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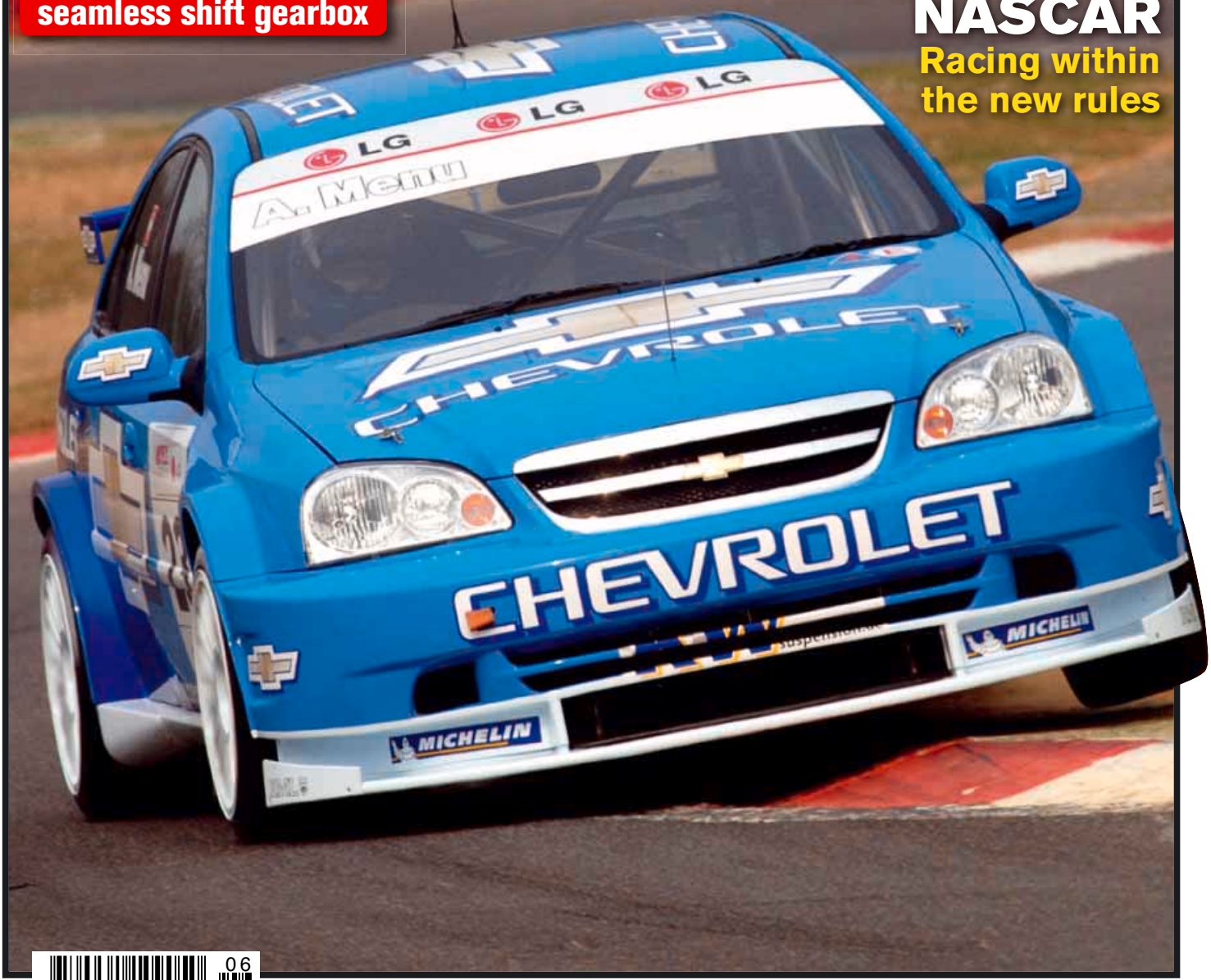

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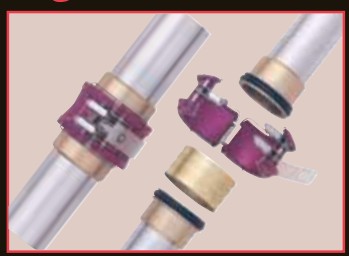

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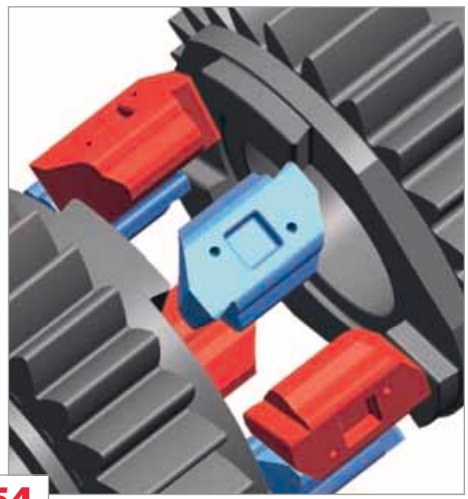

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Write Line

Once again the British newspaper, The Sunday Times, published its annual Rich List and, despite being inevitably very speculative, it does give an enlightening round-up of the UK's very rich. This year, though, I'm left wondering where all the motorsport millionaires have gone? Predictably Bernard Charles Ecclestone holds pole position in 11th place overall although, following a difficult year, his wealth is estimated to be unchanged accounting for his slip from eighth last year.

Next comes his close ally Paddy McNally who, despite his income from Allsport and the Paddock Club, has slipped to 141st from 99th the previous year. After these two, and ignoring Lola owner Martin Birrane at 439th who's fortune is largely the result of activities outside motorsport, we descend to 600th before we find Ron Dennis. A lack of growth in his £82m fortune has seen him slip from 491st, leaving just Dave Richards of Prodrive and Sir Frank Williams to receive honourable mentions in 654th and 740th positions respectively before the 1000th candidate is checked in at just under £50m.

"WHERE HAVE ALL THE MOTORSPORT MILLIONAIRES GONE?"

So where have all the motorsport millionaires gone? Let's face it, motorsport investors have generally found the way to making a small fortune was to start with a big one. It's a cynical old adage, but generally it holds true, except in Formula 1 of course. Ecclestone never misses the opportunity to remind us how many millionaires he has made in F1. But this year's Rich List boasts no new faces and, worryingly, fewer of the old ones. It would suggest that Bernie's claim may well be historically true but not a reflection of the sport today.

Then again, he is running a business, not a charity and there is no high moral principle that obliges him to distribute his company's profits to the less wealthy. Provided there are enough hopefuls vying for entries to single-seater's premiere category to justify the price of taking part and guarantee the show, then his business can look forward to a prosperous future. Except there isn't.

Currently there are two empty slots on the entry list which is bumping along with its contractual minimum. Also, new teams are only being established on the foundations of old ones, like Redbull acquiring Jaguar and Midland F1 buying out Jordan. In reality, talk to anyone considering entering F1 and they will confide that for a start-up effort, the business model is pretty unattractive. Apart from worthwhile margins being impossible to achieve, the confidentiality of the Concorde Agreement prevents you knowing your share of the revenue until after you have been accepted for, and committed to the series. Consequently, working the figures into your plans is out of the question. As for the FIA's suggestion that it might waive the US$48 million (£25m) deposit to assist new teams, that has yet to happen.

If F1 is not an attractive business proposition, the only people funding entries will be car company chiefs running amok with the marketing budget once grand prix fever has robbed them of their judgement. As we have seen in the recent past, this is neither a stable or desirable situation. For a sustainable future, surely the sport needs outfits whose core business is going motor racing. To attract them, it needs to be a realistic business proposition, the value of which can be measured by the queue of investors wanting to sign up.

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Charles Armstrong-Wilson

The International Journal
Racecar engineering

Pit Crew

Vol 15 **No.6**

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Worldwide Subscriptions Racecar Engineering Subscriptions, PO Box 272, Hayward's Heath, West Sussex, RH16 3FS, UK
Typesetting & Repro Planart Ltd
Print Text Benham Goodhead Print,
Cover BR Hubbard Printers
Printed in England ISSN No 0961-1096
USPS No 007-969

Racecar Engineering
is a Focus Network publication, published by IPC Country & Leisure Media Ltd
A part of IPC Media, a TimeWarner company

***Racecar Engineering*, incorporating *Cars & Car Conversions* and *Rallysport*,** is published 12 times per annum and is available on subscription. Although due care has been taken to ensure that the content of this publication is accurate and up-to-date, the publisher can accept no liability for errors and omissions. Unless otherwise stated, this publication has not tested products or services that are described herein, and their inclusion does not imply any form of endorsement. By accepting advertisements in this publication, the publisher does not warrant their accuracy, nor accept responsibility for their contents. The publisher welcomes unsolicited manuscripts and illustrations but can accept no liability for their safe return.

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Radical's new low cost LMP

British sportscar manufacturer Radical has announced it is constructing a low cost car to LMP2 regulations. The Northamptonshire based firm has hired Peter Elleray (designer of the Le Mans wining Bentley) to oversee the design of the new car. The SR9 will feature an all carbon composite monocoque chassis which, when fully constructed, should be on sale for around £120,000 ($228,000) rolling. 'We want to keep the car cost effective, so we are not going to spend lots of expensive hours in the wind tunnel. Instead we have hired the best and are going to get it right first time,' stated Radical's co-founder Mick Hyde. 'Our philosophy is to expend as much effort on engineering a car to a price as we do on the car's performance,' he explained. 'This is a bit of a new experience for us, previously we wrote the rules to our cars, now we have to build a car to someone else's rules.'

Radical's own Powertec RPD Macroblock V8, a variant of the engine found in the company's SR8, but enlarged to 3.0-litres, will power the first cars. Taking advantage of the restrictor break for smaller engines, power is estimated to be 525bhp at 11,350rpm. The total cost for engine and ancillaries is expected to be in the region of £30,000 ($57,000). The chassis, however, will accept other LMP2 engines such as the Nicholson-McLaren unit.

There will be a number of optional extras for the car including carbon brakes and alternative transaxles for those who want extra performance for events like Le Mans. Designer Elleray is also assessing an innovative four-pot/four-pad braking system that would be unique in prototype racing.

The first examples will break cover in early 2006 with works assaults planned on both LMES and ALMS.

● Radical feature – page 44

Tech specs: Radical SR9

Designers	Peter Elleray and Nick Walford
Monocoque	Full carbon composite structure with moulded carbon cockpit surround and front crashbox to FIA specification
Engine	3.0-litre Powertec RPD Macroblock V8 with 44.7mm restrictor
Power	525bhp @ 11,350rpm
Torque	273lb.ft @ 7950rpm
[**Optional extras**	Judd V8 or Nicholson-McLaren engines]
Transaxle	Powertec RQ2 six-speed sequential 'box with integral suspension mounts
[**Options**	Paddle shift system, Hewland NLT]
Bodywork	Quick release, self-coloured, glass fibre nose with integral louvres and engine cover with top exiting exhaust; side pods and cockpit with integral rollbar fairing; bi-plane full width carbon composite wing; integral front diffuser; air management system and rear diffuser to ACO regulations; triple headlights and twin rear lights
Cockpit	Carbon composite surround with driver head protection system
Steering	Rack and pinion
Suspension	Fabricated steel wishbones front and rear; fabricated uprights and forged hubs; triple acting remote reservoir coilover dampers
Brakes	Radical six-pot calipers front and rear with 355/35mm iron discs
[**Options**	six-pot monoblock calipers front and rear with 355/32mm carbon discs]
Wheels	11J × 18-inch front; 14J × 18-inch rear
Tyres	Dunlop
Weight	750kg

Radical SR9 will feature a 3.0-litre Macroblock V8 and a £150,000 price tag

Mazda return to Sportscar racing

BK Motorsports has announced it will bring the Mazda name back into Sportscar racing. The Wisconsin-based team will run an LMP2-spec Courage C65 powered by a Mazda rotary engine in the ALMS. The Mazda and sportsbook.com backed team will also bring Goodyear tyres back to the series.

The triple rotor engine is based on the Mazda Renesis unit, but modified to use peripheral-port induction, as opposed to the production engine's side-port induction. The unit will rev to around 9000rpm, and will breathe through a 49.1mm restrictor.

Mazda's previous foray into prototype racing netted it victory at Le Mans in 1991, also with a rotary-engined car.

Confidence at Riley

Sportscar mainstay Riley Technologies has announced its intention to construct a new prototype to the LMP regulations.

'We currently have two parallel programmes, one for an open cockpit car and one for a closed cockpit car,' stated company vice president Bill Riley. 'The closed design features less drag, whilst the open car has a lower centre of gravity and more ballast to shift as required.' The chassis, the Riley MkXII, features a carbon fibre tub, power steering and paddle shift.

A mix of computational fluid dynamics, full scale wind tunnel testing and coast down testing will be used to develop the bodywork.

'The new Le Mans rules will be to our advantage because of the specified undertray and our history of optimising new rules packages. We have proven numerous times we can build a winning chassis. Now we want to do it with prototypes at Le Mans,' concluded Riley.

● On The Gas with Bill Riley – page 18

A1 GP growing fast

China, Australia, New Zealand, Mexico and Brazil were announced as the latest nations set to field A1 Grand Prix teams. A1 Team Mexico president, Juan Cortina, unveiled the nations entry at the prestigious Hippodrome de Las Americas. 'Mexico has all the ingredients to be very competitive in this new and exciting series and we are very proud to be able to build this winning team,' claimed Cortina.

The founder of the single-seater winter series, Sheikh Maktoum, took the opportunity to announce that there would also be a Brazilian team contesting the series, with Football star Ronaldo owner of the franchise. 'It's an honour to represent Brazil in any way I can, whether that's on the football pitch or by backing our national motorsport team,' he said.

The series organiser went on to celebrate its first birthday by announcing the involvement of A1 Team Australia and A1 Team New Zealand in this year's championship.

World © ©A1 GP Copyright Free

China is among the latest signings to A1 GP, alongside Australia, New Zealand, Mexico and Brazil

The overwhelming public enthusiasm to support a national team within the series has been extended past Team Australia's acceptance, as Australia also became the second nation to be confirmed as a race location (after Great Britain). The organisers confirmed at the Australian launch that the Eastern Creek circuit in Sydney is to host a round of the series, though the event date is still to be confirmed.

Financially backing the New Zealand entry is tycoon Colin Gilchrist, of Gilchrist Holdings, whilst former F1 world champion Alan Jones is fronting the Australian team. Since its launch, the championship has been heavily funded by some of the wealthiest businesses and government officials worldwide, whose net worth is an estimated 50 billion US dollars.

Maktoum continued to clock up the air miles, heading to the Far East to unveil A1 Team China and announce that the country would be host to the winter series final round. The Chinese cars striking red livery features the logos of Air China.

NEWS IN BRIEF

- The team formerly know as Taurus Sport has been re-branded and re-organised for the coming LMES season after gaining funding from APR associates. The team will now be known as Team Diesel. More information in next month's **Racecar Engineering**.

- Lamborghini has pulled out of GT racing as a factory team, handing over its projects to German firm Reiter Engineering, who originally developed the Murcielago R-GT.

- Russian bank SMP has renewed its association with the Minardi Formula 1 team. The deal will assure the team receives a comprehensive funding and marketing support package from SMP.

- A new generation SAFER barrier has been installed at the Indianapolis Motor Speedway. The new variant barrier features a smoother impact surface and a universal Styrofoam shape compatible with IRL and stock cars.

- K&N Engineering has been announced as the official air filter of the IRL. The deal is to include a $10,000 performance-based prize award for the Indianapolis 500.

FIA clarifies new engine rule

'Choosing' not to finish a race will no longer be an option as teams will have to answer to the stewards after the race

The FIA clarified the regulations on last lap retirements after BAR retired two healthy cars on the last lap of the Australian Grand Prix. The retirements allowed the cars of both Takuma Sato and Jenson Button to be fitted with fresh Honda V10s without incurring the penalty (starting 10 positions behind their 'actual' grid spot for the next race) that would normally be applied.

Starting at the Malaysian Grand Prix, any car that failed to finish or, as the case may be, chose not to finish, would have to have the circumstances of its retirement explained to the stewards of the meeting by the team that runs it.

If the stewards decide that the retirement was deliberate or unwarranted, the car could have to start the next race with the same engine or accept the 10 grid spot penalty.

Learning curves

140 teams have registered for this year's Formula SAE event in Pontiac, Michigan. The event, for student engineers to conceive, design, fabricate, and compete with small formula-style racecars, runs from 18 – 22 May and this year promises to be one of the hardest fought yet, with a large number of very strong teams on the entry list.

Particularly notable entries include 2004 champions Cornell University, Formula Student winners RMIT, Formula Australasia winners Georgia Tech, Formula SAE Japan winners UTA and British champions Oxford Brookes University.

For more information on the event, including the full entry list visit www.sae.org

F1 Academy widens its reach

The Renault F1 supported Altran Engineering Academy has widened its scope this year, by accepting entries from 20 different nations. Last year the competition to promote young engineering talent into Formula 1 was run as a trial in the UK.

The Altran Engineering Academy offers, to one dynamic young engineering graduate or final year engineering student, a six-month placement with the Renault F1 team R&D department in Enstone.

A Renault pool vehicle with a business fuel card, a salary of £6500 ($12,200), accommodation in a bedroom flat in Oxford and support from an Altran mentor are also included.

Candidates may register on the official website http://www.altran-academy.com by submitting a project focused on technological innovation in one of the following seven disciplines: aerodynamics; power; performance engineering; vehicle dynamics; control systems; electronics; materials transducers and fuel technology.

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Young, gifted and heading for F1? The Altran Engineering Academy could give you the opportunity

The competition is open until 28 May, with the placement beginning in September 2005.

Champ Car World Series to head out East

The Champ Car World Series will stage a race in China from next year onwards after an agreement was reached between the series organisers and the Beijing Auto and Motor Sports Association (BAMSA).

The event will take place at Goldenport Motor Park, the first privately-owned race circuit in the country, until 2008 and Beijing State-owned Asset Management Company chairman, Li Aiqing, has been announced as the event's prospective promoter.

Early discussions between the two point towards the race being staged in either May or September of 2006. 'This is a major step forward for the Champ Car World Series as we continue to establish our presence in the Asian markets,' said series co-owner Kevin Kalkoven. 'We believe these markets are fundamental to our series growth and future success.'

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Doing exactly what it says on the car - as of 2006 the Champ Car World Series will also run at Beijing in China

New backers mean Team Australia Racing is now big business

Walker Racing has recently publicised the formation of Team Australia Racing, a collaboration between Walker and two new sponsors. Two Australian businessmen, Craig Gore and John Fish, will join the Walker operation, beginning a campaign by entering a two-car team into this year's Champ Car World Series.

LAT

With Aussie Vineyards as its main sponsor, Team Australia joins Champ Car

Craig Gore, of Wright Patton Shakespeare Financial Group, was the first sponsor to be approached by team owner Derek Walker. Gore, already a competitor in the Australian V8 Super Car Series, has been intrigued by Champ Car since last year's Surfer's Paradise event, when the Walker team entered WPS driver David Besnard into the race.

It was Gore who then introduced the second partner and primary sponsor identity John Fish. Fish is the owner of Aussie Vineyards, a company planning to introduce its Australian wine brand into the US market.

However, Walker commented that the new sponsors in no way have part-ownership of his race team. Rather, the involvement of these two businesses was created as an opportunity to introduce new sponsorship and allow them to partake in the ownership of the race programme element. He said: 'Walker Racing is still 100 per cent owned by me and continues to look for business opportunities.'

BETTER BY DEGREES

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New arrivals in BTCC

Japanese drum beats, Samurai swords and just a waft of dry ice heralded the arrival of Team Dynamics' new Honda Integra (Acura) Type-R British touring car. The Japanese car will be the third new chassis on this year's BTCC grid, along with VX Racing's new Vauxhall Astra sport hatch and Speedequipe's Lexus IS200.

After initial testing, driver Matt Neal compared the Integra to last year's mechanically similar Civic Type-R: 'there was more rear end downforce, but I'm wise enough to know we need to work on certain areas to get it spot on.'

Both the Integra and Astra have so far won races in the early stages of the championship.

LAT

New Honda Integra and Vauxhall Astra go head to head

Lexus IS200 has so far proved uncompetitive

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Audi A4 DTM debut

Photos: LAT

Abt Sportsline ran the new Audi A4 DTM racecar for the first time in public at Spa Franchorchamps in April. It will go head to head this year with offerings from Mercedes, Opel and, in the late season, MG.

MG V8 supercar sees action

The MG Xpower SV supercar had a satisfying debut as it raced competitively for the first time in the VdeV Endurance Championships.

Unveiled at the Jarama circuit in Spain, the Xpower SV was entered privately by Peter Lloyd Racing, previously known for his Chemist Group business. The car finished reasonably, in 33rd position out of 43, despite not having any prior track testing and only three weeks groundwork under its wheels.

Created as a road-going track car, the SV has only the minimal amount of modifications necessary to make it race legal. Canadian expert Sean Hyland personally tuned the Xpower's 5.0-litre, 32-valve, quad camshaft, aluminium V8 engine, similar to that found in the SV-R.

Carbon technology plays a role too, as the car's light, yet sturdy, carbon composite body tackles the issue of weight. Supercar designer Peter Stevens also used carbon technology to shape the car's airflow management, resulting in each curve and edge having a much more significant purpose than just its dramatic aesthetics.

MG

A satisfying debut for MG's Xpower SV supercar showed there's more to come

INTERCOM

STUART HEPWORTH

From the glitz and sheer size of the PRI Show last December in Indianapolis, we came down to the large and very exciting Autosport Show a month later in Birmingham, but the huge drop, in size terms, of the Australian Racing Car Show in February came as a total shock. I needed a good two days to wander around the maze of booths at PRI, Autosport took at least a full day to peruse properly, but 25 minutes and the 70 stands of the Australian Racing Car Show had been seen, digested and put somewhere into the back of my mind. For me there was no ambience, no sparkling stands, no tantalising products and, while I was there at least, hardly any visitors – although to be fair I arrived early morning on the very first day.

Housed outside the main downtown area of Melbourne, the show was a little out of the way but, in its favour, was at least on the excellent Tramcar system. The grand sounding venue of the Royal Exhibition Buildings hid the fact that it was simply an old hall attached to a large museum.

The were really only two major events at the show, one being the Breakfast Opening Event, which doubled as a celebration for the 60th birthday of the Australian racing hero Peter Brock, the second being the launch of Ford's V8 BA Falcons in new livery. Of the displays, one entire side of the hall was made up of a line up of classic racing cars that in itself was worth the visit, but for me there was little more of interest.

The Australian performance industry is still in its infancy, when compared to the US and Europe, race attendances are way behind what we might normally expect and this of course affects the amount of sponsorship available to the teams. The majority of non-works teams have to manufacture components in-house as they simply cannot afford to involve specialist manufacturers. This affects the number of companies involved in the sport which, in turn, means not that many companies even capable of having a stand at the show.

On the plus side, there is a diverse range of motorsport in Australia – from touring cars to single seaters and dirt racers to dragsters, but something will have to change if this show is to expand in the future and succeed in showcasing a full array of services to individuals and teams – and with the logistics of bringing all the players in the industry together in one place at one time in a country the size of Australia, this could prove difficult.

Stuart Hepworth

NEWS IN BRIEF

- Tyre manufacturer Dunlop has been announced as the new title sponsor of the British Touring Car Championship for the next three years, replacing roadside assistance Green Flag. The series will now be known as the Dunlop MSA British Touring Car Championship.

- Spy cameras are to be fitted to all BTCC cars to monitor driving standards. Officials will now be able to review drivers' actions during on-track incidents using the footage from the Fujifilm units.

- Vauxhall BTCC team VX Racing has announced a partnership with RS, Britain's leading distributor of electronic, electrical and mechanical components.

- The Confederation of Australian Motorsport (CAMS) has revealed that the base for Rally Australia will move from its traditional location. The news was issued after the Western Australian government advised that it would not host the event in 2006. A number of other regions of the country have expressed an interest in the event.

- Denso Corporation is supplying specifically developed new components for the Subaru World Rally Team and the Toyota F1 team. Its Iridium spark plug, developed for use in the Impreza WRC2005, made its debut on Corona Rally Mexico. Denso has also developed a new alternator for the Toyota TF105 grand prix car.

FIA scraps WRC mandatory fuel rule

The FIA has scrapped a rule that previously forced all competitors on world championship rallies to use a fuel supplied by the governing body. From now on all 'non priority' entries will be allowed to use regular pump fuel from along the route. This should cut costs for competitors significantly, as previously teams using the FIA supply crews could face bills of up to £4500 per event. Welsh privateer Craig Middleton, who competed on rally GB last year in his Hyundai Accent WRC and is considering taking part again this year, commented 'it sounds like a decent idea, it could save us re-mapping the car for the event, and that alone would save us around £400.'

Mitsubishi happy with swap to active centre differential

Mitsubishi, the last of the WRC manufacturers to use a passive centre differential, has reported satisfaction with its new active system after its first competitive outing on the Corona Rally Mexico. Mitsubishi admitted that 'four or five' options were considered before engineering – and budget – considerations decided on a 'conventional' electro-hydraulically activated friction plate unit. Currently the front and rear differentials remain passive.

The team's cars finished fifth and eighth on the event, but had started the season with a fully passive system so effort could be concentrated on the 2005 specification Lancer's semi-automatic gearbox. The team must now make the decision to develop a fully active differential system or work on the car's suspension.

'The results of the last few rallies show that our technical development is improving rally by rally and we haven't had many difficulties since Catalunya last year, despite introducing new components such as the automatic gearshift and now the active differential system,' stated Team Mitsubishi's technical director Mario Fornaris.

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Much activity in Mitsubishi's technical department is starting to pay dividends

Stadium rock boosts crowds for WRC

This year's Acropolis Rally and Wales Rally GB will run stages in stadiums. Whilst the Greek event is using the 70,000 seat Olympic Stadium to construct a 2.4km super special stage with cars competing head to head, Rally GB organisers have decided to run a 1km stage at the Cardiff Millennium Stadium with cars running one at a time.

The Welsh 1km super special stage will start in the basement of the building on the event's second day. Cars will leap into public view one at a time over a specially prepared jump, and run round a figure of eight course. The lower viewing areas of the stadium will be removed for reasons of safety, leaving a capacity of 51,000.

These new stages are a definite step forward for the WRC and follow closely in the footsteps of the successful Race of Champions event in Paris's Stade De France last December which attracted 63,000 spectators.

Rally GB event organisers have also announced a more compact route and lower ticket prices for the forthcoming British event.

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Leaping into the public eye – both Rally GB and Acropolis to run stadium stages

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WRC teams struggle as Citroën brakes

The Citroën Xsara WRC's of Sebastian Loeb and François Duval ran a water cooling system on the front brakes and a fan to cool the rears. A large number of teams struggled with overheating brakes on Corona Rally Mexico, but the French team had fewer problems than the others. The hard-packed surfaces of the Mexican stages, allied to their high-speed nature, caused the problems. In places the surface was so smooth there was audible tyre squeal under cornering loads. Smaller discs and pads used by teams on gravel events were incapable of dealing with the heavier loads exerted upon them as drivers adapted to the harsher, almost asphalt-style braking technique.

Martin Sharp

One step ahead – Citroën's extra brake cooling proved advantageous in Mexico

Rocky road for Citroën Sport

Both works Citroën Xsara WRCs suffered stone impact-induced engine oil leaks on Rally Mexico. The team has struggled with this problem in the past, most notably on Rally Catalunya last year, when a defective sump weld was found to have caused oil loss and subsequent engine failure.

After Loeb's head gasket-induced engine failure on the Rally of Sweden – which immediately preceded Mexico – the team introduced a revised head gasket design for Mexico. This had been already designed before the South American round, and was scheduled for introduction in Sardinia in April, but brought forward for Mexico.

As reported in Racecar previously, Citroën Sport's chief engineer, the renowned Jean-Claude Vaucard, retired from his post at the end of February. His replacement, Xavier Mestelan-Pinon, does not wish to divulge design details of the Xsara WRC's latest head gasket, only to confirm that the team had been aware of the fragility of its predecessor.

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Rally Mexico's rough terrain caused problems for Xsaras but earlier head gasket issues appear to have been addressed

Part-time approval blues for Fabia WRC

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The second stage of the Skoda Fabia WRC's unprecedented 'two-part' homologation was carried out in time for Rally Mexico this year. These second-stage changes improve the car's aerodynamic efficiency through changes to the car's bodywork and rear spoiler, while carbon Kevlar replaces steel for the wings and its fifth door is now aluminium alloy.

