies and image the manufacturers want to sell to their ever-more efficiency-savvy customers. The 2014 rules focus on a combination of internal combustion (IC) engine efficiency and energy recovery. Garage 56 aims to look beyond this, but its first two occupants have been entrepreneurial and innovative small teams that have perhaps been a bit too far out of the box. What the ACO now realises it really wants are manufacturers that will try and exhibit technologies with road car potential. Hence Nissan in 2014 and - if rumours are to be believed - Peugeot in 2015.

Before returning to what the Nissans and the Peugeots of this world might turn up with, let's first look at what a garagiste might do if they got another chance at Garage 56. If I still had the energy of Ben Bowlby, I would have another go at the DeltaWing hypothesis, but take a long, hard look at how to achieve its objectives with a conventional, four-wheel configuration. Nothing other than reducing the weight by 50 per cent is going to deliver a 50 per cent reduction in fuel used, but the greatest impact would be made if people could not see how it was done, and were denied the get-out of 'Oh yes, but it's really only a three-wheeler'. With all the data the DeltaWing generated, and enough budget to carry out extensive wind tunnel testing and FEA-led weight reduction, it should be possible.

And if I was Nissan? Well, I would have been a close party to the DeltaWing project and so it would be hard to un-learn from that. So I would use as my base a four-wheel version that embodies as much as possible of the concept as described above. Then, being a seller of road cars, I would see how efficiently I could generate the power requirements of the car, in a configuration relevant to road car needs.

While the propulsive needs of a road car are somewhat different from a racing car, they are both founded on a common set of technologies. A road car needs real fuel conversion efficiency under normal driving conditions, including cruising on motorways. It also needs to generate low numbers on the NEDC or equivalent cycle outside Europe, in order to compete environmentally with other manufacturers' products and to minimise fines for exceeding the EU figures for CO2 emissions. And finally it must have sufficient occasional performance to


This year's occupier of Garage 56, the GreenGT H2, is the first prototype electric/hydrogen competition car

meet its owner's aspirations. A racing car simply needs to cover the prescribed distance of an event as fast as possible, or the greatest possible distance in an event's prescribed time, including stops to replenish consumables, all within the limitations imposed by the regulations. The Ford EcoBoost engine concept epitomises small road car requirements: a small, 1-litre IC engine working hard and hence efficiently to supply normal driving needs, but boosted to feel like a 1.6-litre engine when required. It easily returns good fuel consumption and CO2 figures below the regulatory figure. Larger engined, heavier cars – especially SUVs – cannot fulfil their owners' expectations with acceptable NEDC results, and so various hybrid powertrains have been developed to help generate figures that minimise the fine and to convince environmentally-minded customers that they are still OK to own. These hybrids do a variety of things:

1. **They harvest kinetic energy under braking, store it, and use it to supplement the energy conversion of fuel under acceleration**
2. **They allow the IC engine to run at its optimum speed, so allowing tuning of the engine to be optimised for a small speed range**
3. **They allow energy to be taken from the electrical grid, stored and to be used instead of fuel**
4. **Finally, and not yet available on production cars, they allow the harvesting of other waste energy including exhaust energy and waste heat**

The best gasoline engines are 30+ per cent efficient, with diesel 35+ per cent at optimum speed and load. The lost 65-70 per cent – or more at off-design point conditions – is lost as exhaust energy, cooling energy, pumping and friction losses. The WEC regulations allow kinetic energy recovery, and in 2014 its scope is expanded through carefully written rules. Performance is controlled by energy flow rate (effectively input power), and tank size (average energy consumption) limitations. While the ACO wishes to encourage such development in racing, it must also provide a fair competitive environment to encourage manufacturers and privateers to come and fill the first 55 garages at Le Mans, and fans to come and watch them race. The 56th garage is an opportunity to look at new directions for future regulations encouraging the development of relevant technologies, yet maintaining good racing. A tough challenge! An unfortunate consequence of this difficult balancing act is that the simple conclusion of the most efficient car winning does not happen. The rules do not allow for building the most efficient car the manufacturers can conceive.

Key core technologies required for road and racing are:

1. **A transmission that allows the IC engine to run at its optimum speed; either multi-speed with seamless, preferably automatic gear-changes, or a CVT**
2. **Or, an IC engine-driven generator and a motor drive system to one or more axles or individual wheels**
3. **A storage system that allows the IC engine to supply the average power per lap or per journey, with the storage system storing excess energy when not required and supplying additional energy at sufficient power to meet the peak requirements**
4. **Waste energy recovery systems, feeding into the storage system**
5. **High efficiency, low mass density, low volume density electrical generators, motors and their control systems**
6. **A high efficiency, low mass-density, low volume-density, long-life storage medium and relevant control system**

The main difference between road and racing car requirements is in the acceptable cost of the systems, and differences in the operating cycles.

The ability to drive the wheels with individual motors brings in the potential for four-wheel-drive, and also for torque vectoring. Both of these technologies significantly alter the performance potential of a racing car and so must be carefully regulated.

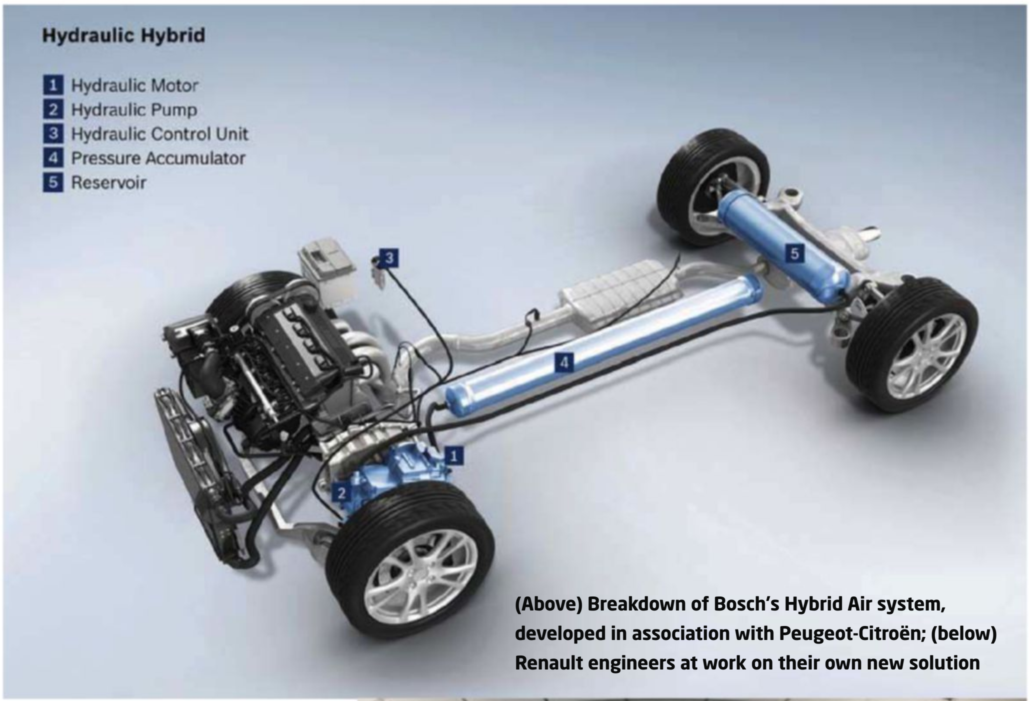
The push towards electric propulsion systems, combined with the use of grid energy, means that 2, 3, 5 and 6 above are the prime impetus for road car manufacturers, but – and it is a big but – the efficiency of an electric propulsion/transmission system, working through a storage system, is low compared to a direct mechanical drive. The round-trip efficiency of a generator > inverter > battery charge > battery discharge > motor > gearbox chain is only ever going to be around 70 per cent compared to 95 per cent for a mechanical drive train. This is why the series-hybrid Chevrolet Volt engages a direct mechanical drive when at cruising speeds.

For racing, the weight and space taken up by a storage system are critical to performance, which is why both Audi (electrical flywheel) and Toyota (ultra-capacitor) have foregone batteries for their hybrid LMP1 cars. The maximum energy to be stored is low enough in the racing cycle to make the power-density of the storage system the dominant design parameter. On the road, energy-density, cost and life are more important, but even here the cost/performance of batteries needs the long-promised,

Some commentators have interpreted Nissan's announcement as meaning that they will come to Le Mans with an all-electric vehicle. They should do the maths


SHD
composites
advanced composite materials
SHD Composite Materials is a company working at the leading edge of advanced composites technology, specialising in the manufacture of composite material prepregs and resin films.
+44 (0) 1529 307629
enquiries@shdcomposites.com
www.shdcomposites.com


GREAVES 3D
ENGINEERING
A new dimension in precision engineering
Greaves 3D Engineering can offer a turnkey manufacturing solution from design to finished part as well as a line of Motorsport Garage and Pit Lane Equipment which includes a Full Fuel Rig Assembly and Carbon Fibre Boom Assembly.
Services
• In house CAD design
• Comprehensively equipped CNC Machine shop with 5 axis machining
• Fabrication
• Metrology Suite for measurement services
Contact: Jamie Clare for full details & information
Email: info@greaves3d.com
Tel: 01733 248146
www.greaves3dengineering.com



(Above) Breakdown of Bosch's Hybrid Air system, developed in association with Peugeot-Citroën; (below) Renault engineers at work on their own new solution

multi-fold improvement before they can become widely accepted as part of everyday cars.

So, what would I actually build if I were a manufacturer with the Garage 56 slot? I would use the best CAE tools at my disposal to build a very lightweight conventional car and endow it with enough downforce generated beneath the car, if the ACO allowed me to, to achieve the desired performance – either LMP2 or LMP1. In this way drag would be kept to a minimum. Simulation tools would now establish the power/energy requirements for best performance, including stops for fuel and tyres. This area is subject to negotiation with the ACO – an important factor in reaching optimisation. The ACO does not want the performance of the Garage 56 entry to show up their regular 'clients', nor the car to run stint lengths that embarrass everyone else. I would choose the most efficient IC engine that suits my product plans – either turbo GDI or turbo diesel, or some new cycle variation under development – and then sit down to negotiate with the ACO about energy flow rate allocation and tank size.

Power would be transmitted via at least an eight-speed automatic, seamless-change gearbox – either as per F1 or a twin-clutch system for smoothness and durability. This would enable the engine to be tuned to operate in a very narrow, high-efficiency speed range. I would harvest kinetic energy with a purely mechanical system – possibly a mechanical flywheel, more probably a hydro-pneumatic system – as Peugeot-Citroën has developed with Bosch, for their Hybrid Air road car application. The system would be controlled electronically, but otherwise simply involves hydro mechanical swash-plate pumps/motors, control electronics, and a filament-wound, pneumatic accumulator. The hydraulic pumps/motors would be fitted to each front wheel and to the rear axle, for optimum kinetic energy harvesting, traction and torque vectoring. This system could be as efficient, light and small as an electrical system, possibly more efficient and requiring less cooling.

For waste exhaust energy recovery I would use a generator in series with the turbo-compressor, with energy stored in a fairly small battery/ultra capacitors/electric flywheel. Making this system electrical allows very close control, and permits the harvested energy to be used to control boost by driving the compressor, minimising the need for throttling in the case of a gasoline engine, or controlling the overall pressure ratio of a diesel. Variable geometry turbines and compressors would be needed to achieve optimum control and efficiency. I doubt if I would have the weight/space-efficient systems technology for recovering any other waste energy.

With this car/powertrain I would try and compete in the chosen class and demonstrate equivalent performance, controlled by the ACO, at significantly reduced fuel consumption. Of course, to validate all the above would need access to the best of applicable technologies and analysis tools to perform the all-important systems-integration and performance analysis. Unfortunately, without these, I am simply using basic maths and whatever engineering instinct I have accumulated. I suspect Nissan will not follow this route, but are more likely to use a series-electric hybrid instead of the mechanical transmission, perhaps with a new battery technology instead of hydro-pneumatic storage. However, maybe Peugeot will use something like my solution to demonstrate its recently announced commitment to pneumatic storage system technology.

If these two, mainstream approaches are tested and demonstrated at Le Mans, and the ACO gain the insights to guide them towards future regulations, then Garage 56 will have achieved its ambitious aims, and it will be well worth the long walk down to the far end of the pits.

PS: there is one technology that would demonstrate that cars, both road and racing, can be entirely environmentally acceptable by being both carbon neutral and not using limited fossil fuels, thereby eliminating the main sources of criticism of our favourite devices. A car that runs on a drop-in (ie not hydrogen) synthetic biofuel that is carbon neutral, uses no biomass, does not compete for land with food, and uses no fossil fuel in its manufacture would mean that the powertrain type is almost irrelevant from an environmental perspective. Garage 56 in 2016? This will be the subject of a future article.

The ACO must provide a fair competitive environment to encourage teams to come and fill the first 55 garages at Le Mans


HEAT EXCHANGER SERVICES
Our ISO graded 'clean room' is available for complete core cleaning and particle cleanliness assessment on radiators, oil coolers and chargecoolers.
Core Cleaning
Ultrasonic, Power Flush, Pulsation, Agitation & Flow Bench
Particle Assessment
ISO 16232, Microscopic & Optical Analysis, Size & Count
Calorimetric, Flow & Pressure Testing
Radiators, Oil, Gearbox, KERs & Chargecoolers
Core Race Preparation
Cleaning, Filtration, Drying
Oil Conditioning and Sealing
www.youngcalibration.co.uk
+44 (0)1273 455572
Unit 4, Ham Business Centre, Brighton Road, Shoreham by Sea, BN43 6RE


Brown & Miller Racing Solutions
BMRS
Professional Race Hose & Fittings
The best connection systems made.
www.bmrs.net
UK: Unit 5 Chancerygate Bus Ctr. / St.Mary's Rd. / Langley, Slough SL3 7FL / 01753.545554
US: 4005 Dearborn Place / Concord, NC 28027 / 704.793.4319
BMRS-UK-2012

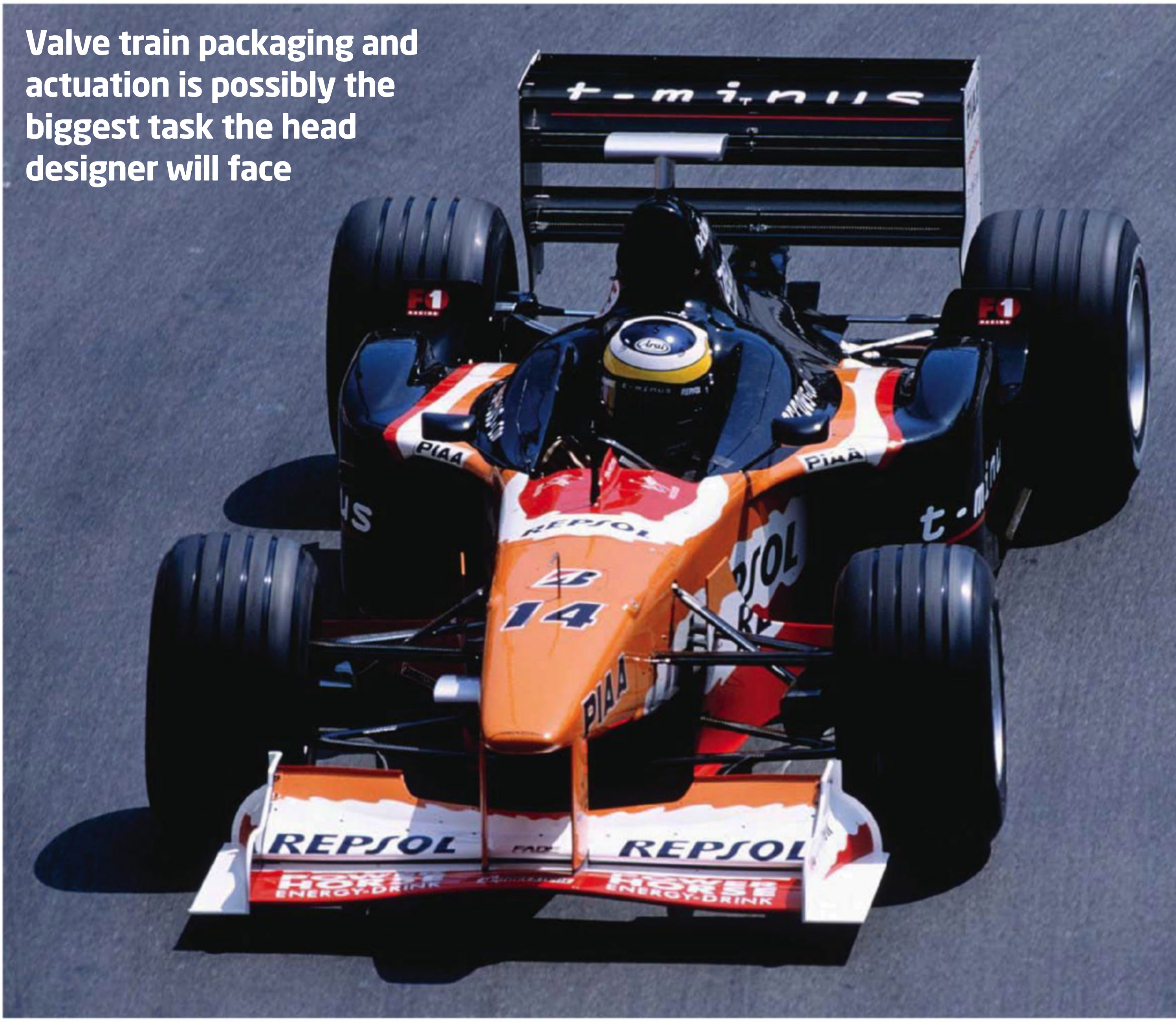
The technology of a 1990s F1 cylinder head

It's a common source of breakdowns – but then this is a part where lots can go wrong…

BY BRIAN GARVEY

Unquestionably, when you're trying to build a high-performance engine, the cylinder head is one of the key items. The most important thing about a good cylinder head is of course good air flow, but there are many other demands placed on a Formula 1 head that are less evident without closer inspection. When an engine breaks down during a race, it is the cylinder head that is at fault, and there are a multitude of points that need to be addressed concerning the design and manufacture of this complex part.

