TECHNOLOGY FOR MOTORSPORT

The International Journal

Racecar Engineering

AOL Keyword: Racecar Engineering

SPEC SERIES STOCK CARS
GT-America is a new low-cost avenue into Trans-Am racing

MoTeC ADL2 REVIEWED
The new dash logger put through its paces in a real-world test

October 2005 · Vol 15 No 10 www.racecar-engineering.com UK £4.50 · USA $8.95

Perfect suspension?

Why this system claims to achieve the impossible

LMP transmissions compared

Inside the top three gearboxes for prototypes

Computers for CAD

Our guide to buying IT hardware for engineering

Crash testing

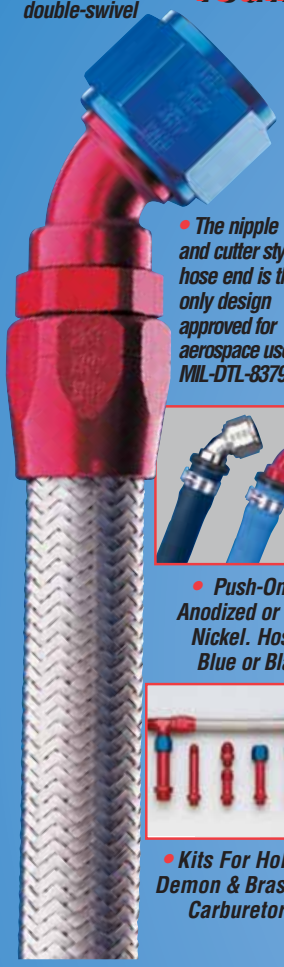
Who does it and why you need to know

Sam Collins

9 770961 109050 10

AEROSPACE QUALITY BROUGHT TO MOTORSPORTS

- Patented piloted nipple & cutter design. U.S. Pat. Off. 5,340,168
- Fully Adjustable. Triple-sealed double-swivel



Four Reasons Why Top Teams Choose XRP Fluid Delivery Systems

- The nipple and cutter style hose end is the only design approved for aerospace use per MIL-DTL-83798

- Push-Ons in Anodized or Super Nickel. Hose in Blue or Black.

#1. XRP Manufactured Products have Earned a Worldwide Reputation for High Quality.

#2. XRP's Proven Designs and Aerospace Quality Materials...Whether it's for our traditional stainless steel braided hose, triple seal hose ends, push on hose and fittings ...or our ultra-light HS-79 professional racing system, a smooth-bore construction of Teflon®, silicone, stainless reinforcing wire with Nomex® cover that offers high temperature & vacuum capability.

#3. Service...Call our tech lines and you'll get the right answers. XRP's extensive inventory assures on-time delivery and availability that you can count on.

#4. Selection...hose ends, adapters, carb kits, power steering, brakelines, as well as many custom specialty fittings!

- Kits For Holley, Demon & Braswell Carburetors

- NEW Super Nickel Finish for Tri Seal & Pushons & Adapters

- Exclusive Ultra Low Profile O-Ring Boss Oil Pan & Oil Pump Fitting

HS-79 The Most Technically Advanced Hose System...Period!

- 4-Ply Construction: Teflon® inner tube, silicone second layer, stainless steel wire reinforcement, Nomex®/Kevlar® outerbraid.
- High Flow Rates. Low Pressure Drop.
- A Higher Temperature Rating: -65° to +400°F
- HS-79XP w/ abrasion-resistant Hypalon® coating.

While others try to keep up, XRP continues to lead the way! Why? Aircraft quality composite construction. Higher hoop strength and temp ratings. Greater vacuum capability and a tighter bend radius. Extremely lightweight and compatible with all racing engine fluids. HS-79...first across the finish line.

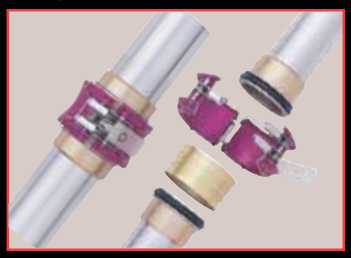
- Tighter bend radius and higher vacuum capability because HS-79 has a higher hoop strength... without using internal support coils that restrict flow.
- Higher pressure.
- Smooth Bore. No Convolutions.
- Larger inner diameter means greater flow capacity. Look inside.

Call for catalog with a large selection of XRP-manufactured hose ends, adapters, carb kits, power steering and brakeline fittings.

Clamshell Quick Release Couplings

XRP's exclusive double o-ring sealed hose ends with clamshell quick release couplings.

Manufactured by Hydraflow, a leader in aerospace fluid transfer systems, the clamshell closures lock automatically when the two halves are snapped together and cannot disengage accidentally. All three latch pawls must be lifted simultaneously to open the latch. For added security, the couplings can be ordered with an optional safety latch that provides for easy visual inspection. Clamshell quick disconnect couplings offer both axial and angular flexibility. Specifications & sizes are available on request.



Flexible tube connectors ... clamshell quick release couplings with optional safety latch.

In U.S.A. XRP, Inc.
5630 Imperial Hwy.
South Gate, CA 90280
562-861-4765

In Europe James Lister & Sons
motorsport@lister.co.uk
tel 44 (0) 121 525 5800
fax 44 (0) 121 553 5951

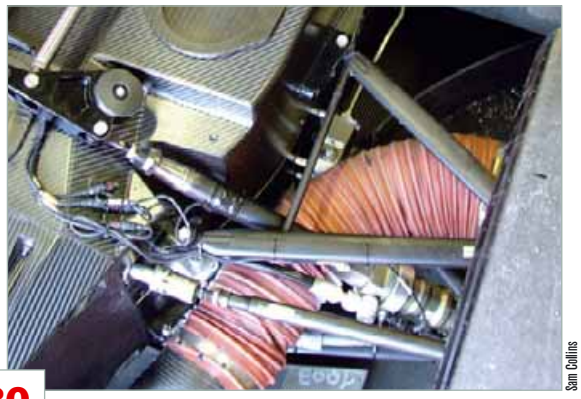
XRP®

"The Xtreme in Racing Plumbing"

Contents

Features

Cover story


Sam Collins

30


LAT

40

Raceworld


LAT

46

Raceshop

Subscriptions

FOR SUBSCRIPTION DETAILS TURN TO
PAGES 64–65
Or visit www.racecar-engineering.com

54

Write Line

Really exciting new ideas in motorsport engineering are as rare as sound foreign policy in the middle east. So when one as good as Creuat's new suspension comes along it deserves any attention it gets. But for all the excitement, what are the chances of it changing the shape of the racecar as we know it? It depresses me to say they are probably pretty slim.

The history of racecar design is punctuated by trendsetting technological milestones that provide the landmarks with which we navigate the past. The mid-engined Cooper, the monocoque Lotus, the ground-effect Lotus, the carbon-tubbed McLaren – all these left their mark on racecars resulting in the single seaters we are familiar with today. Wouldn't it be great to witness another revolution in design? To see conventional springs, dampers and anti-roll bars, with all the compromises they encompass, being swept aside in favour of a more fundamentally pure system. It would be a leap as big as from spaceframe to monocoque or from wings to ground effect.

But I doubt it will happen, and this is why. The commitment from Racing For Holland has to be commended, because taking a new technology into a new environment and blazing a trail with it takes courage. As the late Carroll Smith once said, 'the last of the old will always beat the first of the new,' and with good reason. For a technical advance to pay dividends, it has to be standing on the shoulders of an already optimised package. If not, any advantage it gives will be lost in the deficiencies of the rest of the package. To maintain that level of competitiveness while retaining enough spare capacity to develop something new will always be a challenge.

> **"THE HISTORY OF RACECAR DESIGN IS PUCTUATED BY TRENDSETTING TECHNOLOGICAL MILESTONES"**

Assuming a new technology like Creuat's suspension works, the first hurdle it will encounter is finding a race team willing to put itself through the research and development pain barrier that will have to be breached before a worthwhile advantage is found. However, nothing ventured nothing gained, and with sufficient resolve anything is possible. So the technology starts paying dividends, the car tops the timesheets and becomes the one to beat. That is when you attract the attention of the organisers. What they previously let through scrutineering as an interesting curiosity is now being viewed as an unfair advantage. Under pressure from other teams they will be faced with a choice. Either they let the winning team keep their technology but accept it will mean other teams will inevitably have to follow suit to regain competitiveness. Or, alternatively, the organisers ban the technology, save everyone the expense of development and strike another blow against rising costs in motorsport.

The latter strategy is the favoured tactic in Formula 1 and is already filtering down through other tiers of the sport. As a self-confessed innovation junkie, I find the prospect all too depressing but it may go some way to explaining why, despite a widespread belief in the myth, motorsport no longer improves the breed.

Editor
Charles Armstrong-Wilson

The International Journal
Racecar engineering

Pit Crew

Vol 15 **No.10**
Editor
Charles Armstrong-Wilson
Deputy Editor
Sam Collins
Art Editor
Barbara Stanley Borras
Chief Sub Editor
Mike Pye
Editorial Assistant
Katie Power
Contributing Editors
Paul Van Valkenburgh, Allan Staniforth
Technical Consultant
Peter Wright
Group Art Editor
Patrick Morrissey
Contributors
George Bolt Jr, Dan Carney, Charles Clarke, Dave Hancock, Simon McBeath, Mark Ortiz, Martin Sharp, Ian Wagstaff
Photography
Jakob Ebrey, LAT, Tony Tobias
Business Development Manager
Tony Tobias +44 (0) 20 8726 8328
Mobile 07768 244880 Fax +44 (0) 20 8726 8399
tony_tobias@ipcmedia.com
Advertisement Sales Executive
Andy King +44 (0) 20 8726 8329
andy_king@ipcmedia.com
Group Advertisement Manager
Kevin Attridge
Marketing and Exhibitions Manager
Richard Marcroft
Publisher
Gavin de Carle
General Manager
Niall Clarkson
Managing Director
Paul Williams
Editorial & Advertising
Racecar Engineering, Focus Network, Leon House, 233 High Street, Croydon, Surrey CR9 1HZ, UK
Tel +44 (0)20 8726 8364
Fax +44 (0)20 8726 8399
E-mail racecar@ipcmedia.com
Back Numbers John Denton Services, Unit 1 A1 Parkway. South Gate Way, Orton South Gate, Peterborough PE2 6YN, UK
Tel +44 (0)1733 370800
Fax +44 (0)1733 239356
Worldwide News Trade Distribution
Marketforce (UK) 5th Floor, Low Rise, Kings Reach Tower, Stamford Street, London SE1 9LS, UK
Tel +44 (0)20 7633 3300
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.

Racecar Engineering (USPS 007-969) is published 12 times per year by IPC Media Ltd in England. Periodicals postage paid at Green Brook NJ 08812. US subscriptions cost $79.00 from EWA, 205 US Highway 22, Green Brook, NJ 08812, tel: 800 272 2670. Postmaster: send address changes to *Racecar Engineering*, 205 US Hwy 22, Green Brook NJ 08812 USA

www.racecar-engineering.com

Motor racing world cup becomes reality

Motor racing's world cup looks to have become a reality. At the close of press 17 A1 franchises had taken delivery of their cars. These first teams will all have their main car and a spare in time for the first race at Brands Hatch. Late sign ups, expected to include Ireland, Germany and Italy, will only receive their second cars after the first race.

Most of the franchises are being run by established outfits, although the Malaysian and Indian entries are being run by groups established by the franchise holders.

The man behind A1GP, Sheikh Maktoum, told RE how he came up with the look of the cars, how he made Lola build the car he wanted and how he managed to make the whole thing a reality. 'The initial design ideas that I came up with were from a swordfish and a stingray, and why not, they are the most aerodynamic creatures in the water and that has a density of a thousand times more than air. You cannot argue with nature,' he explained. 'Lola tried to talk me out of the fin initially, now they have actually found an aerodynamic use for it.' There were other areas where Maktoum was keen to keep the car looking 'right'. 'At the start I wanted to have 18in rims and low profile tyres because that looked good, but they talked me out of it, and we went with their suggestion. When they put on their choice of tyres I said it just doesn't look right, because they were smaller. I said to Lola, 'well I want bigger tyres, just bring them.' Eventually they put the bigger tyre on that you see now and it actually fitted the car perfectly, and if it looks right it must be right.'

LAT

A1 cars took to the track in a group for the first time ever at Silverstone in July

Confirmed A1 entries

COUNTRY	TEAM
Australia	Alan Docking Racing
Brazil	ASM Racing
China	TBC
France	DAMS
Mexico	DAMS
Great Britain	Arden International
Lebanon	Carlin Motorsport
Netherlands	Racing For Holland
New Zealand	West Surrey Racing
Pakistan	Super Nova
South Africa	BCN
Switzerland	TBC*
USA	TBC
India	Run in-house

*The Swiss entry was run by DAMS at the Silverstone test but only as a temporary measure

2006 engine deals now done

Williams F1 will run Cosworth 2.4-litre V8 engines in next year's F1 World Championship if reports are to be believed. Originally Williams had planned to use BMW units throughout 2006 but the German firms buyout of the Sauber team, allied to reportedly sour relations between the two, saw the British team without a clear engine deal. Rumour suggests that Williams will use Cosworth engines for one year until Toyota is ready to supply Lexus-badged V8s in 2007.

Cosworth is already committed to supplying Minardi with restricted 3.0-litre V10 units in 2006.

Meanwhile, Toyota announced a new home in the Midlands. Jordan (who become Midland F1 in 2006) already runs the Japanese firm's engines so there will be little change.

Williams has used Cosworth V8 power with success before

2006 engine situation

All teams are using 2.4-litre V8 engines bar Minardi who are using a restricted V10

TEAM	SUPPLIER
McLaren	Mercedes Benz
Ferrari	in-house
Toyota	in-house
Williams	Cosworth (TBC)
Red Bull	Ferrari
BAR	Honda
Sauber/BMW	BMW
Midland	Toyota
Minardi	Cosworth

Honda withdraws from Indy League

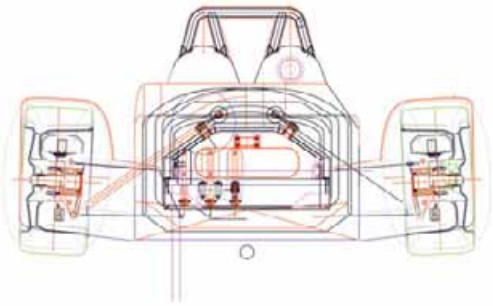
Following Toyota's departure last month, Honda has announced that it too is to withdraw from the Indy Racing League at the end of next season. However, it may not be a permanent withdrawl from the series 'because of a technicality in the IRL rules which automatically renews a contract if no action is taken, we are withdrawing from the IRL to keep our options open,' explained Honda's performance development boss Robert Clark. He went on to say that Honda would have to be convinced not to return to the series in 2007.

Citing a technicality in the rules, Honda aims to keep its options open

New Radical on a roll

Radical has released further details of its forthcoming SR9 LMP2 competitor and has confirmed that it is aiming to be racing at Le Mans in 2006 with Martin Short's Rollcentre Racing team.

Since the SR9 project was revealed (RE V15N6) there have been a number of changes to the car's design. 'Originally the idea was to make a cheap car that's a bit off the pace but is a stepping stone to bigger things,' explains Radicals' Mick Hyde. 'Then we got Peter Elleray on board and changed the plan – let's make it a bit less cheap, on the pace, but still open to whatever engine the customer wants, including our own V8. Finally, after consulting Le Mans teams, we have settled on a single integrated package with AER's twin turbo V8.'



Radical steps its LMP2 plans up a notch, aiming to make its new SR9 competitive from the outset

Three SR9 chassis have been sold so far and more are expected to find customers soon. Radical also confirmed that it will be supplying full support and corporate hospitality at every Le Mans Endurance Series round in 2006.

Formula Atlantic revamped

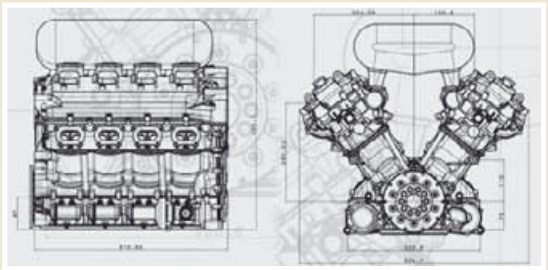
Champ Car's Atlantic series is set for a major revamp with a new chassis and engine, while US racecar manufacturer Swift has been announced as the supplier of the new car. Cosworth will supply the 300bhp, 2.4-litre engine that will be fitted into the back of the all-new 016a chassis.

Cars will cost around $175,000 (£98,000) and at least 18 have already been ordered. Operating costs are being kept to a minimum and are expected to be around $500,000 (£280,000) per team. 'We feel we have created a very affordable and highly-competitive environment for teams to race Atlantics next year,' claims the series' managing director Vicki O'Connor. The championship will continue to run at Champ Car venues next year.

New cars are to be built by Swift and will feature 2.4l engines from Cosworth

AER engine unveiled

AER has unveiled a new sportscar engine. The 3.4-litre, twin turbo V8 features a 75-degree 'V' angle and direct injection



ACO penalises top GTs

One body shape rule means Aston's Le Mans aero kit is out the window

Aston Martin's DBR9 and Corvette's C6-R will have to carry 25kg of ballast in all future races they compete in that are run to ACO rules. Aston will also have to abandon its Le Mans spec aero kit (see RE V15N8) as from now on only one body shape is permitted.

Porsche's GT3-RSR will have to run a smaller air restrictor in the LMES and Le Mans, but potentially not in the ALMS as the ACO has left that decision up to the US-based series organisers.

Rotary turnaround

A bigger air restrictor makes rotary-engined Courage more competitive

BK Motorsports has been granted a dispensation to run a larger air restrictor on its Mazda rotary-engined Courage LMP2. From now on the car will run a 53.5mm restrictor instead of the usual 49.1mm used by other P2 runners.

The team has also changed engine preparation company and will now have Dennis Spencer's group in charge of looking after the twin-rotor unit.

NEWS IN BRIEF

- Cosworth has joined the ranks of sports prototype engine suppliers. The British firm is now offering a twin turbo, 3.6-litre V8 with direct injection.

- Phoenix has been dropped from next year's IRL schedule as a result of poor spectator numbers. The circuit had been on the calendar for nine years.

- Bernie Ecclestone claims to have rejected a $1 billion bid for control of F1. The big money offer is said to have been made by Hong Kong firm Hutchinson Whampoa.

- Next year's Dakar rally is hugely oversubscribed, with 725 applications already lodged. As the event only has capacity for 485 starters the entry has been closed early.

- Last issue of RE reported that Tim Rapley had set up Digital Physical. He has of course set up Physical Digital – a mobile, non-contact, optical digitisation service.

Cosworth in the blood

LAT

Cosworth looks set to return to racing though now under the name Mahle Powertrain

Cosworth Technology, the half of Cosworth that went to Audi following the post-Vickers split, may return to its racing roots under the new name of Mahle Powertrain.

When Vickers sold the company in 1998, it was split into Audi-owned Cosworth Technology and Ford-owned Cosworth Racing, the latter responsible for motorsport business.

Both divisions have subsequently been sold on, although the engine components and filters group, Mahle, made little fuss when it acquired Cosworth Technology at the beginning of this year. In July it re-named the company Mahle Powertrain.

Ulrich Wittwer, chief executive officer of the operation, points out that although it carried out some internal work, such as engineering for the hugely successful Audi R8, it had not been allowed (due to a gentleman's agreement between Ford and Audi) to use the Cosworth name in relation to any motorsport activity. However, the new ownership means that it could soon openly be back in racing.

'Under the former owner we could not officially act in racing, but this has changed and there will be new opportunities for us,' Wittwer said. Professor Dr Heinz Junker, chairman of the Mahle management board said: 'It will be an interesting part of the future. It is too early to say how important, but we no longer have to do it incognito. Our blood is 'Cosworth' and motorsport is on the radar now.'

Cranfield expands course options

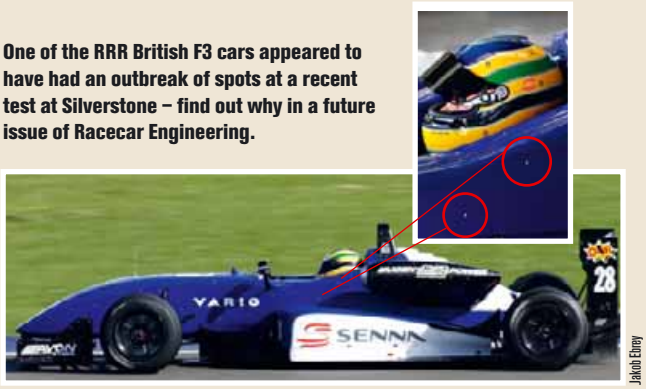
Cranfield University's motorsport group will run a number of short courses over the winter covering the following topics: motorsport electronics and data acquisition; advanced metallic materials for motorsport; project management; composite materials for motorsport; the business of motorsport; structural design for motorsport; aerodynamics; vehicle dynamics; CFD and powertrain design. The courses start mid October and run until mid March – see www.motorsport.cranfield.ac.uk/teaching.htm for more details.

Challenge chassis revealed

Peter Wardle's new 'Challenge' single-seater series was launched at Silverstone in August. More details in the next issue of Racecar Engineering.

F3 car spotted at Silverstone

One of the RRR British F3 cars appeared to have had an outbreak of spots at a recent test at Silverstone – find out why in a future issue of Racecar Engineering.



Jakob Ebrey

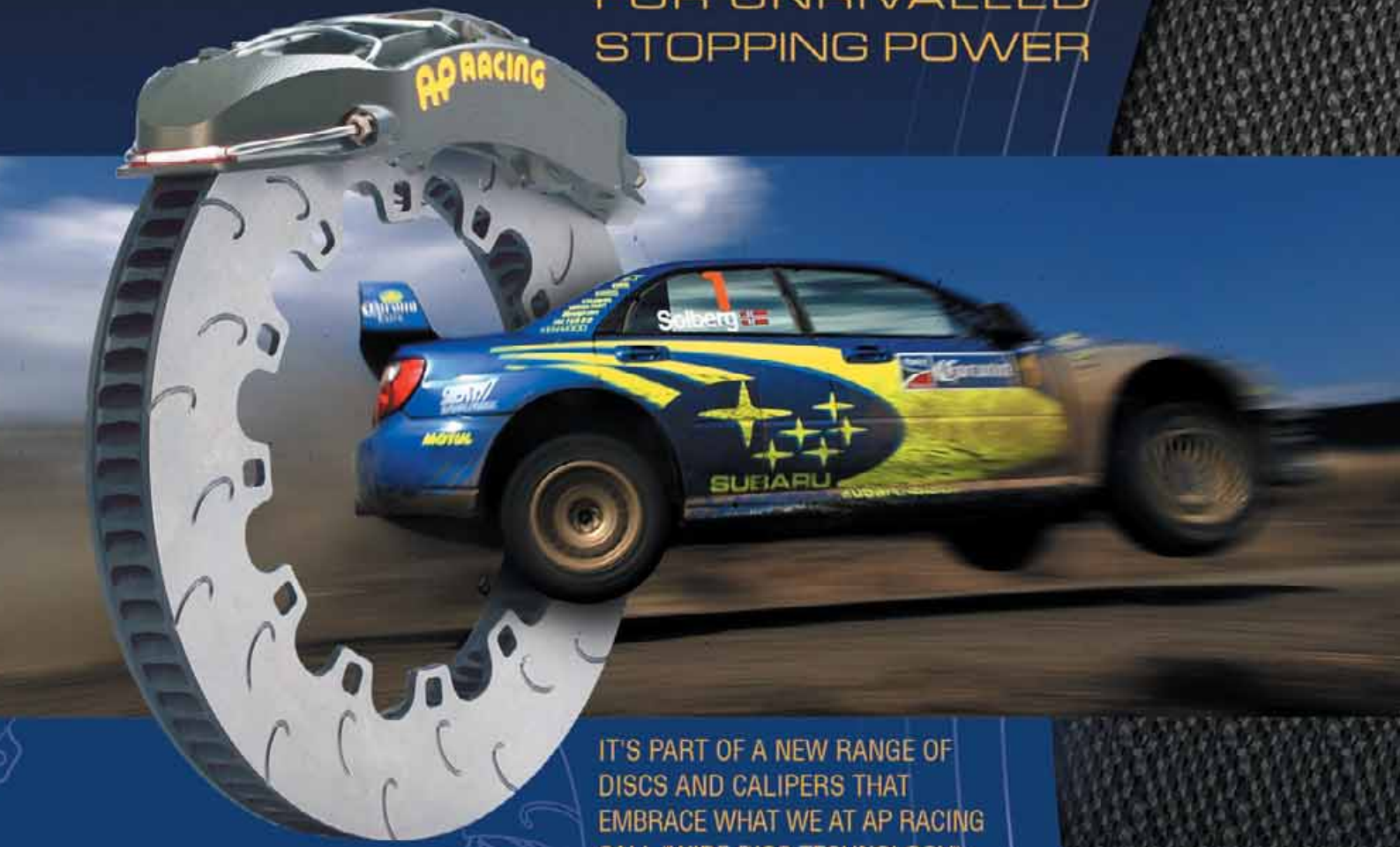
SCSA stock cars withdraw from Europe

The UK-based SCSA stock car series has cancelled its German races this season due to a lack of entries. 'It would damage SCSA's credibility to run a depleted grid in Germany,' explained an SCSA spokesperson.

Eurospeedway Lausitz was scheduled to host the races in August but series organisers may now look to other circuits closer to home, including Belgium's Warneton Speedway – home of the similar CAMSO V8 series – and the Mallory Mile in England. Road courses may also be on the agenda, SCSA cars having tested on the Brands Hatch Indy circuit in the past.

THE COOLEST DISC YET

FOR UNRIVALLED STOPPING POWER



IT'S PART OF A NEW RANGE OF DISCS AND CALIPERS THAT EMBRACE WHAT WE AT AP RACING CALL "WIDE DISC TECHNOLOGY".

Simply, this means exactly what it says: a wider disc allows us to create more, larger, vanes between the swept faces, with no weight penalty.

Result? A disc that runs up to 150°C cooler than conventional discs, enabling your driver to brake harder for longer. Couple this with our new PRF660 high performance brake fluid and suddenly you have that edge over the competition.

Already proven in WRC, NASCAR and Endurance Racing, this leap forward in brake technology should be on your list to investigate.

AP Racing
WRC Range

AP 801

For full details and applications, speak to our Technical Sales Team.

AP RACING
WHELER ROAD
COVENTRY CV3 4LB
ENGLAND
TEL **+44 (0)24 7663 9595**
FAX +44 (0)24 7663 9559
EMAIL sales@apracing.co.uk

AP RACING

THE SCIENCE OF FRICTION

www.apracing.com

NASCAR to be fried in Kentucky?

LAT

No-one is too big to take to court – Kentucky Speedway is suing NASCAR for alleged violation of federal anti-trust laws

Kentucky Speedway is filing a lawsuit against NASCAR and the International Speedway Corp (both of which the France family own) saying the two organisations have violated federal anti-trust laws in the manor they award Nextel Cup events.

The suit also alleges that NASCAR reserves new Cup dates for newly constructed or contracted ISC tracks and seeks an injunction against NASCAR to 'cease and desist from their unlawful monopolisation and conspiracy'.

Kentucky has been a host track for the NASCAR Busch and Craftsman Truck Series and is a facility used widely by Cup teams as a test track as it is not a 'Cup' track. The 1.5-mile facility is a state-of-the-art track that opened in 2000 and has a seating capacity for 66,000 people.

New Ford, re-worked Chevrolet

The all-new Ford Fusion will join the NASCAR action at Daytona in 2006

A new Ford will be seen on the grid at the 2006 Daytona 500. The Detroit firm will replace the Taurus for 2006 in Nextel Cup and the Busch Series with the Fusion model. It's the first new name-plated Ford to be announced and raced in the US since the Torino, 38 years ago, which won the title in its debut year.

During the first week of August Chevrolet unveiled its made-over Monte Carlo with a slightly sleeker looking nose but, unlike the Fusion, it failed NASCAR's on-track portion of the approval process and was re-tested the following week.

F1 designer to oversee R&D at Childress

Richard Childress Racing has hired 20-year Cosworth veteran and F1 engine designer Nick Hayes to its staff. Hayes, 45, will oversee research and development at the organisation's new engine R&D facility. 'I think the re-organisation we've made is a positive new start to our entire engine department,' said Richard Childress, president and CEO of RCR. 'These moves, in addition to bringing on Nick Hayes to head up our engine research and development department, have put RCR in a better position to reach the goals we've set for ourselves.' Hayes formerly worked for the aero division of Rolls Royce Engines until 1984 when he joined Cosworth. He joined Childress full-time in August.

LAT

RCR front runners will benefit from ex-Rolls Royce and Cosworth man Hayes' involvement as head of its new engine facility

SADEV for Super 2000

French supplier SADEV has won the first contract for Super 2000 transmission supplying all S2000 rally cars. It will be a conventional, sequential dog engagement unit with strictly mechanical gear shifting. Active and viscous coupling differentials are prohibited and teams must run SADEV-manufactured mechanical friction plate/ramp limited slip units.

These measures remove the need for costly electronics and a chassis hydraulic system. The front-to-rear torque split provided by the centre diff is 50/50, and the front and rear differentials are identical. Five different ramp angles will enable teams to alter differential settings, and there is further scope allowed by altering the number of friction plates used and pre-load applied.

Additionally, wheel-side CV joints must be interchangeable front to rear, as must those feeding directly into the differential.

Ignis becomes Swift

Possibly the last Super 1600 Junior World Rally Car to be homologated, the Suzuki Swift, made its world rallying debut at this year's Rally Finland. Aimed at bettering the performance and results of its Ignis predecessor, which carried the 2004 Junior World Champion to his title, the Swift is 50kg lighter than the Ignis, yet still heavier than the 1000kg category minimum weight limit.

Suzuki regards the Swift as its first 'World Car', the rally car being based on the road cars produced in Hungary. The 100-strong design engineering team at Suzuki Motosport in Japan has developed the basic design of much of the car, while the three-strong design team at Monster Sport Europe, which prepares and runs the 'works' Suzukis, has collaborated closely to hone the specification to JWRC requirements. The fundamental differences between the two Suzuki rally cars are that the later Swift has independent trailing 'wishbone' arm rear suspension in place of the Ignis' dead beam, and a front subframe to support the MacPherson strut with triangulated lower arm front suspension. The Ignis is devoid of a front subframe and carries torsion arm-supported strut suspension connected directly to the bodyshell.