Engine modifications also included some lightening on the exhaust system and a slightly less heavy Garrett turbocharger with different characteristics. A fly-by-wire throttle arrangement has also been incorporated into the existing Bosch engine management. The rest of the car's electronic control systems are designed and built by Pi Research – as first introduced on the Ford Focus WRC.

Not having contested the full 16-round World Rally Championship season in 2004, Skoda was unable to register as an official manufacturer entry. This meant the Fabia World Rally Car could not undergo a new homologation during 2004. However, discussions with the FIA resulted in its approval for homologation, with changes to be brought in during the latter part of 2004 as part of the 2005 homologation. This was only allowed on the understanding that the team would contest the entire championship with the car this year.

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United States of Europe

With NASCAR planning for the future, leading teams are looking to the UK and Europe to establish a solid engineering foothold

BY IAN WAGSTAFF

Advanced Engine Technology, the brainchild of Nextel Cup team founder Ray Evernham (above), is the first NASCAR engineering company to be based in the UK

The NASCAR fraternity has lately been expressing regard for the UK's Motorsports Valley. Now, Ray Evernham has done more than that with the establishment of Advanced Engine Technology, a 3800sq.ft operation based at Sywell Airfield, part way between Silverstone and Rockingham. Together, Evernham – founder of the eponymous Nextel Cup team – and his engine programme director Mark McArdle own a majority share in AET, leading to claims that this is the first NASCAR team to be operating at this level in Europe.

The other shareholders are the men on the ground in Northamptonshire, Ian Ronnie and Jeremy Wisner, both of them former Ilmor employees – Ronnie from the technical side of the business, Wisner from the operational.

Evernham currently builds Dodge engines while Ilmor is a supplier to Mercedes in F1, leading to speculation as to the reasons for the move. This has been fuelled by the fact that McArdle came from a single-seater background prior to joining Evernham in 2003. Indeed, he claims an 'open wheel mindset'. His CART career includes Truesports and Penske, while in the 1990s he too worked at Ilmor as director of US development and production engine building.

However, Ronnie and McArdle also share a NASCAR connection. The former observes that when he was working in the USA introducing the Penske South operation to Ilmor practices, McArdle was similarly updating the way in which Evernham Motorsports operated. NASCAR teams, he recalls, 'were used to buying components, sticking them on the shelf and then not doing anything with them.'

Initially, AET will be engineering parts for NASCAR engines, although the results are unlikely to be seen until the end of the season. McArdle states that 'the initial intent is to enhance the performance of the 9, 19 and 91 cars' - the Evernham Dodges of Jeremy Mayfield, Kasey Kahne and Bill Elliott.

> **"NASCAR PEOPLE ARE BUYING PARTS FROM EUROPEAN-OWNED FIRMS"**

Evernham also supplies engines to the Petty Enterprises team on an equal footing, and to various in the Busch series. He says this will give 'a captive customer to start with', while providing the environment in which to grow. Manufacture of components is likely to follow later this year for the use in the 2006 season. Ronnie describes the parts to be made as 'anything that moves – valve train and bottom end components.'

The company headcount is expected to reach six by the end of this year. Once established, the operation will evaluate other forms of racing, but Ronnie believes it will be at least 18 months before this happens as systems, processes and relationships with suppliers need to be developed first. Evernham speaks of 'sedan racing', in particular V8 classes, casting an eye on the Rockingham (UK)-based oval series SCSA (formerly known as ASCAR and 'Days of Thunder'), which this year is to be supplied for the first time by fellow NASCAR engine specialist Roush.

NASCAR people are buying parts from European-owned firms like Eibach, Alcon, Brembo, Beru F1, Deutsche and Good Fabrications. However, the existence of AET and of Roush's ownership of Mountune Racing indicates an interest in also operating here. Through Mountune, Roush is, from this year, supplying the GM ASA Vortec 5700 engines used in Europe's only oval series. During its five years Rockingham has developed relationships with NASCAR – the Richard Petty Experience was used to help launch the track and now it has been announced that this year's SCSA champion will be on his way to compete in the USAR Hooters Pro Cup Series. The association with a name like Roush must add further NASCAR-style credibility to the series.

On the subject of F1, Evernham does admit that 'at some point I hope we are successful enough' to be able to think about this. According to McArdle 'anyone involved in technology at this level has got to look in that direction.' It can also be observed that, prior to joining Ilmor, Ronnie at one time worked for Cosworth on the customer F1 programme. However, both Evernham and McArdle are adamant that AET must take a 'crawl, stand, walk approach.' McArdle adds that this company will be market driven: 'we must go where the need is.'

As a crew chief, Evernham masterminded three NASCAR championships for Jeff Gordon before establishing his own team in 1999 and leading the re-entry of Dodge into NASCAR. His reasoning for wanting to operate in the UK is based on the quality of engineers there. He is impressed by the level of F1-driven technology in the UK and believes that it is more obvious to create a base there, 'rather than try and uproot people.' His deputy technical director Tommy Wheeler also points out the high level of suppliers located in the UK. 'Bringing in the resources of Motorsports Valley makes all the sense in the world,' adds McArdle. Ronnie concurs with his American colleagues: 'This is where the skill base is.'

Race people

Derek Bell

Peter Elleray

Gil De Ferran

Prince Rainier

● The Champ Car World Series has announced the hiring of former NFL international executive **Will Wilson** to serve as executive vice president of sales and marketing. In his new post, he will oversee all aspects of the series' sales and marketing.

● Also new to the CCWS is **Scot Elkins** as the new director of technology. His previous role was as chief engineer for NASCAR team Robert Yates Racing. His new role will make him responsible for future development of the series, aerodynamic work and simulations.

● **Gil De Ferran** has been appointed as BAR's sporting director. De Ferran, who won the CART title twice and the Indy 500 during a 20-year career as a driver, will use his experience to assist the team on events. He will leave ABC ESPN's broadcasting team.

● Europe's longest reigning monarch **Prince Rainier of Monaco** has died aged 81. His son, Prince Albert, will assume his father's royal duties.

● **Rob White** has been promoted to deputy managing director of the Renault F1 team following **Bernard Dudot's** retirement.

● Sportscar veteran **Derek Bell** has teamed up with Michael Flux to set up an organisation to compete in the 2006 ALMS. InnovaTech will run twin Corvette C6Rs in the endurance series. Bell will not be involved as a driver.

● Designer of the Le Mans winning Bentleys, **Peter Elleray**, has been hired by Radical as a consultant to oversee the design of it's new SR9 LMP2 sports prototype.

● **Ryuichiro Kuze** has died. The former president of Subaru Technica International was instrumental in Subaru's entry into rallying, and also the agreement to use Prodrive to develop its cars for competition.

● Ford Performance Racing has appointed two new senior figures to its Australian V8 team. **Tim Edwards** is the new director of motorsport of the Prodrive-owned outfit. Edwards, whose previous roles have seen him working at the Jordan grand prix team, will be joined by former Brand Hatch Circuits Group marketing director **Rod Barrett** as commercial director.

● **John Tojeiro**, designer of numerous cars including the Ecurie Ecosse Climax – one of the first mid-engined GT coupés – and the AC Ace that led to the legendary AC Cobra racecars, has died aged 81.

● Formula Vee racer and former ***Motorsport News*** columnist **Sam Collins** has joined ***Racecar Engineering*** as deputy editor.

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

ON THE GAS...

BILL RILEY
Director, Riley Technologies LLC

Riley's job is to oversee all aspects of the SunTrust Racing Daytona Prototype Team and develop future motorsports projects for the company

How did you first get involved in motorsport?
I worked for my father as a detail draftsman when I was 16. I knew I wanted to be in motorsports though when I was five. My parents never pushed it.

What's the most interesting project you've ever worked on?
I have been fortunate to have several. The projects that stand out are the Cadillac LMP, JMR's MkIIIC and chassis engineering for Robert Yates Racing's NASCAR programme. Running a car at LeMans is always at the top of my list.

What achievements are you most proud of?
The win record of the MkIIIA and the Daytona Prototype project.

Can you name your favourite racing car of all time?
The next car we build! I generally do not like the cars I have been involved with because I only see the mistakes. My Father taught me that. If I did pick a car though I would say the GT40 MkIV.

Who do you most admire in racecar engineering and why?
My father. He just turned 74 and still works on racecar design six days a week. He has a great balance of over 50 years of racecar engineering experience on one side and a hunger for the latest technology on the other.

What racing era/formula would you have liked to work in and why?
Indy Cars in the '70s. The Indy 500 was so big and the cars were so different and creative.

What tool/instrument could you not work without?
The obvious answer is my laptop but, the biggest asset I have is the people I work with. It makes racing a lot easier.

What engineering innovation do you most admire?
I feel that ground effects was the biggest engineering innovation in motorsports.

Is motorsport about engineering or entertainment?
It's a mixture of both. I think it changes with the series you're in. In Sportscars, engineering is larger, while in NASCAR it's entertainment. Working on a Nextel Cup team is as challenging as any other project I've ever been involved with. People who think the Nextel Cup is not interesting or challenging are very misinformed in my opinion.

What new technologies in motorsport are you most excited about?
We have been using CFD since 1994 and every year it gets better and better. Because of this, I have more faith in CFD for sportscars than a 40 per cent model.

Is there a future for high technology in motorsport?
There will always be high technology in motorsport but the financial side of motorsport needs to be fixed. They have done this with Daytona Prototypes. I think that the racing and the grids shows it.


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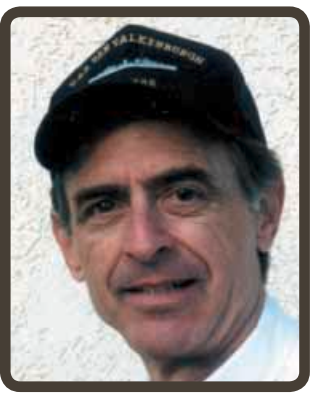
By Paul Van Valkenburgh



Technology potential

Topics for discussion that push the boundaries of contemporary motorsport thinking

Just a little over 50 years ago I got my first job, delivering newspapers, so I could buy a petrol Maytag engine to power my first four-wheel project, which went about walking speed. I never could have fantasised what fortuitous automotive adventures were to come, which so many enthusiasts can only dream about: the projects I've worked on; the great and wonderful people I've worked with; the thrills of test driving and racing. I've tested Chaparral prototypes and the original GT40, raced against Gurney, Parnelli, and Donohue in the Trans-Am, been paid to go to dragster and superspeedway schools, as well as to Mexico, Japan, Italy, and Finland. People still envy my Stingray (Automobile magazine editors voted that the 'coolest' car ever), and I just say, 'well, it gets me there.'

Maybe I'm jaded. Maybe after half a century I've earned a sabbatical. I don't know, but I started wondering if I'd missed some important topics for discussion in my columns. So I sent a plea out to a few friends, to see what they would suggest I write about, and then realised I could use their responses as the column itself. In fact there were so many good comments that it has taken two months – last month on the human element, and this one on technology.

Terry Satchell, consulting race engineer:
'Write a column about NASCAR rules. For front coil springs, they now have restrictions on the wire diameter, coil diameter, number of active coils and the free height, without ever stating what they are trying to accomplish. As they incrementally changed the spring rules, they found that the teams would do something they didn't expect, so they would increment the rule again and so on until we have every factor affecting the design of a spring under a rule limit. And every time they tweaked a rule, the teams had to buy a new library of springs at a cost of several thousand dollars. The gear rule coming up will probably have teams changing cams and manifolds at the track, instead of rear end gears, for optimising performance. And there will be many more races that →

> "I NEVER COULD HAVE FANTASISED WHAT FORTUITOUS AUTOMOTIVE ADVENTURES WERE TO COME"

> "I STARTED WONDERING IF I'D MISSED SOME IMPORTANT TOPICS FOR DISCUSSION IN MY COLUMNS"

they have to race what they qualified. It should cut down on the cost and time to prepare, install, and then remove special vehicle sub-systems specifically optimised for two laps of qualifying. I think the reduction in emphasis on qualifying is good and may make the racing better.

'Or you could write a 'what-if' column about what might happen if NASCAR got rid of carburettors and went to modern, closed loop control fuel injection. That would be a hoot.' [I'm watching the introduction of electronic fuel control in NHRA drag racing.]

Buddy Fey, author of Data Power:

'Here's what I'd like to see someone look into:

1 Neural net software (like the stock market analysts use for pattern recognition) to do automated review of logged data.
2 How to deal constructively with divergence of opinion between the engineer, driver and data. Yeah, I can deal with it from experience, but how about an analytical approach.
3 Nobody seems to have covered race strategy to my satisfaction. I know it's different in each series, but again, how about a general analytical approach. Surely the military has something?
4 Something about seven-post testing (that isn't self-serving for the author), or the use of servo-motor shock dynos.'

[Serious topics that require original research.]

Don Prieto, racing writer:

'Why don't you try to identify the acceleration limits on fuel dragsters and funny cars in terms of elapsed time and miles per hour (driving through the tyres) in the quarter mile? No one has ever done a graph of the progress over time to predict what the future holds.'

[The progress curve has been pretty flat since rules became the limiting factor, rather than physics.]

Dennis Simanaitis, Road & Track editor:

'Here are a few things I've not known and, in fact, barely knew who to ask.

1 Do the proposed F1 changes from V10 back to V8 have balancing issues? How good is a V10 anyway? And does it matter?
2 Your own personal assessment of the five best technical readings of the past five years.
3 Air racing. Does it warrant the coverage of your neat drag racing column?'

[Both air and powerboat racing might have some lessons for us.]

Doug Stokes, track promoter:

'Think about advancing competition by putting the tech-genie back in the bottle. How about re-visiting some of the high tech horrors that you (and your friends) have foisted upon the racing world as 'progress' and set a new course toward making racing interesting again. If racing really is to be an exhibition of driving skill, how about simplifying the racing vehicles to the point at which the average fans can actually see the driver's talent, as opposed to reading it out on some sort of measuring device. I suggest that formula-type racecars (up to and including F1 cars) have their front braking system removed (and everything else left in place) – braking zones would open up exponentially! They still talk about Fangio and Moss and how they overcame bad racecars. Let's purpose-build 'bad' racecars from the ground up, and then see who can saddle 'em and who can ride those sumbitches [sic] the best!'

[Yeah, it would be like 'drifting' in having to re-learn everything you know about chassis set-up.]

Jim Hamilton, IRL engineer:

'How about a racing series that demands very low thermal and CO_2 emission and works on a given fuel energy/fixed race time basis? I learned that the huge oil companies such as Shell and Exxon consider themselves in the energy business, not oil, and are very flexible to alternate sources, whereas it's small suppliers, wildcatters, and the corporations that seem to own our executive branch that resist.'

[A number of racing engineers agree.]

Kim Reynolds, test engineer:

'Probably it's abnormal to keep digging in the same earth forever. How about a discussion of how a tech-type's interest in racing can slip, then return, and when it does, often you see things from a different angle, have fresh ideas, and ultimately are further ahead than if this 'slipping' period never happened. There may be examples from your own career to cite.

I suggest that a serious form of motorsport be created, wherein the big problems facing our energy and transportation futures are tackled via the crucible of racing. The storm clouds are gathering fast over our four-wheel futures, and quick creative thinking is needed to find a way a way out of this mess. Quick, creative thinking is racing. How about a hydrogen series wherein the onboard storage problem must be solved? Or a series where you must create the energy you bring to the track? Who knows, maybe a DARPA prize sort of thing, but with Ford, GM, Toyota etc. as the contestants instead of college students. Unless something is done soon, there won't be a whole lot of racing going on in a few decades otherwise.'

[Actually, some federal agencies are looking into this right now.]

Charlie Mandolia, racing spectator:

'Possible strategies for a writing career extension:

1 Repeat topics, perhaps as an 'update' (after 10 years there are always lots of new readers). Hardcore fans don't care that there's nothing new except today's game.
2 Adjust lap times for technical progress, then compare drivers from different eras.
3 Do a piece on the retro muscle car era – cars that cost so much these days and show that modern engines are really much more powerful.'

[Little did he know, this one already is a repeat topic.]

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Ford Popular

Some years ago, Racecar ran some articles on Formula Ford 1600cc workshop set-up covering engine, chassis, gearbox and general prep [Racecar V3N2 – V4N3]. I kept a number of these articles and have been making good use of them in the running of my own Jamun M92 Formula Ford, and sharing the articles with others I know with FF 1600s. I would like to get hold of the missing articles, I know I missed chassis and set-up but I suspect I missed others. Could you help me in obtaining the articles I am missing? Could you send me a list of all the articles you ran and I can compare them to what I have and then talk to you about how I could obtain reprints.

As an aside, you are probably aware the amount of books or reference material on FF 1600s are few to non-existent, with only the Steve Nickless 'Anatomy of a Formula Ford' being available if and wherever you can find it. With the resurgence in FF 1600s could these workshop articles be brought together in a book available through Racecar? I certainly find the ones I have invaluable as reference material.

Paul Barritt, by email

We are presently looking into ways of making features such as these available again, as unfortunately the back issues no longer are.

It is certainly good to see the resurgence of Formula Ford 1600 in the UK though – Ed

Email the Editor: racecar@ipcmedia.com
or send your letters to: The Editor, Racecar Engineering, IPC Media, Leon House, 233 High Street, Croydon, CR9 1HZ, England Fax: +44 (0)20 8726 8399
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Formula Ford appears to be undergoing a resurgence around the world, at least two Racecar readers think so

Spectrum

Ford Fiesta

There has been quite a bit written about the Formula Ford category in recent issues and I felt it timely to write to you to remind you of the Australian built Spectrum Formula Ford. I have attached photographs of our current offering, the Spectrum 010b (see above).

It is with interest that I read about the imminent changes to the category in the UK, as we will use the 1600cc Duratec engine in Australia from 2006. The engine is from the Fiesta road car and will replace the Kent engine in national competition after this season. This will perhaps be the first time in some years that we will have a uniform set of engine regulations between our countries.

The technical college in the rural Queensland city of Warwick has ordered a car to be used in their specialist motorsport training course. We are just about to deliver this car and it is the first Spectrum to be built with the new 'Fiesta' engine. Indeed, we would be interested to know if this is in fact the first Formula Ford in the world to be built for the new engine.

The category is resurgent down under, with fields of 30+ cars competing at both state and national level. We believe that the continued support of Ford Australia, combined with the reduction in engine maintenance costs that will be afforded by the change to the new engine, bodes very well for the category ongoing.

Paul Zsidy
Borland Racing Developments, by email

That's entertainment!

In response to Edgar Jessop's letter in Racecar V15N5 regarding what F1 fans, switched off by processional races such as the one that took place in Australia, will turn to as an adrenaline-pumping alternative, may I suggest that they look no further than MotoGP.

At the recent opening round in Jerez, Spain the two top riders of the day turned what could have been an F1 Melbourne-style trundle into a fairing bashing thriller.

Perhaps the business brains behind F1 should realise that good characters produce good racing, and in turn good crowds, not hi-tech cars and secrecy. The rider's gestures afterwards were a delight to see.

Mark Evans
Llauo Y Dos
Wales

Words	Carlin Gerbich
Photos	Gerbich; Sutton Images

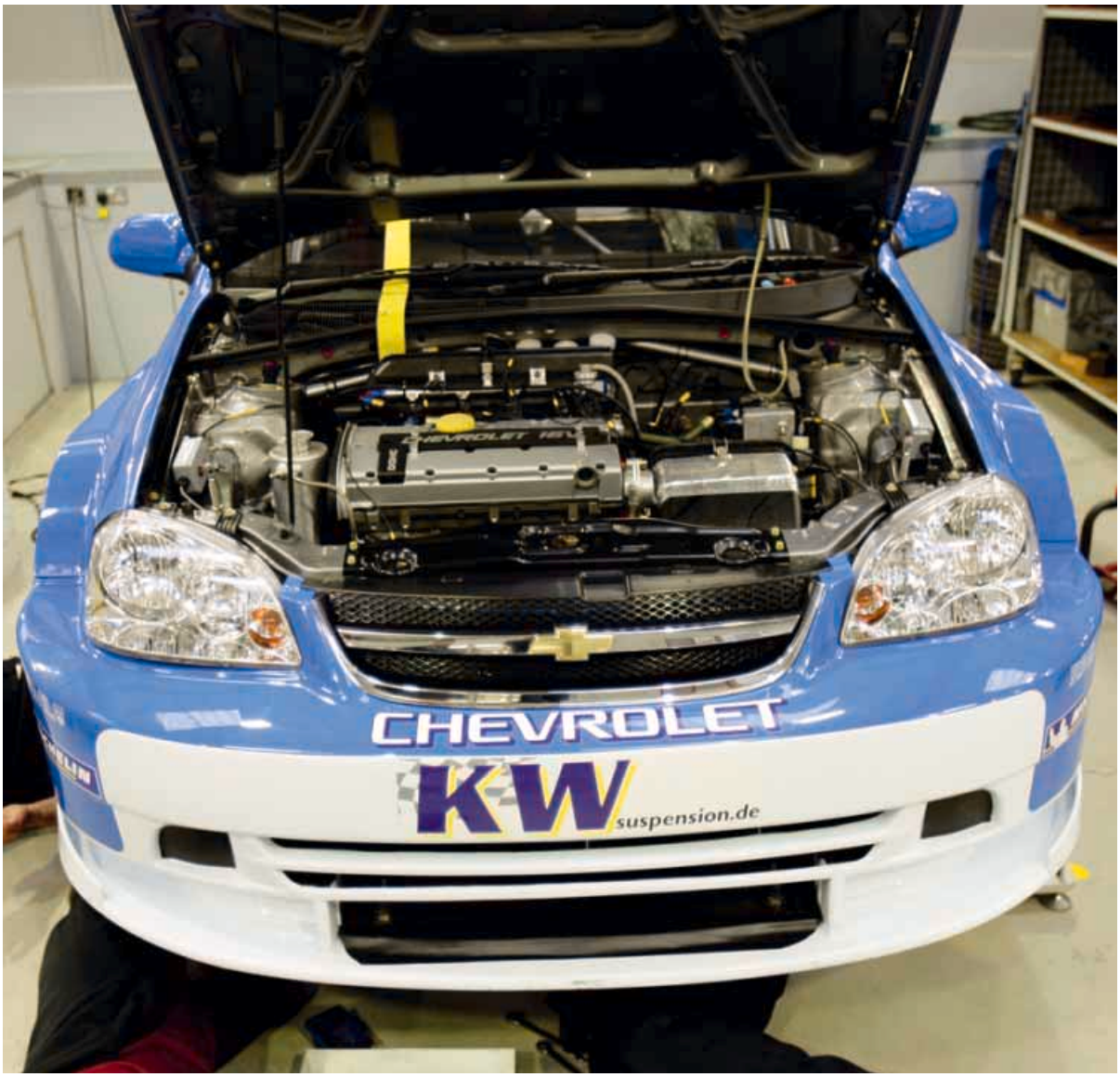
Badge engineering

With Daewoos controversially re-badged as Chevrolets, GM had to find a way to promote the brand, and in World Touring Cars it may just have found it

There's nothing new about using motorsport to promote a brand. Motorsport is founded and fuelled on the principle that success on the racetrack means success in the showrooms. It's a principle that built the Ford brand, and now GM wants to do the same – to address a slump in European revenue by regenerating its product range and marque positioning. Despite a record year for GM globally, GM Europe posted a £385m ($731m) loss in 2004, which followed a loss of £148m ($281m) in 2003. With annual operating costs needing to be cut by around £350m ($664m) GM Europe was forced to re-evaluate its brand.

> "IT GIVES US A WORLD PRESENCE IN MOTORSPORT"

Opel/Vauxhall wasn't setting the world alight, despite an impressive turnaround in product quality and a slight increase in sales, the Daewoo brand had reached its zenith and even Saab products were starting to show their age. The result was that the Daewoo brand was dropped, and its range – the Matiz, Kalos, Nubira, Lacetti and Tacuma – re-badged, in all but a few of the marque markets, as Chevrolets – a name most people in the UK associate with large V8 muscle cars, something GM wants to cash in on. The company wholeheartedly believes that, for the average Joe comparing notes over a pint with his mates, badge



European Lacettis are not available with a 2.0-litre engine, but the Canadian market Optra is, its engine being manufactured by Holden in Australia

Modified by Swindon Racing Engines, the previously 110bhp engine now makes 270bhp with help from MoTeC management

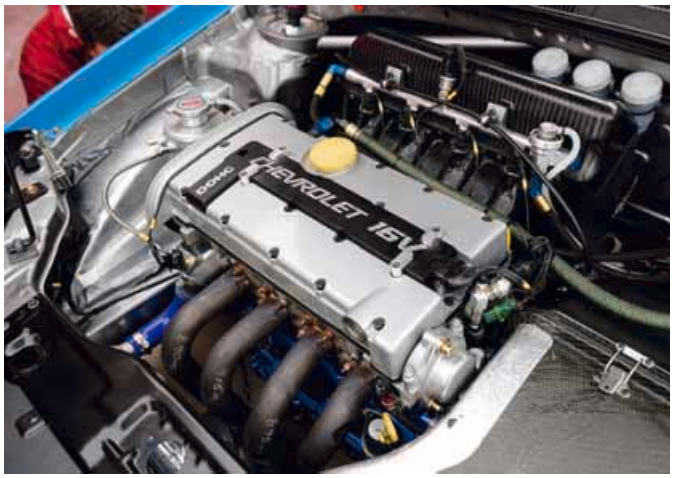
snobbery is an issue and the Daewoo brand was a millstone. No matter how reliable, safe, value-packed or rammed with goodies its products may be, Daewoo simply doesn't have the same pub ammo impact that the Chevrolet badge does. Tell your mates you drive a Chevrolet, and they'll ask a bit more about it as they remember the heyday of American muscle cars and rorty V8s. Tell them you drive a Daewoo and you may as well have told them you work for the Inland Revenue and moonlight as a traffic warden.

So, with a considerable promotional budget, Chevrolet Europe started to shop around for prestigious ways to enhance its 'new' brand image.

Sporting appeal

Speaking during the Lacetti's first run at Albacete in Spain in February, Eric Nève, Chevrolet Europe's motorsport manager, said they looked at various sports to promote the brand, but needed something that related directly to their cars: 'Other sports may come later as we broaden the appeal of the brand as a whole, but for now we need an activity where people can see our products in action – and the World Touring Car Championship gives us that. It's the closest sport for a car manufacturer to be involved with – it gets visibility, and the credibility of building cars that are good. There's a trust that the customer then has for your car.

'It's perfect for us. It goes to every one of our key markets on three continents, and it gives us a world presence in motorsport, and the cars aren't so removed from our products as to look nothing like them. Okay, they're a little different than the road cars, but you can see that the racecar is a Lacetti.'



"ONE OF THE PROBLEMS WAS A LACK OF A 2.0-LITRE ENGINE"

Ray Mallock of Ray Mallock Limited (RML) had been in discussion with GM for four years over its motorsport programme in Europe, and because the company had warmed to the idea of the WTCC championship, they commissioned RML to complete initial research into →

Lacetti 'shell has high inherent stiffness, making it an ideal for a WTC car

Good weight distribution and central roll centre make for a well balanced car

After initially looking at the hatch, the saloon version was deemed preferable

the Lacetti saloon and hatch as a platform for racing last April. For Mallock, the chance to compete in a new championship, with a new car – whether it wore a Daewoo or Chevrolet badge – was a big attraction, particularly given the enthusiasm with which GM was looking at the project.

Mallock says that the step up to World Touring Cars from the British Touring Car Championship was a fresh challenge his team was ready for. 'We learned a lot last year, and it was a good experience. But this is an entirely different thing – it's much bigger and we have more control so we're able to do things our way. We're responsible for building and running the car and sourcing suppliers and partners, so it means we're able to work with people we trust and who we have a long association with. I wouldn't have wanted to stick with the BTCC with this championship running. We'd done that. I wanted to make the next natural step, and Chevrolet trusted us with the job.

'The FIA has a sensible set of rules which looked designed to make the racing close but keep costs down. Nobody disputes the fact that the costs of Super Touring were getting out of hand – we were seeing spare cars and test teams and costs were astronomical. The FIA has settled on a good set of rules – and they've been receptive to sensible ideas, which is great.'