A key aspect with good head design is uniformity across all cylinders. When it comes to the ports themselves, and airflow through them, this isn't too much of a problem, but coolant flow and management around said ports and through the head can be. It is critical that no stagnant areas exist within the coolant galleries as these can lead to hot spots around the combustion chamber. On a normal road car, coolant normally enters the head at the gasket face from cylinder block and then exits



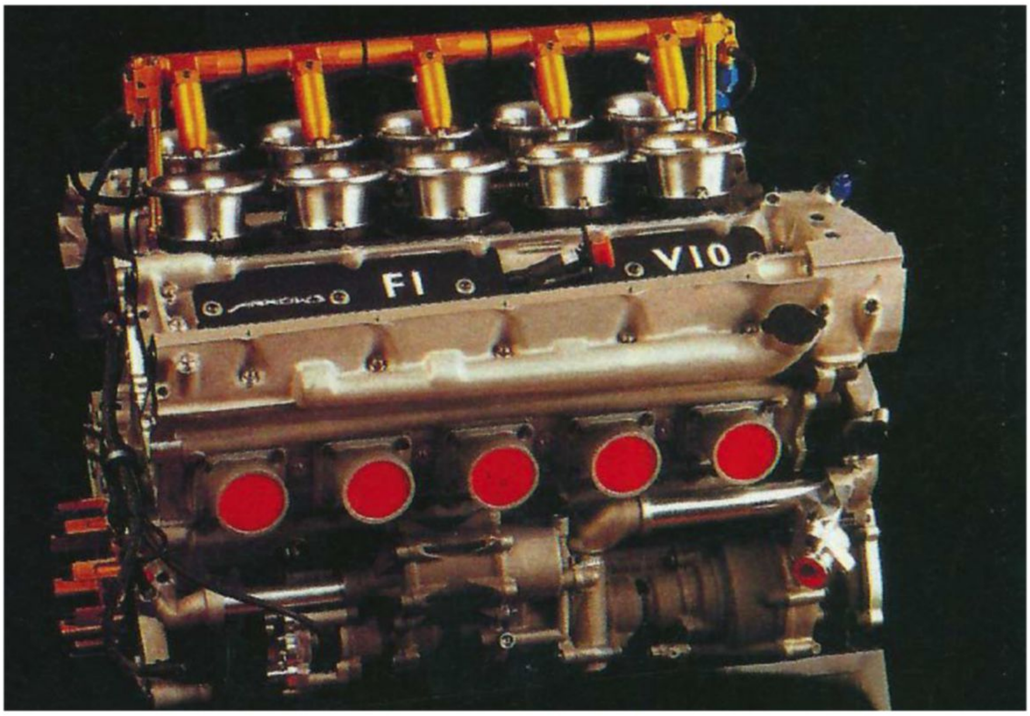
Valve train packaging and actuation is possibly the biggest task the head designer will face

the head casting at one central point. On an F1 head, the cooling of the combustion chambers is stricter and the galleries above them are constructed in a more modular fashion. This ensures better thermal balance across all cylinders and their combustion chambers. Since the engine in an F1 car is also a stressed member, this too has to be taken into account when designing the head castings. Considerable tension and compression forces are exerted through the heads so they have to be constructed to resist these loads without distorting, while at the same time being as light as possible. Valve train packaging and actuation is possibly the biggest task the head designer will face along the way. Above certain rpm, pneumatic valve springs are called for. Last of all, and just as important as coolant management, comes valve train lubrication. With cams spinning at speeds up to 9000rpm, and with each valve opening up to 150 times a second lubrication needs some serious thought too.

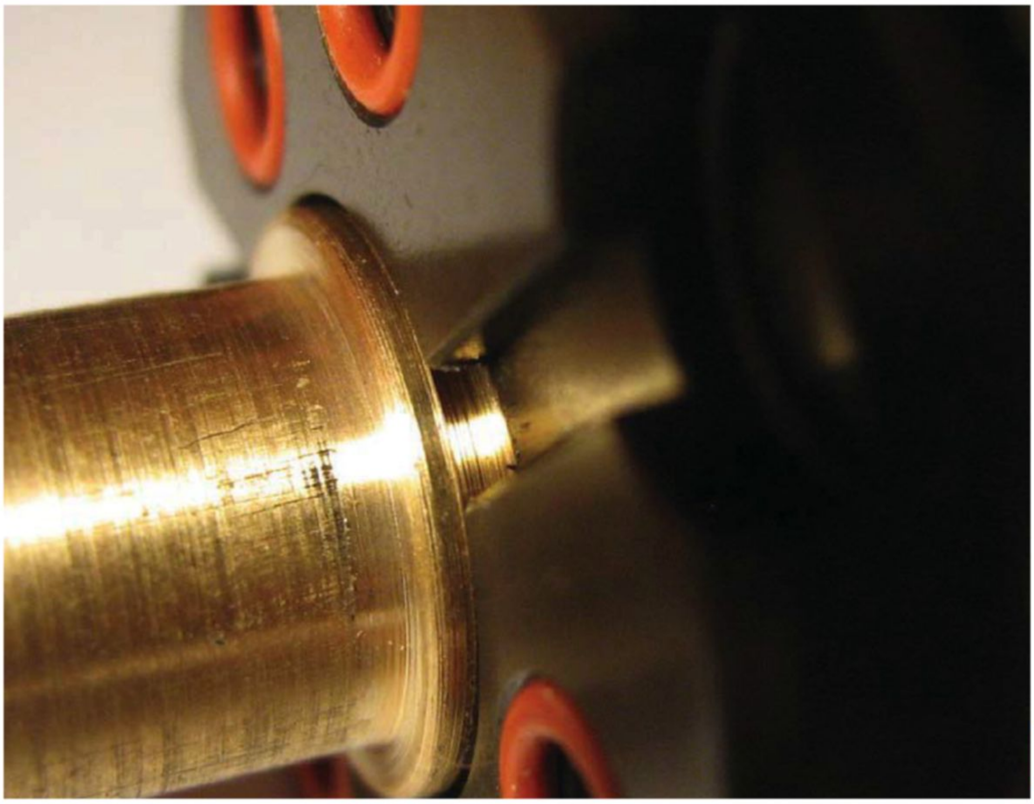
With all of the above in mind, let's dig a little deeper inside an F1 cylinder head in order to discover how some of these hurdles were overcome and also uncover some never-seen-before spring technology. The head in question is from a 3-litre V10 engine, designed by Brian Hart and used in Formula 1 in the 1990s. It features modular-style waterways, bucket tappets, ladder-style cam cover, in-cam oiling, pneumatic valve springs, single barrel throttles, tappet face oil squirters, and is taken from an engine with a rev limit of approximately 18,000 rpm, and which developed in the region of 800hp.

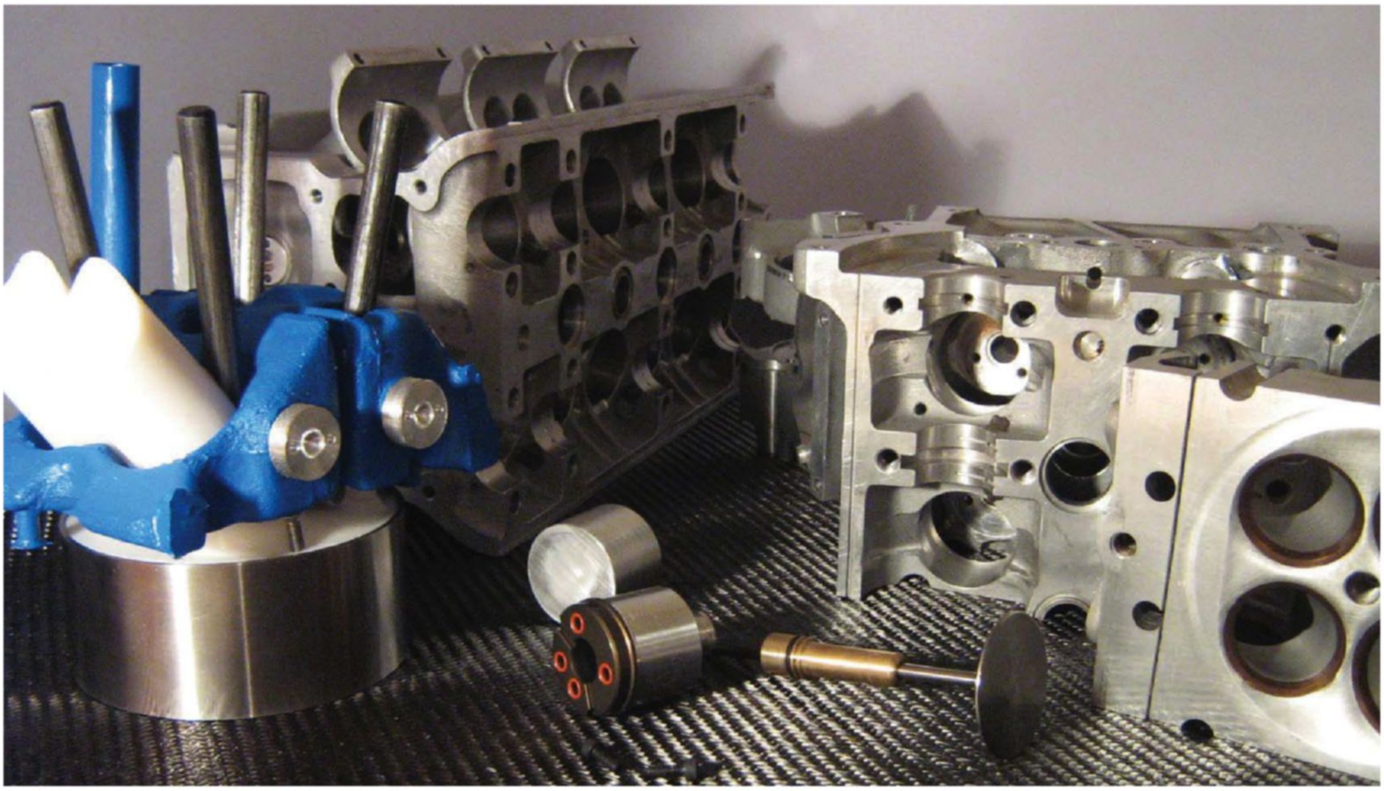
In order to accurately display the internal architecture of the cylinder head, an internal model of the coolant waterway above the combustion chamber is required. The head therefore needs to be sectioned and a silicone mould taken of the internal water passages. This

The Arrows A20, featuring Hart's V10 engine, in 1999



The Arrows T2 V10 engine



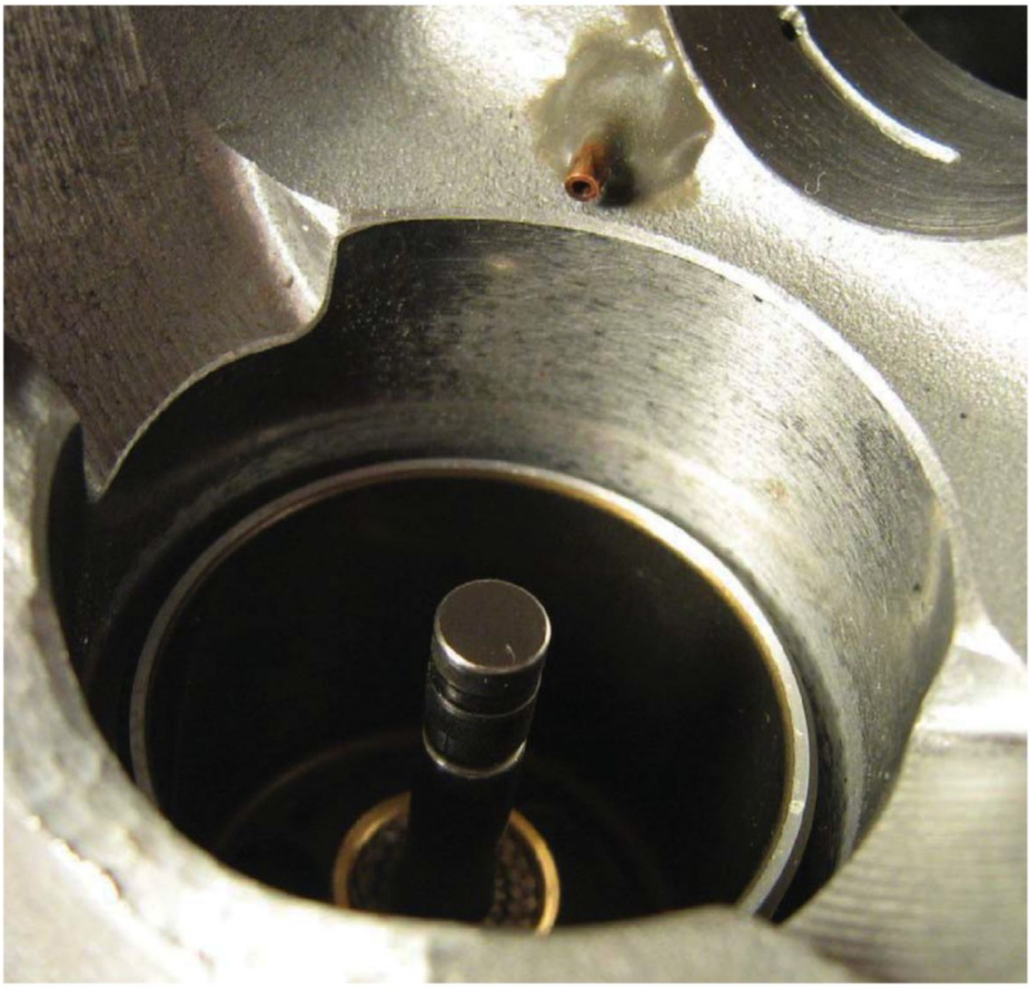


A critical part of the design of a Formula 1 engine involves the cylinder head, and the pneumatic valve has been a major breakthrough

single silicone model reveals not only the coolant distribution, but also how the cores are laid out within the main sand casting. In order to form the waterways within a cylinder head, sand cores need to be placed at exact locations within the main casting which later get washed out once the aluminium has solidified. These cores are made from special fine sand mixed with a binder agent which hardens once cured – binding the sand together. This enables the cores to be handled and placed accurately within the mould without fear of collapse. The cores are located on to 'core prints' in the main sand moulds – these are basically 'hangers' which hold the cores in place while the mould is being filled. Evidence of these hangers can easily be seen on the silicone model. They are also a common sight on nearly all road engines and become the locations of the frost plugs once the block or head has been finished and machined. The same can be seen on the F1 cylinder head where the locations of the core hangers have been drilled, tapped and plugged up with aluminium bungs. With this waterway core model you will also notice something else if you look closer – all the cores are identical across the full length of the head. This leads to even coolant distribution per cylinder, and it also means that only one small core box is needed to make all the cores. Once hard, they can all be bonded together ready for placing. While cores are indeed joined at the sides, which in turn form communication paths for coolant between galleries, the main flow takes place from bottom to top. The location of the core hangers on the core model, as well as the finished bung positions are displayed also. The location of the hangers on the end core lie in the same locations of the core behind it which is bonded to the adjoining core. Oil to the cylinder head is fed into the block into a large radial groove at the end cam journals. Here the oil enters the centre of the hollow camshafts through drillings where it then flows along the length of the cams and exits at each journal though more drillings to provide the necessary hydrodynamic lubrication. An oil groove is formed partway around the lower half of the cam journal, which takes some oil from the live oil drillings inside the rotating cam and feeds it out through small squirters aimed at the tappet and cam lobe surfaces. In-cam oiling also frees up space within the cylinder head casting that would normally be needed for oil galleries. It soon becomes apparent at this stage that high performance and reliability comes with great uniformity in terms of coolant and oil management.

The relationship between the intake and exhaust ports and the surrounding coolant passages can be displayed if another silicone model is taken. Since greater coolant flow is required around the hotter exhaust ports coolant from the block is introduced into the gallery directly below the exhaust port floors through two 8.5mm holes. On the intake side, coolant enters below just one intake port through one 5.5mm hole. The geometry at the highest point of the coolant gallery above the intake ports directs any trapped air towards the exit tubes leading to the tapered coolant pipe cast into the ladder style cam cover. In the case of this cylinder head, the valve centre lines are angled in both directions. While angling the valve centres on one axis is common on most engines, angling the valves on both axes is not. This offers advantages in that it opens up space for a wider journal located between the tappet bores, while at the same time giving more clearance between the bore wall and open valve face. This leads to a better and more stable oil film, and also cuts down on bore shrouding. The area surrounding the sparkplug also requires good coolant flow. One of the main reasons small diameter sparkplugs are used in F1 is to eliminate all chances of the material that makes up the counter-bore for the plug becoming part of the port wall material – which inhibits coolant

Above a certain rpm point, normal valve springs become useless – so pneumatic springs are called for



flow around this area. One last point the head designer needs to keep in mind when setting out the initial design and internal layout is the head studs, and of course access to the nuts. In the past, some F1 engines have featured a two-piece design where the main head section was first bolted on to the block, then a cam tray containing all the valve train was bolted on top of this. Had it been all cast as one unit, the location of valve train parts would have prevented access to head studs. This is less common nowadays since the point at which both parts meet was another possible leak area that also required considerable care when machining to closely match the two parts. It more often than not weighed more too – an important issue considering its distance from the roll centre.

This takes us to the pneumatic valve train. A normal wire spring, simply a torsion bar wound in coil form, can only have so much stress imposed upon it before it fails. You can increase endurance levels by going with beehive or indeed two springs. Springs go into resonance at a certain rpm, because they have mass and stiffness - valve bounce. Two springs allow different frequencies and an interference fit between the springs provides damping. Pneumatic springs are simply low rate, high static load, zero mass springs. To enable designers to cross this barrier, a different type of spring actuation was required in order to return the valve to its seat without float or spring failure at extreme rpm levels. Enter the pneumatic valve spring. The concept is relatively simple, however its execution is not. Inside an F1 engine, the demands on this assembly are far greater than seen in road cars, as you can imagine. Exotic materials and countless hours of testing are required to even get to prototype stages, and every year designs get improved on for better reliability. A pneumatic valve spring design, regardless of whether it sits under a tappet or finger follower, comprises of a cylinder and a piston. The cylinder is attached firmly to the head, while the piston is attached to the top section of the valve stem. Air under pressure supplied to the cylinder causes the piston to rise and return the open valve to its seat. This all sounds relatively simple until you consider the conditions these parts are required to work under. With the valves opening up to 150 times a second with an average lift of 15mm, at temperatures in excess of 100degC, piston seal choice and surface finish of sliding parts becomes a major chore in the research and development department. Engine failure, as mentioned at the start of this technical bulletin, more often than not originates from the failure of these seals – the system is charged from a tank of pressurised gas which is of fixed volume and is not regenerated onboard the car. A single leak therefore has disastrous consequences for the engine. All pneumatic cylinders are fed up from a continual drilling through the length of the casting. In total there are eight seals needed in each pneumatic valve spring assembly – two of which are sliding seals, the other four being static O-ring seal arrangements.

