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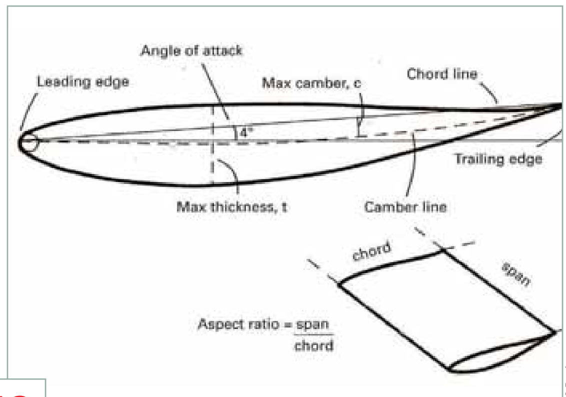

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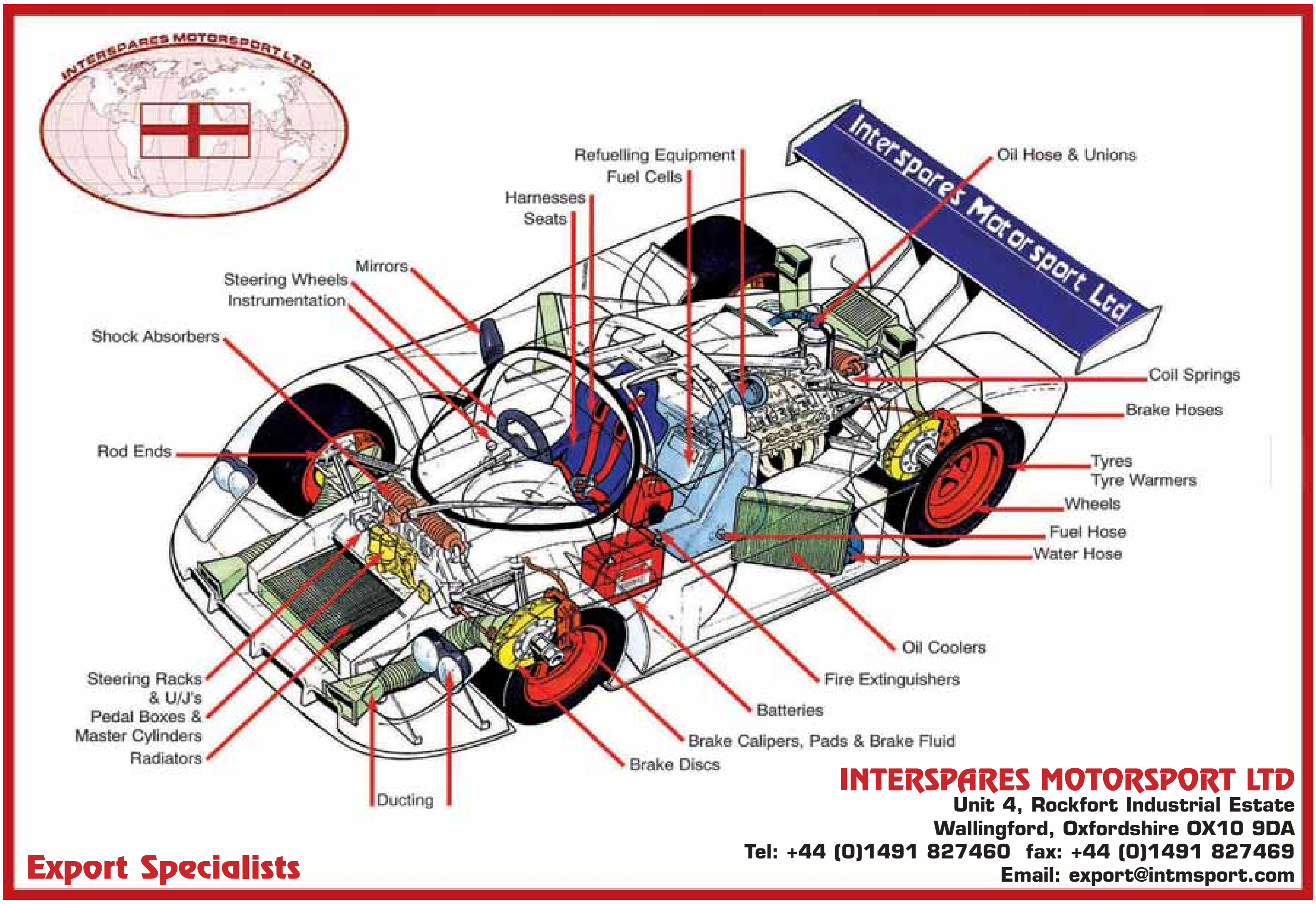
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Write Line

Has motorsport lost its sense of showmanship under the oppressive pressure of its major manufacturer paymasters? I found myself asking this question thanks to a flippant comment from a racing driver at a car launch late last year. The launch in question was the new Audi R10 diesel sports prototype in Paris last year. For the event, the company had gained permission for the new racecar to be driven slowly round the Jardins du Trocadero in the shadow of the Eiffel Tower. When the new car rolled to a standstill, driver Tom Kristensen hopped out to be met by an attractive female interviewer with a microphone. 'How was the drive?' she asked. 'Not bad,' replied Kristensen, 'the Paris traffic was bad but the run up the autoroute was fine.'

Did he... we asked ourselves. Surely not. He hadn't just driven it all the way from Inglostadt had he? Is that possible? Why not? Wind up the ground clearance to clear bumps, register the car for the road – easy. Audi does it with production car prototypes all the time. Wow, what a fantastic stunt. And fuel? Could they even have driven it all the way on one tank? Surely not. But why not? 90 litres, the car running off boost most of the way, cruising at the legal maximum, except of course in Germany where a 200mph squirt would have made the performance point. What a superb way of driving home the synergy with the diesel road cars on both economy and performance.

> **"THE SPORT SEEMS TO HAVE LOST ITS SENSE OF FUN"**

'Of course, we should point out,' said the pretty interviewer, 'that you are only joking.' And puff, the whole sense of theatre was blown out like a candle flame. At the risk of getting Mr Kristensen into trouble, I have to say the launch seemed rather flat after that.

But it does make the point that too often we expect people to love motorsport for its mind and we are inclined to deny it a revealing dress or seductive make-up. However, we live in an age where there is a mass of entertainment fighting for people's attention. If something wants to get noticed it needs to make itself stand out. And that doesn't mean compromising the purity of the racing on the track. The two activities are not mutually exclusive. Look back 30 or 40 years and publicity stunts went hand in hand with good racing. Granted, in those days it often involved the politically incorrect use of women, but it didn't have to.

Today, the sport seems to have lost its sense of fun. It has become rather sober, responsible and respectable. When did you last see motorsport grabbing headlines on the front page? The most recent occasion I can recall was a couple of years ago when they ran F1 cars through London's streets. Crowds turned out in hundreds of thousands and headlines were grabbed everywhere. But such events are all too rare. Is that because the sport we love has become too serious and self important? Or is it that major manufacturers can't reconcile the wow factor with their carefully-crafted, squeaky-clean public images?

Let's face it, you can't imagine a manufacturer backed F1 team doing something crazy like taking one of its cars to Bonneville, can you? Er, hang on...

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Charles Armstrong-Wilson

The International Journal
Racecar engineering

Pit Crew

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Formula One revolution

New regulations issued by the FIA mean that 2008 will see massive change in Formula 1. Control parts, the controversial CDG wing, rev limits and restrictions on development will all hit the grid this season.

As predicted in last month's issue, green solutions will also start to make an appearance in 2008 as all F1 fuel will have at least 5.5 per cent of its content from biological sources. Customer cars will also make a return, as independent teams will be able to purchase complete cars from works teams.

The stated objective of the new regulations is to make substantial reductions in the cost of going grand prix racing. An independent team with a $100 million (£57 million) budget should now be able to compete with a manufacturer team prepared to spend more than three times that amount.

LAT

Once again F1 is changing the regulations in an attempt to reduce costs and encourage independent teams to compete

Comments made by Max Mosley reveal the financial motivation behind these fairly drastic changes: 'the real argument in Formula 1 is about costs, the world championship must remain financially viable for independent teams. Against this, two or three manufacturers want to win by spending unlimited amounts of money. This approach has caused great damage to motorsport, most recently to the Indy Racing League and we don't want it in F1.'

2006 rule change round-up

Technology

New technologies such as front torque transfer or 'brake steer' which give a team a competitive advantage for one season, but which are then adopted by all teams for subsequent seasons at significant expense, will be banned at the end of the first season.

The reason for this is to reduce costs, so a team that develops a new technology still feels the benefit of it, albeit only for the rest of the season. However, this does still allow teams to spend large sums on developing technologies, only to see them banned if it is felt they have no value to the sport. If they are banned, the teams will be obliged to publish full details of the system. Racecar will likely publish any such details.

5.5 per cent of the fuel mix must come from biological sources, and from 2009 regenerative power systems will be permitted, meaning F1 is likely to become hybrid drive. This should increase the relevance of Formula 1 to the development of road car technology.

Aerodynamics

The centreline downwash generating (CDG) wing will become mandatory from 2008. There will be other significant bodywork changes to reduce downforce and keep drag at current levels. Substantial changes to the front of the cars will also be made to make them handle better in traffic. From 2009 the teams will only make two changes to the cars' bodywork after the start of the season. What constitutes a

LAT

Early '90s' F1 cars could give an insight into what 2008 cars may look like

LAT

Simplified aerodynamics and wide slick tyres should help to improve racing

set for 2008

Many of the changes are aimed at reducing the costs of grand prix racing, though previous attempts to do this have, according to some, had the opposite effect, something Mosley counters: 'It must not be forgotten that the new engine rules were originally drawn up and proposed by the car manufacturers to reduce costs. Although some of these manufacturers now claim that costs have risen, it has become clear that for a properly managed engine supplier costs have fallen substantially.'

Formula 1 seems to be looking forward, and all 10 teams have agreed to allow Super Aguri F1 to enter, even though the Japanese outfit still has some very major uncertainties to resolve – a prime example being the construction of a chassis. It's likely the team will start the season with a modified Arrows design, though the team admits that it does not expect to be on the pace until mid season. However, there are still question marks over the very future of the sport, and a rival series organised by a group of manufacturers known as the GPMA still looks likely to go ahead. This would leave Formula 1 with only half its teams.

LAT

Super Aguri F1 will be the first of a new breed of independent teams, using aged Arrows chassis and Honda V8s

F1 calendar 2006

12 March – Bahrain
19 March – Malaysia
2 April – Australia
23 April – San Marino
7 May – Europe (Germany)
14 May – Spain
28 May – Monaco
11 June – Great Britain
25 June – Canada
2 July – USA
16 July – France
30 July – Germany
6 August – Hungary
27 August – Turkey
10 September – Italy
17 September – Belgium
1 October – China
8 October – Japan
22 October – Brazil

change is not yet clear, be it a new winglet or a fully re-worked aero package. There will also be limitations on some 'interesting' areas of aerodynamic research.

No car may produce more than 12,500N of downforce at any time. The purpose of some of these changes is to ensure the cars create a wake and can draft each other. Any aerodynamic device that avoids the purpose will be banned. Winglets and flip-ups have effectively been banned

Chassis
Cars will shed 55kg of weight, bringing the minimum weight to 550kg, to save on teams buying and carrying ballast. Maximum car width has been increased to 2000mm with a minimum width of 1950mm. Restrictions on materials are also in place.

Engine
Engines will be little changed from the current 2.4-litre V8 specification, though the restricted 3.0-litre V10s will be outlawed. One significant change is the adoption of a rev limit of 19,000rpm again to keep costs under control. Although not yet confirmed it is likely that engines will have to last three full race meetings, making it more likely that teams will look to circumvent testing limits by running their units in LMP2 sportscars.

Electronics
Every car will carry a control ECU built by an FIA-selected single supplier, and it may only be connected to the cars' loom, sensors and actuators in a specified fashion. All components of the engine and transmission must be controlled only by this ECU. Digital instrumentation will also be a control part. These measures are supposed to stop any driver aids being used, but a number of industry sources have voiced concern to *Racecar* that teams will still be able to use their own sensors for acquisition purposes, although their loom cannot be connected in any way with the FIA control loom.

Transmission
To reduce costs gear ratios must be made of steel and no thinner than 12mm. It is also likely that transmissions will have to last four race meetings.

Tyres
Control slicks will be supplied by a single manufacturer, known not to be Michelin. Drivers will be able to adjust tyre pressures during a race for safety reasons.

LAT

Complex aerodynamic devices, including winglets, have now been oulawed

Diesel power for Le Mans

Diesel power has returned to sportscar racing with two new projects breaking cover and, as has long been rumoured, Audi's successor to the dominant R8 – the R10 – is diesel powered. The new car was unveiled in Paris shortly before Christmas, some believe as a taunt to Peugeot which is itself constructing a diesel racer for Le Mans. Compared to the R8, the R10 has a longer wheelbase to accommodate the longer V12 engine and wider front tyres. In profile the car has a strong family resemblance to the almost unbeatable R8, but the front end is strikingly different and some say even aesthetically unpleasing. The shrouded front suspension improves airflow, claims Audi, and is reminiscent of Bentley's 2003 Le Mans winner.

A major difference are the twin roll hoops, or 'blades', as they are totally different to any other prototype yet constructed and give much cleaner airflow to the rear of the car.

Audi claims the new, all-aluminium, V12 TDi engine produces 650bhp and a massive 1100Nm (811lb.ft) of torque. This gives rise to a whole new set of challenges, not least in the transmission. The Xtrac gearbox developed for the R10 is lighter than Ricardo's R8 unit, even though is has to handle a 55 per cent increase in torque. Tyres too will be developed with Michelin to cope with the extra loading.

Fuel efficiency has been increased over the petrol R8 with the R10 able to run an extra lap at Le Mans between stops. Already the Audi is the favourite to win this year's Le Mans 24 Hours.

Meanwhile in England, Ian Dawson's Le Mans diesel dream is back on track. Having entered the first diesel-fuelled car at La Sarthe for over 50 years in 2004 – beating Audi by two years – he plans to be back this year with a further development.

Dawson's Taurus Sports team was unable to finance a further season after 2004 and a rescue plan by consultants ARP proved ill conceived. But Dawson has now received support from bio-diesel producer D1 Oils, meaning that he can once again bring something new to Le Mans. Even in 2004 he was already looking beyond the horizon and was talking of using bio-diesel (like the bio-ethanol used by Nasamax, a product made from renewable energy crops). The new team will be known as groupBio team.

Late last year Dawson's Lola B2K/10 was converted by Mountune to run on a mixture of regular diesel and bio-diesel, with the hope of an entry for this year's 24 Hours. The calorific value of bio-diesel is very close to mineral diesel, and the change is mainly down to engine mapping. A new engine has been purchased to replace the old one that was taken from a Volkswagen SUV with turbocharging now courtesy of KKK rather than Garrett. At the time of writing the car had been, said Dawson, 'half hybridised.' This should have been completed in time for the Lola to comply with the 2006 regulations and to be able to enter for the Sebring 12-hour race.

The new sponsor, D1 Oils, is a UK-based global producer of bio-diesel. There are, says Dawson, 'a lot of things it can learn' from the new project. 'What we learn about how different bio-diesel blends perform in our engine is going to be of immense value,' adds D1 CEO Philip Wood. It is also intended to give D1 the opportunity to build up its brand as it plans to expand its planting and refining business. One country in particular where there is interest in bio-diesel is Japan, which means that the team could take advantage of the new Japanese Le Mans Endurance Series.

Ricardo Judd's diesel engine project is also believed to be making progress with help from government money.

Audi

Audi

Diesel-engined R10 is firm favourite for outright victory at Le Mans this year


Tom Wilcox

GroupBio's Lola will run on bio-diesel this season, the first LMP to do so

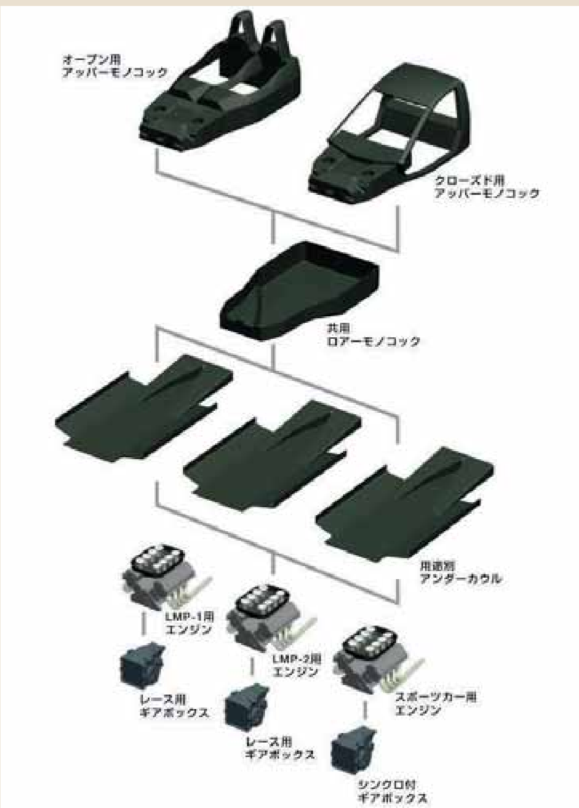
Take Courage


Courage

Courage has revealed an artist's impression of the overall look of its new LC70 LMP chassis. This will be the Le Mans-based firm's first top-class prototype fully compliant with current LMP rules.

Dome's modular concept

Dome has released concept sketches of a new modular prototype racer, adaptable from LMP1 and 2 to GT format with only minor changes. Whilst the idea is new and exciting, sources in Japan say it is unlikely the car will ever be built.



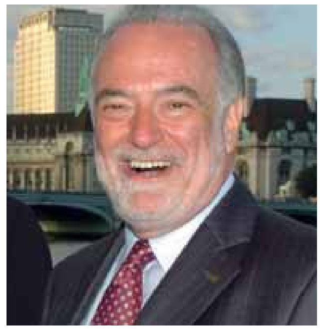
The Motorsport Foundation

The Motorsport Industry Association unveiled a brand new initiative to help the sport in the UK. Called the Motorsport Foundation, it will be a fund aimed at assisting the recruitment of new competitors and audiences, thereby growing the demand for UK motorsport businesses, services and equipment.

In the first instance, the initiatives the Foundation intends to tackle will be focused on marketing to increase the profile of motorsport and establishing a 'National Motorsport Week' in 2006. There will also be a 'kick start' scheme to nurture emerging talent.

The MIA's chief executive, Chris Aylett, said 'I have always believed that creating such a foundation would be very beneficial for the sport and, thereby, the industry. The timing is now right for our industry to help itself from within rather than hoping and waiting for external support.'

MIA chairman, Peter Digby, echoed the sentiments: 'I'm personally delighted that the MIA and its members have taken this initiative. It will deliver new business and improve the profile and reputation of UK motorsport and its industry at a crucial time.



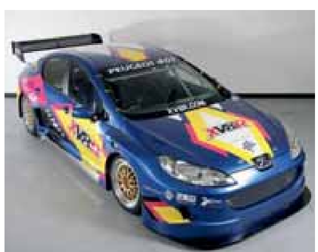
'The timing is now right…' says MIA chief executive Chris Aylett

To raise the resources the MIA plans to solicit support through partnerships with industry, wealthy individuals, government, governing bodies, charities, covenants, annual appeals and special events. A company limited by guarantee, the Foundation will initially form part of the MIA with a charitable subsidiary being developed in due course.

Prototypes dominate Autosport launches

There were plenty of new cars on display at January's Autosport Show in the UK. Of interest was an all-new spaceframe V8 concept racer in the form of the VERCO XV8R.

Meanwhile, Lola made a surprise announcement of its intent to return to amateur racing with its first foray into the LMP3 market, the B06/90.



The car is initially being built for Sports 2000.

Other new prototypes from Juno, Gloria, Norma, Kelforms and Lynx were also on display.

■ See show report on page 30 for more details.

NASCAR TV deal announced

NASCAR has announced its TV deal for 2007 and beyond. The contract involves ESPN and ABC, Fox Speed Channel and TNT and is worth $4.48 billion over an eight-year period. Wall Street however didn't look upon the deal favourably and stocks in the two major NASCAR track operators, Speedway Motorsports and International Speedway Corporation, fell 10 per cent when the news broke, despite the deal being worth 40 per cent more than the current contract. Beginning in 2007, each NASCAR season will be launched on Fox with the telecast of the Daytona 500. Fox will then also carry NASCAR Speedweek's events, including the Budweiser Shootout and Daytona Pole Qualifying, and will broadcast the 12 NASCAR Nextel Cup races following the Daytona 500. TNT will broadcast six consecutive Nextel Cup Series races (races 14-19), while the final 17 Cup Series points races will be broadcast on ABC or ESPN. The final 10 races, the Chase for the Nextel Cup, will be broadcast on ABC. The NASCAR Busch Series will be broadcast on ABC, ESPN or ESPN 2, with no less than four events on ABC. Speed will televise the NASCAR Craftsman Truck Series, with the exception of two events that will be broadcast by Fox.

LAT

Minor rule changes for 2006 mainly revolve around fuel and refuelling systems

NASCAR pocket 10 per cent of the TV purse, while the tracks take 65 per cent and the remaining 25 per cent is added to the race purse. NASCAR also announced that only five races in 2006 will be impound races, where teams practice and qualify then impound the cars. Last year 21 of the 36 races were impound events but changes were made after lobbying from TV networks needing more airtime and track operators wanting more gate money from the cars on track. Both Talladega and Richmond races, plus the July Daytona night race will be impound races.

A number of technical rule changes were also revealed prior to the start of the 2006 season. These include a downsizing of the outlets on the 11-gallon fuel dump cans used during pit stops from two inches to 1 3/4 inches in an effort to slow pit stops and take pressure off the wheel changers. This only applies to the Busch Series and Craftsman Trucks. The tops of fuel cells must also now be level with the top of the rear chassis rails they mount between (in the past teams would lower the cell and frame thus lowering the centre of gravity). *George Bolt Jr*

Citroën C4 back on track

While rumours proliferated last year (many emanating from France) that Citroën Sport's development of the C4 WRC had not ceased, they remained unsubstantiated. *Racecar* reported on the rumours, and the evident frustration of chief engineer Xavier Mestelan-Pinon at not being allowed to get into the C4 project. *RE* can now reveal the full story.

The first, running, C4 WRC prototype was ready for its first test in September 2004. This was a short tarmac shakedown, followed shortly after by a more substantial test on gravel stages in the south of Spain. Then, the following month, Jean-Martin Folz, president of PSA, the parent company of Peugeot and Citroën, dropped the bombshell, announcing that both companies would withdraw their official involvement in the WRC from the end of 2005.

Another dictum from Folz that October was that all work on the C4 WRC must cease forthwith, and it did. Citroën Sport's engineering development emphasis then concentrated entirely on the Xsara WRCar.

Then, at the Catalonia Rally on the final weekend of October 2005, Folz announced that Citroën would make an official return to the 2007 WRC with the C4 WRC. The project was on again, and only then did any work resume on the C4.

Before last Christmas, it was back testing. Dusted off, the car was essentially still in its September 2004 specification, but this is set to change. The initial 2007-specification car is scheduled to be ready for March and its first test is to be between then and May this year.

Citroën's latest WRC challenger will be based on the current C4 road car

In contrast to the entirely revised 2006-specification Ford Focus WRC, the C4 WRCs' running gear is largely similar to that of the Xsara WRC. The current plan configures essentially similar suspension with improved friction, while it is hoped that work on the Xsara's XU7JP4 engine – which, in common with all WRC engines, is devoid of water injection – will bring outputs to above those when it had water injection. This unit is also in the C4, but under-bonnet restrictions mean it cants back about its crank centreline by 25 degrees, while in the Xsaras it is at 30 degrees.

Gearboxes are identical, save for a unique C4 bellhousing to cater for the 'lost' five degrees. Mestelan considers the C4 will continue with six forward ratios, believing there is not enough evidence of an advantage in choosing five speeds.

The C4 retains an hydraulic circuit to power the gear change and active centre diff, which Mestelan believes to be a good solution – heavier perhaps than alternatives, but a simple system providing good actuating power. The new passive front and rear differentials offer a facility to externally adjust their pre-loads by the crew through their casings between stages.

At present, Folz has dictated that this new World Rally Car will be first seen in action in the 2007 WRC, and this is what Mestelan is working toward, in the full knowledge however that match practice is crucial to the development of a car: 'We will be at the World Championship for the test – and alone!' he said. *Martin Sharp*

Hats off to Bowler

With no fewer than 21 of its current Wildcat 200 desert racers entered in this year's Dakar, Bowler Off Road has set its sights on greater goals. Boss of the Derbyshire, UK-based operation, Drew Bowler, describes the Wildcat as a clubman car that carries the potential to be a top privateer car – something the proliferation of Wildcat entries on Dakar would seem to justify. Bowler's next project is a machine that private drivers can buy as a new car and which can effectively be made into a specification similar to that of a works off-road racer: 'The chassis and body designs have to be of a higher quality and of a good enough design that by putting in trick gearboxes and suspension you can actually push it on to the next level. But it's got to be available at a cost that the customer can afford,' says Bowler.

With styling based on the shorter and squatter Range Rover Sport shape, development work on this, as yet un-named, new car has been under way for over a year, and preparation for production is well in hand. The Wildcat carries similar styling cues to a Land Rover and, indeed, some mechanical system componentry is carried over from that Solihull-made machine.

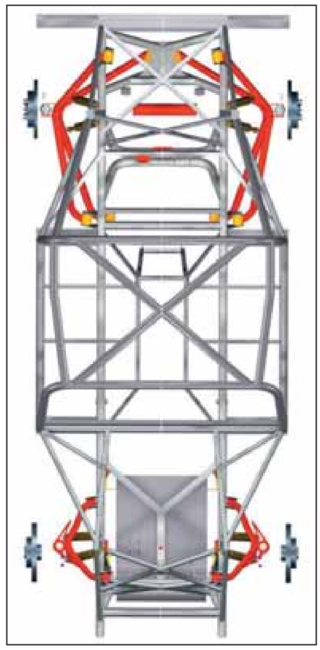
As yet un-named Range Rover-based racer has its sights set on Dakar 2007

Bowler's relationship with Land Rover has been strengthening over the years and, with the new vehicle nearing completion, the bond between the two operations is now very strong. Land Rover is offering engineers, simulation equipment and production engineering expertise to assist in getting this groundbreaking new car right first time.

Bowler has chosen to ensure this by, 'spending the money at the right end of the job. You look at the long-term result, rather than what it's costing you on the first hit.' Accordingly, from Bowler's original CAD designs by designer Jez Siddall, a 1/6th scale model has been made in MDF, and this is being scanned by Simpact to come up with the digital design data to provide an FE model. From this a complete stress and strain simulation can be carried out.

Much of the running gear will be from the Range Rover Sport, as will components such as lights, door handles etc. Land Rover has a tradition of eschewing some (more economical) mass production engineering designs such as locating the front differential in the sump, as favoured by some 4X4 manufacturers. As such, much of the Range Rover Sport's componetry are eminently suitable for rally raids.

With wider, unique wishbones the track will be at the FIA maximum for rally raids, but other suspension parts such as hubs, differentials and gearboxes will be Range Rover Sport, although it is envisaged that when the



top level FIA racer comes on stream, a Sadev gearbox could be used. Engines will either be the Range Rover Sport's supercharged 4.2-litre V8 or the normally aspirated 4.4-litre V8, but for the FIA racer it plans to bring the 4.2 down to 4.0-litres, enabling the car to run at 1825kg minimum weight, despite the vehicle being built to run at 1600kg.

Early models are expected to be built with the 600bhp, 4.4-litre blown V8 and used on non-FIA events to test the car's ruggedness. The target is for the new Bowler to contest Dakar 2007.

Mitsubishi falls on its own WRC sword

Mitsubishi has axed its world rally programme due to budget cuts. With the Monte-Carlo Rally starting in late to mid-January 2006, and this decision arriving just four weeks before the first round, this verdict was very late indeed.

As a motor corporation Mitsubishi is not alone in experiencing financial difficulties, but the split from former parent company DaimlerChrysler last year has worsened the situation. In its last-minute call the Mitsubishi board decided that 2006 WRC budget demands were excessive and scrapped the programme, announcing that it must 'focus management resources on continued promotion of its revitalisation plan.' It is 'hoped' the team will return in 2008, although there is no firm commitment to this. Mitsubishi's Dakar operation, however, will continue.

LAT

Despite making progress with its Lancer WRC, Mitsubishi is now out of the running, leaving just two full-time manufacturers to contest the 2006 series

The irony is that with the Peugeot and Citroën works teams absent from next year's WRC, Mitsubishi could have been looking at regular podiums this year. Since Andrew Cowan won the 1974 Safari Rally, Mitsubishi has maintained a role in world championship rallying and last year it looked to be coming good again. The Lancer WRC had been running to 2006's 'simplified' World Rally Car specification for most of the past two years and was certainly showing progress, as a strong second place in Australia last year demonstrated.

An extremely cohesive bunch of rally technicians and mechanics are now looking for jobs...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MIA Awards

For valuable contributions to motorsport. This year the winners were…

BY CHARLES ARMSTRONG-WILSON

On the Thursday evening of Autosport International the great and the good of motorsport converged on the Motorsport Industry for the MIA Awards. This annual event not only provides a focus for the European industry each year but also honours those that the MIA members feel have made an exceptional contribution to the sport. This year's winners were:

The Business of the Year Award
(sponsored by Xtrac)
Winner: Goodridge
Received by Stuart Goodridge

The Teamwork Award
(sponsored by TAC Europe)
Winner: Renault F1
Received by Pat Symonds

The Small Business of the Year Award *(sponsored by Performance Racing Industry)*
Winner: RML Group
Received by Ray Mallock

The Export Achievement Award
(sponsored by Autosport International)
Winner: Caterham Cars
Received by Jez Coates

The Rally Business of the Year Award *(sponsored by MIRA)*
Winner: International Sportsworld Communications
Received by David Richards

The Technology and Innovation Award *(sponsored by Ricardo UK)*
Winner: Beru F1 Systems
Received by John Bailey

The Service to the Industry Award
(sponsored by the WDA Motorsport Initiative)
Winner: A1 Grand Prix
Received by John Wickham

Above: all the winners and sponsors gathered together at the end of the award's ceremony

Above left: David Richards holds court
Above: Todd Cope - Stasis Engineering and Alessandro Lesma - Ferrari SPA

Above: the MIA president's table
Right: Richard Barnes - SPA group, Rodolfo Alcocer - Pro Car Auto Tecnica and Lynda Randall - SCCA Pro Racing


LAT
Jonathan Wheatley


LAT
Gustav Brunner

LAT
Todd Parrott


LAT
Kevin Hamlin

● Red Bull Racing continues to poach more staff from up and down the F1 pitlane. Former Renault chief mechanic **Jonathan Wheatley** has joined the team, as have ex-Toyota men **Humphrey Corbett** and **Gianfranco Fantuzzi**.

● **Fantuzzi's** departure from his post as logistics manager at Toyota means that the Toyota test team organiser **Andy Beaven** fills his position.

● **Gustav Brunner** has made a surprise departure from his role at Toyota F1. The team has been re-structuring internally and his position of chief designer has been made obsolete. Brunner, however, is likely to stay within Formula 1.

● **Len O'Hagan** has been appointed chairman of the new Rockingham Performance Park in Northampton, UK.

● Former Kraco Racing/Kraco-Galles team owner **Maurice Kraines** has died. His team won the Champ Car title and Indy 500 in the early '90s.

● **Todd Parrott**, who was released from Robert Yates Racing as crew chief for Dale Jarrett, has relocated to Petty Enterprises as the head wrench for Bobby Labonte. Parrott joins other veteran crew chiefs **Paul Andrews** and **Robbie Loomis** who returns as team manager of the team.

● **Roy McCauley**, chief engineer with Penske Racing South, has taken over the role of crew chief for the number two Miller-sponsored Penske Dodge, replacing Larry Carter who was removed from the position during December. Carter was offered another position within the Penske organisation, but instead made the move to Bill Davis Racing in a different role. McCauley had six wins crew chiefing Ryan Newman in just nine starts in the Busch Series during 2005, McCauley was previously with PPI Motorsports.

Penske Racing South also laid off more than 20 employees in a shake up that included closing the 77 Kodak team.

● Crew chief **Kevin Hamlin** has moved with driver Dave Blaney from Richard Childress Racing to the Bill Davis Racing CAT Dodge team that will switch to Toyota in 2007.

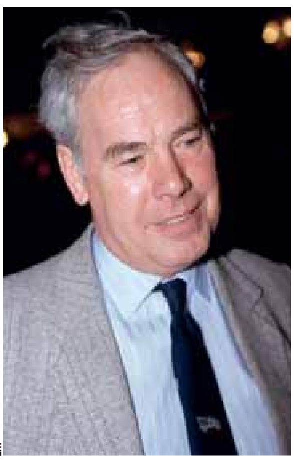
● **Ken Schrader** took his former BAM Racing crew chief, **David Hyder**, with him when he left the team for the Woods Brothers. Former BAM car chief, **Ron Otto**, has been named as crew chief for rookie driver Brent Sherman in 2006 with BAM.

● **Kate Millar**, an engineer with the WPS Racing V8 Supercar team, has been given the inaugural 'Excellence in studies and achievement' award by the Queensland state section of CAMS. Millar joined the team in early 2005.

● **Gavin D. Ireland** has won the 2005 Renault MSA Young Photographer of the Year award for his work with Scuderia Ecosse and on the Autodrome project with *Racecar Engineering* deputy editor Sam Collins. Ireland's work in *Racecar* was also part of the submission.

Send your company and personnel news direct to the *Racecar Engineering* team: tel: +44 (0)20 8726 8363; fax: +44 (0)20 8726 8399 or email racecar@ipcmedia.com

Keith Duckworth 1933–2005


LAT
Keith Duckworth – the man who put the 'worth' in Cosworth

In 1967 a film entitled *Nine Days in Summer* charted a revolution in motorsport engineering. The Lotus 49 and the creation of its now legendary powerplant – the Cosworth DFV. Featuring heavily in the film is an enthusiastic engine designer and Yorkshireman by the name of Keith Duckworth, the man who put the 'worth' in Cosworth.

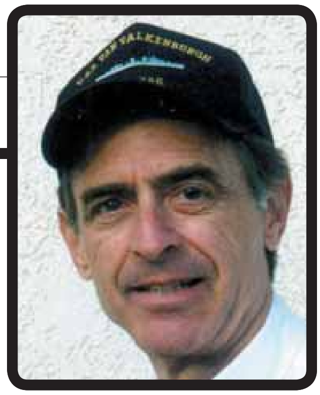
After compulsory service in the UK Royal Air Force, Duckworth attended Imperial College in London to study engineering. After finishing his studies in 1957 he joined Colin Chapman's growing firm – Lotus – as a transmission development engineer. Soon after starting there he met Mike Costin and Cosworth was born.

Duckworth's DFV engine went on to win 154 grands prix and had success in countless other formulas in numerous guises. The DFV will be Duckworth's lasting legacy, along with Cosworth – a company still supplying engines to top teams in Formula 1 today.

An online book of condolence has been set up at www.keithduckworth.co.uk

LAT
Legends together – Graham Hill, Keith Duckworth and the Lotus 49 in 1967

By Paul Van Valkenburgh



Military technology transfer

Has electronic vehicle control has progressed to such levels that drivers could soon become redundant?

A really good engineer in any discipline is always watching for new breakthroughs in technology, even seemingly unrelated ones. And always in the back of his mind is the evaluation, 'how might I use that in my own applications?' My brother, also an engineer, says that when he gets stumped for a solution he wanders through random aisles in a surplus electronics store, and often sees something that triggers an answer. While I was covering the DARPA Challenge entrants last month, I kept wondering how their engineers might handle an 'on-road' challenge like an oval or road racing course. Could professional racers improve their performance by talking with the programmers about their vehicle control logic? That might seem ridiculous, but consider this: after active suspensions were banned, I heard that the engineers who had researched and developed them were able to make conventional suspensions work almost as well.

Granted, the very greatest current computing power is way short of human capacity, but for repeating laps on a closed course, the task really isn't that complex – to me it's almost boring – with the exception of negotiating a pass. Otherwise, alone on the track – as in qualifying – the driver is just a conversion system, sensing a finite number of inputs, integrating (and differentiating) them, and responding with three control modifications: steer, throttle, brake.

So the key question is, how would you compare the sensitivity of a driver to that of electronic sensors, such as those used to control vehicles in the DARPA race? Based on my experience with data acquisition instrumentation, I'd say that in most cases, the best drivers would be pretty poor in comparison.

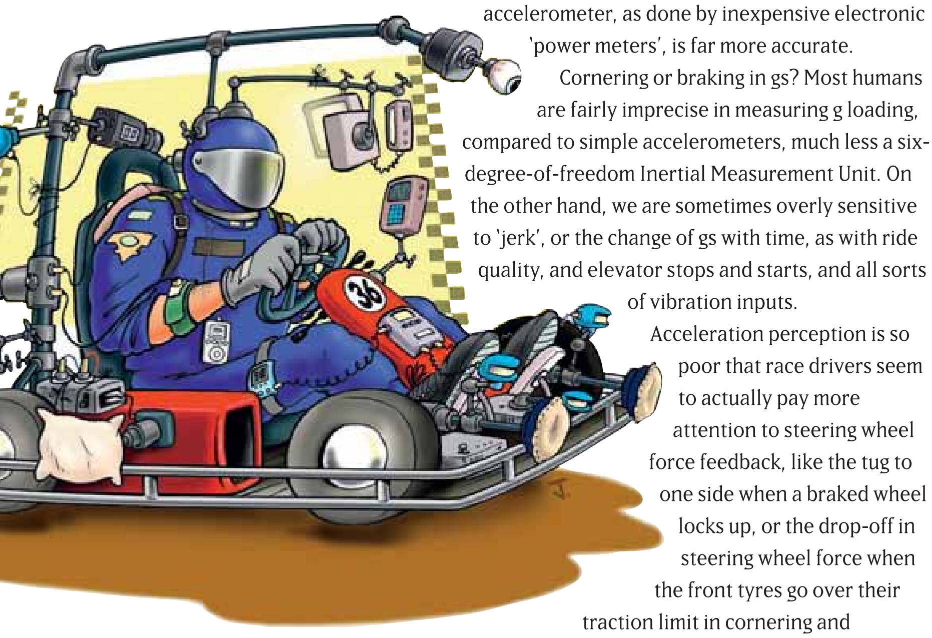
The obvious exception would be vision, →

> "ON TRACK, THE DRIVER IS JUST A CONVERSION SYSTEM"

especially object recognition, where both engineers and neuroscientists are stumped by the abilities of the most primitive organism. Outside of a narrow two-degree 'tunnel vision' cone, human acuity is pretty poor, yet we can easily identify objects in a wide angle of peripheral vision. And our relative depth perception is very good, partly due to other cues, especially using vision for the mental calculus of the interception of two moving objects. Consider, for example, the task of catching a pop fly, or hitting a running receiver with a football. And yet, visual accuracy in distance is really poor compared to a laser rangefinder or GPS,

Let's look at other sensor comparisons, one by one, by the feedback stimulus to be sensed, such as velocity, gs and yaw angle.

> **"COMPARED TO ELECTRONICS, HUMANS DON'T SENSE ANYTHING VERY PRECISELY"**



Velocity is usually determined by instantaneous changes in distance. Ever try to judge your speed out on the open road without looking at the speedometer? Plus or minus 10mph at 80? That's not very precise when compared to the cheapest speedometer, much less GPS, radar, or ladar. During acceleration, even the mathematical integration of the 'g' signal from an accelerometer, as done by inexpensive electronic 'power meters', is far more accurate.

Cornering or braking in gs? Most humans are fairly imprecise in measuring g loading, compared to simple accelerometers, much less a six-degree-of-freedom Inertial Measurement Unit. On the other hand, we are sometimes overly sensitive to 'jerk', or the change of gs with time, as with ride quality, and elevator stops and starts, and all sorts of vibration inputs.

Acceleration perception is so poor that race drivers seem to actually pay more attention to steering wheel force feedback, like the tug to one side when a braked wheel locks up, or the drop-off in steering wheel force when the front tyres go over their traction limit in cornering and understeer. Drivers also seem to use their observation of the extremes of steering angle. But again, even existing data acquisition sensors are more accurate.

Vehicle yaw angle, the driver senses as relative to the vehicle vector path. Yaw gyros have been controlling fighter aircraft better than pilots for decades, although they do have a tendency to drift over time. But two GPS receivers placed at extreme ends of the body worked really well for DARPA entrants, and gyros just supplemented them. Yaw acceleration, like 'jerk', is probably a better feedback, in its sudden instantaneous change, such as when the car loses traction at one end, especially the rear.

When you come right down to it, compared to electronics, it seems like humans don't sense much of anything very precisely, other than images and sound frequencies – and at that, not even intensity to within ten per cent accuracy. There ought to be a great opportunity for cybernetics to supplement those poor skills, if racing rules allowed. Or is it possible to present more precise feedbacks to the driver in legal or concealed ways?

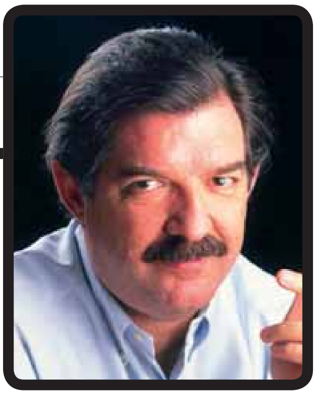
It seems like it would be relatively easy for a computer to steer a racecar around a race track, with previously well-mapped road boundaries, using differential GPS feedbacks that are accurate to a few centimeters. Driving at the limit of traction would then require an IMU with three-axis accelerometers to control cornering and braking at the limit (the vertical accelerometer for adjusting to road roughness). Then a single yaw gyro would manage the heading angle, and fine control of the oversteer/understeer balance that results from changing brake and throttle, and constantly changing front/rear surface coefficients. It is possible all this is already being done in stability control in production passenger cars, where the control is via minor brake applications at each of the individual four wheels.

Running against other vehicles seems a lot more complex. This is closer to the challenge of street traffic, where currently there are very good autonomous vehicle following algorithms, but without the lateral vehicle awareness that would allow it to swerve to avoid an obstacle. You need proximity sensors, and the ability to predict other vehicle's vector path – actually probably like the mission of 'Star Wars Defense' killer missile intercepts, but without the intention of impacting.

Wait a minute! Hasn't all this logic already been analysed by computer race gaming developers? I'm not into that, so you tell me. When you drive against other computer-generated drivers, aren't they driving some realistic optimum lines, and aren't your car boundaries compared to theirs, so that interference (collisions) can be determined, or predicted and avoided? I've heard that you can even input the opposition's skill level of car control. If these programmers' knowledge of vehicle dynamics is really as good at it as their game simulations indicate, then they must be very close to being able to handle the logic in the real world. And the gaming industry might also have someone with the financial justification to go to the effort to transfer this technology to a real racecar. Think of the publicity! And the potential effect on sales of their games. If I were going to be around in this business very much longer, that's a challenge I'd jump on.

The first run-off between a human qualifying lap and one by an autonomous race car would be a sensational event. Like the challenge when World Chess Champion Garry Kasparov lost to IBM's 'Deep Blue'. I hope I live to see the day when vehicle dynamics racing engineers out drive the best of those overpaid Formula 1 and NASCAR celebrities.