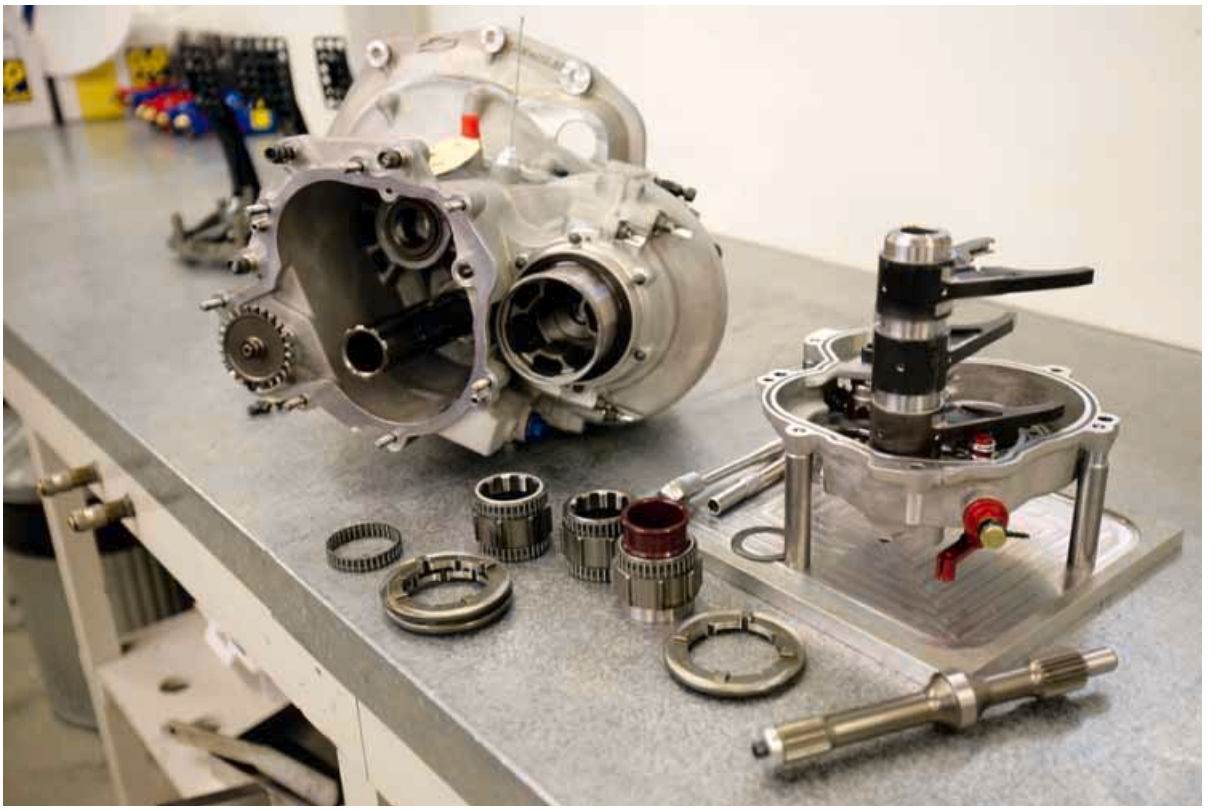
The Lacetti hatch was ruled out fairly early on because the saloon had more favourable lift and drag characteristics, while the positioning of the championship standard rear wing was better aerodynamically than on the hatch. RML's development started on the saloon in April last year, design work started in August and, by January this year, the car was put through its first shakedown at MIRA with former BTCC driver and RML team member Rob Huff at the wheel. From AutoCAD to auto testing in 10 months – par for the course for RML. The team did it with the Saleen S7, too.

Mallock: 'We looked at the base car, then looked at the opposition and weighed up what we had to work with and how we could best build a car to make the most of the regulations. The position of the engine, weight distribution, and the suspension type and geometry all has an important bearing on this. The MacPherson front and rear suspension offers great balance, while the car's inherent stiffness and central roll centre mean it's a nicely balanced car. It's the narrowest of its competitors, so we needed to address that, but the initial period of evaluation showed the car was a good starting point.'

> "BADGE SNOBBERY IS AN ISSUE AND THE DAEWOO BRAND WAS A MILLSTONE"

WTCC rules leave little room for movement from the standard production car, so wind-tunnel time has centred on refining the car's deeper front bumper and the positioning of the common rear wing that each car must carry. The FIA also re-worded regulations restricting the width of the car's track to give all competitors an equal footing. It has meant the Lacetti's track is about 9mm wider each side. That may not sound much, but in a deeply competitive championship, every millimetre will count.

One of the problems to be overcome was a lack of a 2.0-litre engine. →



The gearbox chosen for the WTC version is a Hewland six-speed sequential

To keep costs down, teams are restricted to homologating a maximum of 20 gear ratios per season

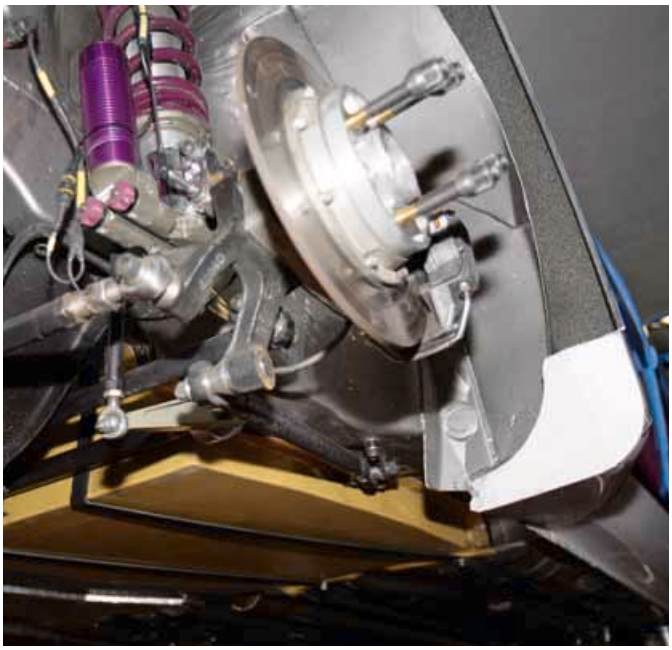
"FEWER RATIOS MEANS LESS TESTING AND FEWER COMPONENTS"

A specially-designed bellhousing is used to mate the gearbox and engine

The largest engine fitted to the Lacetti in Europe will be the 1.8, but a 2.0-litre version is used in the Canadian market Lacetti, the Optra. The engine, part of the GM Family Two range, is designed and built by Holden in Australia and has been raced in F3 for several years. Though there's an obvious link to the engine's GM heritage, Mallock says the engine doesn't share any of its internal components with the Astra F2 kit car engine, nor the engine used in the Astra BTCC winner. Swindon Racing Engines, a company with a long association with RML (Mallock was its first commercial customer when he needed engines for his Formula Atlantic series in the early 1980s), has transformed the 110bhp standard lump into a strong, high revving 270bhp powerplant that uses MoTeC engine management. While peak power is important, the engines also have to last four consecutive sprint races, so engine security is also high on the list of priorities. Balancing reliability with consistency is something only the most experienced teams get right, and RML's attention to detail has served it well in the past.

The engine is mated to a Hewland six-speed sequential gearbox via a specially fabricated bellhousing. Each team is restricted to homologating 20 ratios for the season – a far cry from the 20 or so sets of ratios allowed→

Alcon is the chosen supplier for brake discs and calipers, used front and rear



MacPherson struts all round on the standard road car have to be retained

At RML there is the breadth of skills to create the parts for a racecar project

during the Super Touring era – but another way in which the FIA has limited the costs of competing. Fewer ratios means less testing and fewer components to be carried to events.

The car is fitted with Alcon calipers and discs front and rear, but suppliers for the company's dampers had not been settled when Racecar spoke with Mallock. 'We're still discussing contracts, so I'd rather not say what we're using in competition until it has been settled. We're still developing a lot of prototype components, and we may even race the first event with prototype parts still on the car'

Another big plus for entering World Touring Cars, as far as General Motors is concerned, is the fact that the sport is relatively cheap, at least by Super Touring standards. With restrictions on testing, strict rules designed to cut costs, and an all-inclusive entry fee that includes peripheral expenses such as shipping cars and equipment to the two long-haul events in Mexico and China, as well as promotion through television coverage and an FIA-sanctioned website, the WTCC package is an attractive one. Couple that with an emphasis on preserving engines (each engine must last two consecutive race weekends – four 50km races in total), and 30-minute turnaround times between races, the cost structure can be managed more efficiently. Top-flight competition and well-grounded regulations simply made sense.

> **"THE WTCC PACKAGE IS AN ATTRACTIVE ONE"**

Reaction time

Initial tests at MIRA showed that the car was strong and well balanced. Run simply to see whether it worked, the car impressed Rob Huff – a man who drove for RML's SEAT operation last year, and a driver well positioned to compare the two cars built to Super2000 regulations.

'It's very quick, and very well sorted – but we've a lot of testing to do yet. We need to know what it does at its limits and how we can get the best out of it,' Huff told Racecar.

The first two racecars (three will be built in total, with a fourth 'shell prepped and ready to build should they need it) were sent to Albacete in early February for extreme testing. Cold track temperatures slowed testing, but the team was able to come back with a set of numbers that seemed to make sense and please everyone involved. The trip generated a considerable job list for the team to complete before returning to Spain three weeks later.

Race team manager Mark Busfield said, 'We simply wanted to see what →

RML

Having run the SEAT British Touring Car team in 2004, Mallock said the challenge of developing and running an entire project from the ground up was something he couldn't refuse, particularly as it meant the company would be operating at world level again.

Mallock's history of developing race-winning cars is impressive – and his ability to land his cars on the podium within the first year, and then take a championship the following year is the sort of crucial credential manufacturers look for. Success hasn't come easy – but it's been fairly consistent throughout Mallock's career. The Aston Martin Nimrod was developed and raced by Mallock's fledgling operation in 1984, as was the Ecurie Ecosse C2 sportscar that same year. While each year continued in a similar vein, Mallock's desire to extend his operations led to RML's first road car project – the RML GT40 in 1991 – of which only a handful were made. RML ran ex-factory Vauxhall Cavaliers for the Ecurie Ecosse team in the BTCC in 1992 and in 1993 designed, developed and raced its own Cavaliers that regularly outpaced the factory cars. Vauxhall took it to heart and awarded RML the contract for the BTCC the following year. The team won it with John Cleland in 1995 and was awarded the Nissan BTCC contract for 1997. In 1998 RML won it with the Primera, and in 1999 won it again for Nissan. RML won the British Rally Championship in 2000 with the Vauxhall Astra F2 kit car while also developing the Saleen S7 race and road car, and starting design of the Opel Corsa Super 1600 rally car. In 2001, the Saleen S7R won all but one race of the ELMS series and also won the Sebring 12 hour event, while in 2002 RML won the inaugural ASCAR championship, the Opel Corsa won its first event and the team took ninth place during the Champcar series. The team retained its ASCAR title in 2003 while the Opel Corsa won both the British S1600 and British Junior Rally championships. RML's programme in 2004 was just as busy: sportscar racing at both Le Mans and in the FIA GT Championship with the Saleen S7R and MG Lola. Oh, and let's not forget the nine wins for SEAT's BTCC operation. With this kind of heritage it's easy to see why Chevrolet was so keen to have RML run its cars, particularly as it is well equipped to react quickly to large scale, confidential projects.

RML HQ in Wellingborough occupies two massive adjoining workshops that share a combined floor space of around 42,000sq.ft. One is split between the Chevrolet WTCC team and confidential private client projects (the design team is also based there), while the second houses logistics, management, purchasing, sub-assembly and crack detection section, CNC fabrication shop, transmission assembly workshop, welding areas for wishbones and other components and RML's own wiring loom shop.

'We've all the facilities in-house to enable us to react to any prototype project swiftly, and develop them quickly,' says Mallock. 'The fab shop takes care of bodyshell preparation and suspension, the machine shop has CNC capability, our sub assembly section is very good and our own design work employs up to six design engineers, as and when we need them.

'We sub out engine work, major paintwork and our design team and engineers work closely with our transmission suppliers, whether it's Hewland, Ricardo or Xtrac, to develop products to our specification.'

In all, RML employs between 80-85 people, plus contractors, between its various race and road programmes. Around 25 of those will be present at every WTCC race this season.

Capable of most aspects of a project in-house, RML is a success story

Testing has shown promise, and Chevrolet and RML are committed to winning

the car did, and what is was capable of. All three drivers were happy with the car out of the box, which was something. We expected to have something to work on, but it seemed to go without highlighting any glaring problems.'

Independently, all drivers concurred that the team seemed to have developed a strong package, and even Swiss driver and double BTCC winner Alain Menu told Racecar that he was looking forward to becoming world champion driving a Chevrolet. A little pre-emptive perhaps but a sign that just weeks out from the start of the championship RML's progress is bang on target.

> **"CHEVROLET HAS COMMITTED TO A THREE-YEAR PROGRAMME WITH RML"**

Busfield sides with his boss when it comes to making predictions for the inaugural season of the series: 'We're taking a gradual approach to the season. We're the new boys on the block and we've a lot to prove against other teams who've run at European level for several years. But we expect to be mixing it with them. We've a great driver line-up in Alain [Menu], Nicola [Larini, ex-F1 driver and ETCC Alfa driver] and Rob [Huff, RML signing in 2004 for Seat], and we've got a great working atmosphere.

'They're all team players, and they're as keen as we are to hand Chevrolet a world championship. We've an eye on the goal, but we're not losing sight of where we are now.'

Chevrolet has committed to a three-year programme with RML, and future participation will rest on how well the series serves to promote its products, and how well RML does. After all, racing is about winning, and every manufacturer wants to see its cars succeed on the racetrack. Mallock says they've not even considered a customer car programme for the Lacetti in 2006, but agrees that it's a possibility. 'We're concentrating on making the car as successful as we possibly can over the coming season. Next year is a long way away just yet, and we've a lot to do between now and then to catch up to where the more established teams are now.'

That may well be so, but RML's tendency to dominate every series it contests by the second year means those teams may find themselves running to keep up with the pace of progress pouring out of Mallock's workshops. RE

NASCAR in 2005

Words | Ian Wagstaff
Photos | Sutton Images; Wagstaff

New regulations aimed at cost cutting are forcing NASCAR teams to take a new, more engineering based approach to problem solving. **Racecar** investigates

Perceptions can be deceiving. Despite its pushrod engines, carburettors and 1960's suspension, NASCAR is embracing new technology. At the same time it is regulating to, as team boss Ray Evernham states, 'make racing better for the fans', as well as safer for the drivers and, theoretically at least, cheaper for the teams.

Jeff Andrews of the Hendrick team's engine division believes that his predecessor, the late Randy Dorton, 'started taking notice of the things happening in F1 and brought some of that back to us, starting in the mid-1990s.' He points out that while 'on a regular weekend basis we don't deal with the same kind of technology, if you were to look inside our engines at the different components you would see many similarities.'

F1 technology

Evernham also reflected current NASCAR thinking, following a visit earlier this year to study Formula 1 technology in the UK: 'When you look at series like F1,' he remarked, 'everything is guided by technology.' Jimmy Makar, senior vice president of Joe Gibbs Racing, adds that many of the teams have, for the past three or four years, been looking to Europe to seek suppliers. He talks of finding 'better technology and better, more reliable parts' there, pointing out that such companies are likely to already be supplying to F1. 'They're used to working in a hi-tech environment that we do not have in the States.'

Ray Evernham, team boss of Evernham Motorsports

If Nextel Cup contenders look like dinosaurs, they are more akin in creation to the computer animations of Jurassic Park than the real thing. Jeff Andrews is keen to point to Hendrick's collaboration with UGS as an example. Hendrick uses around 5500 pistons a year. 'We could not find a manufacturer who could deal with those

"UNTIL THIS YEAR, MOST OF THE EMPHASIS WAS ON TRYING TO ACHIEVE AS MUCH FRONTAL DOWNFORCE AS POSSIBLE"

> "REAR SPOILERS HAVE BEEN REDUCED IN HEIGHT BY AN INCH"

Changes to the cars for 2005 are subtle but significant – the 2004 car (above) has a rear spoiler one inch higher than that of the new car (right), although at Superspeedways the spoilers stay the same and the restrictor plate size has been reduced

kind of numbers and keep the quality needed.' It now, therefore, produces its own pistons. 'Having a partner like UGS was critical to their design and development.' It is thought that Hendrick was the first NASCAR organisation to implement product lifecycle management (PLM) software.

Another example of hi-tech involvement is that of Pi Research. The company supplies product that is now found on all of the cars in the Nextel Cup field. In addition, although NASCAR teams are unable to use conventional data logging during the races, Pi Research is able to sell to the teams for fitment at testing. Companies like Beru F1 and Deutsch say teams are now taking an engineering, rather than a mechanical, approach to their problems. As recently as three years ago such firms would have found selling into NASCAR virtually impossible.

For the time being though, a NASCAR contender appears externally the same as it has done for some years previous, and the much heralded 'car of tomorrow' remains just that. However, Evernham observes that NASCAR as an organisation is 'doing the right thing, taking its time. It's more important to get it right than work to a time frame.' The result should be a car with greater cockpit safety and one that is less reliant on aerodynamics and more on mechanical grip. In the meantime NASCAR continues to regulate its existing cars, giving the teams further challenges on which to work.

> "NASCAR STRIVES HARD TO MAINTAIN A LEVEL PLAYING FIELD"

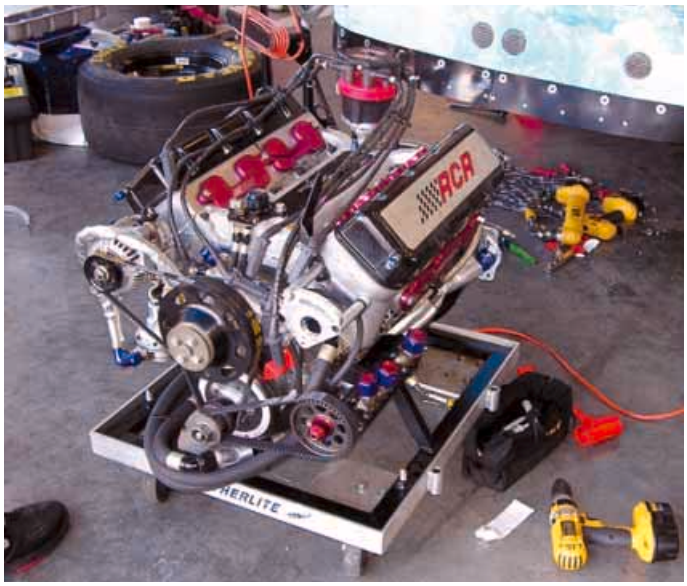
Aero changes

Until this year, most of the emphasis was on trying to achieve as much frontal downforce as possible. Now all that has changed as rear spoilers have been reduced in height by an inch to $4^{1}/_{2}$in for all but the two Superspeedways – Daytona and Talledega. The only change for these tracks has been a reduction of $^{1}/_{64}$in in the size of the restrictor plate. This is part of a programme begun in 2002 to make cars more driveable through their aerodynamics and tyres.

Jimmy Makar points out how the teams have become increasingly dependent on aerodynamics: 'Once we get everything →

Teams, such as Morgan-McClure, are working hard to regain the downforce lost by the spoiler reduction

> "THE TEAMS CAN NO LONGER USE GEAR RATIOS TO MOVE THE POWER RANGE UP THE POWER CURVE"



NASCAR is often criticised for its traditional approach to engine technology but top teams are now looking to F1 and to Europe for innovations and parts suppliers

balanced out it will be better for racing,' he says.

Hendrick Motorsports' vice president of competition, Ken Howes, observes that the spoiler reduction means 'a substantial loss in rear downforce. It is early days to know how that will play out. Some of that downforce the teams will get back just by working in the areas known to be sensitive to air flow.' NASCAR strives hard to maintain a level playing field, with templates that police carefully regulated body shapes, but the teams work just as hard at manipulating those templates. 'Look carefully at the cars,' Howes said at Daytona, 'you'll be looking at very different racecars in California next week, even though they still fit the same basic templates. People can be pretty creative.'

Chris Carrier, crew chief of the Morgan-McClure No.4 car, also observes the grey areas, and that the teams work with their body fabricators to push restrictions as far as they can. He believes that they will be able to regain almost 20 per cent of the rear downforce lost. Carrier reports his driver Mike Wallace has said that, in the meantime, getting round other cars on the higher speed tracks 'is probably going to get ugly.'

At Fontana, the first race under the new rules, former champion and Joe Gibbs driver Tony Stewart said, 'it was like driving a razor blade.'

A regulation has also been introduced with NASCAR-determined gear ratios (3.70 and 3.80), which Jeff Andrews reckons will have the effect of limiting maximum engine revolutions by about 600rpm. Again, the Superspeedways are ➔

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The 2005 Dodge Charger

The new Dodge Charger, which replaces the Intrepid for 2005, might be said to be a child of the new aero rule. Such are NASCAR regulations that a new racer (the street Charger appears in the showrooms in May) simply means a slight change in bodywork. Of over 30 templates mandated by the ruling body, 18 are common to all the manufacturers. However, the Charger has a distinctive crosshair grille that has been lowered in order for it to be integrated into NASCAR rules. Evernham technical director and former aerospace engineer, Eric Warren, believes the new nose to have 'proved a bit advantageous.'

Much of the development of the nose area of the car and also the different tail design was carried out in the knowledge that the rear spoiler was to be reduced in height by an inch. 'We knew when we were developing that car that this was going to happen,' recalls Warren, who worked closely with Dodge during this period.

Distinctive crosshair grille distinguishes the 2005 Charger from its rivals

exempt. Each vehicle is equipped with a data logger that measures RPM during on-track activity. The challenge is now, says Andrews, 'to shift our power band in reverse.' The teams can no longer use gear ratios to move the power range up the power curve. This, he reckons, is currently the biggest focus for the team, with attention being turned to camshaft design and intake manifold and cylinder head design. 'We've been playing around with the air flow and camshaft timing,' says Mose Nowland, senior engineer, engines for Ford Racing. Tommy Wheeler, deputy technical director at Evernham Motorsports, talks of getting more torque into the engine and of trying to maintain a flat engine curve. It seems teams can no longer rely on gear and torque combinations alone.

> "THE CLAIMED GOAL IS COST CONTAINMENT"

Wheeler states that teams were seeing up to 10,000rpm at some tracks last season. With its new gear rule, NASCAR is trying to bring that down to 9500rpm. According to Jimmy Makar, the change is not so crucial for Joe Gibbs Racing. Unlike Hendrick, Yates, Roush and Penske, it had chosen not to pursue extremes of RPM, but admits the team may have suffered last season because of this. However, he believes that by operating at about 9500rpm then, it will now benefit.

Cost containment

The claimed goal is cost containment, but Wheeler wonders whether any rule change actually saved money. Chris Carrier thinks differently, believing that eventually expense will be saved, if not immediately. He also points to the fact that while the gear rule may pose questions for the engine →

departments, the lack of choice makes life simple for crew chiefs such as himself.

Evernham will bring in changes to engine design at pre-determined dates throughout the season. These are then 'quarantined' for a specific period for both its own Dodges and those of its customers. The one exception is that of Bill Elliott who is running a limited programme for his finale year and who will test engine specifications 'a couple of leaps' ahead of the others. This is part of the development curve that Wheeler says is essential in a championship that places emphasis more on reliability than outright wins.

Another rule that will affect the thinking of the teams is the introduction of an impound procedure for over half the races. Following qualifying and an inspection process, all 43 cars in the field will be impounded until race day. Eric Warren, technical director of Evernham Motorsports, states that teams will now spend more time working on race trim and less on qualifying trim, particularly as the top 35 teams are now guaranteed a start. At the time of writing it was not clear what NASCAR would allow to be changed after qualifying. 'It may be a small list of things that teams may be able to gamble on,' says Warren. 'Things like tape and how much opening you have in the grill. I'm sure there will be teams that will push that and gamble for qualifying, but I think a lot of teams will get bit.'

Ford D3 cylinder head

A 'groundbreaking' collaboration between Roush and Yates has made life easier for Ford engineers

At the start of 2004 Ford was allowed to introduce a new cylinder head, the D3, for the Nextel Cup. A year later, use of this head has been extended to the Busch Series runners. Mose Nowland, senior engineer, engines for Ford Racing, points out that his company had been lagging behind as far as port height was concerned, its last new head having been introduced back in 1991. With Dodge having entered the field since then and with Toyota, as Nowland puts it 'prepping for the Nextel Cup,' it was important to Ford that it was allowed to replace the ageing C3 head.

The D3's development brought about what Nowland describes as a 'groundbreaking collaboration' between the Roush and Yates teams. It gradually became apparent to Ford that the two rivals were talking to each other about their progress. One team was said to be strong on bottom end work and reducing friction, the other on airflow management. 'It brought the two teams close together,' says Nowland, who points out how much easier it then was for Ford to make parts for what was, effectively, one entity.

Maintaining grip

The conundrums set by the new regulations are not confined to the teams either. The reduction in spoiler height has shifted the aerodynamic balance of the car towards more oversteer, and that has meant a challenge for tyre supplier Goodyear. As its NASCAR product development chief Rick Campbell states, 'we will do what we can to maintain driveability.' Goodyear has said that it will be pleased if it can make up for just 25 per cent of the grip lost through the new rule.

"TEAMS ARE NOW TAKING AN ENGINEERING, RATHER THAN A MECHANICAL, APPROACH TO THEIR PROBLEMS"

Aerodynamic changes mean tyre manufacturer Goodyear has had to develop new compounds and alter construction and wear rate characteristics for 2005

In some cases this has meant the introduction of a new compound to give higher levels of grip. For intermediate tracks like Charlotte, Michigan, Fontana and Kansas, a new right side compound has been developed. Goodyear has also been able to maintain temperature levels by increasing the wear rate – one of the trade-offs of adding grip is that it typically generates more heat.

The compound has not been changed significantly for all tracks. As Campbell states, 'the bank angle has a tremendous influence on how much grip you get. The flatter tracks are going to present a bigger challenge to us this year. The spoiler change [means] a bigger shift, and this is where the differences will be magnified.' As Jimmy Makar said after initial testing, 'the more the banking, the better the car drives.'

Las Vegas, where the bank angle is only 12 degrees, is an example of the different approach required – a construction change has been made for here in order to stiffen the tyre. One way in which to address the corner entry and stability lost by decreased rear downforce is to increase the lateral stiffness of the tyre.

Rules such as those introduced for 2005 may be made for the best of reasons. However, Eric Warren believes that 'the reduction in downforce will be recovered by the end of the season.' For Warren and his competitors, rule changes are just another engineering challenge to resolve. RE

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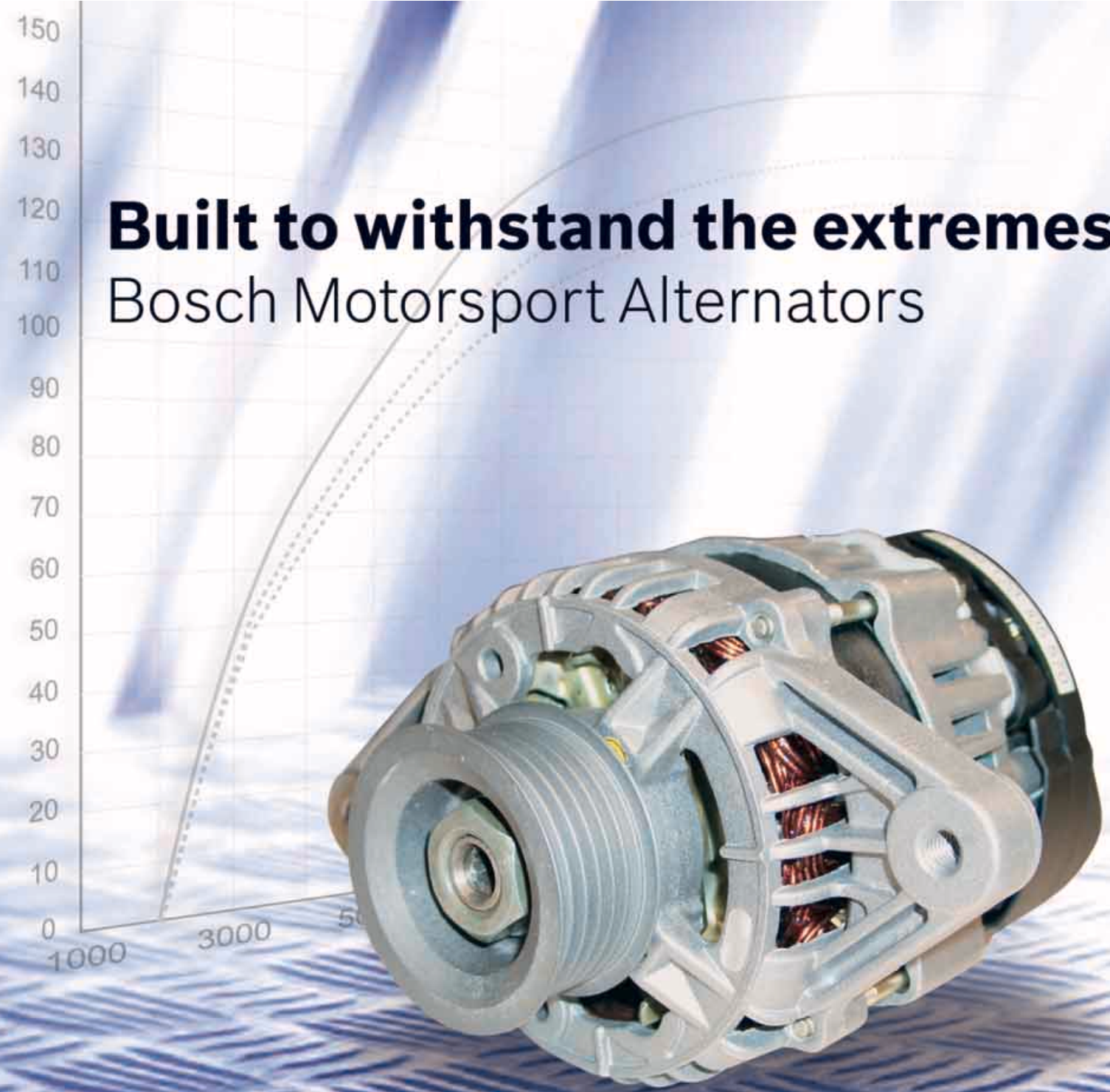

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Getting Radical

With over 400 cars sold and a spine-tingling new V8 on its books, Radical has cemented its position at the pinnacle of the UK race scene. But just what is so radical about Radical?