A single leak in the piston seals will have disastrous consequences for the engine

The first of the sliding seals is situated in the piston itself where it seals against cylinder bore, the second sliding seal resides in the top of the valve stem where it provides a seal with the valve stem. The other four seals are used around cylinder fixing holes, air feed hole, and valve stem hole through the piston. This amounts to a total of 80 seals just in the pneumatic spring assemblies alone. One of the most critical features with such dry sliding seal design we see here is surface finish on the bore walls. It must resist corrosion during periods while the engine is being built, being stored, or is in transit. The cylinder features hardcoat anodic coating internally and externally on the base. The outside has been machined down for tappet skirt clearance. The anodic coating also benefits in terms of lessening sliding friction when impregnated with PTFE. The beryllium copper valve guide contains a groove just below the cylinder sealing O-ring. Excess oil delivered by the tappet squirters finds its way down and flows in a channel cut into the piston base which is located at the highest point when mounted. It flows around the valve guide, further cooling the guide and valve stem before flowing back out at the lower groove. With this information now displayed it is easy to see why F1 engines will always remain a cut above the rest in terms of design, construction, materials, and innovation.

QUALITY AND RELIABILITY

HIGHER FLOW RATES
LESS FRICTION
MORE POWER

With more than 40 years of experience manufacturing high performance racing valves, Supertech utilizes the finest material and design to make available the most durable, high performance racing valves on the market today. Supertech valves are forged, CNC machined, and hand polished for strength and reliability.

All Supertech parts are measured against the strictest tolerances in the industry and utilize finite element analysis, enabling us to provide a high performance product, without sacrificing durability. Regardless of your high performance needs, Supertech is the best choice for you if quality, durability and performance are vital to your needs.

SUPERTECH 3580 Charter Park Dr. San Jose, CA. 95136 USA (408) 448-2001
www.supertechperformance.com

Achieving fluid movement

With additives placing ever-increasing strains on a car's plumbing, hose technology is moving with the times to provide reliability and durability

BY GEORGE BOLT JR

Hoses and fittings used in racing have evolved tremendously over the last 15 years, with many smaller, more specialist European and US manufacturers arriving on the scene to meet the needs of the evolving technology in the higher end racing series around the world.

The familiar stainless steel braided Nitrile rubber-based hose that evolved from surplus in the aerospace and military industries back in the 1950s is still in use by many budget race teams, but the rubber inner core has evolved over the years in an attempt to manufacture a product compatible with the harsh additives in today's fuels and synthetic oils. Non-braided rubber-based hose is also still used in lower pressure, and again by lower budget racing series and teams.

The arrival on the scene by PTFE, or the DuPont trademarked Teflon, has changed the face of racecar plumbing over the years. The Teflon name dates back to 1938, so it's not new, but it's a product that has no limitations in modern-day racing and is inert to all fluids used within a racecar. Another plus for PTFE inner core with oils typically running hotter is that Teflon is able to work up to 204degC. Although not much different to rubber hose in bend radius, a downside to PTFE hose is its lack of flexibility in larger 'dash' sizes, so some manufacturers have developed either fully convoluted or smooth inner and convoluted exterior hose, something that could not be designed into rubber-based equivelents. There are myths that convoluted hose causes turbulence and affects flow, which can be true, but data varies by size and only at very high flow rates – Top Fuel and Funny Car dragsters which can see 100 gallons per minute, for example. In 99 per cent of cases, the flexibility of the hose and the strength to prevent internal collapse under vacuum far outweighs any flow loss. Added to this, less hose is used due to a shorter bend radius, thus equalling less pressure drop. With more resistance to vacuum, convoluted hose has a further advantage over smoothbore hose, especially in dry sump oiling systems. PTFE conducts electricity, so many PTFEs use carbon in the manufacturing process to dissipate any static build-up.

Stäubli developed a custom dry break system which could be fully submerged in fuel cells to complement Gill's ultrasonic fuel flow sensor

THE SFS SOLUTIONS

SFS Performance not only design their premium-grade silicone rubber hoses to thrive on the extreme pressures and temperatures in high performance engines, but every one is made by hand.

The hoses are constructed out of the toughest polymers available, helping them to withstand temperatures from -60degC to 220degC and exposure to UV, water, ozone and oxygen. The hoses are also reinforced with polyester or Nomex, enabling them to tolerate much higher pressures than a standard black rubber hose. SFS Performance also specialise in high temperature ducting, aluminium hose joiners, hose clamps and performance tape.

Following successful trials in testing, the Airwaves Racing Motorbase BTCC team will be using Hydraflow's 14J21 next generation flexible fluid connector for critical under-bonnet applications. The 14J21 is interchangeable with existing clamshell connectors, and improvements include an integral safety strap, articulated hinges, thicker flanges and internal bonding wires. The results are increased performance, durability and safety with no weight penalty.

Oliver Collins, Motorbase Performance team manager welcomes the advancement in this area: 'We realise how much time can be lost during engine/turbo/radiator changes, due to fiddling with hose clips, and the 14J21's single-handed operation – even with gloves – makes life that much quicker and easier.'

The 14J21 series is offered in all tube diameters from 0.5" through to 4", with butt weld aluminium flanges and seals offered to complete the package. CAD models are also available upon request from worldwide distributors Specialty Fasteners & Components.

Smoothbore PTFE is commonly used in higher pressure applications, including brakes, clutch, power steering, air jacks and – in more recent years as pressures have increased – electronic controlled fuel systems. Pressure ratings of the hose decrease as bore increases, so some manufacturers produce a higher pressure-rated hose with thicker PTFE inner core and more strands of stainless steel braid to handle the extra working pressures.

Another advantage of the PTFE inner core is that it's lighter than the rubber-based alternative, so lightweight braids to replace the commonly used stainless steel have become widely used for lower pressure applications. Aramid braids of Nomex and Kevlar – also DuPont products – have long been used due to their higher temperature ratings, and more recently polyester and polymer-type braids have been used with success.

Hose ends have also evolved. Although the JIC or AN-style female nut that seats down on to a 37-degree adaptor is still very popular, port or boss O-ring hose ends, banjos and plug-in-style ends are becoming more widely used. The connection of the hose end to the hose has also evolved, from a simple push fit and hose or jubilee clamp, to the more familiar AN-style reusable threaded tail form and socket nut that simply compresses and seals the rubber hose between the two parts. With the introduction of PTFE hose, the most common way of connecting the hose end to the hose is by crimping with a specialised machine, although reusable-style hose ends are also used, often with a centre olive for sealing the harder PTFE material. Crimping hose ends is a more permanent and reliable way of sealing the hose to the end, with many manufacturers offering a custom hose service where teams can simply specify a hose assembly. Often, these assemblies are pressure tested and marked with a part number and date for ease of re-ordering

Hydraflow's 14J21 flexible fluid connector, designed for critical under-bonnet applications

FHS MOTOR RACING

With hydraulics controlling everything from KERS to the opening of the fuel filler cap on an F1 car, providing hoses and fittings that can cope with heat, vibrations and limited space is essential – and something that FHS Motor Racing have specialised in for over 20 years.

A racecar's hydraulic system is composed of flexible PTFE and metal lines. This combination allows the hose to withstand temperatures up to 260degC, while remaining strong and as small as 0.5mm in diameter. Specific to FHS is the innovative joining process, Swagetite, which permanently joins a flexible hose to a rigid pipe or a pipe to an end fitting. This process only leaves a single join, eliminating many problems found with welded or brazed methods, as Peter Hughes, managing director explains: 'Traditional processes need two joins – one where the weld is and one for the end fitting, increasing the risk of failure and it also requires more complex inspection, necessitating x-ray analysis, which takes time and is costly.'

Swagetite can be used on a range of diameters from 0.5mm to 12mm and is extremely durable, which has been proved off-track in the World Rally Championship and on-track in F1. 'Because of weight, package restrictions and a low oil mass, cooling is minimal,' says Hughes, 'So fluid can be at 100-135degC as opposed to half in some of our other industrial applications. This affects viscosity, the fluid as low as 3-4 centistokes at this temperature, so tolerances are crucial to prevent leaks.'

There are around 30 assemblies on a current F1 car, and FHS estimate that their technology can reduce the number of joints by two or three on each assembly – resulting in a 50 per cent weight saving.

FHS's most popular products are rigid titanium tubes combined with Teflon-lined flexible hoses. 'There are many challenges when supplying to motorsport, but we have found that the hydraulic applications on F1 cars are particularly demanding,' says FHS. 'All of the components have to operate within a very small envelope, which is normally very hot and subject to a high degree of vibration. To ensure 100 per cent reliability, we have developed extensive quality control measures for all the hose and filtration components we supply.

'We have been working for some time on the new design requirements of the 2014 F1 engines. The very nature of turbocharging increases temperatures by significant amounts, but we can provide high temperature sleeving barriers to ensure that our hose assemblies continue to operate reliably.'

and life tracking. This also takes the human element out of a possible failure equation from a team standpoint.

Angled hose ends all used to be three-piece, with a bent tube, a tailform and a 37-degree machined seat brazed to the bent tube. The male or female nut is then simply pinned on to the tube. Some manufacturers continue to use this type of end, but many have adopted the one-piece or billet hose end, which is a heat-treated machined tube, tailform and 37-degree seat. The one-piece fitting is much stronger, more reliable and often lighter than the brazed counterpart.

The male port hose ends can maintain the AN thread specifications, or metric thread is sometimes used in more modern or OEM crossover applications. Instead of a female nut, the hose end has male threads and an O-ring for it to seat against the mating surface. Using this type of hose end eliminates one extra joint – the AN adaptor – so it's essentially safer, less space consuming, lighter and more cost-effective. Plus, rather than the traditional metal-to-metal seating surfaces, it's a more reliable and modern way of sealing using an O-ring.

Plug-in hose ends are being seen more in the higher end racing series where custom orifices are designed into a project, often where space is at a premium. The orifice in an engine block, for example, is machined to a required tolerance with a taper at the opening for a hose end to simply insert into. The hose end itself is tapered on the front side with a groove for an O-ring machined partway down the male portion of the hose end. The hose end is then located in place by a keep plate or bracket with one or two set screws. Plug-in hose ends can also be used with a back-up ring or washer for higher pressure applications – above around 150 bar – although this does fluctuate depending on application and size. Although very reliable and almost fail-safe, plug-in hose ends are more technical than regular AN hose ends. Hardness and section of the O-ring, hardness of the hose end, temperature, port clearance, etc, can all play a part in the correct sealing process.

Wiggins hose ends are another form of fitting used to couple a hose to a part quickly without the need for a spanner or wrench. Wiggins clamps also evolved from the aerospace industry to be used widely in lower pressure (125psi working pressure) applications in motorsports. The clamshell design clamp is made from aluminium and stainless steel and has fingers that lock into place when the clamp is pushed around the hose end or custom weld-on fitting. The female Wiggins hose end or weld-on simply pushes into the male hose end or weld-on, with the male end housing an O-ring to form a tight seal.

Dry-break or quick disconnect type couplings have also made a presence in the fluid control system of many races cars in recent years, although many available are cost prohibitive to smaller race teams. The dry break couplings are the most expensive, but also the safest offering a no air inclusion, no fluid loss disconnect. They can be seen on brake hoses for fast caliper changes in endurance races and on fuel systems with a lanyard attached for a breakaway spill-free coupling in the event of car part separation during an accident. Other non-dry break couplings exist, but are just that. Non-dry break will, from time to time, leak fluid. These are often more industrial-looking couplings than the true dry break version, and can be used for water or oil systems. Many quick disconnects in the marketplace will cause a restriction in flow, so it's very important to check manufacturer data before installing them in-line within a system.

Hard lines, either stainless steel or aluminium – are being seen more where heat or space are at a premium. Some are hand bent, but at the more professional end of our sport, CNC bending is becoming very popular for repetitive manufacturing. Oil and water are the most common systems for hard lines and they can be coupled to flex hose with the appropriate weld on end, mating to Wiggins clamps, AN flare or a crimp-on hose tail form, so the hose is literally crimped to the tube. NASCAR, for example, introduced a rule several years ago removing hot oil lines from inside the cars and mandated the use of stainless steel tubes under the car. These are then connected to the engine mounted dry sump pump and rear mounted oil tank via flex lines.

Hard lines, in steel or aluminium, are being seen more where heat or space are at a premium

GOODRIDGE PRODUCTS

Providing a Total Team Concept (TTC) approach to the global racing market, Goodridge's products offer major advantages for a vast range of motorsport sectors including NASCAR, F1, IndyCar, Moto GP, IPL, NHRA, WSB, BSB, Superstock, GT, F2, F3, Supersoft and WRC.

The G-Line XF smoothbore hose provides the best flow characteristics of any hose and is utilised by top engine builders. Another successful product is the G-Flex convoluted hose, which lays claim to being one of the most durable, flexible, lightweight hoses offered in the racing market.

Jamie Ramsden from Goodridge elaborates: 'The G-Flex 511 and 711 Series has become an instant success in all forms of racing, motorsports, and is compatible with any fuel type. It has a thin wall 100 per cent PTFE carbon impregnated, fully convoluted inner core. Customers have a choice of the ultra-durable stainless steel or the super tough Aramid outer hose covering.

'The new Goodridge range of fittings have been designed with a one-piece construction, high flow tail forms, and machined nuts to save every ounce of weight possible. The high output engines and dynamic chassis designs demand the absolute most in flow and flexibility from the hoses that supply the lifeblood in the vehicles.'


ATL
AERO TEC LABORATORIES LTD
FUEL CELLS
FIA-Approved Fuel Cells for Race & Rally
FIA APPROVED
REFUELLING EQUIPMENT
Stockists of Red Head & Stäubli Refuelling Equipment
FUEL SYSTEM SPARES
Your One-Stop Fuel System Shop
WWW.ATLLTD.COM
sales@atlltd.com
+44(0)1908 351700

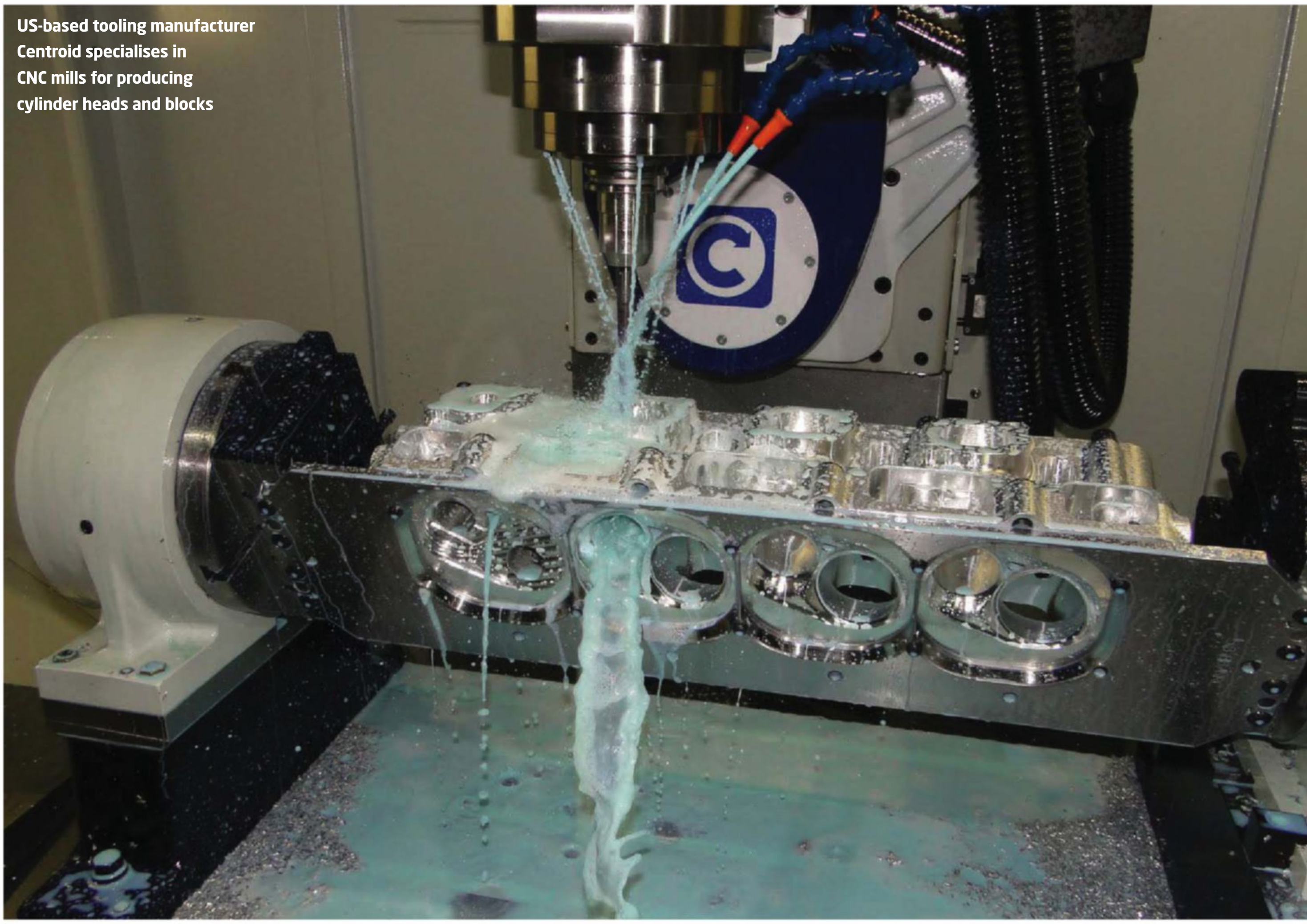

ASTON MARTIN RACING
Gulf
Ontime
prodrive
Goodridge fluid transfer systems, built to last
lap after lap, race after race
en•dur•ance
noun
the ability or strength to continue or ... stress, or other adverse conditions;
• the capacity of something to last or to withstand wear and tear.
ORIGIN late 15th cent. (in the sense [continued existence, ability to last] ; formerly also as indurance): from Old French, from endurer 'make hard' (see ENDURE).
PUSH THE LIMITS
MOTORSPORT INDUSTRY ASSOCIATION
ASTON MARTIN RACING
OFFICIAL SUPPLIER
GOODRIDGE
FLUID TRANSFER SYSTEMS
GOODRIDGE LTD, EXETER, EX5 2UP, ENGLAND
www.goodridge.net
UK • USA • GERMANY • FRANCE • HOLLAND • SPAIN • JAPAN


CNC Heads, Blocks, & Parts
One Machine, One Fixture
A560XL
Port Block
CENTROID
Performance Racing
5-Axis
Patent Pending
• Turn-key Port Block package
• Create all kinds of parts
• No fixtures to swap or realign
Chad Mullins,
Mullins Race Engines
Videos Online
CENTROID™
Performance Racing
email: jcowher@centroidcnc.com
Call (814) 353-9256 x101
www.CentroidPerformanceRacing.com


5 Axis CNC Cylinder Head Digitizing & Porting Machine
ROTTLER
THE CUTTING EDGE
Complete CNC porting system with training
The easiest, fastest way to copy, reproduce and improve your race winning cylinder heads.
P69
Unique Windows Touch Screen Digitizing and Porting Software
allows fast learning and easy modification of port design. Change port design and improve airflow with cross sectional area measurement software.
CNCHEADS UK is the latest customer to order a P69
CNC Heads from Stockport, Manchester will soon receive their new Rottler P69 Digitizing and Porting Machine.
Visit our Web Sites at
www.rottlermfg.com
www.youtube.com/rottlermfg
Tel: +1-253-872-7050 • 1-800-452-0534
8029 South 200th Street • Kent, WA 98032 USA • contact@rottlermfg.com

Rise of the machines

While 3D printing hits the headlines, the latest generation of traditional machining tools is providing complex solutions fast – perfect for the racing industry



US-based tooling manufacturer Centroid specialises in CNC mills for producing cylinder heads and blocks

BY LAWRENCE BUTCHER

The big thing in machinery technology for the racing industry is without doubt the emergence in recent years of rapid prototyping and other rapid manufacturing processes. However, the field of traditional machining is still thriving and has been subject to many new developments, most notably in the area of five-axis milling activities. These developments have encompassed both the level of component complexity which can be produced on such machines and the levels of productivity these machines can provide a team or manufacturing company.