By Sergio Rinland



The uncompetitive edge

Has the role of the racecar designer in the intermediate formulae become obsolete as price outweighs performance?

When I left Argentina to design racing cars I came to the UK because it was the world leader. It had numerous racecar manufacturers, most of the Formula 1 teams and a world-leading edge in racecar know how and technology. It was the place to be, and for anyone with ambitions to be a racecar designer there was no contest. I fulfilled my ambitions working for the country's leading manufacturers and F1 teams, but in recent years I have seen the UK's lead slip away to other areas of Europe. Dallara has taken over Formula 3, GP2, WSbR and Indy Cars, Toyota has set up its Formula 1 team in Germany and specialist suppliers are flourishing in the US, Western and Eastern Europe. Meanwhile, the UK has lost many F1 teams and seen its wealth of racecar manufacturers and suppliers whittled down to a shadow of its former self.

Why is this a concern? We can't claim that the UK has a god given right to this business. The problem is, that the reasons why this business is slipping out of the UK will also make it slip out of Europe. In the future, Eastern Europe, India, China and other emerging economies will be taking whole chunks of the business away from the UK and Western Europe.

The cost of manufacturing in these countries is already legendary. Low labour rates and low overheads, coupled with a steadily rising capability, make it uneconomic to not manufacture parts in these territories. Already some major names in motorsport are having components made in China and India in the full and certain knowledge that if they don't, they won't be around for very long.

Does that mean the whole motorsport industry will move to the east? Not necessarily. It doesn't have to and, to discover why, we need to look at the reasons it is leaving the UK now. In my view it is a failure of the governing bodies and the industry associations to create rules within which the industry can flourish. Right now there is no competition and creativity in single seaters apart from Formula SAE and Formula 1.

LAT

Are control formulae such as Formula BMW (left) killing the competitive edge? Rinland suggests replacing them with an open formula such as Formula 4

Hard to believe? Let's take a look at the single seater spectrum today.

Entry level these days is Formula BMW, or maybe Formula Renault – both car manufacturer controlled formulae with one chassis mandated for each series and very tight rules. Above that is Formula 3, an open-chassis formula but dominated by one manufacturer. However, I'll come back to that later. Then above F3 is GP2, again a car manufacturer controlled formula. Also, consider this. Alongside GP2 are A1GP, Superfund, Formula Nippon, Indy Lights, Renault World Series and even GP Masters – seven series with similar levels of power, grip and performance and all with one chassis devoted to each series.

> **"THE REASONS WHY THIS BUSINESS IS SLIPPING OUT OF THE UK WILL ALSO MAKE IT SLIP OUT OF EUROPE"**

Yes, most of them are made by different manufacturers, but none of them are competing against each other. The only competition is when they pitch for the contract and it's not a battle of performance but a battle of price. The company that can promise to deliver for the lowest price gets the contract. And as soon as the winning bidder has the →

Rinland suggests an open set of rules to encourage competition, bring technical prowess back into motor racing and promote the free market for racecar manufacturers

LAT

signed paperwork in hand he goes back to the factory and says, 'here's the price, now start cutting costs to guarantee a profit that keeps us in business.' There's no danger of the cars being uncompetitive because they will all be the same. If they turn out to be too slow, then the manufacturer just needs to negotiate a bigger wing, more power or wider tyres with the sanctioning body to compensate the deficit.

What all this amounts to is no real motivation to learn and improve for racecar designers. Yes, there are people designing cars for racing but, without the need to build a better car and beat other design teams, you don't need the best resources, human and technical, to create those machines. If you don't have designers designing racecars in a competitive environment, the industry quickly loses the ability to do it and the gap with F1 widens on a regular basis.

Is all this such a problem? If you have competent engineers building cars that only have to compete with themselves, then why make things more complicated? Simply because, if you are only having to compete on price, then the West is guaranteed to lose against the emerging economies. The price competitiveness of India or China will ensure they always win the contract and western racecar manufacturers will only exist in history books. This is why the UK's technical ability ceased to be a factor in its industry lead and the business went to other countries. It is also why the same crisis will strike the European industry if the organisers carry on the way they are going.

"TODAY IN MOTOR RACING WE HAVE SOME SORT OF COMMUNISM"

Unless the FIA takes back control of its racing series, this culture of controlled formulae in the name of (false) economy will guarantee the collapse of the western racecar industry.

Change needs to be made, and I'm willing to stick my neck out to say what that change should be. Those seven single-seater formulae below Formula 1 should be replaced with a single set of rules called, let's say, Formula 2. I'm not re-inventing the wheel here, it is just a case of creating an open set of rules where technical prowess can help win races.

I know we have that in Formula 3, yet the series is dominated by one manufacturer and, as promised, I've come back to that. The engine rules for F3, with them breathing through a restrictor, were fine in the 1970s and 1980s. It was the best solution available for controlling performance. But in the 21st century it has become impossibly expensive to develop those engines, to the point where Opel has to pull out. The investment is too great to justify the return. That leaves Mercedes Benz and Honda, and the price of their engines is so high it dominates the budget of the teams to the point where they can't afford to take a risk on the chassis. Technology has moved on since the '70s and with modern electronics we have better ways of restricting power outputs on engines. The amount of money that is spent on engines could be massively reduced, making more budget available for chassis choice and technical developments.

Below Formula 3, the logical thing would be to get rid of single-make formulae and replace them with something like Formula 4. All these series could have mandated maximum prices for chassis and parts without affecting the free market principle and ensuring competition keeps the engineering moving forward. With this technical edge it would be hard for anyone, with nothing to recommend them other than low labour costs, to steal the industry away. A bi-product of this philosophy will be constant developments of young, talented engineers and technicians that can then move up the ladder to get to the top of the business with solid foundations.

We live in a free world, and for more than 100 years motor racing has been the standard bearer of the free world. The defining characteristic of a free world is competition and the victory of excellence over mediocrity. Today in motor racing we have some sort of communism with no competition. Just make it cheap. It's ludicrous, but unless something changes it will be very difficult to sustain this motorsport industry so dear to many of us.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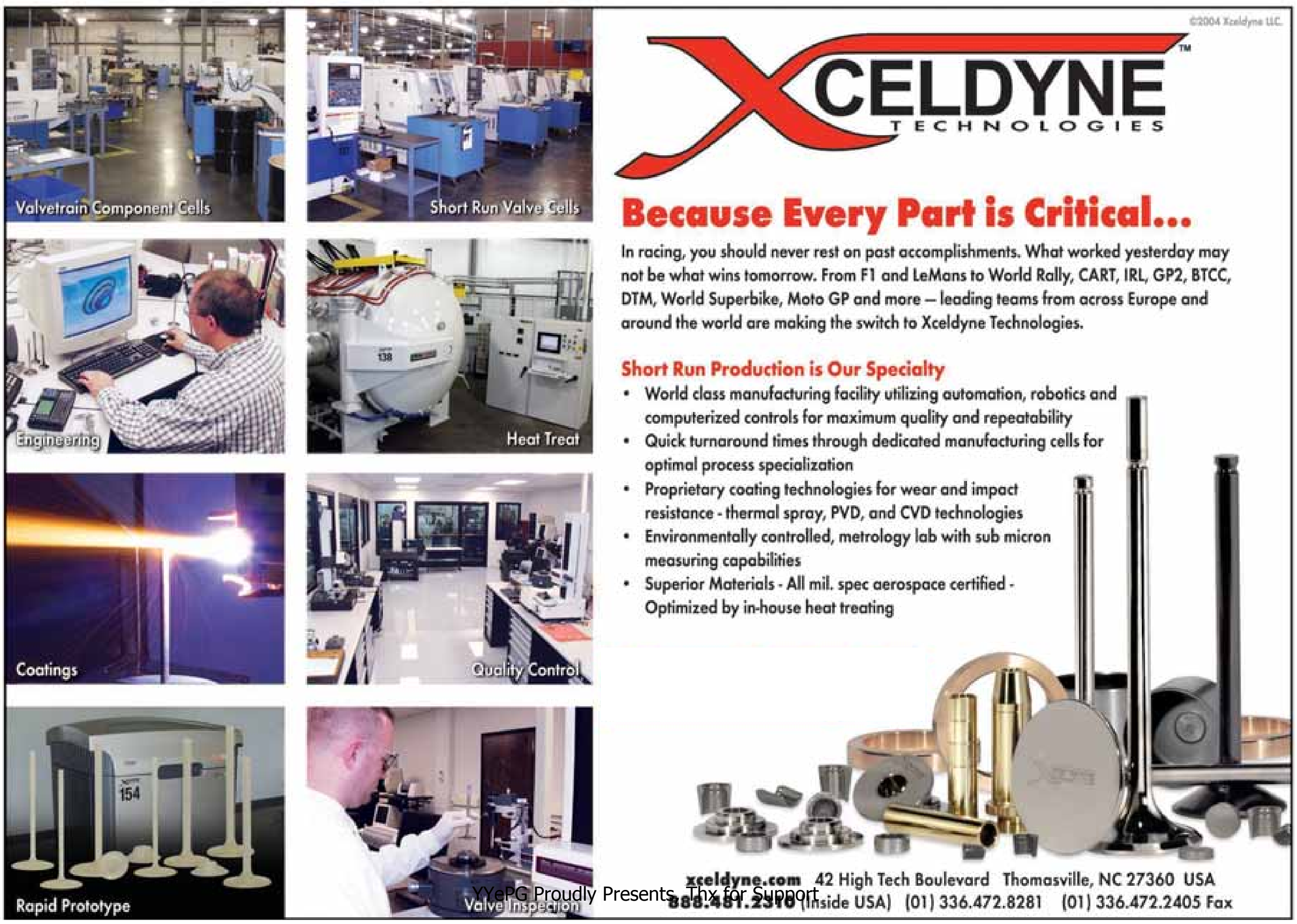
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Green meanie

Regarding the editor's 'Write Line' article in V15N12, I feel I must pass comment. I'm sorry, but stringing together a series of unconnected statements is considerably less than I have come to expect from Racecar Engineering. Indeed, it had all the spin and bad science we have, sadly, come to expect from politicians like Mr Blair and the social meddlers 'advising' him.

Yes, there is climate change, however, considerable scientific data does not link it to increasing CO_2 levels *[Caillon, N, Severinghaus, JP, Jouzel, J, Barnola, JM, Kang, J and Lipenkov, VY 2003. Timing of atmospheric CO_2 and Antarctic temperature changes across Termination III. Science 299: 1728-1731 (2003)].* The Oregon Petition, signed by 18,000 scientists, states: 'There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gasses is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate.'

There is significant correlation between climate change and sunspot activity – the 'Little Ice Age' of 1645 - 1715 coincided exactly with the 'Maunder Minimum' when sunspot activity was almost nil. Chris Folland, from the UK Meteorological Office stated: 'The data doesn't matter. We're not basing our recommendations [for reductions in carbon dioxide emissions] upon the data. We're basing them upon the climate models.' These are climate models that are so inaccurate that, up until recently, didn't include clouds. Mankind is responsible for just 3.5 per cent of global carbon cycle CO_2 emissions and cars 1/7th of that. Automotive Advisers and Associates of Hilden, Germany showed that energy consumption per capita of travelling public is 60 per cent higher for public transport than for private cars.

On the subject of alternative fuels, an under-load diesel engine produces what Kyoto University described as 'possibly the most carcinogenic substance currently known' and so-called 'green fuels' produce the same quantity of CO_2 and other by-products as ordinary ones. Current fashionable fuels such as bio-diesel and bio-ethanol are, quite simply, no different from ordinary diesel and ordinary ethanol if nothing is planted to replace the biomass used in their production.

So please, let's try to keep *RE*'s climate and environmental comment on the same high level as its engineering content.

Tim Lawrence, UK

Email the Editor: racecar@ipcmedia.com
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Visit www.racecar-engineering.com and submit your project for a feature online

LAT

The debate over alternative fuels in racing rages on

Bio futures?

In 'Write Line' V15N12, you worry that in a world threatened by global warming, motorsports emissions will make motorsports as socially unacceptable as smoking. But what you rightly see as a problem might also be looked at as an opportunity. It is through the challenges of racing that the world has developed quicker, stronger and more reliable cars. Today, the rules keep changing but race teams continue to find ways to make cars even better. The racing industry should approach global warming as just another rule change. If it mandates that a race vehicle cannot be powered by an internal combustion engine, it must still find a way to race and it will still have suspensions, aero, tyres etc. The powertrain guys are just going to have to learn some new tricks, but it is still about converting stored energy into motion. Our race team has a head start on this already. ProEV's Electric Imp powered by Kokam's lithium polymer batteries is already competing. The 235bhp, 370ft.lbs torque (at zero rpm), AWD Subaru Impreza chassis is undefeated in SCCA D modified autocross. Our best finish in sprint (around 30 miles) road racing is a rather lucky second place but we expect an honest victory against gas-powered competition in 2006.

Walk around a typical paddock and look at all the intelligence and creativity focused on dropping that extra 10th of a second. Are these not the people who can take the electric car and make it as fast as today's gas-powered cars? Is this not the challenge that can make racing relevant again?

Clifford Rassweiler
by email

Autosport International 2006

Birmingham once again played host to one of the most established events on the motorsport engineering calendar. **Racecar** was there to report on the highlights

Words	Racecar Engineering
Photos	Sam Collins; Tony Butler; LAT

Once again Autosport Engineering provided a focus for the industry at this key point in the season. For two days the aisles were packed with buyers from across the industry and much business was conducted. However, genuinely new products seemed to be thin on the ground, although there were plenty of revised and updated versions of established products. *Racecar* trawled the show and this is what caught our eyes.

Pace Products was showing off its new dry sump system developed for the forthcoming Formula Ford rules – designed in cooperation with Ford, engine builder Mountune and leading chassis builders in the series. It incorporates a cast aluminium sump pan and Pace-designed oil pump, with the aim of keeping costs down and easing installation of the new 1.6 Duratec engine into established and forthcoming chassis designs. The system will be distributed by Sky Ford.

Developments from friction specialist AP Racing included a new strap drive design for mounting discs to hubs. Torque loadings are transmitted using 11 stacks of three spring-steel strips loaded linearly. These offer a degree of lateral movement for the disc in relation to the hub, accommodating heat expansion and realigning the disc automatically, thereby reducing knock off of the pads.

The company was also displaying its new range of high-spec flywheels. Made from high-grade chrome molybdenum steel they offer increased strength and durability with low weight and greatly reduced inertia. For competition applications AP Racing has so far launched versions for the Rover K-Series and Vauxhall/Opel 2.0-litre engines.

ZF Sachs displayed its new range of Porsche racing flywheels that have the unique feature of being detachable from the crank. They are engaged during the start-up procedure then disengaged once the engine is running, reducing the collective inertia of the engine's rotational masses. The company also revealed that its new Formula 1 clutch is 83mm in diameter, reduced from 97mm previously. It has a new steel alloy for the diaphragm spring that is claimed to retain its shape and tension up to 600degC. This is designed to retain the same biting point through repeated starts. Three and four-plate versions will be offered to customers.

Creasey Castings was showing off a casing it produced for the Japanese GT Championship-winning Nissan Skyline. This exceptionally large item is cast in magnesium – a particularly tricky operation incorporating numerous thicknesses of material with different cooling rates.

Frits Altorf, Koni's product manager, OE & Racing, disclosed at Autosport International that his company's FSD (frequency selective damping) technology is currently under test with a Formula 1 team. FSD was launched last year for the road market as a non-electronic answer to the damper manufacturers' age-old problem of whether to offer better road holding or comfort. It features a special valve (the anti-roll chamber) that is added to the damper and is able to control a parallel oil flow next to the one going through the piston. This parallel flow is closed by the FSD feature, resulting in a rise in damping force. Put simply, the FSD feature is a hydraulic amplifier that delays the build up of pressure. It first appeared as original equipment on the Lamborghini Gallardo.

Altorf points out that 'there are other frequencies that you have to take care of,' as well as those that cause problems for road cars. If testing is successful, the concept may find its way into the likes of GP2, where Koni is the mandated damper supplier. It is possible that instead of a four-way damper the company may offer a three-way damper with FSD which, says Altorf, will be 'something unique for racing.'

Fellow shock absorber manufacturer Öhlins also had new product at the show in the form of a range of 46mm piston-type off-road/rally raid dampers with remote reservoirs. These come with a protective sleeve for spring wear and circlips.

Deutsch's Dave Watters described his company's latest products as 'an exciting new step in connector technology.' He points out that the density of a connector package has not changed for about 20 years, which could be why Formula 1 teams were asking at the show how soon they could see a sample of the company's latest double density connector, the 12-41. Watters describes this is as the 'new little brother' for the 14-64 that was launched late last year. Like the 14-64, it offers more connectors than a standard shell, thus significantly reducing the weight of the wiring harness in the vehicle. As its name suggests, the 12-41 double density autosport connector allows 41 connectors in a size 12 connector shell. Further connectors within this family are due to be launched later in the year.

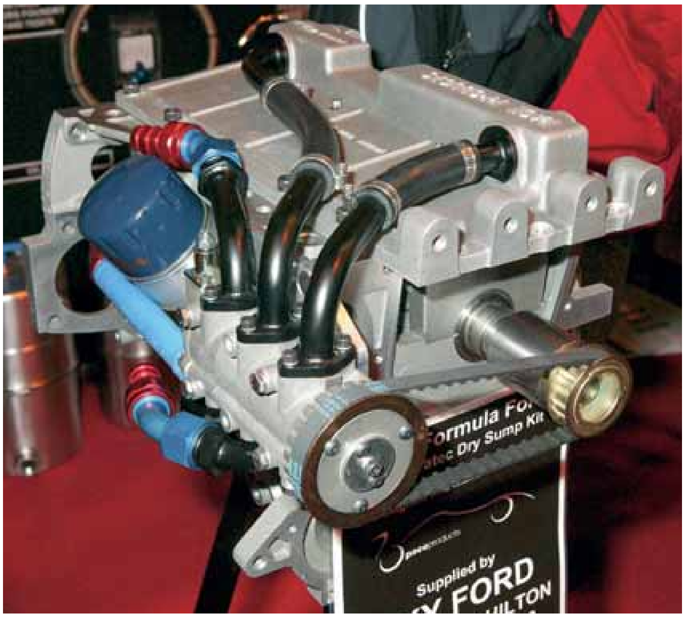
Beru F1 continues to target the North American market, with one of its new products at the show being Digi Tyre DT – a dual tyre pressure monitoring systems for NASCAR. Testing of the product has already been taking place in the UK with production parts scheduled for release in the spring. Understanding what is really happening to both the inner and outer tyre has always been a challenge to NASCAR, but Beru F1 managing director John Bailey says that with Digi Tyre DT it will be possible to accurately measure the pressure and temperature of both the inner liner and outer tyre. Because of the minimal air gap between the two it has previously been impossible to install a conventional system. However, what is described as innovative electronics packaging and a 'radical' new battery technology that will last the full season have made this breakthrough feasible. Beru F1 also used the show to launch Digi Tyre Lite, a cost-effective tyre monitoring system suitable for national sports, GT, saloon and single seaters.

Hoses for motorsport come in two types – the more flexible, fully convoluted type and the smooth bore version with its better flow rates. In the past it has been easier to swage, rather than crimp, onto a fully convoluted hose. Goodridge illustrated at the show that it has now developed a style of collar that enables it to crimp onto a fully convoluted hose. The main advantage of crimping is that the teams can do it themselves.

Elite Racing, which was showing its new TXL-300 6S mid-torque, sequential, six-speed transaxle gearbox, is looking to expand. Managing director Mark Bloor stated that his small family company wishes to grow into the Continental market; last year's Essen Show having been its first foray into this region. It is his belief that there is nobody in Germany that manufacturers similar transmissions to Elite.

Representatives from Clemson University and the CUICAR project were making their fifth appearance at Autosport International. The University's Graduate Engineering Centre is now fully funded and the main building will be complete by the summer, with the first class scheduled for August this year. The first of five Technology Neighbourhoods is also nearly finished, while the BMW research centre was opened last summer. Each of the neighbourhoods will have what is being described as a 'Clemson magnet facility.' The planned wind tunnel is to act as this feature for Technology Neighbourhood 3. A fully-funded package has still to be put together for the tunnel, though a plan is expected in April.

The SAE also announced it is to establish a new strategic office centre on the campus. Sam Konduros, the University's acting motorsports →



Left: new dry sump system from Pace Products designed for 1.6-litre Duratec engines used in Formula Ford

Below left: new from ZF Sachs was an 83mm F1 clutch with a diaphragm spring capable of withstanding temperatures up to 600degC

Below right: also from ZF Sachs came this detachable racing flywheel for GT racing Porsches that can be disengaged after start-up, massively reducing the rotational mass of the engine

Clockwise from above: new prototypes were out in force at the Racing Car Show, many it seems competing for the same customer business: Juno SSV6, soon to be eligible for CN and Sports 2000; Lynx LR1, aimed at Bikesports and SCCA D Sports; Spead's re-vamped RM06, again a Bikespo rts contender; Lola's glorious homage to its classic T70 – the Mk3B; and Kelforms Retoga, another prototype coupé aimed at Bikesports and D Sports

director, hopes a cluster of trade associations will eventually take advantage of the site including, he'd like to think, perhaps the MIA and SEMA.

Further evidence of the importance of the UK racecar industry to the USA was illustrated in a NASCAR seminar headed by Robbie Weiss, managing director of NASCAR International. The presence of both team boss Richard Childress and his new director of engine R&D – former Cosworth man Nick Hayes – underlined the connection. 'The Motorsport Valley has brought a lot of new technology and new opportunities,' said Childress, 'and we are open to business with European companies.' He also said, 'we're here to look at what Evernham and Yeates have already done here,' although he denied that this meant Childress would be establishing a UK operation.

Dodge's John Fernandez pointed out that his company has been coming to Europe now for three years, looking for new technology. Evernham Engines' boss, Mark McArdle, added to this that his company's UK venture, AET, 'is now beginning to do a significant amount of manufacturing.'

Racecar Engineering's stand at the show was the venue for the launch of Simon McBeath's new book *Competition Car Aerodynamics*. As a long-time contributor to the magazine and a wing manufacturer, Simon has been the author of the title's aerodynamics column, Aerobytes, for two years. His new publication is based on his previous book *Competition Car Downforce*, published in 1998, but has drawn heavily on the Aerobytes column to create a title with more scope. The book is in the shops now priced £25 and comes with an accompanying DVD.

Alongside the more serious Autosport Engineering show is the Racing Car Show – traditionally a popular place for manufacturers to unveil new racecars. And this year was no different, with the explosion of small prototype racing showing no signs of slowing down.

Ligier showed its JS49 (see V16N2) for the first time in Britain to try and capture some of the lucrative Britsports market, while Sparco founder, Enrico Gloriso's Gloria company, unveiled its new B6S baby prototype racecar. The Turin, Italy-based firm has based the new car on its already successful B5 open wheeler, with a steel, spaceframe chassis able to accept a wide range of motorcycle powerplants that should suit the UK's new Bikesports series and the USA's SCCA D Sports category perfectly.

Pitched squarely against the Gloria is Lynx AE's new LR1 coupe, which is designed for exactly the same applications as the Italian car. The Lynx has been designed and constructed in the heart of Britain's so-called Motorsport Valley cluster, and the first chassis raced with promising results in late 2005. The firm used the show to reveal details of the customer car plans, with both sale and rental versions likely. Of particular interest is the cars' gearshift system, developed alongside the LR1. Racecar has been invited to track test the car and gearshift system in the next few months so see future issues for more details.

Also on display at the show was the Kelforms Retoga, which was very similar in design and concept to the Lynx.

A surprise announcement saw Lola return to its roots with an all-new addition to its prototype range – the B06/90. With it the company enters the now ultra competitive market for small →

Stand and deliver

Racecar's **Tony Tobias presents the awards for the best presented stands to Caress Precision's John Caress for single unit and to Mountune's Roger Allen for multi unit**

prototypes. Lola, who's recent heritage resides in mass producing cars for high-class series such as A1 Grand Prix and F3, designed the B06/90 chassis after identifying a growing space in the market, though it was the organisers of Sports 2000 in the UK and general enthusiasm for that series that originally directed Lola to design the car. The aluminium monocoque chassis has also been designed to be easily adapted to fit engines suited to VdeV Racing and similar, such as the 2.0-litre Honda. The opportunity to make such modifications allows the chassis to become a concept aimed at more than one market and Lola has no doubt the B06/90 will eventually appear in various other series beyond Sports 2000.

The chassis has been built to withstand up to 400bhp, with the Nissan V6 being an appropriate example of a suitable engine. Lola will be running the car on the track in the next few weeks to make its official announcement, with orders being taken early this season.

Interestingly, this now makes Lola the only racecar manufacturer to supply cars to the complete prototype spectrum – LMP1, 2 and 3. Racecar will watch with interest to see if Courage, Ligier, Dome or other similar outfits follow suit.

The current car to beat in Britsports is the Ewan Baldry-designed Juno SSV6, but the Northern England constructor's cars are not yet eligible for the smaller capacity and lower-cost series such as CN in Europe, but that looks set to change with its new Juno. Aimed once again at the CN/Sports 2000/trackday market, Baldry has used his F1 expertise once again to create a very competent looking machine.

The buzz at the show did seem to be prototype racing, and this appears to be reflected in the industry in general, with both Juno and Gloria announcing moves to larger premises to cope with demand and Norma opening a UK sales arm to market is M20 Evo 3 – also unveiled at the show. Of the international prototype scene there was only one topic of conversation, and that was diesels. The progress of Ricardo, Mountune and Audi projects was widely discussed, but the promised project from Peugeot Sport has become something of a mystery. A number of very significant and well-known firms (who one might expect such a project to outsource at least some components to) approached Racecar enquiring about the French oil burner. This suggests the project may have been quietly cancelled just over six months after being announced at last year's Le Mans 24 Hours.

Meanwhile, away from the world of sports prototypes, another new car was being showcased, though it was received with sceptical comments by some. The VERCO (Vee Eight Racing COmpany) XV8R supersaloon is the fourth attempt unveiled over the years at the show to try and introduce a spaceframe silhouette, V8-powered racecar to the British market. What makes the VERCO different is the fact that its constructors are not proposing launching a new series into an already over saturated market. Instead, it proposes to build a car that will fit within existing classes – a move that could revolutionise the British and even European racing scene. Available with 650bhp naturally-aspirated or 900bhp twin-turbo power options with supplied or leased engine programmes, the cars are designed and engineered to be identical in chassis, engine installation, transmission and running gear, with only bodyshell and driver settings as variables. Power is supplied by Nicholson Mclaren's XB V8 powerplant, via Xtrac transmission, to the rear wheels.

The car is available to order in a number of variations and is priced from £195,000 ($345,000) plus lease engine programme and VAT. Both 650bhp and 900bhp variants are also available to purchase outright, complete with engine units. At each recognised race series official test day and race events, engine, transmission and technical services will be provided.

The cars' design allows the fitting of a wide range of bodyshells and external parts from original manufacturer production steel components from popular, mid-range, four-door saloon cars such as the Peugeot 407. Around 20 different production models can be used as basis for the cars' silhouettes, including the Ford Mondeo, Honda Accord and Vauxhall Vectra.

Racecar's **own Simon McBeath was on hand to launch his new book on racecar aerodynamics**

The sceptics say the VERCO follows in the footsteps of the ill thought out and over publicised failures of the Supercar V8, SCV8 and Touring One championships. At £195,000 the VERCO is moving into a market for serious budgets only and whether the struggling British professional motorsport scene can accommodate it is debatable. It will also be going head to head with proven cars such as the Ford Falcon and Holden Monaro. However, to see big powerful cars like this on British circuits could bring spectators back to the tracks.

Professor Sid Watkins, the now retired F1 chief doctor, managed to persuade his good friend Bernie Ecclestone to make himself available for the 2006 Watkins Lecture. Organised by the Motorsport Safety Fund, this is an event open to marshals and race officials who give their time freely to make motorsport in the UK possible. Last year it was delivered by Ferrari technical director Ross Brawn and the promise of an audience with Mr F1 himself filled the room this year.

In the event, Ecclestone elected not to give a traditional-style talk, instead preferring to be interviewed, in this case by Dr Watkins wife, Susan. Although a journalist and biographer herself, and having collaborated with him on a biography, Mrs Watkins appeared unable to press Ecclestone on major questions of interest. Meanwhile, he wisecracked his way through the interview, dismissing many questions with one-word answers. At one point he aroused the hostility of the audience when he professed himself ignorant of the role of an incident officer.

At the end, the man seemed relieved, while the audience regarded the event as one of the less memorable Watkins lectures. RE

Along came a

Words Jonathan Ingram
Photos Porsche, LAT

Porsche has become part of the legend of the Le Mans 24 Hours, with more victories than any other manufacturer bar none. However, the last time a Porsche was in the running for overall victory at Le Mans was in 1998 with the 911 GT1. Since then it has been content to supply customer GT2 class 911s. Although it toyed with the idea of going to Le Mans with an all-new LMP1 in 2000 the development car was mothballed and left to become obsolete in a secret corner of its Wiessach R&D centre. But pressure from the USA has changed all that and in early 2005 rumours started circulating that Porsche was developing a new car in secret, and last summer the RS Spyder (type 9R6) LMP2 was revealed.

The first mission of the RS Spyder is to win the LMP2 category of the 2006 American Le Mans Series championship in the hands of factory-supported Penske Racing. In 2007, the Spyder is scheduled to become a customer car for LMP2 privateers in North America, as well as in Europe's Le Mans-based series and possibly in Japan, too.

The cars' 3.4-litre V8 engine is purpose-built for the Spyder, but also happens to be very close to the configuration used by the Indy Racing League, raising speculation that Porsche may return to unfinished business at the Indy 500. As for sportscar racing, more than a few engineers have speculated about the right sort of 750kg configuration winning overall at Le Mans, in the race where Porsche first made a name for itself with smaller, lighter-weight vehicles before the brutish 917 scored the company's first of 16 overall victories in 1970.

It is unlike Porsche to build a prototype that, in its present configuration for the LMP2 category, cannot compete for the overall win at Le Mans, and it seems equally unlikely the highly successful Roger Penske is going sportscar racing just to win the North American LMP2 category. More likely is that Penske is lining up a future engine supplier for Indy or a return to the Le Mans 24 Hours in search of an overall win.

Despite horsepower reduced by the LMP2 category's air restrictor, it is worth noting that the new Spyder ran among the LMP1 leaders during the entire four-hour ALMS race on its debut at Laguna Seca Raceway last

Spyder

The arrival of Porsche's 9R6 Spyder prototype at Laguna Seca last October has prompted speculation about the company's future in motorsport

Tech spec	
Car	Porsche 9R6 RS Spyder
Chassis	carbon monocoque
Engine	Porsche MR6 3.4-litre V8 (with 44mm restrictor)
Power	480bhp
Torque	370Nm at 7500rpm
Cams	twin overhead
Gearbox	Porsche GR6 six-speed sequential
Clutch	ZF Sachs triple plate carbon
Suspension	wishbone, ZF Sachs dampers
Weight	750kg
Aerodynamics	twin plane rear wing, ACO spec floor
Length	4650mm
Width	2000mm
Height	1086mm

"OVERALL DESIGN IS AN EFFORT TO PERFECT THE CURRENT RULES PACKAGE"

October. Driver Lucas Luhr set the race's third fastest lap time versus the winning Zytek 04S, the brace of Audi R8s of Champion Racing and the two Lola B01/60s of Dyson Racing. So maybe this car is already in a position to compete for overall victory on tracks such as the narrow, slippery Laguna.

Adding further mystery to the RS Spyder – besides the refusal of Porsche officials to unveil any of the car's mechanicals at Laguna – are the origins of the rapidly designed and built prototype. Officially, the car was commissioned by Porsche Cars North America, although a rumour has circulated that ALMS founder and pharmaceutical magnate Don Panoz paid for the design of the RS Spyder as part of an effort to boost factory and team participation in his series. However, this has been flatly denied by CEO of the group, Scott Atherton, and Don Panoz who stated, 'the only manufacturer who has received financial support from me is the Panoz Esperante GTLM team.'

At a time when the ALMS is under heavy assault from the rival Grand American series, a new prototype from Porsche should work well at the box office, especially in the hands of Penske Racing. No doubt Panoz further understands the ticket sale importance of having a Le Mans-winning car →

The RS spyder is typical of LMP2 design with its twin roll hoops, though it has a low rear deck and dual element rear wing on double struts

in his fields in light of the past appeal of Porsche' s GT1-98 coupé, the BMW V12 LMR and the all-conquering Audi R8s. Is it enough for the ALMS just to have a Porsche prototype designed for North American participation in a secondary category, not a Le Mans contender?

The car's development, meanwhile, and presumably Penske's participation has been underwritten by the major DHL sponsorship, with partial participation by Mobil 1 and Michelin. The German-owned DHL is not only looking to expand its business footprint in North America but also to expand its logistics business with Porsche. Taken together, that justifies a substantial multi-million dollar budget even without the Le Mans angle.

If there is more than meets the eye to Porsche's newest Spyder, we'll have to wait and see, both on the track and in media announcements. The officials

> **"AN INTENSE PROGRAMME OF CFD HAS BEEN APPLIED TO EVERY SQUARE INCH"**

at the German company are anxious to keep their latest prototype strictly on eye level, refusing to unveil anything beneath the bodywork and, at the time of writing, declining to discuss any specifics on its technical capacities. Since then, the car has remained under the notoriously effective cloak of Penske's private testing programme, run out of the enormous Penske Racing South factory in Mooresville, North Carolina.

While the car or engine's future prospects are tantalising, there is no doubt the current programme is configured for profits from privateer car and parts sales starting in 2007. That alone puts the emphasis on a relatively affordable, reliable prototype that can be counted on to beat the 'garagistas' running Courage and Lola chassis mated to a variety of powerplants. 'It's important for a customer programme that you do not put in very expensive technology,' said Hartmut Kristen, who organised the 60-man team that built the RS Spyder.

Much of the crew came from the Carrera GT project—an ironic twist since the use of carbon fibre for both strength and weight savings gleaned from the road car was used to create the racecar. 'A lot of the know how we gained from the Carrera GT we could use very efficiently for the chassis of (the Spyder),' said Kristen, 'particularly since the safety regulations are much, much tighter than they were five or 10 years ago. Our regulations are very close to what you have to fulfil for a street legal car today.'

Instead of a blank sheet of paper, emphasised Kristen, the project started with a 'blank screen' and was done entirely by computer. 'The main thing

The 9R6 has undergone an extensive testing and development programme, including sessions at Estoril (above)

Unlike many other LMP2s, 9R6 has a symetrical appearance, suggesting a genuine two seater

was that everything was calculated. There was nothing hand crafted.'

Given the fast turnaround demanded by the project and its destination as a user-friendly customer car, ie one that is reliable, the car's overall design is an effort to perfect the current rules package more so than break new ground. As such it carries many of the usual design cues of the current generation of prototypes.

Aerodynamic optimum

'If you compare the last 10 years, the cars will not look any different,' said Kristen. 'They're always getting closer and closer to the aerodynamic optimum. You have the package and you have to get the bits and pieces in the car and fight with the air as efficiently as possible.'

The standardisation of prototype sportscar designs arose from back-to-back seasons at Le Mans in 1999-2000. The frightful blow-overs and crashes of the Mercedes CLK-LMs in 1999 brought renewed focus on safety concerning front and rear overhangs and underbody configurations, as well as eventual structural changes including cockpit designs.

The next step came in 2000 with the arrival of the highly successful Audi R8. A re-design of the original R8R, the all-conquering R8 in fact incorporated some of the better features of its rivals from the previous 1999 season. Those key elements included a centrally located low front air intake for brake cooling/aerodynamic benefits, combined with an extended front splitter (whose effectiveness is enhanced by the central opening for the brake ducts) that first appeared on the Panoz LMP-1. Also, the new Audi R8 featured a switch to side-mounted radiators and intakes similar to BMW's LMR, plus the latter's controversial, but approved, single roll hoop.

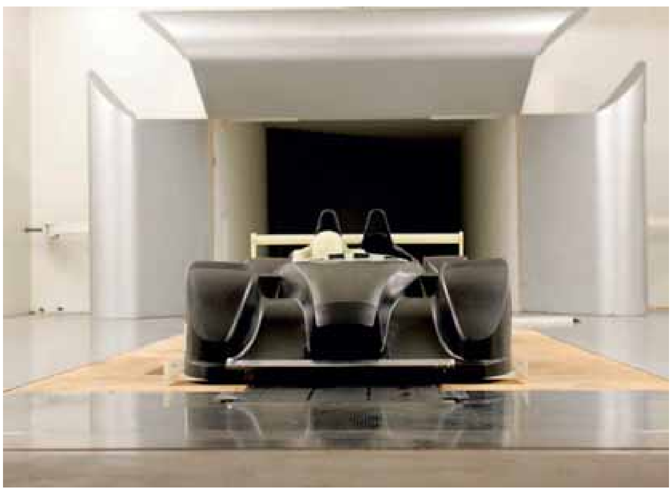
The new prototype designs that have followed, with the exception of the Bentley coupé, have had slight variations on these themes and the RS Spyder is no exception. But while the carefully crafted undulations of the Spyder follow the usual pattern on a large scale, it's clear an intense programme of computational fluid dynamics has been applied to every square inch of detail, as well as to proportions.

The standard aerodynamic features start with a high nose fronted by the centrally located intake for brake cooling. The choice to evacuate that air on either side is a vertical sidepod opening cut into an otherwise unbroken flank. Located about a foot behind the front wheel, the configuration and location for the exit of air are unique to Porsche. Both the arched nose and the wide intake on the snout are similar to the new Courage C65, although the lower nose and front air intake for the Porsche are noticeably larger than any of its predecessors. Meanwhile, at Laguna the team used a deep-set insert to modify the actual opening.

The splitter is stepped up across the central portion of the front end according to the new regulations to prevent excessive lift suddenly developing under the nose (the problem with Mercedes' notorious accidents). The underside must now be flat from the centreline of the front axle all the way to a taper under the gearbox and the groundeffect tunnels are fixed. Kick-ups on the sides where the floor meets the bodywork, as well as a plank are mandatory. In summary, there's no fiddling with the underside to gain an advantage.

Uniquely to the Spyder, there are no raised bodywork bubbles in front of the driver or notional passenger like the C65 or the new Lola-MG LMP2 at Le Mans. The latter two's choices are assumed to get air more efficiently over the newly mandated double-staged supports behind the driver/'passenger'. Porsche's choice is to use the steadily rising broad arch of the nose that concludes in a relatively flat plane in front of the open portion of the cockpit – both an interesting and elegant solution.

"AERODYNAMICALLY THE [OPEN COCKPITS] ACTUALLY DO NOT HAVE A DISADVANTAGE"



Wind tunnel work was done in both full scale and model tunnels at Weissach

Porsche's Spyder is also distinguished by two open roll hoops, versus the single hoop used by Courage or the two solid promontories in the new Lola-MG LMP2 entry. In addition to dual roll hoops, the Porsche cockpit has the symmetrical appearance of literally accommodating two people. On the side of the 'passenger', the engine's air intake is located at head level. As usual, the space given to the 'passenger' is not enough for a person the same size as the driver.

Was there any consideration given to a closed cockpit car? 'It was always the question of what would suit the situation of one given race better than the other solution,' said Kristen. 'At the moment I think definitely there is no question because aerodynamically the [open cockpits] actually do not have a disadvantage. But you have a lot of advantages for the driver in that it's not so hot inside the car. Driver changes are easier and there are safety regulations you have to conform to. So it was never a question about an open cockpit.'

Some designers still believe the effect of less tumbling air over the roof of a closed car overcomes the frontal drag penalty, and it makes for efficient delivery of air to the rear wing as well. But these same designers also concede the engine for a coupé must be a four-cylinder configuration if one hopes to meet the 750kg weight limit, an engine option definitely not considered practical by Porsche. As it is, there's still some question whether the Spyder actually makes weight at 750kg with its customer V8.

Despite a normally aspirated engine, the RS Spyder's radiator openings in the sidepods are ample – a good idea for racing in America, where historically designers have underestimated the demands of cooling on a continent quite a few latitudes south of Europe. There's also a bit of intrigue: what would be the cooling demands of a twin turbo V8 should the car be reconfigured in the future as a 900kg LMP1?

In the rear, the Porsche engineers have succeeded in getting a very low rear deck. The dual-element rear wing is centrally mounted by double struts and the end plates are the dog-eared style that extend down to the kick-up at the back of the dovetailed rear bodywork. All in all, the new Porsche is easy on the eye and aesthetically well balanced.

But what about the internals? If the past is prologue, the drivetrain is where the customers will really get their money's worth. Porsche's entry in the stakes for the all-time most successful endurance racer, the 956/962 series, derived much of its success from the inaugural Bosch Motronic →

A rare look under the skin of the Spyder at Road Atlanta shows brake ducts, front suspension and the crash box design. The car was repainted for its race debut in the distinctive colours of DHL. MoTeC dash is evident in cockpit shot

engine management system and the horsepower of the flat six engines. In the more modern era of air restriction, Audi's claim to having built the greatest endurance racer rests squarely on the mating of the R8's electronically controlled sequential gearbox to its twin turbo V8. In an air-restricted formula, the car that gets off the corners most efficiently gets to top speed sooner and stays there longer – a major advantage cited by many of the Audi R8's early victims. The Audi's strongest suit was often overlooked in place of the ability to quickly exchange gearboxes to replace damaged rear suspensions during the company's initial Le Mans victories.

Porsche no doubt is counting on success from its drivetrain. It relies on a 90-degree V8 whose pitch sounds very much like an engine with a flat crank. The water-cooled V8 has single-cylinder throttle valves and is managed by the Bosch MS 4.2 system. It is mated to a Porsche-engineered, paddle-operated, six-speed, sequential transmission with constant mesh straight cut gears. Rumour has it that the gears themselves were the cause of the RS Spyder's three gearbox failures during a 12-hour test at Road Atlanta. This setback forced a cancellation of its debut in the 1000-mile Petit Le Mans at Don Panoz's track, in favour of the four-hour season finale at Laguna two weeks later.

Whatever the problem, Porsche's Kristen said the gearbox failures resulted from the usual development, without going into any detail, other than to tout Porsche's V8. 'From my point of view, the gearbox has one disadvantage compared to all other parts. The better the engine becomes, the closer the gearbox comes to its limits. That's why we had gearbox problems.' Another scenario would include problems from a lighter weight drivetrain needed to reach the 750kg minimum.

With an eye on reducing weight, the suspension is an adaptation of the LMP1 designed by Norbert Singer in 2000 – the V10 prototype that helped develop the Carrera GTs' engine without ever seeing competition. Instead of racing the LMP1 at Le Mans, the company decided to concentrate its resources on the Cayenne, its very successful entry into the SUV market.