New Suzuki Swift JWRC has vastly improved suspension over previous Ignis model

The only assemblies which carry over from the Ignis to the Swift are the gearbox and differential. The engine, while similar, is modified to a later specification and all engine work is to be undertaken in Japan. Monster Sport Europe simply installs the units in the cars. Suzuki's ability to produce small capacity engines with commendable outputs has put the team in good stead in the past, but it seems there are questions over the power characteristics of the new Swift unit between 7500rpm and maximum.

Shock tactics at Peugeot

In a quest to engineer more competitiveness into the Peugeot 307 WRC, tests have been undertaken on a car equipped with shock absorbers featuring Öhlins hydraulics adapted to some of the Peugeot manufactured damper hardware and casings. Until Rally Finland this year, Peugeot Sport's rally cars have competed equipped with Peugeot's own design of shock absorbers. The team's 307 WRCs had displayed a perplexing lack of competitiveness up that point.

The test was back-to-back with full Peugeot dampers. The team's test driver found that he preferred the original – not easily adjusted – Peugeot units, and the lead driver took his word for it and took a Peugeot damper-equipped 307 WRC to victory in Finland.

2006 Group N modified Impreza STI spec C spied early

The new 2006 Subaru Impreza appeared, in Group N modified form, in a Tommi Mäkinen Racing display at the service area of this year's Rally Finland. After initial reticence from Subaru for the car to be displayed, it was given the go-ahead after the new car's distinctively re-styled snout was masked by a fibreglass cover.

It was the first-ever public appearance of a Group N modified '06 STI spec C, which is 50mm longer, but carries the same 1490/1495mm front/rear track and 2540mm wheelbase as this year's car. The road version of the new car is 20kg heavier than the old one. Minor engine changes bring maximum torque to 422Nm, giving the latest flat six 1994cc engine 10Nm more than the old one, though power remains the same at 280ps. Considerably improved 'variant option' gear ratios for the Group N car provide a 15kph faster top speed, and the central differential of the road car now has a front/rear torque split of 41/59 per cent (this year's car has 35/65 per cent). The new diff gets a revised EMCD electro-magnetic active diff, which is similar to that used in the earlier Group A Mitsubishi Lancer rally cars, although for practicality the Group N rally car runs with a spool centre diff. Mechanical limited slip units are fitted in the front and rear axles. Extra sensors on the new car include a g sensor and steering wheel angle sensor.

LAT

New Group N modified spec C Impreza demonstrates significant aerodynamic alterations, both in the front end and the roof-mounted vane and rear wing

The most striking change for the new Impreza is its aerodynamic treatment – a large rear spoiler is now fitted, with its performance enhanced by a roof-mounted vane that feeds airflow directly at the spoiler. An innovation is the introduction of a diffuser at the rear, under the boot floor.

Racing

Motorsport Matrix Systems.

"If I´m pushing the envelope I don´t need limits."

For optimum performance you need components as perfect as your driving. Our proposal: Sachs Racing Clutch System RCS, a modular system of clutch building blocks. And the Racing Damper System RDS: no-compromise contact with the grid in extreme racing siuations. ZF Sachs Race Engineering. Now introducing Triple Eight Performance Vehicles, the only UK distributor of Sachs racing and perfomance products. Driving technology to win.

888
TRIPLE EIGHT
PERFORMANCE VEHICLES

ZF Sachs Race Engineering GmbH · Ernst-Sachs-Strasse 62 · 97424 Schweinfurt/Germany
service.sre@zf.com · www.sachs-race-engineering.de · + 49 97 21 98 32 58

SACHS
RACE ENGINEERING

At the heart of the world's most powerful engines...

ARROW PRECISION

Here's what some of our customers have said about us . . . . . .

"These rods give us the ability to win championships" Peugeot Sport Engineering

"Arrow Precision take winning as seriously as us!" Hawk Kawasaki

"Without Arrow rods we could not achieve the performance required" WillPower Racing

"the thought of a rod failing in a 72yr old engine is too big a risk" Classic Car Storage Ltd

"Manufactured to the highest quality" Radical Sportscars Ltd

"Simply the best aftermarket con rod's we've ever used" Graham Goode Racing

"Superb Followers, head and shoulders above the rest" Kenny McInstry, Rally Driver

"The service and quality of the product is perfect" Muhlner Motorsport SPRL

ARP

Arrow Precision Engineering Ltd

Tel: 0044 1455 234200

Fax: 0044 1455 233545

Web: www.arrowprecision.com

e-mail: enquiries@arrowprecision.com

MOTORSPORT INDUSTRY ASSOCIATION

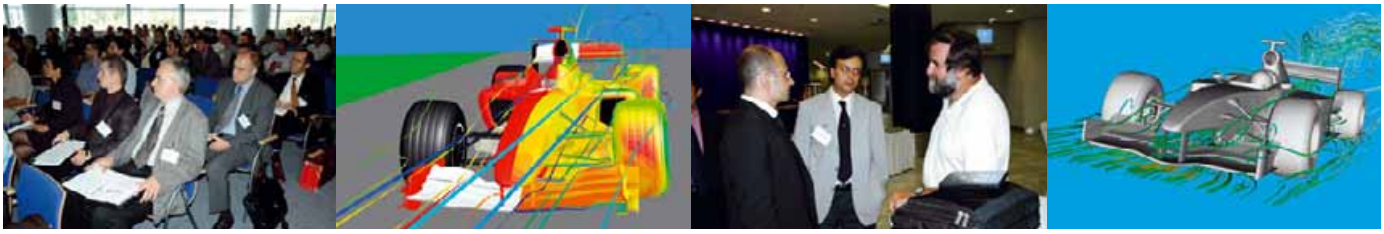
GLOBAL

Certificate No. 91356

The flow of information

CFD has come of age, and with the second European conference a success, the future looks bright for this fast-moving area of motorsport technology

BY CHARLES ARMSTRONG-WILSON



Although road cars were high on the agenda, representatives from Ferrari and Sauber gave presentations and both Williams and Renault F1 were in attendance

The second European Automotive CFD Conference served to demonstrate just how this technology is coming of age. What was once regarded as a rather flaky and unreliable technique has grown in stature massively. At one time, aerodynamic work carried out using computational fluid dynamics would always be validated in a wind tunnel before it was allowed anywhere near a racecar. These days CFD and wind tunnel data are used to validate each other. Also, in these days of short lead times and rapid development cycles, the products of CFD can go straight onto a car, and not just in testing either, but for a race weekend without any other interrogation of the design.

In this environment, there is no mystery surrounding the growth of the CFD industry and the associated software business that supports it. Fluent, the company that hosted the conference in Frankfurt during June, saw its turnover exceed $100 million for the first time in 2004, having doubled since 1999. While this leading software supplier to the industry obviously created the event as a marketing initiative, it was still able to be hands off enough to allow the event to be valid to a broader audience than its own users. Other software suppliers were among the presenters and exhibitors and the event lacked an oppressive product bias in favour of the hosts, at least no more so than one would expect from the market leader.

Much of the conference was concerned with road cars, but that seemed to have little effect on its more widespread appeal to the motorsport fraternity.

Representatives from Ferrari, Williams, Renault and Sauber Formula 1 teams, among others, were there as either attendees or presenters. One of the presentations was even given by Ferrari's head of CFD, Luciano Mariella. He formed the Italian team's CFD department in 1996 and it now comprises nine people. They work on files of up to 35 million cells to get the best possible accuracy for full-car CFD and the quality of the work has been there for all to see in recent seasons. Ferrari was also asked by the FIA to conduct a CFD study of grand prix cars running together to assess the effect of a leading car's wake on the one behind. Mariella displayed the results of the study and concluded that because the wake rises, the effect on the following car is minimal. An outcome that many Formula 1 spectators and perhaps some drivers might query.

> **"THESE DAYS CFD AND WIND TUNNEL DATA ARE USED TO VALIDATE EACH OTHER"**

The other Formula 1 representative to present was Torbjörn Larsson of the Sauber Petronas team that has put a great deal of finance and effort into its CFD programme. This has resulted in the acquisition of Albert, a Linux Cluster supercomputer boasting 500 processors, 1 terrabyte of memory and 10 terrabytes of storage. Larsson recalled a study in 2003 when the team's cars were exhibiting an aerodynamic problem that was proving difficult to identify. They were losing a lot of rear downforce in yaw but the wind tunnel could only simulate up to 4.5 degrees of side slip. However, CFD was able to conduct a study on a file of 100 million cells that could simulate six degrees of yaw. From this it was found that the wakes from the front tyres were upsetting the efficiency of the rear wing. A new set of deflectors for the rear wing were designed and an immediate improvement in performance yielded third and fifth in the US GP.

Much of the development in CFD currently centres on automatic meshing techniques. This was once the bottleneck in the process calling for experienced operators to define the mesh densities for different parts of the model. If the density is too high then time is wasted on calculations of little significance, but if the detail is too low in key areas then the accuracy of the results will be compromised. Hence the focus on knowledge-based meshing software that can produce optimum meshes automatically. Some of the presentations went into more detail on meshing than anyone other than those actively using CFD would want to know. However, for those at the cutting edge it was undoubtedly invaluable insight.

Another technique for reducing meshing times is mesh deformation. Rob Lewis of Advantage CFD explained how this has allowed his company to tackle complex optimisation tasks in a fraction of the time previously required. For more on this technique see Racecar Engineering V14 N4 p48.

As a focus for the world of automotive CFD, the EACC can be counted a success and the breadth of content gave a broad range of appeal. Not only had it sufficient depth for the expert users in the field, but it also gave non-users a valuable perspective of the capability of this technology and how it can be usefully exploited. The event is currently biannual and, with the current pace of development, who knows what the next event will be revealing to the world of motorsport engineering.

Race people

Vic Lee

Johnny Herbert

With the Lola-Dome project concluded, Dome Cars UK will be closed

● VLR team founder **Vic Lee** has been sentenced to 12 years imprisonment after pleading guilty to drug trafficking offences. Three others were also handed down shorter sentences.

● Popular British driver **Johnny Herbert** has joined Jordan Grand Prix as sporting relations manager.

● **Dava McCain** has joined the ALMS organising team as promotions manager. The former Truesports employee will replace **Shelley Cates** in the role.

● **John Travis** has been hired to design the Epsilon Euskadi LMP chassis, which is planned to hit the track late next year.

● Richard Childress Racing has hired 20-year Cosworth veteran and Former F1 engine designer **Nick Hayes** to its engine R&D department – see page 11 for more details.

● **Chuck Rider**, owner of the now defunct Bahari Racing from 1986 to 1999, has passed away at the age of 64. Rider co-owned the team originally with Dick Bahre, and later with Lowrance Harry. Rider bought out Bahre, who continues to build engines for late model stock cars.

● Recent rumours have connected **Robbie Reiser** with an appointment as a crew chief at Dale Earnhardt International.

● **Tadashi Saaski** has left Dome, and Dome Cars Ltd in the UK will be closed down imminently. Dome Japan will not be affected.

● Champ Car has named **Mark S Reilly** as its vice president Broadcast Sales and Distribution. Reilly was formerly the senior partner at Stedmark Associates in New York, following his departure from ESPN Inc.

Cosworth wins 250th Champ Car race

British engineering specialist Cosworth has won its 250th Champ Car victory. The firm has been involved with supplying engines to the open-wheel series since 1976 when their DFX unit made its debut. A Jim Swintal painting was presented to Cosworth's Tim Routsis and Ian Bisco by one of the Champ Car drivers who was behind the wheel of the car that took the 250th win. Cars use the firm's 2.65-litre XFE engine which can produce up to 800bhp.

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...

ERIC BOULLIER
Technical director DAMS

Eric Boullier is the managing and technical director of the Le Mans-based Driot Associates Motor Sport (DAMS), who currently run cars in GP2, A1 Grand Prix and the World Series by Renault.

How did you first get involved in motorsport?
It was when I was a youngster, I was given the opportunity to work at the Le Mans 24 Hours race and, as with many people, that's where the passion started.

What is the most interesting project you have worked on?
Every project I have worked on has been interesting and different. The World Series by Renault and GP2, which I am working on now, are very interesting from a single-seater racing point of view. On the endurance racing and sportscar side, the most complex and interesting project I worked with was the Cadillac LMPs of a few years ago.

What are your biggest achievements in motorsport?
DAMS itself – setting up an efficient team around me to achieve our winning aim.

What is your favourite competition car of all time?
I would have to say the Audi R8. It is astonishing to see how this car has been built, developed and how it has performed so strongly so often for years and years.

Who do you most admire in racecar engineering, and why?
I respect all aeronautical engineers – the complexity of their subject and the mix between such different high engineering levels like aerodynamics, structural engineering, mechanical engineering, electronic and material. All this is a good mix between physical and mathematical skills.

Which era/formula would you have liked to have worked in and why?
Any era of Formula 1, even if only for the environment you get to work in. It allows you to almost be totally free with creativity.

What engineering innovation do you most admire?
Manufacturing solutions, carbon fibre technology and the advances in electronics.

What tool/instrument could you not do without?
My computer, it's essential.

Is motorsport about engineering or entertainment?
Motorsport is firstly engineering, but is essentially based on the entertainment and, at the end of the day, motorsport needs entertainment to live.

What new technologies in motorsport are you excited about?
Structural and manufacturing technologies, combined with the use of new, exotic materials.

Is there a future for high technology in motorsport?
Of course there is!

10 Percent Off

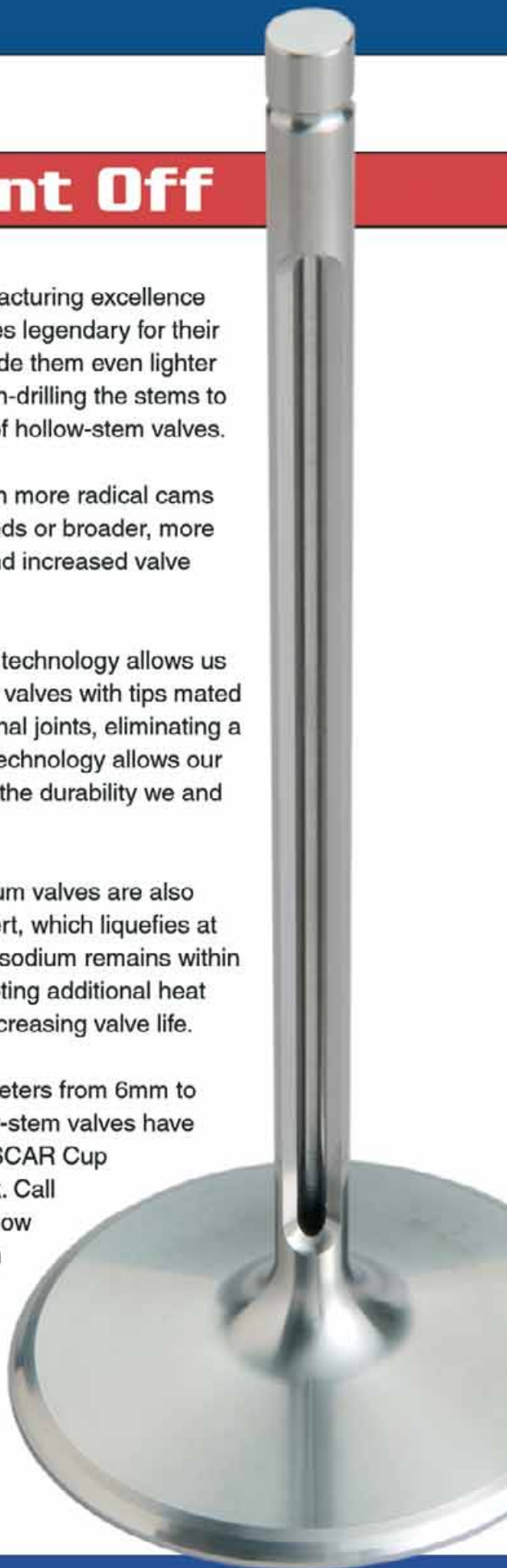
Del West design and manufacturing excellence has made our titanium valves legendary for their light weight. Now, we've made them even lighter – 10 percent lighter – by gun-drilling the stems to produce a new generation of hollow-stem valves.

The result? The ability to run more radical cams for higher peak engine speeds or broader, more 'driveable' torque curves, and increased valve train durability.

Only Del West's proprietary technology allows us to manufacture hollow-stem valves with tips mated to the stems without additional joints, eliminating a potential failure point. This technology allows our hollow-stem valves to meet the durability we and our customers demand.

Del West hollow-stem titanium valves are also available with a sodium insert, which liquefies at operating temperature. The sodium remains within the valve guide area, promoting additional heat transfer to the guide, and increasing valve life.

Available now, in stem diameters from 6mm to 11/32-inch, Del West hollow-stem valves have already been proven in NASCAR Cup racing and NHRA Pro Stock. Call us today, and we'll tell you how to maximize their benefits in your next engine.



Del West USA
Sales/Tech Support 800-990-2779
28128 W. Livingston Avenue
Valencia, CA 91355
(661) 295-5700 Fax (661) 295-8300
www.delwestusa.com

Lightweight valve train components.
Because nothing else even comes close.

Del West Europe
ZI Les Vernes
1852 Roche, Switzerland
0041 21 967 21 21
Fax 0041 21 967 21 27
www.delwesteurope.com

Autosport INTERNATIONAL ENGINEERING SHOW

12-13 JANUARY 2006 NEC, BIRMINGHAM

Want to **WIN business?**

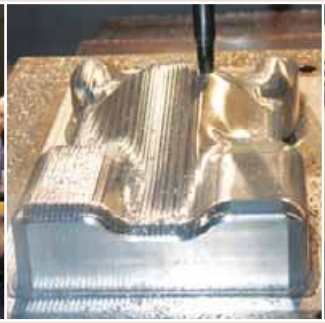
Autosport International is the world's largest motorsport show. With over 840 exhibitors, let them tell you the reasons why you should join this award winning show:

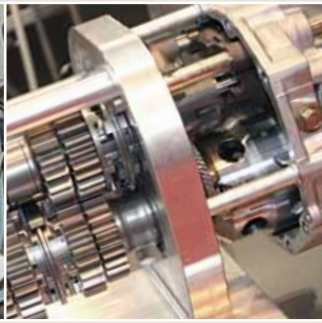
The quality and variety of visitors that Autosport International attracts makes us believe that the show is unmatched in its value as a marketing tool and productive business showcase. If you're serious about the motorsport business, you just can't afford not to be seen there.
Sharon Quaife, Quaife Engineering

It was a great opportunity for us to meet with customers, new and existing - and the response following the show has been fantastic. Roll on Autosport 2006!
Andrea Rodney, Hone-all Precision

Autosport International is the ultimate racing show catering to the European markets.
Oscar Romano, Ferrea Racing Components

- 25,000 trade visitors
- Over £400 million worth of business will be influenced by trade buyers attending Autosport International
- 84% of trade visitors rate the show as an important place to do business
- 54% do not visit any other trade show

To reserve your stand space at Autosport Engineering / Manufacturing Technology contact the Sales Team on: **+44 (0) 20 8267 8300**
or Tony Tobias on: **+44 (0) 7768 244 880, expo@tonytobias.com**
www.autosport-international.com

Supported by:

AMRA AUTOMOTIVE MANUFACTURERS' RACING ASSOCIATION LIMITED

The International Journal Racecar engineering

solutions

Autosport INTERNATIONAL ENGINEERING SHOW

News

Next year's Autosport Engineering show will be hosting a series of firsts as more and more companies are signing up to be first time exhibitors.

Austrian aerospace supplier Pankl has already booked a stand to exhibit at next year's event. Not only will this be its first appearance at the Autosport Engineering show, but it will also be the first time it has ever exhibited as a company at a worldwide event.

Pankl is a cutting edge manufacturer for both aerospace and Formula 1, and now it is introducing its drivetrain systems into the wider motorsport industry.

Pankl is also a company that shares its customer's passion for winning, and is based on a history of motorsport with its original founder, Karl Pankl, being the winner of the 1920 Hungarian Grand Prix.

To accommodate the amount of companies signing up to exhibit at next year's show the Manufacturing section is set to grow even bigger.

Adding to this list of first timers is Mitutoyo. Renowned for being one of the world's leading measurement gauge companies, Mitutoyo has become one of the most recent companies that has booked a stand to exhibit at the 2006 Autosport Engineering show.

To make sure you secure a ticket of your own and to find out more information about the event visit www.autosport-international.com

Talk to TT

If you are thinking of exhibiting at the show and would like to speak to someone about how to go about it, then contact Racecar's Tony Tobias. Email: expo@tonytobias.com or call him direct on 07768 244 880.

Fast company

A fastener manufacturer since 1890, Blanc Aero Technologies is now a leading supplier into motorsport

Words | Katie Power

Leading manufacturer of racing technical fasteners, Blanc Aero Technologies, will be continuing its legacy of exhibiting at the Autosport Engineering by making its eighth appearance at next year's show.

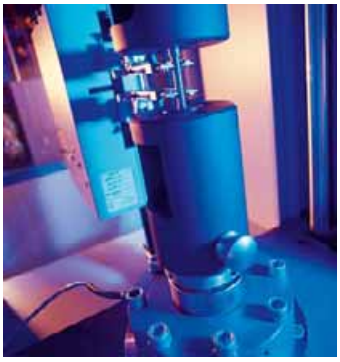
Blanc Aero Technologies is a world recognised company, supplying high performance technical fasteners for the racing industry, as well as prestige cars and motorbikes.

Its wealth of experience stems from belonging to a family of principal fastener manufacturers. Its mother company, LISI Aerospace, is currently the third biggest aerospace fastener producer in the world, and together with help from its sister company, A1 Technologies, Blanc Aero Technologies holds a major position in the racing fastener sector. It currently supplies to NASCAR, IRL and many US drag race series.

The company, located in Plerin, France, began in 1890 manufacturing aerospace fasteners before reallocating its production work in the 1980s to various companies within the LISI group. This allowed Blanc Aero technologies to focus on the production of studs and bolts primarily for racecar use. Today it supplies some of the biggest names in motorsport with its rod bolts and cylinder head studs.

All products are made specifically to order under the strictest of confidence. This is part of Blanc Aero Technologies' constant effort to ensure accurate manufacturing results by liaising with customers directly. Technical assistance is provided on a daily basis, providing help with material selection, torque requirements and design formation. Product testing for tensile strengths, concentricity and thread profile are just a few more examples of the technical assistance available.

At present, Blanc Aero Technologies are mainly recognised for their connecting rod bolts, cylinder head studs and main studs, though it recently introduced into the industry replacement titanium engine studs, too. Regardless of the product, Blanc Aero Technologies prides itself on its ability to provide customers with a quick response delivery service. All production takes place in-house, allowing customers to feel confident about receiving speedy results in panic situations where rapid responses are needed.



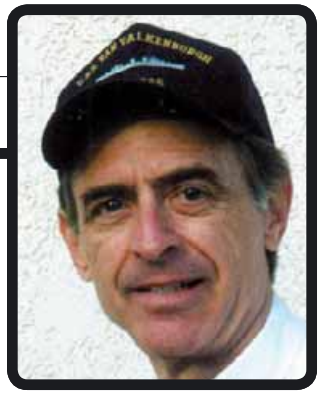
Precision made technical fasteners are an integral part of every racecar. From rod bolts to head studs, Blanc Aero Technologies make them all

Blanc Aero Technologies uses the Autosport Engineering show as an opportunity to meet exciting and prominent figures in the racing world. For those who want to meet the people behind the promise of quality, performance and innovative developments, make sure you visit this company at the 2006 show.

Contact

Address: Blanc Aero Technologies
Le Jouguet
Plerin 22190
France
Tel: +33 296 683 339
Fax: +33 296 683 345
Email: didier.godin@lisi-aerospace.com
Website: www.lisi-group.com

By Paul Van Valkenburgh



Racing chariots – without the horses

There's a new form of motivation ripe for re-engineering. The question is, what direction is it going to go in?

When the first rumours appeared about a new vehicle that was going to change the world, I knew that nothing – nothing – could live up to that PR hyperbole (although it might have made a good Harvard MBA case study). Then, when I first saw the Segway, I said: 'now there's an elegant answer – to a question nobody asked.' But it turned out I was wrong. And when I saw newswire photos of the president of the United States falling off one, I thought, 'now that is a PR firm's worst nightmare...' And then I became a little more sympathetic and open-minded (or was that more brilliant PR strategy?). After riding one, I think maybe that photo said more about President Bush than the stability of the Segway.

A Segway saved my butt. Well actually, it saved the sciatic nerve in my gluteus maximus, which gets pinched whenever I walk too much. I haven't covered many races recently, which can involve a lot of walking and, after I signed up to judge the FSAE event, I wondered how I was going to survive it. Until suddenly it dawned on me – here is a perfect application for the Segway – auto racing pits and paddock!

This is the perfect solution for a person who can stand, but not walk a lot. It goes faster, for longer than most endurance runners. It's finely manoeuvrable, with a smaller footprint in a crowd than a bike. It gets your head and shoulders above the crowd so you can better see what's going on, and it's a little more hip than a golf cart or a wheelchair.

I wondered why I hadn't seen them around racing already – then realised it's because I haven't been around. A couple of pro race team managers use them extensively, including Doug Boles at Panther and →

> "IT'S A LITTLE MORE HIP THAN A GOLF CART OR A WHEELCHAIR"

Brian Stewart Racing. They told me that not only were they great for fast transport between pits, paddock and transporters, but they make awesome marketing tools, painted up and used by sponsors. I even heard that one unnamed race driver got his hands on one and, against all manufacturer warnings, started jumping it over ramps. Apparently Tony George uses one to get around the paddock at Indy, too.

Here's some irony though. After using mine for a few hours at FSAE, the officials I was helping asked me not to ride it in the paddock area. They decided that it set a bad example for the college kids, who were restricted from using wheeled vehicles such as scooters, rollerblades and skateboards – presumably for insurance or safety reasons. It isn't the first time I've been penalised for using an unfair advantage. The irony is that within a few years, probably all officials will be adopting them to replace their golf cart get-a-rounds – unless other tracks come up with a reason to ban them.

Okay, so it makes a good pit vehicle, but what does this have to do with Racecar Engineering? Hell, to guys like us, *everything* has to do with racecar engineering. There are people who race lawn mowers, bar stools, farm tractors – you name it, if it has a motor, somebody races it. And you can bet that some of those pit crews with Segways have had face-offs already.

But what kind of course would be most appropriate? Maybe motocross would be most exciting. But like chariot racing without the horses, it may require some different athletic skills. I'll even confess, that as part of my road testing 'license to skill', I investigated its maximum cornering *g*s, and got thrown when it went up on one wheel. However, safety couldn't be much worse than bicycle or motorcycle racing.

Let's look at the technical challenges – primarily in overcoming totally new dynamics of a vehicle from outer space. Since we've already worked out all the four-wheel and bike dynamic problems, this is something new and interesting – a good exercise, like facing a change in the rules, to challenge your thinking and stimulate your imagination. But now that I realise how much *could* be said, this will just be a brief outline. I'll leave the rest up to you, to consider how that thinking might apply to racecars.

Motor speed. Right away, the real racer would crave a higher top speed. Stock Segways are delivered with three colour-coded keys, each of which calls up a different speed limiter, up to a max of 12.5mph. I've heard that it's possible to re-program the limiter, but only below that max. So it will be necessary to use other tricks, like possibly increasing tyre diameter – although that will void their liability – and reduces range on a battery charge.

Acceleration and braking (which is simply motor reversal), are dependent on how fast the rider can pitch, or lean his body fore and aft, and whether the motor has enough torque (amps) to catch up and re-balance the platform.

Cornering traction/rollover resistance. Centre of gravity is irrelevant – think motorcycle here, and whether you can lean sideways far enough to keep your *g*-vector between that really narrow track width – which will be a key factor in future rules definition.

Aero? You probably don't want to ride one of these things at a speed where aero would matter. But if so, you might borrow positions and clothing from downhill ski racers? Or maybe, if you mounted a platform on the handlebars, you could ride it flat-out prone, Superman-style?

Handling control, or OS/US response. You control turning with a left-hand twist grip and, as part of their three-stage key system, there's also variable yaw response, which is a function of the left/right motor opposing rotation, so it can be increased with speed and rider experience.

Talk about minimising polar moment of inertia – how could you make it any less, in any one of the three axes? And all mechanical damping, whether in pitch/roll or ride, is via (you guessed it) the rider, especially his hands on the bars. As it is, if you let go of the bars, it's likely to start oscillating – at rest.

The next step, after modified Segways are being raced, is that someone will inevitably decide to custom-build a full-race version. You think this technology is too advanced for do-it-yourself? Think again. There's already a website by a guy who built his own, from scratch, including the digital logic for self-balancing, which can be downloaded for free. See www.tlb.org/scooter.html.

Early on in Segway-mania, I recalled that a designer friend, Syd Mead, had proposed a computer-balanced mono-cyle as far back as 1979 (see this 10 Jan 2001 blog: http://www.visuallee.com/weblog/2001_01_01_archive.html). And not to be outdone, the self-proclaimed web nerd built one of those also, although it *does* require some rider skills.

Right now, a Segway is a little pricey just to be just having fun and experimenting with. It's in the 'early innovation' phase, where the biggest business challenge is how to best amortise the millions in development costs, then get volume up, and price cut down to little more than the cost of materials and delivery (compare it to electric scooter prices). Otherwise they may become victims of the familiar 'second-man advantage' of declaring bankruptcy and selling out to another businessman who doesn't have that overhead to pay off.

And remember, the point with any innovation like this is seldom what it appears to be today, but what it is likely to *become*.

"THE POINT WITH ANY INNOVATION LIKE THIS IS SELDOM WHAT IT APPEARS TO BE TODAY, BUT WHAT IT IS LIKELY TO BECOME"

M3

NO COMPROMISES™

CarbonMetallic®
Track Pack Available

PERFORMANCE®
FRICTION
BRAKES

Performance Friction, USA 866 392 9936
www.PerformanceFriction.com

0117.0008

By Alan McConnachie

Resisting change

Has the potential for tuning anti-roll bars been overlooked and their apparent simplicity just accepted, or is there still more that can be learnt?

We take anti-roll bars (ARBs) for granted. They are so simple in function that it is hard to imagine that for the first 50 years of the automobile the best and brightest didn't conceive of the need for them. In reality, the ARB is an ingenious secondary spring system that allows us to have our cake and eat it too – allowing a softer, compliant ride with controlled chassis roll.

ARBs have been refined since their introduction, and sometimes rearranged, like the clever vertical T-bar system found in some cars with pushrod suspension. The cockpit adjustable system was a big leap forward, but overall most racers feel there is nothing left to learn about ARBs. Even W Milliken in his amazing book 'Race Car Vehicle Dynamics' only devotes a few paragraphs to them.