Words	Mike Breslin
Photos	Breslin; Radical

Radical's new offering is a 363bhp, 570kg, 170mph, sports prototype racecar driven by an all new, 2.6-litre, lightweight V8 – all for just £50,000 (US$93,500). Sounds good doesn't it? If you're in tune with the Radical way of thinking though this will not come as a surprise, for this ultra-successful racecar manufacturer always bears five key principles in mind when designing a car. In the words of co-founder and managing director Mick Hyde these are: 'It has to look good, sound good, handle well, it has to be safe, and people have to be able to afford it.' Clearly, this is a company that plays to a different set of rules to most racecar producers, for this is a company that is as much about product development as racecar development. And that is what's radical about Radical.

And it's an approach that's paid dividends, too. Radical can now justifiably claim to be one of the UK's biggest – if not *the* biggest – racecar producers, with 400 cars rolling out of the Peterborough factory gates since the company's inception eight years ago. This past year alone it has produced around 150 cars with, on average, four cars completed every week, which is enough cars to keep around 80 people, throughout the group, in gainful employment while turning over around £6m (US$11.2m) of business a year.

These cars have found homes the world over. Many mixing it with their sister cars in the various one-make championships in the UK and elsewhere, others showing the way in American D

"THIS IS A COMPANY THAT PLAYS TO A DIFFERENT SET OF RULES TO MOST RACECAR PRODUCERS"

Works drive

Mick Hyde, one of Radical's two founders, is both an engineer and a marketeer, and has proved to be extremely successful at both

Below: composites; below right: CNC machine

Radical's SR3 – already over 30 of these racecars have been sold for road use

Mick Hyde points to a jumble of innocuous looking tubes on a workbench in a corner of one of the units that make up Radical's 25,000sq.ft Peterborough, UK, factory complex: 'That,' he says, 'is an SR4.' And that's part of the charm of Radical, it does the lot – from design to chassis fabrication to engine installation, and every point in between. Indeed, now it has its own V8 engine it could perhaps claim to be one of the only racecar manufacturers that truly does just about everything in house. 'Of course there are things that are bought in, such as the steering rack,' says Hyde, 'but even that's manufactured to our own design.'

This set up works because of the web of inter-related companies that form the Radical Group. First, there's Radical Composites, just over the road from the main unit, where pre-coloured fibreglass bodywork and carbon components are turned out of moulds and bucks which are themselves made at the factory.

Meanwhile, Amicon Engineering, another sister company, makes most of the componentry on-site, including hubs, dry sump pans and engine internals, while engines are courtesy of Powertec, also on site. Radical also runs the race team from the factory and keeps up to £1.25m (US$2.3m) worth of spares in stock to ensure its customers are well served.

Development tools include a rolling road and dynamometer, while the Peterborough base's proximity to Huntingdon means that Lola's seven-post rig and several test venues are within easy reach.

Sports competition, and one even shattering the 'road car' record at the legendary Nurburgring Nordschleife. The Radical reach now extends to 18 countries on eight continents across the globe, and it's all grown from a shared vision of how a racecar *should* be built.

> **"THE RADICAL REACH NOW EXTENDS TO 18 COUNTRIES ON EIGHT CONTINENTS"**

Clubland

When it comes to Radical founders, Phil Abbott and Mick Hyde, Jekyll and Hyde analogies are hard to resist. After all, the perceived wisdom is that one is the engineer and one is the marketing man, but nothing in life is quite as neat as that. 'My background is actually as an engineer as well,' says Hyde, who started his working life with a five-year stint in the aerospace industry, 'but then I decided I didn't want to be an engineer because there wasn't enough money in it. I saw the engineers around me, and they were all broke! So, through a series of job changes, I ended up in marketing instead.'

While Hyde saw his business prosper and expand into advertising, PR and commercial photography, Phil Abbott was building up a portfolio of lucrative engineering-led business ventures, among them a company that manufactured health and fitness equipment.

Both were successful businessmen, which allowed them to go racing in the first place – Hyde in TVR Tuscans, then Caterhams, Abbott in Ginettas and a Mazda RX7 – and both had an eye for a good idea. Enter Radical's first car: the ground-breaking Clubsport.

Although Phil Abbott is credited with the idea of slotting a superbike engine into a sports racer, it was gifted in-house designer Nick Walford who penned the prototype. This evolved into the Clubsport, which was an immediate success in 750MC sportscar races and soon spawned the first of Radical's one-make championships – not bad for someone whose previous design experience had been restricted to the engineering needs of Abbott's health and fitness company. 'The Clubsport was my first car,' says Walford, 'and →

before that I had done all sorts of things, from toning tables and electro therapy equipment to the bottling equipment for suntan lotion. In fact, I wouldn't describe myself as a car person at all, although I'm definitely someone who likes to make things.'

Perhaps it was this lack of preconceptions when it came to racecar design that helped Walford come up with such an elegant and effective design for the front suspension of the Clubsport – a solution that was vital if Radical was to stay true to its aesthetics-driven philosophy.

'I wanted a low front on the car, I didn't want a bulge in it,' says Mick Hyde, 'and that's the problem I'd given Nick [Walford].' Hence the 'Nik-link' – an ingenious transverse roll control system which, adds Hyde, 'is named after Nick Walford and is basically a motorcycle suspension, with the back wheel turned sideways.'

'I needed to come up with an anti-roll system that was suitable to the bodywork and the car,' explains Walford. 'I think originally we were looking at using four rose joints, but this system didn't use any, just two bushes... Some people call it a rising rate system, but really it's a spring and damper amplification system.'

Nik-link suspension has been a feature of all Radicals since the Clubsport, as has a steel spaceframe chassis, and Mick Hyde sees no reason to change that. Noting that not only does this keep the costs down but 'it's still the right way to make a chassis: it's strong, and if you hit it hard enough it gives. It won't shatter like carbon fibre.'

Another common denominator of the Radical range is the motorcycle-derived powerplants, the first of which was the 1100cc Kawasaki ZZR in the Clubsport. It's no secret that superbike engines give fantastic power to weight, and they have always been used to great effect in hillclimbers, but Radical was certainly one of the first companies to realise the commercial implications of this, particularly when bearing in mind the amount of cheap engines that were then on the second-hand market. The same philosophy was applied to future Radical designs, with 1300 and 1500 Suzuki Hayabusa and 1200 Kawasaki ZZR units (along with their six-speed sequential gearboxes) appearing in subsequent machines, all tweaked by Radical's engine division Powertec – run by Ted Hurrell, a former sidecar racer.

The ingenious 'Nik-link' suspension system that features on all Radicals is basically a spring and damper amplification system. It also sums up the company philosophy perfectly

Turning pro

The Clubsport was, as Mick Hyde admits, based on the looks of an attractive Sports 2000 car (the Robinson) married to the proven dimensions of the Caterhams Hyde had competed in. Progress though, was partly due to another car Hyde had raced: 'Stage two was the Prosport, and that was inspired by the TVRs [particularly those used in the Tuscan one-make series in the UK]. I was at a meeting and I saw some of them running up to seven degrees negative camber and I thought this might be a way we can move on to Formula 3 size rubber.' With that came a move to a medium downforce package with dive planes, rear venturi and a rear wing (the Clubsport just had a Gurney flap and, later still, a rear undertray) and more power thanks to the fabled Hayabusa engine. The Prosport also features Nik-link suspension, and double wishbones front and rear.

> **"NIK-LINK SUSPENSION HAS BEEN A FEATURE OF ALL THE RADICALS SINCE THE CLUBSPORT"**

Another Radical innovation at this time was the initiation of its first two-driver championship, a cost-saving format borrowed from the classic sportscar internationals, which has now been copied by many a UK championship promoter.

In fact, it seems fair to say this is just one of the ways in which this firm has helped to re-shape the UK motorsport scene. But it has also reacted to change, too. Take track days for example. This non-competitive form of motorsport (if you will excuse the contradiction) is often said to be the industry's fastest growth area. Naturally then, Radical wanted a slice of it.

Enter the SR3, perhaps the best looking of all the Radicals, but always a racecar that was designed for the road as well as the track, which is part of the reason the SR3 dispenses with chain drive and uses a gear drive developed by engine division Powertec and transmission wizard Quaife Engineering.

'We twigged that there was this track day market, and we also twigged that one of the reasons Caterham was so successful was that it had cars you could drive on road and track,' says Hyde. 'So, when we designed the SR3, the headlight position and all of those bits and bobs had to comply with type approval and that was all designed in. We also had to compromise the racer design by allowing for two large people to be able to sit in it – but we did that knowing the majority of our customers are not little squirts!'

Don't let these refinements fool you though, for this is the car that, in its 320bhp turbocharged incarnation, shattered the road car lap record at the Nurburgring Nordschleife last year (7m19s!). Dare to suggest that it's not really a road car and Hyde will counter: 'we've sold about 30 road legal SR3s. And there are a few people who just use them for road cars. It's amazing how many people say that's just bonkers, but I ride a Ducati to work in the summer and you don't think I'm bonkers – so what's the difference between a race replica →

Prior to the SR8, all Radicals used standard superbike engines mounted transversely

Radical model profile

Clubsport

First of the breed. 1100cc Powertec Kawasaki; 185bhp; steel spaceframe; 440kg; 3820mm × 1520mm (L × W); chain driven; six-speed sequential gearbox; LSD; double wishbone with Nik-link front. Turned the UK racing scene on its head when introduced in 1997. Later cars acquired rear AR bars, Gurney and diffusers. Available for as little as £12,000 (US$22,000) second hand

SR3

Track day special and racecar. 1300cc or 1500cc Powertec Suzuki Hayabusa; 205-252bhp (up to 330bhp in turbocharged form); 510kg; 4050mm × 1800mm (L × W); Powertec Quaife gear drive; six-speed sequential gearbox; double wishbones and Nik-links. High downforce racecar that can be supplied road legal, costs around £29,000 (US$54,000)

Prosport

Natural evolution. 1300cc Powertec Hayabusa; 205bhp; steel spaceframe; 470kg; 3820mm × 1520mm (L × W) chain driven; six speed sequential gearbox; LSD; double wishbone with Nik-link front and rear; rear wing, diffuser and dive planes. A mainstay of the UK race scene. Yours for just £24,265 (US$45,000). 1000cc version available for D-Sports in US

SR4

Replacement for Clubsport. 1200cc Powertec Kawasaki ZZR; 190bhp; 450kg; 3730mm × 1630mm (L × W); chain driven; six speed sequential gearbox; LSD, integral reverse gear; double wishbone with Nik-links. High-sided, multi-piece bodywork for extra driver protection; striking LMP styling. Costs around £24,000 (US$45,000)

bike and a race replica car?'

Point taken, but back on track, the arrival of the high downforce SR3 – which goes head-to-head with the Prosport in the Enduro series – also marked a decline in grid sizes for the Biduro series the Clubsport competes in. With take up on a low-cost entry level 'Introsport' version low, mainly because second hand Clubsports were still cheaper and faster, Radical was forced to go back to its first principles and design a new car with groundbreaking aesthetics. And so to the SR4, the design of which owed more than a passing nod to the Bentley Speed 8 Le Mans winner of 2003, albeit a scaled-down version without a roof. Incidentally, there was talk of producing a Clubsport with a roof some years ago, but this was abandoned because it just didn't look right. Which brings us back to where we came in: looks right, sounds right... Next step has to be a V8 then.

Art of noise

That V8 is now with us, unveiled – along with the SR8 racecar designed around it – to massive interest at this year's Autosport International show. And this time it's a real step up in every way. 'This is so powerful,' says Nik Walford. 'And it's a luxury we haven't had before. Motorcycle engines really lack torque, their advantage is the weight. But this engine is just unique, there's nothing else like it.'

And that's the thing, the Powertec RPA (Radical Powertec A-series) Macroblock really is something new – a 2.6-litre, narrow-angle (72-degree), small and lightweight V8 engine that owes more to Formula 1 than superbikes when it comes to its design philosophy. And although it does share some components with the Hayabusa that's found in the Prosport and SR3 (chiefly the race-proven cylinder heads and barrels which helps to keep the price down) this is an all 'car' engine, featuring its own Powertec-originated cylinder block.

Originally it was assumed the unit would make use of the integral motorcycle gearbox and sit transversely in the car, as with other Radicals, but thanks to the efforts of transmission partners Quaife it was soon realised that the engine would go in longitudinally, which means there will now be a far bigger market for it beyond the SR8, and the plan is to sell is as a stand alone product. Indeed, Radical envisages that it might well be fitted in everything from a hillclimb single-seater to a grasstrack racer. Priced at £16,000 (US$30,000) there seems no reason why this engine shouldn't be an instant success and, by changing the crankshaft throw and pistons, there is the likelihood of 2.0-litre and 2.5-litre V8s in the future. There's even talk of a 3.0-litre version, which could be good for up to 500bhp.

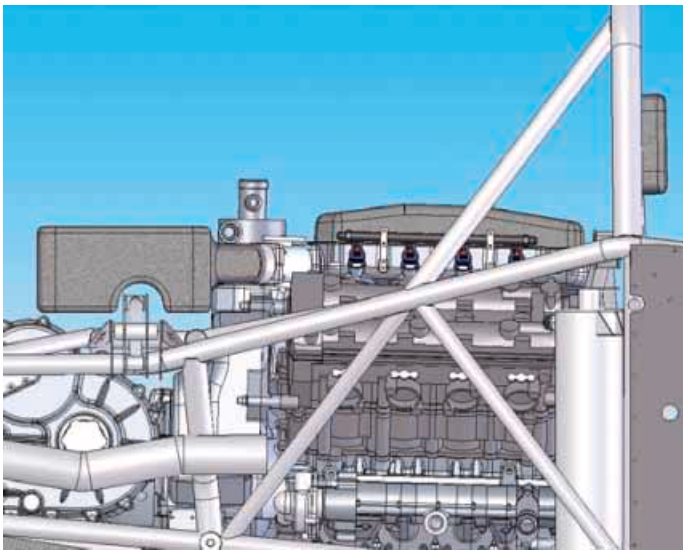
> **"THE DESIGN OF [THE SR4] OWED MORE THAN A PASSING NOD TO THE BENTLEY SPEED 8 LE MANS WINNER"**

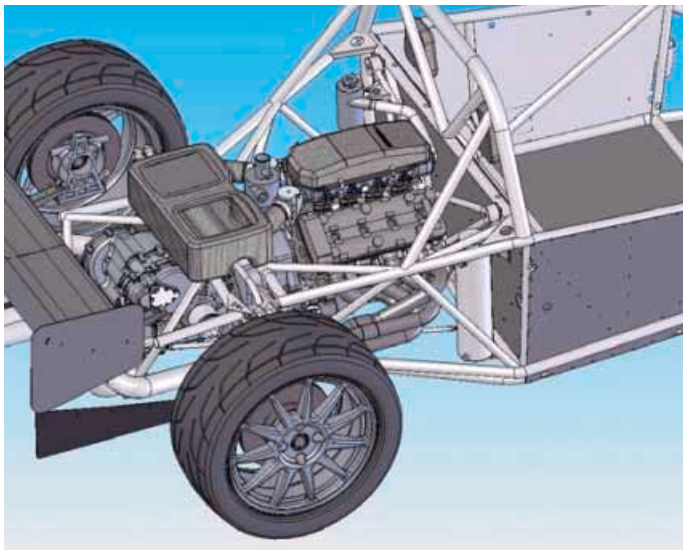
The V8 is the brainchild of Steve Prentice, a well-known engineer who has previously worked on the Jaguar XJ220 and the Prodrive Mondeo V6 engine projects, and early runs on the Powertec dyno and Radical rolling road (fitted in the SR8) showed that he has come up with an absolute gem, with a power figure of 360bhp at 10,000rpm and 200lb.ft of torque within easy reach in a standard state of tune.

Cost has been a major consideration throughout the design and build, which is why there's a lack of exotic materials such as titanium and carbon fibre, but then this is an engine which has to be used on track days as well as race days so that's understandable. But if there's any thought that this smacks of compromise, here's a statistic to bear in mind: the dry weight of engine, gearbox and bellhousing is about 132kg...

And then there's that sound, largely thanks to the flat plane crank, which many have likened to a DFV: 'It's touching on the Formula 1 area,' Nick Walford says, and that analogy can be carried further, the V8 carrying its in-line twin oil and water pumps low down, and featuring a cellular four-pump dry-sump scavenge system for extra reliability. The engine also features twin-rotating balance shafts, driven directly from the crankshaft, which ensures it runs smoothly throughout the range – something that has been deemed important as a road version is planned.

All of this detail work was done on Solid Works, an engineering package that Prentice has introduced to Radical. 'It's been very useful,' says Hyde. 'For example, one of its applications is →



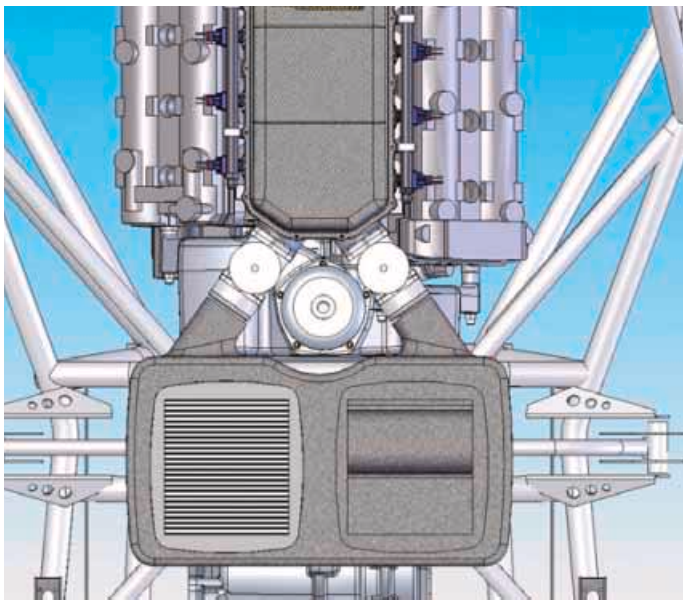


for casting design. You design it in several layers: first designing generally, then going through the detail design phase, and then it will help you produce the pattern which we go to the foundry with. We couldn't have done it for the cost we have without the help of this software.'

Solid Works was also used to great effect when it came to designing the SR8 – the first of the cars the V8 is to sit in. 'I'm actually beginning to love the program,' says Nick Walford, 'You can draw a solid thing, turn it, rotate it, visualise it and change it. It's absolutely marvellous.' As is the car he's come up with using it. →

Above left: compact V8 sits low in SR8 chassis

Above right: Radical uses tried and tested spaceframe design



Right: V8 utilises plenum fuel injection with 2 throttle bodies feeding from the airbox

"THE SR8 DEVELOPS TWO AND A HALF TIMES THE DOWNFORCE OF THE SR3"

Tech specs: Radical SR8

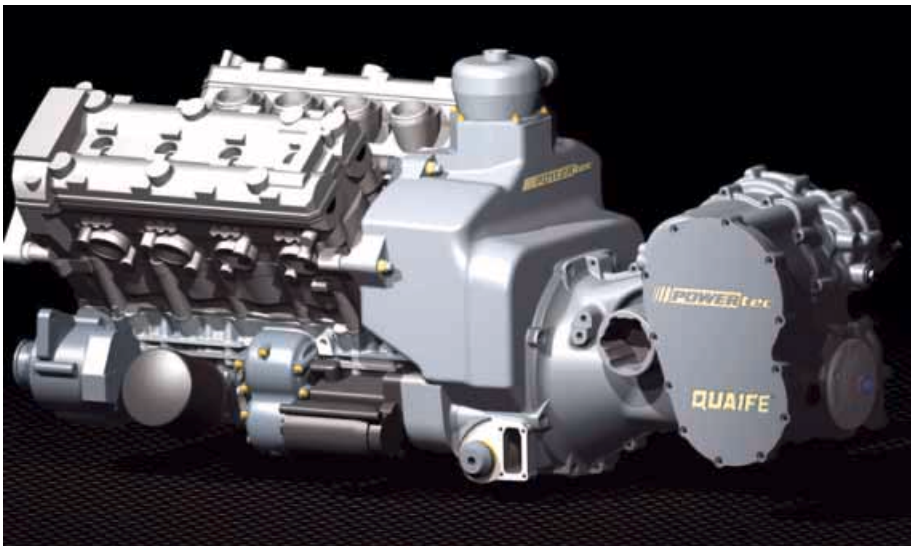
Chassis	Steel spaceframe with integral MSA and SCCA-approved safety cage; stressed aluminium panels; foam-filled side impact pods; aluminium honeycomb front crash box; 54-litre aluminium, foam-filled fuel tank
Suspension	Front and rear Nik-link; double wishbone with fully floating, single adjustable coilover dampers and 'Nik' anti-roll system; optional Radical triple adjustable shock absorbers
Brakes	Four-pot Radical calipers front and rear, 260mm diameter vented discs front and rear; optional 280mm diameter floating vented discs front and rear
Wheels and tyres	Cast alloy centre-lock 7 × 15in front and 8 × 16in rear; slicks and wets (optional 8.5 × 15in front and 10.5 × 16in rear)
Body	Self-coloured glass fibre; sidepods with integral air vents; cooling ducts and foam filled crash structure
Aeros	Carbon fibre wind deflector; front splitter with integral undertray; venturi and water radiator; full width rear wing (single or biplane); front dive planes
Dimensions	**Width:** 1800mm (5ft 11in)
	Length: 5050mm (13ft 3in)
	Ground clearance: 50mm
Weight	570kg

The Radical SR8 – although based on the SR3, with its all new lightweight V8 it's a step up in every way

Tech spec: Powertec RPA Macroblock 2.6-litre V8

Cylinders	V8	
	32-valve quad cam	
Power	360bhp (standard tune)	
Max revs	10,500rpm	
Bore	81mm	
Stroke	63mm	
Compression ratio	11.0:1	
Dimensions:	**Length:** 546mm	**Width:** 513mm
	Height: 440mm	
Dry weight:	92.6kg	
Other	steel flat-plane crankshaft; twin counter-rotating balance shafts; twin pump lubrication system; four scavenge pump dry sump system; rotary vane coolant pump; pre-engaged starter motor; belt driven 45-amp alternator	
Clutch	Single plate dry (optional twin plate)	
Transaxle	Six-speed constant mesh; sequential shift	

The unique bellhousing/ oil tank divides the engine and the gearbox

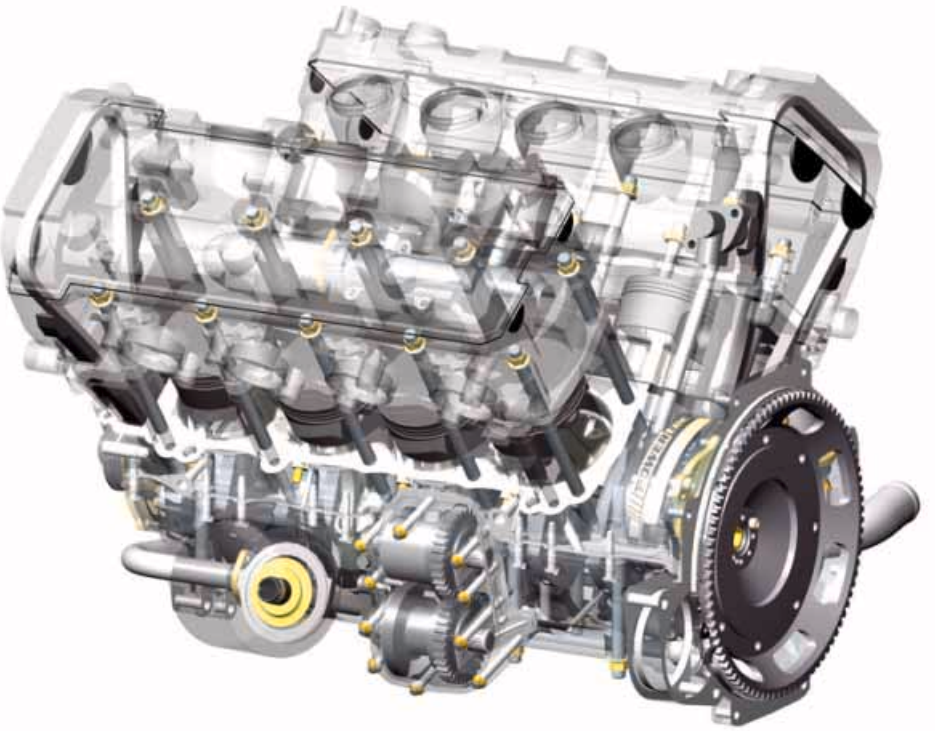


"MANY HAVE LIKENED THE SOUND OF THE V8 TO THAT OF A COSWORTH DFV"

The SR8, though based on the SR3, is very much its own animal, most obviously because of the longitudinal positioning of the V8 (all previous Radicals have had transversely mounted engines). The car also boasts increased cooling for the V8 and for added protection (bear in mind this car is capable of 170mph) there's a new aluminium honeycomb crash structure in the nose section.

SR8 also does without the trademark Radical air-tower, with a lower rear intake in its place, all of which cleans up the airflow to the high-downforce biplane rear wing. Other aero advances include a larger nose splitter, full undertray venturi and dramatic dive planes in front of the wheel arches. All of which amounts to an aero package that, when tested at the MIRA wind tunnel, developed two and a half times the downforce of the SR3. At 170mph the downforce is greater than the car's weight, complete with full fuel load and driver.

Priced at a very competitive £50,000 (US$93,500) plus VAT, the SR8 is set to race across Europe in its own series, the Powertec Cup, this year. While there's also a road version planned – and word is one is to have a go at the Nordshleife record – beyond that, Radical plans to continue its global expansion and to keep on doing what it has always done: 'producing what we perceive the customer requires,' as Mick Hyde puts it. And while there's no SR10 or even SR5 on the drawing board at the moment, you can be sure of one thing: whatever it's called, the next Radical will look good, sound good, handle well, be safe, and people will be able to afford it. Not so radical really, just giving the customer what it wants.



Though the cylinder heads and barrels have been used before, the RPA Macroblock V8 is a truly new engine

Long night ahead?