Five-axis milling machines have been the norm for manufacturing complex metal and epoxy parts for many years, yet advances in CAM software and the automation capabilities of machines are constantly increasing their functionality. Five-axis mills operate on the regular x, y and z axes, but can also move on axes known as c and b. The c axis is one around which the work piece itself can be turned, allowing for asymmetric turning operations, while the fifth – or b – axis takes into account the tilt of the tool bit.

This combination of five axes of freedom allows for very complex shapes to be machined which previously would have been either impossible or would have required several separate operations. Depending on the type of machine used, orientation of the work piece is achieved in one of two ways – either the work piece table is pivoted to allow movement in three dimensions, or the tool bit is mounted on a gimbal head to provide articulation.

The disadvantage of multi-axis machining centres is the time it takes to complete complex operations and the programming required to achieve them. However, advances have been made in CAM software to optimise tool paths to minimise the time the tool spends 'air cutting', where the tool is spinning but not cutting any material, and some of the latest packages allow for rapid roughing out of components using only three axes to reduce process time. *Racecar* spoke to three machine tool manufacturers to find out how they are improving and optimising their products to meet the singular demands of the racing market.

US-based machine tool manufacturer Centroid has been producing dedicated CNC mills for the racing market for many years, with a particular emphasis on tools for producing cylinder heads and blocks. The latest addition to its range is the A560 XL, which allows engine builders to complete both block and head milling operations on the same machine. 'It is really useful to be able to move between block and port machining without having to change your machine setup,' explains Jesse Meagher of Centroid. 'An engine shop may have a customer with a cylinder block to machine in the morning and another wanting head work in the afternoon. The process of swapping the fixtures used to take a considerable amount of time. Removing that wasted time means they can take on more work for more customers.'

Centroid's A560 XL allows engine builders to complete both block and head milling operations on the same machine

An example of Yamazaki Mazak's multi-tasking Integrex range, which can complete turning and machining operations all on one machine

NEW REALISATION

Machines such as the A560 do not just provide engine manufacturers with a more efficient production package. When combined with advanced CAM software they can lead to the realisation of previously impossible design ideas. 'Packages like Master Cam have really revolutionised what you are able to do with these machines,' says Meagher. 'We have developed our machine along with their software and it has had a knock-on effect on what our customers are now able to do. In the past, maybe the most extravagant thing they would do with their machines was boring some lifters. Now, they have the capability with the same package to manufacture complete billet blocks or heads.' This increase in accessible capability has seen billet heads emerge as the latest must-have within the US motorsport market. The design freedom they provide over either modifying traditional cast heads or producing new castings has seen tuners extract ever increasing levels of power from classic V8 engines – still the staple of the circle track and drag racing markets in the US. However, Meagher is keen to point out that thanks to the increase in capability of the machines and software, the growing complexity of machining operations does not place a greater burden on the manufacturers. 'The parts have been able to become much more complex than they were even a few years ago, but in reality they are no more difficult to manufacture. It is simply an improvement in the control systems that the machines use.'

Another company at the heart of engine manufacture and re-manufacture is Washington, USA-based Rottler. The company supplies machine tools to a host of industries, but like Centroid, produces a range of tools aimed squarely at the motorsport market. Where some smaller engine shops may not be able to justify the investment in an all-in-one machine such as the A560, machines such as Rottler's P69 – a mill designed specifically for cylinder head porting work – may be the answer.

The P69 has some neat features, the most useful of which, from an engine builder's perspective, is the ability to rapidly reverse engineer cylinder head port designs. Digitising, as the process is referred to, is done automatically on the machine using a Renishaw probe, eliminating the need for an expensive co-ordinate measuring machine (CMM). All of the programming and measurement can be controlled using the machine's touchscreen controls, which feature a standard Windows interface. The result is that a port design can be developed on the flow bench, where hand modification is still the most efficient method for creating subtle geometry changes. The optimum design can then be rapidly replicated on the CNC machine, without ever having to sit down at a CAD workstation. Theoretically, this allows a cylinder head specialist to have their latest port design in production the same day that they finish testing it.

> **"Machine and software development has had a knock-on effect on what our customers are now able to do"**

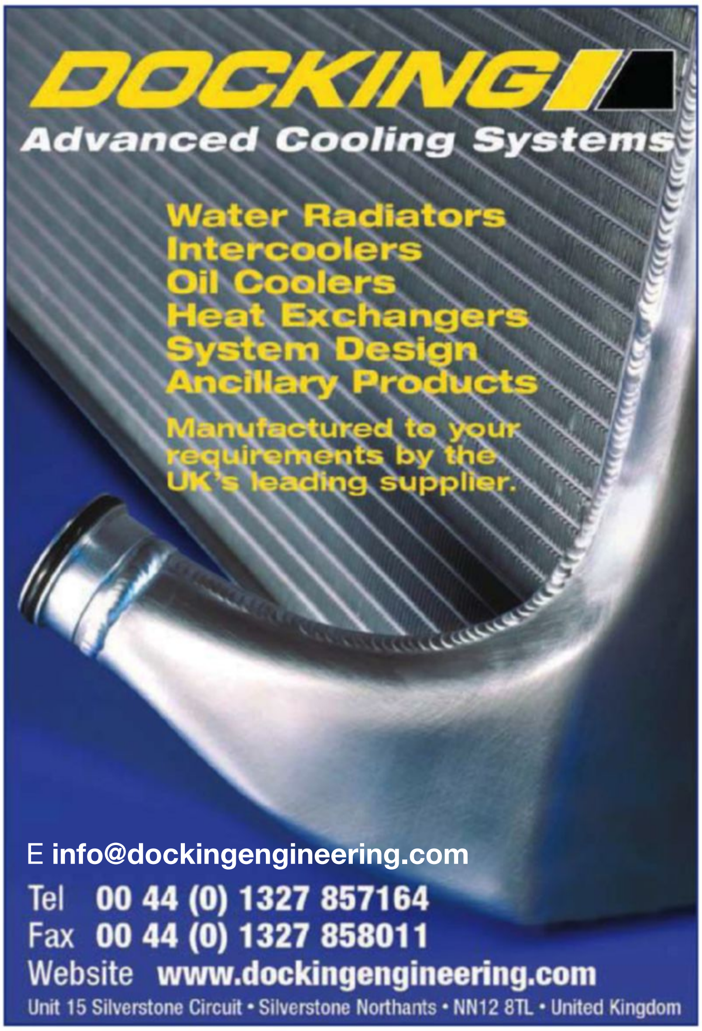
MULTI-TASK MACHINES

For companies looking beyond 'simple' engine machine work and small batch runs – for example, those involved in relatively high production runs of complex machined parts – a new generation of so called 'Done-In-One' machining centres offer a potential route to efficiency and cost savings. Machine tool manufacturer Yamazaki Mazak has recently launched the seventh generation of its successful Integrex range of multi-tasking machines, the I-series. Mazak was the first company to produce a machine that could complete all turning and machining operations from raw material to finished component in one setup and on one machine. These machines are geared towards larger production volumes and can accommodate features such as palletised loading of billets and full 'lights-out' automation. Tony Saunders, UK sales director for Yamazaki Mazak, commented: 'The new Integrex I-series is a complete redesign of the previous Integrex machine, not just a cosmetic makeover. We have listened and consulted with our customers to ensure that the new I-series responds to all of their machining requirements.' Though they represent a considerable capital investment, a machine such as an Integrex I series will be just as happy producing complex differential housings one day as it would crankshafts the next, without ever having to swap the components in question from one machine to another. Essentially, if a machinist can work out how to hold a work piece in the machine, they can machine it.

Despite the growing capabilities of additive manufacturing processes, the demise of the faithful CNC machine is a long way off. Recent advances are opening up new development paths and allowing engineers access to previously unobtainable manufacturing capabilities.


AERODINE
COMPOSITES GROUP
ADVANCED COMPOSITE TECHNOLOGIES
FAA CERTIFIED REPAIR STATION RDMR624X
STRUCTURAL COMPOSITE ENGINEERING
PRODUCT & TOOLING DESIGN
CAD/CAM
FINITE ELEMENT ANALYSIS
PROTOTYPING
MANUFACTURING
STRUCTURAL REPAIR
Serving the Motorsports Industry Since 1989
www.AerodineComposites.com
Tel. +1 001.317.271.1207 • Fax. +1 001.317.271.4455
8201 Indy Lane, Indianapolis, IN 46214


ECU/Exchange Loom/Throttle Body Packages available
Complex modern engine?
We can manage it
ECU solutions for:
Honda S2000 and K20A
Ford ST170 and Duratec
Toyota 2ZZ
BMW Single / Twin VANOS
Audi 1.8T and 5 cylinder
Chevrolet LS7.
DTA fast
Our ECU's are capable of dealing with the most complex of modern engines without the need to change sensors or sacrifice key features such as variable camshafts.
S series
Get the very best from any engine and from only £495.00 + VAT.
DTAfast, 10 Boston Court, Kansas Ave, Salford M50 2GN
Tel: +44 (0)161 877 1419
Fax: +44 (0)161 877 7086
Email: office@dtafast.co.uk
Website: www.dtafast.co.uk


DOCKING
Advanced Cooling Systems
Water Radiators
Intercoolers
Oil Coolers
Heat Exchangers
System Design
Ancillary Products
Manufactured to your requirements by the UK's leading supplier.
E info@dockingengineering.com
Tel 00 44 (0) 1327 857164
Fax 00 44 (0) 1327 858011
Website www.dockingengineering.com
Unit 15 Silverstone Circuit • Silverstone Northants • NN12 8TL • United Kingdom


NEW: KMS Electronic Throttle Body Control
KMS
Kronenburg Management Systems
For more information, free software and prices:
kms.vankronenburg.nl
Join us on Facebook and YouTube:
www.facebook.com/KronenburgManagementSystems
www.youtube.com/KronenburgAutosport

Mathematical reasoning – a must for engineers

Don't just turn to a computer and hope for the best – work the problem yourself

BY DANNY NOWLAN

Recently I have been working with a number of junior engineers at both senior undergraduate and junior postgraduate levels. While their enthusiasm has never been in question, their lack of ability to carry out hand calculations and to reason mathematically is a real cause of concern. The first area motivated an article I wrote a couple of months ago on the joy of hand calculations. Here I'm going to discuss how to reason mathematically.

If you are serious about being a capable engineer in any discipline, this is a must-have skill. When many junior engineers are given a problem, their first instinct is to plug the numbers into something like Solidworks or ChassisSim, hit a button and hope it solves their problem. Don't get me wrong – these are very powerful pieces of software, but if you use them blindly with no idea of the underlying principles, you can find yourself reaching the wrong conclusion. I could give you countless examples of engineering disasters that could have been averted if the time had been taken to have a proper think about the problem in the first place.

To illustrate this, let's consider our first example, which is the conversion of roll bar rates from moment per deg to a spring rate. At first this might seem a little mundane, bordering on the trivial, but it serves as an excellent primer. The problem we need to solve here is how do we convert a bar rate quoted in Nm/deg to an equivalent spring rate in Nm? The answer is not as hard as you might think.

Our first port of call is to calculate the moments generated by the bar for a given spring rate and a roll angle. The force given by the bar can be expressed as shown in **Equation 1** over the page.

There we have:

F_b = force on the roll bar
k_b = bar rate in N/m
t = track width in m
q = roll angle in radians
MR = bar motion ratio (bar movement/wheel)

To keep this discussion simple, let's assume the bar rate and motion ratios are linear. The next step in the process is to calculate the moments being generated by the bar. We have two forces providing moments in equal and opposite directions. Assuming the centre of gravity is in the middle of the car, we may write **Equation 2**.

Here:

M = Rolling moment (Nm)

What we now need to do is to manipulate **Equation 2** to get it to reveal what we need. Dividing **Equation 2** by the roll angle we see **Equation 3.**

And so we are almost there. We have our measure of roll moment per degree expressed as a function of bar rate. However, there is just one last trick. The supplied measure we have is in Nm/deg. What we have in **Equation 2** is in Nm/radian. This is easily fixed. The trick comes from recognising that 1 deg is $\pi/180$ radians. Doing the numbers we arrive at **Equation 4.**

So subbing **Equation 4** into **3** and making k_b the subject we arrive at **Equation 5**.

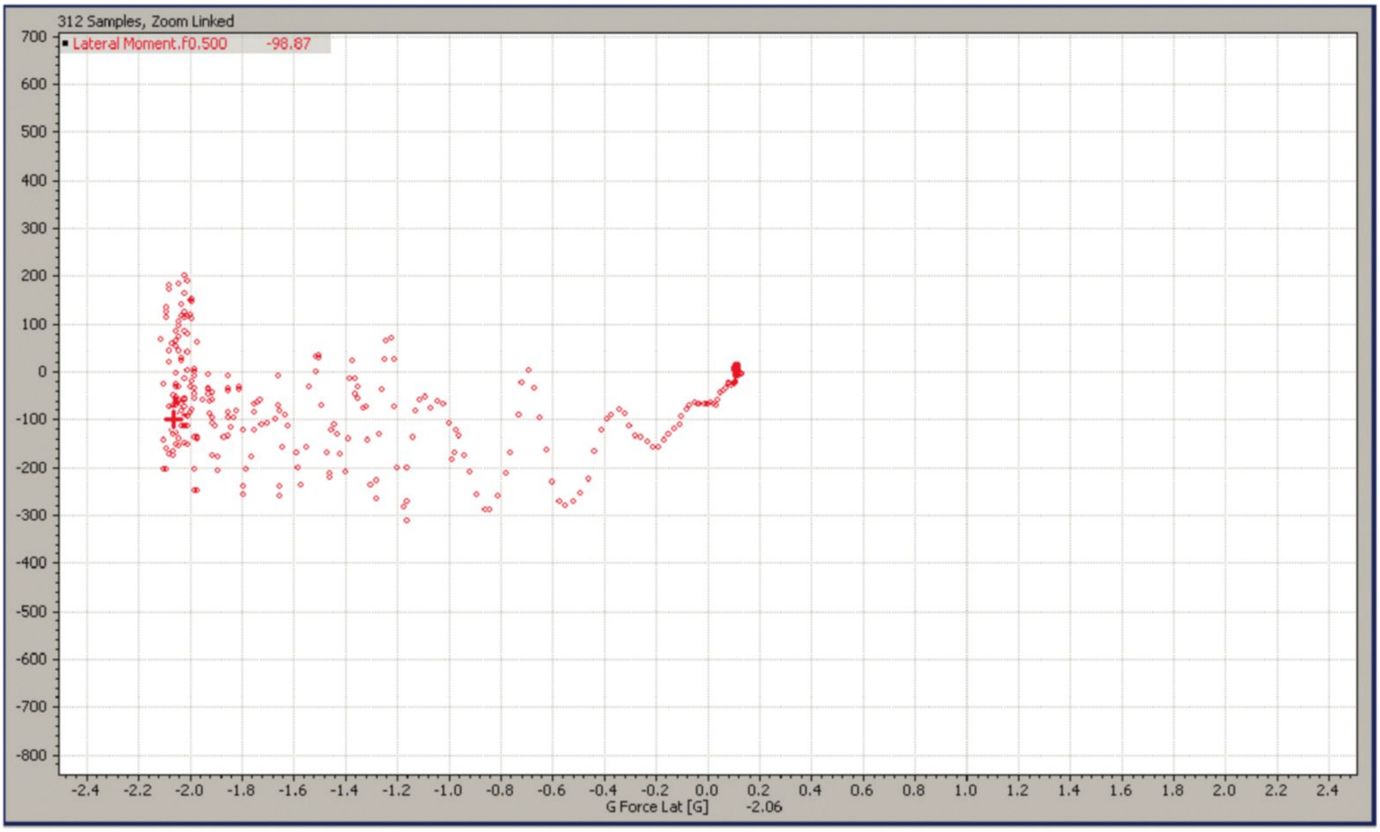


Figure 1: plot of lateral moment vs lateral acceleration

EQUATIONS

Equation 1

$$F_b = k_b \cdot MR \cdot t \cdot \frac{\phi}{2}$$

Equation 2

$$M = 2 \cdot MR \cdot F_b \cdot \frac{t}{2}$$
$$= 2 \cdot MR \cdot k_b \cdot MR \cdot t \cdot \frac{\phi}{2} \cdot \frac{t}{2}$$
$$= k_b \cdot MR^2 \cdot \frac{t^2 \cdot \phi}{2}$$

Equation 3

$$\frac{M}{\phi} = k_b \cdot MR^2 \cdot \frac{t^2}{2}$$

Equation 4

$$\frac{M}{\phi} = \frac{M}{\deg \cdot \pi/180} = \frac{180}{\pi} \cdot \frac{M}{\deg}$$

Equation 5

$$\frac{M}{\phi} = k_b \cdot MR^2 \cdot \frac{t^2}{2}$$
$$\frac{180}{\pi} \cdot \frac{M}{\deg} = k_b \cdot MR^2 \cdot \frac{t^2}{2}$$
$$k_b = \left(\frac{180}{\pi}\right) \cdot \frac{M}{\deg} \cdot \left(\frac{2}{t^2 \cdot MR^2}\right)$$

Equation 5A

$$k_b = \left(\frac{180}{\pi}\right) \cdot \frac{M}{\deg} \cdot \left(\frac{2}{t^2 \cdot MR^2}\right)$$
$$= 57.295 \cdot 2000 \cdot \left(\frac{2}{1.6^2 \cdot 1^2}\right)$$
$$= 89525 N/m$$
$$= 89.53 N/mm$$

Equation 6

$$stbi = \frac{\partial N}{\partial a_y} \cdot \frac{1}{m_t \cdot g \cdot wb}$$

Equation 7

$$N = m_t \left((1 - wdf) \cdot a_{yf} - wdf \cdot a_{yr} \right) \cdot wb \cdot g$$

And there you have it, a surefire way of calculating a bar rate given a bar rating in Nm/deg. Crunching an example calculation assuming a bar moment of 2000 Nm/deg, a motion ratio of 1 and a track width of 1.6m, we have **Equation 5A.**

The great thing about this is that it wasn't rocket science. We started off with a statement of the problem and using some very simple manipulation we have come up with a very powerful tool.