The racecar designers' usual objective with ARBs is to produce tidy packaging and adjustability. The race engineers' relationship with ARBs during the search for perfect car set-up is to select the right amount of roll resistance for the conditions and to divide it up between front and rear wheels for the best balance. But there is an unrealised tune-ability in ARBs. To explain this, we need to look at some of the thought processes that lead to this conclusion.

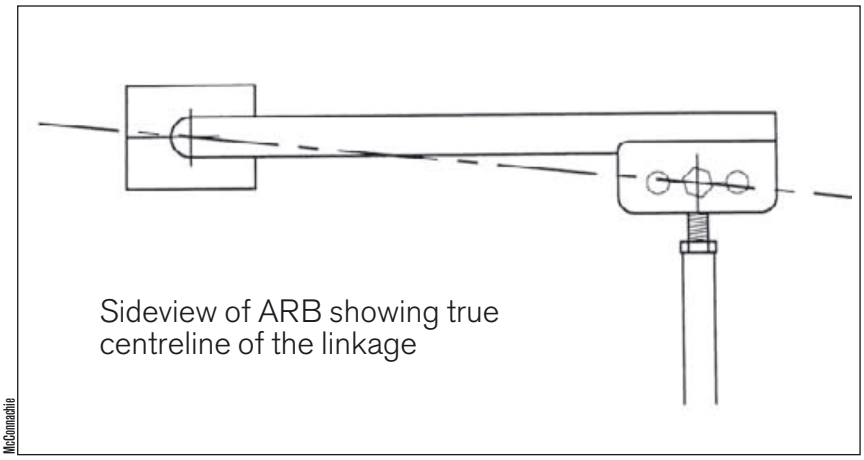
In the GTP days I worked with a well-known designer who had a strong preference for ARB drop links to be as long as possible. His logical thought process was to achieve a minimum of geometry change during articulation of the linkage. I eventually came to the conclusion that this concept might be a bit overrated as many successful cars that won races had short drop links. Coincidence maybe, but perhaps there is an advantage here. It seems that short drop links produce a rising rate as the linkage articulates because the angle between the arm and the drop link moves beyond 90 degrees and the linkage becomes less efficient. In moderate chassis roll situations where traction is at a premium at one end of the car or the other ie trail braking or accelerating out of a corner, softer roll resistance would be better for grip from the pair of tyres most affected. Then, as higher *g*-loads are reached in pure cornering, a rising rate would produce more roll resistance and therefore better chassis attitude.

LAT

Cars in the old German DTM series exhibited perhaps the most advanced anti-roll bars ever used, with active, computer control used to change rates at precise points around the circuits

This led me to wonder if the wheel rate of an ARB changes as it rotates in its mounts during dive and squat and the arm moves away from horizontal. I figured it had to, but by a significant amount? To test the theory I did a practical measurement of an ARB's rate by fixturing a bar on a bench, clamping the pillow blocks to the edge of the bench and resting one arm on a beam from the floor with the arms horizontal. To the other arm I attached a drop link that suspended a heavy weight. A dial gauge was used to measure the vertical deflection of the drop link and this was →

"MOST PEOPLE WOULD ASSUME IT IS UNDESIRABLE TO HAVE STRENGTH VALUES FLUCTUATING DURING NORMAL OPERATION"



McCormachio

Setting front and rear ARBs to point downhill at ride height would soften the front bar and stiffen the rear during dive, with the opposite occuring during squat – a situation that could be beneficial on certain types of racecar

recorded. The bar was then rotated until the arms had a nominal angle of 30 degrees and the process was repeated. The deflection this time was 31 per cent less, meaning the bar was effectively 31 per cent stiffer. This increase is logical because, if you let the bar hang vertically, the rate would be close to infinity. At first glance this seems like a negative, and most people would assume it is undesirable to have strength values fluctuating during normal operation. From this one study one could make a case for longer arms to reduce angle change.

I filed this under interesting but useless information, but some time later began wondering whether this change in strength with angle change

"CHASSIS DIVE WOULD SOFTEN THE FRONT BAR AND STIFFEN THE REAR SIMULTANEOUSLY"

could be utilised for a performance advantage. I had read years before that cars in the old DTM series had active, computer-controlled ARBs that changed rates at precise points around a lap of a circuit. I surmised that the front bar would soften and the rear stiffen entering a corner to assist the front tyre grip at turn in, and the opposite would occur at corner exit to assist traction at the rear driving wheels. At the time DTM was the most advanced series in the world, technology wise, and later virtually priced itself out of existence. But what if you could get the same effect for almost free without the use of computers?

We know that during dive and squat the ARBs rotate in their mounts without offering any resistance, and of course the arms change angle, but does this fact tie in with my previously described tests on changing rate with angle? I concluded from my assumptions about DTM cars that under trail braking a softer front bar might be desirable. I also learned that a bar is softest when the arm is horizontal and at 90 degrees to the drop link. Therefore, we could shorten the drop link length so that under braking and dive the bar arm is horizontal, then at ride height it will be downhill with an angle beyond 90 degrees to the drop link. At the rear, we would like the bar to be softer during acceleration off corners and consequently squat, so we would arrange the ARB arm so it would be horizontal and therefore softest during squat, with the arm downhill at ride height. Again, shorten the drop link. The result would be front and rear bars with a downhill attitude at ride height. Chassis dive would soften the front bar and stiffen the rear simultaneously and the opposite would occur in squat.

This effect would be enhanced by ARB's with shorter arms, and also by increasing dive and squat. For decades these traits – a natural result of weight transfer – have been considered undesirable, with much attention being paid to varying amounts of anti-dive and anti-squat geometry. But there is a price – both these features produce a bind effect that reduces grip, so engineers learned to use them in moderation. I've heard that many drivers prefer some dive during braking as it gives more feel for threshold braking.

Promoting dive and squat, by reducing or eliminating anti-geometry, could be undesirable with cars that are extremely pitch sensitive, as any mechanical gains would be outweighed by loss of aero effect from the underside of the car. But even a modern F1 car, with its high nose and wooden plank under the car, must be nowhere near as pitch sensitive as its type 15 years ago. It would also be unsuitable on cars with high camber gain curves, like some vintage racecars that would be spending more time running on the inner edges of their tyres. Studying modern formula cars, camber gain seems to be the last thing on their designers' minds.

One draw back of ARBs is a loss of ride quality and possibly adhesion over one-wheel bumps. A benefit of our ARB's new positioning is that during dive and squat the pair of tyres being worked the hardest are better able to deal with one-wheel bumps by the ARB at that same end of the car being horizontal and therefore softest. For example, the front tyres are better able to traverse bumps in the braking zone because the front ARB is at its softest, while the rear tyres are better able to maintain traction over bumps at corner exit because the rear ARB is at its softest.

In actual fact, many of us have used this system unknowingly as it was common on older racecars to mount the drop link rod end below the ARB arm, either bolted between welded brackets or in a sliding adjuster where the true centreline of the linkage in side view is through the mounting pillow blocks and the centre of the rod end. If the arm is horizontal at ride height, the true linkage centreline is downhill.

I'm hoping I've created some interest in this concept from race engineers who would be interested in experimenting with it. To test the idea with maximum accuracy, factor in that the effective strength of your bars is higher because of the new off horizontal attitude of the arms, so you need bars softer in the same ratio. According to my tests, if you set your ARB arms at 10 degrees, use bars 7.5 per cent softer. At 20 degrees, use bars 17 per cent softer. To further exploit the potential, use less anti-dive and squat geometry.

If anyone does decide to test these ideas, I would be very interested in your results, kept confidential of course. Contact me at alancmc@mindspring.com

vieweg
technology forum

17 – 18 November 2005 | Frankfurt

GlobalMotorsportsCongress 2005

Performance Technology Transfer **Exhibition**

New Congress Website!
www.globalmotorsportscongress.com

ADVANCED ENGINE TECHNOLOGY

CHASSIS DEVELOPMENT

PERFORMANCE MATERIALS

MEASUREMENT AND TESTING

powered by

ATZ AutoTechnology MTZ

Get the full programme NOW!

Easy and quick by e-mail: motorsports@vieweg.de

vieweg technology forum
Abraham-Lincoln-Str. 46
D-65189 Wiesbaden
Phone +49(0)6130 947890
Fax +49(0)611 7878-407

Speakers include:

Paolo Martinelli, Engine Director, Ferrari
Nick Fry, Managing Director, BAR Honda
Tim Routsis, Managing Director, Cosworth
Hans H. Demant, CEO, Adam Opel
Mike Copson, Technical Manager, Shell
Dr. Ernst Wustinger, CEO, Pankl Racing Systems
Pierre Dupasquier, Director Motorsports, Michelin
Riccardo Baudille, University of Rome
Steven C. Luby, CEO, Vistagy

Zeroshifter

When I first read about ZeroShift ($V_{14}N_2$) I didn't know how they accomplished the uninterrupted transmission of power. The only reason I believed it would work is because of *Racecar Engineering's* credibility. I did know that the laws of physics weren't suspended in deference to ZeroShift and that the instantaneous gear change had to be accompanied by an instantaneous change in engine rpm and an instantaneous torque spike. The missing piece of the puzzle became clear with the statement 'smoothing out a spike is achievable, unlike filling a hole, which is not.'

I can't wait to get a ZeroShift for my Viper. It's a given that when a fair driver exits a corner with a good driver on his bumper the good driver won't be able to pass because anybody can accelerate in a straight line, and in a Viper it's exceptionally easy (yes, a good driver should allow room to get a run on the fair driver but on some tracks the following straight isn't long enough). The combination of ZeroShift and traction control, which I have successfully experimented with and am currently incorporating into a kit, will give me a decided edge in both performance and safety.

Barry Barisic, by email

CADs or bounders?

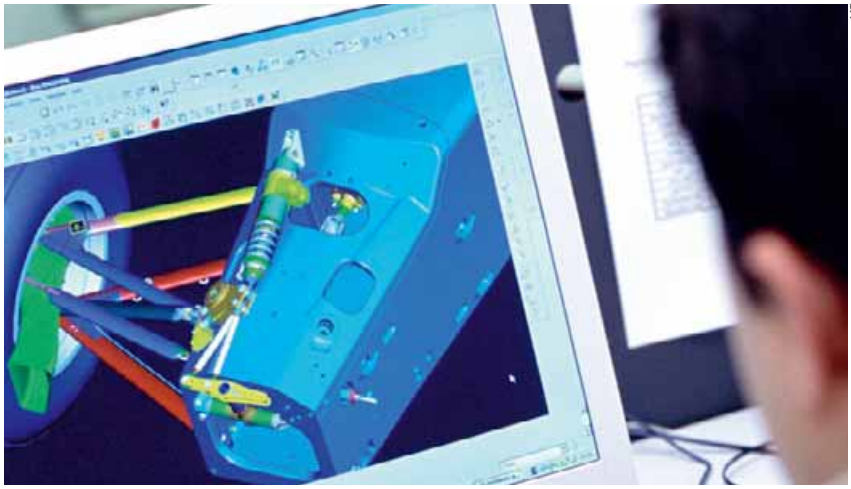
It is interesting to see all this hype about 3D CAD packages. I've seen presentations of most of the lower end stuff, used a couple of them, and they all seem to be the same.

A work colleague put it into perspective for me: 'You can turn a good drafter into a good modeller, but you can't turn a good modeller into any kind of drafter.' And in the people I have interviewed and eventually hired, I have found this statement to be very true. More and more people seem to have lost the ability to visualise. When you are drawing in 2D AutoCAD or similar, you have to think about what the product is going to look like. With 3D it's shown to you on a screen, and people who've used 3D seem to get really caught up in it and can't see any other way around it. You *must* have imagination, or there is no point.

Also, I personally believe 3D is design limiting, as there are certainly things that I can draw in AutoCAD that I have no hope of replicating in Autodesk Inventor, as the software won't allow me, or it is simply a round-the-moon exercise to do a simple thing. 3D has its place, but I believe this to be more in its ability to organise bills of materials and to rapidly produce sections and exploded details that take 2D ages to do, rather than actual equipment design. And as other people have said, at the end of the day, they are TOOLS. If you can't 'see' what you want to achieve in your head, then forget it as none of these products are going to help you.

'Boyracer'
Taken from the www.racecar-engineering.com forum

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
Visit www.racecar-engineering.com and submit your project for a feature online



3D CAD is not all it's cracked up to be, according to one nameless forum lurker

Rallying round

I have just heard the proposals made by the British MSA to effectively ban World Rally Cars from national events, along with Group B cars like the MG Metro $6R_4$. This move seems to be paving the way for the removal of all non-homolgated cars from British special stages, along with pretty much every other car of any technical interest whatsoever. May I urge your UK-based readers to lobby the MSA to drop this daft proposal and to keep interesting cars rallying.

Gwyndaf Flynn,
Newcastle Emlyn, Wales

Confuscious say?

I have just read Paul Van Valkenburgh's V-Angles section about Formula Student ($V_{15}N_9$). It's no wonder some of the students don't understand him, what is he going on about?

Ian Allen, by email

The end of Spring

A Catalan-Flemish company is developing a system that eliminates all the compromises normally encountered in springing and damping on a racecar

Words	Charles Armstrong-Wilson
Photos	Sam Collins; LAT

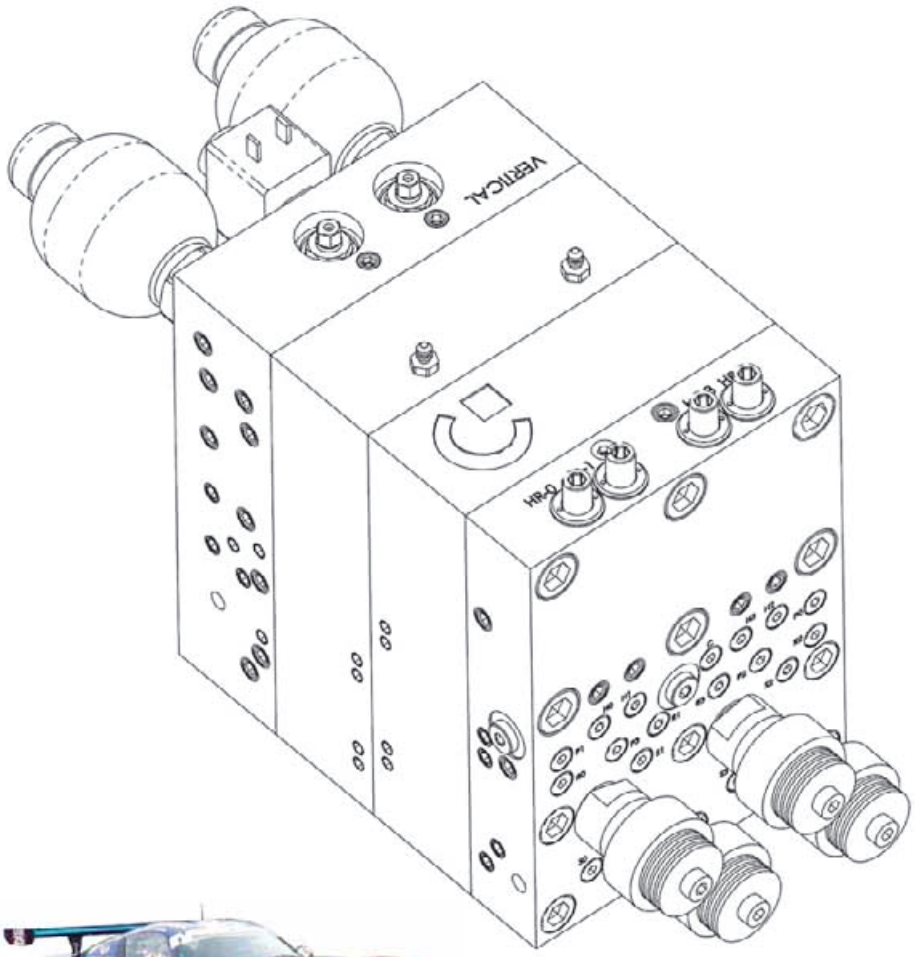
A 24-hour endurance race calls for reliability and durability above all else, so it comes as no surprise that adventurous and innovative ideas are rare in the pitlane at Le Mans. However, the Racing For Holland (RFH) team was bucking the trend with its Dome at this year's race. The car was equipped with a very unconventional suspension medium incorporating hydraulic rams and long lengths of high pressure hose. To the uninitiated it looked like some form of active suspension, although that technology is specifically banned under the ACO's rules. The way the system operated was passive, but no less clever for all that.

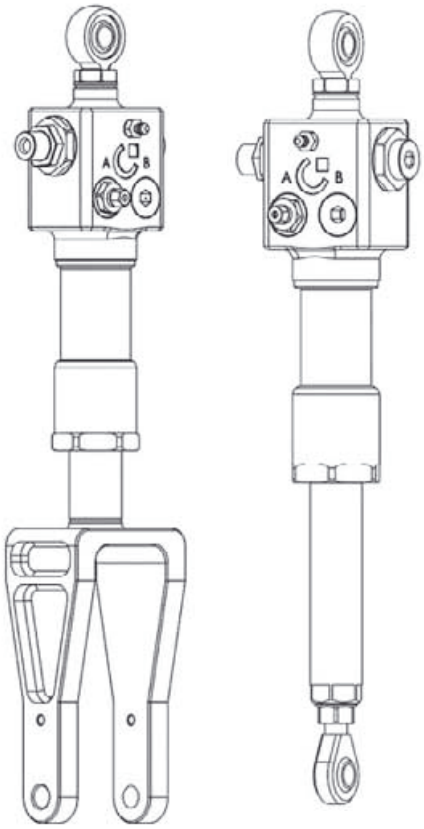
Racecar suspension always brings compromises. Even avoiding that favourite source of pub arguments – suspension geometry and all the permutations of camber control and kinematics – just the spring and damping alone are a complex interaction of trade-offs and compromises. Bump rates are determined by spring stiffness, but to accommodate roll control additional transverse torsion springs are added as anti-roll bars. However, these not only have no influence on pitch which it would be desirable to control, they have an unwelcome influence on diagonal stiffness or warp.

Add to this the problems of tuning spring rates for aero loadings and it can soon be seen that the traditional application of four springs and four dampers can easily be found wanting. Many modern racecars use third spring systems to take these extra loads. Or alternatively they resort to a monoshock and allow for roll through lateral compliance in the rocker system. But this leaves the roll mode undamped, creating a further compromise. Even with a normal spring and damper per wheel, damping for bump and roll is a compromise. Modern four-way adjustable dampers capitalise on the separate frequencies of these different modes to apply unique damping rates, yet even this technology cannot deal with the separate rates of roll and pitch.

> **"IT ALLOWS A DIFFERENT SPRING AND DAMPER RATE TO BE SET FOR EACH DYNAMIC MODE OF THE SUSPENSION"**

In contrast, the suspension fitted to the RFH





The suspension comprises four hydraulic cylinders, one on each corner, connected to a central block with four spring chambers where the springing and damping occurs

Early experiments on a Belcar Dodge Viper were overly complicated but showed promise

Dome at Le Mans claims to be able to deal with all these demands without any compromises. The difference is, instead of fitting a single spring damper unit to each corner, it allows a different spring and damper rate to be set for each dynamic mode of the suspension. A car's chassis experiences four distinct modes of behaviour: roll, pitch, bump and warp. And it was from this position that Catalan company Creuat – pronounced 'craewat' – approached the problem of springing and damping.

The result is an interlinked suspension concept where each of the four main modes of chassis behaviour has its own rate of springing and damping which can be adjusted independently from the others. Two equivalent versions have been developed – a mechanical system consisting of torsion bars and coil springs intended for rugged applications, and a purely hydraulic system that offers complete control of all suspension parameters. The Mechanical version is better suited to off-road vehicles and SUVs, while the hydraulic version provides the greater adjustment needed for sports and racing applications. It was the latter that RFH was testing at the 24-Hour classic with a view to using it in the race.

Behind Creuat is a Catalan engineer, Joesep Fontdecaba, who was intrigued with suspension and the compromises conventional systems imposed on engineers. 'I started thinking about this maybe seven years ago,' he says, 'and I was mad enough to file a patent in 1999. Then I started building some prototypes, typical amateur stuff.' Three years ago Joesep, together with Patrick Cuyvers, the Belgian partner from IFHS, manufacturer of suspension spheres and hydraulic accumulators, formed Creuat to develop and market this concept.

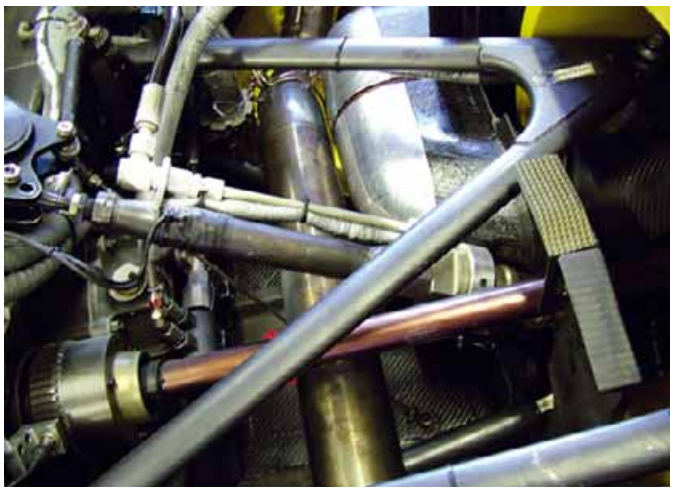
Josep admits to being inspired to some degree by Lotus' experiments with active suspension although the Creuat system has always been passive. Early work concentrated on off-road vehicles and the results of these experiments can be seen on the company website, www.creuat.com. More recently work has centred on motorsport applications.

In its hydraulic form, the suspension comprises four hydraulic cylinders, one on each corner of the suspension. They are connected by hydraulic lines to a central block where the springing and damping takes place. The springing medium is gas which is separated from the oil by pistons in cylinders that work on the same principle as Citroën's hydropneumatic suspension. In fact, the Creuat system uses the same LDS oil in its system as Citroën.

> **"IT TACKLES HEAD ON THE PROBLEMS OF ROLL VERSUS BUMP DAMPING"**

The big difference in the Creuat system is although it has four gas spring chambers, they are not allocated one to each corner of the car. Instead, one handles each mode of chassis behaviour. The stiffest mode is roll so this chamber is given the greatest resistance. However, when the suspension needs to operate in another mode, for instance bump, then the galleries in the unit are designed to allow some of the roll stiffness pressure to be bled off in a way that allows the softer bump compliance to operate. The same applies for the remaining suspension modes of pitch and warp.

Damping can be set individually for each mode as the resistance is generated the same way as in a conventional damper by restricting the flow of fluid with valves. Consequently, when the oil in the system moves in→



No spring and no damper are the most obvious visual differences in the system, replaced instead by a single hydraulic gas and oil filled cylinder at each corner

RFH car was equipped for swap to standard springs and dampers for the race

Central block allows individual spring/damper control of each chassis mode

response to a single chassis mode, damping is only applied to that mode.

All this allows individual control of spring and damping rates of each mode of chassis behaviour, independently of all others. Obviously it tackles head on the problems of roll versus bump damping that four-way dampers attempt to address. Moreover, it can deal with roll and pitch separately, something that conventional systems are unable to do. This is of particular value as cars normally have significantly different roll and pitch frequencies and tuning one rate to deal with both of them will always be a compromise.

The other mode that the system deals with so successfully is diagonal weight transfer or warp. This is often neglected on conventional systems as little can be done to cater for it. The Creuat system, however, can be tuned for this as easily as the other three modes.

It even incorporates an 'isostatic valve' that allows the warp resistance to be removed altogether. This is of limited use on the track as any weight transfer onto one wheel of more than 50 per cent of the vehicle's total would cause that corner to run out of travel and the diagonally opposite wheel to lift off the road. However, it is a big help when setting up the car, as opening the valve instantly creates the optimum diagonal weight distribution. Once the valve is closed again this balance is retained, eliminating the need for corner weight scales.

Ride height is also easily adjusted, being governed by the amount of oil in the system. Oil is pumped in until the vehicle reaches the desired ride height then the system is closed off. There is some ride height change with temperature as the fluid expands, but not enough to cause problems.

> **"ONE [CHAMBER] HANDLES EACH MODE OF CHASSIS BEHAVIOUR"**

In 2003 the team at Creuat met Ludo Helven who runs a Ford Puma in the Belgium Rallycross Championship. This presented unique challenges with the combination of sealed and loose surfaces on each lap. Also the McPherson strut suspension created its own challenges. Being a motorsport application, it was the intention to use a hydraulic version of the system, but installing a set of hydraulic cylinders into the car was not straightforward as they had to form part of the geometry. Consequently they had to design and manufacture from scratch a self-guided McPherson strut.

To assess the spring and damping rates required a complete analysis of the car had to be conducted. The vehicle's dynamic characteristics such as roll and pitch inertias were carefully measured so a useable starting point for the suspension settings could be established. Once installed on the car the driver was pleased with the results and was even able to run the car stiffer than before, gaining more stability without sacrificing grip on the rough parts of the track.

Work has also been progressing on a Dodge Viper being run in the Belgian Belcar series by the GLPK team. Initial analysis showed that some gains could be made, so a system was developed for the car and fitted. Initially, in an attempt to cover all options, the hardware was configured with more elements than were needed, including 18 gas chambers and 24 damping adjusters. Despite the over complication the system did work, covering 250km at Zolder. The drivers reported better and safer corner entry and very good behaviour beyond the limit, but a lack of steering feedback in fast corners. This last trait confused the engineers for a while until they realised it may be due to the lower torsional stiffness of the→

system. The Viper 'shell is not overly stiff and high diagonal inputs make it act as a large, undamped spring that, over bumps, creates effects that can be felt through the steering. With the lower diagonal stiffness, the 'shell was receiving lower twisting loads and was better able to ride bumps.

The diagonal stiffness can also be used to control the degree of understeer – a feature that could prove particularly useful in changing conditions. Two configurations can be set up, one for a dry track and the other for wet. Then, should it rain during a race, the suspension can be switched to the wet option in less time than it takes to change the tyres at a pit stop.

So far the team is still experimenting with the system and has yet to race it but the benefits to lap times have already been seen.

Creuat first spoke to RFH three years ago but initially the team was reluctant to commit to a programme. More recently, RFH engineer Davy Lemmens spent two days in discussion with the company and, seeing the results of the work on the Viper, was sufficiently impressed to give it a try.

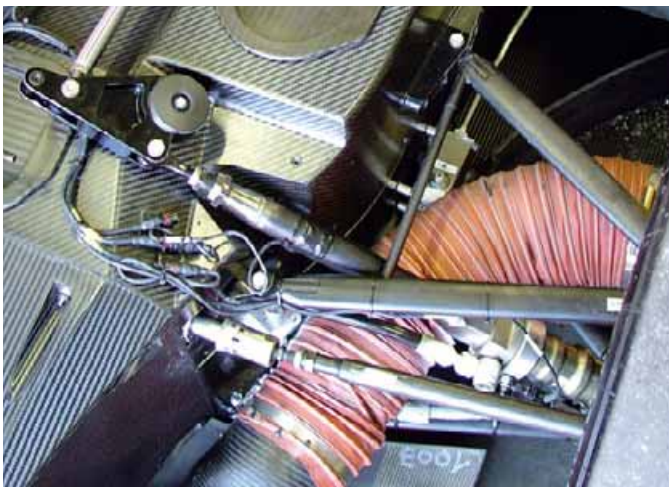
For Le Mans they developed a way of installing it that allowed a quick switch back to conventional suspension. The spring damper units were replaced with solid links and the pushrods replaced by the hydraulic cylinders. That way the anti-roll bars remained fitted but were disabled. With this set-up, the team could swap from one system to the other in four minutes. The hydraulic lines merely act as mechanical links to the central box and, due to the small displacement of the suspension, they can be reasonably narrow without inducing hysteresis. In total, the system contains about 600cc of oil.

Currently the springing and control units are mounted in the cockpit and are bulkier than they could be due to the prototype nature of the system. However, the Dome is already carrying around 100kg of ballast so there is no weight penalty. Also the low and central mounting position is an improvement over the high-mounted spring/damper units.

Once again Creuat did an analysis of the car to arrive at the optimum settings and the car ran on those first time out. 'We just drove out of the box and the driver came back in immediately and said this is fantastic,' recalls Lemmens of that first test. Since having his convictions confirmed, he has become an enthusiast for the system. 'I think splitting the movement is a big gain. When they drive with shock absorbers over the kerb you can really feel it, but with this system you don't know you are on the kerb.

'At the moment we are just looking for mechanical and if we can find all the mechanical grip we need that is fine. Then we have to concentrate on the aerodynamics and, if we can control the aero, then I'm sure that the gain will be much higher than for the mechanical stuff.'

Although the team was finding benefits from the system at Le Mans, there were still some issues regarding the spring and damping rates that they were trying to resolve. In the end prudence made them opt for the conventional suspension in the race. Running such a radical concept for the first time in a 24-hour race may well have been seen as reckless. It seems the benefits of Creuat's interlinked concept are worthwhile and, rule makers permitting, we may be seeing it more often on racecars in the future. RE



Unlike conventional systems, Creuat set-up deals with roll and warp separately

> **"THE LOW, CENTRAL MOUNTING POSITION IS AN IMPROVEMENT OVER THE HIGH-MOUNTED SPRING/DAMPER UNITS"**

Although testing at Le Mans showed definite benefits, in the end Racing for Holland played safe and ran with conventional springs and dampers in the race itself

New acquisition

The new MoTeC ADL2 display and data logger is a significant upgrade on the previous model. We review its new features and speak to RML to assess its performance

Words	Dave Hancock
Photos	Hancock; MoTeC

MoTeC began in Australia in 1987 manufacturing electronic engine management systems for racecars. It now has four main offices in Australia, Europe, Asia and the USA, plus dealers in more than 50 countries and runs a worldwide operation. MoTeC displays, data loggers and ECUs are found on everything from NASCAR racecars in the Nextel Cup to Top Fuel dragsters in Australia and World Superbikes.

Many of its customers have been using the ADL (Advanced Data Logger) – a liquid crystal display (LCD) dashboard with data logging capability. For 2005, MoTeC has introduced the ADL2 dash logger with many new features and the lower priced Sport Dash Logger (SDL). The SDL is a visually identical unit with fewer functions for those with more moderate data acquisition requirements. Visual similarity is, indeed, a key feature of MoTeC displays – the shape and 180mm wide physical dimensions are retained across the new range. Upgrading does not require a familiarity learning curve – the software for the ADL2 and SDL maintains the look and feel of previous versions.

Users' views

In respect of processing power and functionality, the ADL2 is considerably improved compared to the old ADL. To assess these new features, Racecar spent a day with RML (Ray Mallock Limited) while the team tested its Chevrolet Lacetti World Touring Car. RML's data acquisition engineer, Shane Pope, had some experience with the ADL model in British Touring Cars last year before the team moved over to the new ADL2 for the 2005 season.