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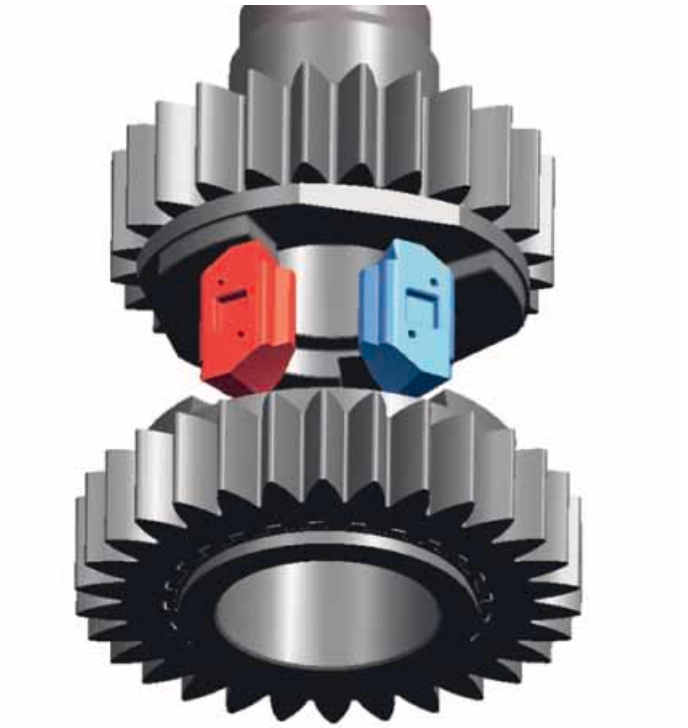


Figure 1: bullets in neutral position between the first and second gear pairs

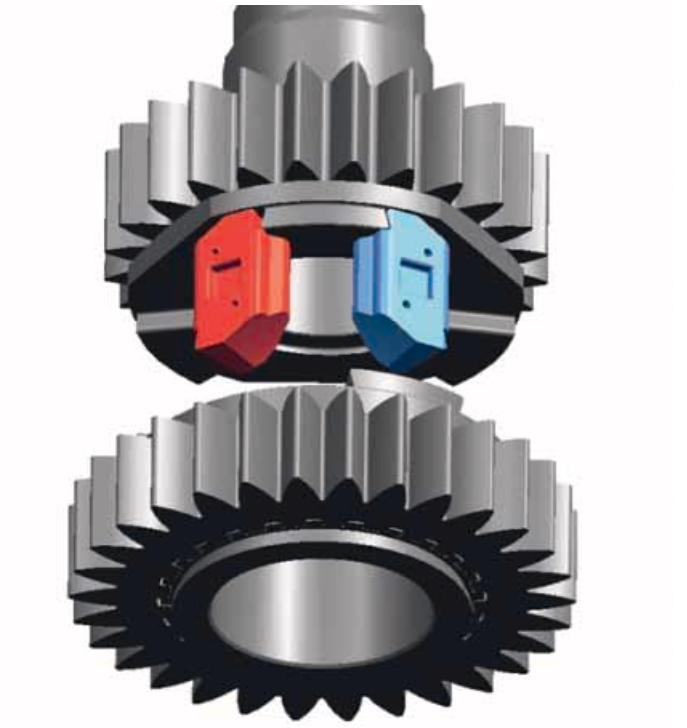


Figure 2: Both bullets in first gear position, allowing minimal backlash

Changing strategies

At last we can reveal the revolutionary principle behind the ZeroShift gearbox and how the company has progressed since it was last featured in these pages

Words	Charles Armstrong-Wilson
Images	ZeroShift

It was in February last year that we broke the story about ZeroShift's revolutionary seamless gearchange system. At the time it was agreed with the company that we wouldn't reveal how the design worked on condition that we could break the story when it was able to go public. It has taken a while but now, for the first time in any magazine in the world, we can reveal the secret of how the ZeroShift system operates. Unless you are extraordinarily patient, you have probably read the panel explaining already. If not, then we urge you to read it and experience that eureka moment, then we can bring you up to date on the company and the latest progress with the system.

When we first visited ZeroShift in late 2003 to research that first feature, the company was very new and very small. It had been founded to develop an invention by one of its founders, Bill Martin. The technology allowed different gear ratios to be selected without any break in the torque delivery from the engine to the wheels. This was ZeroShift and that same principle is still at the core of everything the company is working on today. However, in the intervening period, much else has changed. Initial interest from investors has been turned into a firm financial footing that allows the company to take a more thorough approach to developing the system, rather than rushing to market with a hastily produced product in order to generate funds. It has also enabled the recruitment of a very well qualified and able team of people to take the idea and transform it into something marketable.

Having read the panel, you may be wondering, with such a simple and elegant principle to work with, what is there to develop? In fact there are certain issues that come about during the transfer to the real world. The most obvious one is what happens to all that inertia in the engine when you engage a higher ratio? You cannot dissipate 500 to 10oorpm in a millisecond without producing a big impact and ZeroShift's aim is to achieve a flat acceleration curve on a graph.

Current transmissions break the torque during changes, however briefly, resulting in a hole in the curve, while a raw ZeroShift system produces →

"SMOOTHING OUT A SPIKE IS ACHIEVABLE, UNLIKE FILLING IN A HOLE WHICH IS NOT"

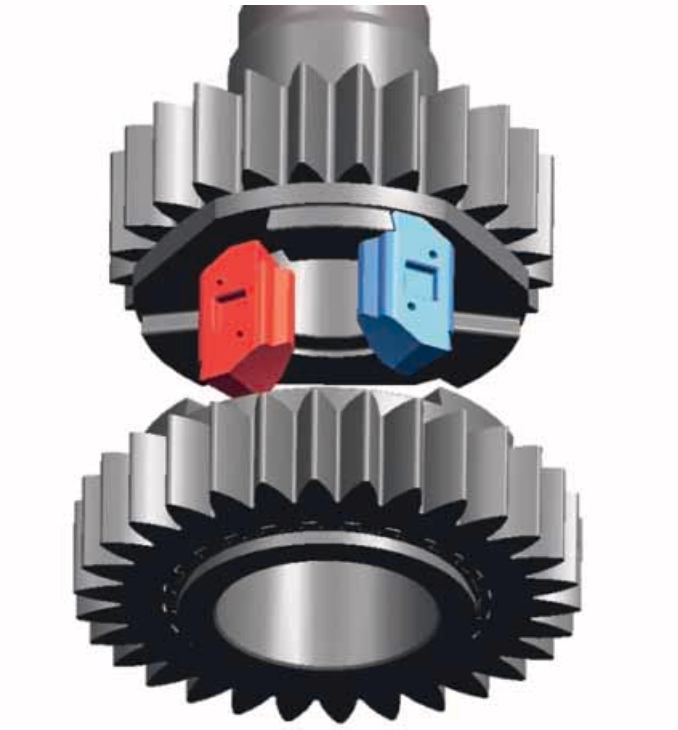


Figure 3: Bullets requested to move across by the selector-mounted springs. Only the unloaded bullets (red) are free to move withdrawing from first gear

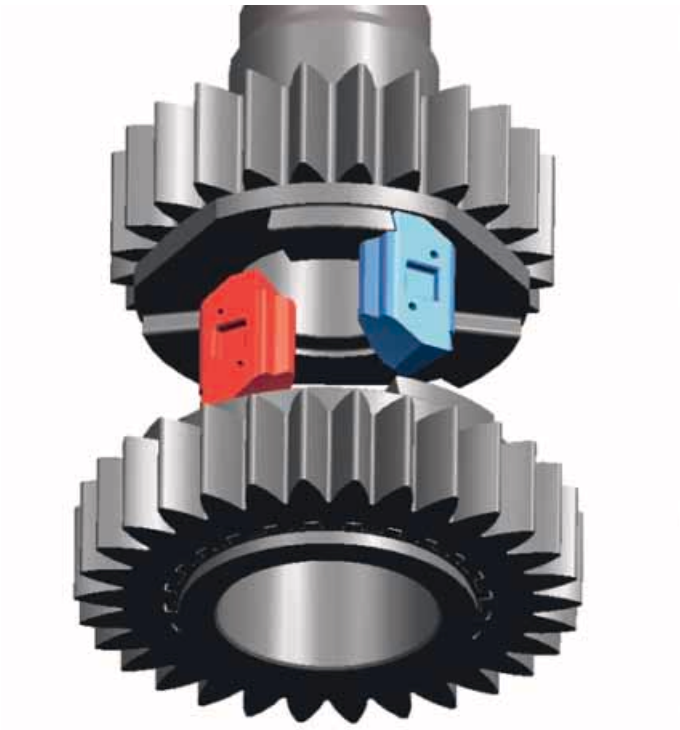
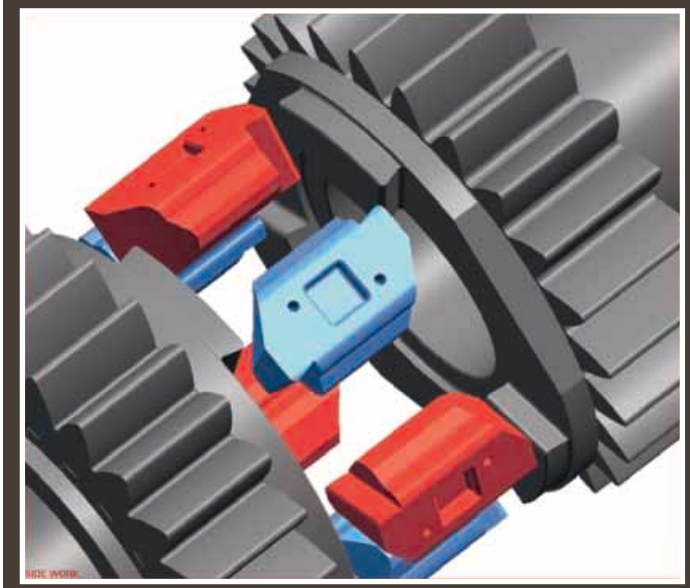


Figure 4: Free bullets (red) slide across to the second gear pair while loaded bullets (blue) remain engaged in first due to retention angle on the dog faces

HOW IT WORKS

ZeroShift is based on a racing-style dog box and could share much of its internals with a typical racing transmission. However, that is not to say it is necessarily crude or difficult to drive in normal traffic. The secret to its operation lies in the ZeroShift hubs that take the place of the dog rings. On a normal dog engagement gearbox, the dog rings typically sit between two gear pairs and slide on the shaft allowing the dogs to engage drive through one gear pair or the other. Obviously, as the ring is pulled out of engagement with one set of dogs, there is a break in the transmission of power before it engages with the other set. If it didn't, then two ratios would be selected at once with explosive results.

In contrast, the ZeroShift hub, instead of having the dogs machined into its faces on either side, has six sliding dogs that the company has christened bullets located in slides around the periphery of the hub (see below). These can be slid from side to side, engaging with either gear pair. This is still very little different to a conventional dog ring. However, where the ZeroShift box differs is in the shape of the bullet ends and the selector mechanism that slides them across. Each bullet has a normal dog profile on one face and a ramp on the other and the same faces are used the other way round on the other end of the bullet. Also all the bullets are connected to the selector fork via springs.



From neutral (figure 1), the selector fork drags the bullets across to engage with the dogs on the first gear pair (figure 2). Under acceleration, the three dogs on the gear pair will engage with three of the bullets but not with the other three because their faces are ramped and with be thrown out of engagement if they meet. However, on overrun, these three dogs take the drive on their opposite faces.

In an upward change under power, the selector fork will attempt to drag the bullets across to engage with the dogs on the other gear pair (figure 3). But because they are connected to the fork by springs, only the unloaded bullets will move, while the loaded ones will remain engaged with the previous gear pair because the force exerted by the spring is not enough to overcome the clamping force applied to the dogs by the torque of the engine. However, the bullets that were free to move (figure 4) will engage with the dogs on the second gear pair that are turning faster (figure 5). This is the point of ZeroShift where the gearbox is effectively in two gears at once and all hell should be breaking loose. But it doesn't because the second gear pair's higher ratio overdrives the first, releasing the clamping force between the dog faces of the latter and the bullets (figure 6). With the force of the springs still acting on them, the bullets are free to slide out of engagement and mesh with the dogs on the second gear pair. Should they be slow in coming out of engagement on the first gear pair, then they will catch up with the face of the next dog (figure 7) but, because the other face of the bullet is chamfered, rather than engaging, the dog will hit the ramp and fire the bullet on its way to engage with the other gears. Once all six bullets are engaged with the new gear then drive under power and in overrun is restored (figure 8).

"THIS IS THE POINT OF ZEROSHIFT WHERE THE GEARBOX IS EFFECTIVELY IN TWO GEARS AT ONCE"

Drive is continuous and unbroken and will not only work between adjacent gear pairs, but also across the gate between non-adjacent pairs, too.

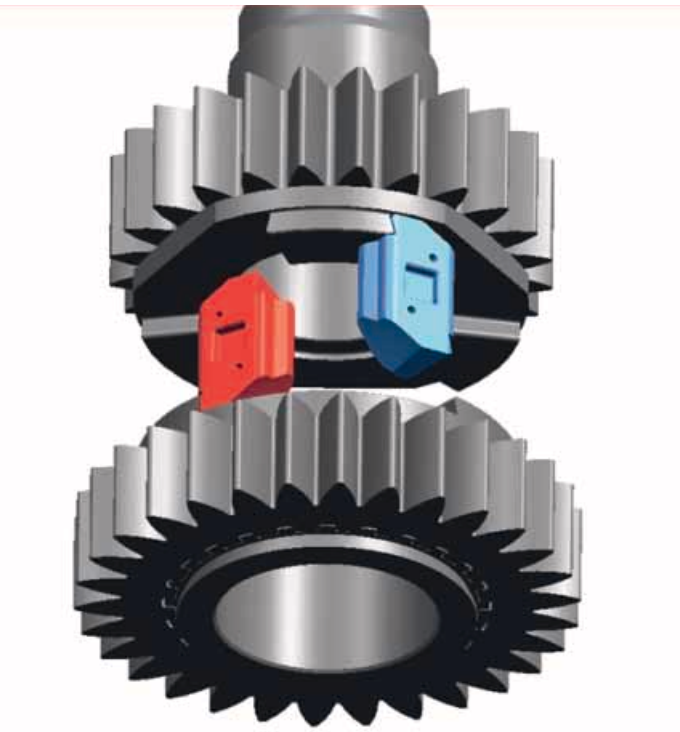


Figure 5: Second gear engages with the bullet accelerating the ZeroShift hub

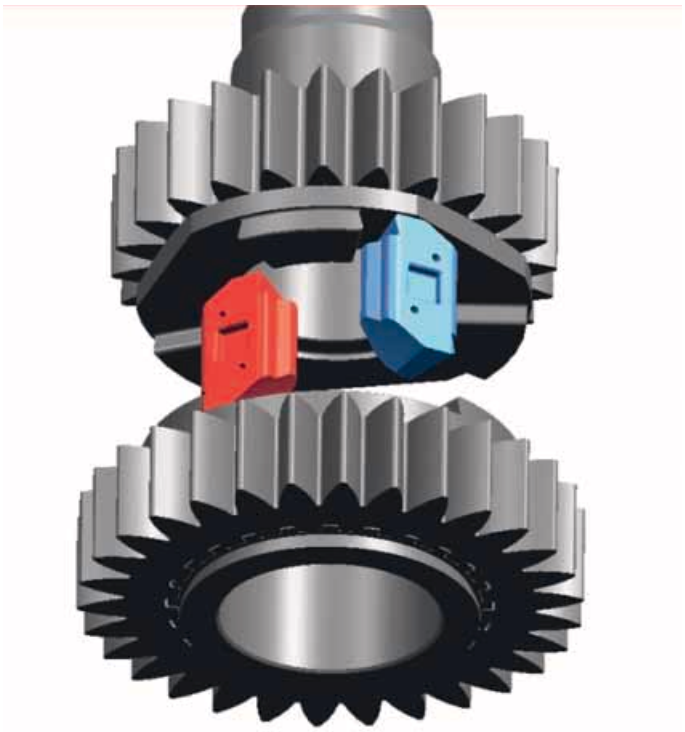
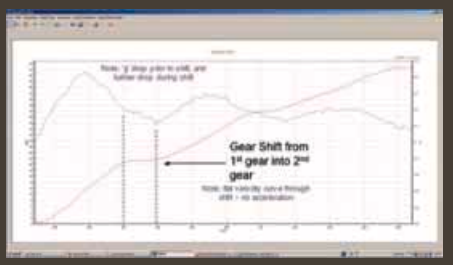


Figure 6: Second gear overdrives first gear unloading the first gear bullet (blue)

Rolls Royce Silver Spirit three-speed auto
During the change the *g* trace exhibits a sharp spike produced by a surge from the engine inertia

Mercedes 320CLK four-speed auto (sports mode)
Dip in the acceleration curve during the change generates a clear plateau on the velocity curve



BMW M3 SMG gearbox
Gradient of the velocity curve drops to zero during the change while the transmission is declutched

a spike as the inertia in the engine delivers a momentary increase in torque while the revs drop to match the road speed in the higher ratio. This is obviously undesirable due to the load it puts on the drivetrain and the tyres. But smoothing out a spike is something that is achievable, unlike filling in a hole which is not.

The team at ZeroShift is working on a number of strategies for smoothing the spike, the simplest of which uses the clutch. By briefly reducing the clamping torque on the plates during the shift, it allows a moment's slip that dissipates the unwanted energy without breaking the transmission of torque to the rear wheels. Other techniques involve cutting the fuel, or spark, or both during a change creating a hole in the engine's torque delivery that can be filled by the unwanted inertia. In addition the company is investigating in-line, driveshaft dampers that can absorb the extra torque, smoothing its impact on the acceleration curve.

> **"OUR SYSTEM IS BASED ON CLOSED LOOP CONTROL SO IT IS SELF-TAUGHT"**

The engineers also showed us other idiosyncrasies with the system and various solutions to other issues that appeared during testing that, in the interests of competitive advantage, we have been asked not to reveal. All this may seem a little daunting, but the company has assembled a team of bright, enthusiastic engineers to tackle them. Their backgrounds include Xtrac, Ricardo, Cosworth, Jaguar Racing and Prodrive, and the issue is not so much a lack of solutions but a question of choosing which ones to follow. Head of design is Miles Ashcroft who has served time at Xtrac, BAR, Nissan and cut his teeth on jet engines. He has been overseeing turning the concept into a practical reality with a view to bringing a product to market.

But in our original feature, we reported that by now the company would already have its first product, an aftermarket version of the T5 gearbox on sale. So what went wrong? Bill Martin is pragmatic and refreshingly honest. 'What happened was two things. First, at that time we didn't know what we didn't know. Secondly, we have taken a more long-term approach to doing things that will take the company toward series production.' The response from investors has put them in a much stronger position and the need for a marketable product is not as pressing as was first envisaged. 'We have been spending a lot of time on automating the system and developing control systems.' Work is currently focusing on NVH and FMEA. 'It's been exciting because we're learning quickly.'

The original concept of ZeroShift was for a passive manual system that worked like an ordinary stick-shift gearbox. That was fine until they started to incorporate systems to smooth out the torque spike. Trying to synchronise these electronic shift management systems with the mechanical input from a gear lever proved more difficult than managing the whole process →

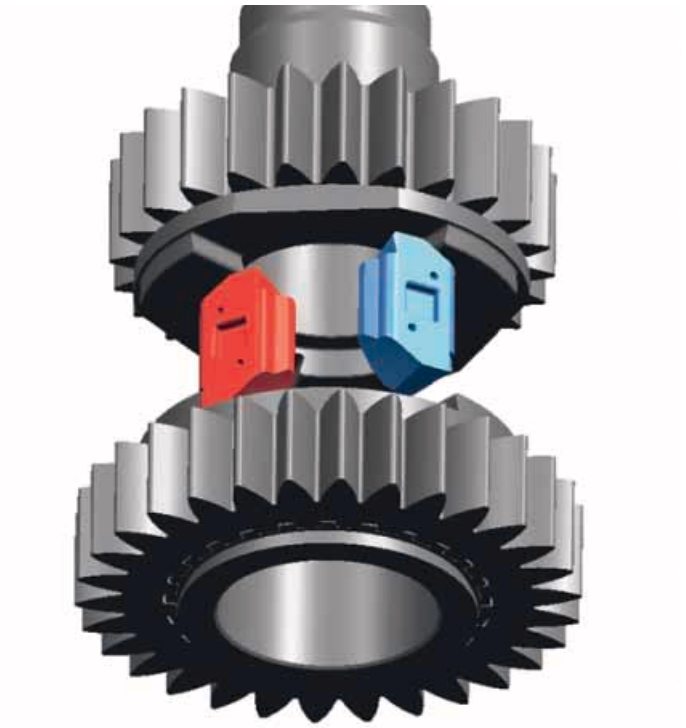


Figure 7: Once unloaded the bullets are withdrawn from first gear by the spring force still being applied from selector fork being pushed toward second gear

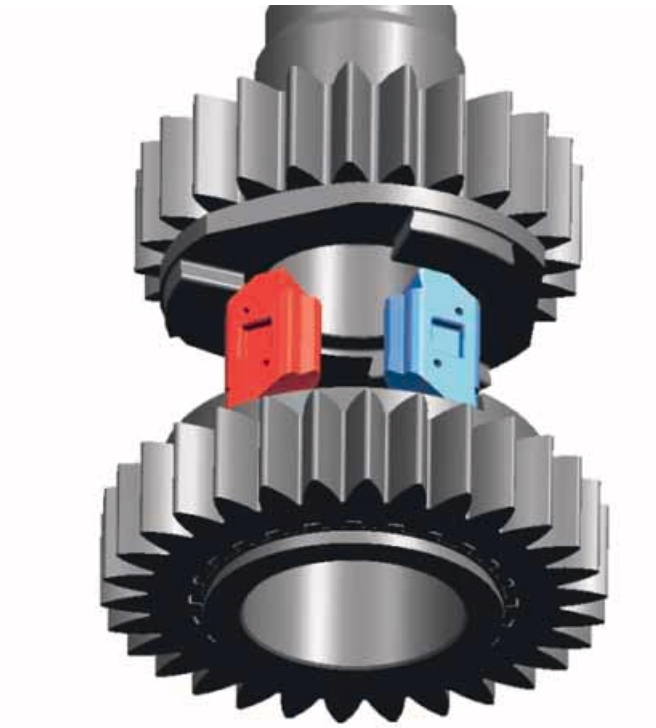
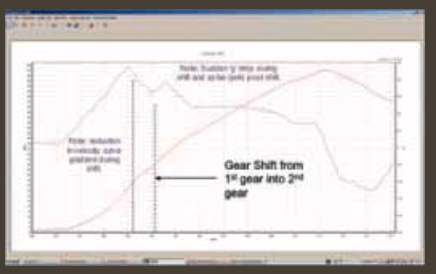
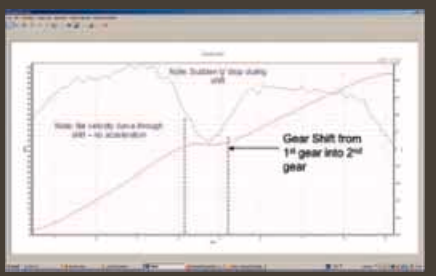


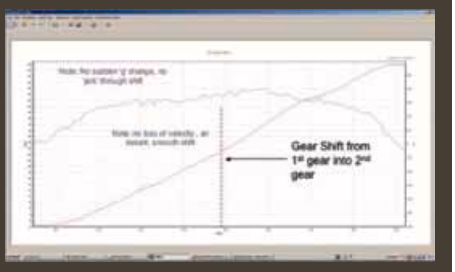
Figure 8. The first gear acceleration bullets become the second gear deceleration bullets as they engage with the second gear dogs



Audi A3 2.0TDi with DSG gearbox (auto mode)
Note the sudden drop in the *g* curve during the shift then a spike on completion of the change



Subaru Impreza 2.0 Turbo with five-speed manual
Classic manual trace with a big drop in *g* during the shift and zero gradient in the velocity curve



TVR Cerbera 4.2 with a ZeroShift gearbox
No dips or spikes in the *g* curve and a velocity curve with a consistent gradient throughout

electronically, so the plan now is to operate the first generation of ZeroShift electronically.

To develop this the company has recruited Andrew Bowyer, an engineer with expertise in industrial automation for manufacturing. Like Martin, he does not have a background in transmissions or even automotive applications so he brings no preconceptions about how things should be done. 'Most car companies are doing it as open loop,' he explains, 'our system is based on closed loop control so it is self taught. The clutch system will be self taught and the cut to the engine will be self taught so it will be constantly changing.' Normally the cost of torque sensors makes this strategy prohibitive, but Bowyer has developed a way of tackling it without one.

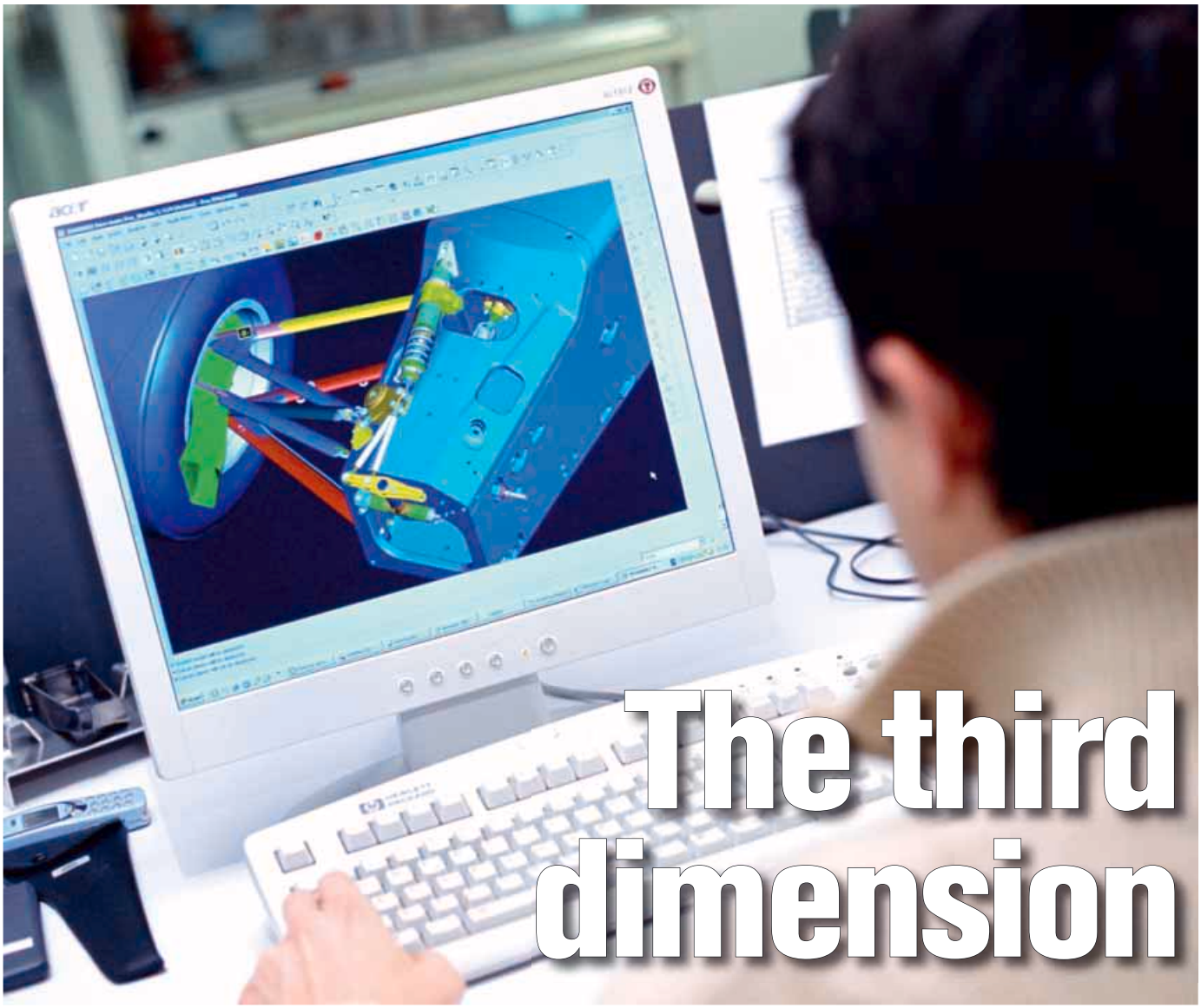
This is another unexpected feature of the company, as the core product drives numerous spin-off technologies that ZeroShift is registering with the intention of licensing in the future.