The next example that's really useful involves using data analysis and our knowledge of calculus to nail down car transient stability. When one mentions the dreaded calculus word it sends people running for the hills in pure terror. I actually think that's hilarious because calculus at its core is all about measuring slopes and calculating areas. That's really all there is to it. The discussion we are about to partake in is about calculating slopes.

Calculus at its core is about measuring slopes and calculating areas

Car transient stability can be articulated by a concept known as the stability index. Mathematically this can be quantified as shown in **Equation 6**, where:

stbi = **the stability index**
N = **sum of yaw moments acting on the car (Nm)**
a_y = **lateral acceleration of the car (g)**
m_t = **total car mass in kg**
g = **acceleration due to gravity (9.8m/s2)**
wb = **car wheel base in m**

What the stability index measures is a non-dimensional measure of the distance between the centre of the lateral forces and its moment arm from the cg. It will return this as a percentage divided by 100. The idea is that negative is stable and positive is unstable.

There are two ways you can measure this. The first way is to have lateral accelerometers fitted on both ends of the car. In this case, the moment N being generated is given by **Equation 7**.

The term wdf is the front weight distribution of the car as a percentage divided by 100. The great thing about **Equation 7** is that it is one of the most straightforward math channels you'll ever put together. The next trip is to plot this against total lateral acceleration and take the slope. This is illustrated in **Figure 1** on p77.

The great thing about this plot is that it gives you the stability index. Also remember the sign of your lateral acceleration. If you have a_y being measured as positive for a left hand turn you'll have to multiply the slope by -1. At an instant you can see what is going on. At low lateral g, the car is quite stable, but as we push the plot becomes more wavy, indicating we have some work to do at high speed. This is not surprising given that this is a simulated plot.

The other way of doing this is to plot yaw rate as a function of total lateral g. From the equations of motion it is seen that the time derivative of yaw rate is the total lateral moment. Consequently we can infer lateral moment by taking the derivative of yaw rate and multiplying it by the Z axis of the second moment of inertia. The trick is to filter the yaw moment derivative.

The great thing about both of these approaches is it gives you are surefire driver lie detector. You ignore a tool like this at your peril in the modern motorsport environment.

The last example I'd like to talk about was one of the most extraordinary technical discussions I've had in recent years. Unfortunately, it was notable for all the wrong reasons. It centred on the discussion of aerodynamic-induced rollover of a racecar. This is a problem that plagues modern sports prototypes. Anyway this discussion tried to apply this to a FSAE car and you should have seen the encouragement to do detailed CFD studies of this scenario. I forwarded it on to colleagues of mine who were senior aerodynamicists in various senior categories, and they where in stunned disbelief at what they where reading.

To discuss why this discussion was so off the mark, it would be wise to do some rough approximations to the mechanisms of what happens in an aerodynamic

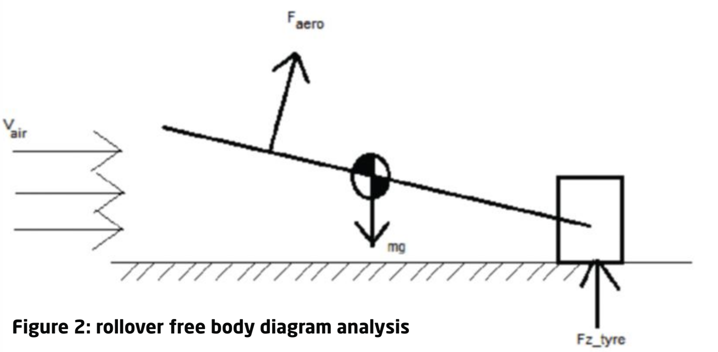


Figure 2: rollover free body diagram analysis

induced rollover. What happens here is that a car gets sideways at speed, the aerodynamic downforce reduces, it hits a bump, the underbody gets exposed to the open airflow and the car cartwheels over.

We can put some basic numbers to this to see whether we have a problem or not. This situation is summarised in the free body diagram shown in **Figure 2** above.

To keep this discussion simple I'm going to assume that the car has gone sideways, so it isn't producing any downforce. As we can see we have two major forces in play. The first is the lift being produced by the underbody as a result of being exposed at an angle to the airflow. This will be applied at the quarter chord or track point. This is what is going to roll us over. The thing that is keeping us in check is the weight of the car. What we need to do is to take moments about the tyre still on the ground. If the aerodynamic moment exceeds the moment produced by the car's weight, it will flip over.

The trick here is to come up with an approximation for the aero forces. Our goal right now is not to try and predict the rollover moment – we just want to see whether we have a problem that needs to be dealt with.

We can look at some typical CL vs angle of attack plots of an air foil to get some ballpark numbers. As rough as this may seem, in this rollover situation this is pretty much what we are dealing with. In terms of some rough dCL/dα numbers (α being in radians) 2π is an OK place to start from. Since this is a non-ideal airfoil, let's approximate dCL/dα at 5. To further flesh this out, let's assume we've hit a bump and the angle of attack is, say, 50. Given that a typical underbody area of a sportscar of 10m^2, the aero forces we are going to generate will be given by **Equation 8**.

Let's assume the car width is 2m and the car weight is 1000kg. Taking moments about the tyre we see **Equation 9**. We are going to have problems when **Equation 9** is equal to 0. Putting **Equation 8** into **9** and solving for the zero condition we see **Equation 10**.

So what all this tells us is that at 180km/h we are prone to aero induced rollover. In reality it's a little bit more than that – usually about 220-240km/h in most circumstances. However, as a ballpark figure, this indicates a situation we need to consider quite seriously.

Let's now see how these numbers look for a FSAE car. Using the same aero figures as the sports prototype – which may I say is giving the aero rollover scenario the considerable benefit of the doubt – we have the following numbers for a FSAE car:

Parameter	Qty
Total mass	250 kg
Width	1.5m
Floor Area	2 m2

So, reviewing **Equation 8** for the FSAE car we arrive at **Equation 11**. And plugging this into our analysis for **Equation 10** we get to **Equation 12**.

What this all means is that we can expect to see an aero rollover situation for a FSAE car at approximately 200km/h. Given that a FSAE car is limited to approx 110km/h, it would be impossible for this to happen. I should also add in sideways view that a FSAE car has all the aerodynamic attributes of a brick, so if we really wanted to get aggressive with this analysis the predicted rollover speed would go up quite significantly.

At this point it would be wise to give you some pointers about how I go about problem-solving. Start off by stating your known variables and unknown variables. Then think about what class of problem it is and write down all the relevant equations. You then work the equations to solve for the unknowns. Remember too: computers are powerful tools, but nothing replaces using pen/pencil and paper to help you solve a problem.

In closing, we have presented three separate but quite pointed examples about how to use mathematical reasoning to get on top of motorsport problems. The common thread in all of these has been to take some basic first principles, put equations to them and then plug in the numbers to quantify where we are at. It may not give you an exact answer, but it will sharpen your instincts so you know what you're looking for. Develop this skill, and it will serve you well throughout your career.

EQUATIONS

Equation 8

$$F_{aero} = \left(\tfrac{1}{2}\right)\cdot\rho\cdot V^2\cdot C_L\cdot A$$
$$= 0.5\cdot 1.225\cdot V^2\cdot 5\cdot\left(\frac{5\pi}{180}\right)\cdot 10$$

Equation 9

$$M = F_{aero}\cdot\frac{3}{4}\cdot t - m\cdot g\cdot\frac{1}{2}\cdot t = t\cdot\left(F_{aero}\cdot\frac{3}{4} - m\cdot g\cdot\frac{1}{2}\right)$$

Equation 10

$$F_{aero}\cdot\frac{3}{4} = m\cdot g\cdot\frac{1}{2}$$
$$V^2 = \frac{2}{3}\cdot\frac{mg}{2.67}$$
$$V = \sqrt{\frac{2}{3}\cdot\frac{mg}{2.67}}$$
$$V = \sqrt{\frac{2}{3}\cdot\frac{1000*9.8}{2.67}}$$
$$V = 49.467m/s = 180km/h$$

Equation 11

$$F_{aero} = \left(\tfrac{1}{2}\right)\cdot\rho\cdot V^2\cdot C_L\cdot A$$
$$= 0.5\cdot 1.225\cdot V^2\cdot 5\cdot\left(\frac{5\pi}{180}\right)\cdot 2$$
$$= 0.534\cdot V^2$$

Equation 12

$$V = \sqrt{\frac{2}{3}\cdot\frac{mg}{2.67}}$$
$$V = \sqrt{\frac{2}{3}\cdot\frac{250*9.8}{0.534}}$$
$$V = 55.3m/s = 199km/h$$

Reverse engineering

Take away all the great motorsport innovations of recent times, and you arrive at an interesting, if daunting, place...

BY PETER WRIGHT

I had a strange dream the other night, but maybe it could be classed as a nightmare depending on your viewpoint: motorsport without CFRP, downforce or computer simulations. These three technologies are indisputably the most significant in motorsport in the last 50 years. All of them emerged during the 1960s and 1970s and were becoming mainstream by the 1990s. Today one can only imagine motorsport without them.

Suppose the research carried out at RAE Farnborough in 1963 had only produced a fibre with lightweight stiffness, but so brittle that its use was severely limited. Suppose that downforce had been banned at its inception in the 60s and 70s – wings, fans, skirts, underbody shaping, exhaust blowing, the lot. You can't uninvent aerodynamics any more than you can tell birds they can't fly, so let's assume it was just plain banned. Finally, suppose that the Bell Laboratory's experiments to replace valves had not led to the transistor, and silicon simply meant a beach somewhere. How would motorsport engineering have developed along alternative paths, and how would racecars look now?

None of these crucial technologies originated in motorsport. They were all borrowed from other disciplines, chiefly aeronautics. CFRP is now the material of choice for a racecar designer – it's the primary structure in the form of monocoque, bodywork, wings, suspension, gearbox case, brakes, ducts and brackets. Metals are only used where the combination of strength and temperature exceeds those of the latest resin matrices available, most notably inside the engine, and for fasteners. Regulations have prevented CFRP being applied to such other areas as the main engine structure and wheels.

Gliders were among the first aircraft to adopt composite primary construction and quickly embraced carbon when it became widely available. Now Boeing has built a commercial airliner almost entirely from CFRP. The easiest way to see how racing car structures might have evolved without CFRP is to look at both military and commercial aircraft metallic construction up until the onset of composites.

One of composite's advantages is the ease with which the material can be built up locally to suit the loads it must support. With metallic structures, the opposite process takes place: machining away unwanted material where it is not needed to produce the lightest possible components. This is a long-winded and expensive process, even when automated. CNC machining, chemical milling and EDM are all used to make the individual components that make up an aircraft primary structure, and then joined together using a variety of techniques. Concentrated loads are fed into the structure at appropriately designed nodes – equivalents to suspension and engine/transmission mounting points being wing mountings, undercarriage, weapons hard points, and engine mounts.

The aircraft industry has developed mechanical jointing and fastening technologies to a high degree of sophistication, rivets and bolts being the most universally employed, often with the addition of bonding between overlapped parts. Welding of thin components is difficult, though the Russians have taken welded titanium structures to a high degree of sophistication. A few years ago, an American small business jet start-up company planned to

Computer-based techniques have bred a new kind of engineer, more interested in simulation results

ALL IMAGES: LAT

Take away composites, and aluminium bodywork – used here on the Auto Union C in 1938 – might still be widely used

Without wind tunnel data or sophisticated simulation, today's racecars would look quite different. Maybe the look of the Porsche 917 would be the norm…

stir-weld the aluminium structure of its aircraft, the Eclipse 500, using a process developed by the UK's Welding Institute. I don't believe it made it to production, but the technology, along with other sophisticated welding techniques, is in use in the aerospace industry. Investment cast, precision and complex nodes, all joined together by chemically milled and hydroformed aluminium panels are a possibility. Suspension members would be fabricated in steel and perhaps titanium, gearboxes investment cast in titanium or aluminium. Suspension would be simple streamlined section tube as any downforce influence is, of course, banned. Bodywork would be aluminium where lightweight was more important than cost; GRP where cost dominated. Carbon brakes would not be necessary.

With downforce banned, drag would dominate the aerodynamicists' minds (you can't ban aerodynamicists… or can you?). Quite how they would ignore the lift component of their wind tunnel measurement is difficult to imagine, but a strict set of rules and the means to enforce them would be necessary, perhaps using independent measurements. Really understanding the drag of the car, open or closed wheels, open or closed cockpit, cooling systems, brake cooling, exhaust gas flow etc would provide useful technology for road cars. Of course, the cornering and braking performance of the cars would be much diminished, dropping from a peak of nearly 5g to under 2g on soft compound tyres. And of course, overtaking would not have been compromised by downforce. A better place?

Computers are simply fast calculating machines, with the ability to store large quantities of input data, and to store results and manipulate them into complex graphical images for interpretation. The speed of calculation has enabled the dynamic motion of complex mechanical systems to be split down into smaller and smaller time increments such that the interactions of all the parts of the system can be simulated. Also, structures can be represented as millions of tiny elements, and the way in which they interact with their neighbours, as the structure is loaded, can be calculated and analysed. Surfaces can be broken down to similar tiny elements and their effect on the fluid in which they are immersed can be assessed. Therefore dynamic systems, fluid dynamics, heat transfer, stressed structures, machine tool paths, business plans, strategic exercises, human responses etc can be simulated, and 'what ifs' performed inside computers in much less time than it would take to perform in reality – and at much less cost. Even adding hardware into the simulation loop, the most notable being driver simulators, is still quicker and cheaper than actual testing.

Motorsport has embraced simulation, and its associated validation technologies: data gathering and analysis.

Overtaking would not have been compromised by downforce. Would this be a better place?

These computer-based techniques have bred a new kind of engineer, less interested in hardware, more interested in sophisticated software and the interpretation of simulation results. These engineers are highly educated and effective from a young age. Without these technologies, the more traditional engineer, with a longer-term education to gain the breadth of experience necessary to design a successful racing car, would be in the greatest demand.

The cars would be simpler because the complexity of a modern racing car cannot be imagined without simulation. Race fans might be able to understand them and so appreciate more of the sport. I do not believe motorsport would be less appealing, exciting, interesting, or entertaining without CFRP, downforce and simulation, but life would be less fulfilling if man ceased to strive to progress. So if carbon fibre, Bernoulli's equation and the transistor had all turned out to be blind alleys, something else would have worked.

Audi getting on-track to boost car sales in the US

Audi is looking at a wide ranging US motorsport programme which could encompass United Sportscars, Indycar and the new DTM America, as it attempts to claim a larger share of the flourishing German car market in the States.

Wolfgang Durheimer, Audi's new research and development boss, has been quoted by media on both sides of the Atlantic as saying that the German marque is currently in the process of evaluating its future US programme, and that a decision on its direction in the US could be made as early as this summer. If this is the case, Audi could conceivably be on the grid for the all-new combined Grand-Am/ALMS United Sportscars, probably in the Prototype class, as early as next year.

Yet while there has been talk of Audi involvement in United Sportscars for some months, it was not widely known that the company was also interested in IndyCar, although Volkswagen – which is part of the same group and also has its motorsport programme overseen by Durheimer – was involved in the formulation of the IndyCar engine regulations.

Audi has expressed interest in taking part in a US DTM series, should one go ahead

As for DTM America, which, if it goes ahead, will kick off in 2015 or 2016, Audi had already made it clear at the announcement of the collaborative agreement between DTM organiser ITR, Grand-Am and IMSA that it would be interested in taking part.

Scott Keogh, president of Audi of America, confirmed that the company is looking at expanding its US motorsport presence, while he also welcomed the chance to compete in a US DTM. 'Audi has a strong and spectacular history in US motorsport,' he said. 'We are currently looking for options that will allow the four rings to be more visible again on racetracks throughout the USA. It's fantastic news that there could soon be a US DTM. The Audi RS models are very popular in America. I'm convinced that our customers will be delighted to see the Audi RS5 DTM in action.'

German car marques are currently flying high in the US, while they are suffering a decline in sales in Europe, and a report by the University of Duisburg-Essen's Centre for Automotive Research states that German car makers will sell 41 per cent more vehicles in the US by 2015, the year DTM America could be launched.

Audi will relish the chance to compete with its DTM rivals in the States, for it is lagging behind BMW and Mercedes in US sales. Recent figures show that BMW sold 33,100 cars in the US in March, an increase of 11.2 per cent over March 2012, while Mercedes sold 26,000, up seven per cent on the same period in 2012. Yet while Audi's US sales saw a double-digit percentage increase in March, growing 14.4 per cent, it shifted significantly fewer units than its two DTM rivals, with just 13,300 cars sold.

SEEN: ASTON MARTIN HYBRID HYDROGEN RAPIDE S

Aston Martin is to break new ground in motorsport when it runs this Rapide in the upcoming Nürburgring 24 Hours. The Hybrid Hydrogen Rapide S, based on Aston's new four-door offering, will become the first hydrogen-powered car to compete in an international event as well as the first zero CO_2 emissions sportscar to complete a race-pace lap at the Nürburgring 24-hours. Aston has worked with hydrogen expert Alset Global to complete the project, while the sportscar manufacturer's engineers have developed a prototype twin turbocharged 6-litre V12 engine that will power the green racer. It can run on pure gasoline, pure gaseous hydrogen, or a blend of both. In pure hydrogen mode Aston Martin and Alset Global aim to show that a zero CO_2 emissions lap of the Nordschleife is possible, while emitting virtually only water from the exhaust.

The Hybrid Hydrogen system comprises a hydrogen fuel rail, storage tanks and a proprietary engine management system, which enables flexibility in the control of the combustion process according to each particular driving situation. Either pure hydrogen, gasoline or an arbitrary blend of both can be selected to ensure optimum power, acceleration and CO_2 reduction. The system includes four carbon fibre tanks holding a total of 3.5kg of hydrogen stored at a pressure of 350bar. Two of the tanks are housed next to the driver and two in the boot of the car.

Customer F1 teams bracing themselves for huge price hikes ahead of new V6 introduction

Formula 1 team bosses expect a hike in engine costs of as much as 100 per cent as the new turbocharged V6 powerplants are introduced next year.

The engine currently falls outside the Resource Restriction Agreement (RRA), and bosses of non-manufacturer teams now fear that they will have to foot a large part of the bill for the development of the new for 2014 1.6-litre units.

Formula 1's RRA is currently under review, and while some team bosses – notably Christian Horner at Red Bull – do not believe F1 needs the RRA, most are in favour of some form of cost control. However, it is believed that the engine/powertrain is unlikely to be enshrined in any new agreement, largely because of the development costs of the new V6, which the engine manufacturers are likely to want to recoup to some degree.