Previous versions came as standard with 1Mb of logging memory – upgradeable to a maximum of 8Mb. Now 8Mb is the standard, with an upgrade option to 16Mb. Typically, RML accumulates files of around 4-5Mb during the 20-

FACT FILE

Description:
An LCD dashboard with data logging capability

Price:
From £2995 + VAT (backlit version £3295 + VAT)

Features:
Memory: up to 16Mb
Downloading speed: 0.5Mb/sec, via USB
Inputs/outputs: up to 50, plus separate Expansion Modules available
Maximum logging rate: 1000 samples/sec
Communications: CAN/RS232

Contact:
MoTeC (Europe) Ltd, Unit 14 Twyford Mill Industrial Estate, Oxford Road, Adderbury, Oxon, OX17 3HJ
Telephone: +44 (0) 8700 119100
email: sales@moteceurope.co.uk

Web:
www.motec.com.au

> "30 INPUT AND OUTPUT CHANNELS AS STANDARD"

25 minute races so the standard memory is adequate. Racecars involved in longer racers are likely to require the larger memory option.

The ADL2 is able to perform calculations on data before downloading and a new processor that is about 25 per cent faster enhances this. However, Pope told us he does not use this facility, preferring to download raw data as quickly as possible for processing in the data analysis software. With three cars to manage and the use of a parc ferme at race meetings, it is vital for Pope that he can download data in the shortest possible time.

Faster downloading

To this end, MoTeC's adoption of USB for communications between the ADL2 and a PC is a significant enhancement. With downloading now about eight times faster at 0.5Mb/sec, Pope says it takes just 10 seconds per car for that 4-5Mb file. The USB is connected via the Autosport 79-pin connector (37-pin on the SDL) on the rear of the ADL2 using a special cable with a Type B USB socket at one end and Autosport pins at the other. The neatest installation is to do as RML has done and run this cable to a place on the bodywork (below the windscreen on the Lacetti) which is easily accessible and out of the way of mechanics working on the tyres or under the bonnet. A standard USB A to B cable can then be used to connect to a PC. The total length of cable (within and without the car) must not exceed five metres, unless USB booster cables are used.

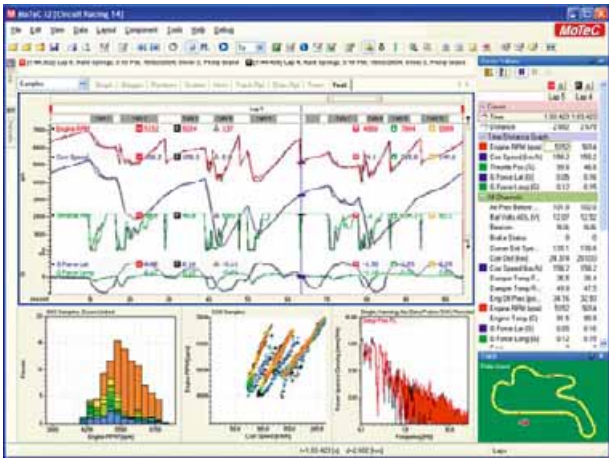
Sensors are a growth area in motorsport, with modern racecars monitoring more and more parameters, and this is mirrored by the RML Lacetti – despite rules restricting the number of sensors that can be used in WTC races. For shakedown tests and race testing, Pope says a multiplicity of sensors is vital. There are too many

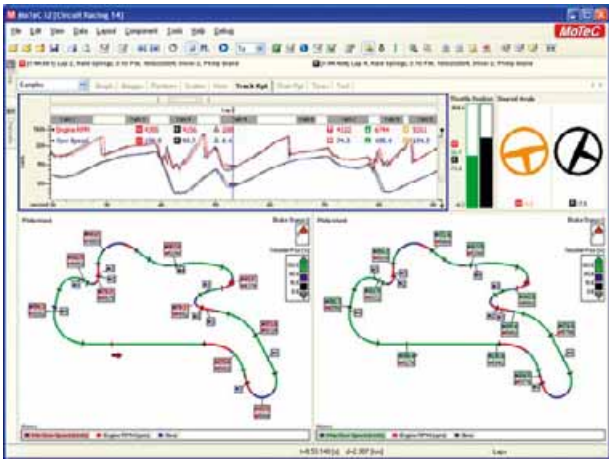
to list here but they include sensors on the dampers, wheel speed sensors, pressure sensors for the power steering, clutch and brakes, the usual temperature sensors and so on.

MoTeC has responded to this trend by offering 30 input and output channels as standard, compared to 22 previously. RML has chosen the ADL2 upgrade which results in 50 inputs/outputs comprising 28 analogue inputs, 12 digital inputs, eight digital auxiliary outputs and two wideband Lambda inputs. Within both the standard and upgraded input/output packages are eight higher resolution inputs. The resolution is three times better thanks to reducing the input measurement range from 15V to 5.5V and is an important feature for generating improved suspension velocity histograms, for example.

For even more sensors, the ADL2's CAN communication system can be used to link one or more MoTeC E888 or E816 Input/Output Expander Modules to the system. In any case, it can be useful to incorporate one or more of these modules as they offer significant advantages when wiring the car. By locating them at the front and rear of the car, the wires to the sensors can be shorter. Also, in the event of an accident, it should not be necessary to replace damaged wires connecting sensors to the ADL2 (which could be time consuming) – only to the respective Expander Module.

The four wheel speed inputs can now be independently designated for either Hall effect or magnetic sensors so that, for instance, different types of sensors could be used on the front compared to the rear. Coincidentally, Pope confirmed that this unusual set-up had been employed by RML as an interim measure until similar sensors were installed on each wheel.





> "IT TAKES JUST 10 SECONDS PER CAR [TO DOWNLOAD] A 4–5MB FILE"

New software

To help analyse the data, MoTeC is introducing a new version of its Interpreter software called i2 (Interpreter 2). While both the new ADL2 and the SDL are compatible with Interpreter, i2 has many new features, including an improved mathematics engine. Those highlighted by Pope as particularly useful are the unlimited screen templates and the fully configurable overlapping graphs. These he says he found invaluable for comparing data from different laps and between different drivers.

As for configuring the display, this is done using MoTeC's Dash Manager software. Again, the ADL2 offers improved configurability – for instance, with the alarm settings. Pope has, in conjunction with the drivers and race engineers, configured all three of the different display pages available. The information displayed when testing is the most comprehensive and includes a range of vital temperatures and pressures, plus things such as brake pressure balance. For warming up the engine before a race or testing, there is a dedicated display that includes, for example, a warning if the alternator is not charging. In the races and for qualifying, the drivers use the simplest display showing essentially just engine speed – via an expanding and contracting arc across the top of the screen – and gear number. In addition, nine alarms are configured to either come on and flash, to come on and go off automatically or to require an acknowledgement (via a steering wheel-mounted button) from the driver. These are shown in the form of alphanumeric symbols across the bottom of the screen. Dash Manager software can be used to set up the display on a laptop – which aids the consultation process with engineers and drivers.

EVALUATION

User:
Ray Mallock Ltd (RML)

Type of business:
Racing team running cars in WTCC and LMES

Who uses the product?
Shane Pope, data acquisition engineer

Overall opinion:
A big improvement over the previous ADL model

It can also operate the actual display so that the driver can see what the ADL2 will look like in use through simulation of input signals.

Watching the numbers

And what about the drivers' eye view? We spoke with RML driver, Rob Huff, who is rising rapidly through the ranks of motorsport and has experience of several other displays. Because he prefers a smaller steering wheel than most drivers, positioning the unit so that he could see it was the first vital step. 'I'm very impressed with it. It is easy to read – including the warnings – and gives more in depth information than I'm used to. It is visible in all sorts of lighting conditions.

'At the end of practice and on slowing down laps, I usually scroll through the screens to check things such as brake balance.

'The gear number is vital – with a sequential 'box it's not obvious which gear you are in and because the ratios are changed often, the third gear of the last race could be fourth now. If I feel a ratio is too long or too short, I can just look down and make a quick mental note of the gear I'm in.'

Interestingly, Huff noted the absence of a gearshift light or lights in the display. This is a deliberate policy of MoTeC, which sells external light units for this purpose, as the positioning of such lights is a personal choice for each driver. Buttons are also separate from the displays for similar reasons. RE

Race smart.

NEW ADL2

Fully configurable + expandable

ADL2 = NEW ADVANCED DASH LOGGER

* USB - Super Fast Download
* 8Mb Logging Memory Standard (16Mb optional)
* FASTER PROCESSOR!
* More CAN templates
* Increased resolution on inputs

→ Uses MoTeC's Interpreter Analysis Software (as used by championship winners worldwide)

* FREE Software
* worldwide support
* 2 year warranty

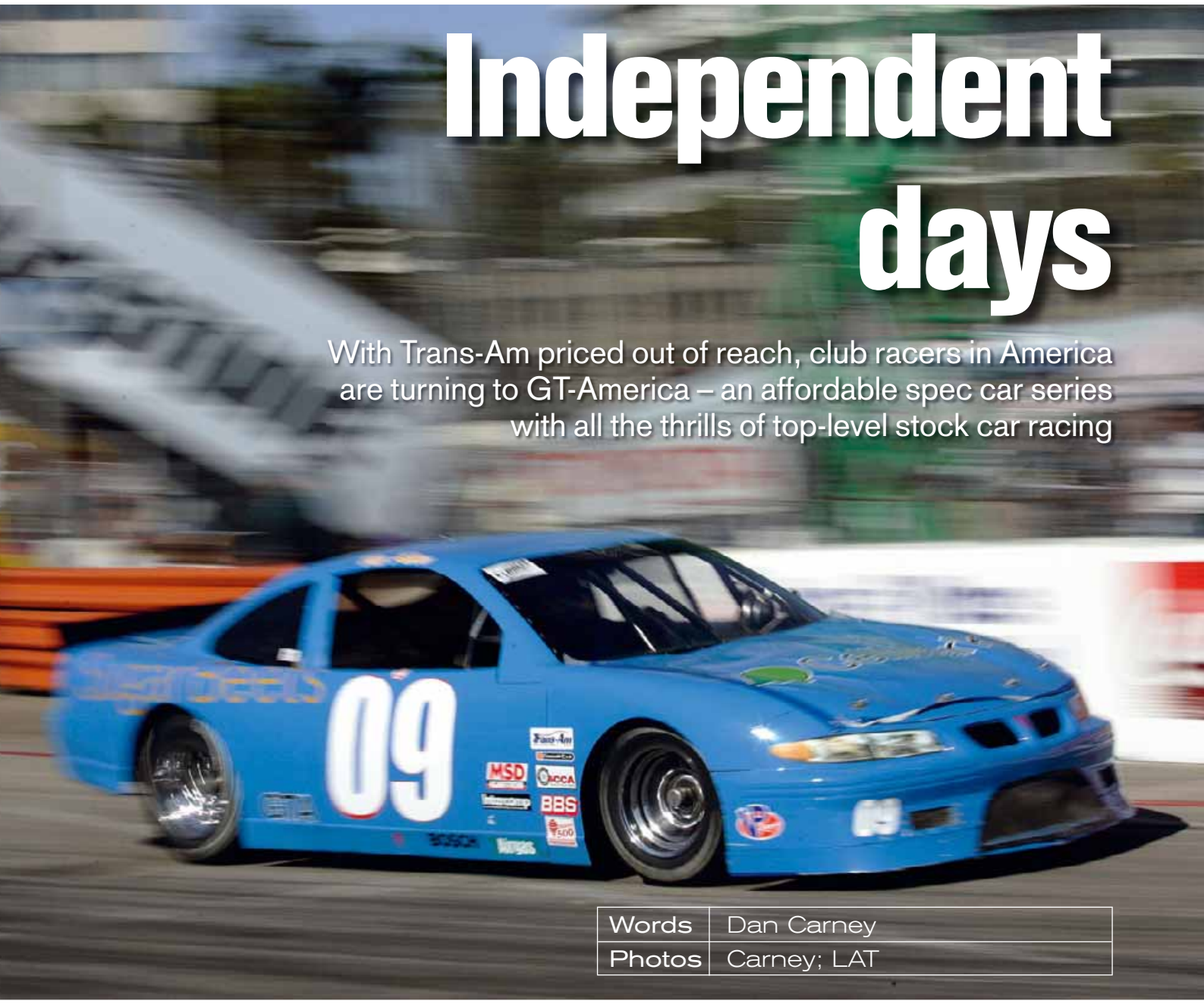
FIND OUT MORE

MoTeC

motec.com.au

Independent days

With Trans-Am priced out of reach, club racers in America are turning to GT-America – an affordable spec car series with all the thrills of top-level stock car racing



Words	Dan Carney
Photos	Carney; LAT

The Trans-Am championship is America's best-known series for tube-framed, full-bodied road racing cars, but the high cost of such racecars and the high cost of participation has driven creative club racers to develop a less-expensive alternative. And in a reversal of fortune, the lowly, inexpensive club racing cars, called GT-America, have been called on to reinforce flagging Motorock Trans-Am fields while that series endures a season of rebuilding.

'Trans-Am has always tried to pride itself on cost containment,' explained executive director John Claggett, 'but the last few years our participation levels have fallen off because the economy hasn't been strong enough to support Trans-Am-level budgets.'

The series also contemplated reviving the popular T/A 2.5 class that saw compact sedans race alongside V8 cars in the '70s. But the GT-A cars not only have stock car appeal, they also have stock car mass, in the event of contact between the field-fillers and the headliners. 'The speed difference is about the same [for T/A 2.5 and GT-A],' said Claggett. 'We feel better that there's not a size difference so if they get tangled up, the GT-A cars will be able to hold their own.'

Now the GT-A cars round out fields with big V8 racers that fit right in with the T/A cars. This isn't the way it was supposed to work. Trans-Am's amateur analog in the Sports Car Club of America is called GT-1. GT-1 is supposed to mirror T/A rules, so that aspiring GT-1 drivers can enter the local round of the T/A series when it comes to town. It is also supposed to provide a market for year-old T/A cars, with front-running GT-1 drivers snapping up the cars they watched compete for the T/A championship just the year before. Sometimes it doesn't even take that long, as T/A championship winning cars have turned up at the SCCA's Run-offs championship race in the hands of a GT-1 competitor with a quick chequebook.

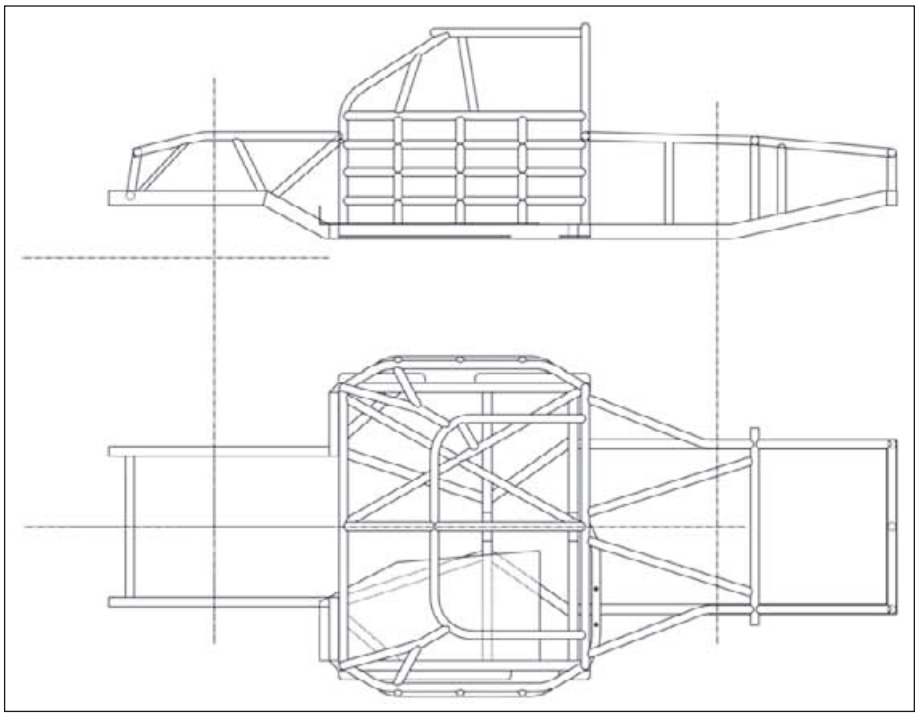
> "IT IS A WONDERFUL CLASS FOR PRIVATEER AND BUDGET RACERS"

But these cars are expensive, and recent rules changes have made differences between GT-1 and T/A an obstacle to club racers participating in the pro races. Hence the development of GT-America. The cars look and sound like GT-1 cars, and run in the GT-1 class outside the two SCCA regions that recognise GT-A, but they are significantly slower

and cheaper than the high-profile true GT-1 cars. That doesn't make them any less fun to drive though, or any less appealing to spectators and sponsors, which is the point of GT-A advocates.

The expectation is that the GT-A cars will be appealing stepping stones for drivers, teams and sponsors who want to participate in Trans-Am, but who haven't been able to muster the necessary budget. 'It allows guys to come into the series at a lower cost and attract some sponsorship,' said GT-A administrator Ron Cortez. 'The lower budget opens sponsorship up to more companies that wanted to get into something like this but couldn't afford a full Trans-Am budget.'

'It is a wonderful class for privateer and budget racers,' said 1996 GT-A champion Vic Rice. 'If you take travel out of the equation, and amortising rebuilds, you can run these cars for $5000 (£2850) a weekend, which is maybe a tenth the cost of Trans-Am.'



Chassis are made in three sections so in the event of a crash usually only a new front or rear clip is needed

Spec chassis

GT-A cars use a spec steel tube frame stock car chassis constructed by Howe Racing Enterprises, wearing composite bodywork supplied by Five Star Fabrication and powered by a V8 engine tuned to produce about 485bhp.

'I'm sure there is some advantage to a Riley and Scott [T/A chassis], but cost-wise we are not even on the same page,' said Chas Howe, president of Howe Racing. A customer ordering a new chassis from Howe and installing a new engine will spend about $60,000 (£34,000) he said. But the flood of available used cars from the defunct American Speed Association spec car oval racing series means year-old cars are now available for around $20,000 (£11,000). 'I don't think there is a more affordable way to get into racing,' Howe opined. Certainly there is no cheaper way to compete in a professional race on the streets of Long Beach in front of large crowds and be shown on television.

All GT-A cars use a similar spec steel tube frame stock car chassis constructed by Howe Racing Enterprises

Howe has built the ASA chassis since 1992, and estimates that there were 150 ASA cars in running condition last year, providing a large pool of potential GT-A cars. The ASA chassis is constructed in three separate sections – a main cabin with replaceable, bolt-on front and rear clips. That means that few ASA or GT-A chassis are ever destroyed in a crash, they usually just require a new clip.

The GT-A class appeared as a regional class in the Sports Car Club of America's San Francisco and Oregon regions a decade ago and has slowly gathered interest. 'We felt there was a hole in the market for guys going from SCCA club races to Trans-Am-type races,' said Cortez. 'There was a huge gap there. We built the cars around the concept that we were drivers and that we didn't want to work on the cars.' That mandated simplicity and limited adjustability, but that doesn't mean slow or dull. 'They were large enough and fun enough to slide around,' he said.

The concept was proven in the season when a family racing operation using an engine assembled at home edged a well-funded team with a supporting transporter for the season championship. Mirroring Chrysler's recent entry into NASCAR racing, relatively few of the GT-A cars are Dodges, with most racers choosing Fords or Chevys instead. But as corporate cousins are permitted, the series would also like to see the arrival of brands like Mazda, Volvo and Jaguar, much as Jaguar competed in Trans-Am with Ford engines for several seasons before introducing its own engine. 'We are looking at bringing in new body styles,' he said, 'because you can run anything Ford is involved with and that would open the door to Mazda, Volvo and Jaguar. We would like to see the Jaguar R-Type and we would love to see someone show up with a Volvo,' he enthused. However, the Trans-Am stalwart Mustang is not invited. 'We want to stay with the sedans,' said Cortez.

An effort to launch GT-A in the stock car-loving East stumbled, but a less restrictive series called the V8 Stock Car Road Racing Series has arisen, incorporating GT-A and GT-1, as well as retired NASCAR racecars from the Winston/Nextel Cup, Busch Grand National and Craftsman Truck series, complete with their high-powered engines.

The wide open V8 SCRRS has attracted plenty of competitors and strong sponsorship as well, with about $3000 (£1700) worth of contingency prizes at each race, according to series organiser Lee Arnold, who hopes to organise an end-of-season shootout with the GT-A series.

Despite the disparity between the cars in →

the SCRRS series, the GT-A cars remain quite competitive because of the challenge in setting up the more complicated GT-1 cars, said Arnold, who drives a GT-A in the series. 'Our car is a lot simpler. I won the race at Moroso (Florida) over a Weaver and a Riley and Scott [Trans-Am chassis]. A lot of times those end up with people who aren't engineers, and the set-up can be tricky. In club racers' hands, you need an engineer to set them up. With the GT-A car, you put one set-up under it and it is good to go wherever you race.'

That doesn't mean the cars are unresponsive sleds though. 'The cars are relatively unsophisticated, but I don't want that misconstrued as [saying] you can't tune them, because you can,' asserted Rice. The primary tools available being rake, ride height, and spring rate. 'Tyre pressures and stagger are also important,' added driver Rudy Revak. 'But it is up to the driver to make this work. It is not just how well you drive but how well you set the car up. Being able to put the right set-up under the car makes all the difference in the world.'

A neat feature of the GT-A cars is the use of internal body mounting fixtures for a clean exterior appearance

> **"THE CARS ARE RELATIVELY UNSOPHISTICATED"**

Revak cited his own experience in missing the set-up for qualifying at the Long Beach Trans-Am race: 'It was a simple mistake – the stagger was wrong on the car. That extra half inch of tyre diameter made a huge difference. That's how sensitive the cars can be.'

Because the stock cars used by GT-A are based on the spec car developed for the entry level ASA stock car series, the bodies used are the traditional American sedans seen in NASCAR: Chevrolet's Monte Carlo, Dodge's Intrepid, Ford's Taurus, Oldsmobile's Cutlass and Pontiac's Grand Prix. Five Star Fabrication has recently introduced composite Dodge Charger bodywork similar to that which appeared in NASCAR this season, so that too could turn up in GT-A in the near future.

A complete body for a car, including windows, is $4000 (£2300), according to Ron Pulera, general manager of Five Star. 'It doesn't use the most advanced technology,' he continued. 'But it is an advanced composite material, hand laid. The idea was the economics of the body.' A Kevlar layer adds to the durability of the bodywork, keeping damaged bodywork from falling apart and onto the track during races. A further feature that adds to the cost, but improves the appearance, is the use of internal mounting flanges to attach panels to the chassis: 'You don't have the seams, so it is a much cleaner looking body,' said Pulera.

358ci V8 engines are all approved, production-based iron blocks with specified stock heads and intakes and a standard Holley four-barrel carb

Composite bodywork from Five Star is simple, durable and, at $4000 for a complete 'shell wth windows, affordable too

Strict restrictions limit the modifications allowed to either the Howe ASA chassis or the Five Star bodywork. The only real variation is the rear spoiler, which is a mandatory 70 degrees (+/- 5.0 degrees) for 2000 and newer cars, while pre-2000 cars may run a 55-degree spoiler. Spoiler height is limited to five inches, but drivers who have never won a GT-A race are permitted a clear Lexan two-inch extension for added downforce. →

Underbody aerodynamics are minimised with a four-inch ride height, 3.5-inch air dam height, and a prohibition on flush-mounted floor pans to make the underside smooth.

Minimum weight is 2800lbs (1270kg), post-race, with driver, evening the competition among small and large drivers.

The 358 cubic inch V8 engines are limited to approved, production-based, iron block designs, with a maximum bore of four inches and maximum compression ratio of 10.7:1. Specified iron heads (supplied by DART for Ford and GM, MOPAR for Dodge) and intake manifolds (from Edelbrock for GM and Dodge, Ford for Ford) must be unmodified, so porting, polishing, filing and other improvements are not allowed. A Holley four-barrel carburettor is mandatory, cams are specified and rocker assemblies are of the production type. A 7000rpm rev limiter contributes to long engine life.

There is also a plan to permit the use of sealed GM crate engines that were used in the ASA series, so that racers can bring those cars directly into GT-A without changing engines. The ASA-spec engines produce about 430bhp, but can be brought up to 500bhp with little effort, according to Howe. 'It's not that hard to turn up an ASA engine to 500bhp,' he said. 'It's just a matter of controlling the electronics.' That is because the ASA engines use GM's production fuel injection system and GT-A engines are carburetted.

Four-speed, H-pattern transmissions are mandated, from Jerico Performance Products, Tex Racing Enterprises Inc. or the Muncie units originally made by General Motors, and now made by Medatronics Corp.

Spec 10x15in Goodyear Economy stock car slicks are available in hard or soft compound, and drivers must race on the tyres they use for qualifying unless the weather changes to or from rain tyres. Treating tyres with traction compound is prohibited. The one-piece, 10x15in steel wheels must weigh at least 20lbs each.

Modifications to the body and chassis are not allowed, though rear spoiler heights and angles differ depending on the age of the car and the experience of the driver in GT-A

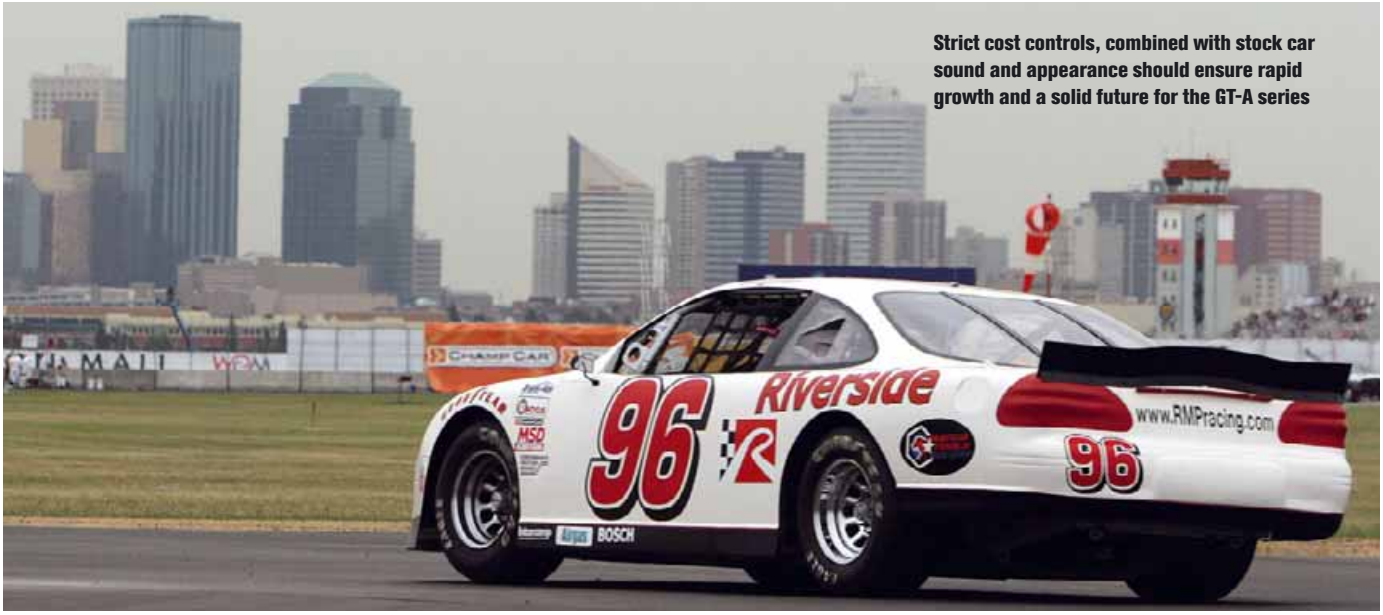
Brakes and shocks are an area of some freedom, but with cost caps and series approval required for parts. Brakes must employ cast iron rotors of 12 3/16th in diameter and 1 3/8in thickness, and calipers must be available at a retail price of $550 (£315) or less. Approved calipers include the Outlaw Disc Brakes 4000 series, Sierra Racing Products Grand National, Coleman Machine Series 4, Wilwood Engineering Superlite III, AP Racing (several), and The Brake Man Inc. F4-Tornado. Until recently, only four-piston calipers have made the approved list, but the drop in price of six-piston calipers is seeing them now added as well. Any type of brake pads may be used, brake fluid re-circulators are permitted and a brake pressure ignition cut-off switch is recommended for safety in the event of brake failure.

> **"YOU PUT ONE SET-UP UNDER IT AND IT IS GOOD TO GO WHEREVER YOU RACE"**

Shock absorbers are similarly restricted, with a $250 (£145) price cap. Approved shocks currently include Koni 30 Series, Bilstein GN and GN2, and Pro Lite and AC models.

The cars are electronics-free zones, with only analogue instruments permitted and data acquisition prohibited during competition. Electronic lap timers are allowed though and, recognising that the cars will use data acquisition during testing, data sensors may remain on the car during races but the wiring must be removed.

While GT-A may have been 10 years in the making, these strict cost controls, combined with impressive stock car sound and appearance and newfound exposure through the Trans-Am series should ensure explosive growth in the class's popularity in the near future. RE



Strict cost controls, combined with stock car sound and appearance should ensure rapid growth and a solid future for the GT-A series

Hardware store

Choosing the hardware to run a 3D CAD system on is a daunting task for a racecar engineer. We try to demystify the process with some sound advice

Words	Charles Clarke
Photos	LAT

If you're having trouble telling your 'front side bus' from your 'torriodal interrupt controller' then the next few pages are for you. CAD is quite a computer intensive activity, which requires fast processors, fast disks and as much memory as you can afford, or as much as your models need (plus a bit). There are a lot of different kinds of computer hardware out there – not all of which is suitable for running today's sophisticated, mid-priced, 3D CAD software.