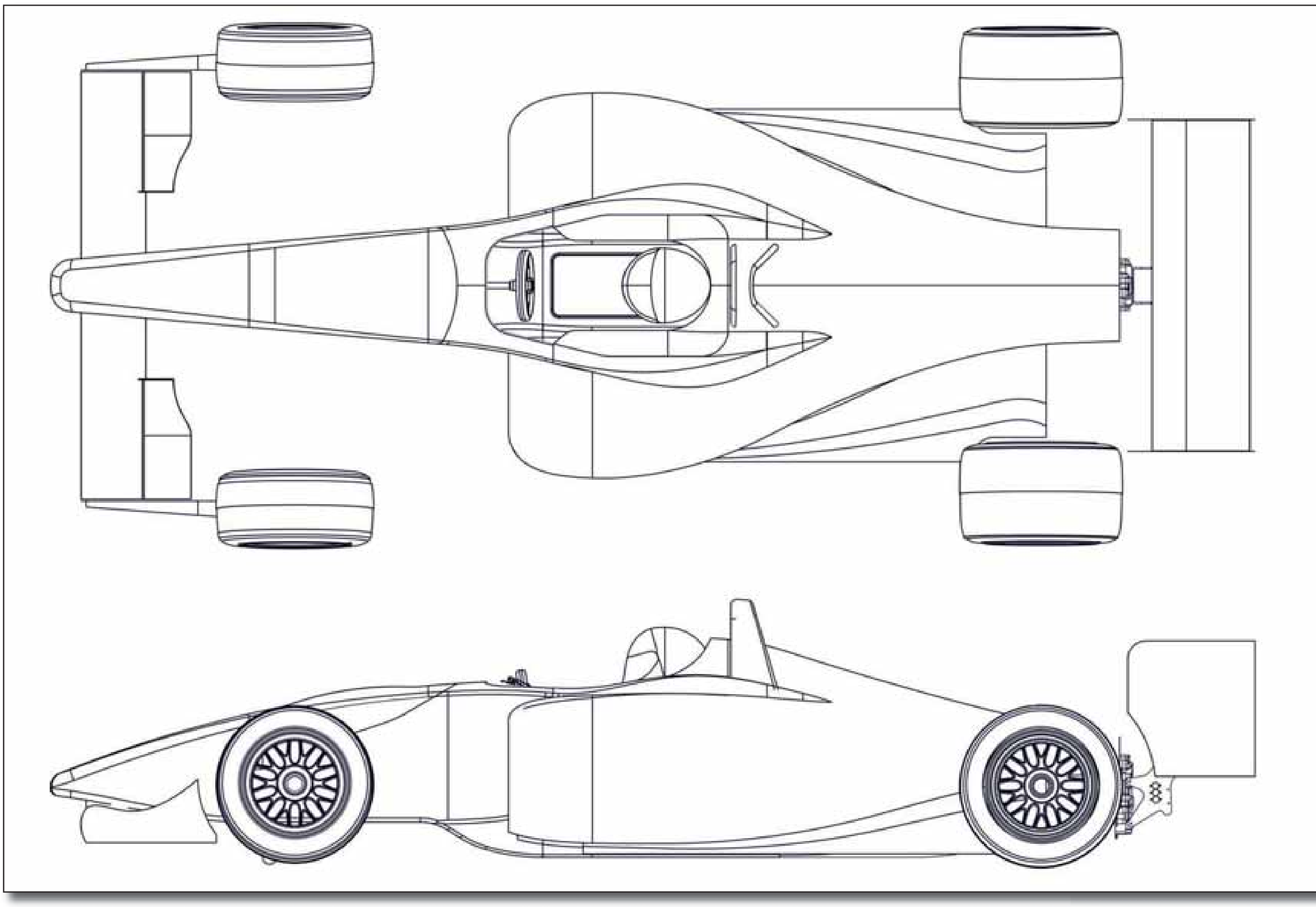
Will the LMP2 category Spyder be the launching point for a return to overall victory contention for Le Mans? Porsche refuses to be drawn on this question, although Kristen acknowledges the current LMP2's air restrictor will prevent it from being competitive on the straights at Le Mans against new LMP1 entries. As for the Indy question, Kristen simply shrugs his shoulders: 'We haven't done the regulations, either for the ACO or for Indianapolis. If these engines are pretty close, it happened...'

> **"THE BETTER THE ENGINE BECOMES, THE CLOSER THE GEARBOX COMES TO ITS LIMITS"**
>
> **Kristen Hartmut, RS Spyder design team**

With the RS Spyder, Porsche once again is concentrating on efficient use of resources, keeping a crack design team at its research facilities in Weissach engaged in a new project that is fully expected to sustain the company's reputation for technical excellence. All this on the heels of a development programme aimed at privateer owner drivers.

There may be no clear design breakthroughs apparent in the new Spyder, but it's likely to set at least one new standard in another area, given the amount of customer interest already established for the 2007 season. RE

A new era for Formula Atlantic



After 17 years of sponsorship and engines by Toyota, Formula Atlantic enters a new phase, with a bigger, faster and more powerful car than ever

Words	Dan Carney
Images	LAT

The 2006-spec Champ Car Atlantic Championship car will still be constructed by Swift Engineering Inc, but engine power will be courtesy of Cosworth, with a 2.3-litre DOHC I-4 employing the Ford Duratec 23 production engine as its foundation.

The new Swift 016a Formula Atlantic car will be bigger, with a longer wheelbase, larger cockpit to accommodate larger drivers and a larger cockpit opening for easier driver extraction. The large displacement Cosworth engine is tuned to reliably produce 300 tractable, driver-friendly horsepower for a lifespan of 2000 racing miles.

These changes reposition Formula Atlantic, moving it closer to its parent Champ Car series in power, and providing some separation from alternative development series such as Pro Formula Mazda, whose cars are very similar in size and speed to the previous Atlantic cars.

The loss of Toyota and the engine supply deal with Cosworth of course means that the series loses a significant revenue stream and marketing partner. But the Cosworth engine deal doesn't preclude an automaker signing on as the title sponsor, asserts Vicki O'Connor, managing director of the Champ Car Atlantic Championship. 'Engines can be badged, so there is always the opportunity for another manufacturer to come in,' she said.

With a Ford corporate engine providing the block and head castings used by Cosworth, the roster of potential sponsor candidates might seem limited to the Ford family of companies, but with Cosworth's assembly of the engines from mostly dedicated racing parts, 'that is not necessarily the case,' O'Connor said. Which, considering that the Pro Formula Mazda series is seen as a competitor to Champ Car's Atlantic series, it might be difficult to convince Ford marketeers that the company's brands should be competing against one another.

Upping the power

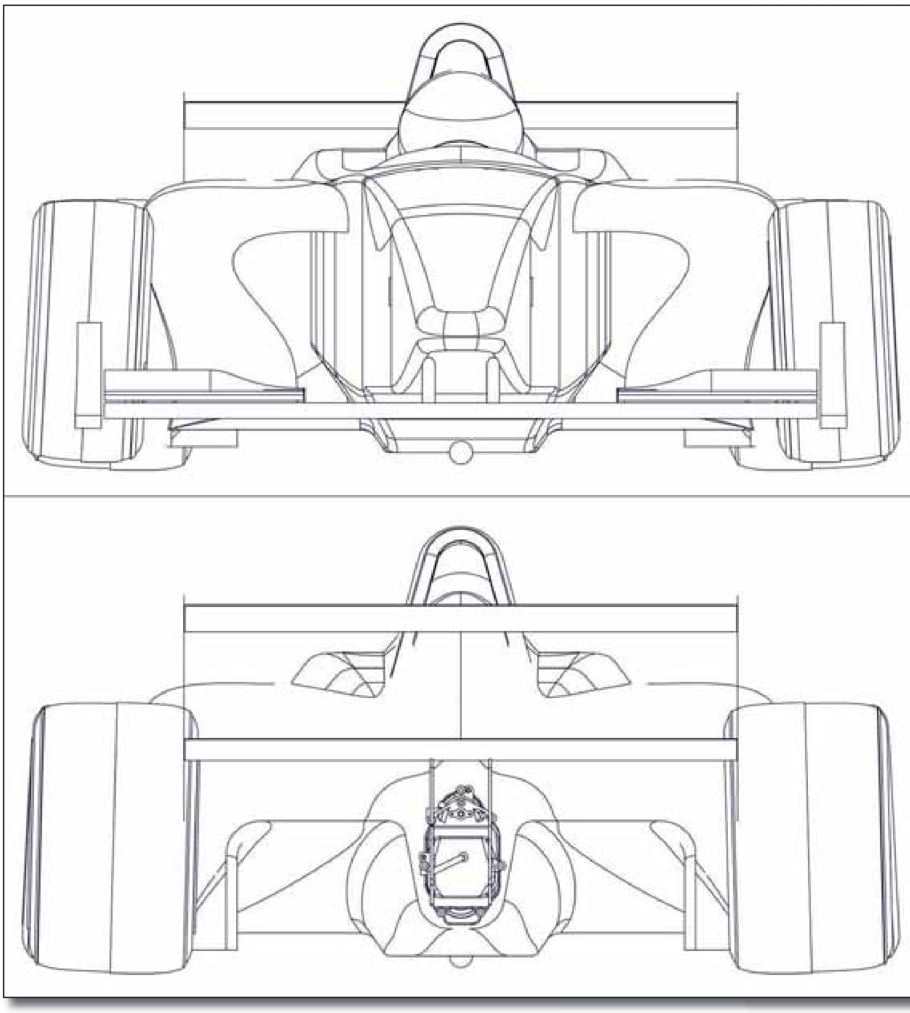
An output of 300bhp boosts Atlantic closer to the power level of the defunct Indy Lights series, the previous direct stepping stone into Champ Cars. With Indy Lights gone, there was a desire to boost the performance of Atlantic cars to a level closer to that of Champ Cars. 'We wanted to re-establish that Atlantic is the top of the heap for training series in North America,' said Steve Sewell, manager, technology, Champ Car.

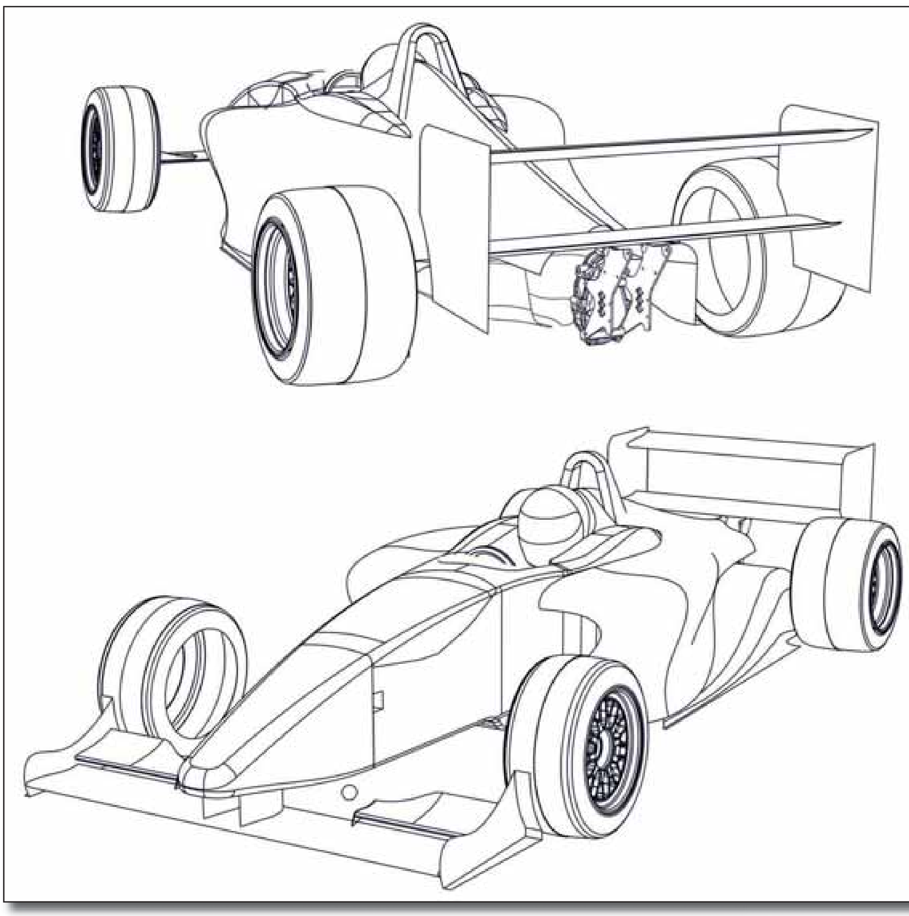
> **"IMPROVED ACCESS FOR PERIODIC MAINTENANCE"**

The engine is available in a range of displacements, but Champ Car and Cosworth chose the largest available displacement because it enables the engine to make more power with less strain, for a longer life and reduced operating expenses. The Cosworth's $39,000 (£22,300) price tag is comparable to the $40,000 bill for the 2005 Toyota 4A-GE engine, but the new engine is designed to last 2000 miles, rather than the 900-1000 miles of the Toyota.

That endurance means teams should be able to complete the season with three rebuilds, which would cost about $35,000 (£20,000), Sewell said. Rebuilds and other engine services will be provided by Cosworth through the same support structure that is already in place for the Champ Car series. This existing infrastructure probably gave Cosworth an advantage in the competition for the engine supply contract. Its ownership by the same partners who own the Champ Car series probably didn't hurt its chances either. Likewise, Pi Research, another member of the Gerald Forsythe/Kevin Kalkhoven/Paul Gentilozzi empire, supplies its Sigma Elite Junior data system for the new car.

The engine's brawny size also makes it easier for Cosworth to build an engine that not only lasts the predicted distance, but that does so with no significant degradation in performance. Of course, a nearly 50 per cent increase in displacement – from 1.6 litres to 2.3 litres – also produces an increase in physical size. The Cosworth engine uses an aluminum Ford block and head, while the Toyota engine's block was iron, so the engine isn't much heavier than →





Swift 016a has longer wheelbase, larger cockpit and, with resultant downforce increase, will be faster, too the outgoing powerplant, according to Cosworth. But the engine is both long and tall. This could present packaging challenges, but with the car itself growing for improved comfort and safety, squeezing in the engine was not as difficult as it might have been.

A predictable roster of bidders turned out to pitch for the contract of the new Atlantic car, with Swift ultimately prevailing over Dallara, Lola, Mygale and Don Panoz's Elan Motorsports Technologies conglomerate of Van Diemen, G-Force and Panoz.

Swift held the advantage of not suffering from the unfavorable exchange rate, shipping costs and import duties endured by the European contenders, but it also prevailed over fellow American constructor Elan. 'Several manufacturers were able to meet the price criteria,' said Sewell, 'but Swift wanted to partner with us on this.' The company also seemed to have the attitude of wanting to prove itself after a rocky launch for its 008a Atlantic, he said.

The 016a will cost $79,500 (£45,300) for a chassis and $175,000 (£100,000) for a race-ready car complete with engine and the sealed series-spec Dynamic Suspension DSSV dampers. BBS wheels and Yokohama tyres continue to be the specified suppliers of those components.

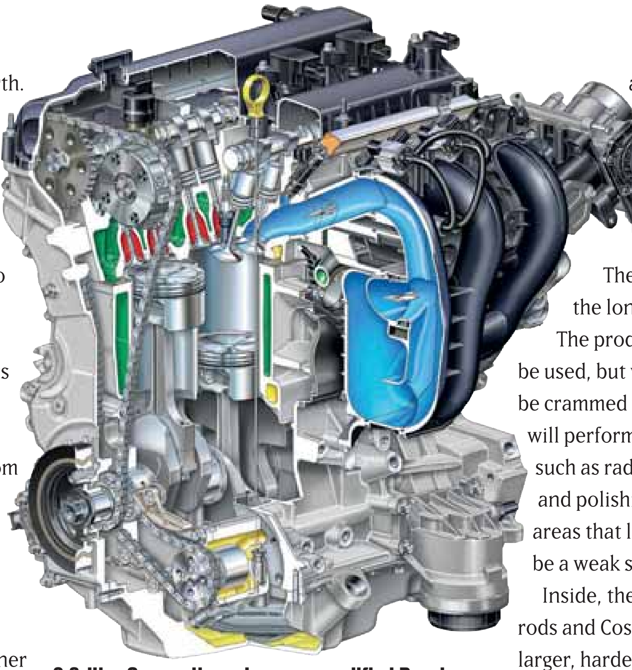
Swift's nine years of experience supplying first the 008a and then the 014a Atlantic cars to the series gave the company some idea of areas where they could save money building the new car, said Chris Norris, director of engineering for Swift. 'We've gained experience with how these cars are run and what teams expect of them.'

By re-shaping the car's monocoque, designers were able to produce an easier-to-manufacture structure. 'The 008a monocoque [carried over for the 014a] was a compound surface, which makes it difficult to get the monocoque built,' said Norris. The flat, planar surfaces popular today in F1 are easier to make, so the new Atlantic is both more contemporary looking and cheaper to build.

The larger monocoque of course adds drag, but it also provides the opportunity for increased downforce from ground effects, so the result is a car that will be faster than its predecessor, Norris said. 'Our target is for the car to be quicker in every track segment,' he said.

Improved reliability

The Swift SG3 gearbox is largely carried over from the 014a, but with some changes for improved serviceability and reliability. 'We've improved the strength of the differential,' Norris said. Designers also improved access for periodic maintenance. 'There were a couple of tasks they had to do rarely, but when they did, they were quite fiddly. It wasn't to do with the day-to-day running, it was the six month or yearly service when they were changing bearings.'



2.3-litre Cosworth engine uses modified Duratec block and head castings, but with all new internals

The company also altered the design of the reverse gear, going to a constant engagement layout using dog rings. There is some parasitic loss in this arrangement that is undesirable in an open series, but in a spec series that doesn't matter. The new design lets teams replace dog rings when the engagement teeth are damaged by a rough shift, rather than having to replace an entire reverse gear set, as was the case before.

The Cosworth engine supply, of course, echoes the series' foundation, when it ran the Cosworth BDA until Toyota took over. This connection has sparked significant interest and curiosity among the racing community, according to Ian Bisco, vice president, Cosworth Inc. 'People think of the past and the Cosworth BDA, and that generated a lot of excitement,' he said. 'I think Swift and ourselves were surprised and very happy that there was so much interest.'

"AN INNOVATIVE BARREL-TYPE THROTTLE REPLACES THE TRADITIONAL BUTTERFLY"

The Ford production connection echoes the long association of the two companies. The production block and head castings will be used, but will see significant attention and will be crammed with all-new moving parts. Cosworth will perform standard block preparation services such as radiusing corners, relieving stress spots and polishing rough areas. 'We'll machine any areas that look like they are suspect, that could be a weak spot,' said Bisco.

Inside, the engine gets a steel crankshaft and rods and Cosworth pistons. The head receives larger, hardened, high-endurance valve seats, bronze valve guides and larger valves. Valve ports are machined for improved flow, and high performance cams replace the standard items. An more sophisticated barrel-type throttle replaces the traditional butterfly, eliminating the obstruction of the throttle shaft during wide-open throttle conditions. Cosworth also casts a dry-sump pan and cam cover that are designed to tie the engine into the car as a stressed unit.

In the interest of longevity, the engine has an 8500rpm redline. 'It has a pretty long stroke,' said Bisco. 'If there were any negatives, it is the long stroke and pretty high piston speed.' However, Cosworth already has track experience with a slightly less powerful version of this engine, in the Caterham racing series, which uses the same engine in a 260bhp state of tune.

Atlantic teams will get a warranty with their engine similar to that on the Champ Car engines, said Bisco. Customers will get a free replacement if an engine fails through no fault of the team in the first 200 miles, and will get a pro-rata discount on the replacement for engines with between 200 and 1400 miles. After 1400 miles, customers will simply exchange a failed engine for a fresh one, the same as if they were buying a replacement. RE

Giles Villeneuve using the power of the original Cosworth BDA engine in Formula Atlantic in the 1 70s

In the second of a new series we look at the need-to-know information in particular aspects of racecar engineering. This month we look at rear wings – how to choose the correct style and profile for your application and what to consider in making this choice

Spoiler for choice

Wondering how to select a racecar wing set-up? Here's one practical approach to a complex problem

Words	Simon McBeath
Images	Advantage CFD; LAT; McBeath

The question of what wing design to use on a racecar arises not just at the initial design stages, but also quite possibly at each track visited. While not everybody has the budget to select a different wing set-up for each type of track, is the best compromise always being utilised? So, assuming technical regulations allow any choice, how do you figure out the configuration of wings you should run, and where do you find suitable wing profiles?

The general idea is to attain the best lap or run time by achieving the right downforce to drag compromise, usually known as optimising aerodynamic efficiency. As wings play a significant role in this quest, it pays to seek the best solution available. The search for the right wing set-up has to begin with clear knowledge of the rules relating to the number of wing elements permitted, and any constraints on dimensions and position of wings. In many restricted categories these go a long way to defining most of the key criteria, although there are often still degrees of freedom that can be explored and exploited. In other categories there are so few restrictions that many more decisions have to be made as to what will work. So, assuming you have some freedom of choice, where do you start?

What configuration?

There is an empirical method for calculating a first approximation of the wing configuration – that is, single element, dual element or whatever – that your racecar will need. A version of this approach is detailed, with examples, in the writer's latest book, *Competition Car Aerodynamics*. The approach originally appeared as an article in Racecar Engineering in V7N4 in 1997. In a nutshell, the method is based on assigning a drag budget to the rear wing, given that rear wings can create significant drag while front wings create relatively little. This wing drag budget is then used to estimate what kind of rear wing is appropriate. The front is then chosen to provide a balance.

The process is not going to be repeated in full here, but it's useful to recap the outline, shown here to the right, for a single seater with front and rear wings. For a racecar without front wings, the rear wing obviously has to be balanced with alternative downforce generating devices. The process is as follows:

1. Measure (if you can find the space) maximum speed without wings. To calculate this requires

"THE RIGHT DOWNFORCE TO DRAG COMPROMISE"

values for the frontal area, the maximum power available at the wheels, the wingless drag coefficient, CD (quite probably a guesstimate in this instance, but likely to be in the range 0.5 to 0.7 for single seaters without wings), and the equation relating power absorbed to speed and drag. In 'semi-metric' form this is

$$\text{bhp absorbed} = \frac{C_D \times A\text{, sq.m} \times (\text{max.speed, m/s})^3}{1225}$$

which rearranges to

$$V_{max}\text{, m/s} = \sqrt[3]{(\text{bhp available} \times 1225)/(C_D \times A\text{, sq.m})}$$

[Note that power to overcome drag is related to speed cubed because drag force is proportional to velocity squared, and power is force multiplied by velocity] Figures 1 and 2 show power absorption plots for high and medium speed ranges for a representative range of CD.A values.

2. Decide by how much you are prepared to reduce that top speed by the addition of a rear wing.
3. Calculate the difference in power absorption figures between the top speed without wings and the reduced top speed you are prepared to accept with wings.
4. The difference between these power absorption figures is the power you 'donate' to the rear wing to overcome its additional drag, which we'll call 'wing bhp'.
5. Calculate the maximum wing CD value that this represents. This requires values for the wingspan and chord dimensions to work out the plan area of the wing, and the power absorption equation rearranged to

$$\text{Wing } C_{Dmax} = \frac{\text{'wing bhp'} \times 1225}{\text{wing plan area, sq.m} \times (\text{selected top speed, m/s})^3}$$

6. Using figure 3, based on published racecar wing data, work out what CL figure corresponds with the calculated maximum wing CD value. Then from figure 4, which shows approximate lift coefficient ranges for three basic wing configurations, work out what basic configuration wing (that is, whether it is single, dual or possibly triple element) ought to provide this CL value.
7. Calculate the theoretical downforce figure that the rear wing will give using the following basic 'lift' equation:

$$\text{'lift' (downforce, N)} = 0.5 \times \text{air density} \times \text{wing plan area, sq.m} \times \text{wing } C_L \times V^2\text{, m/s}$$

(air density = 1.225kg/m³).

Then calculate the downforce required at the front to balance this value (in proportion to the static weight distribution for want of a better starting point, probably with slightly more rearward bias). The front wing dimensions will be needed next, as will the wings' ground clearance so that ground effect can be allowed for in →

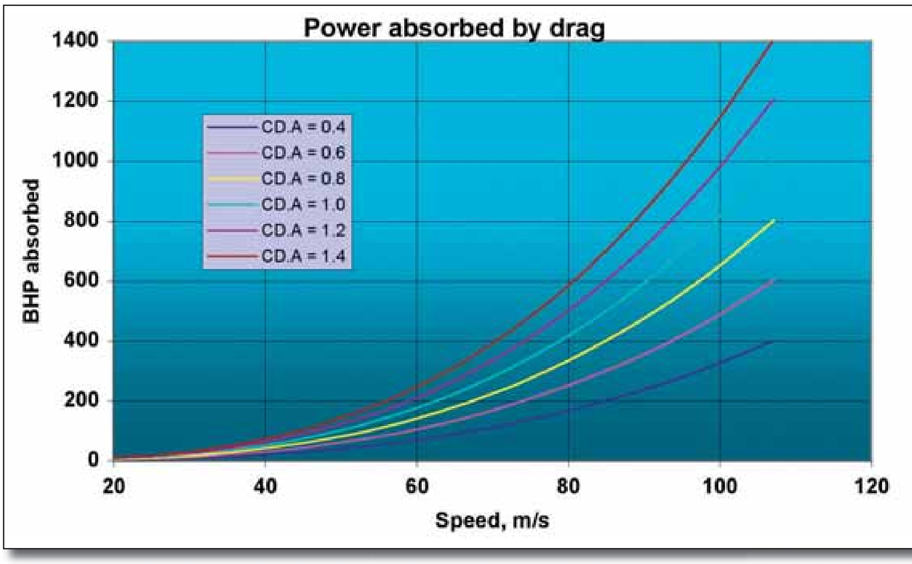


Figure 1: aerodynamic drag absorbs considerable power at higher racecar speeds (McBeath)

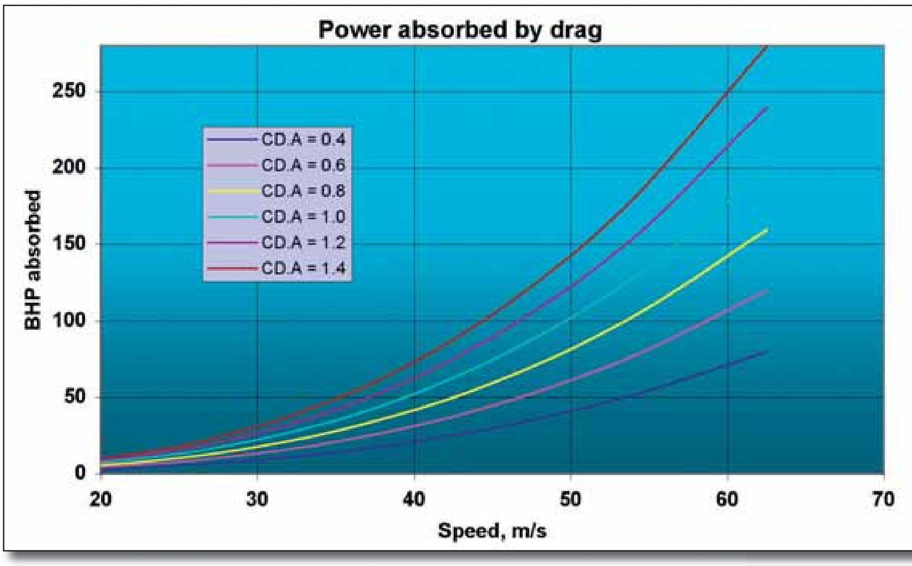


Figure 2: power absorbed by the aerodynamic drag of less rapid racecars (McBeath)

The search for the right wing set-up has to start with a clear understanding of the regulations in any given class

determining the requisite CL(front) value (figure 5 shows a generic plot of 'ground effect amplification'). Then work out what configuration will be needed to attain this CL(front).

8. Finally, determine suitable profiles, or sets of profiles, that will meet the calculated requirements.

This process generally requires a few iterations to produce a practical solution, and it only gives a starting point – a balanced set-up will still have to be attained in testing. You will need to run the calculations for different CD guesstimates, different acceptable top speeds, and different wing dimensions and overhangs, to name but a few of the variables. It is also necessary to take into account that rear wings never work as well in practice as they do in theory, but a rear wing 'inefficiency factor' can be applied.

> **"REAR WINGS NEVER WORK AS WELL IN PRACTICE AS IN THEORY"**

But fundamentally this, and any other method that might try to determine the basic wing configuration you're going to need, always leaves one key question hanging – to fulfil the final stage of the eight-point plan above, where can you find suitable wing profiles?

Profile hunting

There are actually various sources of potentially suitable profiles, assuming we gloss over the possibility of copying someone else's existing design (rife though this practice may be, it's nothing less than theft if the designer's permission has not been granted). The 'traditional' method is to look in the small number of aeronautical textbooks that provide profile catalogues (see the reference list at the end of this article). Although none of these profiles were intended for use on a racecar, among their merits is that they are published, proven, and plottable (ordinates for many of them are readily available). These are two-dimensional profiles, so a decision on the three-dimensional shape of the wing will still be required.

Another useful resource nowadays is the internet, and specifically some of the aerofoil simulation packages to be found there. Some basic ones can be used at no cost, but more advanced ones must be purchased. And while they generally also appear to concentrate on two-dimensional aeronautical profiles, some show simulated flows and allow limited interactive manipulation of fundamental parameters, such as thickness and camber, while displaying the changes to forces or coefficients. And very usefully, ordinates of the shape you decide upon can then be plotted and used for manufacturing your own design of wing. Again, see the references list for a small selection of websites offering these facilities.

But even after consulting these valuable resources there are still some unknowns. For example, although some of the aeronautical textbooks and one (hard to find) racecar wing text provide information and data on multi-element wings, there is little to guide the profile seeker on shapes that are suitable as dual or triple-element

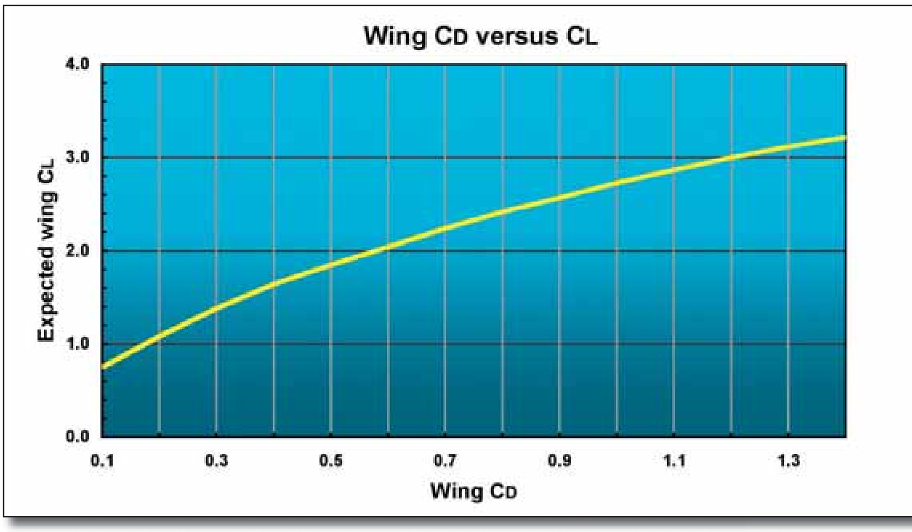


Figure 3: approximate correlation between wing CD and CL, based on published data on racecar wings (*Competition Car Aerodynamics*, McBeath)

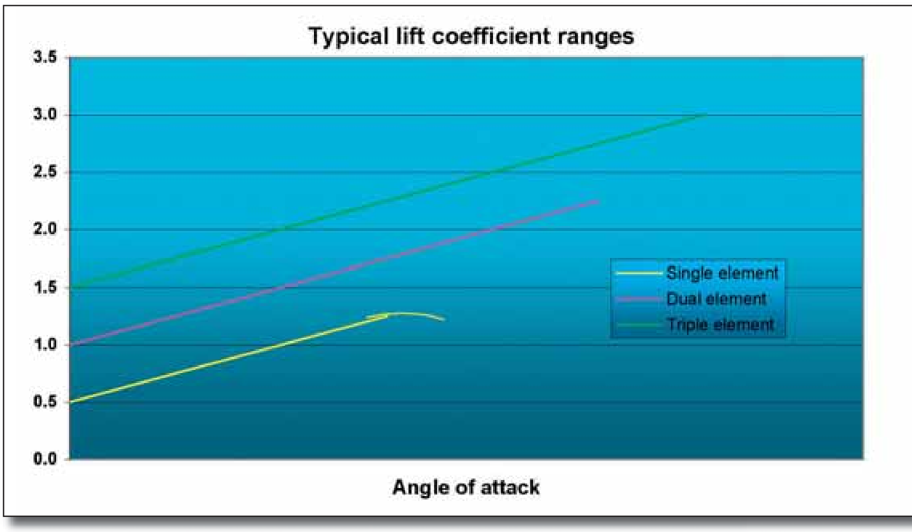


Figure 4: indication of the likely CL ranges for three basic wing configurations (McBeath)

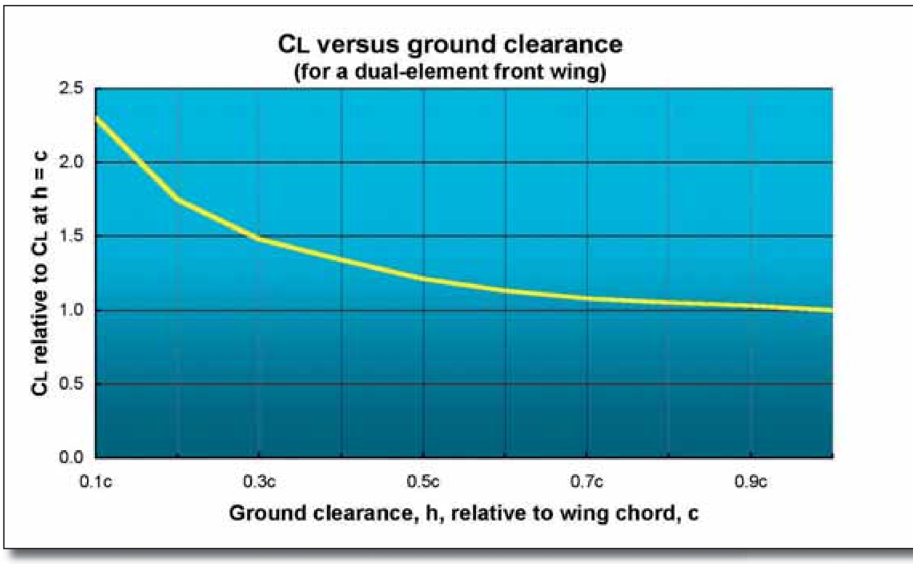
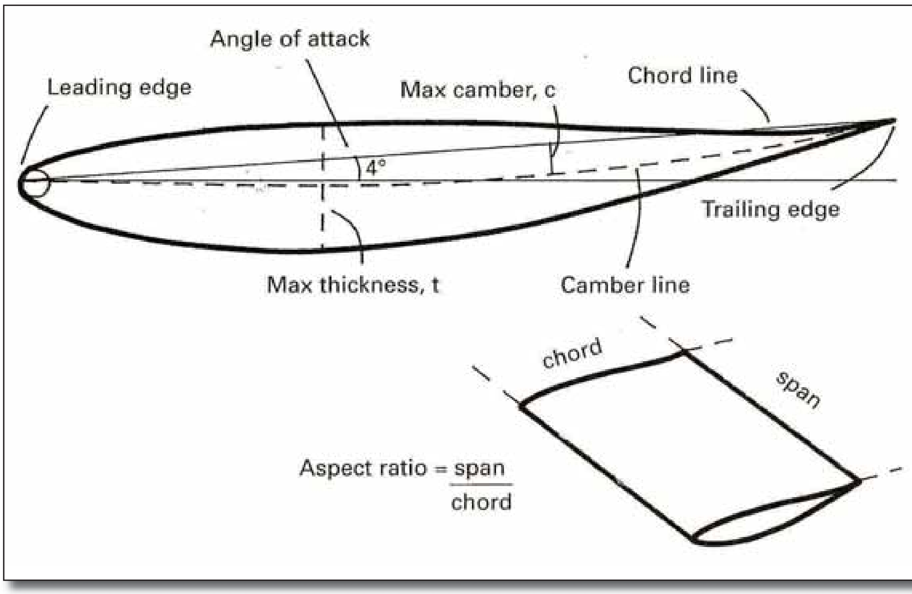


Figure 5: a generic plot, based on dual-element front wing data, of ground effect 'amplification' of downforce prior to viscous blockage at very small ground clearances (*Competition Car Aerodynamics*, McBeath)



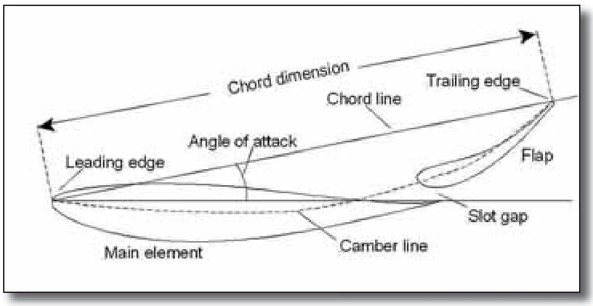


Figure 6 (above): single-element wing terminology (McBeath)

Figure 7 (left): dual-element wing terminology (McBeath)

If a digital model of your car exists, a professional can optimise a wing profile for a specific car using CFD

racecar wings. And more fundamentally, what characteristics does a profile require in order to generate the required performance, possibly over a wide range of angle settings? This type of information is essential if the right choice from a potentially bewildering selection is to be made.

Profile selection

Followers of the Aerobytes series in this magazine will recall that we ran a number of articles on the influence of the basic characteristics of single-element wings in issues V14N6 to V14N8. We also looked at dual-element wings in V14N9. From these and other references it is possible to draw up a list of selection criteria to begin to whittle down the choice.

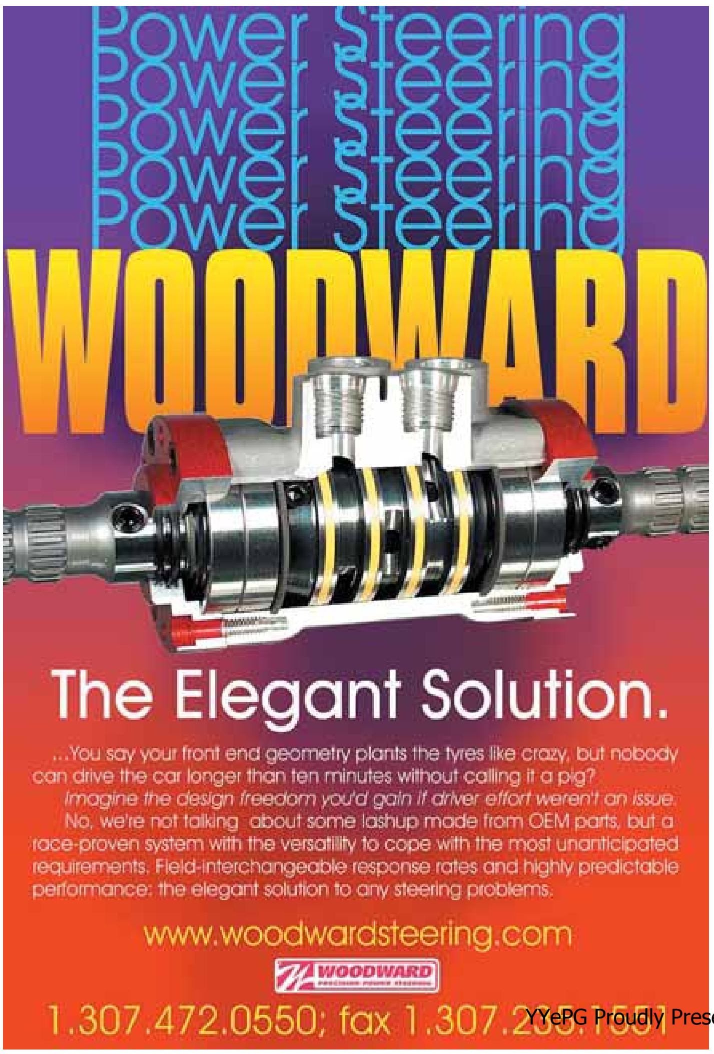
For a single element wing that will be adjusted over a range of angles the aerodynamic parameters (see figure 6) are likely to include:

1. Thin section thickness for a low downforce, low drag set-up – 14 to 16 per cent maximum thickness for best efficiency across the widest range of angles, and 18 to 20 per cent maximum thickness for maximum downforce.
2. Small amounts of camber, perhaps in the range four to six per cent for low downforce, low drag and high efficiency; possibly in excess of 10 per cent camber or so for high downforce. Front wings generally need less camber because of ground effect 'amplification'.
3. Low angle of attack for low downforce and low drag; high angle of attack, up to a maximum of around 14 to 16 degrees relative to the airflow for greater downforce, with inherent drag penalty.
4. Leading edge radius probably in the range one to three per cent of chord, although this parameter is to an extent governed by the thickness and camber distributions. A bigger leading edge radius would be more suitable if the wing is to be run at steeper angles.

> **"THERE ARE VARIOUS SOURCES OF POTENTIALLY SUITABLE PROFILES"**

Indeed, before settling on a shape, judgements – probably intuitive – have to be made on the location of maximum thickness and camber, and the distributions of those two key parameters along the profile. Typically maximum thickness location would be about one third the way along the chord from the leading edge, with maximum camber located about half way along the profile. But there is still theoretically an infinite range of distributions available. In all honesty, the most likely and pragmatic action at this point will be to eyeball and select a profile that fits the basic criteria, and which 'looks right'.

For dual and triple-element profiles, some of the criteria for a single-element wing will still apply to the mainplane design. However, it is said that a thicker mainplane section with a more rounded leading edge radius can work better with flaps. And if the flap chord is at the higher end of the preferred range, say 30 to 40 per cent of overall chord (see figure 7), then a mainplane thickness as high as 20 per cent is said to give a significant increase in downforce compared →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A number of aerofoil simulation packages can be found for free on the internet, though more comprehensive advanced ones generally have to be purchased. These can be useful in early planning stages

to a mainplane of around 10 per cent thickness. The amount of camber in the mainplane will depend on downforce requirement, and is likely to be in the range of five to 15 per cent of chord, and quite possibly 20 per cent or more for high downforce applications, positioned perhaps slightly forward of or around halfway along the mainplane chord. The adjustment to the angle of the flap(s) will have the effect of altering the rearward bias of the camber of the overall wing, which is one of the fundamental means by which the addition of the flap alters downforce.

As for the flaps, as has already been stated, flap chord will most likely be around 30 per cent of mainplane chord, and the flap thickness may need to be, relatively speaking, slightly thicker than the mainplane thickness. The position of the flap's maximum thickness is often fairly well forward, say at around 20 per cent of its chord – this can help to create a beneficial converging slot shape between the flap and the mainplane by producing fairly rapid curvature from the flap's leading edge onto its lower surface. The flap profile does not seem to be overly critical in order that it will perform a useful function. But logic dictates that the same criteria that apply to a single-element mainplane ought to be applicable to the shape of a flap. So it would seem to be a reasonable assumption that a more cambered flap will help to generate more downforce than a less cambered one. Furthermore, the use of a flap with more camber can make it easier to achieve the desired convergent slot shape than if the flap has a flatter profile.

> **“THERE IS, THEORETICALLY, AN INFINITE RANGE OF DISTRIBUTIONS AVAILABLE”**

The maximum angle of inclination of the flap relative to the mainplane chord line can be determined in track testing, but for a dual element will probably not exceed 40 degrees. For triple-element wings a typical configuration might see the second flap perhaps 30 degrees steeper than the first flap, giving second flap angles of 60 degrees or more. Indeed when categories like Formula 1 and ChampCar were permitted to use triple-element wings, second flaps were sometimes run more or less vertical. However, while downforce increases with steeper flap angles, the incremental gains become smaller and increases in drag become larger, so efficiency (lift divided by drag) tails off.