Franz Tost, team principal at Toro Rosso, which sources its engines from Ferrari, said: 'We

have the Resource Restriction Agreement for the chassis, which is not so important because we more or less have the chassis costs under control. We didn't manage to come up with a powertrain RRA which would have been much, much more important, because next year the costs will increase by 80 to 100 per cent, and there we should have worked and should have come up with something.

'But the engine manufacturers, as usual, had some meetings, pushed a little bit, but brought nothing to paper because everybody is doing his development and is thinking of getting an advantage over the others. The teams and the customers have to pay. This is reality and next year will become very, very expensive.'

John Booth, team principal at Marussia, agrees that 2014 will be much more expensive for the smaller teams if costs are not controlled: 'I'm not sure that Formula 1 is sustainable, the way it's heading, so the Resource Restriction is very important,' he said.

However, Ross Brawn, team principal at Mercedes – one of the engine manufacturers along with Ferrari, Renault and Cosworth – feels that while the engine costs will initially rise, they will not escalate quite as much as some fear. 'In our case, taken over a reasonable number of years, the costs will be no higher than existing costs,' he said.

But Brawn admits there will be a greater expense in the first year of the formula. 'Of course there will be a peak at the beginning, because there's going to be a lot of activity, but with the homologation procedures which are in place, and it's our objective to bring the costs down, I don't accept that the costs are going to be 80 to a 100 per cent higher. Not in our case anyway.'

Green-shoots showing at grassroots as UK entry-level motorsport thrives

Fears that too many entry-level single-seater championships in the UK would lead to thin grids have been dispelled with healthy fields featuring in each of the three professional starter series thus far.

This year has seen the all-new Formula 4, the new winged Formula Ford, and the established BARC Formula Renault all vying for entry-level budgets in Britain and the general consensus was that not all could survive.

However, all three have proved attractive to drivers setting out on the professional single-seater path, suggesting that the market has come alive once more, at least at the entry-level.

Formula 4 is the new arrival on the UK scene this year, and the championship managed to sell all of its 24 cars within a month of its announcement. Since then teams have been busy

BARC Formula Renault has thrived, despite competition from other formulas

selling seats with all but a handful filled as *Racecar* went to press.

At the announcement of the championship, series organiser MSV said it was expecting that a season in the eight-meeting (24-race) championship would cost £70,000, although teams were saying it was more likely to be around £90,000. It's actually turned out to be a little more than that. Graham Johnson, team principal at Lanan, which is running two cars in the championship told us: 'It's around the £100,000 mark and we filled our seats almost immediately. We've got a reasonable reputation, we did a good job and we priced it sensibly, not greedily.'

Fighting the corner for multi-chassis competition – albeit it just two, Mygale and Sinter at present – Formula Ford has taken drastic action to try to stem a recent decline in grid numbers following the switch to the EcoBoost motor last year. To this end it's fitted wings for 2013, and has seen its field swell as a result, with 11 cars out for the first round and 15 expected later this year. The budget is up to £150,000 for 30 races over 10 events.

BARC Formula Renault – the championship for the older Tatuus Formula Renault cars – is also looking healthy, with 18 drivers signed up for this year's championship. BARC, which has budgets of between £80,000 and £100,000 (16 races, six meetings), has attracted many overseas drivers and no fewer than 10 nationalities will be represented. In fact, all three championships have a good smattering of non-British drivers (F4 six, FF four), which might suggest that the weakness of the pound against many currencies is helping to make UK championships financially viable.

PEELING BACK THE STICKERS: AIRWAVES

There are some obvious signs as to whether a race series is doing well. One is its grid size, of course, while another is the type of sponsor it attracts. If it only attracts backers with links to the family of the driver, or perhaps simple tie-ups between automotive suppliers and works-backed teams, there's probably nothing much to shout about. If, on the other hand, it brings in unrelated sponsors primarily interested in getting good exposure, then that has to be a good sign.

So Alan Gow, the boss of the British Touring Car Championship (BTCC), will surely be delighted that chewing gum manufacturer Airwaves has upped its backing of Motorbase this year then, for it's a certain indication that the premier British race series is growing in stature.

Airwaves chewing gum – which is a Wrigley brand marketed in the UK and Europe, and in Asia as Cool Air, where it is a market leader – has been involved in motorsport since 2006, when it supported Superbikes, as brand manager Tia Shortall explained: 'In 2006 we had a creative campaign called "kick up a gear", and part of that campaign was our Superbikes sponsorship. Over time we've moved into the BTCC, for a few reasons, not least of them being it's a whopping great canvas you can brand, and we've developed a relationship with Motorbase over time. It's a fantastic canvas for us now, and we really enjoy the working relationship with them. We feel that both parties get a lot out of it.'

So much so that this year it's expanded its involvement and signed on as title sponsor to the Ford Focus-equipped Motorbase team, and while Shortall was not able to go into details about the level of its expenditure, she did tell us: 'We're investing a big chunk of our total media for Airwaves, and it's a multi-million pound media campaign, comprising TV, sponsorship and a few other bits and bobs.

'The BTCC gives us something we can activate right throughout the mix. So we're doing TV spots later this year that will start to bring that to life, we're doing in-store activation, and we've done internal engagement pieces. For the launch the team came to both of our sites – we have an office in Reading and a factory and an office down in Plymouth – and they spent the best part of a week doing the launches with us. They came down, we had competitions, and we got people inside the cars. Everybody is behind it and excited by it.'

Yet while there's obviously far more to the deal than simple exposure, Shortall says the BTCC TV coverage is very useful: 'I think the TV coverage helps, because for companies with brands like ours, TV media is still where it's at. It's where your big audiences are. Having something that gives us a good quantity of TV coverage during the course of the season is quite important to making it work from our side.'

MIA links up with UKTI to offer export help

The Motorsport Industry Association (MIA) has been appointed as the only UKTI Trade Challenge Partner to specifically service the motorsport and high performance engineering sectors.

As part of this tie-up, UK motorsport SMEs (small and medium enterprises) can now access funds from the UKTI (UK trade and Industry) Market Access Programme (MAP) towards the cost of joining an overseas business development visit through the MIA. Also, from August 2013 Trade Access Programme (TAP) grant levels for UK SMEs exhibiting in Europe will increase by £500 to £1500, and elsewhere by £600 to £2000.

Exhibitors at both Professional Motorsport World (PMW) in Cologne and the Performance Industry Show (PRI) in Indianapolis, can now benefit from this increased funding.

Chris Aylett, CEO of the MIA said: 'UK motorsport suppliers are born global. Exporting is second nature to them, and the UK is a hub of international motorsport business success. The MIA, as the business cluster champion, is at the heart of securing funds from UKTI for exporters and welcomes contact from all exporters. These substantially increased funds will help encourage new and established exporters to find new business overseas, and widen their current sales networks. We are now able to review our international trade plans and will soon announce new events to grow exports.'

The MIA tells us that updates about the new funding support available and MIA and UKTI support for motorsport exporters appears regularly on its website, www.the-mia.com. Meanwhile, both new and experienced exporters can link into the UKTI through its Open to Export website, which features dedicated export advice – www.opentoexport.com – or make contact with their local international trade adviser by logging on to www.ukti.gov.uk.

UKTI assistance includes the Passport to Export scheme for new exporters and 'Gateway to Global' for experienced exporters. There is also its Export Communication Review to help improve the export service and UK Export Finance, to help companies gain access to export finance advisers.

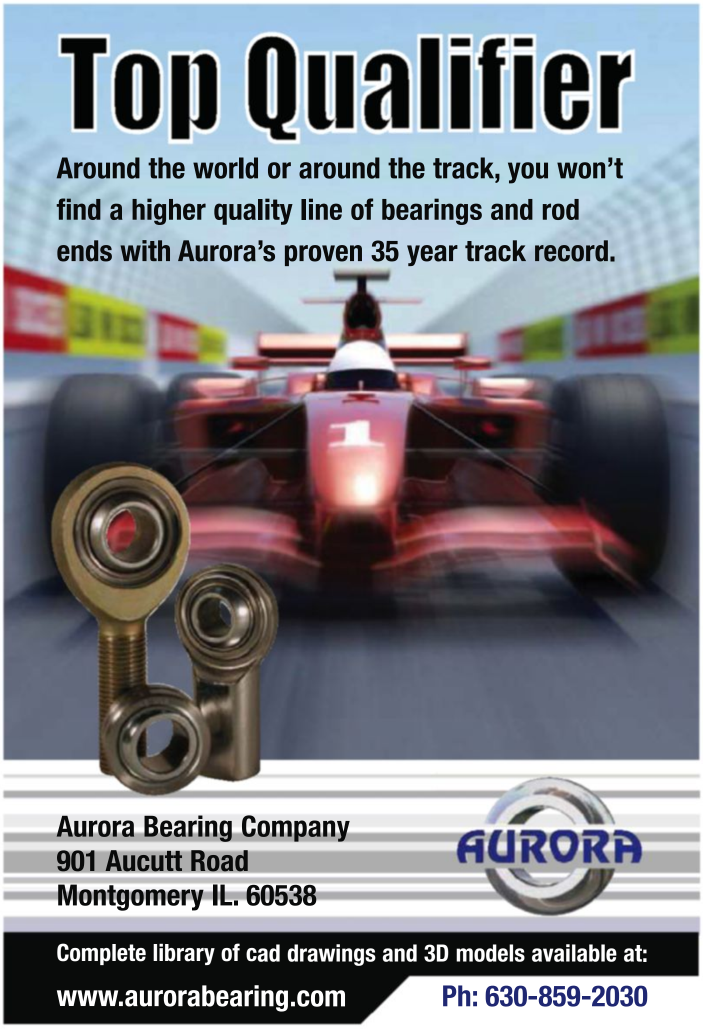
BRIEFLY

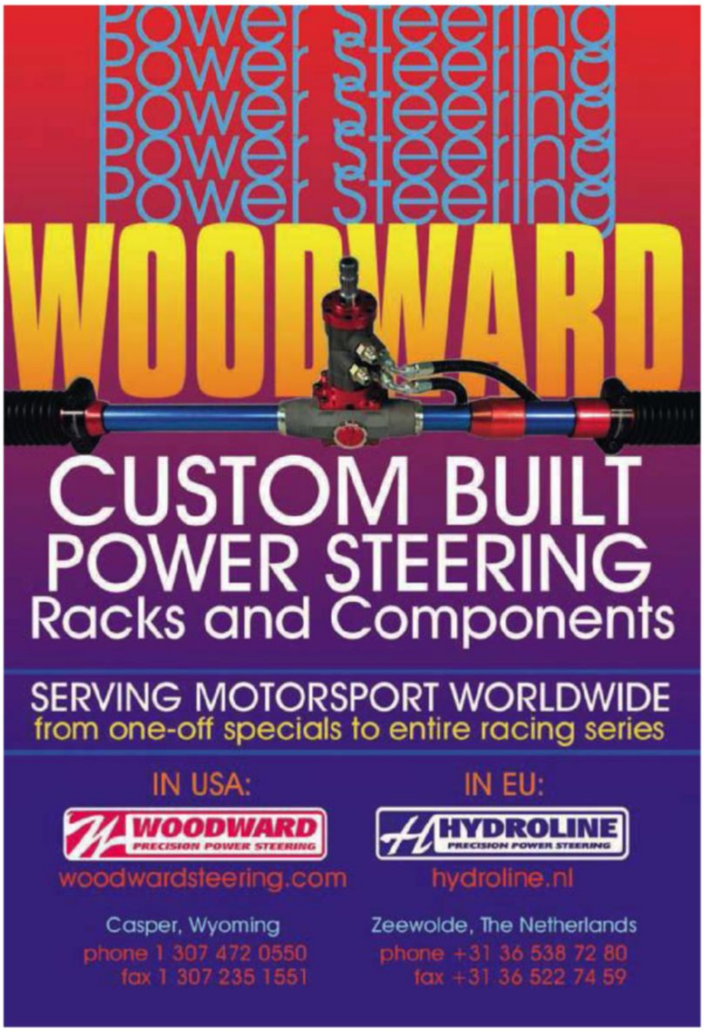
Strakka buys P1

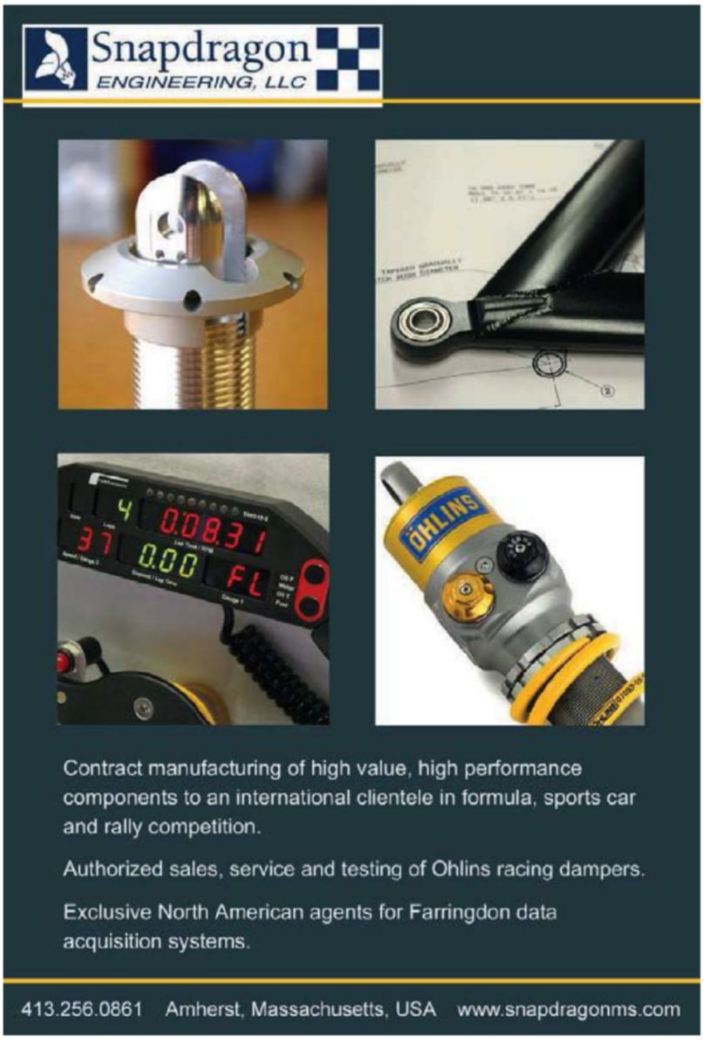
Sportscar team Strakka Racing has expanded its business into the single-seater arena by purchasing the P1 Motorsport Formula Renault 3.5 organisation.

Strakka already owned a pair of previous generation FR3.5s, which it used as part of its thriving driver training division, but it has now taken control of P1 from Walter Grubmuller Sr, who bought the team from its founder, former Brabham F1 mechanic Roly Vincini, just two years ago.

Strakka, which was established in 2008 and this year is running an LMP1 HPD ARX-03c in the World Endurance Championship, says it has no plans to relocate P1 from its current Norfolk base. The P1 name has been in racing since the early-90s, when the team started out in British Formula 3.


Top Qualifier
Around the world or around the track, you won't find a higher quality line of bearings and rod ends with Aurora's proven 35 year track record.
Aurora Bearing Company
901 Aucutt Road
Montgomery IL. 60538
AURORA
Complete library of cad drawings and 3D models available at:
www.aurorabearing.com
Ph: 630-859-2030


Power Steering
Power Steering
Power Steering
Power Steering
Power Steering
WOODWARD
CUSTOM BUILT
POWER STEERING
Racks and Components
SERVING MOTORSPORT WORLDWIDE
from one-off specials to entire racing series
IN USA:
WOODWARD PRECISION POWER STEERING
woodwardsteering.com
Casper, Wyoming
phone 1 307 472 0550
fax 1 307 235 1551
IN EU:
HYDROLINE PRECISION POWER STEERING
hydroline.nl
Zeewolde, The Netherlands
phone +31 36 538 72 80
fax +31 36 522 74 59


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


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

Recycled NASCAR rubber to rejuvenate tired tracks

As part of an innovative new deal with the US's foremost rubber recycler, NASCAR racing tyres will soon end up in some of the asphalt on which they were designed to race.

NASCAR already claims to have the largest recycling programme in sport, including a comprehensive effort that accounts for approximately 120,000 Goodyear tyres recycled across its top three series each year, and a new agreement with Liberty Tire Recycling now intends to build on this.

Liberty is the top provider of tyre recycling services in North America. By recycling more than 140 million tyres annually it reclaims about 1.5 billion pounds of rubber for eco-friendly products. The recycled rubber produced by Liberty is used as crumb rubber and industrial feedstock for moulded products; as tyre-derived fuel for industrial kilns, mills and power plants, and as rubber mulch for landscaping and playgrounds.

Recycled tyres could end up forming part of the asphalt on racetracks

Much of the race rubber will also be turned into rubber mulch for horticulture projects, but some of it will find its way into rubberised asphalt, which will be used to repave racetracks and parking lots at NASCAR racetracks across the USA.

Thomas Carter, Liberty Tire Recycling vice president of alternative fuels, said of the deal: 'We look forward to enhancing NASCAR Green's best-in-class recycling programme by keeping its discarded tyres out of landfills and transforming them into smart, sustainable products that improve people's lives.'

Jim O'Connell, NASCAR chief sales officer, said: 'Adding the nation's premier tyre recycling company to our group of Official NASCAR Green Partners will further enhance NASCAR's position of leadership in sustainability across all sports. Liberty Tire Recycling has positioned itself as a leader in tyre recycling innovation and we are pleased to work towards a common goal of reducing the environmental impact of our sport.'

CAUGHT

Paul Wolfe, the crew chief on the Penske Racing-run Ford of Brad Keselowski, has been hit with a whopping $100,000 fine and suspended from NASCAR for six races after the car was found to be running with suspension components that were not approved by NASCAR. The irregularity was discovered at the Texas Motor Speedway round of the Sprint Cup. The driver and team owner, Roger Penske, have each been docked 25 points in their championship standings.
FINE: $100,000
PENALTY: 25 points

The second Penske Sprint Cup Ford of Joey Logano was also discovered to be running with the same infringement as the Keselowski car at Texas (see above). Its crew chief, Todd Gordon, received an identical fine and penalty as Wolfe, while both driver and team owner, Walt Czarnecki, have been docked 25 points in their championships.
FINE: $100,000
PENALTY: 25 points

NASCAR crew chief Chad Johnston has been fined $25,000 and placed on probation until 5 June after the Michael Waltrip Racing Toyota he tends failed to meet the minimum front ride height at the Texas Motor Speedway round of the Sprint Cup. The team owner, Michael Waltrip, and driver, Martin Truex Jr, were each fined six points in the owner and driver standings.
FINE: $25,000
PENALTY: six points

UK motorsport could benefit from £70m of new small business lending

Small and medium-sized motorsport businesses could pocket a share of a £70m lending boost following a UK government move to increase and diversify the availability of finance.