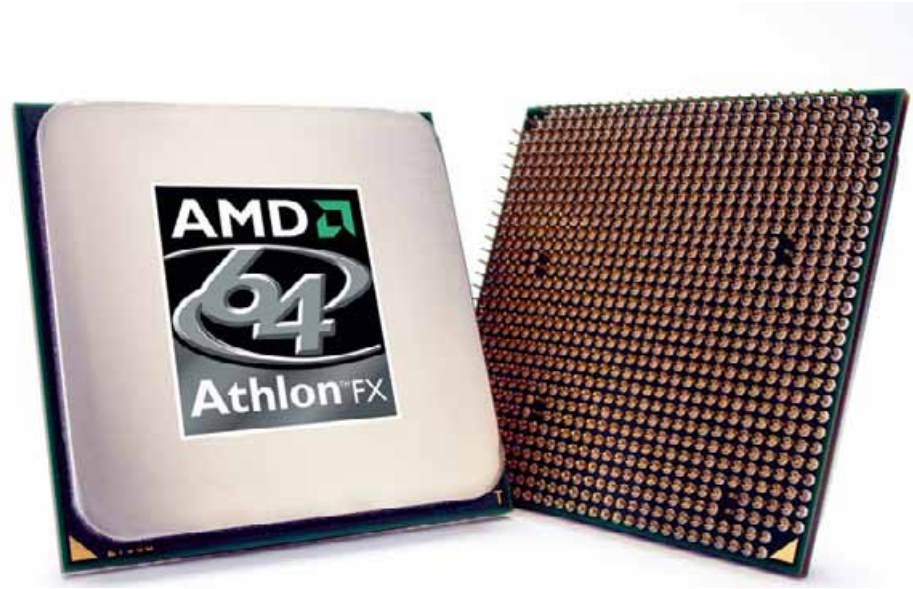
Microsoft Windows seems to be taking over the desktop, whilst UNIX is still regarded as very specialised and for the seriously computer literate only. If you are new to CAD/CAM here are a few pointers to help you choose your computer environment to make best use of your new software technology.

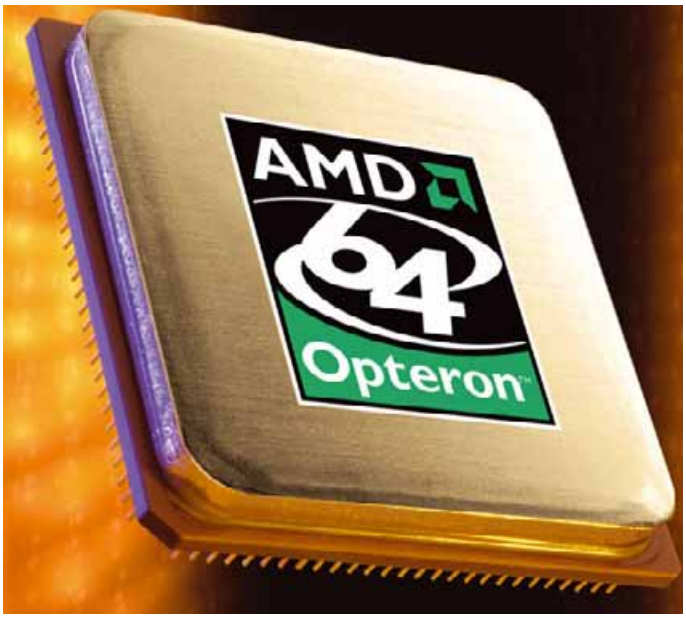
If you are still reading this, you are well on the way to achieving your first objective, which is to have a plan. Far too many IT screw-ups have been achieved by various departments and/or individuals 'doing their own thing' with little or no overall co-ordination by senior management. There is only one rule for formulating IT strategy and that is keep it simple – go back to first principles and decide what you are trying to achieve. In this preliminary analysis the language is the language of business not of computers.

Nigel Hobden, CEO of Random Computing, HP's leading technical systems integrator and long term IT provider to many racing teams, identifies the 'stable computing platform' as the main objective of the IT strategy. 'The stable computing platform maximises the business benefits of the IT system for the company,' says Hobden. 'All too often the IT strategy starts with the hardware and the rest of the specification is worked up from there. The stable computing platform reverses this approach – it starts with the users and maximises their productivity to develop an optimum IT solution for the company.'

> **"THERE IS ONLY ONE RULE FOR FORMULATING IT STRATEGY AND THAT IS KEEP IT SIMPLE"**

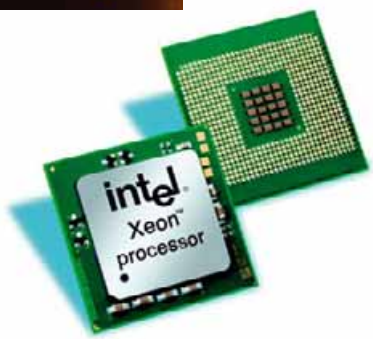
One of the problems with talented engineers is that far too often they don't examine the cost benefits of what they do before they do it – whether it be fixing the office stapler (because they can) or doing a DIY job on designing the





If you are forced to run Windows for CAD work then you can use 64-bit Windows XP, designed to run on a processor like one of AMD's 64-bit offerings

Having plenty of cache is imperative to successful CAD work. Processors such as Intel's Xeon offer plenty but they are expensive



computer infrastructure for their business.

And one of the real downsides of the Windows environment is that Microsoft has simplified 90 per cent of it to the extent that moderately computer literate professionals can get by. When you are contemplating a sophisticated software and hardware installation you will need professional help at some stage so it's better to find and nurture a relationship from the outset. The last thing you need, when you're up against a deadline, is trying to do complicated DIY hardware support in unfamiliar territory.

If you don't understand the technology, get help – it can cost you more in terms of wasted learning time than it will to get good advice from computing professionals who are fully up to speed with current technologies.

Since about 1995, the fact that you used Microsoft products for office or back office applications was given as a good reason for selecting Microsoft hosted CAD systems. A discussion of the rights and wrongs of Microsoft operating systems and applications would take more than the space available here, but suffice to say the greatest impediment in a Microsoft environment is the fact that it is always changing – every 18 months or less – potentially creating the opposite of the stable computing platform. This is the Microsoft business model – keep changing the system and keep the punters dipping into their pockets. This might be excusable for applications, but for operating systems? No sooner had you sorted out the mess of Windows NT and opted for Windows 2000 when Windows XP comes along. This is why Microsoft is putting $1 billion in the bank every month.

Traditionally, UNIX has been 'premium priced', although this is now changing rapidly. For this price though you get a very stable platform where there is no conflict between the hardware and the software. And the added value of only one vendor responsible for everything hardware related.

Another overlooked benefit of UNIX is that it is considered 'unfriendly' – meaning the system is left alone to do its job: users come in, log on, do their work, log off and go home. This should not necessarily be seen as a disadvantage for maximum business performance.

64-bit Windows

At the moment the issue of 64-bit Windows is only really relevant for those users doing serious number crunching, like users of FEA (Finite Element Analysis) or CFD (Computational Fluid Dynamics) software. As yet, many of the CAD vendors haven't really expressed any interest in developing 64-bit versions of their code.

One of the primary benefits of 64-bit Windows is that it will allow you to address more than 2GB of memory per application. While some CAD users are happy to chug away on modest hardware, there are many others that continually push the limits of current workstation technology. Hardware upgrades and driver optimisations can provide a much needed performance boost, but when your model/assembly files get complex you will eventually bump up against the 2GB per application ceiling imposed by Windows. When this happens, no matter how much physical or virtual memory you have in your workstation, the system will grind to a halt.

One way to overcome this is to turn on the /3GB switch in Windows XP. The extra gigabyte should give you 50 per cent more headroom for loading complex models, though this depends on the individual CAD application's support for extended memory.

There are several choices for those who want to model whole cars or entire planes. 64-bit UNIX is one obvious answer, but for those firmly entrenched in the Windows camp, 64-bit Windows XP could provide the perfect solution. Windows XP Professional x64 Edition is designed to run on the 'extended' architectures of AMD's Opteron with AMD64 and with EM64T on Intel's Xeon (codenamed Nocona) and the new Pentium 4 chips.

However, there are a number of limitations and misconceptions about 64-bit Windows, not least of which the fact that it's not going to give users the memory they think it will. In that a 32-bit application, even running on the 64-bit operating system, is still only going to be able to address whatever it was written to address in the first place. So if the application can only address 2GB of memory it will still only address 2GB – it will know nothing of the /3GB switch which extends the reach of some 32-bit applications. You will not be able to address all 4GB unless the application is specifically written to enable you to do that.

The other disappointing issue is related to →

the new Intel 945 chipsets still only supporting 4GB of memory, whatever the operating system (32 or 64 bit) because the processor hardware cannot address any more. There is conflicting information coming from Intel, some of which suggests that the new chipsets can extend their hardware address space beyond 4GB so that applications can see more memory, but this is not confirmed to date.

CPU/motherboard

Many of the components in workstations are used in normal PCs, but there are differences that can increase performance or, more importantly, reliability. All CAD applications put a large load onto the CPU so it is one of the most important aspects of any workstation.

Because of differences in modern chip design it is no longer possible to compare processor speed by using the old MHz or clock speed number. AMD introduced a performance measuring system that could be compared to Intel's MHz rating. So an AMD Athlon XP 2400+ ran at a true speed of 2.0GHz but gave the performance of a 2.4GHz Intel chip in AMD's eyes. In its next range of CPUs, Intel is changing its naming structure in a similar way to AMD, so a Celeron 2.8GHz (don't use this chip for CAD) will be called 335 whereas a 2.8GHz P4 will be called a 520. Confusing isn't it?

A popular 64-bit processor from AMD is the Opteron. This is a little faster in some areas than the Intel P4 when using 32-bit Windows. 64-bit Windows will improve things further but the real performance gain will come from real CAD applications written for 64-bit hardware and operating systems.

All the workstation providers should test their solutions with the relevant software packages – this is the peace of mind you are paying for. Beware of hardware solutions from providers whose major business is in other areas ie home PCs, gaming etc. These providers will fix problems for their major users but not for a small number of CAD customers.

Dual Core

Dual core systems are where two CPUs are connected together on a single chip or die, giving workstations improved multi-tasking and/or multi-processing capabilities. They appear to the operating system as two CPUs even though there is only one physical chip.

To make CPUs go faster the chip makers have been reducing the size of the transistors on the silicon. At this small scale these high-speed chips get very hot. Dual core provides a way of getting increased performance at relatively modest clock speeds (and hence heat levels). This has led to Intel cancelling the P4 4GHz programme and a scramble between AMD and Intel to launch dual core early. All dual cores support 64-bit software.

The main objective of IT strategy is a stable computing platform. If you are planning CAD work, your platform should be devoted solely to that use

PCI Express

Big changes are happening at the moment with motherboards. PCI Express is being launched by the big players, led by Intel. This is a new card slot type that will replace AGP (Advanced Graphics Port) and PCI, with a new serial interface. As clock speeds increase, this method becomes more reliable and gives greater bandwidth to devices like graphics cards. PCI Express not only offers performance, but power management and hot swapping capability, too. For most of the graphics cards you don't need to plug in extra power leads as up to 75w is supplied by the PCI Express slot.

"BUY STANDARD HARDWARE SUPPORTED BY AN ESTABLISHED VENDOR"

Graphics

Graphics cards are an important workstation component and careful consideration needs to be given to which one suits your application best as costs and performance can vary widely.

There are three main players in the market today: ATI with its FireGL range; Nvidia with its Quadro range; and 3Dlabs with its VP and Realizm product families. Each has a slightly different strategy but they all provide specialist drivers, which are required by all professional applications.

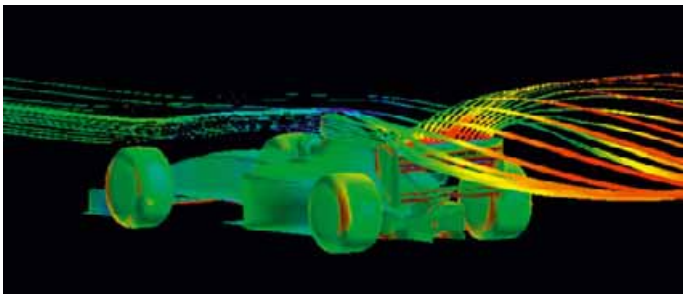
Most current 3D applications (and some 2D) use either OpenGL or DirectX to display geometry on the screen. OpenGL and DirectX are graphics libraries that applications (CAD etc.) use to display geometry on the screen. Some applications create their own interface but these generally rely on more CPU power to get the job done. This can result in poor performance on larger models as the CPU struggles to keep up with several tasks at once. →

Times have changed
with Bosch Laptrigger HF24

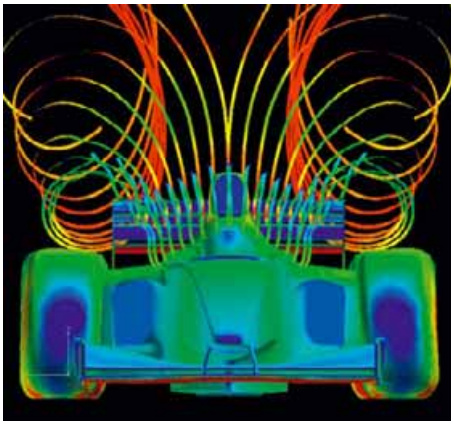
Exact measurement with the Bosch Laptrigger HF24
What makes our Laptrigger so special? This question can not be answered easily in a few words. Maybe we start with the military proofed direction finding principle. It´s unique and besides world-wide approved! The Laptrigger has a very high stability against interferance and a low power consumption. These are only a few advantages of many! More information is available on our homepage **www.bosch-motorsport.com**

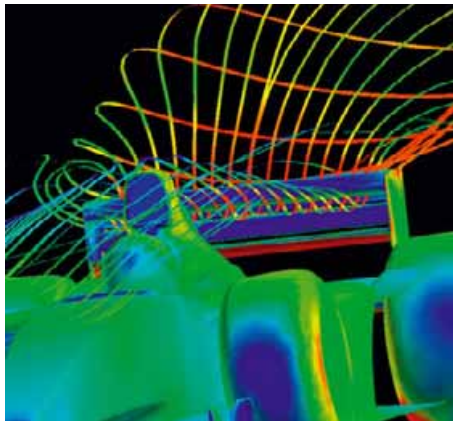
BOSCH
Invented for life

"BUY THE BEST PRICE PERFORMANCE YOU CAN TODAY OR YOU WILL ALWAYS BE WAITING"



Complex CAD and CFD work requires the right choice of hardware to function effectively. The better the IT strategy, the better the working environment will be





Consumer vs professional

Both consumer and professional cards support OpenGL and DirectX. The main difference is the driver. If you are using a 3D application that supports OpenGL, there could be a list of 20 supported commands with a standard card, but with a 'workstation' card there could be many more. This will transfer graphics processing to the graphics card and free up the CPU for its main number crunching task. It's not only about the supported commands but the performance of each of these commands is optimised against the standard consumer cards. Cards such as ATI's Radeon or Nvidia's GeForce range are designed for standard graphics or games that don't necessarily need the same degree of accuracy.

Improving performance

Even the most basic workstation graphics cards can rotate part models or simple assemblies at some speed. A card higher up the range won't rotate these any faster but, as the models get bigger in size with more component parts, it will maintain the high performance level where an inferior card will stall.

The amount of RAM on the card is an important criterion when buying a graphics card but it's only part of the solution. The most important hardware consideration is the GPU (Graphics Processing Unit), then the software driver to exploit it. Most drivers actually put the OpenGL display list into system RAM, taking it away from the application. If you use a lot of textures you will need a card that has a lot of on board RAM but that is generally only required for rendering (ie producing photo-quality images of CAD models) rather than typical CAD operations.

Different cards suit different needs and separate applications place distinct requirements on the card. If you model small assemblies with a solid modeller, a quality card that supports your application will suffice. If you are using a surface modeller and creating complex car body surfaces you need a high-end card that will give you the image quality you require.

The way to improve graphics quality is to turn on 'anti aliasing'. This is where the graphics card fills in the 'jaggies' – the little steps on the edge of diagonal objects. You can turn this on in applications or force it on in most display drivers. Anti-aliasing takes extra processing so it can slow down rotation in many applications but, if ultimate quality is needed, this is the way to go.

Drivers

It is important to use the right driver and settings. All graphic card vendors update their drivers regularly. Sometimes they get it wrong though and by fixing one thing in one application they adversely affect another. Take advice as to which driver works best with which application. Don't put the most recent driver on until you have confirmation that it works properly.

Memory

As a general rule, because RAM is affordable these days, start with at least 1GB for CAD. As most workstations have four memory slots, start by putting two 512Mb modules and keep two free for future upgrades. Matching RAM chips can be tricky. Timing in memory is measured in nano seconds so matching memory modules is important. Get it mixed up and you may well see a lot of blue screens or, at best, just fail to see →

the expected performance benefits.

High performance RAM (CAS2 low latency which takes less clock cycles to access) might give you advantages for overclocking your system (running faster than spec) but it makes a small difference in a standard system. The extra money it costs is better spent in other areas.

Cache

Cache is very fast RAM built into the processor. It is designed to store recently accessed data and supply it faster than going to the main memory. The cache principle is used on hard disks by having RAM on the drive to supply data faster than going to the disks themselves. Different processors have larger or smaller caches. Celerons generally have very small caches to limit the performance at the budget end. You need cache as CAD applications tend to swap data to memory quite frequently. Intel Xeons and other specialist chips offer more cache, but the benefits are often quite marginal and they are expensive.

What to buy?

The best advice currently for high-end applications is to go for the dual Xeon chipset. If you're working on moderate size models then you could stay with 925 XE chipsets – these are 64-bit ready, they will support the 64-bit operating system and when the 64-bit applications come along they will run happily on these workstations.

Dos and don'ts

Today we face a dilemma – Microsoft is everywhere and most of the best affordable CAD software runs under Microsoft Windows, which is not renowned for its reliability. The message is simple: the CAD software and the computer it runs on are just part of a race engineer's toolset and as such must be treated with the same care as your other tools. So just as you would never think of using a nut gun without an oiler, once you have your software running to your liking, you should never mess with the configuration. That means not loading new 'freebee' software when you get the chance – every time you load something new, different versions of the same system files can get loaded inadvertently, which can affect the way your existing software works. In short, when it's loaded and working don't mess with it.

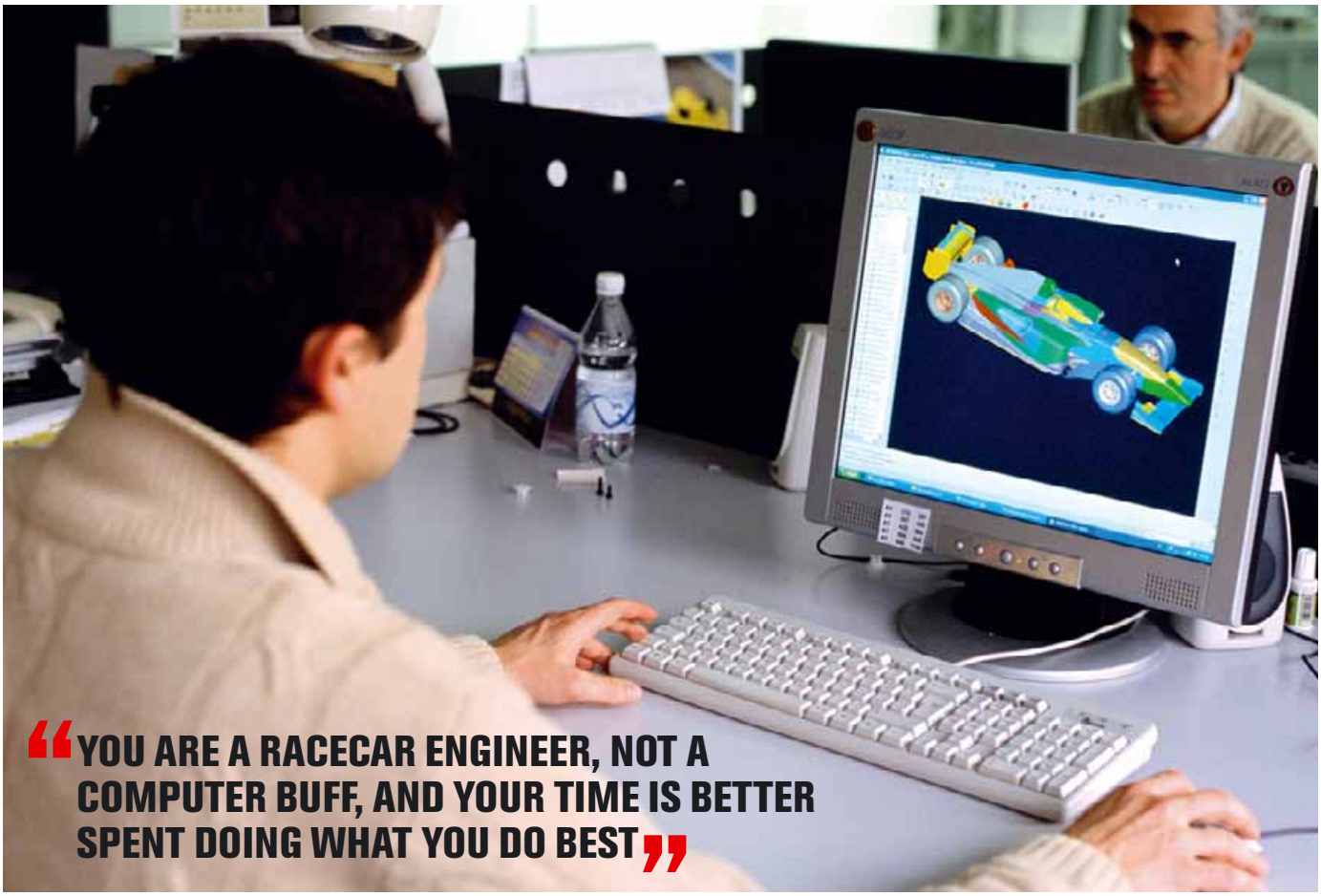
Also don't surf the web using critical engineering hardware. Software firewalls slow things down and, no matter how good your security is, clever programmers from 'undesirable' sites will always get through. Hackers can get into NASA and the Pentagon so no individual system is 100 per cent secure. If you're not connected to the web you don't need persistent (always on) anti-virus software – it is unnecessary for engineering computers and it slows things down.

Avoid DIY hardware projects, too. You are a racecar engineer, not a computer buff, and your time is better spent doing what you do best. Buy standard hardware supported by an established vendor. If possible choose a vendor that will help you out and has a track record supporting motorsport companies. Find someone to have a direct commercial relationship with. If you have to buy from the web and rely on telephone or email support, understand how this can adversely affect your business. Do not believe any of the marketing hype and challenge every claim.

Summary

The recurring question is 'shall I wait to buy this or that new technology or shall I buy now?' The answer to that dilemma is simple – buy the best price performance you can today or you will always be waiting. And don't be afraid to get help. Engineers traditionally think they can fix anything, but in trying to do a DIY job on IT strategy you are taking valuable technical resources away from your core activity.

And as much as you think you or your organisation knows about computer infrastructure and technical software there are experts out there that can make a significant contribution to your plans in short order. You don't make business-changing decisions without consulting your bank manager or your accountants, so making important decisions about your IT infrastructure and your design environment deserve the same consideration. RE



XTRAC

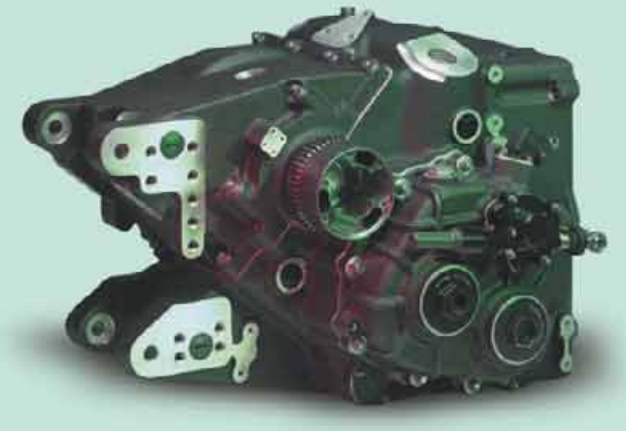
MOTORSPORT TRANSMISSIONS

XTRAC

MOTORSPORT TRANSMISSIONS

THE WORLD'S BEST SPORTSCAR GEARBOX IS NOW EVEN BETTER

Not content with the success of four Le Mans victories, Xtrac have now taken the design of their '229' series gearbox and improved it even further. Fully maximising the latest Le Mans floor regulations the '529' series retains all of the '229's proven reliability qualities whilst being lighter and even more efficient.



For more information on the new Xtrac '529' Gearbox, contact **Cliff Hawkins**
Tel: +44 (0)1635 293 841 Email: cliff_hawkins@xtrac.com

Xtrac Limited, Gables Way, Kennet Park, Thatcham, Berkshire RG19 4ZA, England
Tel: +44 (0)1635 293 800 Fax: +44 (0)1635 293 700 Web: www.xtrac.com

Quality • Performance • Reliability

The cogs of war

Racecar talks to the three leading gearbox suppliers to find out how they built sportscar transmissions to cope with the challenge of Le Mans

Words	Simon McBeath
Photos	Hewland; Ricardo; Xtrac

In any sphere of competition, whether it involves a four-second blast down a quarter mile drag strip or 24 hours pounding the long straights, sweeping curves and chicanes of La Sarthe, the right balance between performance, durability and, in today's economic climate, cost has to be struck. For Le Mans, straightforward, robust design is employed to achieve reliability and avoid undue expense. Racecar Engineering spoke with Hewland, Ricardo and Xtrac to get each company's perspective on the gruelling demands of Le Mans, and to see what they were offering for this specialised race.

Hewland Engineering

The technical challenge imposed by the 24 Heures du Mans, according to managing director William Hewland, 'is not really different to anything else. It's harder to keep an eye on wear, or to maintain the gearbox compared to the same duration in three races for example. So you have to be able to fit and forget because if something does go wrong you get stranded. But we fully support the decision to not allow complete transmission changes during the race – what's the point in being able to do that?

'The challenge is about high power and long life. At Le Mans there's a lot of time spent at high speed, which puts demands on transmission cooling, but at high speeds there's also low torque through the transmission so there is less stress. The Le Mans lap is not really very stressful. Sebring is bumpier, and therefore tougher on the transmission, but Le Mans does create some special needs.'

> "FOR LE MANS, STRAIGHTFORWARD, ROBUST DESIGN IS EMPLOYED TO ACHIEVE RELIABILITY"

Hewland continued: 'the 'box needs to run cool, especially in a magnesium casing, to give the bearings a chance to stay in place. We aim for 100degC [oil temperature] or lower. This also helps to avoid tempering the gear tooth flanks. The oil system also needs to de-aerate and filter the oil thoroughly, too.

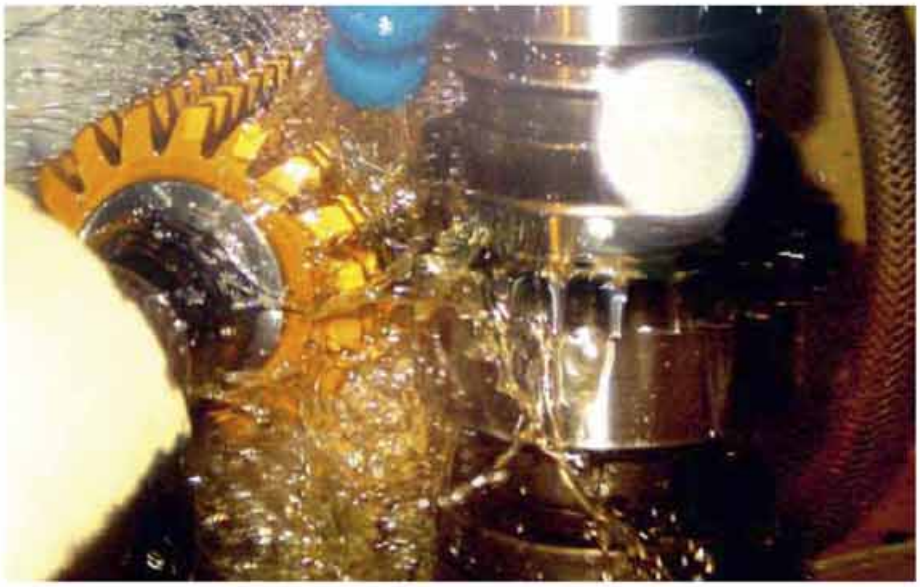
Design director Andy Scott adds: 'greater oil capacity is used [than in other transmissions], and decent filtration, plus a few more magnets [to pick up fine steel debris] are useful.'

The Hewland approach to overall design is to aim for a 24-hour plus life, but if a customer only wants a transmission to last a few hours then components can be 'designed down' to suit. Gears, tooth mesh design, bearings and even face dogs are all 'sized' for the life the customer specifies, which clearly for Le Mans is the duration of qualifying and the race.

The most common wear problem at Le Mans, according to Hewland, is face dog wear. 'The drivers can be something of a variable,' he states diplomatically. 'Our gear cluster life is always very good in all our products. But however good the components are, the driver is a variable, and just one... less skilful driver in a team can wear dogs rapidly. And it's often impossible to pin down which driver in a team is responsible.

'This is why a properly mapped semi-automatic system is such a big help (a poorly mapped one can give just as many problems). Our standard SE selection mechanism, which is relatively very strong compared to others and utilises less moving parts, is very tolerant of light damage. It requires about two thirds of the power to operate that other shift mechanisms need, and has been in every new transmission since the FTR (used in Formula 3 and Formula BMW, among others) was launched. The fact that exactly the same system is installed in our top of the range 'boxes as well as the FTR is testimony to its wide applicability,' asserted Andy Scott.

Impecunious privateers and smaller manufacturer teams make up Hewland's Le Mans clientele. 'Money is tight and this limits the technology that can be used. Our customers at Le Mans, which is not currently our biggest market by a long way, are all of the "what have you got?" type, unlike most of our business now; 80 per cent of our turnover is from bespoke transmissions, not off-the-shelf units,' states Hewland. The LMP2 Courage C65s will be running Hewland's six-speed sequential, transverse TLS transmission this year (as will Lister in LMES events), while any Lolas present will be using the



Machining gears at the Hewland factory in Berkshire where most of the work is bespoke manufacturing

Reliability is crucial at Le Mans, particularly now that gearboxes cannot be changed during the race

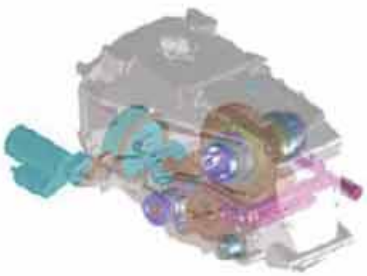
jointly produced unit for which Hewland supplies the internals to fit Lola's layout in its own casing. However, William Hewland expressed a preference to supply the whole transmission system 'from the engine to the wheels, that way we can guarantee the system for 24 hours or we fix it so it will do that.'