A further consideration with multi-element wings is the relative positioning of the flap(s) and the mainplane, and the flaps with respect to each other if there is more than one. In an article entitled 'Wings and flaps' in V10N2 we covered current theory on the mechanisms involved in the interaction between the mainplane and flap for a dual-element wing. In essence, the main element and the flap modify the flow on each other beneficially to reduce the likelihood of flow separation on both, and to enable the development of greater pressure differentials between their upper and lower surfaces. Needless to say the slot gap and overlap are important in this respect.

The aeronautical texts are of limited use in determining efficient, let alone optimum, slot gaps and overlaps for racecar wings, and in any case this parameter would ideally be optimised for any given wing and set of operating conditions. As a start point again though, a vertical gap approximating three to five per cent of mainplane chord, and an overlap of perhaps five to seven per cent of mainplane chord will enable a beneficial interaction between the flap and mainplane. The gap between the first and second flaps will more than likely be a little smaller than this.

Despite all the science, initial judgement on thickness and camber often begins with intuitive guesswork

Scaling to size

To meet the dimensional requirements of either the rules or your own specification it will be necessary to scale the selected wing profiles to full size. Sometimes the technical regulations mandate a maximum permitted chord, but if they do not, what chord dimension should be used? Maximum wingspan is almost universally →

limited by the relevant technical regulations. But should the maximum permitted span be utilised? We have seen that downforce is related to plan area, and so is drag. But we must also look at the 'aspect ratio', AR, the ratio of span to chord.

How does aspect ratio influence wing performance? The high-pressure area above a racecar wing and the low-pressure area below it induce some air to flow around the wing tips, from the high to the low-pressure region. This forms the characteristic tip vortices we sometimes 'see' with high downforce wings on damp or humid days as the humidity condenses in the low-pressure core of the vortices (figure 8 is a CFD visualisation). The flow around the tips decreases downforce by reducing the pressure differential between top and bottom surfaces, and the effect is felt proportionately more with a narrow wing (low AR) than with a wide one (high AR).

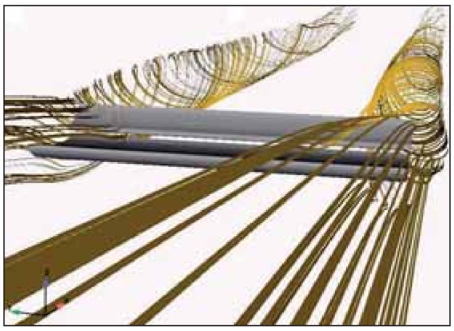
The 'spillage' around the tips is also associated with induced drag, C_{Di}, now referred to as vortex drag, because the wing feels drag from the low pressure in the vortices trailing it. This force is felt proportionately more with a narrow wing.

It follows then that a wider wing will perform better in both respects, and this is too good a bonus to pass up. So there are two conclusions on AR. First, utilise the maximum permitted span. And second, don't assume that using the maximum permitted chord, or indeed the maximum chord that will fit on the car, is necessarily the right choice. A theoretical check on this can be made using the following pair of formulae:

C_L is proportional to $\dfrac{1}{1+(2/AR)}$ (see also figure 9)

and C_{Di} is proportional to $\dfrac{C_L^2}{\pi AR}$

Comparing two wings with the same area but different aspect ratios using these two formulae demonstrates that the wing with the bigger aspect ratio has a higher lift coefficient and a smaller induced drag coefficient. Note too that using suitably large end plates increases the effective aspect ratio of a wing by reducing spillage around the wing tips (see figure 10), as discussed in Aerobytes V15N4.



"MAXIMUM WINGSPAN IS LIMITED BY THE TECHNICAL REGULATIONS"

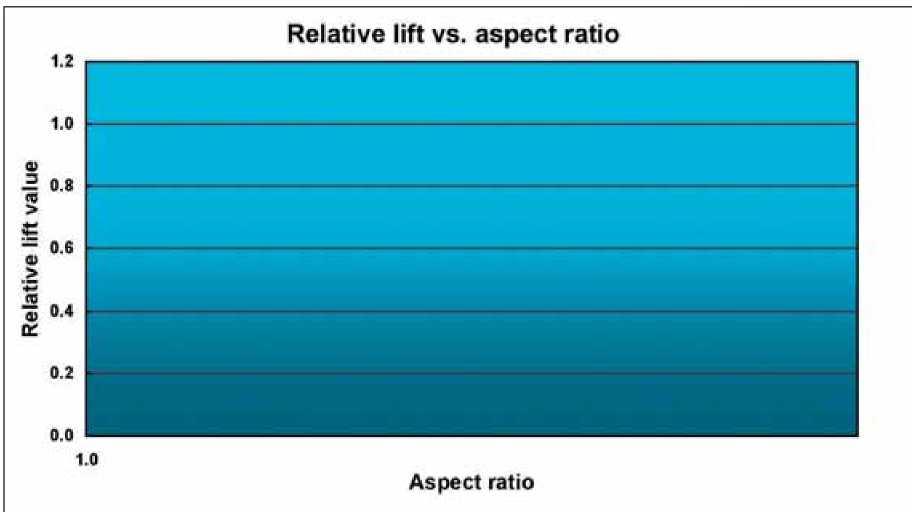


Figure 8 (top): wing tip vortices have a greater proportional influence on a low aspect wing
(Advantage CFD)

Figure 9 (above): increasing the aspect ratio leads to increased lift, or downforce in our context
(*Competition Car Aerodynamics*, McBeath)

Figure 10 (right): end plates increase the effective aspect ratio by lessening the effect of the tip vortices
(Advantage CFD)

Profile variations

Of course, an alternative to all of the above is to go to a commercial provider of aerodynamic analysis and consultancy services and ask them to provide an optimised wing design for your application. This could either be done on a wing in isolation from the car, or if a digital model of the car exists then the wings could be optimised, using CFD, for the flow around the specific car. It is very apparent when looking at any top category racecar nowadays that, for example, wings rarely maintain the same profile right across their span, and this stems from on-car optimisation effort. However, to alter either the chord or the angle across the span with any hope of making gains requires information on the flow structure around the wing. This can only really come from CFD simulations or perhaps detailed wind tunnel work with the racecar to visualise the flow in the vicinity of the wing, and hence make informed changes to the wing itself. And although those facilities are more cost effective than is generally thought, they aren't financially available to all. Furthermore, to manufacture a wing with variable chord or angle ('twist') may also require CNC pattern or mould creation capability, which would pre-suppose the availability of a 3D CAD model — again, not a facility available to all.

But if digital models, CFD analysis, CNC manufacturing and wind tunnel verification are beyond your team's budget, the methods outlined here should get you in the ballpark. RE

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Motorsport's island paradise

Sun, sand, rum and rallying sums up Barbados' motorsport ethos. But underneath there's an untapped pool of motorsport knowledge and enthusiasm, just waiting to shine

Words	Sam Collins
Photos	Collins; Martin Sharp

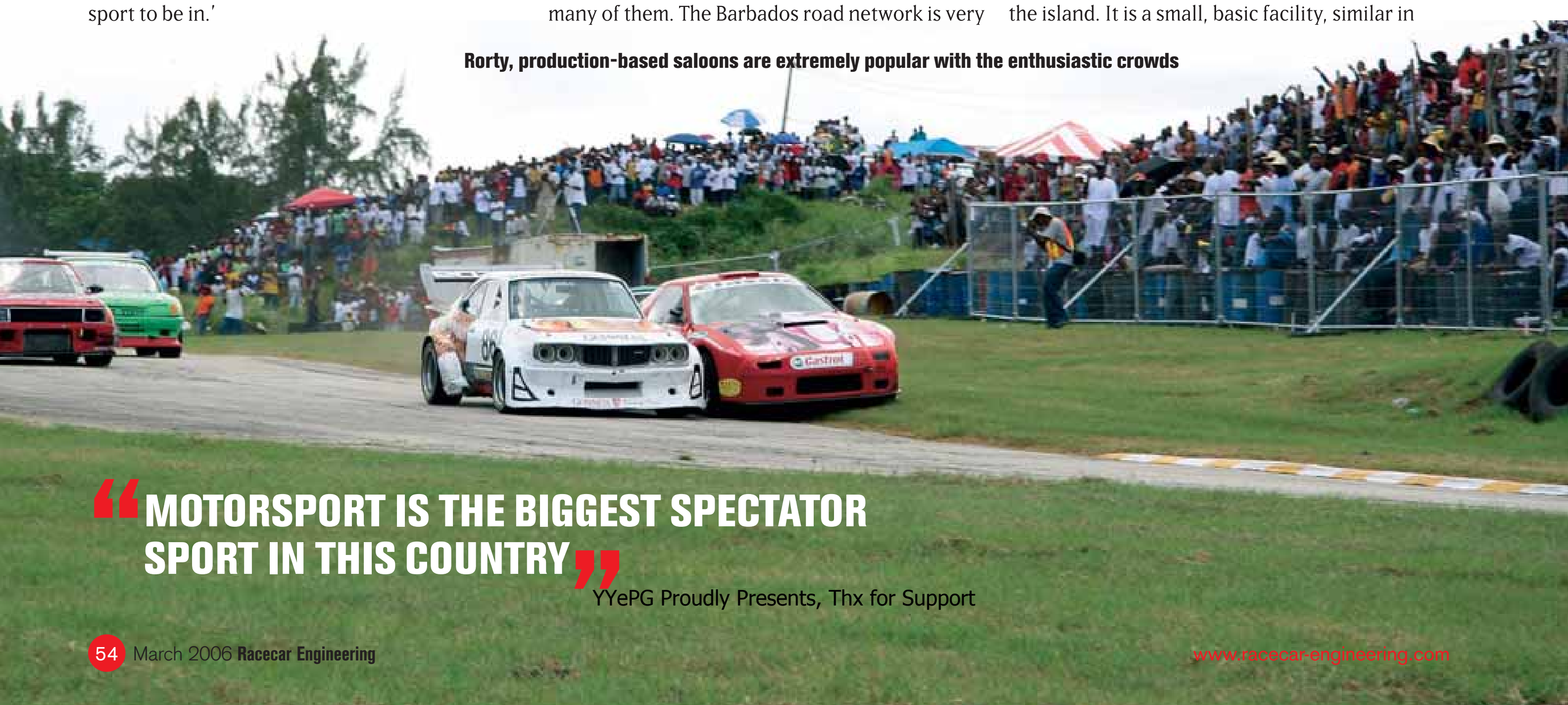
Situated on the southern edge of the Caribbean, Barbados is at first glance totally unremarkable, at least from an automotive point of view. The holiday destination of choice for wealthy Britons is mainly notable as an exporter of rum and laid-back living. It rarely features on the radar of the motorsport industry, but this looks set to change.

This is a nation that has gone, or perhaps always has been, motorsport crazy, and it was estimated that around 10 per cent of the population attend at least two motorsport events a year. 'Motorsport is the biggest spectator sport in this country. Other sports struggle to get crowds,' explained Noel Lynch, the island's minister for tourism. 'But with this the organisers struggle to get all the fans into the circuit in time,' he continued. 'What a fantastic situation for a sport to be in.'

As with any motorsport area with a large fan base, there is a huge aftermarket sector inspired by the on-track antics, and everyone talks about the sport on a fairly constant basis. Antonio 'Stones' Da Silva, one of the people behind the island's biggest motorsport event, Rally Carnival, reveals why: 'People in Barbados are proud of their cars, it is very much a car culture. Although not everyone can afford the best or newest cars, they make the best of what they can get.'

'Rally Carnival' is the island's biggest event, with competitors from Europe and the Caribbean gathering to compete on the island's challenging asphalt rally stages. 'Rallying is what we do best here at the moment,' reasons Da Silva. 'Rally Carnival is just that – a two-week combination of motorsport and partying. Our roads are perfect for rallying, partly because we probably have too many of them. The Barbados road network is very dense in comparison to the rest of the Caribbean; every plantation used to be bordered by roads so they run everywhere.' Crowds of up to 25,000 spectators turn out to see local entries take on the top amateur crews from Europe – helped by the event organisers striking a deal with a shipping line to transport competitors' cars to Barbados. 'A lot of professionals, or those who chase championships, don't do it because they effectively lose their car for three months,' said Da Silva. 'But we attract a lot of amateurs who just compete for fun. For them, it's the ideal holiday – sun, sea, sand, rum and rallying.'

Motorsport in Barbados is not just limited to rallying on the country's numerous closed roads, there are also two permanent facilities: Vaulcuse Raceway Park and Bushy Park. However, of these, Bushy Park is currently the only race circuit on the island. It is a small, basic facility, similar in



Rorty, production-based saloons are extremely popular with the enthusiastic crowds

"MOTORSPORT IS THE BIGGEST SPECTATOR SPORT IN THIS COUNTRY"

Nowhere else in the world has quite the same attitude to motorsport…

character and size to Lydden Hill in England. Safety measures are almost non existent: small unsupported tyre walls in key spots, allied to some empty oil drums on the starting grid. There are no physical barriers between the track and pit area, and in places nothing between the action and the spectators other than common sense.

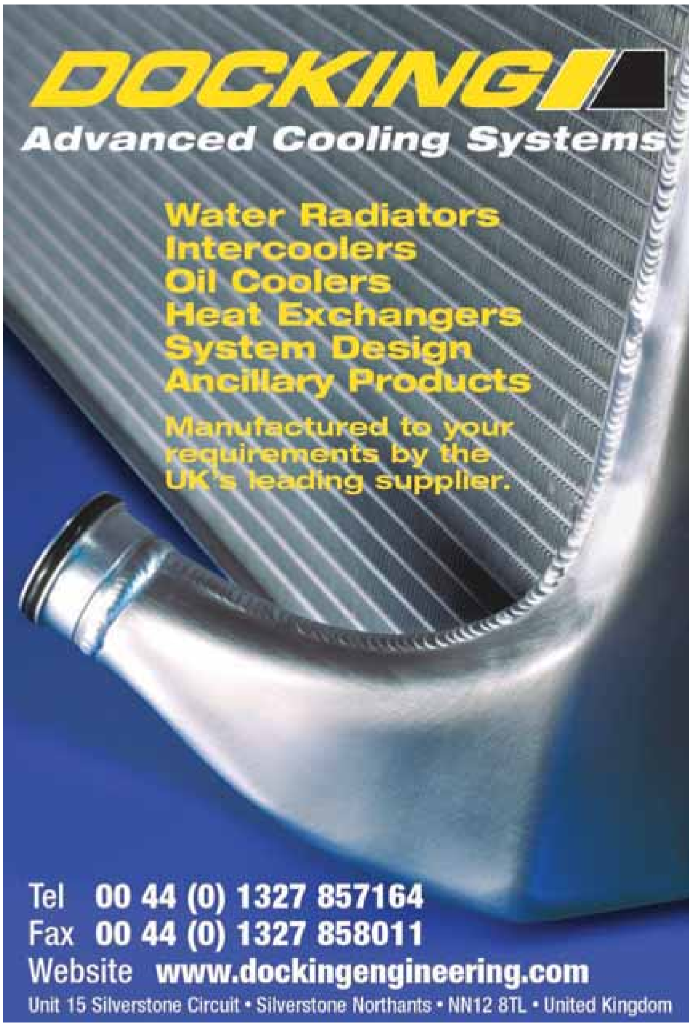
The pit garages are just wooden frames. Any international entries (who mainly come from Guyana) have their car's shipping crate in addition to act as covered garages. It is an aged venue and its 0.8-mile layout, whilst challenging, is under developed, due to a prolonged period of inactivity that ended a few years ago. The surface is very rough, crazed and broken up in places, and nature has reclaimed some of the circuit's width where the edges have crumbled away to nothing. But the circuit has a strong spectator following and a lot of charm. A lively open saloon car series entertains at every opportunity, with the enthusiastic crowd cheering audibly over the noise of the unsilenced racers. RE visited the Bushy Park circuit on a day when it was 'closed', and was surprised to see a good number of spectators in the track's only grandstand. A handful of the international entries had organised an impromptu test session and were running just under race pace – shaking down their cars and learning the track. Yet locals were turning out just to watch the unofficial testing. Motorsport it seems is a very popular thing amongst the black contingent of the island who make up 95 per cent of the total population.

> **"OUR FANS LIKE SALOONS, BECAUSE THEY CAN ASPIRE TO THEM"**

There are local heroes to cheer on in highly modified and spectacular fire-spitting machines. During the recent 'International Show Down' at the track the real passion that Bajans hold for motorsport was demonstrated. A record crowd witnessed the circuit champion and the Guyanan lap record holder play out a high-speed grudge match on track, driving the spectators into a frenzy that only a high speed drifting demonstration and a new car launch could pacify. It was the stuff that made series like NASCAR and the BTCC famous and attractive to spectators and sponsors alike.

Because there are few rules, the cars range from humble Minis and Volkswagens to flame- →

Rallying in Barbados has reached an international level with a number of ex-works World Rally Cars currently active on the island's rough asphalt road courses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Bushy Park is the island's premier but undeveloped venue


Safety standards are almost non existent, allowing spectators to really get involved with the thrill of the sport


Vaucluse Raceway Park, currently a rallysprint course, has the potential to be developed into a good standard facility


The pits at Bushy Park are spartan at best, but with tropical weather who needs walls?

belching, rotary-engined beasts, and some homegrown engineering talent is starting to show through. Looking over the cars in the paddock reveals that a Barbados motorsport industry, although still embryonic, is starting to grow. Yet seemingly no European or US-based racing supplies firm is making a serious effort to trade with the islanders.

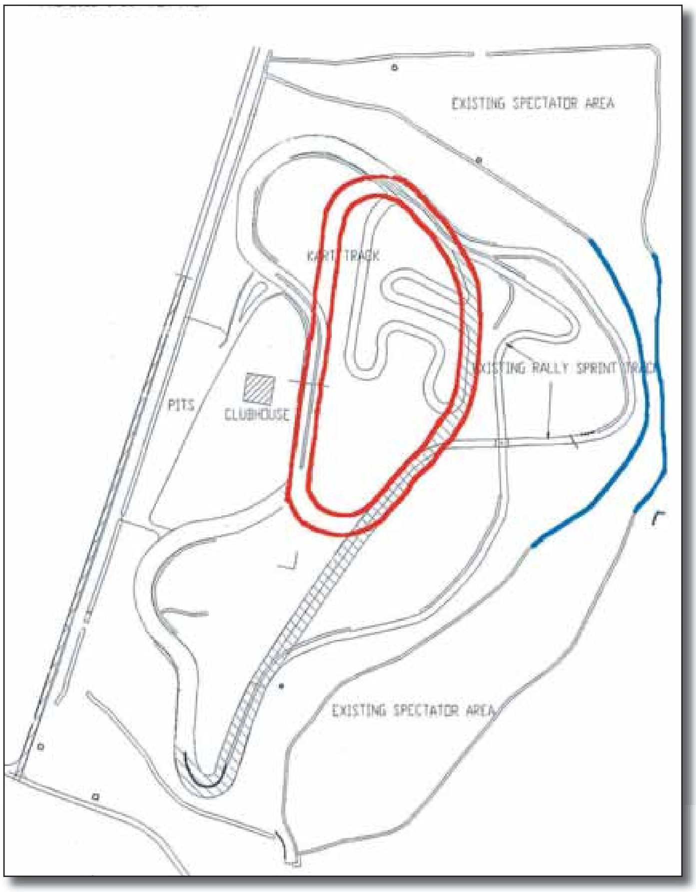
Vaucluse Raceway Park is situated on one of the island's high points, not far from the affluent west coast of the island. Developed by rally carnival organisers, it is currently a 2.8km rally sprint course, but has real development potential, and its current operators are keen to make it a significant motorsport complex. Like Bushy Park, the facilities are basic, and further development must be undertaken to sustain activity. Currently the venue closes for six months of the year.

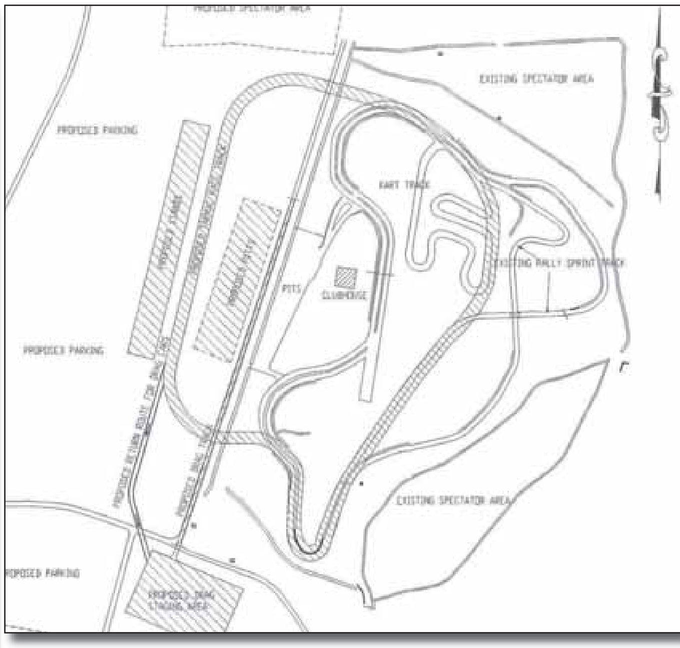
Greg Cozier is one of the men behind Vaucluse Park, and has some ideas about how to further the sport on the island: 'We are currently at a bit of a turning point. Between this year and next year, some decisions have to be made.' He continues to

"SOME HOME-GROWN ENGINEERING TALENT IS STARTING TO SHOW THROUGH"

pass opinion on the state of the nation, 'As far as rallying is concerned I think we have gone as far as we can go. Circuit racing hasn't got near that level yet, but unfortunately it is very difficult to sustain both. We are still a small island with a relatively small amount of active drivers,' he warns. 'I would like to see rallying continue at the level it is, with the Rally Carnival doing as well as it has done for the last five years. We need to settle on a single formula for some kind of circuit racing that wouldn't eat into the size of the rallying scene – something that wouldn't take away drivers, cars or sponsors. That's where we are and we want to see how best to do that.'

One plan is to build a half-mile oval track at Vaucluse Park to attract NHRPA Hot Rods and Legends from Europe, and perhaps even a number of cars from the USA for some kind of international championship event, as well as developing a domestic NHRPA-style class. Cozier expands: 'We are thinking about something that is preferably rear-wheel drive, loud and quick. Also something that can be supported by all the dealers because we don't really have any dealer support here. That's why the whole idea of the National Hot Rods came up because the cars are exciting, light and fast. They are cheap and easy to maintain and run, and whilst contact is frequent, they are very easy to repair. Also they are marketable and sponsor friendly. We can →





Plans for the development of Vaucluse could include a half mile tri oval (shown here in red), as well as a drag strip and kart circuit. Event organisers are particularly keen to attract more competitors from Europe and the USA

“WE HAVE ALL THE FACILITIES IN BARBADOS”

get local dealers involved and they can fit any plastic body on they want over the spaceframe.'

Stock car racing seems to fit with the Barbados scene as there is apparently 'little interest in bringing single-seat or prototype racing to the island, our fans like saloons or what look like road-based cars, because they aspire to them.'

So, on an island where even the minibus taxis are fitted with aftermarket spoilers, perhaps UK-style National Hot Rods are the logical answer, especially as they have been described by some publications as 'Europe's answer to NASCAR' and 'a boy racer's wet dream.'

Cozier continues: 'The oval track idea came about because motorsport on the island has to be sustainable locally, and around here competitors come from very varied levels of society. Some of them are a lot wealthier than others so it's important to find a formula where people can compete fairly at a reasonable budget. At the same time, the spectators are very knowledgeable and sensitive to what's going on in the rest of the motorsport world. They also like the spectacle of driving so it's got to be an exciting formula.'

Vaucluse Park is an ideal location for a stock car circuit as it forms a natural bowl, so offers the good spectator viewing that is essential for oval racing to be a success. The current format of Bushy Park could also accept the oval track cars, allowing for at least a two-circuit championship to take place on the island.

Other ideas include creating drag strips and a race circuit somewhere on the island to attract series like international Formula 3 – an idea popular with some of the local competitors, including golf club groundsman and driver of a racing Volkswagen Beetle, Henief Gooding: 'In five years time I would like to see a very international-type circuit here, with a drag strip, and perhaps even able to accommodate Formula 1 cars. We have all the facilities in Barbados: good health facilities, good housing and incredible hotel accommodation. I think the crowds are only going to increase.' It is clear that Barbados could become a good destination for a motorsporting holiday, both for the engineer or driver and also their family.

West Surrey Racing's circuit designer, Clive Bowen, spent time on the island during the international race week, flown in by local businessman and motorsport enthusiast Bizzy Williams, to see what ideas are feasible for the future development of the sport in Barbados. Whilst no firm plans were made, these are certainly moves in the right direction.

Whatever the future holds for Bajan motorsport, it is certain that it will continue to grow, and there seems unlikely to be a shortage of amateur racers and rallyists willing to journey there from Europe to compete on what is fast becoming motorsport's paradise island. RE

Bolt-on goodies

Aftermarket is a huge sector on the island of Barbados. Everything from minibuses to Subarus has some kind of non-standard bit on it from 'go faster, get noisy' exhausts to spoilers and racing seats. And there is huge enthusiasm for any kind of performance car.

Looking over the Bajan and Guyanan competition cars in action at Bushy Park is like reading a who's who of motorsport engineering firms, including everyone from ATL to Zircotec. It appears, however, that few of these firms have noticed this rapidly-growing market. There are no speed shops here, no Demon Tweeks, Atech or similar. Performance exhausts are sold in electrical equipment shops and almost everything else is imported. Whilst the market is small, it is vibrant and active, with a good amount of competitors and a seemingly limitless amount of aftermarket customers, there is a real opportunity for an EU or US-based competition car supplies company to set up shop here.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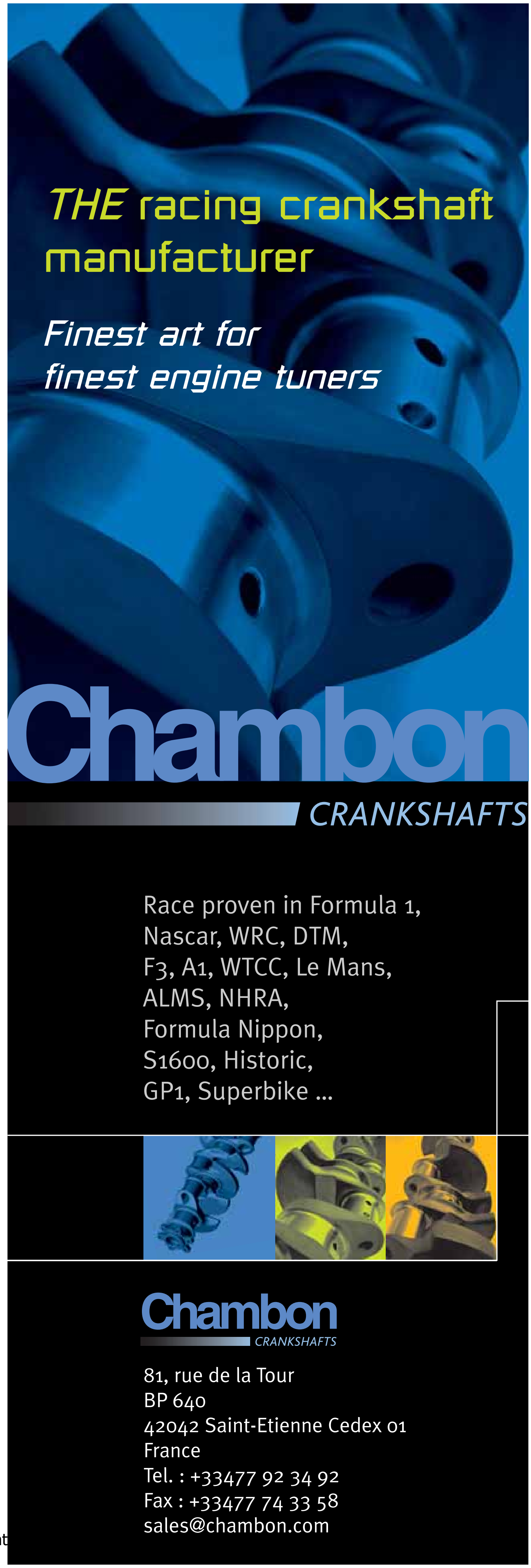
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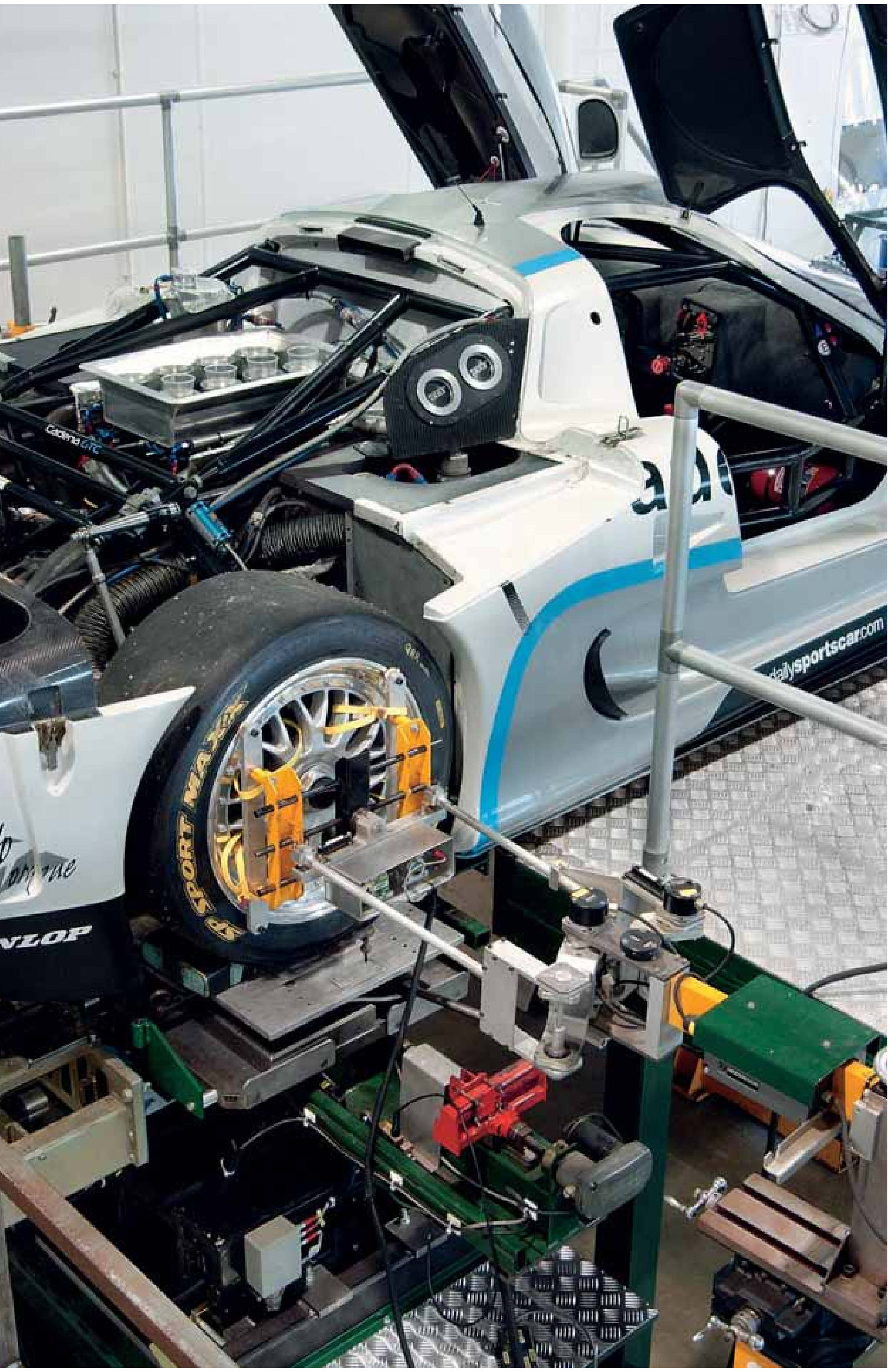


Character of deformation

Kinematics and compliance testing are key to extracting the best performance from a chassis. Lotus Engineering explains how it works

Words	Charles Clarke
Photos	LAT

SKCMS is Lotus Engineering speak for Suspension Kinematics and Compliance Measurement System. This in turn is a fancy name for a custom vehicle measurement rig designed, developed and made in-house by Lotus Engineering.

'We did some early kinematics and compliance tests about 14 years ago, really before anybody was looking at K and C measurements,' says Ray Hill, vehicle testing validation area manager at Lotus Engineering. 'We had a small test rig, which we used for our own in-house measurements. This development preceded our kinematic software development by about a year or two. We'd had the rig for about five years before PCs had developed to the extent that they could do anything useful with kinematic lab data.'

When Lotus started this work the 386 was the popular PC, which just about had enough puff to handle spreadsheets and word processing. The 386 and 486 were only marginally capable of controlling the test machine and simple data logging. 'For our first machine the test results populated an Excel spreadsheet which you could use to get x, y plots with slopes,' says Hill.

As computers developed, standard software like MatLab took over the results capture, display and interpretation. Data was presented to MatLab from the machine in the way that the software required. Around the same time, because of the greater general availability of computer power, Lotus Engineering started to develop its own kinematics and compliance analysis software (see *Racecar Engineering* V15N2).

'It all started with a notion to try and quantify some of the ride and handling characteristics of the vehicle,' says Hill. 'When the rig was first developed, there were only three similar rigs throughout the world – one in the US, one in Germany and one in France. These were mainly owned by the tyre companies who used them to gain quantitative information about their tyres.'

Because of the type of development and consultancy work done by Lotus Engineering it needed something to measure vehicle kinematics and compliance parameters. Initially it rented time on the tyre company machines on a project-by-project basis, but it soon became clear that it would be much more convenient to have a machine in-house.

'We would be doing a development project with Goodyear or Michelin and would have to go to their machine to run tests,' say Hill. 'Also, generally speaking, the information we got from these machines was not always in the right format and in many situations it was a case of the data being appropriate for tyres but not for suspensions. So we decided to build our own machine. At the time the Shark (kinematic) software suite was being developed so we had a fairly good idea of the kinds of data we needed the rig to capture. We knew the kinds of characteristics that were important and needed to be measured and the kinds of things we needed to change to improve the vehicle performance.'

Based on discussions with the suspension analysis department and the ride and handling engineers a detailed specification for the rig was put together. 'In terms of the design process, we examined the measurements we needed to take and basically designed the rig around these requirements,' says Hill. 'To some extent the initial design was influenced by the kinds of machines that were in use by the tyre companies, although their machines operated in a slightly different way.'

Linear ball screws in the motors ensure no hydraulic leakage over time and accurate repeatability

"YOU ARE NOT FORCED TO ASSUME THAT COMPONENTS ARE PERFORMING TO SPECIFICATION"

The Lotus SKCMS machine can be split into four basic areas:

1. A system to measure the movement of each wheel in all directions (six degrees of freedom – three translational and three rotational).
2. A system that measures the deflection of the body relative to ground in six degrees of freedom. (When a test is performed these values are subtracted to produce absolute values so the test results are not influenced by the fixing of the vehicle to the test machine.)
3. There is a force measuring system that mechanically splits the x, y and z forces without any cross coupling, which means that no mathematical corrections are necessary on the force measurement system. The vertical →

The Lotus rig measures the movement of each wheel in all directions – three translational and three rotational. It also measures deflection relative to the ground load cells only measure vertical load, the lateral load cells only the lateral loads and likewise the fore and aft cells. This was one of the objectives of the initial design.

4. The machine has an electro-mechanical drive system which uses high response servo motors with linear balls screws – these are very quiet, reliable and the big advantage is that when the drive stops the system remains in that position indefinitely. (If the drive mechanism were hydraulic, like a traditional four-post rig, you would get leakage over time and the system would eventually settle.)

'If you hit the emergency stop for any reason the mechanism is locked and it stays in that position,' says Hill. 'By that token the results are repeatable and accurate. We also have a very simple mechanism for clamping the vehicle in place.'

Gavan Kershaw, a senior hide and handling engineer at Lotus Engineering, is a talented sportscar racer in his own right. His current weapon of choice is a GT2-specification Mosler MT900R that has been spending some time on the SKCMS rig. 'The work we were doing on Gavan's Mosler fits squarely into the category of suspension refinement,' says Hill. 'Gavan is an experienced ride and handling engineer and has a very good idea of how he wants the geometry to behave under load. With racecars you can quantify things like anti-roll bar stiffness so that if the anti-roll bar is adjustable you know exactly the level of stiffness that each level of adjustment provides. You can get true wheel rates and it allows you to ensure that the theoretical situation is as close as you could possibly get to the physical one.'

There have been instances in the past where Lotus Engineering has been testing racecars with so-called 'adjustable components' that were not providing the level of adjustment originally specified. This generally helped to explain why the appropriate performance changes were not experienced when adjustments were made based on the initial specifications. 'It's not necessarily a case of the manufacturers misleading the customer, other things can be happening with other components to negate the adjustment,' says Hill. 'Things like the anti-roll bar supports deflecting in an undesirable fashion when maximum anti-roll bar stiffness is applied. Only when you get the car on a rig where you can isolate and identify the contribution of all components can you identify these problems with any level of certainty and you know exactly what's happening when particular adjustments are made.'

“IT CAN FILTER THE MASS OF INFLUENCES ON RIDE AND HANDLING PERFORMANCE”

You can also use the rig to set up certain suspension characteristics. 'In the case of the Mosler we were setting up the rear bump steer,' says Hill. 'This is adjustable on the toe link for height so we were able to quantify how each increment changed the bump steer and exactly the extent of the toe-in for each increment. We can then set the bump steer to match required values that we get from the kinematics software.'

Once you've done an analysis like this you are much better able to postulate behaviours from what you know about the vehicle. 'It's far easier than sticking a wet finger in the air in the circuit garage,' says Hill. 'For people like Gavan, because of his experience he's got a pretty good idea of what sort of compliant steer and bump steer curves he's expecting, to give the response in the vehicle that he likes. For him, supplying the curves is enough, effectively calibrating his car. When he goes out and experiences a certain behaviour, because he knows so much about the kinematics and compliance of the whole car, he's got a better chance of tuning the behaviour to his liking than someone using a trial and error process in isolation.'

For other clients the information from the test machine can be used with Lotus' kinematics and compliance software to help diagnose problems – this is a bit more time consuming and expensive but it provides the whole package.

In an ideal world, on a new project you would probably end up with a mule-type car. You would do some measurements and see how they compared to what you believed you'd designed. Hopefully they would be close, and then from the results of the test machine they can be used in the

'Quasi-static, low-speed testing' eliminates interference from rubber bushes and dampers which could otherwise affect test results

The ability to isolate every individual component means subjective track test results can be confirmed and specific parameters quantified and investigated

kinematics and compliance software to predict how you would expect that vehicle to behave on the road or test track. Or you could find out how to correct the mule vehicle to make it behave the way you wanted it to.

'Recently a manufacturer came to us for us to assess their new car,' says Hill. 'Initially we gave them a subjective opinion of the car and identified some issues with the steering just from taking it around the track and on public roads. We then put the car on the rig to quantify the front and rear suspension characteristics and from that we identified some parameters that were probably contributing to some of the steering issues. Things like rear axle lateral stiffness that was not really appropriate to the type of vehicle. We then did a short exercise to address these issues through various component changes – different rate rubbers and bushings, different wheel bearings and some other things. We verified the changes on the rig and then drove the vehicle and the customer went away happy.

The whole duration of this exercise was probably about three weeks. 'Chances are that the problems would not have been identified in this relatively short period of time using trial and error techniques. Also, trial and error would have taken a very long time to identify some other more discreet and obscure component interactions, if they could be found at all. The beauty of SKCMS analysis is that every component can be isolated and measured and its effect on performance can be quantified with software. Also, you are not forced to assume that components are performing to specification – if you have no way of measuring the lateral stiffness of a wheel bearing in situ you may be erroneously assuming it's okay.'

The rig is only designed to measure suspension kinematics and compliance characteristics. According to Hill, 'If you take some measurements and identify some small changes that you think will help and still don't solve the problem, perhaps it's an issue with the overall basic torsional stiffness of the vehicle. In which case, as long as the client agrees, we would use our body torsion test rig to calibrate the torsional characteristics of the vehicle and to look at what we need to do to improve them.'

> **"THE RESULTS ARE REPEATABLE AND ACCURATE"**

From the measurements on the SKCMS rig you will normally have a very good idea of what other systems could be contributing to the poor performance (other than the suspension and steering). This will usually direct attention to other test equipment.

Many ride and handling issues can be addressed with different shock absorber settings and spring rates. 'It could even be a problem with the design of the shock absorber itself, which is limiting what you can achieve with the vehicle,' notes Hill. 'This is quite common with vehicles at the economy end of the market.'

Where there are complex interactions taking place it is sometimes very difficult to identify the offending components without detailed SKCMS data, and without the data it is very difficult to come up with remedial actions. It is doubly difficult for the weekend racer who does not have extensive ride and handling engineering experience to attempt any kind of rigorous remedial trial and error programme that has any hope of success.

If a particular vehicle has some undesirable characteristics and these are not being addressed by reasonable trial and error then, rather than continue the unsatisfactory experience, a visit to an SKCMS rig could probably yield beneficial results relatively quickly.

'Normally the first order of business is a brief assessment on the test track by our ride and handling engineers,' says Hill. 'This will identify issues and from there we would do a fairly short exercise to quantify the suspension on the SKCMS machine,' says Hill. Based on previous experience, this kind of exercise can be done in as little as two days. 'We've done a number of short racecar projects of the order of two days and generally speaking the customer goes away happier (you'll never satisfy racers 100 per cent of the time). Also, there are usually some things that cannot be fixed under the regulations, even if we find a problem.' →

Lotus Engineering developed its rig in stages as its knowledge and requirements for data acquisition and processing increased. 'We had the basics of our current machine when we were approached by a Japanese bus manufacturer to do some tests on his vehicles,' Hill told us. 'This required us to dismantle and re-configure our machine to take a 10,000kg test load. We found a fundamental problem in this particular case that was fixed relatively easily and, because of the experience, the manufacturer asked us if we could supply them with a test machine. So we designed a 10,000kg machine especially for them. This led us to supply machines for other clients. All the time we were doing this work we were evolving the technology of the basic SKCMS machine so that our own equipment benefited from the development of the concept for other clients. Since then we've sold another two machines to other locations around the world.'

"EVERY COMPONENT CAN BE ISOLATED AND MEASURED AND ITS EFFECT ON PERFORMANCE CAN BE QUANTIFIED WITH SOFTWARE"

When Lotus was first thinking about developing its own machine a lot of the early ideas came from the machine tool industry. Things like linear ball screws are fairly commonplace on machine tools. 'We went for this kind of technology because it has proven to be inherently reliable over the years and is readily available,' says Hill. 'This is why we decided to make the machine an electromechanical device. This kind of technology for controlling machine motion with motors was in its infancy when we started, and since then it has become much more mainstream.'

'Our current tests we describe as "body static at low speed". We do this for two reasons – we don't want to excite the shock absorbers (which we test separately) and, when you're testing rubber-bushed suspension, it is essential to test at a constant loading velocity because of the inherent damping characteristics of the rubber in the bushes. Rubber has a dynamic performance which responds to changes in frequency so we concentrate on quasi-static, low-speed tests.