> "THE GEARSHIFT IS ONLY BETRAYED BY A SUBDUED CLONK AND A BARELY PERCEPTIBLE SURGE"

The team obviously has a great deal of talent and experience within it, but the burning question is are they turning ZeroShift into a workable system? Our experience of the company's long-suffering TVR test bed suggests it is. Even with the bare minimum of smoothing strategies in operation the change is only betrayed by a subdued clonk and a barely perceptible surge. It really is a seamless change with no break in torque delivery, the big giveaway being the lack of acceleration reversal at any point in the change. In fact, when demonstrating ZeroShift to potential customers, the subject of luxury cars as suitable applications is often raised by representatives of car manufacturers. The guests will also ask to be shown the system without the control systems to gauge its appeal to the sports market in its raw form.

So, when can we expect a ZeroShift gearbox on the market? With less need to generate revenue than originally anticipated, the company is taking more care over its first retail product. The five-speed T5 originally intended as a base is now considered less suitable. Instead work is switching to a production six-speed unit, and the team now expects to have an aftermarket ZeroShift version on the market late in 2006.

And what about its application in motorsport? The company is currently in talks with a number of outfits and while we were there, Ashcroft gave us a glimpse of a concept for a Formula 1 gearbox. This demonstrated the ability to provide seamless selection of all seven gears in a unit as restricted as the smallest currently in use in F1 today. It seems this dynamic new company has some exciting times ahead. RE



The third dimension

If you've not taken the plunge and bought into the 3D CAD environment yet, then your business could be missing out on a tool now vital to successful racecar design

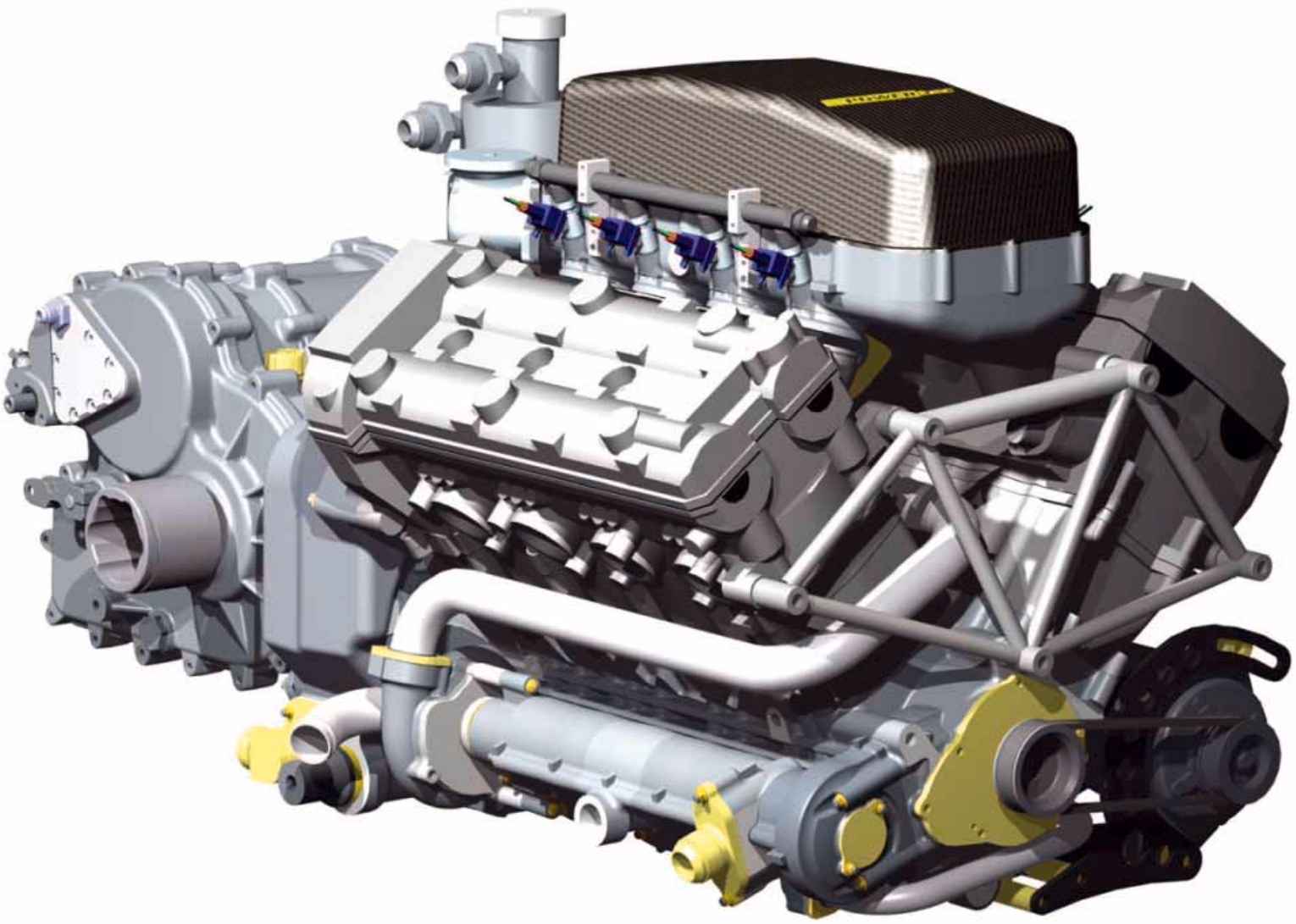
Words	Charles Clarke
Images	Sutton Images

"MEASURABLE AND TANGIBLE GAINS CAN BE BROUGHT ABOUT BY USING HIGH PERFORMANCE SOLID MODELLING SOFTWARE"

Most senior engineers and designers in motorsport will tell you that success is a combination of a good driver, a good engine, good tyres and a good car package. Generally the only thing a team can influence directly is the car package. This it does through the quality and dedication of its design and manufacturing staff and the quality and capability of their systems.

CAD has been central to racecar design for nearly three decades now. For much of this time the focus has been on 2D and the production of quality drawings for in-house manufacture and/or for manufacture by subcontractors. But times have changed. 3D, and in particular 3D solid modelling, has come of age. With the advent of the new so-called mid-range or 'mainstream' solid modellers (principally SolidWorks, Solid Edge and Autodesk Inventor Series) it is now accessible and affordable to all teams at every level in motorsport.

Time was when computer hardware was slow and expensive, solid modelling software was expensive and, because of immature algorithms, it was too slow and tedious to use. Early 3D software was complicated and required



dedicated, expensive users. Now all this has changed though – for £1500 ($2850) or less depending on the brand, you can buy a PC workstation more powerful than the machines that landed men on the moon. If you are an AutoCAD user, for around £2,000 ($3800) you can upgrade to 3D from AutoCAD in the shape of Autodesk Inventor Series.

Real benefits

Solid modelling is the only way that a computer representation can produce a meaningful replica of a physical part. With a solid model there is no ambiguity. Nothing can exist inside the solid envelope by mistake. It is as solid as if it were made of steel or plastic and yet, because of all the other features of solid modelling technology, it can be manipulated and tested in ways that are impossible with real objects. This provides real benefits for the design and manufacturing engineer: prototypes can be built in the computer; their design can be rigorously tested and optimised; and their manufacture, assembly and use can be simulated. The ability to carry out these procedures early in the design process improves the quality of the design and shortens the time to production.

Using high performance solid modelling software can bring about measurable and tangible gains. Today, speed is critical – the faster you can make the design process, the sooner you can commence manufacture. Solid modelling enables you to freeze your designs earlier, get your car on the track sooner, and start the development earlier. The right product modelling environment can make the difference between coming first or last in today's highly competitive environment.

> **"IF YOU ARE NOT USING 3D YOU ARE SQUANDERING COMPETITIVE ADVANTAGE"**

These benefits have been known for decades, but its cost was prohibitive for all but those with the deepest of pockets. It was also hard to use and was hosted by arcane computer environments. Nowadays, irrespective of the opportunities for linking data to other processes, if you are not using 3D you are squandering competitive advantage, quality and time-to-market, to the detriment of your whole operation.

3D is a far more effective way of working and, if you need actual drawings, as long as the drafting process allows you to include the information you need, it can act as the primary mechanism to produce completely error free drawings from 'solid' virtual components.

CAD has always been very partisan. It's very 'us and them', fuelled by vendor's marketing messages extolling the virtues (or otherwise) of either 2D or 3D. In reality, a mixed design environment has been with us for years. Good engineering design usually needs a mixture of both 2D and 3D disciplines in order to function to its optimum potential. 2D is still useful in the early stages for sketching concepts or →

Types of CAD technology

There are basically three fundamental modelling technologies: wireframe, surfaces, and solids. The level of software sophistication, complexity of computation, and geometric integrity increases from wireframe to solids

Wireframe modellers

As the name suggests, this technology constructs geometry as if it were building the shape from wire elements. Each element is a line, an arc or a spline (curve) between end points or nodes. These nodes are defined in 2D or 3D space. This is the oldest technology and has its origins in the translation of 2D drawings into a 2D or 3D computer internal representation – the so-called electronic drawing board.

2D drafting is a special case of wireframe modelling. Detailing complex geometry with 2D systems is a highly skilled activity. Even with skilled draftsmen mistakes are often made because there are no facilities for validating the input. Also, interpretation of complex drawings requires a considerable amount of skill.

In traditional manufacturing, where drawings are passed between departments, significant conflict can arise between design and manufacturing if one cannot understand the other's drawings. These conflicts disappear with solid models, which can be viewed from all directions by people of any skill level to ensure total understanding.

3D wireframes deal with approximate representations of objects made up of lines, which represent edges or surfaces. Objects made up in this way have no geometric integrity, so the mass of lines or surfaces can hide errors that only become apparent when the object is made.

Wireframe systems are only really useful in automating the drawing process – they do not lend themselves to downstream applications like stress analysis or manufacturing. It is not possible to calculate physical properties and, because the space inside the wireframe model has no physical attributes, interference detection is virtually impossible.

However, in terms of design automation they are better than drawing boards. 2D or 3D wireframe drawings can be reproduced over and over again to a consistently high quality. They can be easily modified and can be stored in a database for future use and modification. Drawing co-ordinates can be measured and dimensioned with precision, and drawing items can be copied and manipulated.

The drawing is just a pictorial representation – in most drafting systems there is no intrinsic link between the pictorial representation of the geometry and that of the dimensions. Consequently the dimensioning regime on a drawing can be changed, much like using an electronic 'razor blade', while the geometry stays the same. It is not unusual to find, even in leading companies, many thousands of production drawings on which the dimensions have been changed many times over and where the geometry bears little resemblance to the dimensioning regime.

The only prominent 2D system in use today is AutoCAD and its position is maintained because of the size of its user base and the fact that it was very successful in the 1980s and '90s at capturing market share from the other competitive 2D systems.

Surface modellers

Surface modellers were originally developed to overcome the limitations of wireframe modellers for documenting the free form characteristics of car bodies and/or aircraft. However, surface patches could be drawn using wireframe techniques, and this led to the development of several different kinds of surface modellers.

Surface modellers, like wireframe modellers, were only a compromise – they worked effectively in certain circumstances but suffered from numerous drawbacks. It was not possible to tell on which side of the surface solid material lay. Interference could not be checked unless partial surface penetration was involved. There were no automatic techniques to ensure the surface integrity of a complex body and this could cause problems with manufacturing applications if the surface had holes in it. Again, physical properties were difficult to calculate. Surface modelling was an improvement on wireframe systems, but it was still a compromise.

Apart from the surfacing modules in the high-end CAD packages (CATIA, UG-NX and Pro/ENGINEER) Alias and ICEMSurf are the popular specialist surfacing systems. These are used in the industrial design and styling markets for the design of consumer products and automotive applications where high quality surface definition is important. They are relatively expensive (when compared to mid-range solid modelling systems) and they require highly skilled operators.

Solid modellers

Originally, solid modellers were developed as assemblies of primitives that used only planar or singly curved surfaces (ie only prismatic parts such as planes, cylinders, cones, spheres etc.). This solved the problem of generating true solid geometry, but it could only be used in simple cases. The real technology breakthrough came with the 'hybrid' modeller, which combined solid and surface technology in a modeller that could be applied to virtually any design situation.

Solid modellers facilitate downstream applications such as finite element analysis, moulding analysis, rapid prototyping and manufacturing. Furthermore, since solid modelling defines an object totally, it is possible to calculate the object's physical properties – mass, volume, centre of gravity and moments of inertia. These can be computed accurately, even for complex parts.

Hybrid solid modellers

Hybrid solid modellers are an adaptation of the standard solid modeller, which uses multiple data structures and various modelling techniques. For example, they can use 3D wireframe structures for rapid geometry creation and modification, solid structures for geometrical and topological integrity, facets for fast graphical display, a history tree or history of solid modelling operations coupled with feature based design, parametric and variational modelling for better design modification.

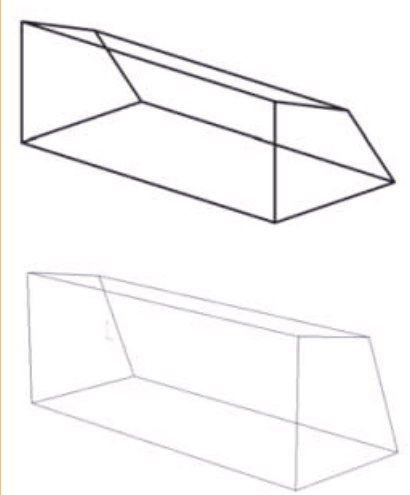
They can also incorporate several geometric representations, including analytic solids, Bezier curves and surfaces, b-spline curves and surfaces, and NURBS (non-uniform rational b-splines).

Pro/ENGINEER was the first parametric solid modeller and SDRC's I-deas Master Series (now part of UG-NX) was the first variational modeller. All these techniques – hybrid data structures, feature based, parametric and variational design can be found in the new mid-range solid modellers.

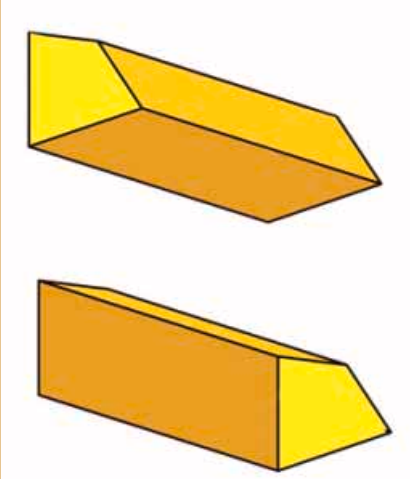
Assembly modelling

Modelling engineering assemblies can be a laborious and repetitive task. Most assemblies encompass multiple instances of the same part(s). To facilitate assembly modelling, all solid modelling systems allow designers to use copies of parts at any location or orientation. In this way a user avoids having to recreate each instance of a common part.

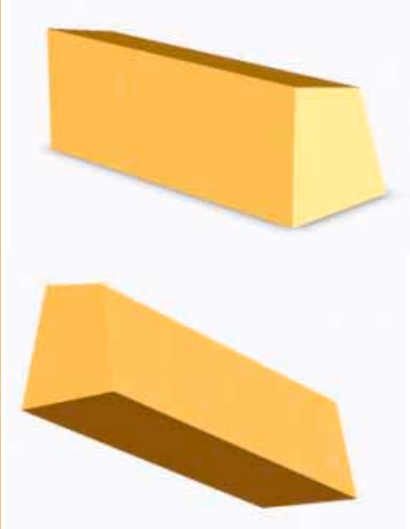
Some systems allow a user to insert one or more references to a part model in the assembly rather than an actual copy of the part. When the part is changed, all the copies of the part are updated automatically. ➔



The most basic form of modelling is wireframe but its use today is limited mostly to old users



Surface modelling was a step up, but was still very limiting in complex design processes



Solid modelling started as a basic method but, as hybrid systems developed, so did its accuracy

Radical Powertec A-series Macroblock V8 engine is a triumph of 3D CAD design

Features such as its in-line twin oil and water pumps, four-pump scavenge system and twin rotating balance shafts were all designed in SolidWorks

The result is a fantastic engineering package built on time and on a budget

> "DECISIONS [CAN BE] MADE ON THE BASIS OF FACT AND NOT GUESSWORK"

checking simple mechanisms, but the ultimate goal is a 3D solid model – how you get there is completely up to you.

Moving to 3D is not a binary state and it does not and should not force you to abandon 2D. Also it is not fair to compare the validity of a 2D or a 3D definition of an object, as these are just isolated elements in a total process. The only thing you can do with 2D is to look at it – there is very little to pass on to any other stage.

With 3D you have to plan your model construction looking much further forward, because it's more difficult to change, even with current technology. You have to assume that what you're doing now is a good guess in the context of 'now', but it's not going to be the final one. If you want to modify a 3D model, the simpler the geometry and 3D constraints, the quicker and easier it is to control the changes. Consequently, it's more likely that you are prepared to change it, rather than start again from scratch or compromise the design.

The efficiency you get from having a good forward view does ultimately produce a better product. This is more pronounced when your design environment is centred on 'one-offs'. It becomes a little easier if you are doing family of parts work, or variations on what you did before.

You have to make use of history trees. In some instances, you actually plan the build of the history tree, because you are looking forward to what you might want to treat as variables. Modern software is rich in tools that allow you to reach 'constraint gridlock' much too easily and much too quickly – keep it simple and constrain as little as you have to.

If you give ultimate rein to creative people, you get history trees that turn into forests – 3D has to be approached with discipline. Too many designers just use their right brain, the creative side – the 'I'm sitting in front of it, so I'll fix it!' mentality. These kinds of designers should be encouraged to use a little more left brain – the logical, analytical, rational side. In a recent example requiring a model rebuild the history tree was reduced by 80 per cent, for the same component. This is the difference between someone who is good and someone who is just using the software. This kind of discipline can be taught and/or coached.

Buying decisions

It is also becoming increasingly difficult to differentiate between the mid-range products. Most do the modelling adequately and most can satisfy the check lists of prospective users, so buying decisions are increasingly being made for other than technical reasons – does it use my flavour of Windows? Does it fit my budget? Does it handle my legacy data? Can I communicate data with my suppliers or customers? Does it link to my analysis code etc?

The primary question has to be will it do my work? Followed by will it fit my existing or my required design environment? Another key concern is support. The mid-range market is characterised by indirect selling – is the VAR (value added re-seller) up to supporting my business? Buying software is like getting married – you have to find a partner you can live with, because within six months you'll become dependent on each other.

Buying a solid modelling product has the capacity to affect whole businesses, not just the design department. It opens up whole new areas of development like rapid prototyping, CNC machining, advanced static and dynamic analysis, concurrent engineering, collaborative working etc. as well as providing realistic renderings for marketing and accurate weight and centre of gravity data for the shipping department.

Because price and margins are low, VARs will resist the traditional demo/benchmark engagement. You have to do your research in different ways – talk to users, engage consultants and, if all else fails, buy it and try it. Sometimes it's more cost effective to decide early and buy a product to try, rather than waste six months on the ultimate evaluation project – that way you will only have wasted about £4000 and you will have gained significant insight.

As a general rule, systems that use proven technology: industry standard hardware, →

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accepted software techniques and database structures, along with a state-of-the-art user interface, will prove to be a sound investment. These systems should connect to existing design and network environments. Above all they should allow users to evolve, and not require them to change methodologies or working practices overnight.

Price is usually a good indicator. Good mid-range modellers cost between £4000 and £6000 ($7700-$11,500) and reputable dealers tend not to discount. If it's cheaper, you have to decide whether it is good enough for your purpose and whether the vendor will be in business next year. There are established vendors offering product at very attractive prices but there tends to be other agendas operating than offering customers unrivalled value for money.

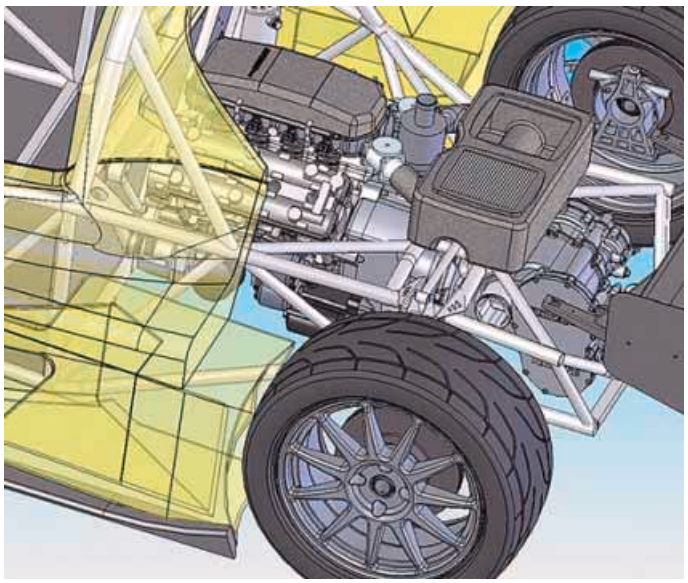
The leading mid-range product, SolidWorks, has a bundle called Office Professional for around £6500 ($12,500) which comes with integrated entry level finite element analysis and PDM (product data management). There are still the 'big CAD' systems like CATIA from IBM, NX (formerly Unigraphics) from UGS and Pro/ENGINEER from PTC. These are often called PLM (product lifecycle management) systems these days. There has been some significant re-structuring of these products and consequent price reductions, but they still remain expensive for the first time buyer and their complexity tends to overwhelm novice users.

> **"3D HAS TO BE APPROACHED WITH DISCIPLINE"**

Modern mid-range modellers are not difficult to learn and use – they are like video games in comparison to the early software. All products use the Windows interface and the early credo of the mid-range market that 'if you can use MS-Word then you can use solid modelling' still applies, but with qualification.

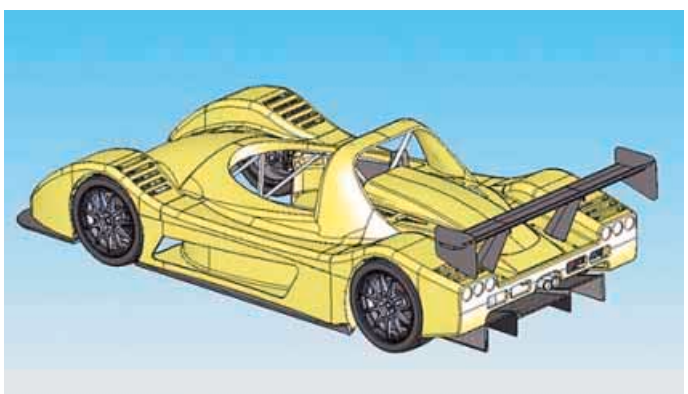
Software training

A Windows user interface is not an excuse to avoid software training either. The ability to use Windows means you are just qualified to start using this system. To use the system well and efficiently you need to be taught how to model efficiently. Many data translation horror stories are a result of using systems inefficiently or starting to model without pre-planning your modelling strategy. Consequently, modelling operations are attempted repetitively to get it right and, at each iteration, extraneous data is left to pollute the model file. →



Radical's SR8 sports prototype was its first car designed entirely on SolidWorks –a program the company now describes as indispensable

Solid modelling provides a means of creating geometry with 100 per cent accuracy that can be acted on and modified at every stage of the design process…



…allowing design teams to go through the processes of concept, drawing, pattern and to final product quicker than ever before

Using 3D CAD means the process from initial design, through detail design to production of final assemblies, such as these Dallara GP2 chassis, is accelerated

According to Mick Hyde of Radical Motorsport, 'To go from feasibility study, to concept, to engineering drawing, to pattern, to casting, to machined crankcase has never been so easy. The SR8 sports prototype was our first car designed on Solidworks. Our designer Nick Walford now finds it indispensable, and I can get involved with the detail design process at a much earlier stage. Seeing the finished component in location is a huge benefit.'

'The Radical V8 engine was essentially a niche waiting to happen,' says Steve Prentice of Steve Prentice Design (SPD), the engine's designer. 'It is in this context that the role of NT CADCAM and SolidWorks can be best understood. The engine simply couldn't have been designed in the time frame it was without SolidWorks. We would have expected to go through a secondary design stage to compensate for components that would have required further refinement or complete re-design. The sheer range of functionality that SolidWorks provides was instrumental in SPD choosing it when it first came to the UK in 1997. It was and remains simply in a different league to the competition. In fact, on the Radical project, SolidWorks has proved more capable than a fully configured suite of Pro/Engineer by delivering functionality that Pro/Engineer couldn't match, and at a price that is totally affordable. The support and assistance from the NT CADCAM team has been first class.'

> **"SOLID MODELLING IS NO LONGER SLOW AND EXPENSIVE"**

Even greater benefits will be realised if solid modelling is seen as the heart of a product modelling environment. This will be a common point of reference for the entire development team throughout the development programme. Under this environment, concurrent use of applications will speed design refinement, verification, manufacturing and documentation. Linked to these will be the process instructions such as routing and approval lists, engineering notes and test results. Therefore providing a route to exploit the benefits of simultaneous engineering and to maintain electronic control and distribution of all design and manufacturing documents and drawings. Consequently, as a project proceeds, the accumulated knowledge can be accessed and decisions made on the basis of fact, not guesswork.

Solid modelling is no longer slow and expensive. It is now a mature technology and this, coupled with the dramatic increase in performance and the reduction in cost of engineering workstations over the last few years, means there is a real opportunity today to exploit 3D applications. Companies that fail to recognise the opportunities that 3D and solid modelling in particular presents will have difficulty competing in today's fast moving environment.

However, this is not to say that the use of solid modellers makes designers infallible. What the best solid modellers accomplish is to provide a means of creating geometry with 100 per cent integrity that can be acted upon at every stage in the design process. This single geometric model is the mathematical representation of the product, which can then be manufactured directly from this data. RE

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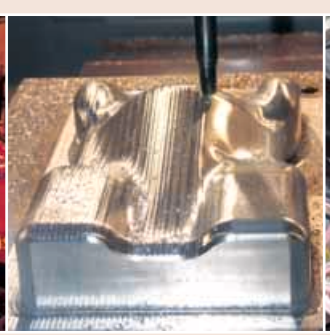


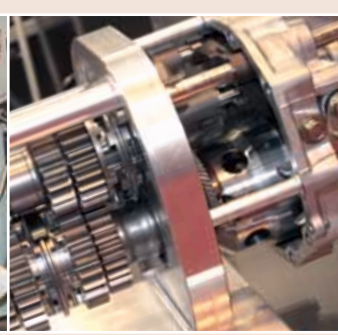

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Material benefits

A fresh approach to composite material structure could yield benefits to racecar and component manufacturers alike

Words | Charles Armstrong-Wilson

The difference is in the weave – main picture shows Oxeon's innovative 50×50mm wide strand weave, while inset picture above shows an alternative 20×50mm weave

We've come a long way since the chopped strand mat of early composite materials. These days everyone is familiar with the sleek, reflective qualities of carbon mat and the strength-to-weight benefits it offers. Now a Swedish company is striving to take the concept further with an innovative approach to composite matrix design.

Born out of the technology incubator of Chalmers University of Technology, Oxeon comprises a group of technical entrepreneurs planning to develop their business around innovation in composite materials. The latest product to emerge from the company is the Oxeon Textreme range that takes a different approach to producing fibre weave. Rather than the close weave normally associated with carbon fabrics, Oxeon has developed one made from wide tapes that gives a number of benefits over a typical narrow-strand fabric.

The company claims the fibres are much more efficient due to the greatly reduced crimping between weaves,

> "MANY MORE FIBRES CAN BE SQUEEZED INTO THE MATERIAL FOR A GIVEN THICKNESS"

allowing them to carry axial loads more effectively. Also, many more fibres can be squeezed into the material for a given thickness, improving the strength-to-weight ratio of a component. In addition, the manufacturer is claiming better drapability and wettability for its fabrics, creating mouldings with greater integrity and less chance of voids in the finished composite.

Textreme is created from tapes comprising unidirectional fibres and ranging from 20mm to 50mm wide. The individual fibres are held in orientation by threads bonded diagonally

in a diamond pattern. These tapes are woven together in the same way as normal materials but the process is said to be gentler, avoiding damage to the brittle fibres.

Different widths of tape can be used for the warp and weft, biasing the characteristics of the material and the subsequent moulding. It can be used in place of normal close weave materials or multiple layers of unidirectional sheets and, through having fewer interlacing points, it produces a smoother finish. The process can be used for all glass, aramid and carbon materials and can also be applied to very brittle materials like boron and ceramic.

Oxeon is taking an imaginative approach to the exploitation of composites and it seems likely that its products will soon be finding more applications than the company's founders could have imagined. RE

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Easy on airlance

German-based manufacturer of fittings and hose systems, Krontec, has developed a new, durable airlance connection for air jack systems.