The TLS gearbox has been made in eight different versions, each tailored to specific customer installation requirements but with almost identical layout and internals. The main case is always one-piece (no split line across the differential), offering a stiff structure, but the three-shaft layout and options on case design make for flexible applicability. The shafts can be positioned for the required input and output heights, while a constant running input bevel gear in a choice of ratios enables the speed of the gearbox internals to suit maximum engine speeds from 6000 to 12,000rpm. TLS has been used in front engined, remote rear transmission set-ups in GT cars, with an integral bellhousing that incorporates the oil tank, through to short casings mated to mid-located engines in LMP examples. Hewland believes that with this flexibility and its proven internals, TLS can provide a tailor-made solution for many applications. It also meets the new underbody dimension regulations.

Hewland still offers its earlier LSG-A transmission – a longitudinal, six-speed sequential or H-gate unit with the gear cluster ahead of the driveline, as used by the Courage →

"AT HIGH SPEEDS THERE'S ALSO LOW TORQUE THROUGH THE TRANSMISSION SO THERE IS LESS STRESS"

Hewland's TLS sportscar gearbox



C52 Peugeot that finished fourth at Le Mans in 2000, but the company has found customers keener to run transverse units these days.

Xtrac

The views of Xtrac's development director Cliff Hawkins and technical director Adrian Moore on the challenges posed by Le Mans complement those of Hewland Engineering. While agreeing about the need to provide effective cooling, Xtrac also believes that the large number of gear changes, and the track sectors that incorporate chicanes followed by hard acceleration, both provide a fairly serious additional challenge.

The fundamental need to design a transmission that will last for 24 hours plus is supplemented by Adrian Moore's comment that 'the gearbox must also be repairable quickly, in order to minimise risk to our customers. Our 'boxes are a pretty solid, straightforward design that's not too heavy [72-76kg], with attention to detail in key areas.' Cliff Hawkins also remarked that 'it's increasingly important these days to use as many common parts [from across the product range] as possible to help contain costs.'

Like Hewland, Xtrac runs its transmissions cooler at Le Mans than anywhere else to aid durability. And it incorporates 'the biggest sump possible [within vehicle and rule constraints] so that the gears aren't running in the oil' – a measure to assist cooling and mechanical efficiency. Xtrac uses tri-lobe oil pumps that 'scavenge well, have a high capacity and can pump aerated oil efficiently.'

'The starter package is an important detail, too,' continued Hawkins. 'Because of the large number of starts [the rules requiring on-board starters to be used], some teams build in two starters so that should one fail there is always a back-up unit available.' Such a requirement obviously forms part of the original design of the bellhousing/adaptor situated between the engine and gearbox.

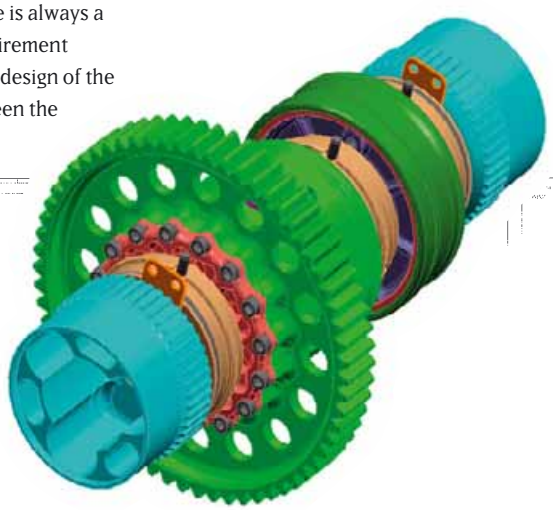
Several of the LMP1 cars will be running Xtrac's '229' transverse sequential gearbox this year. This design began life in the mid-1990s in McLaren F1 GTRs, using some of the key components from Xtrac's Ferrari F40 transmission of that period, and the Williams-assisted BMW used a variation of it in 1999. The '229' is essentially a customer version that has subsequently been used by →

Differentials

There are variations in the types and operating principles of the differentials provided by each of the main suppliers. Hewland reports that most Le Mans customers run the plate-type Salisbury differential, although there are wear issues with the friction material involved. Hewland design director Andy Scott reported that Hewland has tried different friction materials and also some 'springing' to retain consistent differential loads (and hence, consistent differential performance) whatever level of wear occurs. Hewland's diffs are adjustable from outside the car.

All Xtrac's Le Mans customers use its 'VCP' or viscous combined plate differential which, as the name implies, combines mechanical plate and viscous coupling operating principles. It offers differential tuning with both torque and speed sensitivity and, according to Adrian Moore, 'a very smooth locking action that's essential for endurance racing.'

Ricardo fits what it calls a visco-mechanical differential to its Le Mans gearboxes. The company's preference is to supply a combination that offers consistent characteristics over the 24-hour race – a difficult target to achieve. Some customers request adjustability but Ricardo Motorsport's chief designer Tim Gee commented that 'this can be a source of unreliability, by adding to complexity without a performance benefit that can be realised over the 24 hours.'



Above: Xtrac differential and (left) exploded diagram of the company's 229 transverse sportscar gearbox

Cadillac, Courage, Dallara, Dome, and Riley & Scott, while the Bentley endurance racers used a bespoke-cased version.

As with its other products, Xtrac uses its own grades of steel: X36C for most of the internals and vacuum re-melted XVAR1 for the high-loaded bevel gears, final drive sets and pinion. Casings are usually 'very cost/performance efficient' sand-cast RZ5 magnesium. Options are provided for suspension mounts through machining specific locations, while side covers are standard components to keep costs down. The bearings are 'conventional polyamide cage, taper roller bearings, though we look at angular contact bearings for improved efficiency, depending on the customer's requirements and the loads involved,' added Moore. The standard gear change is ratchet-operated sequential, with an H-gate option, and some customers use assisted changes such as the Megaline, which Xtrac says are not essential, but do give the face dogs and the driver an easier life. Assisted changes are also allowed in LMP2 now.

Xtrac supports the moves to create safer aerodynamics through technical regulation changes, but found that its 229 design was too wide to fit the specified dimensions of the rear underbody. So it has had to produce a new design for LMP in 2006 onwards. Although it thought this would bring to an end the use of the 229, Pratt & Miller tried it successfully in the GT1 Chevrolet Corvette C5 and it has been carried over to the C6. This may add yet another three years to this unit's long service record. However, 2005 is the last time that 229 will be used in LMP cars, and replacing it for 2006 is the unit designated 429.

With the 429, Xtrac has in essence turned largely the same set of internals from the transverse 229 through 90 degrees to make a narrow longitudinal 'box that fits the new underbody regulations yet retains the same length as the 229. In fact, the front face that mates to the engine is the same, the distance from the front face to the differential centreline is the same and the outputs are in the same locations, so the 429 will plug in where a 229 used to reside.

Xtrac's new longitudinal 429 'box uses the cluster from the 229 turned through 90 degrees

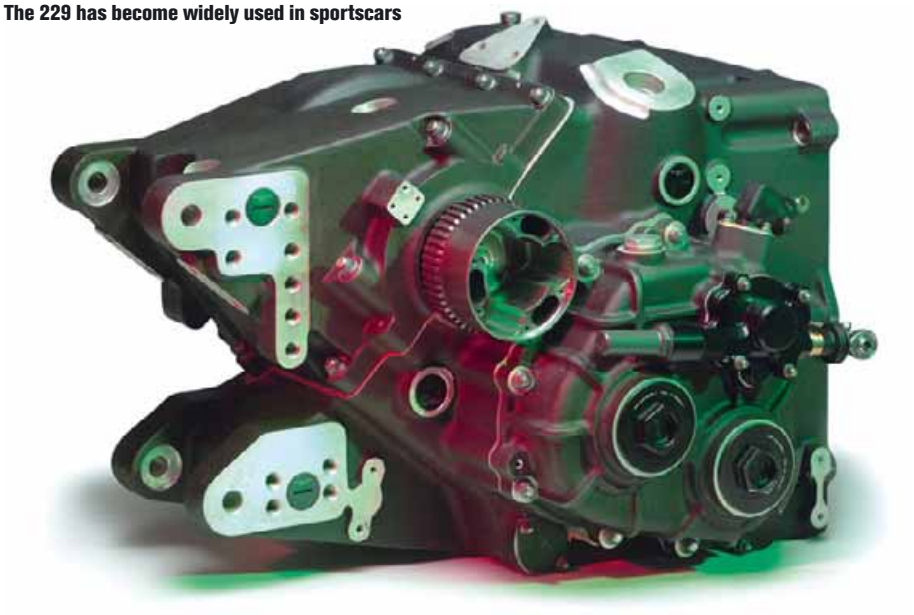
> **"A SPECIAL LE MANS OPTION IS RATIO GEARS WITH XTREM SUPER-POLISHED FINISH"**

Although the re-design was forced upon it, Xtrac did not miss the opportunity to incorporate some new features in the 429. The 'box incorporates an integral pneumatic cylinder to power an assisted gearchange mechanism (although a manual sequential change is still possible). Most interestingly, the layout comprises two pairs of drop gears that allow the torque and rpm into the gear cluster to be matched to the engine. So, for example, low rpm/high torque engines such as diesels can be accommodated, as can high rpm petrol/gasoline engines. Although the powertrain incorporates an extra pair of gears, being fully form-ground spur gears their efficiency is said to be very high, so power loss will be 'minimal'. The additional drop gears could be used to match the car's overall gearing to a given track. This arrangement is based heavily on Xtrac's Indy Racing League transmission, but sized to suit the particular demands of a sportscar.

The longitudinal layout enables access to the gear cluster from the rear without suspension disassembly and Xtrac has integrated the oil filter and pump into the cluster assembly so they are simultaneously replaced – a configuration used on its IRL gearbox. The 429 'box uses a combination of taper roller and angular contact bearings to achieve a balance between cost and efficiency. The RZ5 magnesium casing again offers options for suspension mounts.

Other features include a 'spectacle plate' between the two gear shafts to prevent flex, and low friction PTFE seals in the input and output flanges for minimum drag. A special Le Mans option is ratio gears with Xtrem super-polished finish, or as full form ground.

The 229 has become widely used in sportscars



Ricardo Motorsport

The recent record of Ricardo at Le Mans goes hand in hand with that of the Audis, and in 2004 that association netted first, second, third and fifth places. In 2005 Ricardo's longitudinal ➔

Worldwide distributor for many famous manufacturers. Discover our ranges of high performance engine parts and don't hesitate to contact us for further informations.

Visit our web site !!

JE Forged Pistons
Cars - Bikes

Forged Rods
SAENZ

Forged & Titanium
Valves MPI

Fasteners ARP

Camshafts
KENT CAMS

Forged Pistons
IASA

Throttle bodies
TWM

Headgaskets
COMETIC

Insulating Products
COOL-IT

Valves Springs
EIBACH

Pistons rings
NPR

JACQUEMIN TUNING
233, Avenue de La République
59110 La Madeleine
France
Tél: 00 33 [0]3 20 74 64 80
Fax: 00 33 [0]3 20 74 64 89
www.jacquemintuning.com

transmission was again seen in the winning Audi R8, while it also had a transverse design running in the Team Jota works Zytek and the Creation Autosportif DBA Judd. Next year a new LMP2 car from Zulltec will join the Ricardo ranks.

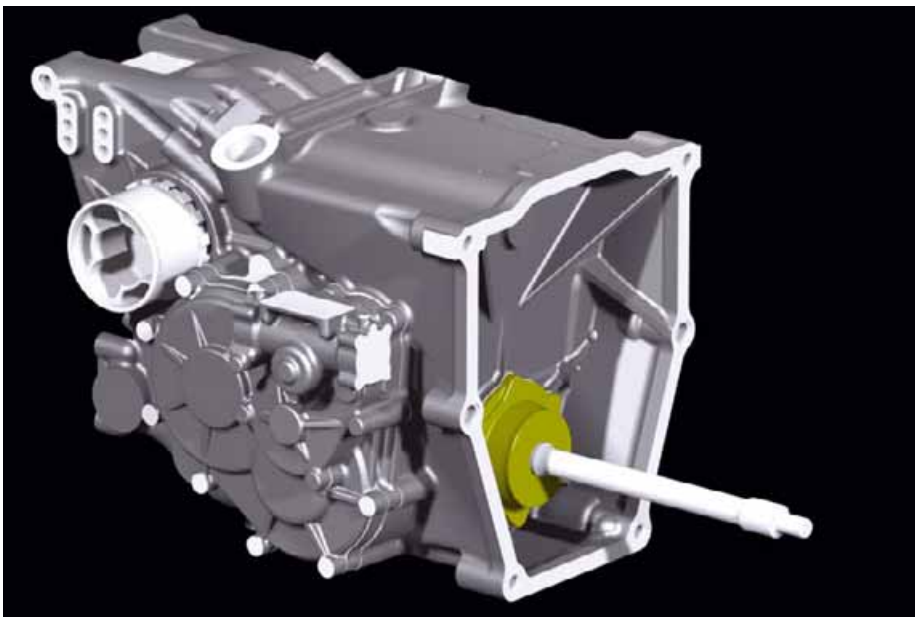
Ricardo's business development director Iain Wight and chief designer Tim Gee see the challenge of Le Mans mainly in terms of the fatigue requirements of the gearbox internals, but seem relaxed about the issue of temperature. 'We aim to not generate heat, and that means that tooth forms and bearings are important – details we seem to be good at. Other than that it's just a case of getting the oil cooler size right. We have a tiny oil pump (capacity is more important than pressure), there are baffle plates and anti-surge systems in the gearbox sump, and we had to give appropriate thought to the pick-up location. Maybe we got lucky, but it seems to work!' said a modest Tim Gee. 'It's easy to over-complicate, but our philosophy is to keep it simple. Minimising the number of parts generates less heat. And the bevel set in the Audi 'box helps with this.'

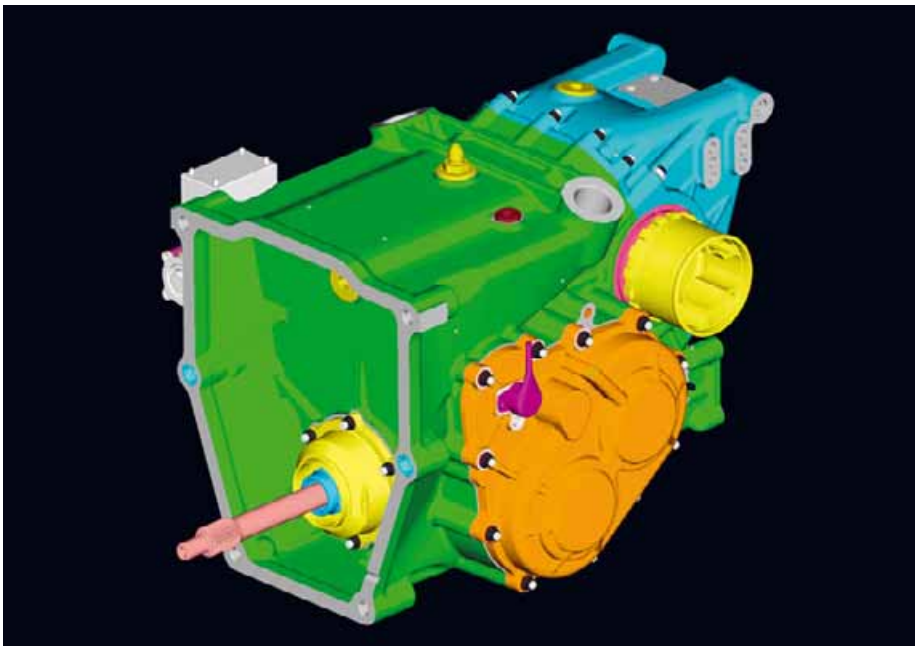
> **"THE CHALLENGE OF LE MANS [IS] MAINLY IN TERMS OF THE FATIGUE REQUIREMENTS OF THE GEARBOX INTERNALS"**

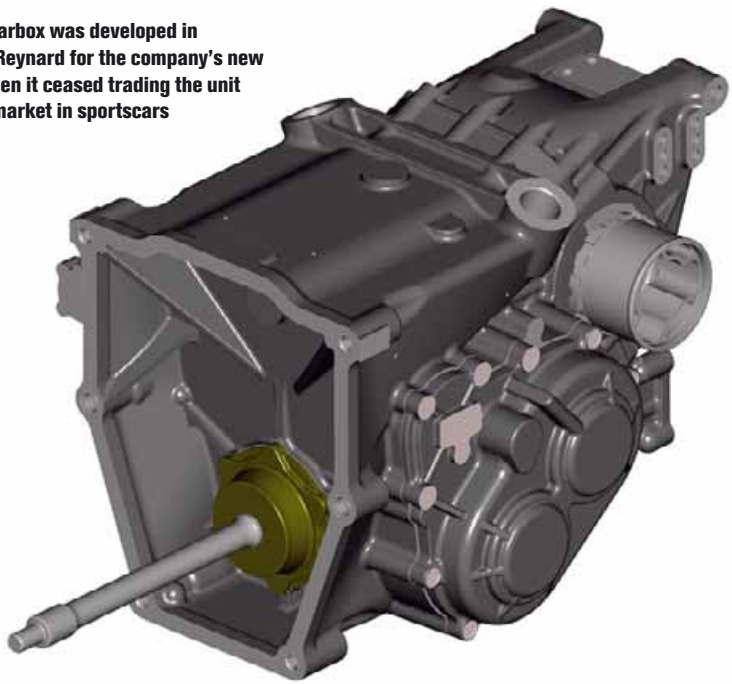
Iain Wight added that 'engaging with a manufacturer means invaluable data becomes available. With Audi we received information on torque output and such like that helped with the initial design. And the budgets allow for testing. You tend not to get that with private teams.' Like its rivals, Ricardo is happier now that transmissions must last the entire 24 hours of the race. As Iain Wight remarked, 'this puts significant emphasis on the transmission reliability but can also show how effective a well designed transmission can be.'

The Audi transmission design has remained essentially unchanged for six years now. In 1999 Audi made the casing and Ricardo supplied the internals, but for 2000 Ricardo did a complete re-design, saving around 15kg in the process. The layout is 'gears in front longitudinal', with the input shaft at the bottom driving up to the output shaft through the gears, and a bevel set turns the drive sideways before a spur gear set transfers drive directly up to the differential. The sequential shift barrel is located above the cluster, and is actuated by a direct acting pneumatic piston housed on top of the 'box.

Ricardo's casing was referred to as 'double skinned' because in effect it had separate casings to contain the gear cluster and carry the →







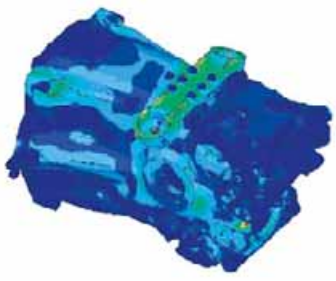
Ricardo's LMP gearbox was developed in association with Reynard for the company's new prototype, but when it ceased trading the unit found a broader market in sportscars

suspension. What is known as 'topology optimisation' was used to help define the casing shape 'though the shape is substantially defined by the components you have to accommodate,' said Tim Gee. 'Finite element analysis (FEA) was far more important in defining the casing detail.'

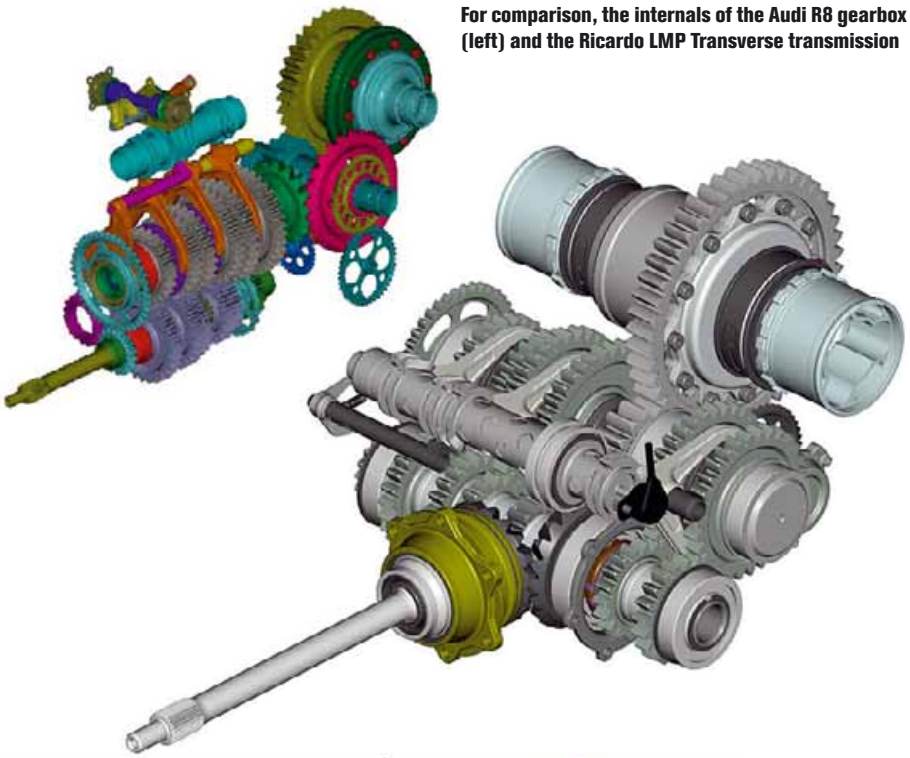
Ricardo's 'LMP transverse' transmission has an entirely separate ancestry. This unit was originally a bespoke design for the Reynard 02S, a car that metamorphosed into the Zytek and the DBA. The original design brief was to construct a transmission that would cater for different engines in different categories and different racing series. 'It was a complicated design,' commented Tim Gee. 'and we had to make two ranges of gears of different widths, different bevel gears and different differentials. But because of the design options its applications are very flexible. It can cater for an 11,000rpm V10 as well as a 7000rpm V8, with a semi-auto or a manual shift. It was meant to be the most reliable and lightest in class (it weighs just 58kg) and fits the new rules [on underbody space]. When Reynard shut down, development stopped for a while, but once the car ran again it became clear that the transmission didn't actually need any more development.'

The right side of the Ricardo Transverse and...

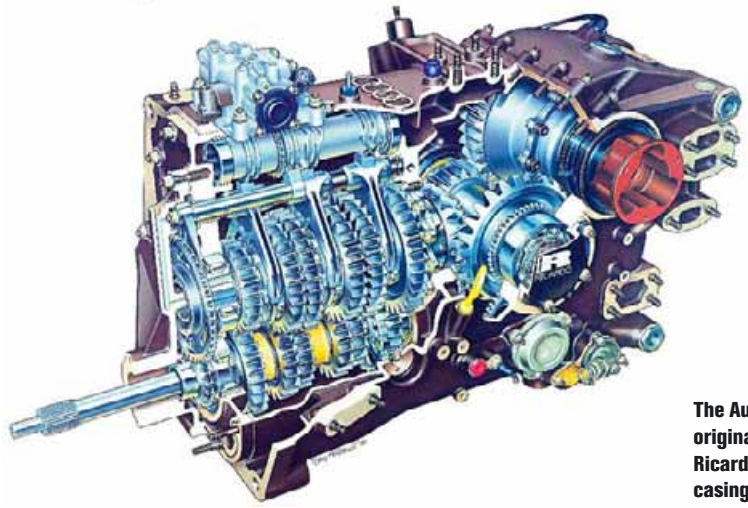
...the left side of the transmission



FEA study of the unit's casing under load



For comparison, the internals of the Audi R8 gearbox (left) and the Ricardo LMP Transverse transmission



The Audi transmission as originally used with Ricardo internals in a casing made by Audi

The sequential shift mechanism also features a direct acting piston on the selector barrel, as opposed to lever actuation, which provides an improved shift and neater packaging. Two types of assisted change system are in use, pneumatic (such as provided by Megaline) and electric, as designed and used by Zytek in 2004. This features a pair of solenoids, one each end of the selector barrel, and an energy storage system that enables the requisite power to be provided in the short time needed for a fast gearshift. The system is said to be lighter and simpler than the alternatives because there is no compressor, reservoir or filtration system required. There are however some fairly complex electrics and electronics.

> **"WE AIM TO NOT GENERATE HEAT"**

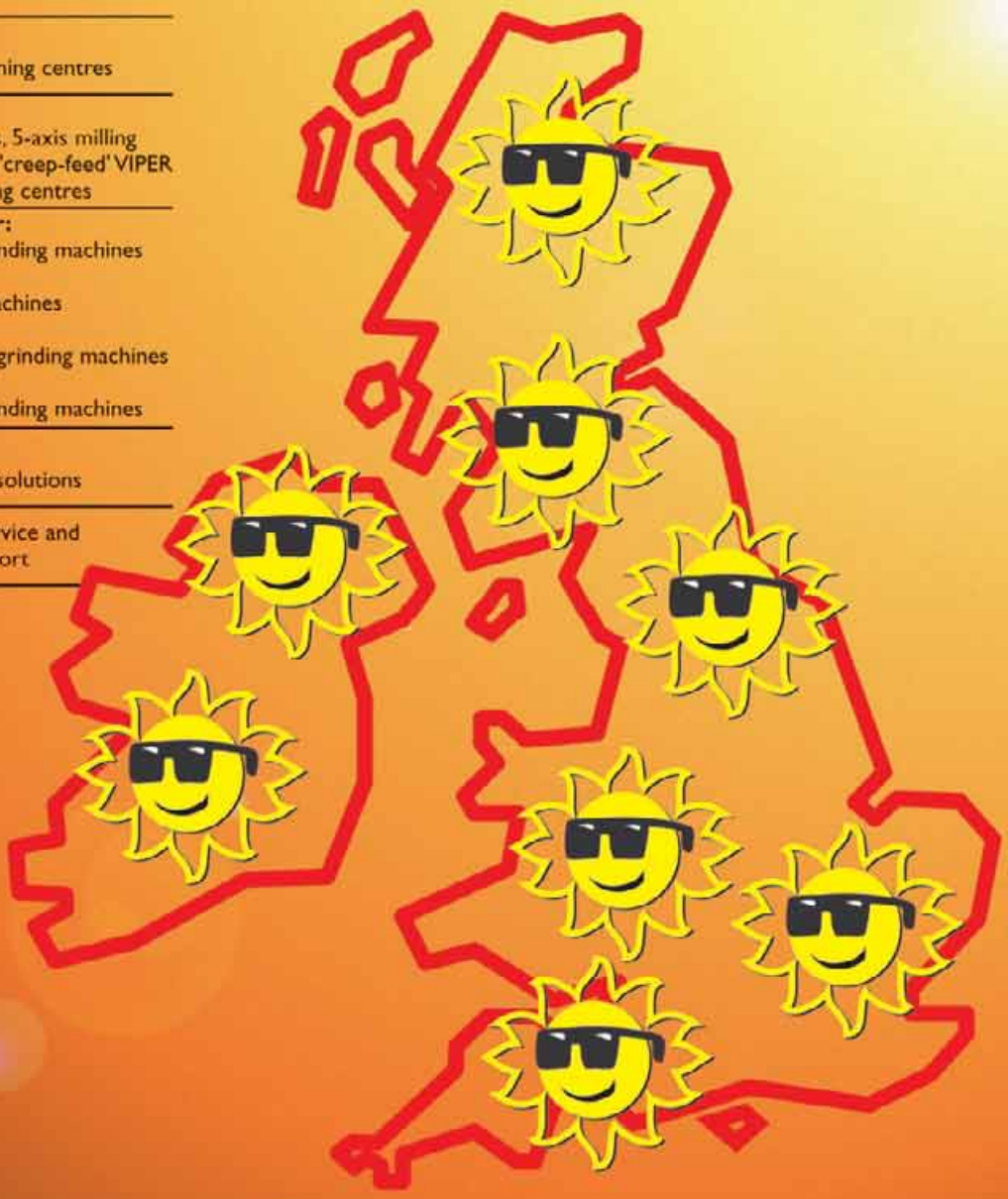
The selector mechanism on the LMP transverse 'box was influenced by that on the Audi. The barrel has been lightened, reducing inertia to help with fast shifts and avoid 'overrun' into a gear beyond the one selected. And aspects of the selector fork design have been carried over, too. 'The forks are sensitive to the driver and to ignition cut [in power shift systems] so it was better for us to stay with proven designs – it helps to be confident in those areas,' remarked Gee. Ricardo also utilised a refined version of the 'two pad' selector fork design, now apparently being copied by its rivals in the transmission market. It not only applies the load to the dog rings along the desired axis but also, by acting as springs, serves as a mechanical energy storage device that helps to make the shift occur when the dogs come into mesh.

With all the many factors taken into account then, the choice facing the Le Mans constructor of which gearbox to use is far from easy. RE

TURNING • MILLING • GRINDING • WORKHOLDING

Happy days are here again!

HOT	**Hardinge:** lathes and turning centres
HOT	**Bridgeport:** VMC's, HMC's, 5-axis milling machines and 'creep-feed' VIPER flexible grinding centres
HOT	**Kellenberger:** Cylindrical grinding machines **Hauser:** Jig grinding machines **Tripet:** CNC ID/OD grinding machines **Tschudin:** Cylindrical grinding machines
HOT	**Hardinge:** Workholding solutions
HOT	After-sales service and technical support



Expect more hot stuff in the months to come!

Phew! Over the last six months we've really turned the heat up on the competition. (It's no wonder they're getting hot under the collar!)

Our sales leads and enquiries are at an all time high. And orders for our comprehensive range of competitively-priced machine tools look set to break all records too!

In fact all of our forecasts predict a great year ahead for us... and for our customers.

EMO Hannover 14-21-9-2005

Hall 16, E05/C04 • Hall 11, D60/F61

OK - if you're not yet a Hardinge Bridgeport customer - you might be forgiven for thinking that all of this is a lot of hot air. But with our new, high-performance turning, milling and grinding machines - all ready to be launched at EMO in September - we reckon it's only a matter of time before you'll be hot-footing it to our Exeter or Leicester facilities to find out more.

To avoid the rush and get your manufacturing operation off to a blistering start this Autumn - call us on our hot line 01392 208181 and 0116 2869900 or visit our websites www.hardinge.co.uk and www.bpt.com where you'll find all the latest information (yes - you guessed it)... hot off the press!