'The purpose of the quasi-static SKCMS testing is to check out the "as built" situation against the "as designed",' says Hill. 'Chasing down problems is much easier in the static environment.'

Most of the dynamic testing will be done on a four-post 'shaker' rig to examine damper settings and things that can affect the overall dynamic characteristics of the vehicle. 'Gavan uses a four-post rig to check the damper settings for different tyres (wets, intermediates and drys). We are looking at getting one of these rigs next year,' explains Hill.

Shock absorber adjustment and testing is a science in its own right,' he continues. 'It is a common fallacy that if you buy adjustable shock absorbers then all your bases are covered – this could not be further from the truth. Firstly, buying cheap adjustable shock absorbers is not a very cost effective way of solving the problem and secondly, shock absorbers have ranges of adjustment some or all of which may not be suitable for addressing the particular problems of your vehicle.'

Alongside the SKCMS machine Lotus Engineering has a number of specific shock absorber testing machines. Usually, if a client wanted a 'total test package', that would involve rating the shock absorbers at every valve setting to suit the application. 'And,' says Hill, 'from there you can get a good idea of what type of settings would suit the particular vehicle and particular racing conditions.'

This goes a long way to taking the guesswork out of the set-up process. If the vehicle is fully calibrated you can start the set-up process with parameters that are very close to the optimum for the particular conditions, the fuel loads and the tyres. It is interesting to observe that even an experienced racer like Kershaw recognises the importance of continually testing on the SKCMS rig. Even with his experience he relies on the hard data gathered from test measurement, as well as the subjective feel of the test track.

The beauty of SKCMS analysis is that it can filter the mass of influences on ride and handling performance. It identifies problems and you can come away with more problems fixed than the ones you thought existed before you went in. RE

Gavan Kershaw

Cadena GTC Team in its previous guise as Gavan Kershaw Racing won the 2004 British GT Cup Class Dunlop Superpole Award at its first attempt. Gavan and team mate Barrie Whight claiming three race wins, four podiums and the majority of fastest race laps in the process.

For 2004 the team thoroughly re-worked a Lotus Motorsport Elise, making it the most advanced example of its type in the world, and it will approach the preparation and running of its newly acquired GT2-specification Mosler MT900R in exactly the same way.

The team, now re-named Cadena GTC, is made up of highly skilled and motivated personnel, all of whom have the desire to win.

Kershaw's racing career started at a young age, winning several karting championship titles. He then progressed to stock cars where he won multiple British championships. More recently, he has been crowned 2003 Lotus Roadsports Series Champion and 2004 British GT Cup Dunlop Superpole Champion.

Kershaw is also principal vehicle dynamics engineer for Lotus Cars. His role is to extract the best out of Lotus cars to make them the fantastic drivers' cars they are famous as. He was involved in the development of the Mark 2 Elise/

Kershaw (left) with team mate Barrie Whight

Exige, the VX220 and the Motorsport Elise.

Away from the racing circuit, Kershaw has appeared on BBC Top Gear, as well as other television programmes and magazines. He has also won the Autocar Oversteer Challenge four years running, beating F1 and rally stars in the process.

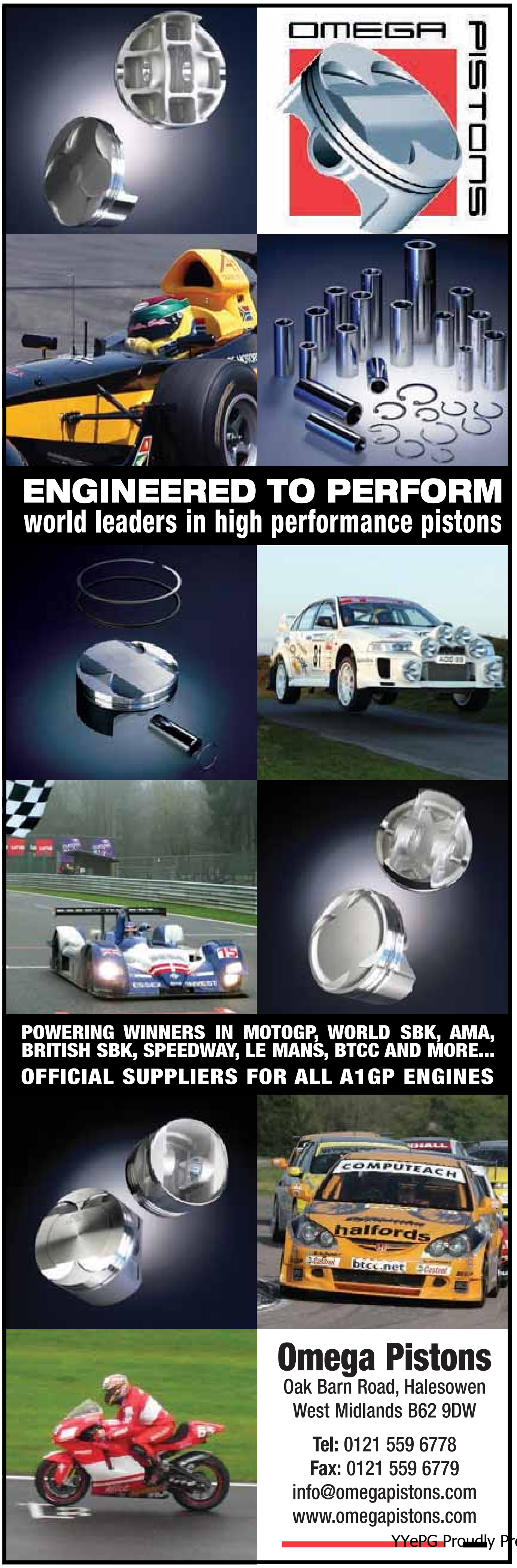
Website: www.cadena-gtc.com

Team results:

2005 Tag Heuer GT250 winners

2004 British GT Cup Class Dunlop Superpole Award winner; dailysportscar.com National Motorsport Car of The Year; Gavan Kershaw voted British GT Driver of The Year; British GT Cup Class – three race wins

2003 Lotus Roadsports Series Champion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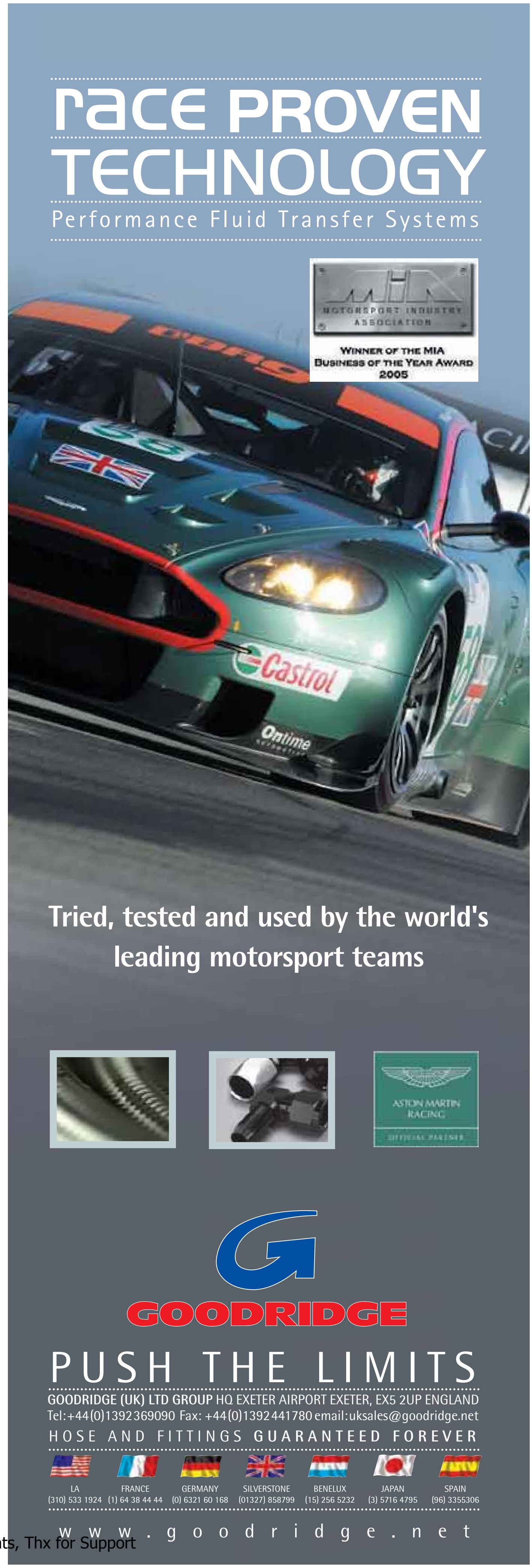
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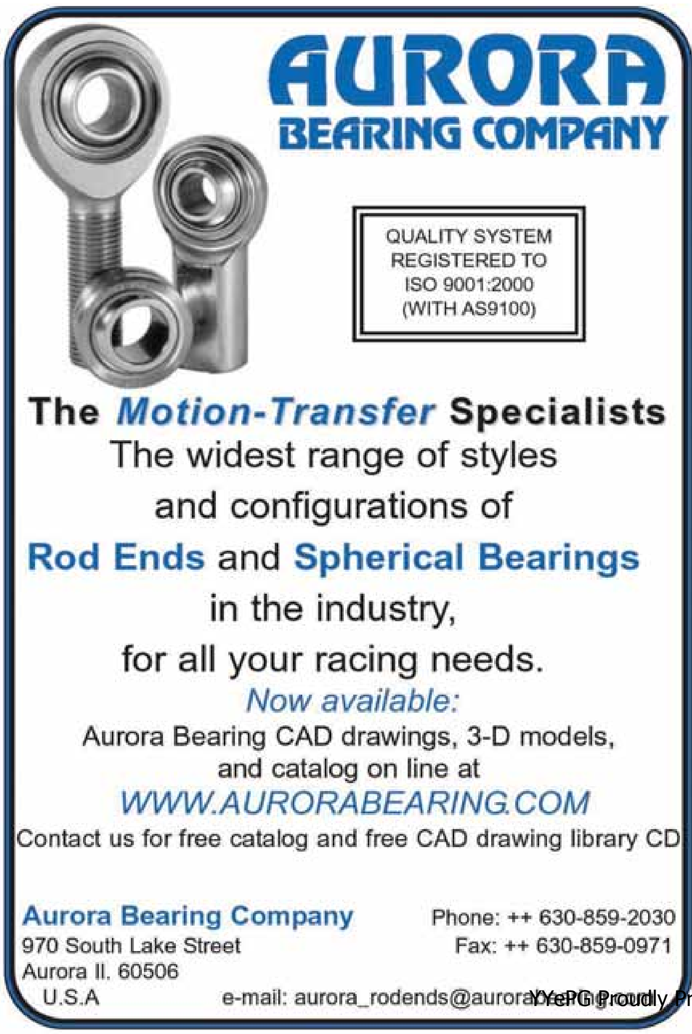
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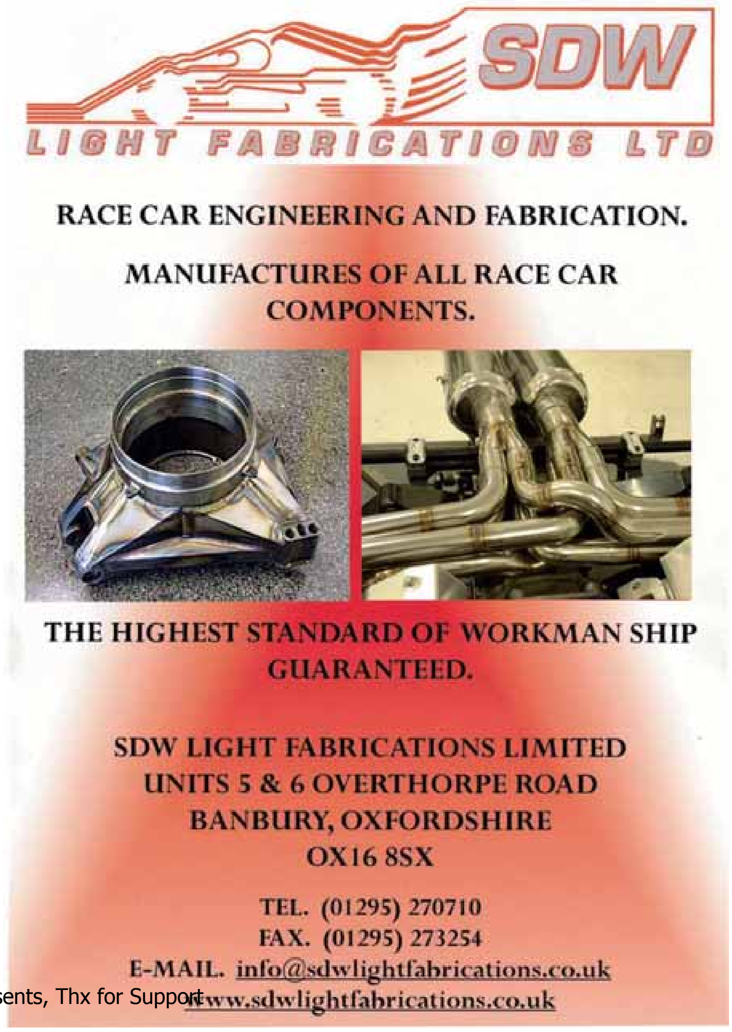
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Shocks away!

Damper suppliers in top-level motorsport is often kept secret, but here is **Racecar's** rundown of the major players in this fiercely competitive market

Words | Ian Wagstaff

Choosing the right damper is critical to extracting the optimum performance from a racecar, but knowing how to set them up is another skill altogether

The shock absorber, or more correctly, damper market is a highly competitive one with a large number of players. Some, like Penske, specialises in performance and motorsports, while others, such as ZF Sachs, are major original equipment suppliers to the passenger car market. Included are names like Öhlins, Showa, Dynamics (MTCE), Extremtech, Koni, Moton, Bilstein, AVO, Spax and Leda, with the specialists and major component suppliers competing at all levels.

Penske Racing Shocks, which were first developed for Indy Car in the USA, have been used in virtually all forms of racing throughout the world, including Formula 1, NASCAR, Champ Car, Le Mans and IRL. The latest from the company is the 8770 series 4, which is said to feature relatively recent Formula 1 technology and is suitable for sportscar, touring car and, indeed, anywhere that needs true four-way damping. The need for this has, says Penske, presented itself during the last few seasons with teams requesting more adjustment from their dampers because of the limited amount of testing possible during race weekends.

"IT IS UNUSUAL FOR A SUPPLIER TO DECLARE ITS CUSTOMERS IN FORMULA 1"

Penske's first four-way damper was introduced for Formula 1 in 1990 and was successful in its first appearance. Since then the design has been upgraded and re-packaged and has now been on the winners of 75 grands prix. The 8770 is an evolution of this. By offering high and low-speed compression and rebound, it is said to offer the most versatility with external adjustment, reducing the need for re-valves. With four clearly defined adjusters, two affecting bleed, the others high-speed forces, chassis tuning is reckoned to be simpler.

Penske is also expanding into the historic market with a range that debuted at the 2006 Autosport International show. It will also display at the Historic Motor Sport Show in the UK, through its distributor for Europe and Japan, Penske Racing Shocks UK – a division of SPA Designs. →


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Penske Racing Shocks has been manufacturing four-way adjustable dampers since 1990. Its 8770 series 4 is the latest evolution, suitable for many different forms of motorsport

MTCE, under the name Dynamic Suspension, offers a complete, four-way adjustable suspension programme called DSSV

German supplier ZF Sachs revolutionised F1 damping with its rotational damper (below), as documented in *Racecar* V15N5

Öhlins is another supplier to Formula 1, and its dampers have also been used on the all-conquering Audi R8 and on around 30 of the competitors in the Paris Dakar. Another reasonably new four way-adjustable shock absorber is its twin tube TTX40. This has a 40mm piston and a through-rod shaft without any external gas reservoir. The top eye can be re-clocked without opening the damper. The controls for the external adjustment of this have been collected in a single location, while compression and rebound ranges have been kept separate so each adjustment affects only the parameter it is intended to affect. The number of positions (40 on the low-speed adjusters and 50 on the high-speed adjusters) has also been increased relative to earlier products. The weight has also been reduced compared to Öhlins' TT40 damper. For example, the weight of a TTX40 (not including end eye and spring platforms) with 56mm of stroke is about 850g. A number of the NASCAR teams and Indy Racing League currently run on TTX dampers.

"KRYPTON GAS IS SAID TO BE ALMOST IMPOSSIBLE TO DESTABILISE"

MTCE (Multimatic Technical Centre Europe) introduced its DSSV (dynamic suspensions spool valve) technology to a wider market last year, having developed the concept in Champ Car racing with the Newman-Haas team. Until 2005 it had only been available through exclusive arrangements, but now it has been used on such as the Panoz Elan GT car, as well as in the British GT series and both the Japanese Formula 3 and Formula Nippon series.

The P1 Formula 3 Lola team of Danilo Dirani was one to switch to the product during the course of the season. Dirani reckoned that they were particularly responsive to change, especially during a long test session. Following the partnership with Lola that resulted from this, MTCE has designed an SSV specifically targeted at the Formula 3 market for 2006. This will be suitable for Dallaras as well as Lolas. In addition, MTCE dampers are to be supplied to the new Champ Car Atlantic series.

DSSX is another pure four-way damper which features independent high and low speed valves for control of both bump and rebound. It includes linear indexed adjusters, matched from damper to damper to optimise the symmetry rating across each axle. The external, cartridge-based configuration of the valves means they can be replaced on the damper without the need to disassemble, re-build or bleed the unit.

MTCE, which operates using the Dynamic Suspensions brand, claims that DSSV is more than just a damper, being rather a complete programme that incorporates hardware, software and engineering services.

Koni's shock absorbers have been standard on the GP2 series during its fledgling year. The product used has been its 2822 MkII series four-way adjustable damper, which has a wide damping adjustment range in both high and low piston speeds, in both rebound as well as bump. Koni was also the damper supplier to the Red Bull Formula 1 cars last year. While it will not be seen on the first team's racecars in 2006, it will be a supplier to the second string Toro Rosso team.

It is unusual for a supplier to declare its customers in Formula 1, commercial conditions dictating whether it does or does not name names. ZF Sachs has, in recent years, made much of its association with Ferrari and in May last year, *Racecar Engineering* carried details of the collaboration between the Italian race team and its German supplier that resulted in a re-think over rear dampers. Its concept, first seen on the F2003-GA grand prix car, dispenses with telescopic dampers and replaces them with non-adjustable rotational units. These not only reduce weight but also allow for a smaller gearbox to be used. Instead of the three conventional dampers of the rear suspension, two rotational dampers integrated in the rocker handle the bulk of the work, replacing two of →

the conventional dampers. The pivoted rocker is a type of triangular lever arm that diverts bounce and rebound motion from the wheel to the spring and anti-roll bar. The idea subsequently found its way on to other Formula 1 cars and during 2005 Sauber, Toyota and Minardi all used ZF Sachs product, although the latter had conventional dampers all round.

Ferrari and Sauber also last year used ZF Sachs' TRD (through-rod dampers) at the front. Unlike conventional dampers these have a titanium rod running all the way thought the aluminium cylinder barrel with the damper elements, protruding at both ends of the damper. A TRD damper weighs just 200g and is claimed to absorb the shocks of a bumpy track faster than a conventional unit.

In addition to those who operate at the rarefied altitudes of Formula 1, there are a number who specialise more in national and club racing. Leda Suspension, which now exports to over 40 countries, will be launching a new monoshock, shimstack damper this year manufactured from aerospace specification aluminium that uses a new method of hard anodising from Germany. Sales director John Stubbs says that the product will be of high quality, very adjustable and suitable for such as British Touring Car Championship teams. A number of electronic 'add ons' will be featured which, even though they may unable to be used during a race, will be suitable for setting up the car. Stubbs denies that the setting up of

"SPAX HAS A PARTICULAR FOLLOWING ON THE HISTORIC SCENE"

dampers is a 'black art' and says that the new product will be sold with guidelines on how to operate it.

Last July Spax launched a new range of steel bodied, gas-pressurised dampers designed specifically for clubman and historic racing. The basic principle of the CSX range, as it is known, is that it allows competitors to create their own specification of damper from a menu of options. The customer specifies the end fittings (spherical bearing, stem, rubber bush), damper length, rebound to bump ratio, spring fittings and options. All CSX dampers are pressurised with inert krypton gas, which is said to be almost impossible to destabilise, thus producing more stable valving. Spax's older aluminium-bodied TrackSPAX range has also been revamped. Single (SA) and double adjustable (DA) versions are available, the former with 25 points of adjustment in bump, the latter with 25 adjustment points each for bump and rebound.

Adjustable bump and rebound damping on the CSX are fixed by means

Leda offers a range of touring car and rally dampers, like this three-way unit

UK manufacturer Spax has recently revamped its aluminium-bodied Trakspax range, available in single and double adjustable formats

New from Spax is its rebuildable, steel-bodied, krypton-filled CSX range, aimed primarily at clubman and historic racers

of an adjuster knob, while ride height can be altered via an extra long thread on the damper body. The range has also been designed so that it can be serviced, re-valved and repaired, if required, using Spax's three-day rebuild service.

Spax has a particular following on the historic scene and is a supplier to Classic Team Lotus. It also points out that it supplies dampers for such as the John Cooper Mini Challenge and has product on several cars in the Nürburgring 24-hours. Product is purchased direct from the factory.

Over the past year AVO has introduced monotube coilover and telescopic dampers specifically for competition use. These can be single, double or triple adjustable and all are gas pressurised with remote canisters. The company also still offers twin-tube dampers, indeed reckons to be the only one to sell a twin-tube damper with independent bump and rebound without a remote canister. Currently the company deals more in rallying and is to supply the Rover Challenge during 2006. It also runs its own Escort Cosworth Group A car and its products are to be found in such UK national race championships as those for Ginettas and Mazda MX5s.


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Black magic

Performance Friction believes it has taken a leap forward in carbon/carbon brake technology with its new continuous fibre disc

Words | Charles Armstrong-Wilson

Performance Friction carbon discs are the first to feature continuous fibres running across the thickness of the disc, dramatically improving heat dissipation toward the core

"WOUND FROM A CONTINUOUS FIBRE IN THREE DIRECTIONS"

The carbon/carbon disc and pad combination is nothing new on a racecar. Developed for racing in the 1980s, it offers light weight, good wear properties and legendary retardation. The technology is reasonably described as mature and advances are rare and incremental in nature.

Performance Friction, by comparison, is still something of a new kid on the block in the brake market. However, it has characterised its approach by endeavouring to bring something new to every product market it enters. Starting with brake pads, it followed with discs and calipers. Now it has eyed the carbon/carbon brake market, but to tackle it in the company's traditional style the company needed to find an advantage to set its product apart from the rest.

Despite all its benefits, carbon/carbon does have one weakness as a braking medium. Carbon fibres are very good at conducting heat down their length, but they are not very efficient at conducting heat between fibres. Most carbon brakes are produced from chopped strand or woven fabric laid in layers and compressed before being baked to reduce the material to carbon. This produces fibres lying in the X and Y directions but none in the Z direction across the thickness of the disc.

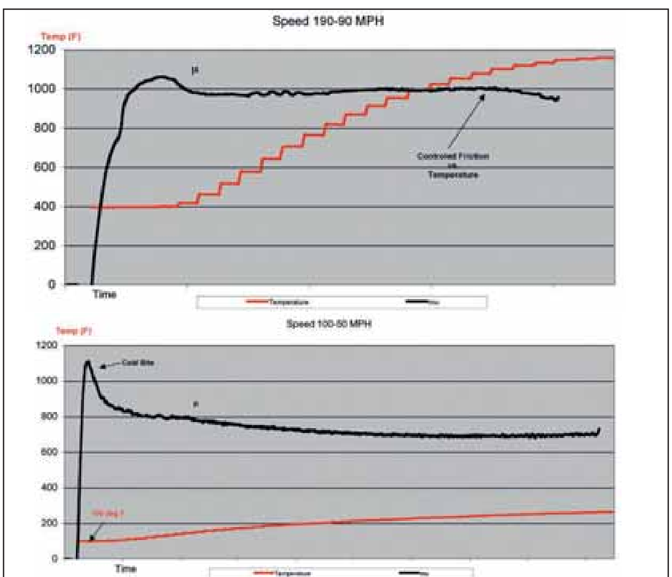
The result is, under braking, the surface of the disc becomes very hot, but the heat does not conduct easily away from the surface to the core of the disc. Obviously this means the surface can easily become overheated and start breaking down.

Some manufacturers have experimented with ways of creating fibres in the Z direction to aid heat conduction across the disc with varying degrees of success.

Performance Friction looked at the problem slightly differently. Rather than trying to connect the layers of carbon with bridging fibre, it wound its disc from a continuous fibre in three directions. This creates a blank with unbroken heat paths in all directions allowing heat to conduct through to the core of the disc. It results in a higher heat capacity as the temperature soaks through to the core and less extreme readings on the surface.

In early testing the disc has demonstrated greater longevity and more stable braking performance as illustrated by the accompanying graphs. Early examples of the disc have even been able to dispense with cooling holes around their perimeter, aiding structural integrity. Applications will begin in sportscars and, at the time of writing, work was beginning with American Le Mans Series teams. RE

Early tests have exhibited improved longevity and more stable braking potential



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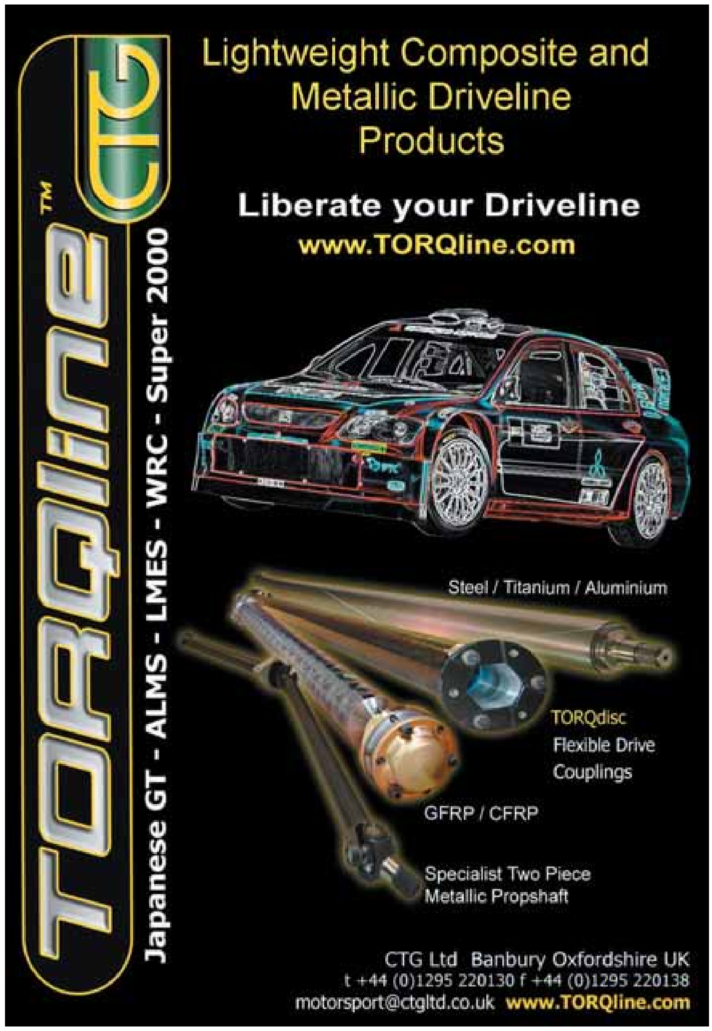
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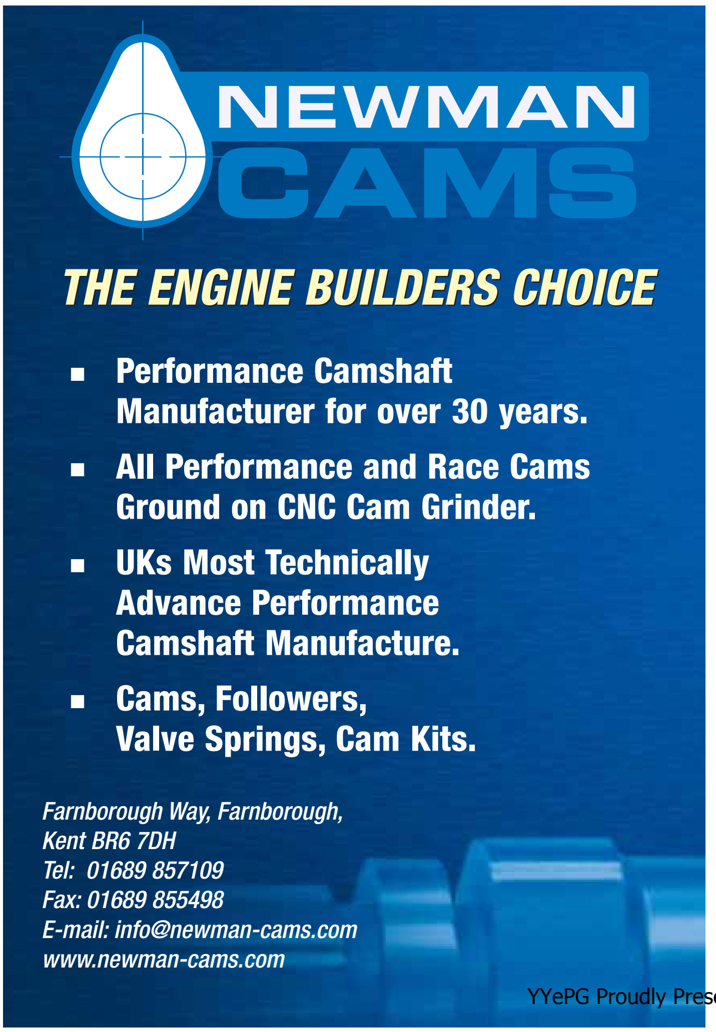
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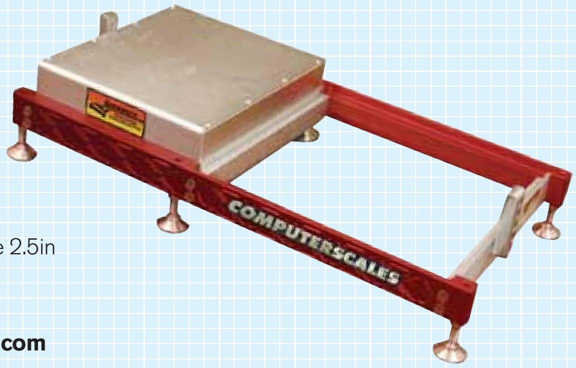
Rolling levellers

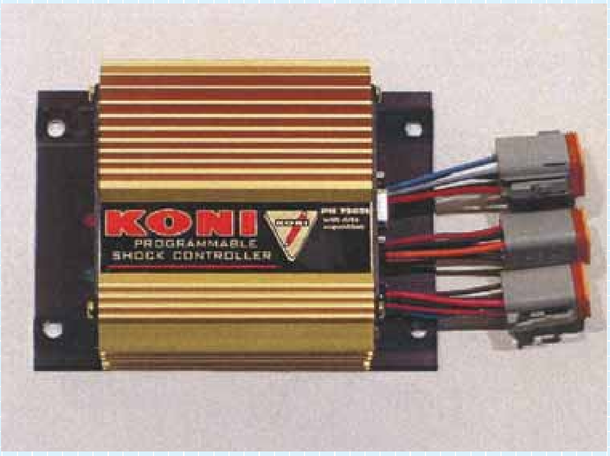


Longacre Racing Products has released its new roll-off levellers, made from 6061 T6 aluminium.

Designed for dead flat accuracy, the roll offs allow the user to move the vehicle on and off scales easily to release tyre bind and side loads. The billet aluminium levellers are manufactured with six different swivel adjusters for added ease.

Each leveller kit comes with four individual roll offs and with an option for low-profile 2.5in (6.35cm) pads or 4in (10.16cm) pads.

● **For more information call +(1) 360 453 2030 or visit www.longacreracing.com**



Shock control

Koni has introduced a new control system and wiring for its electric drag racing shock absorber.

Via a laptop or MSD controller, the new system allows racers to set, map and save timed, shock-damping adjustments. After each pass shock data can be downloaded to observe velocity and suspension motion. The system has an internal timer, as well as burnout control settings and hosts an independent control for left and right shocks as well as rebound and compression damping.

Kits can be purchased either complete with Koni's electric drag shocks or as a separate controller and wiring kit to fit existing Koni drag shocks.

● **For more information visit www.koni.com**

Da Video dash

A new extensive video and data logging system has been developed by Aim Sports LLC.

The DaVid data logger expands on Aim's experience in this field by introducing new video technology. It combines two cameras to channel separate video signals to the dash display where the user can then examine crucial statistics such as speed, rpm and brake/throttle positions from earlier driving sessions.

Easy connection technology (ECT) allows DaVid to be connected to many commonly used ECUs by selecting from a custom database. Even if an ECU does not provide a serial connection, the DaVid flexible analogue inputs allow sensors to work without compatibility problems in any situations.

As with many other Aim products, the DaVid also provides the option of configuring the dash display according to personal taste.

● **For more information call +(1) 951 674 9090 or visit www.aimsports.com**

Leading loggers

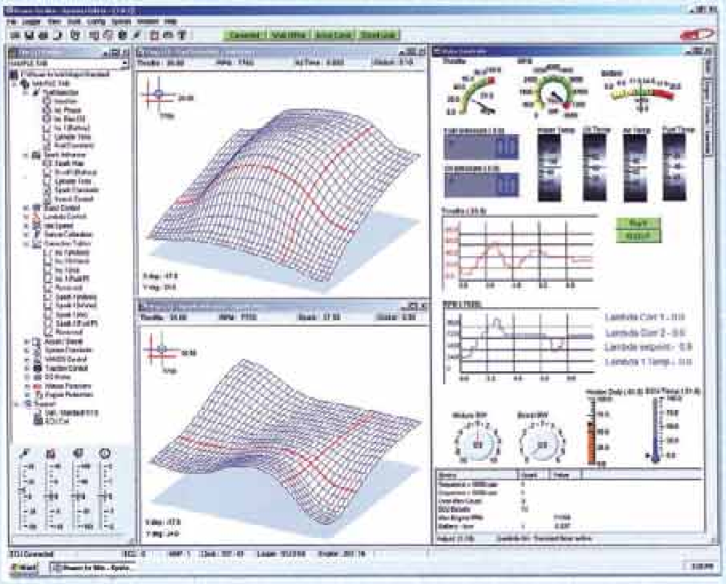
Race Technology has recently announced the release of its new data acquisition system, the DL2.

The British manufacturer of racing data logger systems has developed the DL2 to be the next generation of its already successful DL1 system. The unit has been custom designed for automotive data acquisition where speed, acceleration and vehicle position is recorded via a mixture of GPS and accelerometers.

Race Technology's 20Hz GPS solution has been combined with 16 analogue sensor input channels and four wheel/shaft speed inputs. Recorded data can be graphed, combined or analysed through 30 various channels using either the included analysis software or exported to an external source.

● **For more information email sales@race-technology.com or visit www.race-technology.com**

Winning software



Power to Win version 7.0 is the new engine software from EFI Technology Inc that provides current maps in the ECU to be edited in real time.

The software is a fully integrated systems editor and communications application that, when connected, instantly updates any modifications made to the maps to be changed directly in the ECU.

The data control window comprises 16 various user pages to store all engine channel data. User defined controls allow the information to be displayed according to preference and all maps can be edited to be either graphic or numeric displays.

All previous 6.0 engine maps and loggers are compatible with the new 7.0 software.

● **For more information call +(1) 310 793 2505 or visit www.efitechnology.com**

A new breed

The 8860 ECU from EMS is the leader of the company's new engine management computer generation, offering a user friendly and practical service aimed at reducing the time spent on tuning an engine.

The 8860 ECU examines and re-calculates each engine parameter over 600 times per second enabling each individual cylinder to be analysed and optimised before firing the ignition and injectors.

In instances when engines may have two load measuring devices, any two sensors can be programmed for use and has the flexibility to read almost any type of sensor by hosting easy-to-use calibration tables.

Accuracy is claimed to be 100 per cent as trigger inputs are filtered for noise, plus engine speeds are always precisely timed by means of an advanced auto signal tracking system.

● **For more information call +(1) 877 936 7872 or visit www.emsnorthamerica.com**

Multi-task display

The multi-function Race Pro IIID dash display is now available from SenDEC Racing Products. Offering a variety of features, including ultra large LCD display characters and a bar graph tachometer, along with simple menus, long life and reliability.

It comes with SenDEC's patented and programmable tachometer input, up to two temperature inputs and is compatible with CHT sensors, EGT sensors and water temperature sensors. It can be programmed for temperature over limit warnings and includes lap timers that can be adapted to different track splits and hide times, as well as session run times, total engine run time and available memory.

● **For more information call +(1) 315 986 1812 or visit www.sendecracing.com**

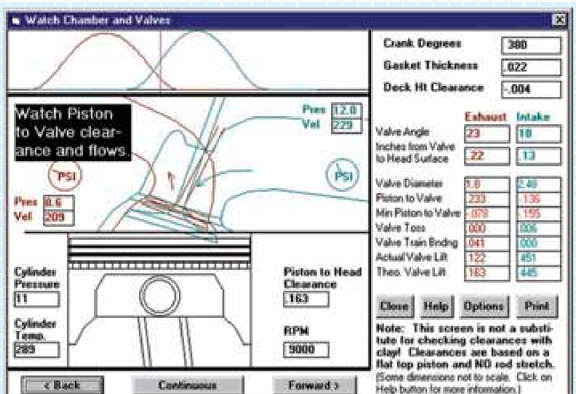
Engine detective

Engine Analyzer Pro V3.3 is a detailed software package from Performance Trends Inc that allows the professional engineer to simulate engine builds or adjustments on the computer prior to building them for real.

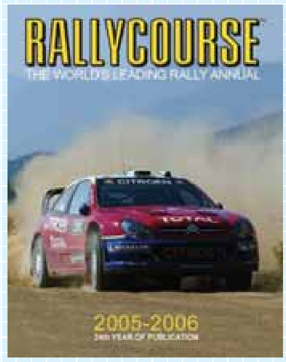
The software prevents wearing out the engine on the dyno and the excess costs involved by enabling users to investigate and experiment with various engine combinations on the computer whilst attempting to find maximum power.

All applications are included, whether it be turbocharged, nitrous oxide injected, naturally aspirated or restricted. Spark advance on detonation, ring leakage on blow-by and cam profiles are just some of the detailed calculations included in the investigation process which assists the user to gain a better insight into engine theory.

● **For more information call +(1) 248 473 9230 or visit www.performancetrends.com**



Rallycourse 2005–2006



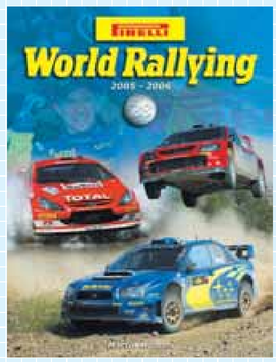
Edited by David Williams

Rallycourse is the final work of David Williams who died unexpectedly last year and, as usual, is the essential blow-by-blow account of the World Rally year. 2005 could be one of the most significant years in the history of the WRC – the loss of Richard Burns to illness and Michael Park in a crash will no doubt call for changes in the sports safety provisions. *Racecar's* own WRC correspondent, Martin Sharp, examines the development of shock absorbers and suggests improvements to side impact protection in some detail.

Whilst at first glance light on technical content, what there is in *Rallycourse* is excellent.

● **Published by: Crash Media Group (www.crashmediagroup.com); ISBN 1-905334-06-0; £30.00 ($49.95)**

Pirelli World Rallying 28



By Martin Holmes

Rally fans will probably have hoped for a DVD for Christmas, with action images of an action sport. Rally enthusiasts will have hoped for the 28th edition of World Rallying. Its 200 plus pages allow for a calmer, more reflective review of the 2005 season. There's a WRC round-by-round account with statistics and informative sidebars. There are also plenty of photographs and some detailed tables to pore over.

But what about *Racecar Engineering* technophiles? It's good news – Pirelli World Rallying 28 also has chapters to grab your attention. There's an informative WRC specification table plus an overview of technical developments (including Group N, Super 1600 and Super 2000 cars). And Pierre Genon, principal engineer at Subaru World Rally Team, explains about aerodynamics although, sadly, gives little away.

Background chapters on, for example, Suzuki Sport and rally control technology are interesting if frustratingly short. Many of the photographs are also worth close scrutiny, although it's a pity chief photographer, Maurice Selden, doesn't point his lenses in and around the interesting parts of the cars more often.

Is *Pirelli World Rallying 28* worth buying? Yes it is, but not if it means sacrificing your subscription to *Racecar Engineering*.

● **Published by: Vinehouse UK?? (www.vinehouseuk.co.uk); ISBN 0-9545433-2-7; £24.95**

Database

Section 1 lists manufacturers of Brand-Name Racecars.