Designed with reliability and ease of use in mind, the new LL-03 'easy push' provides an effortless connection procedure with pressures of up to 40bar at the valve.

The airlance system is offered in three different connection variants. The LL-12, the most lightweight race-appropriate model is just a nipple valve without any additional function, whereas the LL-13 has an integrated ball valve allowing the option of keeping the system pressurised after disconnecting. Lastly, the LL-14 has a push-pull method of operation to manually control the valve.

For more information call **+49 (0) 9401 52530** email **info@krontec.de** or visit **www.krontec.de**

On the case

The ATI SuperCase is the new high standard Powerglide transmission case and bellhousing unit from Baltimore, USA-based ATI Performance Products.

Made from 356 T-6 cast aluminium, the SuperCase has been designed to address all problem areas found in original GM Powerglides. It will accept all Powerglide replacement parts and has a precision machined detachable bellhousing that does not use the traditional pump bolts for mounting as before.

The SuperCase is SFI 4.1 certified and includes a lightweight 29oz (902g) internal steel anti-explosion liner. The bellhousing has SFI 30.1 manufacturer certification and no external shields are necessary. Currently available in Chevy pattern but soon to be available to fit Ford, Chrysler, GM BPO and Toyota V8s.

For more information call **+(1) 410 298 4343** or visit **www.atiperformanceproducts.com**

Zero friction seals

Leading manufacturer of low-friction motorsport seals, Race-Tec NAK, has taken another step towards creating the ultimate zero load, zero friction seal, with its new range of PL6 oil and grease seals.

Using finite element analysis computer modelling during development has resulted in seals that reduce power losses by between 80 and 85 per cent, judged against competitive seals. Available in both single and dual lip designs, the extremely high tolerance PTFE lips are virtually unaffected by high vacuum levels in tests up to 20,000rpm.

Designed with challenging 2005 Formula 1 regulations in mind, the seal's complex, low-friction PTFE materials are claimed to dramatically reduce friction losses and wear in a variety of applications including engines, suspension components and gearboxes.

For more information call **+44 (0)2380 246986**, email **nak@race-tec.com** or visit **www.race-tec.com**

Isolation innovations

Cartek has produced a new solid state battery isolator to enhance safety standards and reliability in motorsport vehicles. Using current MOSFET expertise, Cartek's new safety conscious engine and battery isolator meets FIA regulations.

Weighing just 150g, the completely electronic isolator is controlled by microprocessors to regulate and survey internal temperature, short–circuit protection and false trigger detection.

The device, operating between 8 and 18v, is surrounded by an aluminium shell to withstand vibration and shock and has the added benefit of extra kill switches, compared to the traditional single switch on other models.

For more information call **+44 (0)1489 799905** or email **info@cartek.biz**

RACEGEAR

New Products and Services for Racecar Engineers

Hi-tech high flow

UK-based Lee Products, specialists in the construction of precise fluid control mechanisms, has launched a new range of Hi-Bar safety screens, designed to work together with traditional in-line wire mesh filters.

The new one-piece screens are available in steel or aluminium and feature up to 37,000 evenly spaced laser-drilled holes between 75 and 400 microns in diameter. Fully clogged Hi-Bar screens can withstand pressures up to 518 bar without collapse and allow bi-directional oil flow.

Hi-Bar screens are available in flange and boss-mounted options.

For more information call **+44 (0)1753 886664**, email **sales@leeproducts.co.uk** or visit **www.leeproducts.co.uk**

Easy welding

UK-based welding specialists ESAB has launched its new OrigoArc 150 and 200 MMA welding machines. Appropriate for use on a wide range of ferrous metals, including stainless steel, both machines have been designed for ease of use, dependability outside of the workshop and practicality.

A single control knob sets the current rate accurately, while the ESAB ArcPlus feature provides automatic control of arc conditions. With the OrigoArc 200 weighing 8kg and the 150 just 6.9kg, and both models operating direct from a standard 230v mains supply, they are ideal for transportation and use in a motorsport environment.

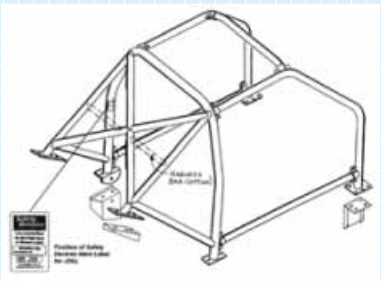
For more information call **+44 0800 3893152** or email **info@esab.co.uk**

Classic Jag cage

UK-based supplier of rally and racecar safety apparatus, Safety Devices, has launched a new rollcage design for the Jaguar XJ6, designed in conjunction with Jaguar specialists Classic Spares.

The XJ6 is fast becoming a favourite for entry-level club motorsport events, and the new cage has been developed with these competitors in mind, ensuring optimum safety within an affordable budget.

The six-point, bolt-in cage is suitable for the 1986 onward XJ40/ X3000 series saloon cars and is made from CDS tubing, then powdercoated in phosphate and polyester. High-impact padding is also available.



Self-installation kits are available, or professional fitting can be undertaken at either Safety Devices premises in Cambridgeshire or Classic Spares workshops in Hertfordshire.

For further information call Safety Devices on **+44 (0)1353 724200** or Classic Spares on **+44 (0)1992 716236**. Alternatively, visit **www.safetydevices.co.uk**

Top Deck cooler

Pace Products in the UK has launched a brand new air-to-water combination intercooler chargecooler for '96-2000 and 2001-on Subaru Impreza/Legacy models called Top Deck.

By combining a modified air-to-air unit and a more efficient remote water cooling system Pace claims the Top Deck unit is able to maintain consistently low inlet temperatures and more efficient performance across a wider power range.

For more information call **+44 (0)1440 760960**, email **sales@paceproducts.co.uk** or visit **www.paceproducts.co.uk**

RACEGEAR

New Products and Services for Racecar Engineers

On–line 3D catalogue

UK-based parts distributor WDS has divided its comprehensive workholding solutions catalogue into six volumes in an effort to make it simpler and more effective for designers and engineers to use. Standard Parts is the first title in the series and includes the original range available from WDS, along with over 50 new products. The other five are Machine Accessories, Hydraulic Workholding, Broaching, Indexing and General Workholding.

Aimed primarily at OEM manufacturers and designers, as an incentive WDS has also removed all surcharges on small purchases and maintained its discount rates on large orders.

Current versions of the catalogues are available on-line or on CD with 2D dxf files. Of particular interest to designers is the fact that over 10,000 of its components are available on-line as downloadable 3D CAD files in most current CAD formats.

For more information call **+44 0845 6066677** or visit **www.wdsltd.co.uk**

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Goodridge 2005

UK-based hose and fitting company, Goodridge, has launched its new 2005 catalogue.

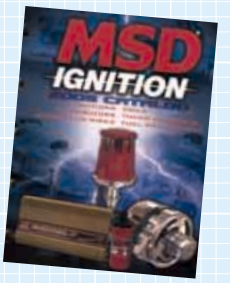
Goodridge has been a major supplier to the racing industry for over 35 years and this comprehensive catalogue showcases the company's extensive line of products, ranging from push-fit applications to intricate high-pressure systems.

The catalogue includes Goodridge's own G-Line hoses and fittings and a full range of adaptors, as well as assembly instructions and technical info sections.

For more information call **+44 (0)1392 369090**, email **sales@goodridge.net** or visit **www.goodridge.net**

Bright sparks

US-based MSD Ignition has released its comprehensive, full colour 2005 catalogue of parts and products. As well as their established range of coils, ignition control modules, spark plug wires and timing accessories, new products include digital E-curve distributors and turbo-diesel injection systems.



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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

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Overthorpe Road, Banbury, Oxfordshire OX16 4PN England

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

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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
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Lower College, Hothersall Lane, Longridge, Preston, Lancashire PR3 2XB

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Gould Engineering Services, Unit 7, Arnhem Road, Newbury, Berks, RG14 5RU

ICP/CITATION USA (1) 317 273 0089
Indianapolis Competition Products, 1717 Expo Lane, Indianapolis, IN 46214, USA

JADE Tel 01883 744 443
Fax 01883 744 443
Address Jade Motorsport Engineering, Unit 2 Pendell Farm, Pendell Road Bletchingley Surrey RH1 4QH

JEDI Tel 01933 440774
John Corbyn Motors, 36A Stanley Road, Wellingborough, Northamptonshire NN8 1DY, England

KBS USA (1) 909 355 4800
Fax (1) 909 355 5933
KBS Engineering, 8296 Fremontia, Suite B, Fontana, CA 91404, USA

KUDZU USA (1) 404 457 6300
Fax (1) 404 458 6118
5096 Peachtree Road, Atlanta, GA 30341, USA

LAZER USA (1) 906 863 5003
Campbell Motorsport, W7719 Fernwood Drive, Menominee, MI 49858, USA

LOLA Tel 01480 451301
Fax 01480 456722
Lola Cars International, Glebe Road, St Peters Hill, Huntingdon, Cambridgeshire PE18 7DS, England
US Importer
Tel (1) 317 244 2277 Fax (1) 317 390 2121
Lola Cars Inc, Suite B, 2801 Fortune Circle East, Indianapolis, IN 46241, USA

LUCCHINI Italy (39) 0376 391271
Fax (39) 0376 391200
Lucchini Engineering, via Valeggio 2, 45100 Mantova, Italy

LYNCAR ENGINEERING Tel 01635 860066
Fax 01635 860066
Email: lyncar001@btopenworld.com
Briff Lane, Bucklebury, Reading, Berkshire RG7 6SN

MAGNUM Tel 01933 442861
Fax 01933 22552
141 Laurence Leyland Industrial Estate, Wellingborough, Northamptonshire NN8 1RA, England

MALLOCK Tel 01604 863504
Fax 01604 863807
Mallock Racing, Rowley Wood Lane, Hartwell, Northamptonshire NN7 2QT, England

MARK BAILEY RACING Tel 01380 850130
Fax 01380 850140
MBR Building, 8A Jockey Lane Bromham, Chippenham, Wiltshire, SN15 2EZ

MATT WATERMAN MOTORSPORT DESIGN Tel 0408 216357

MYGALE Tel France 33 3 8621 8621
Fax France 33 3 8621 8622
Technopole du Circuit, 58470 Magny-Cors, France

OSELLA S.R.L Tel 0972 715852
Fax 0972 715391
Z.I Valle di Vitalba, 85020 Atella, (PZ)

PANOZ Tel USA (1) 770 967 2310
Fax USA (1) 770 965 8762
5294 Winder Highway, Braselton, GA 30517, USA

PHOENIX USA USA (1) 813 655 1199
Phoenix Race Cars, 364 Hairpin Drive, Sebring, FL 33870, USA Fax (1) 813 665 1199

PICCHIO S.p.A Tel 0039 0861 816015/16
Fax 0039 0861 86246/805651
Email: picchio@picchio.com or picchiospa@email.it
Website: www.picchio.com
Zona Industriale Ancarano 64010 - Ancarano (Teramo) Italy

PILBEAM Tel 01778 424838
Fax 01778 393032
Pilbeam Racing Design, Graham Hill Way,Cherry Halt Road, Bourne, Lincolnshire, PE10 9PJ

PIPER USA (1) 708 365 5334
Piper Engineering, 5N461 Meadowview Lane, St Charles, IL 60175, USA

PREDATOR USA (1) 313 681 1377
Fax (1) 248 681 1377
Crossroads Fabrication, 265 Hillcliff, Waterford, MI 48328, USA

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

PROTOFORM USA (1) 607 739 7345
Protoform Race Engineering, 51 Ponderosa Drive, Horseheads, NY 14845, USA

RACEFAB USA (1) 713 694 8335
Fax (1) 713 694 8335
8307 Beauman Road, Houston, TX 77022, USA

RALT 01865 883354
Fax 01865 883789
Ralt Engineering, Sutton Farm House, Sutton, Witney, Oxfordshire OX29 5RD, England
US Importer
Tel (1) 310 533 1144 Fax (1) 310 530 0139
Ralt American, 23110 Kashiwa Court, Torrance, CA 90505, USA

RAPTOR USA (1) 215 775 1938
Performance Engineering, RD5 Box 5435, Mohnton, PA 19540, USA

RAY Tel 0208 680 9418
Fax 0208 688 4026
15 Silverwing Industrial Park, Horatius Way, Croydon, Surrey CR0 4RU, England

RILEY & SCOTT USA (1) 317 248 9470
Fax (1) 317 248 0182
1200 Main Street, Speedway, Indianapolis IN 46224, USA

RML LTD Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Ind Est, Wellingborough, Northants NN8 6TY England

SABRE USA (1) 714 693 0296
USA Race Cars, 1535 Harmony Circle, Anaheim, CA 92807, USA Fax (1) 714 693 3164

SCCA USA (1) 303 693 2111
Fax (1) 303 680 5633
Spec Racer, 7476 South Eagle Street, Unit 5, Englewood, CO 80112, USA

SCARAB Tel 01636 822033R
RS Racing & Specialised Services, High House,Kirton Road, Egmanton, Newark, Nottinghamshire NG22 0HF, England
SEZIO FLORIDA RACING
Tel: 001 776 878145

SHELBY USA (1) 310 538 2914
Fax (1) 310 538 0126
Shelby Can-Am, Shelby Technologies Inc, 19021 South Figueroa, Gardena, CA 90248, USA

SPECTRUM Australia (61) 3 95 80 52 36
Fax (61) 3 95 80 53 31
Spectrum Racing Cars, Borland Racing Developments, 39 Industrial Drive, Braeside, Victoria, Australia 3195

STRYX Tel 01789 750567
Fax 01789 292183
Minerva Developments, Grafton Lodge, Binton, Stratford-on-Avon, Warwickshire CV37 9TX, England

SPICE RACING CARS LTD Tel 01483 203956
Fax 01483 203956
Int House, 31 Church Road, Hendon, NW4 4EB, England

SWIFT US Importer International Racing Products
Tel (1) 800 793 0496
1034 Riva Ridge, Great Falls, VA 22066, USA

SYMBOL Italy (39) 0362 903967
Symbol Team srl, via Fiume 17, Carate Brianza, 20048 MI, Italy

TAMPOLLI Italy (39) 055 8873268
Fax (39) 055 8825777
Tampolli Engineering, via degli Artigiani 44-46, Calenzano, 50041 FI, Italy

TOM'S Japan (81) 3370 46801
Fax (81) 3370 46805
6-13-10 Todoroki Setagaya-ku, Tokyo, Japan 158

TPG 0039 682 32225

VAN DIEMEN Tel 01953 888195
Fax 01953 888178
Van Diemen International Racing Services, Chalk Road, Snetterton, Norfolk NR16 2JZ, England
US Importer Primus Racing
Tel (1) 813 522 7544 Fax (1) 813 522 7417
3608 Morris Street, St Petersburg, FL 33407, USA

Database 2
COMPETITION CAR CHASSIS COMPONENTS

2.1 Chassis/BodyWork Ancillaries

AEROFOILS

ACTIVE ENG USA (1) 714 637 1155
AERODINE USA (1) 317 271 1207
ANDREAM LTD
CUSTOMIZED COMPOSITE WINGS
Tel: 01953 885775
Fax: 01953 884176
Email: dave.greenwood@eidisnet.co.uk
Unit 12 Norwich Road Industrial Estate, Watton, Norfolk IP25 6DR
C&B CONSULTANTS 01202 661707
DJ RACECARS LTD 01663 734518
JANUS TECHNOLOGY 01753 869996
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

LOLA **Tel 01480 451301**
Fax 01480 456722
Lola Cars International, Glebe Road, St Peters Hill, Huntingdon, Cambridgeshire PE18 7DS, England
US Importer
Tel (1) 317 244 2277 Fax (1) 317 390 2121
Lola Cars Inc, Suite B, 2801 Fortune Circle East, Indianapolis, IN 46241, USA
ROAD & STAGE M/SPORT 01524 844066
SARDOU France (33) 1 60 01 03 67
THE WING SHOP **Tel: 01258 860716**
Fax: 01258 860716
E-mail: info@wingshop.co.uk
Web: www.wingshop.co.uk
SPA AEROFOILS LTD 01827 260026
UNI OF MARYLAND USA (1)301 405 6861
QINETIQ 02700 100942
ZEUS MOTORSPORT 01604 878101

FASTENERS

ABC AUTOSPORT BEARINGS • COMPONENTS
Tel : +44(0)1932 225777 Fax : +44(0)1932 222215
Unit 3 Shepperton Business Park
Shepperton, Middlesex TW17 8AA
ALL WAYS FORWARD 01242228111
ARP USA (1) 805 525 5152
ARROW SUPPLY 01234 840404
CLARENDON **01455 841200**
COAST FABRICATION USA (1) 714 842 2603
DATUM ENGINEERING 02476 383032
DZUS FASTENERS EUROPE 01252 714422
FASTENER FACTORY 01327 311018
FLUID CONTROL PRODUCTS INC **USA (1) 217 324 3737**
Fax (1) 217 324 3717
PROTEX FASTENERS LTD **01527 63231**
SPECIALITY FASTENERS 01803 866371
STAUBLI France (33) 4 50 65 60 60
TRIDENT RACING SUPPLIES **TEL 01327 857822**
FAX 01327 858096
Unit 31, Silverstone Circuit, Northants NN12 8TN

FIRE EXTINGUISHERS

LIFELINE **02476 712999**
LINREAD NORTHBRIDGE MOTORSPORT 01162 572924
RALLY DESIGN 01795 531871
SAFETY DEVICES **01353 724202**
SPA DESIGN **01827 288328**
SPA TECHNIQUE **USA (1) 317 271 7941**
ATL **USA (1) 201 825 1400 Fax (1) 201 825 1962**
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
KS MOTORSPORT Germany (49) 2271 44905
PRONALS France (33) 320 99 75 10
TRANSAUTOSPORT **01772 454647**
ACTIVE ENG USA 001 714 637 1155
GARTRAC 01428 682263
ROLLCENTRE 01480 464052
SAFETY DEVICES **01353 724202**
SIGMA **Switzerland (41) 61 9717600**
CORBEAU 01424 854499
GRAND PRIX RACEWEAR 020 8987 5500
MOMO USA 001 714 637 1155
EARS MOTORSPORTS 01625 433773
KS MOTORSPORT Germany (49) 2271 44905
OMP USA (1) 973 361 0508
MOMO USA 001 714 637 1155
LUKE 01323 844791
Total Restraint Systems 01722 326080
TRW SABELT 020 7736 2881
WILLANS **01264 810712**

RUBBER & ELASTOMERIC COMPONENTS

BUTSER RUBBER LTD Tel: 01730 894034

2.2 Electrical Systems

REDLINE MOTORSPORT **Tel 01606 737500**
Fax 01606 737683

ALTERNATORS

BOSCH 01895 834466
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 / web www.centurycables.com
IS MOTORSPORT USA (1) 317 244 6643
PERFORMANCE WIRING SOLUTIONS +44 (0)1954 253620
SPEEDY CABLES 020 7226 9228
SPOT ON CONTROL 0118 979 0682
TRIDENT RACING 01327 857822
CONTINENTAL USA (1) 513 459 8863

CONNECTORS

BERU F1 SYSTEMS 01374 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
RAYCHEM 01793 572217

DISTRIBUTORS

IS MOTORSPORT USA (1) 317 244 6643
MM COMPETITION **08707 444666**
PALLAS CONNECTIONS 01869 277053
PAD RACING NZ (64) 3 3386 288

IGNITION SYSTEMS

BOSCH **UK 01895 834466**
Germany (49) 711 8111 USA (1) 312 865 5200
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

LIGHTS

HELLA 01295 272233
PRODRIVE 01295 254400

LOAD CELLS

NOVATECH MEASUREMENTS **01424 852 744**

SPARKPLUGS

BERU 01295 272233
BOSCH Germany (49) 711 8111
UK 01895 834466 USA (1) 312 865 5200
CHAMPION AUTO 0151 522 3000
KS MOTORSPORTS Germany (49) 2271 44905
MAGNETI MARELLI **Italy (39) 02 972 27570**
MM COMPETITION **08707 444666**
NGK Japan (81) 52 872 5937 UK 0208 202 2151

SPARKPLUG LEADS

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

WIRING HARNESSES

A.N. MOTORSPORT DESIGN 01628 776320
COMPETITION DATA SYS USA (1) 716 631 2880
DC ELECTRONICS 01621 856451
SBD MOTORSPORT 0208 391 0121
EFI TECH USA (1) 310 793 2505
BERU F1 SYSTEMS 01374 646200
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
PALLAS CONNECTIONS 01869 277053
PERFORMANCE WIRING SOLUTIONS +44 (0)1954 253620
RAYCHEM 01793 572217

SAKATA MOTORSPORT ELEC. INC. **Tel (714) 446 9473**
Fax (714) 446 9247
Website www.sakatamotorsport.com
689 S. State College Blvd, Unit F Fullerton, CA 92831
SERVO & ELECTRONIC SALES LTD 01797 322500
THE STRAIN GAUGING CO **01256 320666**
TONY JAMES **01379 854485**

2.3 Controls

GEARSHIFT SYSTEMS

CENTURY CABLES **Tel 01733 211600 / Fax 01733 211082**
Email kwhincup@yahoo / web www.centurycables.com
DAVID BROWN 01484 422180
SBD MOTORSPORT 0208 391 0121
HEWLAND ENG 01628 827600
JACK KNIGHT 01483 764326
PRODRIVE 01295 273355
QUAIFE ENGINEERING 01732 741144
RICARDO MIDLANDS TECHNICAL CENTRE 01926 319399
RINGSPANN (UK) 01234 342511
THE STRAIN GAUGING CO **01256 320666**
STONE FOUNDRIES 020 8853 4648

HYDRAULIC VALVES

A.N. MOTORSPORT DESIGN 01628 776320
LEE PRODUCTS 01753 886664
MOOG CONTROLS 01684 296600

INSTRUMENTATION

ACTIVE SENSORS 01202 480620
CRANFIELD IMPACT CENTRE 01234 750944
LMI STACK USA 001 714 637 1155
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
PENNY & GILES 01202 409409
PI RESEARCH 01954 253600
QINETIQ 08700 100942
SPA DESIGN 01827 288328
STACK 01869 240404
McCLAREN ELECTRONICS 01483 261400
THE STRAIN GAUGING CO **01256 320666**
VARIOHM 01327 351004

MIRRORS

GRAND PRIX RACEWEAR 0208 987 5500
SPA DESIGN 01827 288328

PEDALS

AP RACING 02476 63595
CHEVRON RACING 01565 777395
LOLA **Tel 01480 451301**
Fax 01480 456722
TILTON **USA (1) 805 688 2353**
WILWOOD ENG **USA (1) 805 388 1188**

STEERING SYSTEMS

FLAMING RIVER USA (1) 440 826 4488
MOBILIS Canada (1) 450 647 1890
RALLY DESIGN 01795 531871
ZF Germany (49) 7541 772543
UK 0115 9869211

WOODWARD MACHINE CORP **TEL: USA (1) 307 472 0550**
FAX: USA (1) 307 235 1551
Website: www.woodwardsteering.com
PO Box 4479, 3592 Burd Road, Casper, WY82604, USA

STEERING WHEELS

DEMON TWEEKS 01978 664466
MOUNTNEY 01525 383055

SWITCHES & KILL-SWITCHES

IS MOTORSPORT USA (1) 317 244 6643
MAGNETI MARELLI Italy (39) 02 972 27570
MM COMPETITION 08707 444666
SAKATA MOTORSPORT ELEC. INC. (714) 446 9473
TONY JAMES **01379 854485**
TRIDENT RACING **01536 770777**

THROTTLE CABLE

JLS MOTORSPORT 0121 525 7733
KINSLER USA (1) 810 362 1145
LUMENITION 020 8403 4334
RALLY DESIGN 01795 531871
SPOT-ON CONTROL 0118 9790682
RINGSPANN 01234 342511

2.4 Suspension Systems

DEREK BENNETT ENG **01565 777433**
DON FOSTER RACING **France**
(33) 4 70 58 0308
DYNAMIC SUSPENSIONS 01842 755744
GROUND CONTROL USA (1) 916 638 7888
LOLA **Tel 01480 451301**
Fax 01480 456722
PROFLEX UK **01200 442345**
RICARDO MIDLANDS TECHNICAL CENTRE 01926 477208
ROD MILLEN MOTORSPORT USA (1) 714 8472111

2.5 Suspension Components

ANTIROLL BARS

COIL SPRINGS 01142 758573
COMPTECH USA USA (1) 916 933 1080
DEREK BENNETT ENG **01565 777395**
DON FOSTER RACING **France (33) 4 70 58 0308**
DTM CONSULTANTS UK 01865 407726
GROUND CONTROL USA (1) 916 638 7888
KIC INT MOTORSPORTS USA (1) 604 589 3354
HARROP Australia (61) 3 9499 7433
PRECISION USA (1) 708 766 4402

BEARINGS & BUSHES

ABC AUTOSPORT BEARINGS • COMPONENTS
Tel : +44(0)1932 225777
Fax : +44(0)1932 222215
Unit 3 Shepperton Business Park
Shepperton, Middlesex TW17 8AA
AURORA BEARING USA (1) 630 859 2030
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

COILSPRINGS

COIL SPRINGS 01142 758 573
COMPTECH USA USA (1) 916 933 1080
EIBACH 01455 285850
EIBACH Germany (49) 2721 511220
GROUND CONTROL USA (1) 916 638 7888
HYPERCOILS **USA (1) 574 753 6622**
HERBERT TERRY 01527 64261
PERFORMANCE SPRINGS **01253 716900**
WOODHEAD 0113 2441202

DAMPERS

DTM CONSULTANTS UK 01865 407726
DYNAMIC SUSPENSIONS 01842 755744
PROFLEX UK 01200 442345
GROUND CONTROL USA (1) 916 638 7888
JRZ SUSPENSION +314 026191155
MONROE AUTO EQUIPMENT 01904 631441
MORRIS DAMPERS INC USA (1) 586 826 9141
MOTON Netherlands (31) 413 259838
OHLINS RACING UK 0208 974 1615
PENSKE RACING SHOCKS USA (1) 215 375 6180
UK 01827 288328
ROEHRIG **USA (1) 336 431 1827**

RODS & ROD-ENDS

AURORA BEARING CO **USA (1) 630 859 2030**

ABC AUTOSPORT BEARINGS • COMPONENTS
Tel : +44(0)1932 225777 Fax : +44(0)1932 222215
Unit 3 Shepperton Business Park
Shepperton, Middlesex TW17 8AA

FASTENER FACTORY 01327 311018
GOLDLINE BEARINGS 01952 292401
GROUND CONTROL USA (1) 916 638 7888
KINSLER USA (1) 810 362 1145
RESB INTERNATIONAL 0208 390 8076
ROSE BEARINGS 01522 500933
SPECIALITY FASTENERS 01803 866371

SEALS
SPECIALITY FASTENERS 01803 866371
WALTHER 01442 891929

STRUT BRACES
DEMON TWEEKS 01978 664466
EIBACH Germany (39) 2721 5110
UK 0455 285850
USA (1) 714 727 3700
FASTENER FACTORY 01327 311018
OHLINS RACING UK 0208 974 1615

2.6 Braking Systems
ALCON COMPONENTS 01827 312500
AP RACING 02476 639595
ATE 0208 654 8836
CARBONE INDUSTRIE France (33) 0472 355700

CIRCUIT SUPPLIES (U.K.) LTD
CIRCUIT SUPPLIES (UK) LTD Tel 01525 385888
Fax 01525 385898
Unit 22, Harmill Ind Est, Grovebury Road, Leighton Buzzard, Beds, LU6 8ff
Email: info@circuitsupplies.com
Web: www.circuitsupplies.com
BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
DELPHI BRAKE SYSTEMS 01926 472472
EBC BRAKES 01604 583344
ENDLESS BRAKES Japan (81) 267 68 0071

brembo
GRANDPRIX RACEWEAR
Tel: 01908 220777
Email: info@grandprixwear.com
Web: www.grandprixwear.com
Unit 3 Fitzhamon Court, Featherstone Road, Wolverton Mill, Milton Keynes MK12 6LB
GOODRIDGE UK 01392 369090
USA (1) 310 533 1924 USA (1) 317 244 1000 USA (1) 704 662 9095
MOSA FREIN Belgium (32) 81 73 32 73