Hardinge Machine Tools Ltd.
Silverton Road, Matford Park, Marsh Barton, Exeter, Devon, EX2 8NN
Tel: (0) 1392 208181 Fax: (0) 1392 208199
e-mail: sales@hardinge.co.uk

Leicester site - Hardinge Bridgeport, Whiteacres, Cambridge Road, Whetstone, Leicester LE8 6BD
Tel: (0) 116 2869900 Fax: (0) 116 2869901 e-mail: sales@bpt.com

HARDINGE Bridgeport

www.bpt.com • www.hardinge.co.uk

The International Journal

Racecar engineering

YES! I would like to subscribe to Racecar Engineering

Please tick whichever of the following applies to you:

- ☐ **USA $86.10 Save 30%**
- ☐ **UK (6-monthly Direct Debit) £18.90 Save 30%**
- ☐ **UK Annual £37.80 Save 30%**
- ☐ **Western Europe & Eire** (airmail) **€64.75 Save 30%**
- ☐ **Rest of World - £53.90 Save 30%**

Complete this coupon and send with your payment to:

UK: Racecar Engineering, IPC Subscriptions, FREEPOST CY1061, Haywards Heath, West Sussex, RH16 3BR (No stamp needed)

Overseas: Racecar Engineering, IPC Subscriptions, PO Box 272, Haywards Heath, West Sussex, RH16 3FS, UK (Please affix correct postage)

Your Details

Mr/Mrs/Ms/Miss: Forename:

Surname:

Address:

Country: Post/Zipcode:

Home Tel No.
(inc.country and area code)

If you would like to receive emails from Racecar Engineering and IPC containing news, special offers, product and service information and online research questionnaires, please include your email below.

Email:

Date of Birth: D D M M Y Y Y Y

Choose from 3 easy ways to pay

1. I enclose a cheque/International money order made payable to IPC Media Ltd., for the amount of £/€/$_____

2. Please debit my: ☐ Visa ☐ Mastercard ☐ Amex ☐ Switch/Maestro

Card No (Switch/Maestro)

Expiry date: _____ /_____ Card issue No (Switch/Maestro)

Signature: Date:
(I am over 18)

3. Pay by 6-monthly Direct Debit (UK only)

Instruction to your Bank or Building Society to pay by Direct Debit

For office use only. Originator's reference - 764 221

DIRECT Debit

A/C no

Name of Bank:

Address:

Postcode:

Account name:

Sort code: Account No:

Please pay IPC Media Ltd. Direct Debits from the account detailed on this instruction subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction may remain with IPC Media Ltd. and if so, details will be passed electronically to my Bank or Building Society.

Signature: Date:
(I am over 18)

All subscriptions will begin with the first available issue. Offer only available to new subscribers. **The offer closes 10th October 2005. For enquiries please call +44 (0)845 676 7778, fax +44 (0)1444 445599 or email: ipcsubs@qss-uk.com** Racecar Engineering, published by IPC Media Ltd (IPC), will collect your personal information to process your order. Racecar Engineering and IPC would like to contact you by post or telephone to promote and ask your opinion on our magazines and services. Please tick here if you prefer not to hear from us. ☐ IPC may occasionally pass your details to carefully selected organisations so they can contact you by telephone or post with regards to promoting and researching their products and services. Please tick here if you prefer not to be contacted. ☐

28A

SAV

Great benefits when you subscribe:

- **SAVE 30%**
- Direct delivery to your door every month – anywhere in the world
- Never miss an issue
- Money Back Guarantee on any unmailed issues
- No price increase during your initial subscription period
- Get all the latest industry news and views before the competition!

SUBSCRIPTION RATES

USA Save 30%	**$86.10**
UK (6 monthly Direct Debit) **Save 30%**	**£18.90**
UK Annual Save 30%	**£37.80**
Western Europe & Eire (airmail) **Save 30%**	**€64.75**
Rest of World Save 30%	**£53.90**

THE DIRECT DEBIT GUARANTEE

This Guarantee is offered by all Banks and Building Societies that take part in the Direct Debit Scheme. The efficiency and security of the Scheme is monitored and protected by your own Bank or Building Society. If the amounts to be paid or the payment dates change IPC Media Ltd. will notify you at least ten days in advance of your account being debited or as otherwise agreed. If an error is made by IPC Media Ltd. or your Bank or Building Society you are guaranteed a full and immediate refund from your branch of the amount paid. You can cancel a Direct Debit at any time by writing to your Bank or Building Society. Please also send a copy of the letter to us. Direct Debits can ONLY be paid through a Bank or Building Society. Your Direct Debit price will stay the same for 1 year from start date.

£30%

Subscribe today and stay one step ahead for only £3.15 an issue

For a faster service call the Order Hotline on:

+44 (0) 845 676 7778

Phone lines open 7 days, 9am to 9pm. Quote code: **28A** Please have your payment details ready when you call

or subscribe online at: www.racecar-engineering.com

Please note offers vary online

Why not download the digital edition straight to your PC?

Racecar Engineering, in partnership with Zinio, delivers a new and exciting digital magazine version of the world's leading technology publication for the motorsport industry. You get the same indispensable news, views and insight with additional powerful interactive features to enhance your reading experience – whether at your desk, at the airport or at the circuit.

For more information, to download a free sample or to sign up today, visit **www.racecar-engineering.com/content/zinio.htm**

RACECAR ENGINEERING BACK ISSUES

V14N12 VX Racing rear suspension – How LSDs affect handling – Brake dyno – WRC tyres – Honda ECU make-over

V15N1 BAR front torque transfer system – Spirit WL05 – WRC weight placement – Rover K-series myths exploded

V15N2 F1 gearbox trends – Lotus chassis software – Magnesium in motorsport – D-Sports – Autosport guide

V15N3 Designing uprights – Engine simulation – Historic motorsport – Show reports: PRI and Autosport Engineering

V15N4 F1 2005 launches – Race simulation software – CFD optimisation – Sport compact dragsters – Rally Raid

V15N5 Lola LMP2 prototype – Rotary dampers – Composite bonding – Engine balancing – Sporting trials – Dynamometers

V15N6 Chevy Lacetti WTC – NASCAR in 2005 – Radical profile – Zeroshift explained – Introduction to 3D CAD

V15N7 Aston Martin DBR9 – Dufournier tyre optimisation – Inside EuroBOSS – Aerodyn wind tunnel – Allard J2X

V15N8 Formula 3 2005 – Dave Richards interview – Le Mans technology – Lotus MSc – Motorsport wheels

V15N9 New wave prototypes – Per Eklund Rallycross SAAB – Lotus Sport Exige – Formula SAE 2005 – Ross Brawn on F1

BACK NUMBERS AND BINDERS PRICE LIST

For a full *Racecar Engineering* features index log on to our website at www.racecar-engineering.com. To obtain back issues fill in form below

BACK ISSUES AND BINDERS ORDER FORM

Complete this form, attach payment and send to:

RACECAR ENGINEERING BACK ISSUES DEPT,
John Denton Services, Unit 1, A1 Parkway, South Gate Way,
Orton South Gate, Peterborough, PE2 6YN, UK.
Tel: +44 (0)1733 370800 **Fax +44 (0)1733 239356**
www.mags-uk.com/ipc **Email: info@mags-uk.com**

☐ I would like.....binder(s) Total £.....
(see below for prices)

☐ I would like the following back issues

V.....N...., V.....N...., V.....N...., V.....N...., V.....N..... (check below for availability & prices)

Number of back issues..... Total £.....

Back issue prices

UK only (1st class mail)	£6.00
Europe (airmail)	£7.00
Rest of World (airmail)	£8.00

Binder prices

UK only (1st class mail)	£8.00
Europe (airmail)	£12.00
Rest of world (airmail)	£13.00

Availability

Note that editions not shown on this list are out of print: V11N4, V11N6, V11N7, V11N8, V11N9, V11N11, V11N12, V12N1, V12N2, V12N3, V12N4, V12N5, V12N6, V12N7, V12N8, V12N9, V12N10, V12N11, V12N12, V13N1, V13N2, V13N4, V13N5, V13N6, V13N7, V13N8, V13N9, V13N10, V13N11, V13N12, V14N1, V14N2, V14N3, V14N4, V14N5, V14N6, V14N7, V14N8, V14N9, V14N10, V14N11, V14N12, V15N1, V15N2, V15N3, V15N4, V15N5, V15N6, V15N7, V15N8, V15N9

Data protection: Racecar Engineering Magazine, published by IPC Media Ltd (IPC), will collect your personal information to process your order.

Would you like to receive emails from Racecar Engineering and IPC containing news, special offers and product and service information and take part in our magazine research via email? If yes, please tick here ☐. Racecar Engineering and IPC would like to contact you by post or by telephone to promote and ask your opinion on our magazines and services. Please tick here if you prefer not to hear from us ☐. IPC may occasionally pass your details to carefully selected organisations so they can contact you by telephone or post with regards to promoting and researching their products and services. Please tick here if you prefer not to be contacted ☐.

YOUR DETAILS

Title..... Initial..... Surname.....

Address.....

.....

.....

Postcode..... Country.....

Daytime tel..... Evening tel.....

Email.....

PAYMENT DETAILS

☐ I enclose a cheque for £..... made payable to IPC MEDIA LTD

☐ I wish to pay by:

☐ Mastercard ☐ Visa ☐ Amex
☐ Diners ☐ Delta ☐ Switch

Expiry date ☐☐☐☐ Switch card issue no: ☐☐

Card number ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Signature..... Date.....

ORLANDO

ONE MILLION SQUARE FEET

More New Racing Technology Than Anywhere On Earth

- **1,400 Exhibiting Companies**
- **3,900 Booths**
- **45,000 Buyers From 40 Countries**
- **Discover The Latest Advances In Motorsport Engineering**

18 ANNUAL Performance Racing Industry

DECEMBER 1–3, 2005

ORLANDO, FLORIDA • USA

Orange County Convention Center • North/South Building

FOR MORE INFORMATION

www.performanceracing.com

31706 South Coast Hwy

Laguna Beach, CA 92651-6974, USA

Tel: +1 949.499.5413 • Fax: +1 949.499.0410

Raceshop

Raceshop is a section of *Racecar Engineering* written for people who are in the process of designing, building or running racecars. Raceshop is designed to be interactive. We want you, our readers, to let us know about your company, your new products and your engineering problems. Raceshop can provide you with a showcase for your products or the answers to your engineering questions.

Send your details to those listed below for each of Raceshop's sections. You can either send material direct to the Leon House address on Page 5, or to the email addresses below…

Racegear: racecar@ipcmedia.com

Database: Tony Tobias
tony_tobias@ipcmedia.com

The Consultant: Mark Ortiz
markortiz@vnet.net

Aerobytes: Simon McBeath
via: racecar@ipcmedia.com

High impact

Repeatable crash testing is paramount to the future of motorsport. **Racecar** looks at the leading companies involved in this complex science in the UK

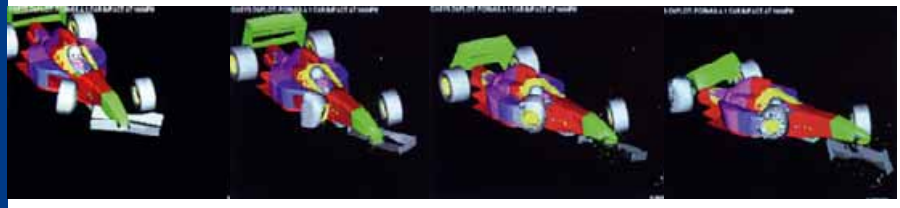
Words | Ian Wagstaff

MIRA's Richard Adams points out that motorsport crashworthiness development is philosophically different to passenger car development in one key aspect. The FIA approach relies on component level testing, rather than proving the racecar as a system, using a whole vehicle crash test.

MIRA is an FIA certified test house, whose role can involve far more than mandatory testing using its crash labs and impact sleds. When the FIA realised it needed to improve the safety of Formula 1 cars, Professor Sid Watkins and Charlie Whiting turned to MIRA to develop new safety rules.

"MIRA STATES IT IS THE ONLY COMPANY IN THE UK AUTHORISED BY THE FIA TO DESIGN AND CERTIFY ROLLCAGES"

MIRA's reverse accelerator (HYGE) gun delivered numerous crash pulses in the development programme – without the need to replace sacrificial components such as nose cones and pylons or damage the expensive tub. The outcome included revising the height of the cockpit sides, harness specification and mounting locations. Other HYGE applications include sports seat certification for rally, touring and sportscar racing. →



This series of images from MIRA depicts a simulated 100mph crash into a wall in an F1 car

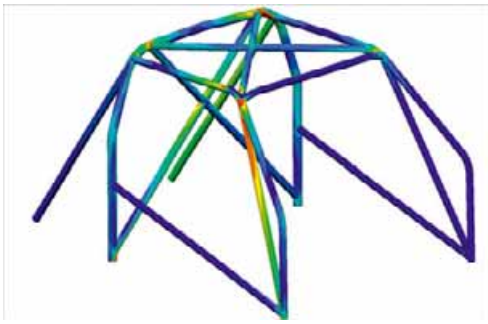
HYGE (reverse accelerator) test sequence

In passenger car safety testing, the driver is partially decelerated by the restraint system – supplemented by the airbag – to deliver a reduced *g* loading on the occupant. In racecars, airbags are obviously not required as the driver is securely strapped into the vehicle, thus preventing the head from impacting the steering wheel. More importantly, the driver is assumed to be decelerated at virtually the same rate as the vehicle. The load limiting nature of harnesses allows the belts to stretch and reduce this driver deceleration rate slightly.

For crashworthiness purposes, racecars can be easily split into two main styles: those with a purpose-built, composite structure and those that are derived from production cars. When considering production-based racecars such as touring cars, the sole FIA requirement is to test the structural properties of the rollcage. MIRA states it is the only company in the UK authorised by the FIA to design and certify rollcages by either FEA simulation or a physical crush test. This special dispensation has, says Adams, been awarded due to the consistently high degree of correlation between MIRA's simulation approach and its in-house validation facilities. MIRA is actively involved in the design and certification of rollcages for the British Touring Car Championship, FIA GT, WRC, Super 2000/1600 and Paris-Dakar.

In addition to offering superior dynamic handling characteristics the role of the 'cage is to prevent intrusion. No part of the 'cage is designed to crush in a controlled manner, instead the vehicles' original crush features are relied on. This is despite fundamental design changes in key areas necessitated by the desire to lower the centre of gravity, improve the powertrain cooling and deliver a radically different aerodynamic flow.

Composite single-seater and LMP1/LMP2 cars should be considered together as, if the wheel shroud is taken away from a prototype sports racer, you are left with the same nose cone and tub arrangement. With these cars, the composite tub is deliberately stiff to provide the safety cell – analogous to the rollcage in the production car environment. However, the expendable, crushable items such as the nose cone, rear pylon and side pods are required to pass simple component 'crash' tests in an attempt to provide the vehicle with a 'crumple zone'.



An FEA plot of a rollcage under torsional load. Red is high stress, blue is low stress

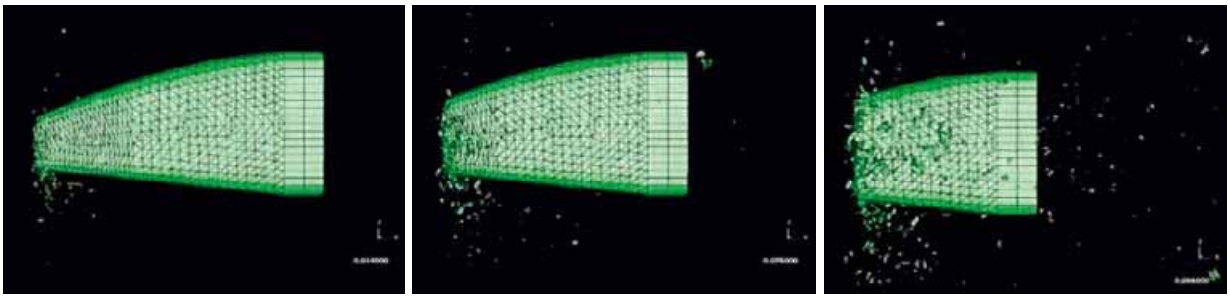
MIRA's F1 buck was constructed to undertake development work with the FIA on cockpit regulation changes

Like nosecones, rear pylons are designed to be expendable and are required to pass the same component crash tests

Despite success in modelling such impacts with an FEA solver, MIRA is required to perform physical crash tests on these components to certify them to FIA standards. This is traditionally conducted on one of MIRA's gravity sleds or the crash lab, depending on the application. In the case of nose cones and pylons, the component impacts the crash block at typically 60mph and the deceleration of the tub is measured. The best designs in motorsport satisfy simultaneous requirements. A well-designed nose/pylon cone is both aerodynamic in shape and conceived to collapse inwards, gradually increasing in area to deliver a controlled deceleration, where the pointed end acts as the initiator. The kinetic energy of the racecar is used to fracture the carbon layers. This is fundamentally different to the kinetic energy that goes into the bending transformation that occurs in the steel crumple zone of production cars.

Like MIRA, the Cranfield Impact Centre is certified for both static and dynamic FIA crash testing. According to manager testing section, Robin Butler, both static loaded tests and dynamic testing is carried out. TRL (Transport Research Laboratory), the former UK government agency, →

Nose cone impact sequence. The measure of a well designed nose cone is given away by the size of the carbon fragments left afterwards



> **"THE [MOTORSPORT] INDUSTRY IS LOOKING TO THIRD PARTY ORGANISATIONS FOR HELP SETTING PERFORMANCE PARAMETERS"**

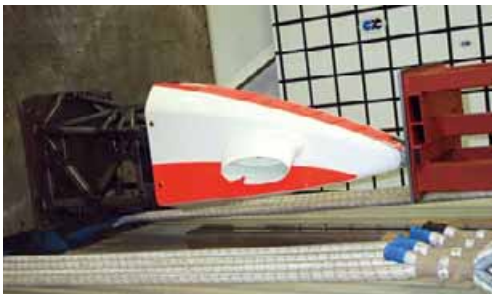
privatised nine years ago, offers similar work.

As with MIRA, several dynamic tests are offered by the CIC and TRL including the front impact test of nose or monocoque. At the CIC both are mounted on a sled and run into a solid wall at 14m per second with an impact mass of 780kg. TRL's Robert Flenley points to similar figures for his facility. The front impact test features a dummy occupant, the chest of which must not see more than 60*g* for three milliseconds. The monocoque will also have a full fuel load of, as Butler understandably points out, water. Flenley adds that TRL offers a double impact test for such as IRL where a car could well hit the barrier more than once. For the rear impact test, the gearbox is mounted onto the impact wall and the sled run into it at 12m per second, again with an impact mass of 780kg. Flenley indicates how different this is from conventional road car work, as EuroNCAP does not require a rear impact test. For the side impact test the sled is run into the vehicle at 10m per second. A fourth dynamic test at CIC concerns the steering column where a mass of 8kg strikes the steering wheel at 7m per second.

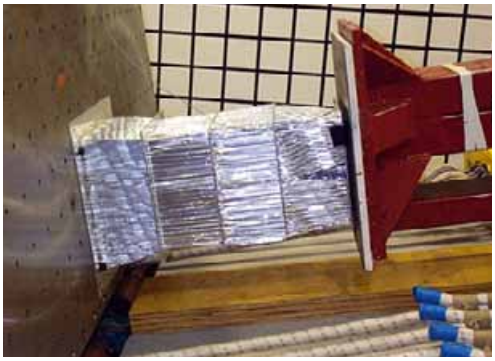
TRL also carries out a combination of seat impact tests including front, side and rear, as well as panel impact testing looking for side intrusion. It numbers F1, F3, LMES and IRL manufacturers amongst its customers.

CIC is wholly owned by Cranfield University. Through its industry-backed MSc in Motorsport Engineering and Management, Cranfield is developing postgraduate-level engineers who go onto careers with the likes of Williams, BAR, McLaren, Ferrari, Red Bull, Toyota, M-Sport and Prodrive. Students on the Masters programme have the opportunity to work on impact-related projects for their MSc thesis projects, and this year's Prodrive-supported group project investigated side impact systems for WRC cars.

CIC and Cranfield University work together in relation to research work associated with structural integrity testing and advanced materials development. The University is investing in infrastructure for impact testing that includes a new state-of-the-art sled facility with a deceleration facility, composites centre, numerical simulation suite and motorsport laboratory. These new facilities should be operational in 2006. RE



Cranfield offers students the chance to work on impact-related projects as part of its MSc in Motorsport Engineering and Management



While together with its testing centre (CIC) it also does research on structural integrity and advanced material development

Cranfield is also certified for dynamic testing on nosecones and monocoques

Through its MSc, Cranfield is feeding students into the motorsport industry

Setting the standards

In terms of safety, the motorsport industry has come a long way in a relatively short space of time. Yet a significant proportion of this sector has no formal design and construction standards to work with.

Steps continue to be taken to reduce the consequence of accidents and, for the most part, safety records are very good. However, the industry is said to be increasingly looking to specialist third party organisations for help in setting performance parameters, including ultimate crash simulation and testing.

One such is the motorsport division of the UK's vehicle approval authority, VCA. Part of the UK Department for Transport, VCA has over 30 years experience of working with all of the major vehicle manufacturers on a variety of crashworthiness issues. Its recently formed Motorsport division came about to satisfy the growing demand for support. According to VCA chief executive officer Paul Markwick, 'our considerable automotive experience translates very well into the motorsport arena. Certification to an agreed standard provides advantages on so many levels – the confidence inherent in credible third party verification and the creation of a level playing field being the most obvious.'

The VCA reckons that its experience can help in the setting of appropriate standards and acceptance criterion for designers to create an optimum package. It can provide a 'one stop' shop, from helping to develop a sensible set of design standards to arranging and witnessing the test itself. A management experience programme should ensure that by the time the vehicle comes to test, manufacturers have the best possible chance of a positive outcome.

Building a compliant vehicle, component or system means very little if there are not the systems in place to produce repeatable results. A part of VCA's service is to look at the issue of Conformity of Production (COP) and providing advice as required. It points out that often the best way to achieve conformity is to adopt a set of business processes backed by ISO certification. Increasingly a prerequisite of supply to others, ISO-backed certification is a clear statement of intent to produce a quality product. VCA is accredited by UKAS to provide ISO certification, as well as being recognised by the SMMT in terms of certification to ISO/TS 16949.

VCA plans to run seminars in conjunction with the MIA over the coming months, which will seek to outline ways in which it can support the industry.

A fine whine

Evergreen racing transmission manufacturer Hewland has launched another unit destined to restore its place as the first choice for budget racers

Words | Charles Armstrong-Wilson

Hewland's new JFR gearbox is a lower-cost, five-speed version of its FTR, rated to 240lb.ft and designed to retro fit to an LD200 mounting

Even so many years later Hewland is widely known for its domination of the racing gearbox market with the ubiquitous Mk9 transaxle. Despite being able to trace its lineage back to the humble Volkswagen Beetle gearbox, the Berkshire, UK, racing concern developed it into a tough and reliable transmission that appeared in a huge range of racecars.

More recently the company unveiled a new family of transmissions centred on the FTR. Short for Formula Three Race it was aimed squarely at the F3 market which it successfully won over when it was adopted by Dallara at a time when the Italian chassis manufacturer dominated the series worldwide. Manufacturing in volume brings economies that allow lower prices and the FTR was soon found applied in a wide range of applications from prototypes to controlled formulae.

> "A SPIRITUAL DESCENDENT OF THE LEGENDARY MK9"

Realising that it had a spiritual descendant of the legendary Mk9 on its hands, Hewland has endeavoured to make the unit's benefits available to a broader market with a new lower-cost version, the JFR. This shares the same architecture as the FTR but has five instead of six ratios and a simplified casing to reduce the cost. Despite the simpler design, the unit is still rated with a torque capacity of 240lb.ft, allowing it to cope with most small racing cars. Unlike the FTR, the simpler casing no longer has an integral oil tank but it retains the sequential shift. With the front face designed to retro fit to an LD200 mounting it offers a swap for the older design, allowing all the advantages of the new unit including the sequential shift to be accessed.

In five-speed form the JFR is smaller and lighter than the FTR, or alternatively a six-speed version, the JFR6, is also available. They can be supplied with an open differential or Hewland's Powerflow limited-slip version. With the former final drive fitted, prices for the JFR start at £4300 ($7650) versus £4900 ($8700) for the FTR. However, prices improve significantly depending on the number of units in an order and the spares packages purchased. The FTR will be appearing on Radical sportscars later this year and customer deliveries will begin after that.

With the launch of the JFR, Hewland may have ensured that its FTR-based family of racing transmissions will become as universal as the old Mk9 transaxle once was in racing. RE

Hewland Engineering Limited
Waltham Road
White Waltham
Maidenhead
Berkshire
SL6 3LR
United Kingdom
Tel: +44 (0) 1628 827600
Fax: +44 (0) 1628 829706
Email: enquiries@hewland.com
www.hewland-engineering.co.uk

Long night ahead?

Better have good equipment.

woodwardsteering.com

WOODWARD
PRECISION POWER STEERING

1.307.472.0550

RACEGEAR

New products and services for racecar engineers

Micro filters

US-based fuel system specialists, Barry Grant Inc, has developed a new in-line mini fuel filter to protect the pump from grime and any other unwanted fragments. Each compact filter features a billet aluminium housing with a pleated, two-inch, stainless steel filter element capable of screening to eight microns. Each reusable element works effectively in tight environments and has been designed for petrol use only. The filters, complete with screw cap, are suitable for a wide range of applications and are available in -6, -8 and 3/8in NPT measurements.

● **For more information call +1 (706) 864 8544 or visit www.barrygrant.com**

Gripper slippers

Hampshire, UK-based Andy Robinson Race Cars has recently been named as the sole suppliers of Gripper Diff's range of UK-built limited slip differentials.

The multi-plate differentials, now available for both eight and nine-inch axles, are said to embody unique features of detailed design, making them both reliable and compact and easily installed in applications where previously no LSD has been available.

Both rigorous testing and successful results on track have proved the differentials high performance and resilience. Pre-loads can be altered to suit individual driver's specifications, making these differentials suitable in a wide variety of race applications up to a maximum of 600bhp (depending on weight and spec of vehicles).

● **For more information call +44 (0) 1256 880589 or visit www.robinson-race-cars.co.uk**

Technology in miniature

Lee Products continues its development of miniature fluid control components by producing what it claims is the smallest insert check valve in the world.

Design engineers are persistently requiring smaller and lighter weight components to meet the demands of high technology applications. To meet these demands, Lee Products has created the Lee check valve, with the smallest valve measuring just 3mm in diameter and 13mm in length.

The valves are available in three different configurations ranging from 0.187in to 0.343in diameter axial flow. The configurations are available screened or unscreened and with either forward or reverse flow requirements.

● **For more information call +44 (0) 1753 886664 or visit www.leeproducts.co.uk**

Gotta lotta copper

UK-based thermal and acoustic protection specialist, Agriemach, now has available a copper exhaust wrap that it claims will increase heat resistance, produce more horsepower and improve fuel economy by introducing cleaner scavenging of the cylinders, ensuring combustion improvement.

By using a new, propriety coating the heat resistance of the copper exhaust wrap is said to have been enhanced by 30 per cent compared with present technology on the market. Extensive research has also proved copper threads to be the most efficient material to be woven into the wrap, providing the most effective abrasive resistance.

Agriemach Generation II copper exhaust wrap is available in one-inch and two-inch widths and in 50ft lengths.

● **For more information call +44 (0) 1342 713743 or visit www.agriemach.com**

RACEGEAR

New products and services for racecar engineers

DEI anniversary special

Design Engineering Inc, the US-based aftermarket supplier of thermal tuning and heat control products to motorsport, is celebrating its 10-year anniversary with the release of a new colour catalogue.

The 10-year, 28-page catalogue coincides with the release of many of the company's new products, including its SEMA award winning CryO2 range of cryogenic products and its Cell Saver protective battery wrap.

DEI is expanding its market of thermal tuning products to build upon its position in the heat protective sector.

● For more information call +1 800 264 9472 or visit www.designengineering.com

Hi-po filter mount

C&R Racing has designed a new, improved model to replace its existing oil filter bypass mount.

The all-aluminium mount has been enhanced to include an updated adapter, allowing it to be compatible with a larger range of performance filters. It also now comes with an internal oil cooler bypass valve, intended to improve the cleanliness of the plumbing in the engine compartment.

Each lightweight mount is CNC machined and comes with AN fittings. The mount is available in large and small housings and is ideally suited to NASCAR applications.

● For more information call +1 (317) 293 4100 or visit www.crracing.com

RACEGEAR

New products and services for racecar engineers

Limited edition

MAC Tools has produced a new Superbike tool box to celebrate its partnership with the present British Superbike champions, Rizla Suzuki.

Only 250 of the limited edition boxes have been created, aimed at those whose, the company says, 'avid enthusiasm for motorbikes necessitates them to own high performance, professional tools.'

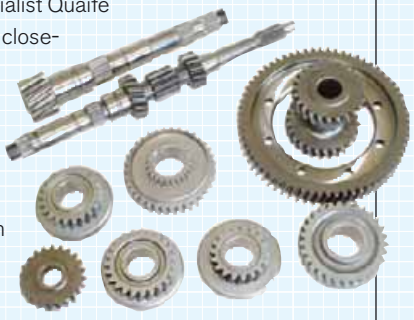
Each box, measuring 64in high by 54in wide, features a display of limited edition Rizla graphics, with full length drawer pulls and quick release ball-bearing track slides. Two gas-filled cylinders are also included for the easy opening, gas-operated lid.

A free Rizla Suzuki branded deluxe utility cart will also be given away with each purchase.

● For more information call 08701 650 650 in the UK for more information

Close ratio Pug

Transmission manufacturing specialist Quaife Engineering Ltd has introduced a close-ratio, five-speed gear kit designed specifically to improve performance of the Peugeot 205 GTi. Appropriate for the BE3 gearbox and previous BE4/BE5 gearbox models, each kit can be fitted into a standard gear casing without adjustment.



Speciality features of the new gear kit include synchromesh engagement, with the opportunity to select a lower final drive for enhanced acceleration.

Each gear kit, with final drive, costs £1430 ($2580) excluding VAT, with additional final drives available for an additional £470+VAT.

● For more information call +44 (0) 1732 741144 or visit www.quaife.co.uk

RACEGEAR

New products and services for racecar engineers

Action replay

Specialist data acquisition and video logging manufacturer Stack has developed a new way to benefit from the widespread uses of data logging, without the need for a PC.

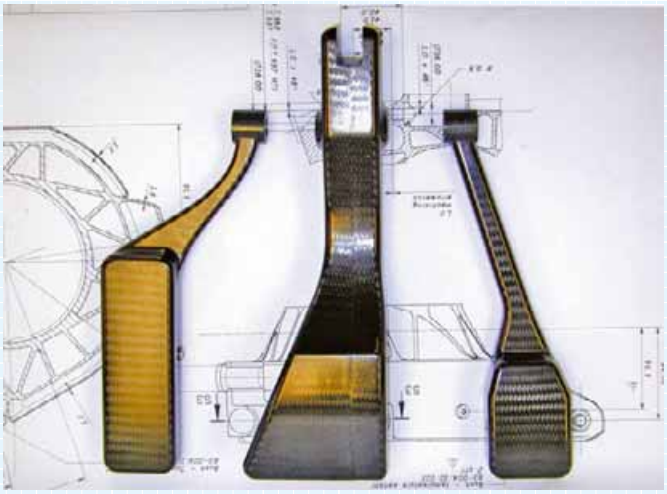
The company's new Action Replay Dash profits from the combination of the action replay feature seen on its current range of tachometers and the functions of its multi-channel dash displays.