Sections 2-3 list component manufacturers. Section 2 is dedicated to Chassis Components, Section 3 to Engine and Transmission Components

Sections 4-5-6 list equipment manufacturers Section 4 is dedicated to Factory Equipment Section 5 to Circuit Equipment Sections 6 to Driver Equipment

Sections 7-8-9-10 list companies that supply services. Section 7 is devoted to Chassis Engineering Services, Section 8 to Engine / Transmission / Suspension Services Section 9 to Testing Services Section 10 to Non-Engineering Services

To get your company listed in the racecar database please contact Andy King - 0208 726 8329 andy_kings@ipcmedia.com

Costs listed below:
Name and number £50 - 12 issues
Name and number bold
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Logo and full company details
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www.
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Andy King on
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Fax (1) 408 988 8998
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Suite 2, Santa Clara, CA 95050, USA

ASCARI **Tel 01295 254800**
Fax 01295 255944
Overthorpe Road, Banbury,
Oxfordshire OX16 4PN England

APOLLO RACING DESIGN LTD **Tel 01280 813580**
Fax 01280 823015
Email info@apolloracingdesign.com
Website www.apolloracingdesign.com
Millgate Barn, Radclive, Bucks
MK18 4AB, England

BARRELLI **Italy (39) 02 782427**
Flli Barrelli, Via La Spezia 5, 20156 Milan, Italy

BRD Race Cars Inc. **Tel (1) 716 637 9467**
16 Hollybrook Road, Brockport, NY 14420, USA

BODOLA **Tel Sweden 46 171 27690**
Fax Sweden 46 171 27690
Bodin ChassiTeknik, Skalbygatan 8,
745 37 Enkoping, Sweden

BREDA **Italy (39) 049 9001895**
Fax (390) 49 900 2821
Breda Racing s.r.l, via Buonarotti 10a,
35035 Mestrino,PD, Italy

BRYTEC **Tel 01772 786500**
Fax 01772 786500
Lower College, Hothersall Lane, Longridge,
Preston, Lancashire PR3 2XB

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Fax (1) 262 375 1602
Carbir Race Cars Inc, 1220 Falls Road,
Grafton, WI 53024, USA

CHEEK **Norway (47) 90 78 70 32**
Fax (47) 69 19 02 55
Cheek Racing Cars, Flatebyvn 3, 1792 Tistedal, Norway

CHEETAH **USA (1) 408 492 1331**
Fax USA (1) 408 492 1333
Omni Fab, 380 Martin Avenue, Santa Clara, CA 95050

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Nr Dorchester, Dorset DT2 7RF, England
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Lola Cars International, Glebe Road, St Peters Hill,
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US Importer
Tel (1) 317 244 2277 **Fax (1) 317 390 2121**
Lola Cars Inc, Suite B, 2801 Fortune Circle East,
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Fax (39) 0376 391200
Lucchini Engineering, via Valeggio 2,
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Mallock Racing, Rowley Wood Lane, Hartwell,
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Fax 01778 393032
Pilbeam Racing Design, Graham Hill Way,Cherry Halt
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RS Racing & Specialised Services,
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TPG **0039 682 32225**

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Fax 01953 888178
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CGB CONSULTANTS — (0) 1202 673666
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Tel (1) 317 244 2277 / Fax (1) 317 390 2121
Lola Cars Inc, Suite B, 2801 Fortune Circle East, Indianapolis, IN 46241, USA

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Aero Tec Laboratories Inc.
Spear Road Industrial Park, Ramsey, NJ 07446-1221, USA

FUEL CELLS
ATL — **UK 01908 351700 Fax 01908 351750**
Aero Tec Laboratories Ltd (Europe),
1 Patriot Drive, Rooksley, Milton Keynes MK13 8PU
FUEL SAFE SYSTEMS — USA (1) 714 842 2211
GOMM METAL DEVELOPMENTS — 01483 764876
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PRONALS — France (33) 320 99 75 10
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EARS MOTORSPORTS — 01625 433773
KS MOTORSPORT — Germany (49) 2271 44905
OMP — USA (1) 973 361 0508
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TRW SABELT — 020 7736 2881
WILLANS — **01264 810712**

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2.2 Electrical Systems

REDLINE MOTORSPORT — **Tel 01606 737500**
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ALTERNATORS
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Germany (49) 711 8111 USA (1) 312 865 5200
BRISE AUTO ELECTRICS — **01322 277622**
MM COMPETITION — **08707 444666**
McCLAREN ELECTRONICS — 01483 261400

CABLES
CENTURY CABLES Tel 01733 211600 / Fax 01733 211082
Email kwhincup@yahoo.com / web www.centurycables.com
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PERFORMANCE WIRING SOLUTIONS — +44 (0)1954 253620
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SPEEDY CABLES — 020 7226 9228
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CONNECTORS
BERU F1 SYSTEMS — 01379 646200
DEUTSCH — 01424 852721
IS MOTORSPORT — USA (1) 317 244 6643
MAGNETI MARELLI — **Italy (39) 02 972 27570**
MM COMPETITION — **08707 444666**
PERFORMANCE WIRING SOLUTIONS — +44 (0)1954 253620
SAKATA MOTORSPORT ELEC. INC. — (714) 446 9473
SERVO & ELECTRONIC SALES LTD — 01797 322500
SPECIALITY FASTENERS — 01803 868677
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IS MOTORSPORT — USA (1) 317 244 6643
MM COMPETITION — **08707 444666**
PALLAS CONNECTIONS — 01869 277053
PAD RACING — NZ (64) 3 3386 288

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SBD MOTORSPORT — 0208 391 0121
EFI TECH — USA (1) 310 793 2505
HELLA UK — 01295 272233
LUMENITION — 020 7403 4334
MAGNETI MARELLI — Italy (39) 02 972 27570
MM COMPETITION — **08707 444666**
MOTEC — Australia (61) 3 9761 5050
MOTEC (EUROPE) — UK 08700 119100
MOTEC JAPAN — Japan (81) 489 46 1734
MOTEC SYSTEMS USA — USA (1) 714 897 6804
MSD IGNITION — USA (1) 915 857 5200
PI RESEARCH — 01954 253600
PIAA (UK) — 01934 814812
STACK — 01869 240404
McCLAREN ELECTRONICS — 01483 261400

THE STRAIN GAUGING CO — 01256 320666

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NGK — Japan (81) 52 872 5937 UK 0208 202 2151

SPARKPLUG LEADS
MAGNETI MARELLI — **Italy (39) 02 972 27570**
MM COMPETITION UK — **08707 444666**

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COMPETITION DATA SYS — USA (1) 716 631 2880
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PRODRIVE — 01295 273355
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RINGSPANN (UK) — 01234 342511
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STONE FOUNDRIES — 020 8853 4648

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LEE PRODUCTS — 01753 886664
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CRANFIELD IMPACT CENTRE — 01234 750944
LMI STACK — USA 001 714 637 1155
LUMENITION — 020 7403 4334
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MOTEC JAPAN — Japan (81) 489 46 1734
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PI RESEARCH — 01954 253600
QINETIQ — 08700 100942
SPA DESIGN — 01827 288328
STACK — 01869 240404
McCLAREN ELECTRONICS — 01483 261400
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CHEVRON RACING — 01565 777395
LOLA — **Tel 01480 451301**
Fax 01480 456722
TILTON — **USA (1) 805 688 2353**
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RALLY DESIGN — 01795 531871
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DON FOSTER RACING — **France (33) 4 70 58 0308**
DYNAMIC SUSPENSIONS — 01842 755744
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2.5 Suspension Components

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HARROP — Australia (61) 3 9499 7433
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FASTENER FACTORY — **01327 311018**
GETECNO — Italy (39) 010 835 6016
QINETIQ — **08700 100942**

GOLDLINE BEARINGS — **Tel 01952 292401**
Fax 01952 292403
Stafford Park 17, Telford, TF3 3DG
GROUND CONTROL — USA (1) 916 638 7888
RESB — 0121 520 8271
ROSE BEARINGS — 01522 500933

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COMPTECH USA — USA (1) 916 933 1080
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EIBACH — Germany (49) 2721 511220
GROUND CONTROL — USA (1) 916 638 7888
HYPERCOILS — **USA (1) 574 753 6622**
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DTM CONSULTANTS UK — 01865 407726
DYNAMIC SUSPENSIONS — 01842 755744
PROFLEX UK — 01200 442345
GROUND CONTROL — USA (1) 916 638 7888
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UK 0455 285850
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FASTENER FACTORY 01327 311018
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ATE 0208 654 8836
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USA (1) 239 772 4261
DELPHI BRAKE SYSTEMS 01926 472472
EBC BRAKES 01604 583344
ENDLESS BRAKES Japan (81) 267 68 0071

brembo

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Web: www.grandprixwear.com
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Wolverton Mill, Milton Keynes MK12 6LB

GOODRIDGE UK 01392 369090
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E-mail info@redlinemotorsport.co.uk

WILWOOD ENG USA (1) 805 388 1188

2.7 Brake Components

CALIPERS

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BREMBO Italy (39) 035 605111
UK 02476 679168
BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
GKN SQUEEZEFORM 01952 244321
PERFORMANCE FRICTION USA (1) 803 222 2141
01280 843390
EUROPE +44 (0) 1280 843 390
PROFESSIONAL M/SPORTS 01626 332289
QINETIQ 08700 100942
RACE BRAKES New Zealand (64) 9377 2000
TAR.OX Italy (39) 039 587814
WILWOOD USA (1) 805 388 1188

DISCS

ALCON COMPS 01827 312500
AP RACING 02476 639595
ATE 020 8654 8836
BREMBO Italy (39) 2 240 9631
UK 01280 700664
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ALCON COMS 01827 312500
AP RACING 02476 639595
BENDIX France (33) 14 972 2305
UK 01942 723828
CASTROL 01793 512712
CASTROL Malaysia (603) 245 2642
CASTROL USA (1) 305 270 9433
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TILTON USA (1) 805 688 2353
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MINTEX 01274 854000
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01280 843390
RAYBESTOS USA (1) 815 363 9000
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TILTON USA (1) 805 688 2353
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HILLGARD Sweden (46) 300 60590
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USA (1) 216 796 2121
Canada (1) 416 684 7418
MICHELIN 01782 403284
France (33) 73 90 77 341
TOYO 01933 411144
YOKOHAMA 01582 633339
Japan (81) 33 432 7111

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BP 01442 232323
BURMAH 01793 511521
PETROCHEM CARLESS 01372 380532
CASTROL 01793 512712
CASTROL Malaysia (603) 245 2642
CASTROL USA (1) 305 270 9433
CASTROL USA (1) 973 305 3912
CENTURY 01782 202521
DUCKHAMS OILS 0208 290 0600
ELF France (33) 1 4744 4546
UK 0208 902 8820
ESSO UK 01372 222000
MILLERS OILS 01484 713201
QINETIQ 08700 100942
RED LINE OILS 01476 861195
REPSOL Spain (34) 91 456 53 00
UK 0207 581 1933
SLICK 50 UK 0116 2881522
USA (1) 713 932 9954
STP USA (1) 305 771 1010
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TECH-LINE USA (1) 919 480 0905
TEXACO UK 0207 719 3000
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Database 3
ENGINE & TRANSMISSION COMPONENTS

3.1 Engine Components

BEARINGS

BRITISH TIMKEN 01604 730047
CONNAUGHT 01795 843802
FASTENER FACTORY 01327 311018
RESB 0121 520 8271
QINETIQ 08700 100942
QUAIFE ENGINEERING 01732 353747
VANDERVELL 01788 538500

BLOCKS

INTEGRAL POWERTRAIN 01908 278600
PERFORMANCE CONNAUGHT 01795 843802
MILLINGTON 01746 789268
STONE FOUNDRIES 020 8853 4648
TREMELLING PATTERN 01494 533897

CAMSHAFTS

AUTOSPRINT 01675 464857
CAT-CAMS Belgium (32) 3 320 2560
COMPETITION CAMS USA (1) 901 795 2400
CONNAUGHT 01795 843802
CROWER USA (1) 619 422 1191
DAVID NEWMAN 01689 857109
SBD MOTORSPORT 0208 391 0121
DUNNELL ENGINES 01449 677726
FGR 01885 400639
HARROP Australia (61) 3 9499 7433
KATECH USA (1) 313 791 4120
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KENT CAMS BY JT FRANCE (33) 3207 46480
LUNATI USA (1) 901 365 0950
PAD RACING New Zealand (64) 3 3386 288

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SWINDON RACING ENGINES 01793 531321
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Email: enquiries@arrowprecision.co.uk
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SWINDON RACING ENGINES 01793 531321

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COMPTECH USA USA 001 916 933 1080
FARNDON ENG 02476 366910
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GOETZE Germany (49) 221 21 74690
GORE-TEX USA (1) 410 392 3200

HEADS

INTEGRAL POWERTRAIN 01908 278600
DUNNELL ENGINES 01449 677726
KENT AEROSPACE 01795 415000

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ASNU 0208 420 4494
HOLLEY PERFORMANCE USA (1) 502 781 9741
KINSLER USA (1) 810 362 1145
KS MOTORSPORT Germany (49) 2271 44905
MARREN USA (1) 203 732 4565

INTAKE MANIFOLDS

SBD MOTORSPORT 0208 391 0121
DUNNELL ENGINES 01449 677726
EDELBROCK USA (1) 310 781 2222
GRAINGER & WORRALL 01902 324460

- JENVEY DYNAMICS 01746 768810
- KINSLER USA (1) 810 362 1145
- LINGENFELTER USA (1) 219 724 2552
- SCHRICK Germany (49) 21 91 9500
- SWINDON RACING ENGINES 01793 531321

LINERS
- AE PISTONS 01274 729595
- APPERLEY HONING 01242 525868
- DATRON SLEEVES USA (1) 760 603 9895
- GKN SQUEEZEFORM 01952 244321
- LAYSTALL ENG 01902 451789
- MAHLE Germany (49) 217 4690

OIL SEALS
- **RACETEK NAK 02380 246986**

PISTONS
- ACCRALITE PISTONS Tel 0121 525 6450, Fax 0121 553 5951, **Accralite Piston Division, Spon Lane South, Smethwick, West Midlands B66 1QJ**
- AE PISTON PRODUCTS 01274 729595
- ARIAS 01403 784022
- ARIAS FORGED PISTONS USA (1) 310 532 9737
- BATTEN PERFORMANCE USA (1) 313 946 9850
- COSWORTH 01604 752444, USA (1) 310 534 1390
- JE PISTONS USA (1) 714 898 9763
- MALVERN RACING USA (1) 804 971 9668
- MANLEY PERFORMANCE USA (1) 732 905 3366
- OMEGA PISTONS 0121 559 6778

PERFECT BORE +44 (0) 1264 774330

ROSS PISTON STOCKISTS
Tel 01384 216102 Fax 01384 216109
Website: www.coordsport.com
Email: sales@coordsport.com
Kings Street, Dudley West Midlands DY2 8PX

- SWINDON RACING ENGINES 01793 531321
- TOTAL SEAL USA (1) 602 678 4977
- WISECO PISTON USA (1) 216 951 6600, Canada 800 265 1029

PISTON RINGS
- AE PISTON PRODUCTS 01274 729595
- ARIAS FORGED PISTONS USA (1) 310 532 97371900
- CORDS PISTON RING 0208 998 9923
- FORD AUTO ENG USA (1) 805 2983785
- GOETZE Germany (49) 221 217 4690
- HI-TECH USA (1) 801 972 8766
- TOTAL SEAL USA (1) 602 678 4977
- TWR ENGINES 01993 871000

RUBBER & ELASTOMERIC COMPONENTS
BUTSER RUBBER LTD Tel: 01730 894034 / Fax: 01730 894344
Website: www.butserrubber.com
Email: butserrubber@btinternet.com
Mint Road, Liss, Hampshire GU33 7BQ

VALVES
DEL WEST ENG USA Tel: (1) 661 295 5700, Fax: (1) 661 295 8300
28128 West Livingston, Valencia CA 91355, USA

- FERREA USA (1) 954 733 2505
- GGS VALVES LTD 01483 415444
- QINETIQ 08700 100942
- MANLEY PERFORMANCE USA (1) 732 905 3366
- RACING ENGINE VALVES USA (1) 954 772 6060
- SCHRICK Germany (49) 21 91 9500
- SUPERTECH PERFORMANCE USA (1) 408 448 2001
- SWINDON RACING ENGINES 01793 531321
- VALVE TECHNICS 01604 706541
- XCELDYNE TECHNOLOGIES USA (1) 336 472 8281

VALVE SEATS
- **ARROW PRECISION ENGINEERING LTD Tel +44 (0) 1455 234200, Fax +44 (0) 1455 233545**
- **CHE PRECISION INC Tel (1) 805 499 8885, Fax (1) 805 499 7810, 2640 Lavery CT, Unit C, Newbury Park, CA91320, USA**
- SERDI 01895 232215
- SWINDON RACING ENGINES 01793 531321

VALVESPRINGS
- CONNAUGHT 01795 843802
- DIAMOND USA (1) 313 792 6620
- EDELBROCK USA (1) 213 781 2222
- HERBERT TERRY & SONS 01527 64261
- **KENT CAMS 01303 248666**
- KURT KAUFFMANN Germany (49) 711 518300
- MANLEY PERFORMANCE USA (1) 732 905 3366
- **PERFORMANCE SPRINGS 01253 716900**
- SCHMITTHELM Germany (49) 62 217060

VALVE SPRING RETAINERS
- GGS VALVES LTD 01483 415444

VALVE GUIDES
- **ARROW PRECISION ENGINEERING LTD Tel +44 (0) 01455 234200, Fax +44 (0) 01455 233545**
- KAITEN PRODUCTS USA (1) 714 220 2227
- SERDI 01895 232215

3.2 Engine Ancillaries

AIR FILTERS
INDUCTION TECH GROUP Tel 02476 305386
Fax 02476 307999
Unit B, Quinn Close, Seven Stars Industrial Estate, Whitley, Coventry CV3 4LH

- K&N ENGINEERING USA 800 858 3333
- K&N FILTERS (EUROPE) UK 01925 636950
- KINSLER USA (1) 248 362 1145
- **PIPERCROSS 01604 671100**

CARBURETTORS
- BG FUEL SYSTEMS USA (1) 706 864 8544
- CARBURETOR SHOP USA (1) 909 481 5816
- SOLEX France (33) 14 729 7171
- WEBER Italy (39) 51 417995
- WEBCON 01932 787100

EXHAUST SYSTEMS
- ACTIVE ENGINEERING USA (1) 714 637 1155
- BURNS STAINLESS USA (1) 949 631 5120

GDS EXHAUSTS Tel: 01280 702510 / Fax: 01280 705225
Email: sales@gds-exhausts.co.uk
Website: www.gds-exhausts.co.uk
Unit 8C Boundary Road, Brackley NN13 7ES

GOOD FABRICATIONS LTD
Tel: +44 (0)1844 202850 / Fax:(0)1844 202833
Email: info@goodfabs.com www.goodfabs.com
Unit 3a, Drakes Farm, Drakes Drive, Long Crendon, Aylesbury, Bucks HP18 9BA England

- FLOWMASTER USA (1) 616 463 4113
- JETEX EXHAUSTS 01789 298989
- MARK ORTIZ USA (1) 715 835 3292
- PIPER CAMS 01233 500200
- SPECIALISED EXHAUST 0208 648 4786

FUEL FILTERS
- **AN MOTORSPORT DESIGN 01628 776320**
- CONNAUGHT 01795 843802
- **EARL'S PERFORMANCE UK 01327 858221, Fax 01327 858473**, Unit 17 Silverstone Circuit, Towcester, Northamptonshire NN12 8TL, England
- ED PINK RACING ENGINES USA 818 785 6740
- **EXACT ENGINEERING 01803 866464**
- **FHS MOTOR RACING 01753 513080**
- **FLUID CONTROL PRODUCTS INC USA (1) 217 324 3737**
- FRAM EUROPE 01443 223000
- KINSLER USA (1) 248 362 1145
- LEE PRODUCTS 01753 886664
- SPV RACING Australia (61) 2 791 9899
- THINK AUTOMOTIVE 0208 568 1172
- TJ FILTERS 01752 667675
- WEBCON 01932 287100

FUEL INJECTION
- AC ROCHESTER USA (1) 716 359 6361
- ASNU Tel 0208 420 4494
- BGC MOTORSPORT 0208 880 4205
- BOSCH 01895 834466, Germany (49) 711 8111, USA (1) 312 865 5200
- CONNAUGHT 01795 843802
- SBD MOTORSPORT 0208 391 0121
- **FLUID CONTROL PRODUCTS Tel (1) 314 291 7223**
- GENESIS ELECTRONIC SYSTEMS 01635 582255
- **INDUCTION TECHNOLOGY 02476 305386**
- JENVEY DYNAMICS 01746 768810
- JOHN WILCOX COMPETITION 01455 230576

KINSLER FUEL INJECTION Tel: USA (1) 248 362 1145
Fax: USA (1) 248 362 1032
Email: kinsler@kinsler.com Website: www.kinsler.com

- **LINGENFELTER USA (1) 219 724 2552**
- MAGNETI MARELLI Italy (39) 2 618 351
- MM COMPETITION SYSTEMS 08707 444666
- MARREN USA (1) 203 732 4565
- MILLINGTON 01746 789268
- MOTEC Australia (61) 3 9761 5050
- MOTEC (EUROPE) UK 08700 119100
- MOTEC JAPAN Japan (81) 489 46 1734
- MOTEC SYSTEMS USA USA (1) 714 897 6804
- NIPPON DENSO Japan (81) 56 625 5511, UK 0208 591 7700
- PECTEL CONTROL SYSTEMS +44 (0)1954 253610
- SAKATA MOTORSPORT ELEC. INC. (714) 446 9471
- **TWM INDUCTION USA (1) 805 967 9478**

FUEL LINES
- AEROQUIP USA (1) 419 238 1190
- **AN MOTORSPORT DESIGN 01628 776320**

ATL USA (1) 201 825 1400
Fax (1) 201 825 1962
Aero Tec Laboratories Inc, Spear Road Industrial Park, Ramsey, NJ 07446-1221, USA
ATL UK 01908 351700 / Fax 01908 351750
Aero Tec Laboratories Ltd (Europe), 1 Patriot Drive, Rooksley, Milton Keynes, MK13 8PU

- BROWN AND MILLER UK 01753 553610, USA 704 793 4319
- CONNAUGHT 01795 843802
- **EXACT ENGINEERING 01803 866464**
- **FAE MACHINE USA 317 243 3092**
- **FLEXOLITE 01684 891898**
- FUEL SAFE UK 01799 541955, USA (1) 714 842 2211
- **GOODRIDGE CA USA (1) 310 533 1924**
- **GOODRIDGE INDY USA (1) 317 244 1000**
- **GOODRIDGE EAST USA (1) 704 662 9095**

GOODRIDGE UK Tel 01392 369090 / Fax 01392 441780
Exeter Airport Business Park, Exeter, EX5 2UP

- HENRY'S ENG USA (1) 410 535 3142
- **JLS MOTORSPORT Tel 0121 525 7733**

KRONTEC MASCHINENBAU GmbH
Fitting & Hose Systems
Pommernstraße 33 93073 Neutraubling
Tel: 09401 5253-0
Fax: 09401 5253-10

- KS MOTORSPORTS Germany (49) 2271 44905
- PRONAL'S France (33) 320 99 75 10
- SPECIALITY FASTENERS 01803 866371
- SPV RACING Australia (61) 2 791 9899
- THINK AUTOMOTIVE 0208 568 1172
- **FLEXOLITE 01684 891898**
- GOODRIDGE 01392 369090
- PRONALS France 33 3 20997510
- RACETECH 01327 359912
- WELDON RACING PUMPS USA (1) 216 232 2282

XRP INC Tel USA (1) 562 861 4765
FAX USA (1) 562 861 5503
5630 Imperial Highway, South Gate, CA 90280, USA

FUEL VALVES
- **AN MOTORSPORT DESIGN 01628 776320**
- **ATL USA (1) 201 825 1400, UK 01908 351700**
- **EXACT ENG 01803 866464**
- KINSLER USA (1) 248 362 1145
- **PRONALS France 33 3 20 997510**
- SPECIALITY FASTNERS 01803 866371

HOSES & HOSE-ENDS
- AEROQUIP USA (1) 419 238 1190
- **AN MOTORSPORT DESIGN 01628 776320**

BROWN AND MILLER UK Tel: 01753 553610
Fax: 01753 577477
Unit 7-7A, Langley House, Middle Green Trading Estate, Langley, SL3 6DF USA Tel: 704 793 4319
Fax: 704 793 4321
4005 Dearborn Place NW, Concord, NC 28027

- **DELPHI BRAKES SYSTEMS 01926 472472**
- **EARL'S USA (1) 310 609 1602**
- **EXACT ENG 01803 866464**
- **FASTENER FACTORY 01327 311018**
- **FHS MOTOR RACING 01753 570863**
- **FLUID CONTROL PRODUCTS INC USA (1) 217 324 3737, Fax (1) 217 324 3717**
- **GOODRIDGE UK 01392 369090**
- **GOODRIDGE CA USA (1) 310 533 1924**
- **GOODRIDGE INDY USA (1) 317 244 1000**
- **GOODRIDGE EAST USA (1) 704 662 9095**
- HCL FASTENERS 01282 411992
- HENRY'S ENG USA (1) 410 435 3142
- **JLS MOTORSPORT 0121 525 7733**
- KINSLER USA (1) 248 362 1145
- SAMCO SPORT 01443 238464

SFS PERFORMANCE Tel: 01582 488040
Fax: 01582 412277
Website: www.sfsperformance.co.uk
Unit E Kingsway Industrial Estate, Kingsway Luton LU1 1LP

- SPECIALITY FASTNERS 01803 866371
- SPEED FLOW 0208 530 6664
- THINK AUTOMOTIVE 0208 568 1172
- UNICLIP AUTOMOTIVE 01932 355277
- XRP INC USA (1) 562 861 4765

INTERCOOLERS
- AH FABRICATIONS 01432 354704
- ALLARD MOTOR CO. 01425 500 333
- **FLUID CONTROL PRODUCTS INC USA (1) 217 324 3737, Fax (1) 217 324 3717**
- PACE PRODUCTS 01440 760960
- SERCK MARSTON 0208 965 2151
- SFS PERFORMANCE 01582 412 697

OIL COOLERS
- AEROQUIP USA (1) 419 238 1190
- CV PRODUCTS USA (1) 910 883 4096
- DOCKING & CO 01372 857164
- **EARL'S USA (1) 310 609 1602**
- **EXACT ENGINEERING 01803 866464**
- **FAE MACHINE USA 317 243 3092**
- **FLUID CONTROL PRODUCTS INC USA (1) 217 324 3737, Fax (1) 217 324 3717**
- **GOODRIDGE UK 01392 369090**
- **GOODRIDGE CA USA (1) 310 533 1924**
- **GOODRIDGE INDY USA (1) 317 244 1000**
- **GOODRIDGE EAST USA (1) 704 662 9095**
- LAMINOVA Sweden (46) 85 907 4045
- PROCOMP 0121 350 3258
- SECAN France (33) 14 790 6512
- SERCK MARSTON 020 8965 2151
- SETRAB Sweden (46) 40 158060
- SPECIALTY FASTNERS 01803 866371
- SPV RACING Australia (61) 2 791 9899
- THINK AUTOMOTIVE 020 8568 1172
- TREVOR MORRIS ENG 01547 530289

OIL FILTERS
- **AN MOTORSPORT DESIGN 01628 776320**
- **COSWORTH 01604 752444, USA (1) 310 534 1390**
- **EARL'S USA (1) 310 609 1602**
- **ED PINK ENGINES USA 818 785 6740**
- **EXACT ENGINEERING 01803 866464**
- **FLEXIBLE HOSE 01753 570863**
- **FRAM FILTERS 01443 223000**
- KINSLER USA (1) 248 362 1145

OIL PUMPS
- **ED PINK RACING ENGINES USA 818 785 6740**
- **KENT CAMS 01303 248666**
- PACE PRODUCTS 01440 760960
- PACET 01628 526754
- SPV RACING Australia (61) 2 791 9899
- SWINDON RACING ENGINES 01793 531321
- TITAN MOTORSPORT 01480 474402

OILS & LUBRICANTS
OLD HALL PERFORMANCE LTD +44 (0) 24 7671 7100
Fax +44 (0) 24 7671 7400
email sales@redlineoil-europe.com
www.redlineoil-europe.com

OIL SEALS
- RACE-TEC NAK 02380 246986
- PIONEER WESTON (WYKO) 0161 703 2011

OIL SUMPS
- AH FABRICATIONS 01432 354704

A.R.E DRY SUMP SYSTEMS USA: (1) 916 987 7629
www.drysump.com

- **CONNAUGHT 01795 843802**
- JENVEY DYNAMICS 01746 768810
- MILODON USA (1) 818 407 1211
- PACE PRODUCTS 01440 760960
- STONE FOUNDRIES 0208 853 4648
- SWINDON RACING ENGINES 01793 531321
- TITAN MOTORSPORT 01480 474402
- TREVOR MORRIS ENG 01547 530289

OIL TANKS
- BS ENGINEERING 01908 618080
- GARTRAC 01428 682263
- GOMM METAL DEVELOPMENTS 01483 764876
- KS MOTORSPORT Germany (49) 2271 44905
- MIDAS METALCRAFT 01933 355512
- PACE PRODUCTS 01440 760960
- THINK AUTOMOTIVE 020 8568 1172

RUBBER & ELASTOMERIC COMPONENTS
- BUTSER RUBBER LTD Tel: 01730 894034

STARTER MOTORS
- ARK RACING 01785 715234
- **EARL'S USA (1) 310 609 1602**
- **RTRAC Germany (49) 9725 5075**
- **STARTLINE UK LTD 01933 665752**

THROTTLE BODIES
- **JENVEY DYNAMICS 01746 768810**
- KINSLER USA (1) 248 362 1145
- **LINGENFELTER USA (1) 219 724 2552**
- LUMENITION 0207 403 4334
- SWINDON RACING ENGINES 01793 531321
- **TWM INDUCTION USA (1) 805 967 9478**

THROTTLE VALVES
- **JENVEY DYNAMICS 01746 768810**
- KINSLER USA (1) 248 362 1145
- LUMENITION 0207 403 4334
- TREVOR MORRIS ENG 01547 530289
- **TWM INDUCTION USA (1) 805 967 9478**

TURBOCHARGERS
- GARRETT AUTOMOTIVE 01695 22391
- HOLSET ENG 01484 422244
- INTERPRO ENGINEERING 01454 412777
- QINETIQ 08700 100942
- TURBO TECHNICS 01604 764005
- ALLARD MOTOR CO. 01425 500 333

WATER COOLERS
- AH FABRICATIONS 01432 354704
- DOCKING & CO 01327 857164
- DENSO MARSTON 01274 582266
- NIPPON DENSO Japan (81) 56 625 5511, UK 0208 591 7700
- PACE PRODUCTS 01440 760960
- SERCK MARSTON 0208 965 2151

WATER INJECTION
- ERL 01273 581007

WATER PUMPS
- DAVIES, CRAIG Australia (61) 39 499 7433
- ED PINK RACING ENGINES USA 818 785 6740
- EDELBROCK USA (1) 213 781 2222
- TREVOR MORRIS ENG 01547 530289

3.3 Engine Electronics

COMPUTER SUPPLIERS
ACES 01206 395324
ADVANCED AUTOMOTIVE 01753 642019
COMPETITION DATA USA (1) 716 631 2880
FUELTRONICS Australia (61) 88363 2199
PAD RACING New Zealand (64) 3 3386 288
PERFORMANCE TRENDS USA (1) 248 473 9230
RACELOGIC 01280 823803

DATA-ACQUISITION
ACTIVE SENSORS Tel 01202 480620
Fax 0120 2480664
ADVANCED AUTOMOTIVE 01753 642019
B&G RACING USA (1) 602 274 2537
BOSCH 01895 834466
Germany (49) 711 8111
USA (1) 312 865 5200
COMPETITION DATA SYS USA (1) 716 631 2880
COMPUTECH SYSTEMS USA 800 870 8383
COMPUTERACE TIMING 01905 796090
CORSA INSTRUMENTS USA (1) 313 761 1545
2D DEBUS Germany (49) 721 944850
DATASPARES ACQUISITION 0208 463 9222
DATRON TECHNOLOGY 01908 261655
DIGICON ENGINEERING Canada (1) 604 984 9437
FOREFRONT USA (1) 404 448 9550

INTERCOMP **USA Tel (1) 763 476 2531**
Fax (1) 763 476 2613
14465 23rd Avenue N, Minneapolis, MN 55447, USA
ISAAC INSTRUMENTS INC. **Tel: (450) 658 7520**
Fax: (450) 658 3322
Email: isaac@isaac.ca
Website www.isaac.ca
25 Robert, Chamby, Quebec, Canada J3L 1S2
LONGACRE USA (1) 425 485 0620
McCLAREN ELECTRONICS 01483 261400
MM COMPETITION SYSTEMS 08707 444666
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
MOTECH USA (1) 804 973 1399
MOTOR SPORT ELEC Australia (61) 7 3290 1309
MOTORSPORTS INTERFACE 01327 311011
MTS Powertrain Tech **Tel 01932 351516**
Fax 01932 351517
7 Glen Court, Canada Road, Byfleet, Surrey KT14 7JL
NIPPON DENSO Japan (81) 56 625 6951
PECTEL CONTROL SYSTEMS +44 (0)1954 253610
PENNY & GILES 01202 409409
PERFORMANCE TRENDS USA (1) 248 473 9230
PI RESEARCH **01954 253600**
POLY LOGIC 01462 621066
QINETIQ 08700 100942
QUANTUM SUSPENSION 01243 865058
RACE DATA ENGINEERING USA (1) 714 449 1445
SAKATA MOTORSPORT ELEC. INC. (714) 446 9473
STACK **Tel 01869 240404**
Fax 01869 245500
email: sales@stackltd.com
Wedgewood Road, Bicester Oxfordshire, OX26 4UL
STEVE BUNKHALL 01223 303025
VARIOHM 01327 351004

ENGINE MANAGEMENT SYSTEMS
ADVANCED AUTOMOTIVE 01753 642019
ASNU 0208 420 4494
BOSCH 01895 834466
Germany (49) 711 8111
USA (1) 312 865 5200
CONNAUGHT 01795 843802
DATASPARES 0208 463 9229
SBD MOTORSPORT 0208 391 0121
McCLAREN ELECTRONICS 01483 261400
MM COMPETITION 08707 444666

MOTEC PTY LTD **Aus Tel: 613 9761 5050**
Aus Fax: 613 9761 5051
Japan +81 489 461 734
121 Merringdale Drive
Croydon South Victoria Australia
UK: +44 8700 119100
USA +1 714 895 7001
PECTEL CONTROL SYSTEMS +44 (0)1954 253610
PRECISION RACE SERVICES USA (1) 248 844 1060
SAKATA MOTORSPORT ELEC. INC. (714) 446 9473
STACK **01869 240404**
SUPERCHIPS 01280 816781
TERRY SHEPHERD TUNING 01695 574454
WALBRO ENGINE MANAGEMENT **USA (1)989 872 7091**
ZYTEK SYSTEMS 0121 323 2323

ENGINE SENSORS
ACTIVE SENSORS Tel 01202 480620
Fax 01202 480664
Unit 12, Wilverley Rd, Christchurch, Dorset, BH23 3RU England
AVL DEUTSCHLAND (49) 6134 7179-0
Gmbh Germany
DATASPARES 0208 463 9229
ENTRAN 01923 893 999
KISTLER INSTRUMENTS 01420 544477

KULITE SENSORS **Tel 01256 461646**
Kulite House, Stroudley Road, Basingstoke, RG24 8UG, England

MAGCANICA INC USA 858 454 8950
McCLAREN ELECTRONICS 01483 261400
THE STRAIN GAUGING CO **01256 320666**
VARIOHM 01327 351004

REV-LIMITERS
LUCAS ELECTRICAL 0121 536 5050
LUMENITION 020 7403 4344
MM COMPETITION 08707 444666

3.4 Transmission Components

CLUTCHES

ALCON **Tel +44 (0) 1827 723700**
Fax +44 (0) 1827 723701
Email info@alcon.co.uk
www.alcon.co.uk
Apollo, Tamworth, Staffordshire B79 7TN

AP RACING **(0)24 7663 9595**
Fax (0) 24 7663 9559
Wheler Road, Coventry, CV3 4LB
FICHTEL & SACHS 0208 654 8835
GOODRIDGE **01392 369090**
LOLA **Tel 01480 451301**
Fax 01480 456722
QUARTER MASTER **USA (1) 847 540 8999**
Fax (1) 847 540 0526
510 Telser Road, Lake Zurich, IL 60047, USA
SUPER CLUTCH UK 01926 812136
RTRAC Germany (49) 9725 5075

SACHS RACE ENGINEERING GmbH
Tel +49 9721-984300
Fax +49 9721-984299
Email service.sre@sachs.de
Website www.sachs-race-engineering.de
Ernst-Sachs-Strasse 62, 97424 Schweinfurt, Germany
SACHS BOGE UK 01788 822353
TILTON ENGINEERING **USA (1) 805 688 2353**
Fax (1) 805 688 2745
25 Easy Street, Buellton, CA 93427 USA
WILWOOD ENGINEERING **Fax (1) 805 388 4938**
USA (1) 805 388 1188
416 Calle San Pablo, Camarillo, CA 93012, USA

COMPLETE TRANSMISSIONS

RICARDO MIDLANDS TECHNICAL CENTRE
Tel: 01926 447152
Fax: 01926 319352
Email: iain.wight@ricardo.com
Website: www.ricardo.com
Southam Road, Radford Semele,
Leamington Spa CV31 1FQ

CWP'S
DAVID BROWN 01484 422180
DTS USA (1) 313 778 0540
JCM TRANSAXLES USA (1) 303 695 6093
MARK BAILEY RACING 01380 850130
XTRAC LTD **01635 293800**

DIFFERENTIALS
AJEC INDUSTRIES 01242 222739
GEARACE LIMITED 01869 277563
GKN AXLES 0207 930 2424
HEWLAND ENG 01628 827600
JCM TRANSAXLES USA (1) 303 695 6093
MARK BAILEY RACING 01380 850130
QUAIFE ENGINEERING 01732 741144
RICARDO 01273 455611
RICARDO MIDLANDS TECHNICAL CENTRE 01926 319399
TOM'S DIFFERENTIALS USA (1) 310 634 8431
TRAN-X GEARS LTD 02476 659061
XTRAC LTD **01635 293800**
ZEXEL-GLEASON USA (1) 716 464 5000

DRIVESHAFTS

CTG **Tel: +44 (0)1295 220130**
Fax: +44 (0)1295 220138
Email: motorsport@ctgltd.co.uk
www.ctgltd.co.uk
Thorpe Park, Thorpe Way, Banbury, Oxfordshire
OX16 4SU United Kingdom

GKN MOTOR SPORT **Tel 0121 313 1661**
Fax 0121 313 2074
Unit 5, Kingsbury Business Park,
Kingsbury Road, Minworth, Sutton Coldfield,
Birmingham B76 9DL, England

METALORE USA (1) 310 643 0360
PANKL 0043 3862 33999
TEX RACING USA (1) 910 428 9522
TRAN-X GEARS LTD 02476 659061

GEARS

B&M **001 818 882 6422**
www.bmracing.com
Chatsworth CA 91311 USA
COLLEDGE & MORLEY 02476 462328
COMPTECH USA USA (1) 916 933 1080
DAVID BROWN 01484 422180
GEARACE LIMITED 01869 277563
HEWLAND ENG 01628 827600
JCM TRANSAXLES **USA (1) 303 695 6093**
KERSCHBAUMER **Ger (49) 6074 47 663**
MARK BAILEY RACING 01380 850130
PANKL 0043 3862 33999
TEX RACING USA (1) 910 428 9522
RICARDO MIDLANDS TECHNICAL CENTRE 01926 319399
TRAN-X GEARS LTD 02476 659061
XTRAC LTD 01635 293800

UNIVERSAL JOINTS
FLAMING RIVER USA (1) 440 826 4488
GEARACE LIMITED 01869 277563

Database 4
FACTORY EQUIPMENT

4.1 Factory Hardware

AIR LINES & FITTINGS
A.N. MOTORSPORT DESIGN 01628 776320
EARL'S **UK 01327 858221**
EXACT ENGINEERING **01803 866464**
Fhs Motor Racing Ltd **01753 513080**
GOODRIDGE UK **01392 369090**
GOODRIDGE CA USA (1) 310 533 1924
GOODRIDGE INDY USA (1) 317 244 1000
GOODRIDGE EAST USA(1) 704 662 9095
INGERSOLL RAND 01204 690690
JLS MOTORSPORT **0121 525 7733**
KRONTEC **Germany (49) 9401 703062**
REGENT 01908 612602
ROTOTEST Sweden 46 8532 55890
THINK AUTOMOTIVE 0208 568 1172

AIR TOOLS
DESOUTTER AUTOMOTIVE 0208 205 4884

DINO PAOLI S.R.L. **Tel: +390 522 300828**
Fax: +390 522 304864
email: info@dinopaoli.com
Website: www.dinopaoli.com
Via Guido Dorso, 542100, Reggio Emilia, Italy
FACOM 01932 566099
INGERSOLL RAND 01204 690690
JLS MOTORSPORT 0121 525 7733

CNC MACHINING CENTRES
ABSOLUTE MACHINE TOOL USA (1) 440 324 5133
BOSTON DIGITAL USA (1) 508 473 4561
BRIDGEPORT MACHINE USA (1) 248 299 1750
DEREK ROBINSON 0116 266 2222
DEWCO USA (1) 765 962 7201
MACHINERY SALES USA (1) 510 490 4000
MAKINO USA (1) 800 552 3288
MEDDINGS MACHINES 01752 893277
MILLS ENGINEERING 01603 745531
MILLSITE ENGINEERING USA (1) 304 273 5353
RGS PERFORMANCE USA (1) 716 434 2509
RMT MECHATRONICS 01565 650411
SERDI **01895 232215**
SOUTHWESTERN IND USA (1) 310 608 4422
SPA AEROFOILS LTD 01827 260026
T&S USA (1) 940 668 1002
TOYODA EUROPE 02476 547200

CRACK DETECTION
ABS PRODUCTS USA (1) 714 671 0728
DCM TECH USA (1) 800 533 5339
KRAUTKRAMER BRANSON USA (1) 717 242 0327

CRYOGENIC TEMPERING
FROZEN SOLID 01449 674914

DUST EXTRACTION EQUIP
DENCER 01789 470198

DYNAMOMETERS: CHASSIS
FROUDE CONSINE 01905 856800
International Dynamometers LTD/Dynapack
USA 001 559 292 3800 New Zealand 64 4587 0484
LAND & SEA USA (1) 603 329 5645
KISTLER Instruments Ltd 01420 544477
ROTOTEST Sweden (46) 8 532 55890
SUPERFLOW USA (1) 800 471 7701
Belgium 3215 216300
UNICO (UK) LTD 01908 260000

DYNAMOMETERS: DAMPER
BEHRENTS SPEED CENTER USA (1) 914 651 7389
CZECH MATE USA (1) 800 819 7223
DYNAMIC SUSPENSIONS **Can (1) 905 470 8778**
UK 01842 755744
ND TECH SHOCK DYNOS USA (1) 520 624 3907
SCHMITT EUROPE UK 02476 697192
SPA DESIGN **01827 260026**
SPA TECHNIQUE **USA (1) 317 271 7941**
TAT Germany (49) 7252 84258

DYNAMOMETERS: ENGINE
AVL Germany (49) 61 34 71 790
DSP TECHNOLOGY 01932 351516
DYNAMIC TEST SYSTEMS 01842 755744
ENGINE & DYNAMOMETER **01708 857108**
FROUDE CONSINE 01905 856800
JKM AUTOMOTIVE USA (1) 508 966 2531
LAND & SEA USA (1) 603 329 5645
LOTUS ENGINEERING 01953 608000
MOTORSPORTS INTERFACE 01788 890412
TAT **Germany (49) 7252 84258**

DYNAMOMETER INSTRUMENTATION
AQUIRED DATA SYSTEMS USA (1) 810 566 0131
DEPAC DYNO SYSTEMS USA (1) 315 339 1265
DYNOLAB USA (1) 206 243 8877
FROUDE CONSINE 01905 856800
LAND & SEA USA (1) 603 329 5645
KISTLER Instruments Ltd 01420 544477
PERFORMANCE TRENDS **USA (1) 248 473 9230**
QUADRANT SCIENTIFIC **USA (1) 303 666 8414**
ROEHRIG ENGINEERING **USA (1) 336 431 1827**
SUPERFLOW USA (1) 800 471 7701
Belgium 3215 216300
TAT Germany (49) 7252 84258

ENGINE BALANCING EQUIP
ABS PRODUCTS USA (1) 714 671 0728
BC GEROLAMY USA (1) 916 638 9008
POWERHOUSE PRODUCTS USA 800 872 7223
SCHMITT EUROPE 02476 697192
SUNNEN PRODUCTS USA (1) 800 772 2878
WINONA VAN Canada (1) 800 833 4870

ENGINE HOISTS
MR GASKET PERFORMANCE USA (1) 216 398 8300
SILVER SEAL USA (1) 800 521 2936

ENGINE STANDS
ABS PRODUCTS USA (1) 714 671 0728
BLUEBIRD USA (1) 800 808 2473
C-LINE USA (1) 800 645 7267
DYNAMIC TEST SYSTEMS USA (1) 800 243 3966
GOODSON **USA (1) 507 452 1830**
JEGS USA (1) 614 294 5451
MOROSO PERFORMANCE USA (1) 203 453 6571
MR GASKET PERFORMANCE USA (1) 216 398 8300
RACER COMPONENTS USA (1) 903 581 5976
SCRIBNER USA (1) 916 638 1515