PERFORMANCE FRICTION BRAKES
PERFORMANCE FRICTION (1) 800 521 8874
EUROPE +44 (0) 1280 843 390

REDLINE MOTORSPORT
REDLINE MOTORSPORT Tel 01606 737500
Fax 01606 737683
E-mail info@redlinemotorsport.co.uk
WILWOOD ENG USA (1) 805 388 1188

2.7 Brake Components
CALIPERS
ALCON COMPONENTS 01827 312500
AP RACING 02476 639595
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
BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
CARBONE INDUSTRIE France (33) 0472 355700

HAWK PERFORMANCE
GRANDPRIX RACEWEAR
Tel: 01908 220777
Email: info@grandprixwear.com
Web: www.grandprixwear.com
Unit 3 Fitzhamon Court, Featherstone Road, Wolverton Mill, Milton Keynes MK12 6LB
PERFORMANCE FRICTION USA (1) 803 222 2141
EUROPE +44 (0) 1280 843 390
MARDI GRAS M/SPORTS 01327 858 006
RAYBESTOS USA (1) 815 363 9000
TAR.OX Italy (39) 039 587814
TILTON USA (1) 805 688 2353
WILWOOD USA (1) 805 388 1188

FLUIDS
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
CASTROL USA (1) 973 305 3912
PERFORMANCE FRICTION USA (1) 803 222 2141
01280 843390
TILTON USA (1) 805 688 2353
WILWOOD USA (1) 805 388 1188

PADS
ALCON COMPS 01827 312 500
AP RACING 02476 639595
BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
CARBONE INDUSTRIE France (33) 14 972 2305

Carbon Metallic
PERFORMANCE FRICTION (1) 803 222 2141
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ENDLESS BRAKES Japan (81) 267 68 0071
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FGR 01885 400639
MINTEX 01274 854000
PAGID MOTORSPORTS USA (1) 941 772 4261
PERFORMANCE FRICTION USA (1) 803 222 2141
01280 843390
RAYBESTOS USA (1) 815 363 9000
TAR.OX Italy (39) 039 587814
TILTON USA (1) 805 688 2353
WILWOOD USA (1) 805 388 1188

VALVES
ALCON COMPS 01827 312 500
AP RACING 02476 639595
TILTON USA (1) 805 688 2353
WILWOOD USA (1) 805 388 1188

2.8 Wheels
DYMAG RACING UK 01249 655481
HILLGARD Sweden (46) 300 60590
KINESIS MOTORSPORT USA (1) 760 598 5300
MOMO Italy (39) 0276 111072
SPARCO Italy (39) 011 470 2343

WHEEL TETHERS
TRS LIMITED
THE RIG SHOP LTD
Tel/Fax: +44(0) 2380 338341
Ocean Village, Marina Service area, Maritime Walk, Southampton SO14 3TL

futurefibres
FUTURE FIBRES Specialists in Flexible Composite Wheel Tethers
Tel: 023 8066 1160 Fax: 023 8066 1161
Unit 4dd Marchwood Industrial Park, Southampton SO40 4PB

2.9 Tyres
AVON RACING 01225 703101
CO-ORD SPORT 01384 216102
DUNLOP 0121 306 6000
Australia (61) 330 50333
Ireland (353) 178 3599

DUNLOP
VINTAGE TYRES LTD
(Distributor of Dunlop Race Tyres in North America)
Tel Canada (1) 902 228 2335
Fax Canada (1) 902 2282241
Email vintyre@aol.com
255 Southwest Cove Road, Hubbards, Nova Scotia, Canada, B0J 1T0
GOODYEAR Germany (49) 2234 82031
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

2.10 Fuels & Lubricants
AGIP Italy (39) 65 9981
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
UK 01488 682655
TECH-LINE USA (1) 919 480 0905
TEXACO UK 0207 719 3000
VALVOLINE USA (1) 606 264 7222

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
KENT CAMS Tel 01303 248666
KENT CAMS BY JT FRANCE (33) 3207 46480
LUNATI USA (1) 901 365 0950
PAD RACING New Zealand (64) 3 3386 288

PIPER CAMS
PIPER CAMS Tel 01233 500200
Fax 01233 500300
www.pipercams.co.uk
2 St. John's Court, Ashford Business Park, Ashford, Kent, TN24 0SJ
QUAIFE ENGINEERING 01732 353747
SWINDON RACING ENGINES 01793 531321
TWR ENGINES 01993 871000
ULTRADYNE USA (1) 601 349 4447

CAMSHAFT DRIVES
CONNAUGHT 01795 843802
DAVID BROWN 01484 422180
SBD MOTORSPORT 0208 391 0121
KENT CAMS 01303 248666
PIPER CAMS 01233 500200
QUAIFE ENGINEERING 01732 353747
SWINDON RACING ENGINES 01793 531321

CONRODS
ARIAS FORGED PISTONS USA (1) 310 532 9737
ARROW PRECISION 01455 234200
ATECH MOTORSPORTS USA (1) 330 630 0888
CLARENDON ENG 01455 841200

ARROW
ARROW PRECISION ENGINEERING LTD
Tel +44 (0) 1455 234200
Fax +44 (0) 1455 233545
Website www.arrowprecision.co.uk
Email: enquiries@arrowprecision.co.uk
12 Barleyfield, Hinckley, Leicester LE10 1YE
CARILLO IND. USA (1) 949 498 1800
CONNAUGHT 01795 843802
CO-ORD SPORT 01384 216102
CROWER USA (1) 619 422 1191
SBD MOTORSPORT 0208 391 0121
ENGINES & DYNO SERVICES 01708 857108
FARNDON ENG 02476 366910
MANLEY PERFORMANCE USA (1) 732 905 3366
OLIVER USA (1) 616 451 8333
PANKL Austria (43) 3862 512500

JACQUEMIN TUNING
SAENZ EUROPE-JACQUEMIN TUNING
France Tel: +33(0)320746480
Fax: +33(0)320746489
Email: jmjacquemin@nordnet.fr
Website: www.jacquemintuning.com
SAENZ USA (1) 305 717 3422
SCHRICK Germany (49) 21 91 9500
SWINDON RACING ENGINES 01793 531321

CONROD BOLTS
ARIAS FORGED PISTONS USA (1) 310 532 9737

ARP automotive high performance products
A.R.P. USA Tel: (1) 805 339 2200
Fax: (1) 805 650 0742
Website www.arp-bolts.com
1863 Eastman Avenue, Ventura 93003

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ARROW PRECISION ENGINEERING LTD
Tel +44 (0) 1455 234200
Fax +44 (0) 1455 233545
Website www.arrowprecision.co.uk
Email: enquiries@arrowprecision.co.uk
12 Barleyfield, Hinckley, Leicester LE10 1YE
BLANC AERO France (33) 296 68 33 39
CARRILLO INDUSTRIES USA (1) 949 498 1800
COAST FABRICATION USA (1) 714 842 2603)
COSWORTH 01604 752444
USA (1) 310 534 1390
CROWER USA (1) 213 543 1390
SBD MOTORSPORT 0208 391 0121
LINREAD NORTHBRIDGE MOTORSPORT
Tel 01162 572924 Fax 01162 572901
Viking Road, Wigston, Leicester, LE18 2BL
PANKL Austria (43) 386 251 2500
ATECH MOTORSPORTS USA (1) 330 630 0888

Co-ordsport
CO-ORD SPORT
ARP, FIDANZA, ROSS & OLIVER DISTRIBUTORS
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Fax: +44 (0)1384 216109
Email: sales@coordsport.com
Kings Street, Dudley, West Midlands DY2 8PX, UK
DKE 01455 273738
EAGLE USA (1) 901 345 5886
FARNDON ENG 02476 366910
GRAINGER & WORRALL 01902 324460
LAYSTALL ENGINEERING 01902 451789

NORTHBRIDGE MOTORSPORT
LINREAD NORTHBRIDGE MOTORSPORT Tel 01162 572924
Fax 01162 572901
Viking Road, Wigston, Leicester, LE18 2BL
MILLINGTON 01746 789268
SWINDON RACING ENGINES 01793 531321

CRANKSHAFTS
CUSTOM CRANK Tel: 01902 422144
Fax: 01902 422133
Web: www.customcrank.co.uk
Email: markhenry.rigg@btinternet.com
THE CRANKSHAFT PEOPLE

CRANKSHAFT DAMPERS
VIBRATECH USA (1) 716 895 8000

FLYWHEELS
ALVIS ATL 02476 539311
ARROW PRECISION ENGINEERING LTD
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Fax +44 (0) 01455 233545
COMPTECH USA USA 001 916 933 1080
FARNDON ENG 02476 366910
HARROP Australia (61) 39 499 7433
KAITEN PRODUCTS USA (1) 714 220 2227
QUARTERMASTER USA (1) 847 540 8999
SWINDON RACING ENGINES 01793 531321

GASKETS
COMETIC BY JT FRANCE (33) 03207 46480
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

INJECTORS
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
CROMARD 01902 451789
DATRON SLEEVES USA (1) 760 603 9895
GOETZE Germany (49) 217 4690
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
CONNAUGHT 01795 843801
COSWORTH 01604 752444
USA (1) 310 534 1390
HEPWORTH & GRANDAGE 01274 729595
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
PAD RACING New Zealand (64) 3 3386 288
ROSS USA (1) 310 644 9779

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

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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
G&S 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

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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

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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

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CARBURETOR SHOP USA (1) 909 481 5816
SOLEX France (33) 14 729 7171
WEBER Italy (39) 51 417995
WEBCON 01932 787100

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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
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 9473
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 84380
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
SPECIALTY 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
SPECIALTY 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
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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
SPECIALTY 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
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

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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

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

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 IS2

LONGACRE	USA (1) 425 485 0620
McLAREN 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 319399
Fax: 01926 319352
Email: rasimmonds@mtc.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

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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

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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
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
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 01132 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
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
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
ILONGACRE 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 01374 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

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
AERODYNAMIC CONSULTANTS (661) 729 5628
APPLIED FIBREGLASS 01842 765339
ASQUITH BROTHERS 01924 402001
C&B Consultants Aerodynamics 01202 617 1707
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
APPLIED FIBREGLASS 01842 765339
ASTEC 01332 875451
B&K RESINS 0208 464 7734
C&B CONSULTANT AERODYNAMICS 01202 661707
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 0AL
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 NE38 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 477208 Fax 01926 477222
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) 317 248 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
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 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, OL4 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

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 7979111

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) 3862552200
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 2443311
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
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 0SP

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 451545
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 810110
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 648208
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 9319
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 01374 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 01202 661707 Fax 01202 685588
Email candbaero.uk@candbconsultants.com
www.candbconsultants.com
Unit2B, 8 Cowley Road, Nuffield Ind Est, Poole, Dorset, BH17 0UJ
C & B INTERNATIONAL INCORPORATED
Tel 317 291 0978 Fax 317 536 0656
email candbaero_indy@email.msn.com
6210 La Pas Trail, Indianapolis, IN 46268, USA
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 818188
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 865032
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 7327377
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: dmorrison@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) 52 224 111
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

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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
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AEROBYTES

With Simon McBeath

Small details matter

Small, yet far from insignificant – front wing strakes and their effect examined in detail

Last month's column quoted what might be a truism of racecar aerodynamics: 'what happens at the back of the car affects what happens at the front, and vice versa...' Another maxim might be that one can rarely make reliable assumptions about the likely benefits of a modification, and in particular the overall effects, however small the change may be. This is why the ability to model the effects of changes is so valuable. This month we examine the surprising ramifications of a very small change at the front of a Formula 1 car.

A frequently seen feature on current F1 cars are front wing strakes – a pair of vertical fences attached to the underside of the wing a little inboard of the end plate, probably at a small angle to the centreline of the car and most likely curved in plan view. Figure 1 shows the geometry of one strake set up evaluated by Advantage CFD for its parent company, BAR Honda.

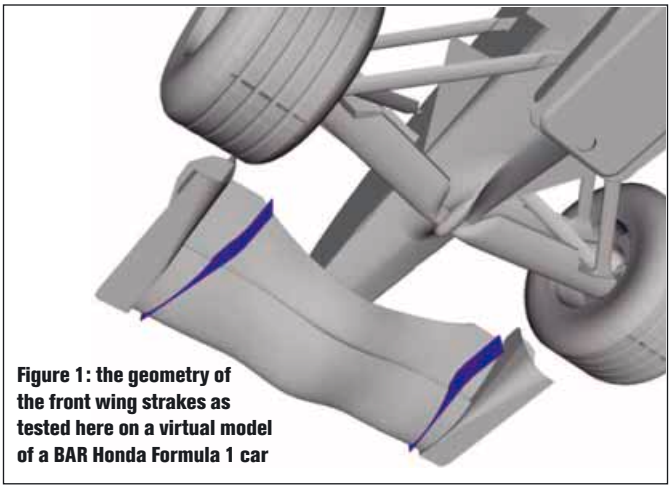

Figure 1: the geometry of the front wing strakes as tested here on a virtual model of a BAR Honda Formula 1 car

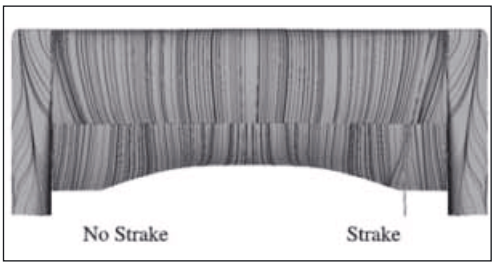

Figure 2: a simulated oilflow plot shows the flow across the lower front wing surfaces with and without the strakes

What benefit would have been sought from the fitment of devices like this? The strake is one of a family that Milliken and Milliken describe as 'flow control devices' that are capable of exerting a greater influence on the overall aerodynamic forces (and their distribution) than the forces the devices themselves experience. More specifically, the role of such a device is 'locally guiding the flow'. The implication, and perhaps the expectation then, is that steering the flow with strakes under the front could have a local benefit, that is, to the front wing. However, the Millikens also suggest that there might be changes to static pressure distributions, velocity (speed as well as direction) and vorticity (flow rotation), and given that the devices are installed at the front of the car, it might also be reasonable to expect changes to manifest themselves some distance downstream.

This study produced some expected results and some unexpected ones. Front wing downforce did indeed increase but only by around 0.3 per cent, while intriguingly, rear wing downforce increased by 3.1 per cent. This result immediately affirms both our opening statements, and also points to the surprisingly 'global' effect that these small plates had on the airflow. Other results bear this thinking out too, as the table below shows (we→

A small but efficient benefit

	Downforce change	Drag change
Total	+0.5%	+0.1%
Body (excl. wheels)	-0.4%	+0.7%
Front body	-1.7%	-
Rear body	+0.5%	-
Front wheels	+50.6%	+1.5%
Rear wheels	+8.7%	-2.6%
Front wing	+0.3%	+0.1%
Rear wing	+3.1%	+1.9%
Front mainplane	+1.0%	-0.7%
Front flap	+1.0%	+0.7%
Front end plate	-3.9%	-6.9%
Rear top mainplane	+4.1%	+3.3%
Rear top flap	+2.7%	+2.6%
Rear upper forward	+1.0%	-10.2%
Rear lower	+1.0%	-2.6%

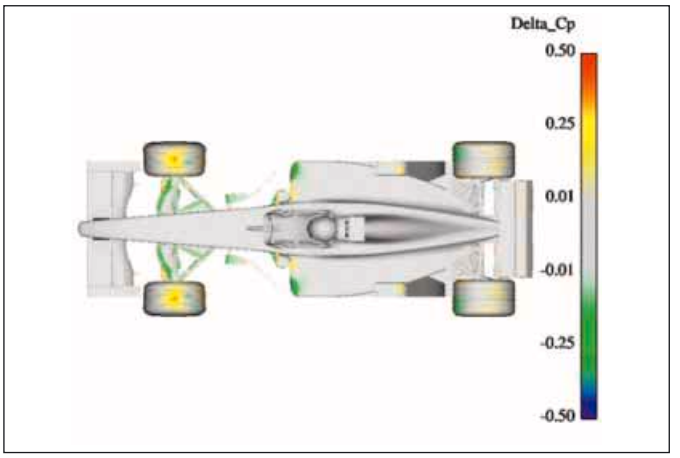

Figure 3: changes to the pressure coefficients over the upper surfaces

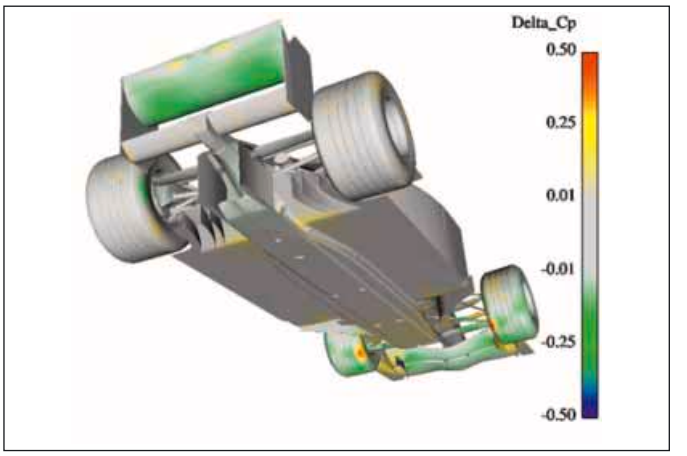

Figure 5: changes to the pressure coefficients on the lower and rear surfaces

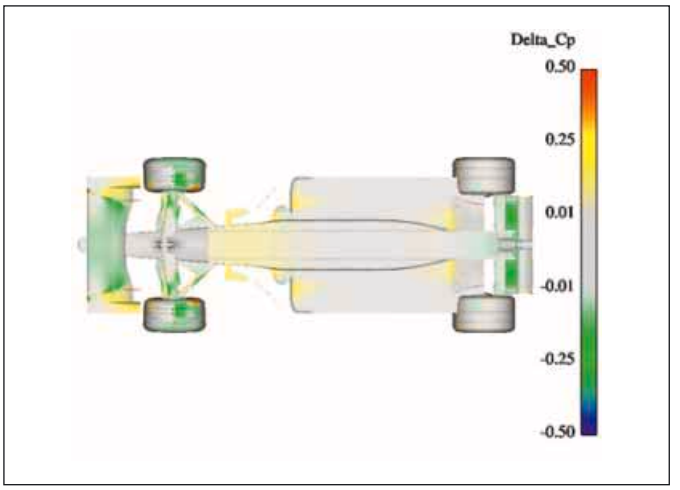

Figure 4: changes to the pressure coefficients on the lower surfaces

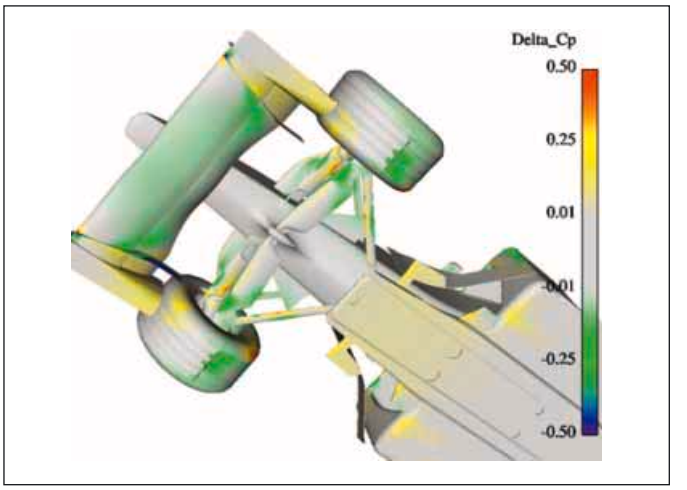

Figure 6: changes to pressure coefficients under the front half of the car

are only able to relate percentage changes, not absolute forces here, for confidentiality reasons).

The overall result of fitting the strakes was a 0.5 per cent gain in downforce for a 0.1 per cent increase in drag – a small but efficient benefit. But there was also a rearward shift in overall balance, further emphasising that changes at the front have effects at the back. The dominant producer of change was actually the rear wing, which created more downforce but also as a result more drag. The lift generated by the wheels, which changed significantly (especially at the front, as shown in the table as a benefit to downforce) and as suggested by the reduction in 'body' downforce at the front (where the 'body' is everything except the wheels). There was also a loss of downforce from the underfloor, particularly in the forward section.

So why did these strakes cause these changes? The first point to make is that a reduction in mass flow under the car was determined, and this would explain the reduction in underfloor downforce (less air flow = less flow contraction = less velocity increase = less reduction in static pressure). And decreased mass flow under the car would probably mean increased flow over the car. Hence the rear wing receives faster flowing air so it generates more downforce (and drag).

But how could such a small pair of devices as these wing strakes alter the flow pattern to this extent? It seems that a vortex formed on the inside face of each strake, and this had the effect of deflecting more air over the car and less beneath it. Figure 2 is a simulated oil flow comparison showing how the flow across the underside of the front wing and especially the flap was, apparently, subtly altered by the strakes. But this superficially minor change to the flow pattern at the wing surface near the strake is evidence of this vortex formation.

Figures 3 to 6 are delta Cp plots from various viewpoints of the car, and these show the *differences* in the pressure coefficients (Cp) over the car's surfaces as the result of fitting the strakes. Blues and greens show where pressure coefficients decreased, and reds and yellows where they increased. An increase on an upper surface indicates an increase in downforce, as does a decrease on a lower surface, and vice versa. Similarly an increased Cp on forward facing surfaces shows more drag, as does a decreased Cp on a rearward facing surface, and vice versa. It's worth noting the power of delta Cp plots to isolate effect of changes, something that is not possible in a wind tunnel. This is a distinct advantage of CFD.

Figure 3 shows an increased Cp on the front tyre tops, which corresponds with the drop in front wheel lift. Figure 4 shows the areas under the front wing and the rear wing that produced lower pressure (= more downforce), but also that the front of the underbody and the transition into the diffuser developed an increased Cp, corresponding with reduced downforce here. Figure 5 shows that not just the rear mainplane underside developed lower pressure but also that the flap produced lower pressure near its trailing edge, which corresponds with delayed flow separation here. Figure 6 shows the ups and downs at the front of the car, with less downforce from the outboard sections of the front wing, but by virtue of the large portion of its span at lower pressure, more downforce from the span between the strakes. The decreased Cp visible on the inside face of the strakes is further evidence of the above-mentioned vortex.

So, there have been gains and losses from areas all over the car – some surprising, some not, with a small, net overall benefit, albeit with a rearward shift in balance. That the overall gains were at the 'wrong' end of the car should make us wary of presumptions and keener to check things out carefully, as Advantage CFD did here. Of course a different strake configuration may have yielded a quite different result...

Mark Ortiz is

THE CONSULTANT

Rear percentage vs yaw inertia

Setting up race cars is invariably a compromise. Most are well documented, but there seems to be little written on the compromise between longitudinal weight distribution and polar moment of inertia

Q I race a 250bhp, 900kg V8 MGB that has a frontal weight bias of around 60 per cent. The 40-litre fuel tank overhangs the rear axle, which creates a moment around the rear axle and thus helps to remove weight from the front. There is space in front of the rear axle to place two tanks which would have the effect of reducing the polar moment of inertia, while slightly lowering the centre of gravity and possibly allowing softer rear springing. I would be grateful if you could comment on the benefits or otherwise of this approach. From a vehicle dynamics standpoint, I would opt for more rear percentage rather than less yaw inertia, especially in a car that is so nose heavy now.

A Within limits, yaw inertia can be coped with by driving technique. In some situations, it can even make the car faster. Overall though, less yaw inertia is better, particularly when the course demands high yaw accelerations, such as when negotiating chicanes or turns on a street circuit that come in quick succession. But steady-state handling and the ability to put power down are more important. A rear-drive car with only 40 per cent rear weight and a powerful engine is seriously traction-challenged, especially when exiting turns. Any further reduction would not be good.

With more front percentage, you will actually have to stiffen the rear suspension, at least in roll, with respect to the front. Otherwise, you will be adding understeer. The inside rear will then be extremely light when cornering. It probably is now.

One situation where yaw inertia can make a car faster is where the car may unexpectedly encounter a slippery spot in the middle of a turn. If the slippery patch is short enough so the front and rear of the car hit it separately, the car will experience understeer and then oversteer in very quick succession: it will do a wiggle. If it has little yaw inertia, it will do a big wiggle. If it is close to the limit, it may spin. If the driver wants to allow a →

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**

Dale Earnhardt Jr recieved burns in this flaming incident when the fuel tank ruptured

margin of safety to increase the chances of catching the wiggle before it becomes a spin, for a given level of risk the driver must stay further from the limit in a car with little yaw inertia.

For this reason, in the days of high-speed open-road racing, many engineers regarded yaw inertia as desirable, and this was thought to be one of the advantages of a front-engined car with a transaxle, and a problem for the rear-mid-engine layout.

Even back then, everybody recognised that weight distribution change with fuel burn-off was not good. The Lancia-Ferrari of the mid-1950s, with its pontoon fuel tanks between the front and rear wheel on each side, appears designed to get much of the fuel amidships longitudinally, while preserving high yaw inertia. As Ferrari developed the car after taking it over from Lancia, they moved the side tanks inside the body, reducing yaw inertia, and this is generally thought to have improved the handling.

It is worth noting that the Lancia-Ferrari pre-dated foam-baffled fuel containers. Even with some sheet metal baffles, there must have been considerable fuel slosh in those tanks which can't have helped controllability.

As regards crash safety and fire risk with the fuel inside the wheelbase versus outside, there are pros and cons both ways. If the fuel is within the wheelbase, it is less likely to spill when the rear takes a hit. On the other hand, if it does spill, it is more likely to spill into the driver's compartment. And it can still spill, as recently demonstrated in Dale Earnhardt Jr.'s crash in the Corvette at Sebring.

At the recent SAE Motorsports Conference in Dearborn, Michigan, I had the opportunity to ask a very distinguished panel of safety experts about the safety aspects of fuel location in racecars. Gary Nelson of NASCAR said that they strongly considered having the fuel stored ahead of the axle in the new NASCAR chassis they are developing, but eventually decided against it. The reason, he said, was that the greatest risk of fuel fires occurs in refuelling during pit stops. The present rear location was considered preferable from that standpoint. This may be less of a factor where the races are short and there are no fuel stops. RE

Pontoon fuel tanks, designed to keep the weight of the fuel load amidships was exploited on the Lancia-Ferrari D50

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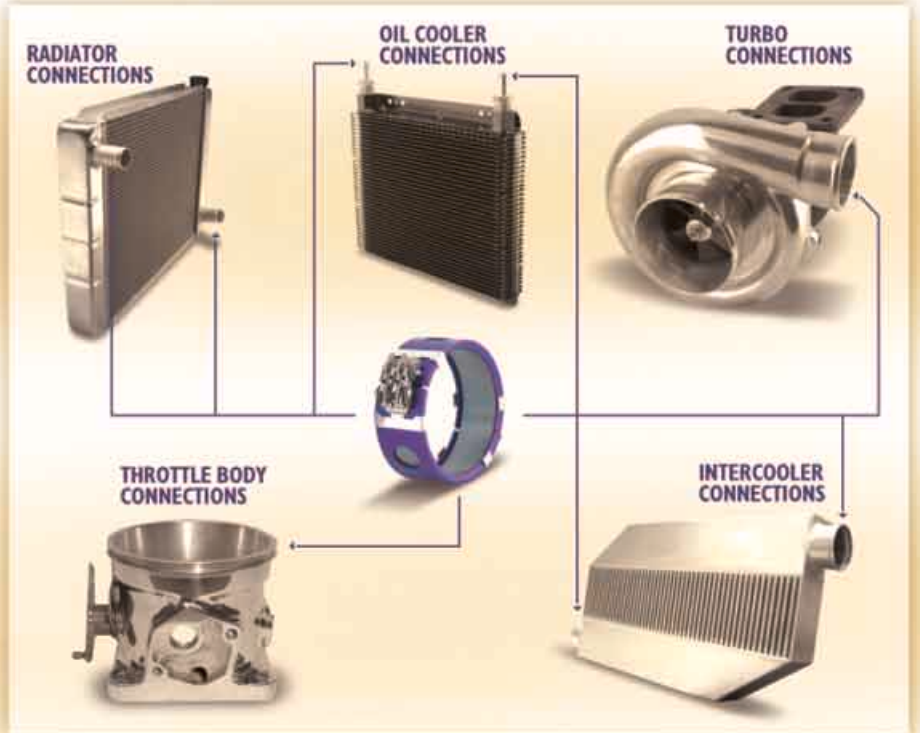

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