As part of the plan, three new lenders – Market Invoice, Urica and Beechbrook Capital – will share more than £30m of government funding to offer small and medium enterprises (SMEs) alternatives to traditional bank lending. Each of the three lenders has also committed to attracting additional funding from private sector investors, with the total expected to boost the pool of credit available to SMEs from these three lenders by more than £70m.

Business secretary Vince Cable said of the initiative: 'A lack of access to finance is still choking off too many small businesses, preventing them from growing, taking on new staff or investing in new equipment. We are taking a range of actions to support SMEs and shake up business finance markets, including through the new business bank. The £30m announcement is an important boost for non-traditional lenders with creative and innovative solutions. It will increase competition and create a more diverse and balanced market for business lending.'

The funding comes from the small business tranche of the Business Finance Partnership (BFP). Through the BFP, the government committed to provide £100m of funding for non-traditional lenders in order to diversify the sources of finance available to SMEs and improve competition. Currently 85 per cent of all business loans are handled by the big four banks.

This is the second allocation of funding by BIS (Department for Business Innovation and Skills). The first allocation was made in December, when four lenders – Funding Circle, Zopa, BOOST&Co, and Credit Asset Management Ltd – were allocated £55m.

BRIEFLY

Bentley's boost

Bentley Motors has reported a startling financial performance for the year ending December 2012, which might augur well for an escalation in its motorsport activities. The VW group-owned luxury car maker reported a significant increase in its operating profit with €100.5m, compared to €8m in 2011. It also boosted its total turnover by 29.9 per cent to €1.5bn, while its profit margin increased to seven per cent. Exports accounted for 87.3 per cent of Bentley's total turnover, equating to a total export value of €1.3bn. As a result of these figures the company's market share in the luxury segment rose by 4.9 percentage points to 20.1 per cent.


D.A.T.A.S. LTD.
Data Analysis Tools And Simulation
RaceSim version 2.7
• Expert: Steady state, transient, 4 post, optimisation, strategy, etc
• Standard: Low cost lap simulation
• NasCar: Stock cars with live axle
• F3 Lite: Incl. Dallara F3 car model
• RaceAlyzer: Race strategy tool
• ManagePart: Parts management tool
Consultancy
• Vehicle Dynamics
• Racetrack support
• Software Development
Multi Media
• Photo realistic virtual animations
• Technical Features for TV
• Animated virtual walk thro' grid
D.A.T.A.S. LTD. THE OLD CHAPEL NORFOLK IP21 4XP
TEL: +44 (0)1603 506526 +44 (0)7802 770345
http:// www. datas-ltd.com e-mail: info@datas-ltd.com


ADEL WIGGINS GROUP Flexible Tube Connectors
SECURE THE WIN!
Stay connected with Adel Wiggins Flexible Tube Connectors! The difference between winning and losing is in the connection. Do not sacrifice a win to a simple hose blowout or burst. This occurs when conventional hose clamps or barbs fail to secure the hose located between the connections or components. Adel Wiggins Flexible Tube Connectors eliminate these failures. This is why so many professional racers today confide in them. SECURE YOUR VICTORY!
CONNECTOR APPLICATIONS:
• Full Engine • Radiator • Intercooler
• Oil Cooler • Turbo & Blower • Throttle Body
FCP
Fluid Control Products, Inc.
Toll Free in NA: 800-541-2345
Worldwide: 217-324-3737
www.fluidcontrol.net


PRO-SHIFT™
electronic gearshift
Championship Winning
Semi-Automatic
Electronic Gearshifters
for Racecars & Superbikes
Now available
This superfast and highly sophisticated
Gearshifting PS3 Paddleshift System suitable
for Racecars and Superbikes with over 170
adjustable parameters
PS3 System
Offering Fully Closed Loop Gearshifting for
both Racecars and Superbikes
Auto-Blip & Downshift Lockout
For clutchless downshifts plus engine over-rev protection
Graduated Ignition Cuts
Individually programmable for all gears
Auto Upshift Facility
Max power upshifting at full throttle..!
For more information:
email: info@proshift.com
telephone: +44 (0)1332 668100
www.proshift.com


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

INTERVIEW: DAVID CUNLIFFE

Managing director David Cunliffe is the 'DC' in DC Electronics. He started working in motorsport with Nissan Motorsports Europe after leaving the RAF in 1996. After spotting a gap in the market, Cunliffe and his wife, Sandra, founded DCE in 1997. The company manufactures wiring harnesses, electric power steering systems (EPAS) and other electronic products. It has manufacturing facilities in Maldon, Essex in the UK and in Mooresville, North Carolina in the US.

How has the motorsport electronics business changed in the years since you started DCE?
There is a lot more competition today than when we started – mainly smaller companies, but we all go after the same contracts. The other big change is the general awareness of how a decent electrical system can not only increase reliability but can also increase performance. For example, we just delivered a GT car back to a customer and removed close to 9kg of weight from the car's electrical system, while adding additional functionality by using intelligent design and better components.

Approximately how much of your work is to do with motorsport?
Roughly 70 per cent of what we do is motorsport. The rest is made up of mainly OEM and military. We are continuing to build our OEM business, particularly the R&D side where we are finding that manufacturers like the fact that motorsport businesses are quick to react with product development and manage to cut through the red tape.

What motorsport sectors are you involved in?
Our products are found in F1, IndyCar, NASCAR, ALMS, WEC, Grand-Am, WRC, Global Rallycross, BTCC and even the America's Cup, to name just a few.

What's your involvement with the Bloodhound project and what are the challenges involved in designing a loom for an LSR vehicle?
We will be providing all of the wiring harnesses and the electric power steering on the vehicle. The biggest challenge is the constantly moving goalposts. As no one has ever built a car like this before, the design is constantly evolving, meaning we needed to build plenty of redundancy into the systems to allow for the design changes that will come in the future as the record attempt progresses.

You have recently setup a base in the US. What was the reason for this and how is it doing?
We have been supplying our EPAS systems into the USA via a distributor since 2006. In 2009 we joined the MIA on a business development visit to look at NASCAR and IndyCar. This gave us plenty of contacts, and when NASCAR announced it was going to fuel injection we already had the contacts. It very quickly became apparent if we wanted to supply the top teams, we would need a US base. With all but one of the teams located within a 30 mile radius of Mooresville, it became the obvious choice for our US production facility. Since opening the factory we have now started to supply more of the ALMS and Grand-Am teams as well as IndyCar, NHRA, ADRL and SCCA.

Claire Williams: 'my new senior position will not alter team dynamic'

Claire Williams (pictured), the new deputy team principal at the Formula 1 team that bears her name, says her new position will not affect the way the organisation is run.

Williams, who is the daughter of team boss and founder Sir Frank, was named as deputy team principal and her father's successor at the start of the F1 season. She previously held the role of director of marketing and communications with the team, which she started working for in 2002 after a successful career in motorsport PR outside of the family business.

Frank said that he sees Claire's new role as part of a succession plan. 'With Claire being appointed deputy team principal, I know the future of Williams is in extremely safe hands,' he said.

For the meantime, however, the younger Williams feels there will be little difference in the way the team goes about its business. She also insists her duties have not fundamentally changed and she will continue to focus on the financial side of the operation. 'My primary focus has always been the commercial side of the team – to get the budget in, to keep us going racing. That will remain my primary concern,' she said. 'Obviously with the deputy team principal title comes some responsibility for the technical side of what we do, so I'm going to be working with our technical director, Mike Coughlan, to ensure that we have the resources we need to get us back up to the top. And then inevitably there's the governance side of the role as well, so working with FIA [and] FOM issues.'

The structure of the Williams team, which has made a poor start to the season with no points after four rounds at the time of writing, will also remain the same. 'We have a board at Williams made up of an executive committee that runs the team and the wider business on a day-to-day basis,' Claire said. 'Frank is still our main leader and that doesn't change.'

The naming of Claire Williams as deputy team principal comes after a flurry of management shakeups in recent times, including the departure of chairman Adam Parr early last year and Toto Wolff's move to Mercedes in January.

BRIEFLY

Tuning Japanese

The first Formula 3 engines operating to the new regulations have performed well in their debut race weekend, with all seven cars fitted with them finishing.

The honour of blooding the new FIA-spec engine fell to the Japanese Formula 3 Championship, and its opening round saw two TOM's Toyota, two Mugen Honda and three Toda Racing units in action.

The new regulations, which have not been adopted in Europe this year due to cost issues, allow bespoke racing powerplants to race alongside production-based engines.

Reports from Japan suggest that cars featuring the new engines were averaging a second a lap quicker than last year's times, while top speeds were up by around five per cent.

What are the main requirements for a motorsport loom?
Number one is reliability. It's no good making a wonderful lightweight loom if it fails. Number two is fit for purpose. The loom can be designed to run an engine for example, no more no less, or it can have expansion ports built in to future proof the design – ideal in a car designed to last more than one season such as GT.

What have been the main technological advances in the wiring world in recent years?
The biggest change in recent times is the introduction of power distribution modules and CAN bus technology. Between these two devices, cable bundle sizes have come down as the complexity of the harnesses reduce. These devices have also allowed the amount of systems the driver needs to monitor and manage to be greatly reduced as many can now be automated.

What's the future for motorsport wiring?
One possible step forward would be going to a higher voltage such as 24v or 48v. Each time you double the voltage, you halve the current draw on the electrical system making the use of electric ancillaries such as oil, water and AC pumps more attractive. As the trend for downsizing engine capacity continues, removal of traditional mechanical pumps is more important to reduce parasitic losses and wasted horsepower.

What's the future for DC Electronics?
Both the UK and US factories continue to grow in terms of customer base and staffing levels, and we are now looking at other sites around the globe in emerging markets for possible locations for additional production sites.

OBITUARY - GIULIO BORSARI

Long-time Ferrari F1 mechanic Giulio Borsari has died at the age of 88. Borsari, who was born in Montale, not far from Ferrari's factory, first worked at Maserati (from 1947 to 1957) and then other teams and automotive organisations before joining Ferrari in 1962. He went on to spend 17 years with the Scuderia, much of this time as its chief mechanic, working with many legends of the sport and forging a particularly strong relationship with John Surtees – who won the world championship for Ferrari in 1964.

On hearing of Borsari's passing Surtees said: 'My time with Ferrari was characterised by highs and lows, but as Enzo Ferrari told me shortly before his death, we must remember the good things and not the mistakes. I remember Giulio with great affection and gratitude for being such a great help to me both in the good times and the bad and for knowing how to express that special emotion you can only find in Italy, when we scored our victories together.'

Borsari's last season in Formula 1 was in 1979 and coincided with Jody Scheckter's championship win and the team taking the constructors' crown. He went on to found the Club Meccanici Anziani in 1988 – an association for former F1 mechanics from Ferrari, Alfa Romeo and Maserati – and was the head of the the Ferrari Shell Historic Challenge technical commission from 2000 to 2008. Ferrari said: 'His in-depth knowledge of racecars meant he was a reference point for everyone who shared a passion for these cars and for the racing history of the marque'.

Giulio Borsari 1925-2013

RACE MOVES

Well known touring car race engineer **Dave Benbow** has returned to the BTCC to tend the Eurotech Honda Civic driven by **Jeff Smith**. Benbow worked in the DTM last season, looking after the Abt Audi that was piloted by **Adrien Tambay**.

Nick Bunting is the new chief executive of the UK's motorsport governing body, the Motor Sport Association (MSA). Bunting takes over from **Colin Hilton**, who has retired after more than 20 years at the MSA but will stay on in a consultancy role until the end of the year at least. Bunting is vastly experienced in sports administration, having once been the COO of the Rugby Football Union, while he was also an adviser to the organising committee of the London Olympics.

Tony George has returned to the board of directors of Hulman & Co, the company that owns IndyCar and the Indianapolis Motor Speedway (IMS). George, a former IndyCar and IMS boss, quit the board last year due to a perceived conflict of interest – he was linked to a group said to be planning on buying the series. Since then, however, the buyout has collapsed and IndyCar now says there is no longer a barrier to George sitting on the board.

Race mechanic **Brian Holliday** has died in hospital two months after undergoing heart surgery, he was 60. In 1976 Holliday set up HWR Motorsport with **Jeff Wilson**, an outfit renowned for its outlandish but effective racecars, which included a Formula 5000-based Beetle silhouette Super Saloon, a Chevron B30-based BMW M1, as well as its more recent Jade-based Lotus Elise.

There has been some movement within the engineering staff at the Audi DTM family of teams. Mattias Ekström's new race engineer is aerodynamic specialist **Florian Modlinger,** who has worked at Audi Sport in Ingolstadt since January, while Ekström's long-standing race engineer **Alexander Stehlig** now oversees Audi newcomer **Jamie Green** at Audi Sport Team Abt Sportsline. **Franco Chiocchetti** becomes the new race engineer for Adrien Tambay. Every other Audi driver retains the same race engineer as last year.

Hyundai has continued with its recruitment drive as it builds up to its re-entry into the WRC next year, filling several of its senior posts. On the technical side chief designer **Bertrand Vallat** now leads the engineering project on the i20 WRC. The Frenchman's most recent previous role was at Peugeot Sport, where he was actively involved in the highly successful 207 S2000 project.

Nick Fry (above) has stepped down from his position as CEO of the Mercedes Formula 1 team. **Toto Wolff** will now take on many of Fry's responsibilities within the team. Fry, who will still have a consultancy role with the organisation, originally joined the Mercedes team when it was British American Racing and he played a major part, working alongside **Ross Brawn**, in keeping the outfit alive following the withdrawal of Honda from the sport at the end of 2008.

Stephane Girard has also joined Hyundai Motorsport, as engine manager. Girard has extensive experience in motorsport having previously worked for Peugeot Sport, Maserati Corse, Subaru World Rally Team Prodrive and Citroën Sport, among others.

Also at Hyundai, **Alain Penasse,** the former organiser of Rally Ypres – who has also worked at Toyota Team Europe and Peugeot Sport – is now team manager, while **Ernst Kopp** takes charge of the workshop and **Stefan Henrich** joins as director of marketing and PR.

Jenson Button has replaced **Felipe Massa** as director of the Grand Prix Drivers' Association (GPDA). **Sebastian Vettel** is also a director, staying in the role he held last year, while **Pedro de la Rosa** is still the chairman of the body, despite the fact that he no longer races in F1 after the demise of his HRT team.

OBITUARY – RALPH SANCHEZ

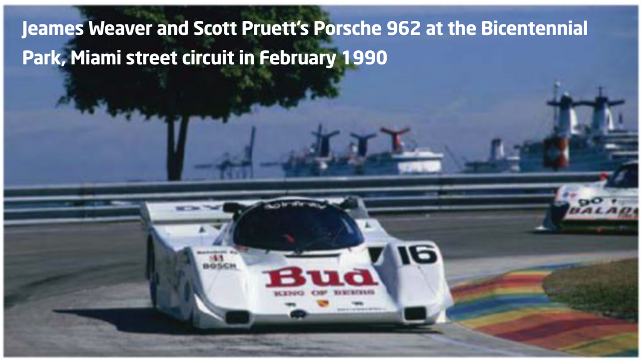
Cuban-born US race promoter Ralph Sanchez, the man behind the Miami street race back in the 1980s, has died at the age of 64 after a long illness. Sanchez arrived in the United States from Cuba on a 'Freedom Flight' for political refugees in his teens, before training as an accountant and going on to become a successful property developer.

As a lifelong race fan Sanchez raced and entered his own cars and then had the idea of bringing racing to the streets of his adopted hometown, Miami, in the early 1980s. The first race in 1983 did not go to plan, as it was hit by a tropical storm and was unsuccessful from a financial standpoint. But, undeterred, Sanchez brought it back the following year – persuading Emerson Fittipaldi out of retirement to compete in the race and thereby launching his second career in the US – and the event subsequently became a permanent fixture on the IMSA calendar.

Sanchez was also responsible for the Homestead-Miami Speedway, a 1.5-mile oval that was completed in 1995 and went on to host CART, NASCAR and top level sportscar races, the latter making use of its infield layout.

He sold Homestead to International Speedway Corporation in 1999, but his involvement in racing was by no means over and he then formed the Panoz-Sanchez Group with American Le Mans Series founder Don Panoz. On hearing of Sanchez's death, Scott Atherton, president and CEO of the ALMS, said: 'He was a true motorsports promoter, an accomplished businessman, a family man and a visionary – all wrapped in designer suits and old-school gentleman's etiquette.'

Rafael 'Ralph' Sanchez
1949-2013



Jeames Weaver and Scott Pruett's Porsche 962 at the Bicentennial Park, Miami street circuit in February 1990

LAT

SPONSORSHIP

McLaren has signed a new marketing deal with **Gillette**, which will focus on the Asian market. The Procter & Gamble brand will create advertising in Asia which will feature the team and drivers.

The **DTM** has signed a partnership deal with Berlin-based car parts and accessory business **kfzteile24**. The sponsorship agreement will see their logo displayed at prominent points around the circuit at DTM races.

WEC manufacturer **Toyota Racing** has signed a technical partnership with **ZF Friedrichshafen AG**, which will see the German company's clutch technology used in the TS030 Hybrid racecars.

The **Sauber** F1 team has signed up Swiss company **Planzer** as a promotional partner to handle transportation.

Russian bank **SMP** is making a bit of a splash in **Formula Renault 3.5** this year, its Russian flag inspired colours worn by three separate cars: two from **Comtec Racing** and one from **Tech 1**.

RACE MOVES

The co-founder of the Minardi racing team, **Giancarlo Martini,** has died at the age of 65 after a long illness. Martini was better known as a driver, enjoying success in the Formula Italia championship in the early-70s before graduating to Formula 2 and then F1 with a borrowed Minardi-run Ferrari 312T in the mid-70s. After some years back in F2, Martini's driving career fizzled out, but the link with Minardi continued when his nephew, **Pierluigi Martini**, drove for the team when it entered Formula 1 in 1985.

URT Group, a composites manufacturer and engineering solutions provider, has appointed three new directors to its board. **Alan Smithers** is now managing director, while **Darren Weston** takes on the post of commercial director and **Kevin Emmett** is technical and training director. Smithers, who has previously held management roles at a number of companies, was promoted from the position of production manager at URT. Weston and Emmett were also promoted from within the organisation.

Former Sauber F1 head of vehicle dynamics, **Pierre Wache**, (pictured) was set to switch teams to join Red Bull Racing at the time of writing. **Ben Waterhouse**, who previously worked at Red Bull and moved to the Swiss team three years ago, has now taken up Wache's old position.