FLOW BENCHES
ASNU 0208 420 4494
AUDIE TECHNOLOGY USA (1) 610 630 5895
CV PRODUCTS USA (1) 800 448 1223
CLO-FLOW South Africa (27) 11 963128
DEPAC DYNO SYSTEMS USA (1) 315 339 1265
FLOWDATA USA (1) 714 632 7828
HODGE MFG USA (1) 800 262 4634
PERFORMANCE TRENDS USA (1) 248 473 9230
ROEHRIG ENGINEERING USA (1) 336 431 1827
SUPERFLOW USA (1) 800 471 7701
Belgium 3215 216300
TAT Germany (49) 7252 84258

GENERATORS: PORTABLE
HANCO GENERATING USA (1) 800 413 6688
LINCOLN ELECTRIC USA (1) 216 481 8100

HORIZONTAL/VERTICAL MACHINING CENTRES
MAKINO USA (1) 800 552 3288
MILLS 01603 745531
MITSUBISHI-YAMAZEN 0208 549 9161
RGS PERFORMANCE USA (1) 716 434 2509
TOYODA 02476 547200

LATHES
RMT MECHATRONICS 01565 650411
LOCK-N-STITCH USA (1) 800 736 8261
MAGNAFLUX USA (1) 847 657 5300
THE STRAIN GAUGING CO 01256 320666

RAPID PROTOTYPING
CRP TECHNOLOGY Italy (39) 059 821135
3D SYSTEMS UK 01442 282600

TOOL CABINETS
DURA 01295 712800

GWS Systems Oy
Tel: 01403 276445
Fax: 01403 276434
Email: sales@gwssystems.co.uk
Website: gwssystems.co.uk
Units 10-12 Horsham Court, City Business Centre, 6 Brighton Road, Horsham, West Sussex RH13 5BA
LISTA 01908 222333
MAC TOOLS USA (1) 614 755 7000

WELDING EQUIPMENT
AMILLER ELECTRIC MFG USA (1) 800 426 4553

4.2 Factory Software

CAD & CAM SOFTWARE
BRIDGEPORT MACHINE USA (1) 248 299 1750
DASSAULT SYSTEMES USA (1) 818 673 2134
DELCAM 0121 766 5544
EXA USA (1) 781 676 8551
MITUTOYO UK 01264 353123
PARAMETRIC TECHNOLOGY 01252 817000
QinetiQ 08700 100942

PARTS USE LIFING
ADVANCED RACING SYSTEMS USA (1) 513 893 2773
LIFECHECK 01285 720665
KINETIC RACING TECHNOLOGIES USA (1) 248 245 2330
NOSKECOMP Australia 07 32 88 3895

PERF. SIMULATION
D.A.T.A.S 01603 506526
PI RESEARCH 01954 253600
PERFORMANCE TRENDS USA (1) 248 473 9230
RICARDO USA (1) 734 397 6666
SERVOTEST 0208 707 1400
VEHICLE DYNAMICS PERFORMANCE USA (1) 512 450 1035

Database 5
CIRCUIT EQUIPMENT

5.1 Pits Equipment

AIR COMPRESSORS
COMPAIR UK 01494 465000
COMPAIR UK 01473 602222
ROTOTEST Sweden 46 8532 55 890

AIR LINES & FITTINGS
EXACT ENGINEERING 01803 866464
FASTENER FACTORY 01327 311018
FHS Motor Racing Ltd 01753 513080
GOODRIDGE UK 01392 369090
GOODRIDGE CA USA (1) 310 533 1924
GOODRIDGE INDY USA (1) 317 244 1000
GOODRIDGE EAST USA (1) 704 662 9095
JLS MOTORSPORT 0121 525 7733
KRONTEC Germany (49) 9401 703062
Fax (49) 9401 70 24 76
Berliner Straße 31, 93073 Neutraubling, Germany
MOTORSPORTS NZ NZ 0064 2596 5599
THINK AUTOMOTIVE 0208 568 1172

BATTERY CHARGERS
POWER TRANS SOLUTIONS -Tel 01722 332126
Fax 01722 333 522
www.wynall.com
Stephens Road, Church Fields
Salisbury, Wiltshire, FP2 7NX
TRIDENT 01327 857822

CAMBER GAUGES
DEMON TWEEKS 01978 664466
75 Ash Road South, Wrexham Industrial Estate, Wrexham, Clwyd LL13 9UG, Wales

HARRISON AUTO USA (1) 602 254 0024
LONGACRE RACING USA (1) 425 885 3823
OMS RACING 0113 2575956
PACE PRODUCTS 01284 850960

REDLINE MOTORSPORT Tel 01606 737500
Fax 01606 737683
E-mail info@redlinemotorsport.co.uk
TRIDENT 01327 857822

CHASSIS STANDS
DEMON TWEEKS 01978 664466
SMR COMPONENTS USA (1) 708 949 9100

COMPUTER HARDWARE
ADVANCED AUTOMOTIVE 01753 642019
CALEX INSTRUMENTATION 01525 373128
CRANFIELD 01234 751361
DYNOLAB USA (1) 206 243 8877
FASTER SYSTEMS USA (1) 415 332 6064
FUELTRONICS Australia (61) 0883632199
FUJITSU 0208 573 4444
GENESIS 01635 582255
KISTLER Switzerland (41) 52 224 1111
NOVA USA (1) 615 832 6355
OLIVETTI 0208 785 6666
PERFORMANCE TRENDS USA (1) 248 473 9230
RACING CAR COMPUTERS 01279 812496
STACK 01869 240404

CORNER SCALES
A.R.T. USA (1) 914 889 4499
DEMON TWEEKS 01978 664466
LONGACRE RACING USA (1) 206 885 3823
NOVATECH 01424 852744
REDLINE MOTORSPORT Tel 01606 737500
ROLLCENTRE 01480 464052

DAMPER DYNAMOMETERS (PORTABLE)
DYNAMIC SUSPENSIONS 01842 755744
ROEHRIG ENGINEERING USA (1) 313 344 8120
SERVOTEST LTD 020 8707 1400
SPA DESIGN 01827 288328
SPA TECHNIQUE USA (1) 317 271 7941

EAR DEFENDERS
DEMON TWEEKS 01978 664466
FASTENER FACTORY 01327 311018
RACING RADIOS USA (1) 404 366 3796
REDLINE MOTORSPORT Tel 01606 737500

ELECTRIC STARTERS
POWER TRANS SOLUTIONS 01722 332126

ENGINE HOISTS
DUNLOP AUTOMOTIVE 0121 384 4444
FACOM UK 01932 566099

ENGINE STANDS
GUYON RACING Canada (1) 403 277 6020
TITAN MOTORSPORT 01480 474402

FIRE EXTINGUISHERS
CHUBB 01932 785588

FEV Tel 01243 555566 Fax 01234 555660
Email sales@f-e-v.co.uk
www.f-e-v.co.uk
Unit 10 Ford Lane Business Park, Ford, West Sussex BN18 0UZ
FIREMASTER 0208 852 8585
LIFELINE FIRE SYSTEMS 02476 712999
Mardi Gras Motorsports 01327 858 006
OMP 0208 656 7031
Italy (39) 10 680 851
QINETIQ 08700 100942
SILVERSTONE RACE SERVICES 01327 858441
SPA DESIGN 01827 288328
SPA TECHNIQUE USA (1)317 271 7941
TRIDENT 01327 857822

FLOOR CRANES
ANRICK TRADING NZ (04) 5899371
FASTNER FACTORY 01327 311018
SLINGSBY 01274 721591

FUME EXTRACTORS
DENCER 01789 470198
INGERSOLL RAND 01204 690690

HAND PUMPS
EXACT ENGINEERING 01803 866464
FACOM 01932 566099
SILVERSTONE RACE SERVICES 01327 858441
SNAP-ON USA (1) 414 656 5372
0161 969 0126
WURTH UK 0208 310 6666

HAND TRUCKS
OMS RACING 0113 575956
SILVERSTONE RACE SERVICES 01327 858441

HEAD TORCHES
ESSEX RACING USA (1) 404 889 4096
HELLA 01295 272233

JACKS
ARGO MANUFACTURING USA (1) 630 377 1750
DEMON TWEEKS 01978 664466
DUNLOP AUTOMOTIVE 02476 667738
FACOM UK 01932 566099
FASTENER FACTORY 01327 311018
JLS MOTORSPORT 0121 525 7733
KS MOTORSPORT Germany (49) 2271 44905
PADDY HOPKIRK LTD 01525 850800
PERFORMANCE MACHINE USA (1) 303 828 4546
REDLINE MOTORSPORT Tel 01606 737500
SLINGSBY 01274 721591
DEMON TWEEKS 01978 664466
KS MOTORSPORT Germany (49) 2271 44905
MARDI GRAS MOTORSPORTS 01327 858 006
MECHANIX WEAR USA (1) 661 257 0474
RALLY DESIGN 01795 531871
SILVERSTONE RACE SERVICES 01327 858441

NOISE METERS
CIRRUS RESEARCH 01723 891655

PIT BARRIERS
KAISER & KRAFT 01923 233312
SLINGSBY 01274 721591

PIT BOARDS
ACTIVE ENGINEERING USA 001 714 637 1155
DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 0208 987 5500
KS MOTORSPORT Germany (49) 2271 44905
REDLINE MOTORSPORT Tel 01606 737500
TRIDENT 01327 857822

PIT CANOPIES
PIT BITS 01727 858297

PIT LANE MARKERS
KAISER & KRAFT 01923 233312
SLINGSBY 01274 721591

PIT TROLLEYS
CHAMPION 01953 888664
DEMON TWEEKS 01978 664466
GTC COMPETITION 01483 272151
LISTA 01908 222333
REDLINE MOTORSPORT Tel 01606 737500
OMS RACING 0113 2575956

PYROMETERS
AP RACING Tel 02476 639595
Fax 02476 639559
Wheler Road, Coventry, CV3 4LB

RADIO SCANNERS
QINETIQ 08700 100942
RACING RADIOS USA (1) 404 366 3796

RADIO SYSTEMS/INTERCOMS
AUTOCOM 01926 431249
AUTOTEL RACE RADIO 01508 528837
MRTC 0150 981 2610
QINETIQ 08700 100942
STRODE SOUND 01761 419248

RAIN SUITS
DEMON TWEEKS 01978 664466
GRAND PRIX PROMOTIONS 01474 879524
JAYBRAND 01733 68247
REDLINE MOTORSPORT Tel 01606 737500

REFUELLING LINES & VALVES
DUNLOP 01235 863863
EXACT ENGINEERING 01803 866464
GTC COMPETITION 01483 272151
KRONTEC Germany (49) 9401 703062
PREMIER FUEL SYSTEMS 01332 850515
THE STRAIN GAUGING CO 01256 320666

REFUELLING RIGS
DEMON TWEEKS 01978 664466
GTC COMPETITION 01483 272 151
PREMIER FUEL SYSTEMS 01332 850515
REDLINE MOTORSPORT Tel 01606 737500
SPA DESIGN 01827 288328
THE STRAIN GAUGING CO 01256 320666

SCISSOR PLATFORMS
SLINGSBY 01274 721591

SETUP FLOORS
ACTIVE ENGINEERING USA 001 714 637 1155
4-PATCH 01376 348246
KS MOTORSPORT Germany (49) 2271 44905
ME MOTORSPORT 01884 253070
RML 01933 402440
THE STRAIN GAUGING CO 01256 320666
SPA AEROFOILS LTD 01827 260026
UNIVERSITY OF HERTFORDSHIRE 01707 284270

SETUP GAUGES
A.R.T. USA (1) 914 889 4499
CYBER DYNAMICS 01869 347812
DEMON TWEEKS 01978 664466
LONGACRE RACING USA (1) 206 885 3823
ME MOTORSPORT 01884 253070

REDLINE MOTORSPORT Tel 01606 737500
THE STRAIN GAUGING CO 01256 320666

SPACE HEATERS
FASTENER FACTORY 01327 311018

STOPWATCHES
CASIO 0208 450 9131
DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 020 8987 5500
KS MOTORSPORT Germany (49) 2271 44905
RACING RADIOS USA (1) 404 366 3796
REDLINE MOTORSPORT Tel 01606 737500
TRIDENT 01327 857822

STORAGE SYSTEMS
KAISER & KRAFT 01923 233312
LISTA (UK) LTD 01908 222333
POLSTORE STORAGE 01403 750000
PRONALS France (33) 3201 997510

TAPE
DEMON TWEEKS 01978 664466
CLARENDON 01455 841200
DRC RACE CAR USA (1) 609 397 4455
FASTENER FACTORY 01327 311018
KS MOTORSPORT Germany (49) 2271 44905
RALLY DESIGN 01795 531871
REDLINE MOTORSPORT Tel 01606 737500
TRIDENT 01327 857822

TIMING SYSTEMS
CASIO 0208 450 9131
CONTINENTAL SPORT USA (1) 513 459 8888
ME MOTORSPORT 01884 253070
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
MST SPORTS TIMING 01684 573479
PI RESEARCH 01954 253600
PIT BITS 01727 858297
STACK 01869 240404
UNISYS 0208 453 5562
VULCAN ENTERPRISES USA (1) 602 759 7926

TOOL CABINETS
FACOM UK 01932 566099
KAISER & KRAFT 01923 233312
POLSTORE STORAGE 01403 750000
SLINGSBY 01274 721591

TORQUE WRENCHES
FACOM UK 01932 566099
NORBAR TORQUE TOOLS 01295 270333
RALLY DESIGN 01795 531871

TRACKING GAUGES
A.R.T. USA (1) 914 889 4499
DEMON TWEEKS 01978 664466
GMD COMPUTRACK Austra (61) 2 9644 1946
REDLINE MOTORSPORT Tel 01606 737500
THE STRAIN GAUGING CO 01256 320666

TYRE PRESSURE GAUGES
BERU F1 SYSTEMS 01379 646200
GRAND PRIX RACEWEAR 0208 987 5500
THE STRAIN GAUGING CO 01256 320666
TRIDENT 01327 857822

TYRE TEMPERATURE GAUGES
THE STRAIN GAUGING CO 01256 320666
TRIDENT 01327 857822

TYRE TROLLEYS
OMS RACING 01132 575956

TYRE WARMERS
BANDIT Australia (61) 3 9318 0644
DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 020 8987 5500
JAYBRAND 0733 68247
REDLINE MOTORSPORT Tel 01606 737500
SEEKERS 0151 524 0919

5.2 Paddock Equipment

AWNINGS
ALFRED BULL 01483 575492
ALRESFORD TECTONICS 01962 736316
AWNING COMPANY 01204 363463
BARKERS 020 8653 1988
DEANS AWNINGS 01942 241399
MAYFLOWER 01494 712131
PIT BITS 01727 858297
TOP MARQUEES 01623 740777

MOTORHOME HIRE
ATLANTIC COAST 01297 552222
DAVID WILSON'S TRAILERS 01825 740696
DUDLEYS 01993 703774
MIDLAND INTERNATIONAL 02476 336411
SPIRES OF OXFORD 01865 875539
WESTCROFT AMERICAN 01902 731324

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Database 6
COMPETITION CAR CHASSIS COMPONENTS

6.1 Driver's Equipment

ANTI MIST FLUIDS
DEMON TWEEKS Tel 01978 664466 / Fax 01978 664467
Hugmore Lane, Llan-y-Pwll, Wrexham, Clwyd LL13 9YE, Wales
GRAND PRIX RACEWEAR Tel 0208 987 5500
Fax 0208 742 8999
Power Road, Chiswick, London, W4 5PY, England

REDLINE MOTORSPORT Tel 01606 737500
Fax 01606 737683
E-mail info@redlinemotorsport.co.uk

BOOTS & GLOVES
DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 0208 987 5500
MECHANIXWEAR USA (1) 805 257 0474
REDLINE MOTORSPORT Tel 01606 737500

COOL CAPS & SUITS
DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 020 8987 5500
REDLINE MOTORSPORT Tel 01606 737500

DRIVING SUITS & ACCESSORIES
DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 020 8987 5500
REDLINE MOTORSPORT Tel 01606 737500

HELMETS & ACCESSORIES
QINETIQ Tel 44 (0) 8700 100942
www.QinetiQ.com
Cody Technology Park,
Ively Road , Farnborough, Hampshire, GU14 OLX

Database 7
CHASSIS ENGINEERING SERVICES

7.1 Chassis Services

BODYWORK SPECIALISTS
ABBEY PANELS 02476 644999
ADVANCED COMPOSITES 01773 763441
ANDY ROUSE ENGINEERING 02476 635182
AERO APPLICATIONS USA (1) 562 597 0001
AERODINE COMPOSITES USA (1) 317 271 1207
AERODYNAMIC CONSULTANTS (661) 729 5628
APPLIED FIBREGLASS 01842 765339
ASQUITH BROTHERS 01924 402001
C&B CONSULTANTS AERODYNAMICS (0) 1202 673666
CML GROUP 0151 647 5531
COMPOSITE DESIGN USA (1) 727 539 0605
CRANFIELD UNIVERSITY 01234 754152
CROPREDY BRIDGE GARAGE 01295 758444
DEREK PALMER ENGINEERING 01555 893315
DON FOSTER France (33) 470 580308
EARS MOTORSPORT 01625 433773
FIBRESPORTS 01268 527331
GRAHAM HATHAWAY RACING 01621 856956
GTC COMPETITION 01483 272151
GTI ENGINEERING 01280 700800
HAMLYN MOTOR SERVICES 01582 841284
HEDDINGTON COACHWORKS 01380 850198
INTAPORSCH 01273 834241
LOTUS ENGINEERING 01953 608000
LYNX MOTORS 01424 851277
MERLIN BODYCRAFT 01280 705156
MITCHELL NZ (64) 78236188
PODIUM DESIGN 07000 763486
SPA COMPOSITES 01543 432904

COMPOSITES SPECIALISTS
Active engineering USA 001 714 637 1155
ACTIVA TECHNOLOGY 020 8974 1615
ÆOLUS TECHNOLOGY USA (1) 970 472 1288
AERODINE COMPOSITES USA (1) 317 271 1207
APPLIED FIBREGLASS 01842 765339
ASTEC 01332 875451
B&K RESINS 0208 464 7734
C&B CONSULTANT AERODYNAMICS (0) 1202 673666
CARBON FIBRE TECHNOLOGY 01508 488257
CARBONE INDUSTRIE France (33) 14 972 2305
COMPOSITE AUTOMOTIVE TECH 01249 443438
COMPOSITE DESIGN USA (1) 727 539 0605
COMPOSITE WINGS 01953 885478

CRANFIELD UNIVERSITY Tel 01234 754902
Fax 01234 751671
Cranfield, Bedfordshire, MK43 OAL
www.motorsport.cranfield.ac.uk
motorsport@cranfield.ac.uk

CROSBY GRP 01327 857042
CTG +44 (0)1295 220130
CTS 01480 459378
DELTA COMPOSITES 01280 824498
DEREK BENNETT 01565 777395
ELAN COMPOSITES USA (1) 706 658 2853
DU PONT UK 01438 734000
Switzerland (41) 22 717 5111
USA (1) 302 774 1000
FIBREGLASS FABRICATIONS 0208 568 0293
G FORCE COMPOSITES 01243 544192
HEYES ENGINEERING 01453 750491
HITCO USA (1) 213 516 5707
JANUS TECHNOLOGY 01753 869996

KOMPREX Tel 0191 416 8200 Fax 0191 415 5962
Website www.komprex.com
Email sales@komprex.com
58-59 Hutton Close, Crowther Ind Est,
Tyne & Wear NE58 0AH

LOTUS ENGINEERING 01953 608000
MICRO CRAFT USA (1) 909 947 1843
MIRA 0247 6355 000
NERO 01254 202085
PANKL Austria (43) 3862 512500
PODIUM DESIGN 07000 763486
PRONAL'S France (33) 320 99 75 10
QINETIQ 08700 100942
RICHARD HINTON RACING 01279 771667
RMCS (CRANFIELD) 01793 785359
SAMCO sport 01443 238 464
SECART USA (1) 203 798 6698
SCOTT BADER 01933 663100
SPA COMPOSITES 01543 432904
SQUARE ONE MOTORSPORT 01825 723425
STRAND GLASSFIBRE 0208 568 7191
TAG EQUIPMENT 01787 477790
TECHFLEX USA (1) 201 729 6253
TECHNICAL RESIN BONDERS 01480 52381
TONY THOMPSON RACING 01664 812454
TURBO HEAT 01535 664903
UNIVERSITY OF HERTFORDSHIRE 01707 284270
VIN MALKIE RACING 01565 777395
ZEUS M/SPORT ENG LTD 01604 878101

DESIGN AND ANALYSIS
ENABLING TECHNOLOGIES CONSULTING ENGINEERS LTD
Tel +44 (0)1983 550480 Fax +44 (0)1983 550489
Email office@enablingtechnologies.co.uk
Web enablingtechnologies.co.uk
Innovation Centre, St Cross Business Park,
Monks Brook, New Port, Isle of Wight PO30 5WB, England
LOLA Tel 01480 451301
Fax 01480 456722

RICARDO MIDLANDS TECHNICAL CENTRE
Tel 01926 477152 Fax 01926 319352
Email: pmarkwick@mtc.ricardo.com
Website: www.ricardo.com
Southam Rd, Radford Semele, Leamington Spa CV31 1FQ

FABRICATION
ABBEY PANELS 02476 644999
A-MAC FABRICATION USA (1) 408 727 9288
ANDY ROUSE ENGINEERING 02476 635182
ANEX SYSTEMS 01869 345038

AUTOMOTIVE FABRICATION Tel/Fax 001 214 745 1148
Email weld666@airmail.net
1027 Levee Street Dallas, Texas 75207

ASTEC 01332 875451
AZTEK 01509 261299
BBW 01483 722 713
BOB SPARSHOTT ENGINEERING 01908 618080
BRADY FABRICATIONS 01869 252750
BRISE ALLOY FABRICATIONS 01322 222343
BSS PARTS 01772 601602
CHEVRON RACING 01565 777395
CHIP GANASSI RACING 01243 544192
CML GROUP 0151 647 5531
COLMET PRECISION 01296 681658
COMPOSITE DESIGN USA (1) 727 539 0605
COMPETITION FABRICATIONS 01953 454573
CRANFIELD UNIVERSITY 01234 754152
CTG RACING 01202 871102
DEREK BENNETT 01565 777395
DJ RACECARS 01663 734518
DOCKING ENGINEERING 01327 857164

EUROTECH MOTORSPORT 0121 3314944
FOXCRAFT ENGINEERING 01264 810110
B Y G.FORCE PRECISION ENG 01243 544192
GOMM METAL DEVELOPMENTS 01483 764876
GRAHAM HATHAWAY RACING 01621 856956
GTC COMPETITION 01483 272151
HAMLYN MOTOR SERVICES 01582 600745
HAUS OF PERFORMANCE USA (1) 714 545 2755
JAGO DEVELOPMENTS 01243 789366
KRONTEC MASCHINENBAU (49) 9401 700352
LOTUS ENGINEERING 01953 608000
LYNX MOTORS 01424 851277
MACDONALD RACE ENG 0208 889 1633
MATRIX ENGINEERING USA (1) 888 249 0013
MASON ENGINEERING USA (1) 805 527 6624
MICRO CRAFT USA (1) 909 947 1843
MIKE TAYLOR DEVELOPMENTS 01609 780123
MIRKO RACING USA (1) 408 776 0073
POLSON 01440 820371
PREMIER AEROSPACE 01332 850515
QinetiQ 08700 100942
RACEPREP 3001 01903 734499
RBS 01788 543094
RETRO TRACK & AIR UK 01453 545360
RICARDO MIDLANDS TECHNICAL CENTRE
Tel: 01926 477152
Fax: 01926 319352
Email: iain.wight@ricardo.com
RILEY & SCOTT USA (1) 317 247 9470
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate,
Wellingborough, Northants NN8 6TY England
SNAPDRAGON MOTORSPORTS USA (1) 413 2560861
SPA AEROFOILS LTD 01827 260026
SOUTH CERNEY ENGINEERING 01285 860295
UNICLIP AUTOMOTIVE 01932 355277
VAN DYNE ENGINEERING USA (1) 714 847 4417
VIN MALKIE RACING 01565 777395

MOULDING
ADVANCED COMPOSITES 01773 763441
AERODINE COMPOSITES USA (1) 317 271 1207
ASTEC 01332 875451
BENTLEY CHEMICAL TRADING 01562 515121
BUTSER RUBBER 01730 894034
CML GROUP 0151 647 5531
COMPOSITE DESIGN USA (1) 727 539 0605
COMPOSITE WINGS 01953 885478
CROSBY GRP 01327 857042
CROMPTON TECH GROUP 01295 220130
CTG +44 (0)1295 220130
G FORCE COMPOSITES 01243 544192
GRIFFITHS ENGINEERING 01582 600629
JANUS TECHNOLOGY 01753 869996
MICRO CRAFT USA (1) 909 947 1843
PROTECH COMPOSITES LTD Tel: +44(0) 1420 471 400
Fax: +44 (0) 1420 487 047
www.protechcomposites.co.uk
Unit 62, Woolmer Trading Estate
Bordon, Hampshire, GU35 9QF, UK
ROSS COURTNEY 01384 291919
STARTLINE UK LTD 01933 665752
SECART ENGINEERING 001 203 798 6698

SPACEFRAME DESIGN
ÆOLUS TECHNOLOGY USA (1) 970 472 1288
ENABLING TECHNOLOGIES LTD 01983 550483
COSINE TECHNOLOGY 01706 378851
CRANFIELD UNIVERSITY 01234 754152
DAVID POTTER CONSULTING 0033(0) 494 339090
DEREK BENNETT ENGINEERING 01565 777395
MAGNUM CARS 01933 442861
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate,
Wellingborough, Northants NN8 6TY England
STARTLINE UK LTD 01933 665752

Database 8
DRIVETRAIN & SUSPENSION ENGINEERING SERVICES

8.1 Engine Services

RACE PREPARATION
ALDON 01384 572553
ANDY ROUSE ENGINEERING 02476 635182
AUTOKRAFT 0121 777 2083
AZTEK 01509 261299
BJ MOTOR ENGINEERS 0161 748 8663
BR MOTORSPORT 01926 451545
DAVE CROSS MOTOR SERVICES 01246 477566
SBD MOTORSPORT 0208 391 0121
CLEM COMPETITION USA (1) 214 503 8044
CONCEPT MOTORSPORT 0208 568 0293
CONTINENTAL M/SPORT USA (1) 513 459 8888
DBR MotorSport Tel 0161 627 4189 Fax 0161 627 4189
Unit 4 Forge Ind Estate, Green Acres Road,
Oldham Lancashire, 014 7LE
DJ RACECARS 01663 734518
DTM POWER 01865 407726
DUNNELL ENGINES 01449 677726
EARS MOTORSPORT 01625 433773

EDS 01708 857108
ELABORAZIONE COLASUNO 0207 738 8331
ENGINE DATA ANALYSIS 01977 516622
ENGINE SHOP 01280 812199
FISCHER ENGINEERING USA (1) 818 767 8840
FORWARD ENGINEERING 01676 523526
GEMINI ENGINEERING 01474 534779
GEOFF RICHARDSON ENGINEERING 01480 861599
GF BECK MOTORSPORT PREPARATION 01646 621184
GOLDFLOW 01491 875554
GOODMAN RACING ENGINES 01327 300422
GRAHAM HATHAWAY RACING 01621 856956
GRIFFIN MOTORSPORT 01793 771802
HARPERS PERFORMANCE 01642 818188
HARTWELL 01202 556566
HAUS OF PERFORMANCE USA (1) 714 545 2755
HT RACING 01474 872888
IRMSCHER 01543 414466
IVAN DUTTON 01923 816277
JANSPEED MOTORSPORT 01722 321833
J MATTIS ENGINETECH Greece 003 019 512 761
JOHN WILCOX COMPETITION ENG 01455 230576
JONDEL 01933 411993
KENT AUTO DEVELOPMENTS 01303 874082
KREMER RACING Germany (49) 221 171025
LE SPORT France (33) 14 582 4400
LIGHTNING PERFORMANCE USA (1) 904 439 5283
LINGENFELTER USA (1) 219 724 2552
MARDI GRAS MOTORSPORTS 01327 858 006
MATHWALL ENGINEERING 01252 703191
MATRIX ENGINEERING USA (1) 888 249 0013
MAXSYM ENGINE TECH 01608 685155
MERLIN DEVELOPMENTS 01283 511184
MILLINGTON 01746 789268
MINERVA MOTORSPORT 01509 233970
MINISTER RACING ENGINES 01634 682577
MIRKO RACING USA (1) 408 776 0073
MIS M/SPORTTECHNIK GERMANY (49)263680394
MOUNTUNE RACE ENGINES 01621 854029
NEIL BROWN ENGINEERING 01775 723052
PHIL JONES ENGINE DEV 01454 310936
PHIL MARKS ENGINE DEV 01564 824869
PRICE MOTORSPORT USA (1) 812 546 4220
PRIMA RACING 0115 9491903
PRODRIVE 01295 273355
QUICKSILVER RACE USA (1) 301698 9009
QUORN ENGINE DEVELOPMENTS 01509 412317
RACE ENGINE DEVELOPMENT USA (1) 760 630 0450
RACESPEC 01925 636959
RACE TECHNIQUES 01242 245640
RACING BENT USA (1) 714 779 8677
RANDLINGER Germany (49) 761 16373
ROAD & STAGE MOTORSPORT 01524 844066
ROADSPEED PERFORMANCE 01453 750864
RPM FRANCE (33) 3 86 66 00 08
SCARBOROUGH Canada (1) 416 759 9309
SEARLE 0208 305 2250
STEVE CARBONE RACING USA (1) 918 835 6596
SWAYMAR 01932 868377
SWINDON RACING ENGINES 01793 531321
TECNO 01268 764047
TERRY SHEPHERD TUNING 01695 574454
THINK AUTOMOTIVE Tel 0208 568 1172
Fax 0208 847 5338
Email matt@thinkauto.co.uk
292 Worton Road, Isleworth, Middlesex, TW7 6EI
THUNDERBIRD RACING INT LTD 01623 622848
VAN DYNE ENGINEERING USA (1) 714 847 4417
WARRIOR 01825 764833
ZYTEK ENGINEERING 01332 48974
ZEUS MOTORSPORT ENGINEERING LIMITED
Tel 01604 878101 Fax 01604 878111
The Racing Stables, Blisworth Hill Farm,
Stoke Road, Blisworth, Northants NN7 3DB

8.2 Engine Services

REBUILDS
ANDREASON RACING 01300 348499
ANEX SYSTEMS 01869 345038
BTR PREPARATIONS 01977 522348
EARS MOTORSPORT 01625 433773
GTC COMPETITION 01483 272151
HAUS OF PERFORMANCE USA (1) 714 545 2755

HEWLAND ENGINEERING Tel 01628 827600
Fax 01628 829706
Waltham Road, Maidenhead, Berks, SL6 3LR
JACK KNIGHT 01483 764326
JP RACE CENTRE 01327 858151
KREMSPEED EQUIPMENT INC. USA (1)814 724 4086
MARK BAILEY RACING 01380 850130
MATRIX ENGINEERING USA (1) 888 249 0013
ME MOTORSPORTS 01884 253070
QUAIFE ENGINEERING Tel 01732 741144
Fax 01732 741555
Email info@quaife.co.uk
www.quaife.co.uk
Vestry Road, Sevenoaks, Kent, TN14 5EL
ROADSPEED PERFORMANCE 01453 750864
TONY THOMPSON RACING 01664 812454d
ZF Germany (49) 7541 77 2543
UK 0115 9869211

8.3 Suspension Services

SETUP SPECIALISTS

ACTIVE ENGINEERING USA (1) 714 637 1155
ANDREASON RACING 01300 348499
ATHON MOTORSPORT 0114 2490 272
AZTEK 01509 261299
BEAUFORT RESTORATION 01795 830288
DAVID POTTER CONSULTING 0033(0)494 339090
BRADY FABRICATIONS 01869 252750
CRANFIELD UNIVERSITY 01234 754152
DON FOSTER France (33) 470 580308
EARS MOTORSPORT 01625 433773
GEOSCAN (G.I.L. Design) 01225 790568
LOLA Tel 01480 451301
Fax 01480 456722
HAUS OF PERFORMANCE USA (1) 714 545 2755
INTERPRO ENGINEERING 01454 412777
LOTUS ENGINEERING 01953 608000
MARDI GRAS MOTORSPORT 01327 858006
MARK ORTIZ USA (1) 704 933 8876
PILBEAM RACING DESIGNS 01778 424838
PODIUM DESIGNS 07000 763 486
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
FSUSPENSION TECHNOLOGY 01327 858558
SHOCKBOX DAMPER SERVICES Tel: 07919 340550
Website: www.shockbox.co.uk
Email: ghbj@compuserve.com
67 Blackthorn Road, Attleborough, Norfolk, NR17 1YJ UK
THE STRAIN GAUGING CO 01256 320666
UNIVERSITY OF HERTFORDSHIRE 01707 284270

ENGINEERING SERVICES

RACING INDUSTRY TECHNICAL SERVICES USA (1) 248 645 1724

8.4 Metal Services

BEAD & SAND BLASTING

BLAST-IT-ALL USA (1) 800 353 2612
CAMCOAT PERFORMANCE COATINGS 01925 445003
COMPAIR AUTOPOWER 01494 465000
HANKOE MOTORSPORT 01753 522779
MACDONALD RACE ENG 0208 889 1633
SWAYMAR CASTING 01932 868377
AEROMET 01795 415000
GM DESIGN 0117 985 9964
GRIFFITHS ENGINEERING 01582 600629
HILLGARD Sweden (46) 300 60590
JENVEY DYNAMICS 01746 768810
KENT AEROSPACE CASTINGS 01795 476333
PANKL Austria (43) 3862 512500
QUAIFE ENGINEERING 01732 741144
QDF COMPONENTS 01332 760260
QUARTERMASTER USA (1) 847 540 8999
QINETIQ Tel 08700 100942
www.QinetiQ.com
Cody Technology Park, Ively Road, Farnborough, Hampshire, GU14 0LX
ZEUS ALUMINIUM 01384 482222

COATINGS

BALZERS LTD Tel 01908 377277 Fax 01908 361362
www.balzers.co.uk
Bradbourne Drive, Tilbrook, Milton Keynes, MK7 8AT, UK
CAMCOAT PERFORMANCE COATINGS 01925 445003
CTG Tel: +44 (0)1295 220130 Fax: +44 (0)1295 220138
E-mail: motorsport@ctgltd.co.uk
www.ctgltd.co.uk
Thorpe Park, Thorpe Way, Banbury, Oxfordshire OX16 4SU United Kingdom
LURO COTE USA (1) 909 885 3223
KENT MOTORSPORT CASTINGS 01795 662288
POETON 01452 300500
POLYMER DYNAMICS USA (1) 713 694 3296
QINETIQ 0 8700 100942
SWAIN TECH USA (1) 716 889 2786
WALLWARK HEAT TREATMENT 0161 797911
ZIRCOTEC PERFORMANCE COATINGS
Tel: 0870 190 8480 Fax: 0870 190 8488
E-mail: enquiries@zircotek.co.uk
www. zircotek.com
528.10 Unit 2 Harwell business Centre, Didcot, Oxfordshire OX11 0QJ United Kingdom

FINISHING

ALUMINIUM SPECIAL 01384 291900
APPERLEY HONING 01242 525868
ARMORALL PRODUCTS 01799 513130
CML GROUP 0151 647 5531
GRIFFITHS ENGINEERING 01582 600629
HEPWORTH INTERNATIONAL 01484 711720
JENVEY DYNAMICS 01746 768810
KENT AEROSPACE CASTINGS 01795 476333
QUAIFE ENGINEERING 01732 741144

QINETIQ 0 8700 100942
RICHARD BARRETT MOULDS USA 353 282 9842
ZEUS ALUMINIUM PRODUCTS 01384 482222

FOUNDRIES

AEROMET 01795 415000
BA HARRISON 0116 2769351
GM DESIGN 0117 985 9964
FINECAST 01903 765821
H GRIFFITHS ENGINEERING 01582 600629
JENVEY DYNAMICS 01746 768810
KENT AEROSPACE CASTINGS 01795 476333
KENT MOTORSPORT CASTINGS 01795 662288
QUALCAST 01332 760260
UK RACING CASTINGS 01227 750877

HEAT TREATMENT

AR CORNELL 01245 268098
AUTOSPRINT 01675 464857
AVONBAR 01932 840058
BEAUFORT RESTORATION 01795 830288
JENVEY DYNAMICS 01746 768810
PANKL Austria (43) 3862 512500
QUANTUM HEAT TREATMENT 01908 642242
TECVAC 01954 233700
ZEUS MOTORSPORT 01604 878101

MACHINING

ABBEY PANELS 02476 644999
ACTIVE ENGINEERING USA (1) 714 637 1155
APPERLEY HONING 01242 525868
ATHENA MANUFACTURING LP USA (1)512 928 2693
AVONBAR 01932 840058
AZTEK 01509 261299
BEAUFORT RESTORATION 01795 830288
CML GROUP 0151 647 5531
COLEMAN MACHINE USA (1) 906 863 8945
DATUM ENGINEERING 02476 383032
FORMULA FABRICATIONS 01953 605490
DONCASTERS LTD 01332 864900
JENVEY DYNAMICS 01746 768810
KRONTEC GMBH Tel Germany (49) 9401 5253-0
Fax Germany (49) 9401 5253-10
Pommernstrabe 33, 93073 Neutraubling, Germany
LANGSTONE ENGINEERING LTD 02392 452430
LINGENFELTER USA (1) 219 724 2552
LOTUS ENGINEERING 01953 608000
MACDONALD RACE ENG 0208 889 1633
MASON ENGINEERING USA (1) 805 527 6624
METAL SPINNERS 0191 267 1011
MILSPEC PRODUCTS USA (1) 407 814 8997
QINETIQ 0 8700 100942
PANKL AUSTRIA (43) 386255122500
PERFORMANCE MACHINE USA (1) 303 828 4546
PREMIER AEROSPACE 01332 850515
PREMIER FUEL SYSTEMS 01332 850515
QUAIFE ENGINEERING 01732 741144
RICARDO INC USA (1) 734 397 6666
RICHARD BARRETT MOULDS USA 353 282 9842
TITAN MOTORSPORTS 01480 474402
TREVOR MORRIS ENGINES 015474 289
TRICK MACHINING 01493 751666
VIN MALKIE 01565 777395

METAL MATRIX COMPOSITES

BP METAL COMPOSITES 01252 37
CRANFIELD UNIVERSITY Tel 01234 754902
Fax 01234 751671
Email motorsport@cranfield.ac.uk
www.motorsport.cranfield.ac.uk
Motorsport Group, Cranfield University, Cranfield, Bedfordshire, MK43 0AL
GM DESIGN 0117 985 9964
MMCC USA (1) 617 893 4449
PANKL Austria (43) 3 8625 12500

METAL SUPPLIERS

ADVANCED METALS INTERNAT 01923 210250
AIRCO METALS LTD 0118 973 0509
ALUMINIUM SPECIAL 01384 291900
APPERLEY HONING 01242 525868
BRADY FABRICATIONS 01869 252750
BRITISH ALCAN ALUMINIUM 01753 887373
AVESTOPOLART LTD 0114 244331
BYWORTH MATERIAL SERVICES 01453 821609
COLUMBIA METALS 01604 810191
CROMPTON TECH GROUP 01295 220130
MASON ENG USA (1) 805 527 6624
RICHARD BARRETT MOULDS USA 353 282 9842
RGB STAINLESS 0121 558 3111
SMITHS HIGH PERFORMANCE 01767 604708
SPA AEROFOILS LTD 01827 260026
Tel: +44 (0) 1908 260707 Fax: +44 (0) 1908 260404
Email: sales@superalloys.co.uk
Number 1 Garamonde Drive, Wymbush Milton Keynes MK8 9DF UK.

TITANIUM SPECIALISTS

AIRCO METALS LTD 0118 973 0509
A.N. MOTORSPORT DESIGN 01628 776320
APPERLEY HONING 01242 525868
ATHENA MANUFACTURING LP USA (1)512 928 2693
CML GROUP 0151 647 5531
COAST FABRICATION USA (1) 714 842 2603
DATUM ENGINEERING 02476 383032
DONCASTERS LTD 01332 864900
PANKL Austria (43) 3 8625 12500
QINETIQ 0 8700 100942
SPA AEROFOILS LTD 01827 260026
TITANIUM INTERNATIONAL Tel: 0121 789 5764
Fax: 0121 784 8054
Email: nhoskison@tiltd.co.uk
Keys House, Granby Avenue, Garretts Green, Birmingham B33 OSP

TUBE FORMING

CONTRACT MFG & ASM USA (1) 920 720 4225
MALVERN AIRCRAFT 01684 892600
SPA AEROFOILS LTD 01827 260026

8.5 Race Preparation

CHASSIS

ACTIVE ENGINEERING USA (1) 714 637 1155
AMS 01831 501363
AMT MOTORSPORT 01444 483477
ANEX SYSTEMS 01869 345038
AUTOMECH 0161 775 1851
AVONBAR 01932 840058
BARWELL MOTORSPORT 0208 397 4411
BR MOTORSPORT 01926 452545
BRR MOTORSPORT 01327 858055
CHRIS LEWIS MOTORSPORT 01677 422623
DEREK BENNET ENG 01565 777395
PRO MOTORSPORT 01555 893315
DOME CARS LTD Japan (81) 75 744 3131
DON FOSTER France (33) 470 580308
FOXCRAFT ENGINEERING 01264 810010
FRP RACING 01494 771609
GRAHAM WISEMAN 01278 685349
HAUS OF PERFORMANCE USA (1) 714 545 2755
HAWKINS RACING 0208 579 1438
INTERPRO ENGINEERING 01454 412777IVAN
JACK CRONE RACING USA (1) 909 371 6090
JOHN VILLAGE AUTOMOTIVE 01246 450580
K2 RACE ENGINEERING 01825 766728
MACDONALD RACE ENG 020 8889 1633
MARDI GRAS MOTORSPORT 01327 857246
MARK BAILEY RACING 01380 850130
MARK DUNHAM RACE ENG 01353 648922
MATRIX ENGINEERING USA (1) 888 249 0013
MELTUNE PX MOTORSPORT 01923 242536
MIRKO RACING Tel USA (1) 408 776 0073
Fax USA(1) 408 779 9329
16890 Church Street, Building no.14, Morgan Hill, CA 95037, USA
PLANET MOTORSPORT 01403 891553
PODIUM DESIGNS 07000 763486
QINETIQ 0 8700 100942
RACECRAFT INTERNATIONAL 01789 297000
RACE TEC DESIGN & ENGINEERING 01386 871292
RILEY & SCOTT USA (1) 317 248 9470
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
ROY KENNEDY RACING 01327 858055
SCHNITZER Germany (49) 8654 2034
SHENPAR PRODUCTS 01332 862901
STARTLINE UK LTD 01933 665752
STORM MOTORSPORT 01474 85 4367
TECH-CRAFT MOTORSPORT 01926 496075
TOLLBAR RACING 01433 631698
TT AUTOMOTIVE RACING 0147 485 3456
VIN MALKIE 01565 777395
ZAKSPEED Germany (49) 2636 87923

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TESTING SERVICES

9.1 Chassis Testing

CALIBRATION SERVICES

RICARDO INC USA 001 734 397 6666
THE STRAIN GAUGING CO 01256 320666
TORQUE FAST CALIBRATION 01782 744212
UNIVERSITY OF HERTFORDSHIRE 01707 284270

CRASH TESTING

CRANFIELD UNIVERSITY 01234 754152
CRANFIELD IMPACT CENTRE 01234 751361
KISTLER INSTRUMENTS LTD 01420 544477
MIRA LTD 0247 635 5000
QINETIQ 0 8700 100942
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
THE STRAIN GAUGING CO 01256 320666

MEASUREMENT EQUIPMENT

AUTOSPRINT 01675 464857
BEAUFORT RESTORATION 01795 83288
BERU F1 SYSTEMS 01379 646200
CCA DATA SYSTEMS 01525 378938
CRANFIELD INSTITUTE 01908 694134
GENESIS ELECTRONIC SYSTEMS 01923 893 999
INSTRON SCHENK 01494 456789
INTERCOMP USA +763 476 2531
KISTLER INSTRUMENTS LTD 01420 544477
LONGACRE USA (1) 425 485 0620
LOTUS ENGINEERING 01953 608000
MICROLEASE 0208 427 8822
MIRA LTD 0247 635 5000
MOTORSPORTS INTERFACE 01788 890412
QINETIQ 0 8700 100942
ROEHRIG ENGINEERING Tel USA (1) 336 431 1827
ROTO TEST AB Sweden (46) 85 325 5890
THE STRAIN GAUGING CO 01256 320666

ROLLING ROADS

ALDON AUTOMOTIVE 01384 78508
AUTOMECH 0161 775 1851
AUTOPOINT 01842 766226
AUTOSPRINT 01675 464857
BD ENGINEERING 01795 843980
PIT STOP 01993 850654
B&J MOTOR ENGINEERS 0161 748 8663
BOSCH 01895 834466
BBR GTI LTD 01280 702389
BRUNO HANSON Denmark (45) 65 99 1616
CARBURETTOR CENTRE 0208 340 5057
CHAMPION MOTORS 01621 857444
CRANFIELD INSTITUTE 01908 694134
DERBY AUTO ACCESSORIES 01332 671493
DTM CONSULTANTS (UK) 01865 407726
ELABORAZIONE COLASUNO 0207 738 8331
FGR 01885 400639
FROUDE CONSINE 01905 856800
INTERPRO ENGINEERING 01454 412777
JANSPEED MOTORSPORT 01722 321833
MACHTECH 01923 269788
MATRIX ENGINEERING USA (1) 888 249 0013
MIRA LTD 0247 635 5000
MOTORSCOPE 01609 780155
OHIO STATE UNIVERSITY USA (1) 614 292 5491
OSELLI ENGINEERING 01865 248100
RE PERFORMANCE CENTRE 0161 761 1177
RICHARD LONGMAN RACING 01202 486569
ROADSPEED PERFORMANCE 01453 750864
SARDOU France (33) 16 00 10 367
SCHENCK 01869 321111
SOUTHAMPTON UNIVERSITY 01703 585044
TIM STILES RACING 01278 453036
TIPTON GARAGE 01404 812091

STRESS ANALYSIS

COSINE TECHNOLOGY 01706 378851
LOLA Tel 01480 451301
Fax 01480 456722

WELD TESTING

C & B CONSULTANTS, AERODYNAMICS LTD
Tel +44 (0) 1202 673666 / Fax +44 (0) 1202 671776
Email candbaero.uk@candbconsultants.com
www.candbconsultants.com
194 Stanley Green Road, Poole, Dorset BH15 3AH
C & B INTERNATIONAL INC
Tel +1 317 291 0978 / Fax +1 317 536 0656
email candbaero_indy@msn.com
6210 La Pas Trail, Indianapolis, Indiana 46268
KISTLER INSTRUMENTS LTD 01420 544477
WIND TUNNELS ACTIVA TECH 0208 974 1615
AIOLOS ENG Canada (1) 416 674 3017
CRANFIELD INSTITUTE 01908 694134
CRANFIELD UNIVERSITY 01234 754152
DOME CARS LTD Japan (81) 75 744 3131
IMPERIAL COLLEGE LONDON 0207 589 5111
LANGLEY FULL-SCALE USA (1) 757 766 2266
MARCH 01280 704160
MICRO CRAFT USA (1) 909 947 1843
MIRA LTD 0247 635 5000
OHIO STATE UNIVERSITY USA (1) 614 292 5491
RMCS (CRANFIELD) 01793 785359
QINETIQ 0 8700 100942
SARDOU SA France (33) 16 00 10 367
UNIVERSITY OF MARYLAND USA(1) 301 405 6861
WESTLAND HELICOPTERS 01935 702190

WIND TUNNEL MODELS

ADVANCED COMPOSITES 01773 763441
AERODINE COMPOSITES USA (1) 317 271 1207
CAPITAL PATTERNS 0208 777 9276
COMPOSITE DESIGN USA (1) 727 539 0605
DOME CARS LTD Japan (81) 75 744 3131
MARTIN FELDWICK 01603 712611
MICRO CRAFT USA (1) 909 947 1843
MIRA 0247 635 5000
SARDOU SA France (33) 16 00 10 367
THE STRAIN GAUGING CO 01256 320666

9.2 Engine Testing

COMBUSTION ANALYSIS

AM TEST SYSTEMS 01253 780780
AUTOSPRINT 0121 236 5133
AVL DEUTSCHLAND GmbH GERMANY (49) 6134 7179-0
CRANFIELD INSTITUTE 01908 694134
CRANFIELD UNIVERSITY 01234 754152
INTEGRAL POWERTRAIN 01908 278600
KISTLER Instruments Ltd 01420 544477
LOTUS ENGINEERING 01953 608000
MACHTECH 01923 269788

MIRA LTD 0247 635 5000
MOTORSPORTS INTERFACE 01788 890412
MTS Powertrain Tech Tel 01932 351516
PETROCHEM CARLESS LTD 01372 360000
PRECISION AUTOMOTIVE USA (1) 708 766 4402
RICARDO 01273 794144
RICARDO INC USA (1) 734 397 6666
QINETIQ 0 8700 100942
RICARDO 01273 45561
TREVOR MORRIS ENGINES 0154 74289

DYNAMOMETER SUPPLIERS

AVL DEUTSCHLAND GmbH GERMANY (49) 6134 7179-0
BEAUFORT RESTORATION 01795 83288
CRANFIELD UNIVERSITY 01234 754152
DEPAC DYNO USA (1) 315 339 1265
DYNAMIC TEST USA (1) 800 243 3966
DYNOMITE USA (1) 603 329 5645
ENGINE & DYNAMOMETER 01708 857108
FROUDE CONSINE 01905 856800
LOTUS ENGINEERING 01953 608000
MACHTECH 01923 269788
MIS M/SPORTTECHNIK Germany (49)263680394
MOTORSPORTS INTERFACE 01788 890412
Ricardo Inc USA (1) 734 397 6666
ROTOTEST Sweden (46) 8 532 55890
SUPERFLOW USA (1) 719 471 1746
BELGIUM 32 15 216300
TAT Germany (49) 7252 84258

DYNAMOMETER SERVICES

ACCURATE ENGINEERING USA (1) 216 232 1156
CELTIC PERFORMANCE ENG 01362 696729
AIRFLOW RESEARCH USA (1) 818 890 0616
ALDON AUTOMOTIVE 01384 78508
AMG MOTORENBAU Germany (49) 7144 3020
ANDY ROUSE ENGINEERING 02476 635182
ARIAS 01403 784022
ATKINSONS MOTORSPORT 01539 732500
AUTOKRAFT 0121 777 2083
AUTOMECH 0161 7751851
AUTO SPECIALISTS USA (1) 704 786 0187
AVONBAR 01932 840058
EVOLUTION ENGINEERING 0207 703 2225
BERTILS ENGINES USA (1) 708 395 4244
BJ MOTOR ENGINEERS 0161 748 8663
BOB WIRTH RACING USA (1) 510 487 3279
BRAYTON ENGINEERING USA (1) 517 279 8458
BR MOTORSPORT 01926 451545
BRODIE BRITTAIN (BBR) 01280 702389
CAMBRIDGESHIRE SPORTS 01954 210248
CARBONE RACING USA (1) 918 835 6596
CENTRAL AUTO TECH 0121 4558392
COMPETITION ENGINE 01296 435389
CONCEPT MOTORSPORT 0208 568 0293
CONNAUGHT 01795 843802
DAVE CROFTS 01246 477566
DAWSON AUTO DEVELOPMENT 01327 857729
DESIGN & DEVELOPMENT 01695 574454
DRAGON PROJECT RACING TEL 0118 974 4175
DUNNELL ENGINES 01449 677726
DYNOMITE USA (1) 603 329 5645
EAGLE ENGINE CO USA (1) 805 373 6806
ELABORAZIONE COLASUNO 0207 738 8331
ELLIOTT & SON 01306 711275
EDS 01708 857108
ENGINE DATA ANALYSIS 01977 516622
FAST CAR CLINIC 01274 579564
FISCHER ENGINEERING USA (1) 818 504 0300
FONTANA AUTOMOTIVE USA (1) 310 538 2505
FROUDE CONSINE 01905 856800
GAERTE ENGINES USA (1) 219 223 3016
GEMINI ENGINEERING 01474 534779
GEOFF RICHARDSON ENG 01480 861599
GMH ENGINEERING USA (1) 801 225 8970
GOODMAN RACING ENGINES 01327 300422
GRAHAM HATHAWAY RACING 01621 856956
HARPERS PERFORMANCE 01642 808188
GEORGE HARTWELL 01202 556566
HASSELGREN ENGINES USA (1) 510 524 2485
HAUS OF PERFORMANCE USA (1) 714 545 2755
HIGHGATE ENGINEERING 0208 951 4923
HODSON ENGINEERINBG 01732 463658
HOLBAY RACE ENGINES 01473 623000
HOLMAN AUTOMOTIVE USA (1) 704 394 2151
HUDDART 01270 665405
INTEGRAL POWERTRAIN 01908 278600
INTERPRO ENGINEERING 01454 412777
INTER-TUNING Belgium (32) 473 652 216
IVAN DUTTON 01923 816277
JANSPEED ENGINEERING 01722 321833
JENNETTS ENGINES 01993 891776
JF ENGINES 01491 680719
JOHN BROWN ENGINEERING 01903 773022
KREMER RACING Germany (49) 221 17 1025
LANGFORD & PECK 01933 441661
LINGENFELTER USA (1) 219 724 2552
LISTER CARS 01372 377474
LOTUS ENGINEERING 01953 608000
LYNX MOTORS 01424 851277
MRE 0208 889 1633
MAXSYM ENGINE TECHNOLOGY 01608 685155
MACHTECH 01923 269788
MATHWALL ENGINEERING 01252 703191
MERLIN DEVELOPMENTS 01283 511184
MICKEY MAROLLO USA (1) 607 734 2148
MINERVA MOTORSPORT 01509 233970
MINISTER RACING ENGINES 01634 682577
MOUNTUNE 01621 854029
NEIL BROWN ENGINEERING 01775 723052
NELSON ENGINE SERVICES 01249 815929
OSELLI ENGINEERING 01865 248100
PAUL PFAFF RACE USA (1) 714 894 7573
PHIL JONES ENGINE DEVELOPMENTS 01454 310 936
01564 824869
PIPER FM 01233 727377
PRICE MOTORSPORT USA (1) 812 546 4220
PRIMA RACING 0115 9491903
PRO/CAM USA (1) 616 847 5000
PRODRIVE 01295 273355
QUAIFE ENGINEERING 01732 741144
QUICKSILVER USA (1) 301 698 9009
QUORN ENGINE DEVELOPMENTS 01509 412317
RACING BENT USA (1) 714 779 8677
RICARDO INC USA (1) 734 397 6666
RICARDO 01273 794144
ROAD & STAGE MOTORSPORT 01524 844066
ROTO TEST Sweden (46) 8 532 55890
SCARBOROUGH Canada (1) 416 759 9309
SEARLE 0208 305 2250
SCHENCK PEGASUS USA (1) 248 689 9000
SOUTH CERNEY ENGINEERING 01285 860295
SPECIALISED ENGINES 01375 378606
STERLING ENGINES USA (1)209 267 5081
SWIFT MOTORSPORT 0191 5867311
SWINDON RACING ENGINES 01793 531321
TREVOR MORRIS ENGINES 0154 74289
VAN DYNE ENGINEERING USA (1) 714 847 4417
WARRIOR 01825 764833
WESLAKE DEVELOPMENTS 01797 224000

ENGINE BALANCING

AUTOMOTIVE BALANCING USA (1) 562 861 5344

FLOWBENCH ANALYSIS

ADVANTEC NEW TECHNOLOGY (49) 2261 61901
AM TEST SYSTEMS 01253 780780
BOB WIRTH RACING USA (1) 510 487 3279
CRANFIELD UNIVERSITY 01234 754152
HAUS OF PERFORMANCE USA (1) 714 545 2755
INTEGRAL POWERTRAIN 01908 278600
LINGENFELTER USA (1) 219 724 2552
LOTUS ENG 01953 608000
MAXSYM ENGINE TECH 01608 685155
MOBILIS LAB CANADA (1) 450 647 1890
NEIL BOLD ENGINEERING 01204 71636
RACE ENGINE DEV USA (1) 760 630 0450
RACE TECHNIQUES 01242 245640
RICARDO INC USA (1) 734 397 6666
RICARDO 01273 794144
TREVOR MORRIS ENGINES 0154 74289
U.M.P.S 01784 439771

FUEL ANALYSIS

AM TEST SYSTEMS 01253 780780
BOB WIRTH RACING USA (1) 510 487 3279
CRANFIELD INSTITUTE 01908 694134
LOTUS ENGINEERING 01953 608000
QINETIQ 0 8700 100942

INJECTION ANALYSIS

ASNU 0208 420 4494

OIL ANALYSIS

AM TEST SYSTEMS 01253 780780
BOB WIRTH RACING USA (1) 510 487 3279
CRANFIELD INSTITUTE 01908 694134
LOTUS ENGINEERING 01953 608000
QINETIQ 0 8700 100942
RICARDO 01273 794144

RACE ENGINE DESIGN

RICARDO CONSULTING ENGINEERS
Tel 01273 794144 Fax 01273 794572
Email: dave.morrison@ricardo.com
Website: www.ricardo.com
Shoreham by Sea, West Sussex. BN43 5FG

TEMPERATURE MONITORING

AM TEST SYSTEMS 01253 780780
BOB WIRTH RACING USA (1) 510 487 3279
CALEX ELECTRONICS 01525 373178
CCA DATASYSTEMS 01525 378938
CONNAUGHT ENGINES 01795 843802
INTEGRAL POWERTRAIN 01908 278600
LOTUS ENGINEERING 01953 608000
MACHTECH 01923 269788
MIRA LTD 0247 635 5000
MOTOR SPORT ELE AUS (61) 73290 1309
MOTORSPORTS INTERFACE 01788 890412
QINETIQ 0 8700 100942
RACEPARTS 01491 37142
RICARDO 01273 794144
THE STRAIN GAUGING CO 01256 320666
TREVOR MORRIS ENGINES 0154 74289

TEST BED SUPPLIERS

AVL DEUTSCHLAND GmbH GERMANY (49) 6134 7179-0

TEST CELL DESIGN

MARTYR TEST TECHNOLOGY 01386 792125

9.3 Transmission Testing

TESTING SERVICES

ANEX SYSTEMS 01869 345038
ANTHONY BEST DYNAMICS 01225 867575
AVL DEUTSCHLAND GmbH GERMANY (49) 6134 7179-0
AVONBAR 01932 840058
BEAUFORT RESTORATION 01795 83288
CRANFIELD INSTITUTE 01908 694134
DAVID BROWN VEHICLE TRANS 01484 422180
EUROTECH MOTORSPORT 02476 672959
HALIBRAND USA (1) 800 824 7947
UK 01978 361176
HAUS OF PERFORMANCE USA (1) 714 545 2755
HEWLAND ENGINEERING 01628 827600
LOTUS ENGINEERING 01953 608000
MACHTECH 01923 269788
MARK BAILEY RACING 01264 860114
MIRA LTD 0247 635 5000
PDS RACING 01977 611928
QUAIFE ENGINEERING Tel 01732 741144
Fax 01732 741555
Email info@quaife.co.uk www.quaife.co.uk
Vestry Road, Sevenoaks, Kent, TN14 5EL
RICARDO 01273 794144
RICARDO 01926 319399
ROADSPEED PERFORMANCE 01453 750864
SCHENCK PEGASUS CORP (1) 248 689 9000
SERVOTEST LTD 020 8707 1400
SIEMENS AG Germany (49) 941 790 5313
THE STRAIN GAUGING CO 01256 320666
ZF Germany (49) 7541 77 2543
UK 0115 9869211

9.4 Suspension Testing

TESTING SERVICES

ANDY ROUSE ENGINEERING 02476 635182
CRANFIELD INSTITUTE 01908 694134
EUROTECH MOTORSPORT 02476 672959
HAUS OF PERFORMANCE USA (1) 714 545 2755
INSTRON SCHENK 01494 456789
JENVEY DYNAMICS 01746 768810
LOLA Tel 01480 451301
Fax 01480 456722
MARDI GRAS MOTORSPORT 01327 858006
MIRA LTD 0247 635 5000
PILBEAM RACING DESIGNS 01778 424838
RACE TEC DESIGN & ENG 01386 871292
RACRAFT MOTORSPORT 01707 45946
RATRACE MOTORSPORT 0208 203 8700
RICARDO 01273 794144
RICHARD HINTON RACING 01279 771667
RMCS (CRANFIELD) 01793 785359
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate,
Wellingborough, Northants NN8 6TY England
ROEHRIG ENGINEERING USA (1) 336 431 1827
SERVOTEST LTD 020 8707 1400
SCHENCK PEGASUS USA (1) 248 689 9000
SPA DESIGN LTD 01827 288328
STARTLINE UK LTD 01933 665752

9.5 Brake Testing

DYNAMOMETER SUPPLIERS

BOSCH 01895 834466
MTS POWERTRAIN TECHNOLOGY 01932 351516
DYNOMITE USA (1) 603 329 5645
KISTLER INSTRUMENTS AG Tel Switz (41) 52 224 1111
Fax Switz (41) 52 224 1414
Email info@kistler.com
PO Box, CH-8408 Winterhur, Switzerland
MIRA LTD 0247 635 5000
WILWOOD ENG USA USA (1) 805 3881188
UNICO (UK) LTD 01908 260000

TESTING SERVICES

HAUS OF PERFORMANCE USA (1) 714 545 2755
EUROPEAN FRICTION 0117 9714837
MIRA LTD 0247 635 5000
RICARDO 01273 45561
SIEMENS AG Germany (49) 941 790 5313
THE STRAIN GAUGING CO 01256 320666

9.6 Metal Testing

CRACK TESTING

BEAUFORT RESTORATION 01795 83288
CML GROUP 0151 647 5531
CRANFIELD UNIVERSITY 01234 754152
GM DESIGN 0117 985 9964
MIRA LTD 0247 635 5000
ORANGE COUNTY USA (1) 800 359 8378
QINETIQ 0 8700 100942
RICARDO 01273 45561
RMCS (CRANFIELD) 01793 785359
SCHENCK PEGASUS USA (1) 248 689 9000
SPA AEROFOILS LTD 01827 260026
STRAIN GAUGING CO 01256 320666
SWINDON RACING ENGINES 01793 531321
UNIVERSITY OF HERTFORDSHIRE 01707 284270
VIN MALKIE RACING 01565 777395
WESTLAND HELICOPTERS 01935 702190

STRENGTH TESTING

AR CORNELL 01245 268098
ARMOR-ALL PRODUCTS 01799 513130
AVONBAR 01932 840058
BA HARRISON 0116 2769351
CML GROUP 0151 647 5531
CRANFIELD UNIVERSITY 01234 754152
GRIFFITHS ENGINEERING 01582 600629
HIGH TECH PERFORMANCE USA (1) 818 908 0943
DONCASTERS 01332 864900
MRE 0208 889 1633
MIRA LTD 0247 635 5000
NITRIDING SERVICES 01952 677372
ORANGE COUNTY USA (1) 800 359 8378
RICARDO 01273 45561
QINETIQ 0 8700 100942
RMCS (CRANFIELD) 01793 785359
ROUSH RACING USA (1) 315 591 4384
SCHENCK PEGASUS USA (1) 248 689 9000
THE STRAIN GAUGING CO 01256 320666
UNIVERSITY OF HERTFORDSHIRE 01707 284270
ZEUS MOTORSPORT 01604 878101

Database 10

SERVICES - GENERAL

10.2 Paddock Services

AIR FREIGHT FORWARDERS

ALL WAYS FORWARD 01242 228111
EMO AIR CARGO 0208 577 5100
FIRSTAIR 01784 421451
JIM RUSSELL FREIGHT 01332 811931
MSAS 0208 890 1355
MW FREIGHT SERVICES 01753 680800
RAPID INTERNATIONAL 01895 446442
UNION AIR TRANSPORT 0161 436 7074
WINWEST Australia (61) 2 522 4618

MOTORHOME

ATLANTIC COAST 01297 552222
CHESHIRE AMERICAN MOTORHOMES
Tel +44(0) 161 427 6868
Fax +44(0) 161 426 0010
Website www.americanmotorhomes.co.uk
Email sales@americanmotorhomes.co.uk
Lomberhaey Farm, Andrewlane,
Highlane Village, Stockport SK6 8HY
DAVID WILSON'S TRAILERS 01825 740696
DUDLEYS 01993 703774
MIDLAND INTERNATIONAL 02476 336411
SPIRES OF OXFORD 01865 875539
ULTRA INTERNATIONAL 01766 770011
WESTCROFT AMERICAN 01902 731324

TRAILER HIRE

11/56 MOTORSPORT 01543 480309
BRIAN JAMES TRAILERS 01327 260733
DAVID WILSON'S TRAILERS 01825 740696
DC TRAILERS 01406 380224
ELLIS ENGINEERING 01277 631274
HOPKINS MOTORSPORT 0117 9509294
MOBILE PROMOTIONS 01832 733460
NEIL BAINBRIDGE RACING 01296 714547
TON HIRE 01892 836155
WARWICK TRAILERS 01962 732681
WARWICKSHIRE TRAILERS 01564 792337

AEROBYTES

With Simon McBeath

Integrating the details

The influence of a single-seater front wing on downstream aerodynamics around the car

Last month we looked at the distribution of static pressures – and the aerodynamic forces arising – around a full model of a 2001 Reynard Champ Car. Examining static pressure plots it was possible to visualise the dominant sources of 'pressure drag' (that element of drag arising from overall pressure differences) and downforce. This month we look at the area of the car around the front wing to see its influence in its immediate vicinity and some way downstream. Figure 1 shows the model, with static pressures mapped on the upper surfaces.

CFD enables various methods of visualising aerodynamic properties. In particular, it is possible to look at properties along single planes in any of the three directions, defined usually as x, y and z. In this way, 'slices' through the air surrounding a racecar can be examined. To enable us to study the influence of the front wing we're going to utilise predominantly transverse slices in the vertical plane at stations along the length of the car.

The majority of these plots, such as figure 2, show two different properties.

> **"SLICES THROUGH THE AIR SURROUNDING A RACECAR"**

On the left is 'total pressure', which is a measure of the energy in the airflow at any particular point. As air passes over the surfaces of a body like a racecar it loses energy due to viscous effects (eg skin friction) and flow separation (where there are changes in surface shape that prevent the airflow from remaining attached). Total pressure is therefore high in areas where viscous effects or flow separation have not 'stolen' energy. But where energy losses have occurred because of one or both of these mechanisms, total pressure decreases. These plots use red for maximum total pressure (total pressure coefficient, CpT = 1), through yellows, greens and blues (CpT = 0) showing decreasing total pressure.

On the right is static pressure, which is the form of pressure that exerts forces on the racecar surfaces. In conditions where Bernoulli's Equation applies, static pressure decreases as velocity increases (and vice versa). Positive static pressures are shown as red and orange and negative static pressures are shown by green and blue.

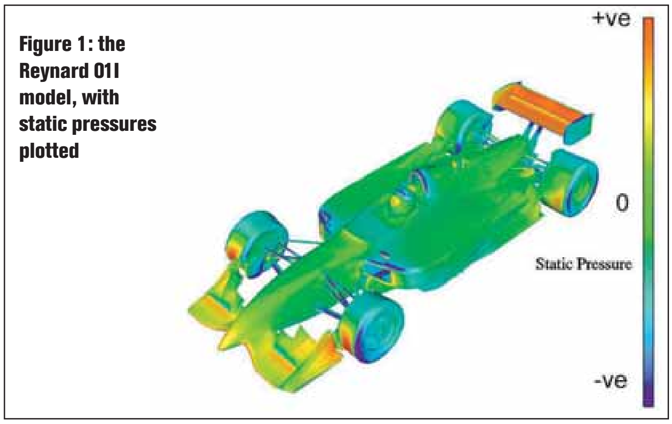

Figure 1: the Reynard 01I model, with static pressures plotted

Illustrations courtesy: Advantage CFD

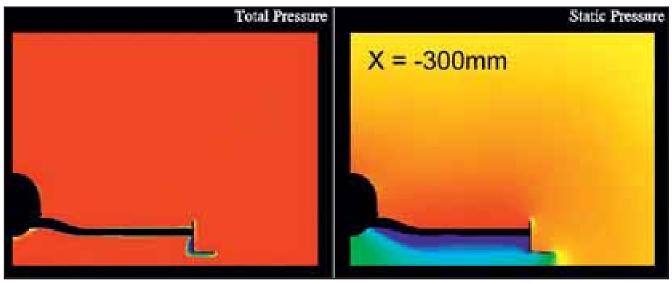

Figure 2: cross section, looking rearwards, of the nosecone and left side front wing, 150mm aft of the leading edge

Figure 2 is a slice looking rearwards, taken about 150mm back from the front wing mainplane leading edge (at x = -300mm, where x = 0mm at the front of the chassis tub, 300mm aft of this slice). Only the left side of the car is shown – the black half oval on the left is the nosecone. The static pressure plot shows negative static pressure below the wing and positive static pressure above it that jointly contribute to downforce. The total pressure plot reveals only minor losses in energy near the wing and nose surfaces, and under the end plate 'footplate'.

Moving 400mm downstream to just aft of the front wing flap trailing edge, at x = 100mm (figure 3) and things have developed. The different static pressures that developed above and below the wing have now merged to virtually the same level, and the total pressure plot shows the wing's wake. The red area in the static pressure plot is where the airflow has slowed ahead of the front wheel – hence the high static pressure, which produces pressure drag on the wheel. Static pressure is also high above the end plate footplate and low beneath it, creating an increment of downforce. Most obvious though is the circular (blue) wing tip vortex. The air in the vortex →

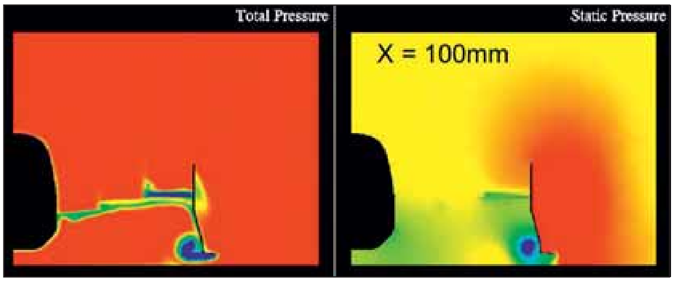

Figure 3: cross section in line with the front wing flap trailing edge

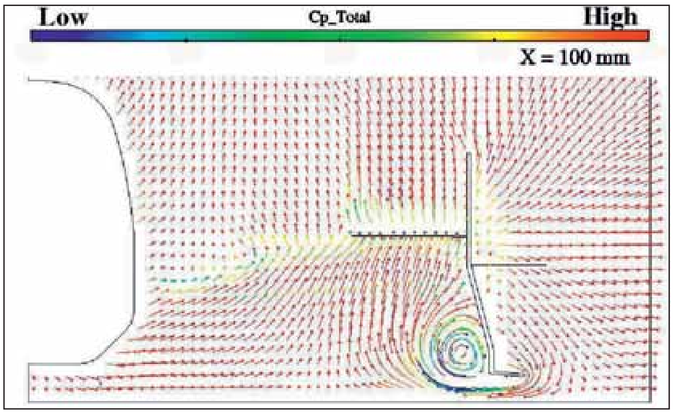

Figure 3a: in plane velocity vectors show the wing tip vortex

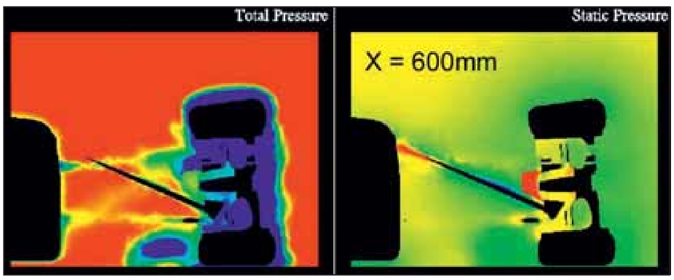

Figure 4: cross section in line with the front wheel centre

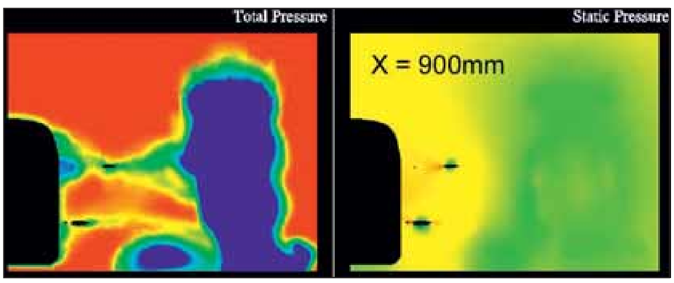

Figure 5: cross section just aft of the front wheel

has lost significant total pressure (energy), which is also associated with low static pressure. The vortex is initiated by air flowing from the high static pressure area outboard of the wing to the low static pressure area beneath, the flow then separating at the bottom of the end plate. Figure 3a, showing in-plane velocity vectors, confirms this. Notice the end plate has been angled outwards to 'accommodate' the vortex.

Figure 4 (x = 600mm) is in line with the wheel centre. Static pressure is low above the wheel, leading to aerodynamic lift, and high in the brake cooling duct. The total pressure plot shows substantial energy losses within and around the wheel, and smaller losses in the wakes of the forward suspension links. The faint yellow diagonal from the centre to the lower left of the total pressure plot is the residual front wing wake. The wing tip vortex is still in evidence in the total pressure plot, but less so in the static pressure plot.

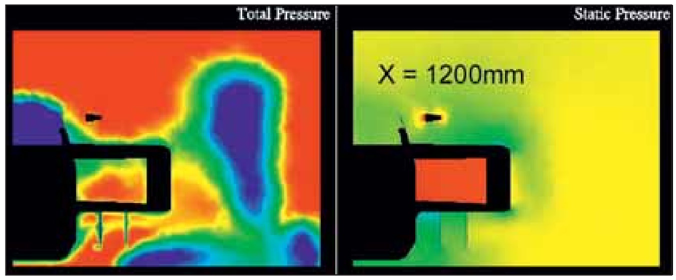

Figure 6: cross section in line with the front of the sidepod

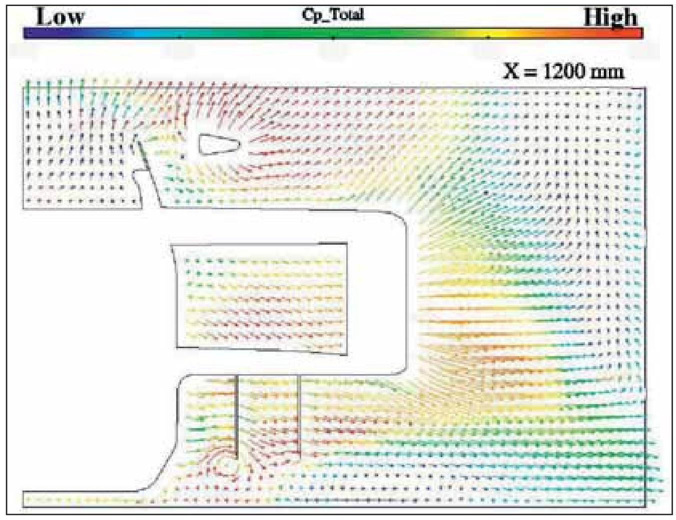

Figure 6a: in plane velocity vectors in line with the front of the sidepod

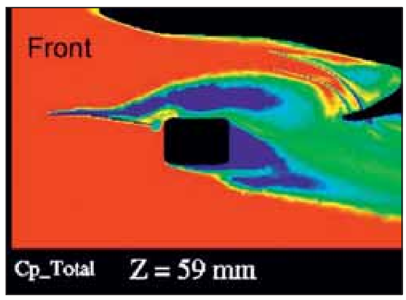

Figure 7: cross section, viewed from above, of total pressure at sidepod base height around the front, left corner of the car

At x = 900mm (figure 5) static pressure is slightly negative immediately behind the wheel, adding pressure drag. The total pressure plot shows the large wake from the wheel, and the wing tip vortex is still very apparent, but it has flattened and shifted inboard slightly.

At x = 1200mm (figure 6) the cockpit, mirror, sidepod, radiator inlet duct and the 'vortex generators' (the curved turning vanes) in the front of the underbody are visible. Static pressure is high in the radiator inlet duct, as it needs to be to drive cooling air through the system, but has started to reduce in the underbody. The total pressure plot shows the wheel wake to be well outboard of the sidepod. The low total pressure 'residue' of the wing tip vortex is also still apparent (bottom centre) but figure 6a shows the circulation has virtually ceased. There is, however, a new vortex being formed – by the vortex generators – which influences the forces generated by the underbody.

Figure 7, looking from above at sidepod base height, illustrates that the wing tip vortex has in fact been steered outboard by the vortex generators – as it might be by a bargeboard, or a front endplate extension such as Formula 1 outlawed in 1994. The air flowing into the underbody is therefore at higher energy than if the now 'tired' wing tip vortex were allowed to enter that area, to the improvement of underbody and diffuser performance. In this way, the front wing has positive and potentially negative influences.

Next month we'll see what happens in the underbody. RE


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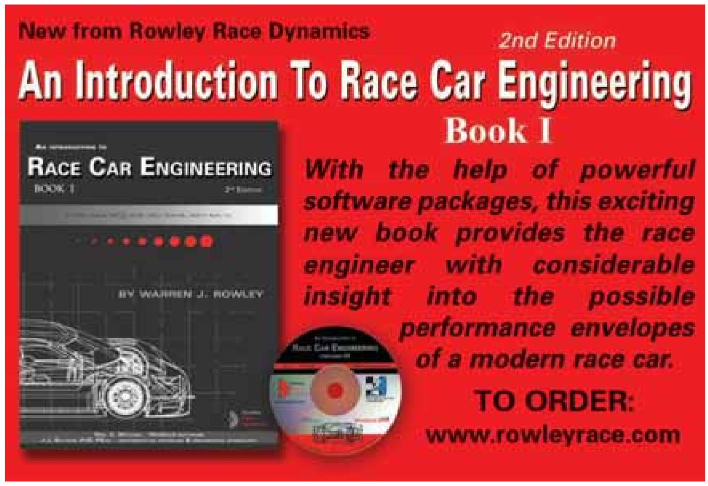
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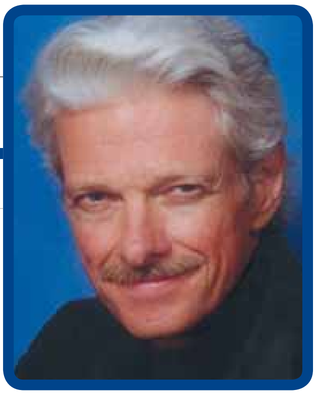

Tyre pressures in the snow

Tyres do not cut through the snow, at any inflation pressure, rather they compact it vertically and ride over it. Traction comes from the action of the tyre interlocking with the snow itself

LAT

Q I have heard two schools of thought on tyre pressure for winter driving, in particular driving on snow-covered roads. The first is that tyres should be kept at the upper end of the manufacturers' specifications to help in cutting through the snow — the thinking being that the contact patch is smaller, hence more weight per square inch, as well as less sidewall deflection — which may decrease the potential for hydroplaning on the snow. The other is that running the pressure at the lower end allows for better bite for the tread in the snow and more stability. What do you think?

A I'm with the low-pressure school. It's said that one measurement is worth a thousand expert opinions and really, you'd think this might be measurable. Surely somebody has tried measuring, say, how steep a hill a vehicle can climb at various tyre pressures? I would be willing to defer to any actual measurement that contradicts my expert opinion. That said, I offer my expert opinion, based on a lot of time spent in Wisconsin, where there are long, snowy winters.

Mark Ortiz Automotive is a chassis consulting service primarily serving oval track and road racers. In these pages Mark answers your queries on chassis set-up and handling. If you have a question to put to him, email to **markortiz@vnet.net**, call **704-933-8876** or write to **Mark Ortiz, 155 Wankel Dr., Kannapolis, NC 28083-8200 USA**

First, tyre pressure effects in snow are surprisingly subtle compared to other variables, and effects due to other variables are surprisingly large. That explains why there is controversy about inflation pressures.

One reason tyre testing was moved indoors, with rollers or belts substituting for pavement, is that even on hard, dry pavement, weather, surface contamination, pavement temperature, pavement age, and other factors make enough difference that small variations in tyre performance are hard to measure repeatably.

"COMPARED TO SNOW, PAVEMENT IS SIMPLE AND CONSISTENT"

When we're dealing with snow, we have similar variability, exaggerated at least tenfold. Snow and ice come in dozens of different varieties and depths, and all of these have properties that are highly temperature sensitive. Compared to snow, pavement is simple and consistent.

The explanation I have heard from sources that advocate high tyre →

pressures is that the tyre needs to penetrate the snow and get to the pavement, where it can find traction. But clearly, in most snow conditions that never happens, at any inflation pressure. If it did, we'd see bare pavement where the tyre passed.

Instead, we see compacted snow, with an imprint of the tyre tread. Or at least we see that if the tyre is rolling, and not spinning or sliding – and if we are dealing with snow that has not already been compacted. We also usually see a small area alongside the track where the snow appears slightly raised, apparently having been pushed out of the way, perhaps just by the sidewall. This is not a lot of snow, however. Most of the snow stays put horizontally, and gets compacted vertically. The tyre evidently gets traction by packing the snow into a relatively solid form, and simultaneously interlocking with it. To break traction, the compacted snow projections residing in the tread grooves must be sheared off, and the layer of snow lying under the tread blocks must also fail in some manner.

The failure of the snow in the grooves is easily visualised as simple breakage. The failure of the snow under the tread blocks is a bit harder to visualise. It appears that the snow under the tread blocks contributes more to traction than one would imagine, because the tyre's grip is greatly improved by siping (cutting small slits or grooves into) the tread blocks. It also helps to roughen the surface of the tread blocks.

I do not claim to perfectly understand the mechanics of structural failure of snow in a tyre contact patch, but I do know that it is normally a combination of breakage and melting. Ice (and snow is ice crystals) can be melted by mechanical pressure – or, stating it differently, the melting point of ice is lowered by mechanical stress, either compressive or shear stress. Any place snow or ice liquefies, its mechanical strength disappears and it turns into a lubricant. The closer the ice or snow is to its melting point, the less mechanical stress is required to turn it to liquid.

So, when we compact snow, we make it stronger, but only up to the point where we start to get localised melting. The unit loading required to reach this point depends on how cold the snow or ice is. Moreover, short of the point where we encounter melting by compression alone, we see an increased likelihood of melting by the combination of compression and shear. In other words, as unit loading increases, we gain hardness but lose melt resistance. The hardness gain is fairly independent of temperature. The melt resistance loss is heavily affected by temperature, or at least its importance is.

"THE TYRE GETS TRACTION BY PACKING THE SNOW INTO A RELATIVELY SOLID FORM"

Contact patch size

From this, we might logically expect that the ideal contact patch size would be smaller in really cold weather than when we're near thaw temperature. I suspect that this is academic, however. I think the optimum contact patch size is far bigger than we can ever get with a tyre. Consider the transportation devices that people have devised specifically for snow: snow cats; snowmobiles; snowshoes; cross-country skis etc. All of these operate by compacting the snow minimally over a large area, and then trying to get maximum purchase on that large interface. For best performance on snow, or any other soft surface, we really want a belt or track, not a tyre at all.

It would seem to follow that the more we can get a tyre to act like a track, the better it should work. That would suggest a radial tyre, at low pressure. Note that it does not necessarily follow that we want a wide tyre. It is generally agreed that for most winter conditions, a tyre should be narrow. I think, based on the reasoning above, there will be winter conditions where a wide tyre may be preferable. These may include bare ice and hard-packed snow, probably even shallow soft snow. But in snow of significant depth, narrow tyres are better. The reason for this doesn't have to do with an increase in traction when the tyre is narrow, as such. It has to do with the force required to move the tyres, which is less when the tyres are narrow.

As the tyre rolls forward, it is resisted by the snow in front of it. To advance, the tyre must, in effect, climb a ramp of snow. The ramp of snow is not strong enough to support the tyre, and it is continually collapsing under the weight of the car. The amount of collapse is fairly similar regardless of the width of the tyre. For any practical tyre size, we will compact the snow to a pretty solid state, no matter what. Yet the snow has substantial resistance to this compaction, and this translates to a resistance to the wheel's forward motion. The taller and wider the mass of snow, the greater the resistance to motion. The height of the snow we must compact depends on the snow's depth. The width we must compact depends on the width of the tyre. It would also seem that a narrow tyre should provide more directional control, since it is better shaped to act like a blade or rudder.

From this reasoning, we might expect that the ideal tyre for deep snow would resemble a bicycle tyre. Such a tyre would be easy to push along, and should have good directional stability. However, it doesn't quite work that way with really narrow tyres, as anybody who has tried riding a bicycle in deep snow will attest. The problem is that the ramp of compacted snow that the tyre rides on is so narrow that the tyre is forever sliding off the side of it into the soft snow alongside. As soon as the tyre moves forward again, another narrow compacted ramp is formed beneath it, and again it slides off one side or the other – no predicting which side. The result is that the tyre absolutely will not run straight.

So there is such a thing as too narrow. The tyre needs to be wide enough to sit on top of the compacted ramp it is making for itself. A square-shouldered profile, or one with concave shoulders that compact a sort of retaining berm along the side of the main ramp can be expected to help

Returning to the question of inflation pressure, this also affects resistance to forward motion. And even this relationship is not as straightforward as one might think. Based on our experience with tyres on pavement, on a smooth, hard surface, the higher the inflation pressure, the easier the tyre rolls (within practical limits). But on a rough surface, a softer pressure can actually roll more easily. For this to be so, the surface must have roughness as opposed to waviness – that is, the ups and downs must be fairly close together. The tyre rolls easier because it can yield to the bumps rather than having to climb over them. This was realised early in the history of the pneumatic tyre. John Dunlop noticed that his new pneumatic tyre would roll further across his bumpy back yard than a solid tyre.

This has relevance to driving in snow because often the situation that gets us stuck is one where one or more wheels are in a fairly modest-sized depression, and we have to move the tyre over the lip of the depression with the meager traction available. In at least some such situations, soft inflation will make getting over that lip easier.

It will be apparent that I am writing here from a mixture of practical experience and inference. I invite readers with further experience, or contradictory experience, to comment. RE

A tyre's grip on snow can be greatly improved by siping the tread blocks

LAT

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