Personalities from the race engineering and management side of the sport feature strongly on the list of nominees for the 2013 NASCAR Hall of Fame. Among the 25 nominees are engine builder **Ray Fox**, team owners **Richard Childress**, **Rick Hendrick** and **Raymond Parks** and from the world of track management **Bruton Smith**, **Raymond Parks**, **Les Richter** and **H Clay Earles**. **Anne Bledsoe France** is also on the list. She helped build the sport with husband Bill France Sr and she is the first woman to be nominated for induction into its Hall of Fame.

Lesa France Kennedy and **Glenn S Ritchey** have been elected to the board of directors of the NASCAR Foundation – a charity setup by the US stockcar governing body. Kennedy's day job is CEO and vice chairperson of the board of directors for International Speedway Corporation, as well as vice chairperson for NASCAR. Ritchey is the president and CEO of the Jon Hall Automotive Group/Ritchey Autos Southeast Automotive Management, one of the US's most successful automotive companies.

Michael Schumacher has taken on an ambassadorial role with Mercedes. The seven-time world champion, who retired from driving for the second time last year, will now also be working on developing safety and comfort systems for Mercedes road cars, as well as joining its road safety projects.

UK car magazine **Autocar** and **Courland International** are calling for university students to enter the 2013 Autocar-Courland Next Generation Award. The 2013 winner will be rewarded with a priceless work experience package of one month at each of the contest sponsors – Jaguar Land Rover, McLaren Automotive, Peugeot, Skoda and Toyota – as well as a £7500 cash prize. For more information go to autocar.co.uk/nextgenerationaward

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

BUSINESS TALK: CHRIS AYLETT

Invested in motorsport

Can governments really help the racing business grow, and if so, how?

Every week I get asked this question, implying 'does government really care about motorsport?', and the answer is a resounding yes, but we need to learn how best to engage with government to get maximum benefit.

UK Motorsport Valley has weathered the winter, started deliveries for the new season and business predictions for 2013 are pretty good. Following the UK government's recent budget announcements, the UK is described as a new 'R&D Tax Haven' for innovative companies, with very low corporation tax and ever-reducing personal income tax. With a 10 per cent tax rate on profits from patented inventions, there is a bright future for motorsport companies who fully exploit their R&D investments.

A pro-active, valuable partnership between the UK government and its booming automotive industry will see hundreds of millions of pounds urgently invested in finding innovative, low carbon and energy efficiency solutions. The MIA has, recently, been invited to sit on the Automotive Council Technology Group, so putting the motorsport industry at the heart of the technology strategic planning process for these huge UK automotive customers. This appointment shows their urgent need to engage with new suppliers of innovative solutions.

Jerry Hardcastle, VP at Nissan Technical Centre Europe says: 'The motorsport industry can provide the knowledge to help the automotive industry progress new technology ideas to Technology Readiness Level 6, and Manufacturing Readiness Level 5'.

This business is not high volume – good news for motorsport companies – but instead focuses on short run, pre-reproduction, prototype work. Such substantial customers give more security and a long-term future to offset the instability of motorsport customers, which depend on sponsorship and success on-track.

The MIA has been asked by the UK government to identify what needs to be done to ensure future business growth in our sector. To establish this, the MIA has commissioned Motorsport Research Associates to carry out a vital National Survey of motorsport engineering and services – the first one of its kind since 2000 – involving over 8000 high-performance engineering's UK businesses. MRA will analyse the results and, with further input from MIA members, will present key business growth issues to central government, who will publish a new, far reaching Industrial Automotive Policy in summer 2013. Motorsport must get its key issues incorporated into that major policy, so that in future, government can commit resources to deliver business growth, as advised by industry.

Government help can drive success

Industry sectors, such as motorsport, working together through their sector association, can influence government policy in a way that individual businesses, however large and influential they may consider themselves, cannot. Make your voice heard – email helen.jones@the-mia.com to check your response is in – and don't miss the opportunity to secure future funding for exports, access to finance for growth, taxes, skills training and other resources to benefit your business.

Government support certainly benefits export growth. Motorsport Valley is a world centre for international motorsport, with its companies travelling extensively to meet buyers and find new suppliers too. The MIA is the only motorsport and high-performance engineering UKTI Trade Challenge Partner, securing and directing funding to UK motorsport companies to help them grow business in established and emerging global markets. Input from our exporting members directly influences export plans of government and directs funding to where it is most needed.

I see substantial new business in the USA growing. The largely unregulated, off-road racing is a great example, where our recent successful trip to Arizona has led us to plan another in May to California. Each time we visit, new business is found. These customers want increased performance, more power and fast delivery at good prices. IndyCar reconsidering its supplier base should open up business in 2014 and beyond. The NASCAR-owned United SportsCar series – the new name for ALMS and Grand-Am from 2014 – offers great possibilities. Even now, Grand-Am alone gets grids in excess of 50 cars – by NASCAR unifying US sportscar racing, wealthy US owners will begin to enjoy sportscar racing once again. NASCAR, through their sister company ISC, owns some of the great road racing tracks in the USA, and can host, over the same weekend, both NASCAR Sprint Cup and United SportsCar races too, reaching a whole new audience. The MIA, with government support, is taking a motorsport group to all these centres for new business from 23-31 May – check www.the-mia.com for details.

The UK minister of defence, Philip Dunne, actively encourages SME diversification from motorsport to defence. This summer, the MIA will take motorsport companies to the largest defence shows in Europe – DVD at Millbrook, UK, 19-20 June and then DSEi at Excel, London, 10-13 September – so why not join these groups and find new business? Real defence business is done here, and many secure new suppliers. Motorsport is now at the front of the line, building on recent success. Take a look at the Centre for Defence Enterprise – visit bit.ly/CDEweb – they have substantial funding for new suppliers with good ideas.

To make your own government connections, why not open your factory to local schools and communities? During National Motorsport Week, 29 June-7 July, you can show the good work you do and the employment you offer – see www.nationalmotorsportweek.co.uk and invite your local MP along to brief him on your business issues, so he can speak for you in parliament.

My final tip is to contact your Local Enterprise Partnership (LEP) via the web, and get to know them. UK government plans to deliver substantial business growth funds locally through LEPs, and if you plan to grow employment they want to hear from you and help. As always, if we can help in any way, just let us know at info@the-mia.com as we only exist to see motorsport business grow, and we want you to be part of that success.

PUMPS

Aeromotive Stealth pump

The 340 Stealth Fuel Pump is a high-output, in-tank, electric fuel pump that fits most popular EFI applications. It is a compact, lightweight pump that bolts into many existing OEM hanger assemblies. The pump is claimed to provide superior flow throughout a wide pressure range compared to similar pumps: at 40psi the pump produces more than 340lph of flow. The pump is intended for applications requiring an increased flow rate while retaining the factory lines. It can also be used as a universal replacement for applications that require more flow to support forced induction, such as turbo and supercharged applications. **For more information visit www.aeromotiveinc.com**

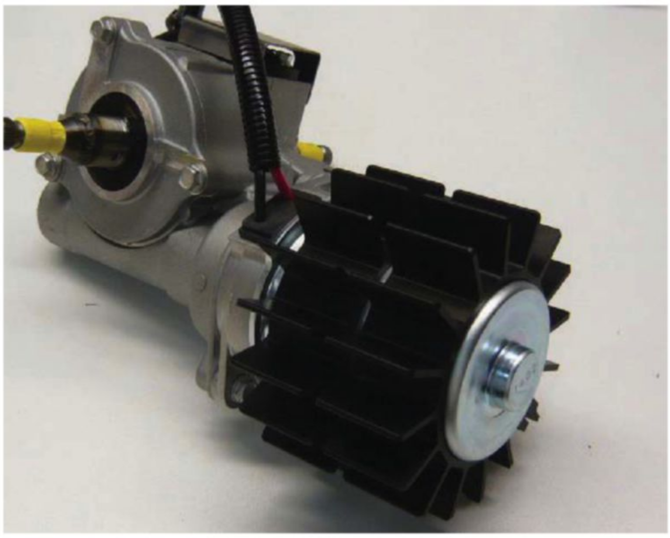
BRAKE SYSTEMS

Wilwood proportioning valve

Wilwood's new Combination Proportioning Valve is designed to substantially simplify mounting, plumbing, wiring and brake proportioning adjustments on vehicles with custom brake systems. The combination block maintains full isolation between front and rear fluid circuits and can be used in conjunction with any tandem outlet or dual mount master cylinder assemblies. The rear circuit has a single inlet and single outlet with the adjustable proportioning valve, while the front circuit has a single inlet with two outlets. The new combination proportioning valve can be run as a single outlet with one outlet plugged, or used to split the plumbing on its way to the front calipers. **For more information visit www.wilwood.com**

HEAT MANAGEMENT

DC EPAS custom heatsinks

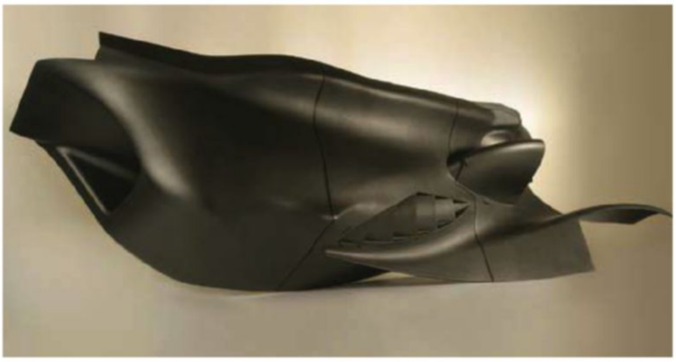


DC Electronics has released custom heatsinks for their Motorsport EPAS Systems. The heatsinks are designed to help radiate heat away from the EPAS motor. A cooler motor has less electrical resistance, which will in turn allow more current to pass and therefore reduces the loss of assistance felt due to overheating. Comprising of two individual heatsinks, the kits are supplied with a thermal compound paste to ensure maximum heat transfer between the motor and the heatsinks. The products, which weigh 234g each, are simple to install and slide over the motor housing before being clamped in place by tightening the captive screws contained within the heatsink. **For more information log on to www.wiringlooms.com**

3D PRINTING

Windform for functioning parts

CRP Technology has recently launched a new polyamide-based additive manufacturing material, Windform SP. It is a composite polyamide-based carbon-filled material characterised by a deep black colour, and it can be considered a top-level material within the company's polyamide Windform range for 3D Printing and additive manufacturing. CRP claims that the material has excellent mechanical properties and – additionally – it has the advantage of increased resistance to shocks, vibrations and deformations over previous Windform materials. These properties – combined with a greater resistance to elevated temperatures – makes it ideal for producing functional parts, as opposed to simple prototypes. **For more information visit www.crptechnology.com**



LUBRICANTS

Ravenol

Cambridge Motorsport Parts is now supplying Ravenol's dedicated range of racing lubricants. The oils available range from semi-synthetic RFS 15w-50 for classic racing through to fully synthetic RSE 10w-50 and RSS 10w-60 for modern applications. The range also includes transmission oils such as the 75w-90 synthetic multigrade gear oil and the 75w-140 Limited Slip oil for LSD differentials and dog boxes.
For more information visit www.cambridgemotorsport.com

LUBRICANTS

Total Seal break in oils

Piston ring supplier Total Seal is now offering a new range of break-in oils, developed in conjunction with Driven Racing Oils. The new oils contain high levels of ZDDP, which provides a protective film on components during break-in. The oils will happily run for two hours before needing to be changed for regular oil, and are especially effective in engines running flat tappets. The new formulations are also suitable for use in alcohol and other alternative fuelled engines. To complement the break-in oils, the company is also producing an assembly lubricant for use on highly loaded surfaces.
For more information visit www.totalseal.com

TOOLS

Laser compact sockets

Access to fasteners can often be an issue in confined racecar engine bays. With this in mind, a new product in Laser Tools' Alldrive range could prove a useful addition to any pit box. It consists of a compact ¼-inch ratchet driver, with an articulated shaft and T-shaped handle, providing access in tight spaces while still giving plenty of leverage. The Alldrive socket system has a unique tapered profile that fits metric, AF, Whitworth, spline and star fasteners, so the five sockets included (8, 10, 11, 12 and 13mm) cover many applications. Also included is a bit holder and 50mm extension bar. The head of the ratchet handle swivels and the handle itself swings out to form a handy T-bar.
For details check out www.lasertools.co.uk

VIDEO CAPTURE

MoTec HD-VCS

ECU and electronics specialist MoTeC has recently released a new video capture system. The HD VCS produces genuine high definition footage with 1080p resolution at 30 frames per second, giving excellent clarity and image capture quality. It also includes an automatic start/stop function to ensure that recording always takes place and over five hours of full high definition footage can be recorded onto the 32gb removable SD card. The MP4 video files can be played directly from the card. The unit uses the vehicles power supply, so there are no batteries to run out – except for the vehicle's, but if that is flat you have bigger worries than your track video! The HD-VCS is also compatible with MoTeC's range of ECUs and data loggers, allowing it to automatically overlay data on to the video feed with no post processing required.
For more information, see www.motec.com

Racecar Engineering
The International Journal of Motorsport Technology

PIT CREW

Editor
Andrew Cotton
@RacecarEd
Deputy editor
Sam Collins
@RacecarEngineer
News editor
Mike Breslin
Design
Dave Oswald
Chief sub editor
Stuart Goodwin
Contributing editors
Paul Van Valkenburgh
Technical consultant
Peter Wright
Contributors
Mike Blanchet, George Bolt jr, Lawrence Butcher, Ricardo Divila, Brian Garvey, Gemma Hatton, Simon McBeath, Danny Nowlan, Mark Ortiz, Peter Wright
Photography
LAT, WRi2
Deputy managing director
Steve Ross
Tel +44 (0) 20 7349 3730
Email steve.ross@chelseamagazines.com
Head of business development
Tony Tobias
Tel +44 (0) 20 7349 3743
Email tony.tobias@chelseamagazines.com
Advertisement manager
Lauren Mills
Tel +44 (0) 20 7349 3740
Email lauren.mills@chelseamagazines.com
Marketing manager
William Delmont
+44 (0) 20 7349 3710
will.delmont@chelseamagazines.com
Publisher Simon Temlett
Managing director Paul Dobson
Editorial
Racecar Engineering, Chelsea Magazine Company, Jubilee House, 2 Jubilee Place, London, SW3 3TQ
Tel +44 (0) 20 7349 3700
Advertising
Racecar Engineering, Chelsea Magazine Company, Jubilee House, 2 Jubilee Place, London, SW3 3TQ
Tel +44 (0) 20 7349 3700
Fax +44 (0) 20 7349 3701
Subscriptions
Subscriptions Department
800 Guillat Avenue, Kent Science Park
Sittingbourne, Kent ME9 8GU
Telephone +44 (0) 1795 419837
Email racecar@servicehelpline.co.uk
http://racecar.subscribeonline.co.uk
Subscription rates
UK £66 (12 issues)
USA $162 (12 issues)
ROW £84 (12 issues)
News distribution
COMAG, Tavistock Road, West Drayton, Middx UB7 7QE
Printed by Wyndeham Heron
Printed in England
ISSN No 0961-1096
USPS No 007-969

recycle

www.racecar-engineering.com

GT racing finds a good home

The Belgian town of Hasselt was the scene of one of the most bizarre car launches in the FIA GT Championship's history. The story is long, and involves a Ford Escort van, a nightclub, fireworks, an unlikely boyband and a Pagani Zonda. It was, we concluded in the bar as we attended the second round of the FIA GT series this year, just what the championship is all about. In fact, it is pretty much what international endurance racing in Europe is all about.

We recounted Laurence Pearce stories at length, recalling his jamming open of the throttle of Jamie Campbell-Walter's Lister Storm at Magny-Cours to allow his driver to reach the finish when the cable broke with three laps remaining. 'Let the rev limiter take care of it,' said the team owner as his driver went back out to scare himself. We recalled the time that Pearce used a solar-powered calculator to work out fuel strategy, only for the team to see it sailing over the pit lane and a torrent of abuse shouted after it as it got dark.

And we recalled Toine Hezemans's efforts to make the Chrysler Viper work better than the ORECA team, which led to the front falling off, the carbon prop shaft failing, and the oil tank moved to the rear of the car with catastrophic consequences. This was all highly entertaining as we looked back at it.

> **"We are no longer going to have cars floating around in containers for two months"**

When Stephane Ratel tried to take his championship to a world stage, it felt as though he was pushing water uphill. It made sense when you discussed it with him, but throughout the three-year programme there was a sense of fragility that couldn't be ignored.

Back in Hasselt for the Zolder race, it felt much more as though the series had found its natural home. The circuits may not be much to write home about – Karun Chandhok wondered if this was the only circuit in Europe where you had to pay to pee, and the media in the press room were more concerned with having their pictures taken with the grid girls than directing questions to the winning drivers. Yet the championship has a solid base and the questions in the paddock were more about how the championship would grow than how it would fail.

The GT series races at Nogaro, Zolder, Zandvoort, Slovakia-Ring and Navarra, plus a circuit outside Europe. The latter venue is the only fly in the ointment for Ratel and his teams – will he go world championship again as the rumour is that this will be at Abu Dhabi? Ratel himself says no. 'My final conclusion of these hard three years are that it is hard, not to say impossible, to sustain the logistic and promotion cost of a world championship unless you have the same revenue streams,' he said. 'We succeeded in having events that financially contributed, and that was a good thing, but then you need TV revenues, which is almost impossible, and also sponsors. Having only one of the three, with fluctuations, is not enough to cover the cost to sustain to the teams. The key is to get the TV coverage that allows sponsors to advertise according to visibility. That is a hard point of any world championship.'

The field is limited to 28 cars to control costs (read limit congestion on track), the homologation has been frozen for two years to limit the upgrade costs to teams, the calendar is pretty much fixed, and if anyone wants the championship to come to them, they have to pay. No longer does Ratel have to have races on three continents, leaving him free to pick his tracks. 'We are no longer going to put cars on containers and have them floating about for two months,' said Ratel. 'If you want us, you send two cargo planes, bring us back and then we can come. We are very well in Europe. If you want our show, come, pay and we come. Maybe no one will ever pay, maybe they will.'

Already, however, the series has taken steps in the positive direction. Ten Brazilian drivers, Brazilian teams, Chinese and Indian drivers, German television with RTL, and a contract with Al Jazeera. Pirelli is the sole tyre supplier to the GT series and to Blancpain, primarily because it wants to be associated in racing with brands that it wants to buy its tyres. Then Ratel signed a deal with Total that sees Elf become the official supplier of two series. The reason? According to the press release: 'The ELF CM G2 fuel has characteristics that fit both naturally-aspirated and turbo/supercharged engines. This includes six, eight, 10 and 12 cylinder units.' In other words, it, too, wants to be associated with the cars that are competing in the championship.

This is a real target for national teams to aspire to. Europe is the rightful home for the series, and from there a solid base can be built.

EDITOR
Andrew Cotton