The data logger uses an 'on-display' method through its LCD readouts to record and play back the engine speed data through the use of an analogue dial.

Vehicle and performance functions are also recorded, such as temperatures and pressures, clearly indicating in the playback the time frame in which they occurred. Replays can be paused, as well as back tracked, to allow closer scrutiny of specific points of data.

● **For more information call +44 (0) 1869 240404 or 888 867 5183 in the USA. Alternatively, visit www.stackltd.com**

Carbon pedals



B3 Technologies has used its experience of composite technology to develop a new weight saving pedal set aimed at racecar manufacturers and drivers.

The carbon fibre pedals have been manufactured with current F1 designs in mind and are obtainable in throttle/ brake or throttle/brake/ clutch combinations.

Considerably lighter than those produced from steel, aluminium or titanium, the company claims they provide the driver with a more sensitive feel when driving.

Prices start at £2500 ($4500) for two pedals and £2900 ($5250) for three, both including mounting brackets.

● **For more information call +44 (0) 1483 450900 or visit www.b3technologies.com**

Who Works in Motorsports 2005

By François-Michel Grégoire

Most usefully, the 650 pages of this directory are sandwiched between thick hard covers as this is a book that will soon be well thumbed. A new addition to the Who Works series, WWIM covers the major championships from Formula 1, Champ Car and NASCAR, to DTM and WRC. Brief but vital details and key personnel are listed for the teams in each of the championships, together with contact information. Similar data for major sponsors and suppliers is also included. Instead of biographies for the 370 drivers listed, WWIM has their best results and contact information. Short sections on circuits, rallies and series officials complete the package. Not forgetting PR people, journalists and photographers, of course!

For very important people in motorsport who are sought rather than seekers, WIMM will be a waste of money. For everybody else, the £39.50 purchase price will be repaid endlessly.

● **Who Works in Motorsport 2005**
Author and publisher: François-Michel Grégoire; ISBN 1 9017 1140 4; price £39.50; distributed by Vine House Distribution Ltd; website www.whoworksin.com

KONI's wide range of racing dampers offer unrivalled performance in all kinds of road racing.

Take a lead with the new generation 4-way adjustable KONI 2822

UNIQUE FEATURES: ADJUSTMENT • In bump and rebound independently • In high and low speed independently • No needle valves • 8 distinct and repeatable steps. DAMPING FORCES • In bump and rebound generated by piston area • Not effected by rod displacement • Negligible phase lag • Low speed in 2 stages •Wide range, in equal steps.
OTHER FEATURES: No need for external reservoir • Adjustable spring platform • Matches 2¼" springs • Works in any position • Light weight • Hard anodised parts • Tailor made, individually tested • Highest quality standards.

KONI carry a wide range of competition dampers being built on half a century of successful motorsport experience, up to Official Supplier in Formula One. The new KONI 2822 series offer the ultimate tuneability for maximum control. Please ask your local KONI race distributor for further information. **FOR MORE CONTROL DRIVE KONI**

SPORTSLINE SUSPENSION LTD
Koni Technical Centre +44 (0) 1280 702633

www.koni.com

KONI

ITT Industries

Database

Section 1 lists manufacturers of Brand-Name Racecars.

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

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

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

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

Costs listed below:
Name and number £50 - 12 issues
Name and number bold
£70 - 12 issues
Logo and full company details
£420 - 12 issues including web, address, email etc etc
£210 - 6 issues

www.racecarengineering.com

Andy King on Tel: +44 (0)20 8726 8329

andy_king@ipcmedia.com

Database 1
RACECAR MANUFACTURERS

1.1
Racecar Manufacturers

A-MAC USA (1) 408 727 9288
Fax (1) 408 988 8998
A-Mac Fabrication, 1745 Grant Street, Suite 2, Santa Clara, CA 95050, USA

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

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

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

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

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

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

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

CARBIR USA (1) 262 377 2850
Fax (1) 262 375 1602
Carbir Race Cars Inc, 1220 Falls Road, Grafton, WI 53024, USA

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

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

CHEVRON Tel 01300 348499
The Chevron Centre, Piddle Trenthide, Nr Dorchester, Dorset DT2 7RF, England

US Importer Continental Crossle Tel (1) 513 777 4545
9000 Debbie Drive, West Chester, OH 45069, USA

DALLARA Italy (390) 525 550711
Fax (390) 525 53478
Dallara Automobili, Via Provinciale 33, 43040 Varano Melegari, Parma, Italy

DEBORA France (33) 381 52 02 10 36
Fax (33) 381 51 18 51
bis Rue du Docteur Moras, 25000 Besancon, France

DAN GURNEY'S ALL AMERICAN RACERS, INC
Tel USA 714 540 1771
Fax USA 714 540 3749
2334 South Broadway PO BOX 2186, Santa Ana, CA 92707, USA

DJ RACECARS Tel 01663 734518
Fax 01663 732 130
Email del@djracecars.fsnet.co.uk
Unit 10, Britannia Rd Est, Buxworth, Nr Whaley Bridge, High Peak, SK23 7NF

DOME CO. LTD 198-1 Hanajiricho, Yase, Sakyoku, Kyoto, Japan
Tel 81 (0)75744-3131
Fax 81 (0)75744-3035

DOME CARS. LTD Roebuck House
Cox Lane, Chessington, Surrey KT9 1DG England
Tel 0208 397 9999
Fax 0208 397 6830

DOWNS ENGINEERING Tel USA 707 938 1001
Fax USA 707 935 0481
19564 8th St. East, Sonoma, CA 95476 USA

DRAGON USA (1) 413 267 0904
Small Fortune Racing, 77 Stafford Hollow Road, Monson, MA 01057, USA

ELISE France (33) 1 47 49 15 66
1 Rue Pierre Cassin, 92500 Rueil Malmaison, Paris, France

EUROCAR Tel 01353 861168
Fax 01353 861877
SHP Motorsport, Unit 7 Farraday Business Park, Littleport, Ely, Cambridgeshire CB6 1SE, England

EXTREME CARS Australia (61) 396 822225
(61) 396 821119
(61) 396 900809
Email mrpro07@tpg.com.au
King Way House, 188-190 Kings Way, South Melbourne, Victoria 3205 Aus.

FABCAR USA (1) 317 872 3664
Fax (1) 317 872 3835
4148 West 99 Street Carmel Indiana

FORCE RACING CARS Tel/Fax 01823 698117
Clyse Farm, Stathe, Nr Bridgwater TA7 0JN England

GRAN TOURING CLASSICS 001 562 596 9242

GOULD Tel 01635 44466
Fax 01635 30056
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 COMPOSITES GROUP, LLC
Tel: 317 271 1207 Fax: 317 271 4455
www.aerodinecomposites.com
8201 Indy Lane, Indianapolis, Indiana 46214

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

C6B 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.com / web www.centurycables.com
IS MOTORSPORT USA (1) 317 244 6643
PERFORMANCE WIRING SOLUTIONS +44 (0)1954 253620
RINGSPANN 01234 342511
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 866677
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.com / 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

CENTURY CABLES **Tel 01733 211 600 / Fax 01733 211 082**
Email: kwhincup@yahoo.com
Web: www.centurycables.com
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 02619155
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
EUROPE +44 (0) 1280 843 390
EBC BRAKES 01604 583344
ENDLESS BRAKES Japan (81) 267 68 0071
FERODO 01298 812520
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, BOJ 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 Racing 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

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
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
Tel: +44 (0)1384 216102
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
Tel +44 (0) 01455 234200
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 843802
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 STOCKITS
Tel 01384 216102 Fax 01384 216109
Website: www.coordsport.com
Email: sales@coordsport.com
Kings Street, Dudley West Midlands DY2 8PX
SWINDON RACING ENGINES 01793 531321
TOTAL SEAL USA (1) 602 678 4977
WISECO PISTON USA (1) 216 951 6600
Canada 800 265 1029

PISTON RINGS

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

RUBBER & ELASTOMERIC COMPONENTS

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

VALVES

DEL WEST ENG USA Tel: (1) 661 295 5700
Fax: (1) 661 295 8300
28128 West Livingston, Valencia CA 91355, USA
FERREA USA (1) 954 733 2505
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

VALVE SEATS

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

VALVESPRINGS

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

VALVE SPRING RETAINERS

G&S VALVES LTD 01483 415444

VALVE GUIDES

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

3.2 Engine Ancillaries

AIR FILTERS

INDUCTION TECH GROUP Tel 02476 305386
Fax 02476 307999
Unit B, Quinn Close, Seven Stars Industrial Estate, Whitley, Coventry CV3 4LH
K&N ENGINEERING USA 800 858 3333
K&N FILTERS (EUROPE) UK 01925 636950
KINSLER USA (1) 248 362 1145
PIPERCROSS 01604 671100

CARBURETTORS

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

EXHAUST SYSTEMS

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

GDS EXHAUSTS Tel: 01280 702510
Fax: 01280 705225
Email: sales@gds-exhausts.co.uk
Website: www.gds-exhausts.co.uk
Unit 8C Boundary Road, Brackley NN13 7ES
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 01759 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
FLUID CONTROL PRODUCTS INC USA (1) 217 324 3737
Fax (1) 217 324 3717
GOODRIDGE UK 01392 369090
GOODRIDGE CA USA (1) 310 533 1924
GOODRIDGE INDY USA (1) 317 244 1000
GOODRIDGE EAST USA (1) 704 662 9095
HCL FASTENERS 01282 411992
HENRY'S ENG USA (1) 410 435 3142
JLS MOTORSPORT 0121 525 7733
KINSLER USA (1) 248 362 1145
SAMCO SPORT 01443 238464

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

OIL COOLERS

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

OIL FILTERS

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

OIL PUMPS

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

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

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

ENGINE MANAGEMENT SYSTEMS

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

MoTeC

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

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

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

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

SACHS RACE ENGINEERING GmbH
Tel +49 9721-984300
Fax +49 9721-984399
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

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

TORQline CTG Composite Driveline Products

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

Motor Sport

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

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

UNIVERSAL JOINTS

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

Database 4

FACTORY EQUIPMENT

4.1 Factory Hardware

AIR LINES & FITTINGS

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

AIR TOOLS

DESOUTTER AUTOMOTIVE 0208 205 4884

paoli AVVITATORI

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

GWS Systems Oy **Tel: 01403 276445**
Fax: 01403 276434
Email: sales@gwssystems.co.uk
Website: gwssystems.co.uk
Units 10-12 Horsham Court, City Business Centre, 6 Brighton Road, Horsham, West Sussex RH13 5BA

LISTA 01908 222333
MAC TOOLS USA (1) 614 755 7000

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

4.2 Factory Software

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

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

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

Database 5

CIRCUIT EQUIPMENT

5.1 Pits Equipment

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

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

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

CAMBER GAUGES
DEMON TWEEKS **01978 664466**
75 Ash Road South, Wrexham Industrial Estate, Wrexham, Clwyd LL13 9UG, Wales
HARRISON AUTO USA (1) 602 254 0024
LONGACRE RACING USA (1) 425 885 3823
OMS RACING **0113 2575956**
PACE PRODUCTS 01284 850960

Redline Motorsport

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

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

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

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

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

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

ELECTRIC STARTERS
POWER TRANS SOLUTIONS **01722 332126**

ENGINE HOISTS
DUNLOP AUTOMOTIVE 0121 384 4444
FACOM UK 01932 566099

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

FIRE EXTINGUISHERS
CHUBB 01932 785588

FEV

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

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

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

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

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

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

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

SCISSOR PLATFORMS
SLINGSBY 01274 721591

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

SETUP GAUGES
A.R.T. **USA (1) 914 889 4499**
CYBER DYNAMICS **01869 347812**
DEMON TWEEKS **01978 664466**
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
AERODINE	**USA (1) 317 271 1207**
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**
AERODINE	**USA (1) 317 271 1207**
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 812454
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.rmimallock.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) 3862552122500
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 777393
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 648922
MATRIX ENGINEERING USA (1) 888 249 0013
MELTUNE PX MOTORSPORT 01923 242536
MIRKO RACING Tel USA (1) 408 776 0073
Fax USA(1) 408 779 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.rmimallock.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

Database 9
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.rmimallock.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

Database 10

SERVICES - GENERAL

10.2 Paddock Services

AIR FREIGHT FORWARDERS

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

MOTORHOME

ATLANTIC COAST 01297 552222

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

TRAILER HIRE

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

The Technology to Win

Now in our 48th year as one of the world's leading race car manufacturers, Lola are proud to play a prominent role in the success of teams and drivers around the globe.

Lola have dominated Champ Car competition for the past three years, and were commissioned to create the one-make chassis for the exciting new A1 Grand Prix series. Our all-new LMP2 design has claimed ALMS, LMES, and Le Mans 24 Hours class wins in its debut season, and will be joined by an LMP1 customer model in 2006.

But you don't have to buy a Lola chassis to take advantage of our industry-leading facilities and expertise.

Our world-class 50% scale rolling road wind tunnel (used by Formula 1 teams) and 7-post vehicle dynamics test rig with full circuit simulation capability are among the motorsport industry's most advanced – and most accessible.

Lola's state-of-the-art composites operation supply components to half the F1 field, and have built chassis and bodywork for five of the last 10 Le Mans winners.

So whether you're looking for a turn-key project solution or a critical design and development resource, contact us today.

LOLA CARS INTERNATIONAL LTD *Glebe Road, St Peter's Road, Huntingdon, Cambridgeshire PE29 7DS United Kingdom*
Telephone +44 (0)1480 451301 / Facsimile +44 (0)1480 482970 / Email lola@lolacars.com

Airbox inlets

Engine airbox inlet design is worth a close study

As you might expect, there's much more to a competition airbox than meets the eye. Shape and placement are just two of the more obvious factors to be considered

LAT

Assuming technical regulations do not mandate an engine restrictor, how big should an airbox inlet be? Gut feel immediately suggests engine capacity and rpm are critical factors, but where do we go from there?

A race engine, like any internal combustion engine, is a pump. The amount of air it shifts depends on its swept volume, rpm and volumetric efficiency (the ability to pump more than the engine's capacity). It's relatively simple to calculate, for a given engine size and across a range of rpm, the volume (or mass) flow rate of air that enters the engine. Figure 1 illustrates this for an engine of 3.0-litre capacity, and over a rev range representative of a current Formula 1 engine, with the simplifying assumption that volumetric efficiency is 115 per cent across the rev range.

A reasonably large airbox volume is generally deemed necessary so that the engine has an adequate reservoir of slow moving, 'clean' air to inhale. For external aerodynamic efficiency the entry to the airbox inlet should be small and, ideally, properly matched to the engine's needs so that it scoops in just the right amount of air. But a quick glance at figure 1 shows that the engine has a wide range of volumetric flow requirements across such a working rev range.

The following concept, suggested by Advantage CFD, relates the vehicle's forward speed to the volume flow rate of air inhaled by the engine at various rpm levels, and considers the air being sucked in as a column of air entering the airbox inlet. By dividing the volume flow rate by the car's speed we can calculate the theoretical cross sectional area of this column at the inlet, over the relevant range of car speeds and engine rpm. For clarity, this can be calculated as if it were the diameter of a cylindrical column, and this data is graphed in figure 2. So, in short, the size of the column of air entering the inlet varies with car speed and engine rpm and yet, pretty obviously, the actual inlet orifice size is fixed on a racecar. ➔

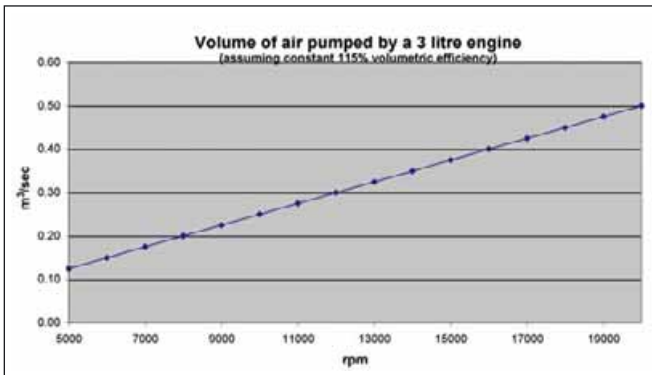


Figure 1: volume flow rate of a 3.0-litre engine – 5000 to 20,000rpm

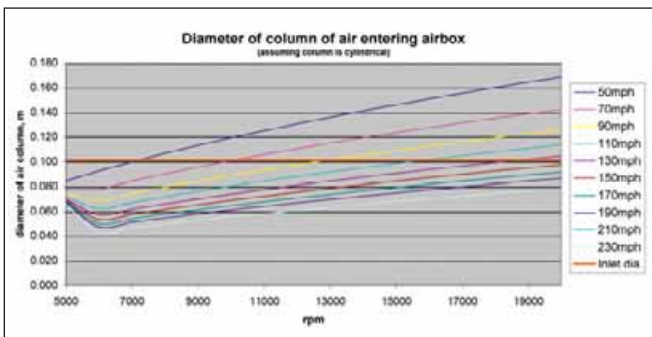


Figure 2: diameter of the column of air (assuming it's cylindrical) entering an airbox inlet across a range of car speeds and engine rpm

Illustrations courtesy: Advantage CFD

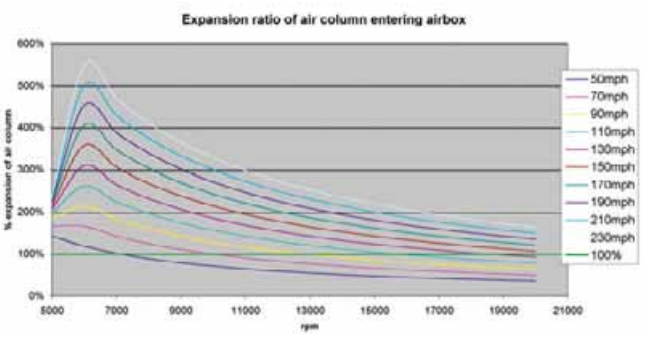


Figure 3: expansion ratio of air entering the airbox inlet, calculated as a percentage of the airbox inlet area

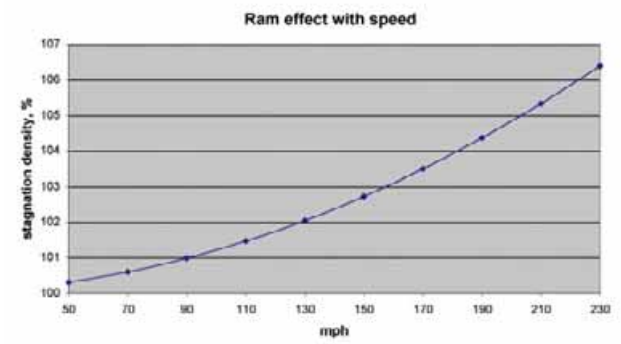


Figure 4: ram effect across a racecar speed range, assuming dynamic pressure is converted to static pressure then added to ambient pressure

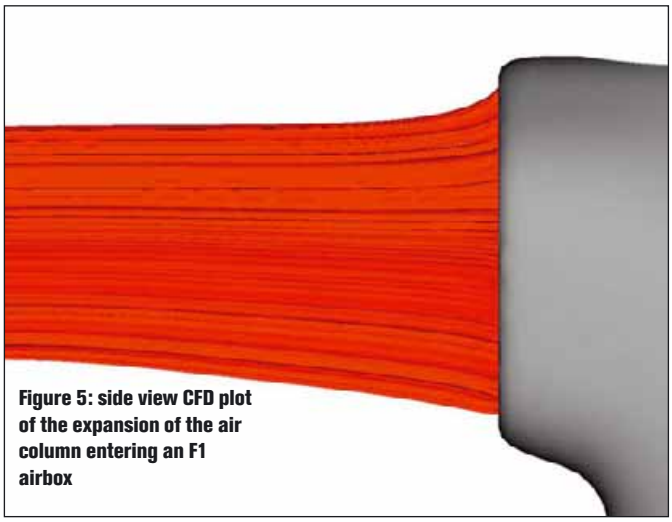


Figure 5: side view CFD plot of the expansion of the air column entering an F1 airbox

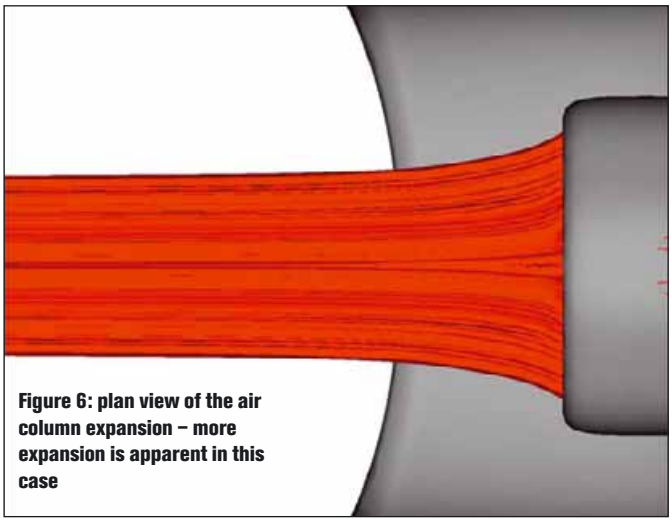


Figure 6: plan view of the air column expansion – more expansion is apparent in this case

Take a typical F1 airbox inlet area, said to be 0.008m^2, equivalent to approximately 0.1m diameter if the orifice were circular, and depicted in the graph as the line marked 'inlet dia.'. When the column of air approaching the inlet is smaller than this then the column will expand as it enters the inlet. And when the column of air is larger than the inlet area it must then contract at the inlet. In either situation the inlet design must try and prevent unwanted flow separation using properly radiused edges and careful shaping.

Figure 3 shows this data calculated as the 'expansion ratio' of the air column by dividing this actual inlet area by the air column area at each combination of speed and rpm shown here. An 'expansion ratio' less than 100 per cent means the column has to contract as it enters the inlet, and ratios greater than 100 per cent mean the column will expand as it enters the inlet. The intersection of the line marked '100 per cent' with the other graph lines shows the limited number of rpm/speed combinations at which the air column diameter matches the inlet size. Obviously if gearing was taken into account it would be apparent that many of these speed and rpm combinations will not actually be encountered, but disregarding those there are still many relevant combinations.

Contraction, it seems, loses more energy than expansion of the column, and would probably lead to less efficient power production. However, contraction occurs mostly at low car speed and high rpm combinations, where the likelihood is that power will exceed grip, so some losses would be tolerable. Nevertheless, the contracting airflow needs a smoothly radiused lip on the inlet to minimise the risk of flow separation here, which would increase those losses. In the 'expansion zone' (above the 100 per cent line) clearly the emphasis will be on designing an inlet that enables the initial expansion here to be smooth and efficient, again requiring radiused lips and smooth shape transitions.

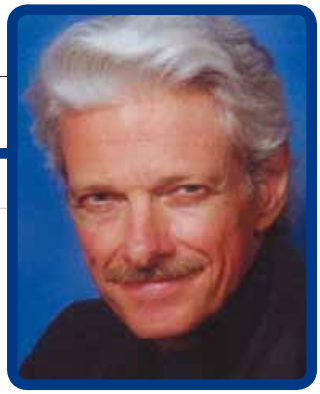
In all cases the airbox then needs to expand the flow further and gradually towards the engine trumpets so as to recover static pressure while avoiding flow separation or even stall. This will probably require a long diffuser section, regulations and practicalities permitting. In the 1970s when F1 rules permitted extremely tall airboxes, the thinking was that inlets needed to be high in order to grab 'clean' air. But often the inlets were oddly shaped (tall rectangles for example) with sharp edges, neither characteristic being at all efficient. That they worked was possibly more because their height provided a long, gradual diffuser to slow the air down efficiently before it entered the engine.

Another interesting issue is the exploitation of 'ram effect', where an airbox inlet faces directly into freestream air. However, though reasonably significant at high speeds, this effect is smaller at motorsport speeds than is often thought. Figure 4 shows what can be achieved if the inlet catches and 'stagnates' (ie stops) the airflow and converts all its dynamic pressure (kinetic energy) into static pressure (potential energy) from which the engine can benefit. The graph is based on calculating the dynamic pressure (1/2 x air density x velocity squared) at each speed, and then working out the increase in effective air density if all of that dynamic pressure was converted to static pressure, and then added to the absolute (ambient) air pressure. If we assume that engine power is proportional to inlet air density then figure 4 suggests that at speeds over 200mph a gain in power of five or six per cent might be possible (about 45bhp for a current F1 engine).

Perhaps more significant is feeding an engine with cool air since this provides the highest available air density right across the speed range. The inlet needs to be positioned away from on-board sources of heat, and well above ground level as air adjacent to the track surface can be much hotter than that even a few inches above ground. As we can see, there's rather more to an airbox than just a hole and a reservoir...

Mark Ortiz is

THE CONSULTANT



Finer points of anti-roll bars on stock cars

In most cases running the car lower and with maximum forward rake in turns will benefit the geometry. This can be achieved with softer springs and a stiffer anti-roll bar

LAT

Q I race primarily on two ovals, one a 1/3 mile with seven degree banking and short straights, and one a 5/8 mile with 15 degree banking and long straights. I am not clear on some of the finer points of set-up and adjustment of front anti-roll bars for a specific track, especially for a car running at two tracks such as these. Most cars in my area run a solid link to the anti-roll bar on the right and a slider link on the left. I have run many cars with this set-up, and a few with solid links on both sides, but I don't really understand why there would be a preference for one over the other.

Another concern I have is that I'm not always sure in which situation it would be best to change the bar rate as opposed to the front spring rate.

A It has long been common on oval track stock cars to use some type of 'soft link' on the front anti-roll bar. These may take the form of a slider, a chain, or a pad on the anti-roll bar arm that bears against a pad on the lower control arm. The last of these is the form commonly seen in the upper divisions of stock car racing. Chains and sliders are common in 'street stock'-type cars, where the suspension components actually come from production passenger cars.

> "THE 'SOFT LINK' IS A MIXED BLESSING"

All these variations do the same thing though: they create a connection that transmits force in only one direction. The anti-roll bar resists rightward roll only. The bar may be pre-loaded, in which case it will resist leftward roll up to the point where the pre-load is relieved. →

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**

The reason the soft link is there at all is to make the front suspension more compliant when the driver gets the left front wheel on the flat apron of a banked track. In this situation, the car tends to go loose (develop oversteer) and spin. This is partly because of the leftward yaw moment created when the left front encounters increased resistance, and partly because the car de-wedges (load increases on the left front and right rear, and decreases on the right front and left rear). If the suspension is more compliant, both effects are reduced, especially the de-wedging.

However, even in this situation the front suspension only acts softer beyond the point where the left front suspension compresses enough to put slack in the bar. If the bar has no play and no pre-load, the front suspension must go into leftward roll (left front compressed more than right front) before the soft link has any effect. And the soft link will make the car looser if the driver needs to turn right to avoid a wreck. So the soft link is a mixed blessing.

Wheel rates and arm end rates of anti-roll bars are a confusing subject for many. The main cause of this confusion is that there is no agreed convention as to what an inch of arm end or wheel motion means. Does it mean an inch of motion at just one wheel? An inch of motion in opposite directions at both wheels? An inch of difference between the two wheels?

I find it convenient to express the rates of all springing devices, including interconnective ones such as anti-roll bars, in terms of pounds per inch per wheel. This agrees with the way we always express the rate of non-interconnective springing devices ie the main springs or ride springs. We then have numbers that easily tell us what change of anti-roll bar rate equates to what change of spring rate.

Often, we encounter situations where we do not have 'pure' roll motion. Pure roll, for a front or rear wheel pair, would mean equal amounts of suspension motion at each wheel, in opposite directions. Pure ride would mean equal amounts of motion at each wheel, in the same direction. Ride and roll are the two modes of motion for a front or rear wheel pair. Any possible motion of that wheel pair can be resolved into some amount of ride and some amount of roll.

Applying this to the questioner's example of a situation where a car in a banked left turn rolls purely by compressing the right front suspension, and the left front neither compresses nor extends, that is a condition of equal ride and roll. If the right front compresses an inch and the left front doesn't move, we have half an inch per wheel of rightward roll, plus half an inch per wheel of compressive ride. On the left wheel, the effects are subtractive and exactly cancel. On the right wheel, the effects are additive, and we have twice the half-inch per mode, or one inch of compression.

If we compare this to a pure roll situation (zero ride motion) that creates an inch of compression at the right front, yes, the bar creates twice as much force. But the bar's rate is the same. The difference is that there is twice as much roll. If the roll were equal to the previous example, the right front compression would be only half an inch, the difference between right front and left front would still be an inch, and the force generated by the bar would be the same as in the first example. Once we learn to separate the ride and roll components of the motion, and remember that the bar acts only in response to the roll component, things get much simpler.

Regarding how much of the front wheel rate in roll should come from the springs and how much from the bar, it mainly comes down to how much we want the front of the car to drop in the turns due to the banking. This in turn relates to both suspension geometry and aerodynamics.

"A FLATTER TRACK CALLS FOR MORE OF A SOFT-SPRING/BIG-BAR APPROACH THAN A STEEPLY-BANKED TRACK"

More compliant front suspension reduces the chance of a spin if a car touches the apron

It is normal in all stock car racing classes to have a minimum static ground clearance requirement, yet we would like the valance to run just off the track, and have as much forward rake in the car as possible through the turns. This gets us the greatest aerodynamic downforce available, within the rules.

Additionally, with passenger car front suspension, we usually have insufficient camber recovery in roll for racing. The control arms are close to parallel at static, causing the wheel to change camber very little in ride, but a lot in roll. This is good for tyre wear in gentle driving, but not good for hard cornering. In some cases, the rules will allow us to use extended upper ball joints to improve the geometry for racing. Sometimes this is enough, but in most cases the geometry will benefit if we run the car lower. To do this, within the ride height rule, we need to soften the springs and stiffen the bar.

In the upper divisions of stock car racing, we can get as much camber recovery as we want, so only the aerodynamic factor argues for soft front springs. In general, with soft front springs and a big bar, we'll want the front view instant centres a bit higher and further from the wheels at static than we'd want with stiffer springs and a softer bar.

In either case, a flatter track calls for more of a soft-spring/big-bar approach than a steeply-banked track.

Regarding rate of a bar with slack in it: the bar has a rate of zero until the slack takes up. Then it has the same rate it would have without slack.

We can speak of the bar's rate as an instantaneous value, at any given point in roll travel, or we may speak of its average rate, over a specified interval of travel. When there is slack in the system for a portion of the interval, but not at the end of the interval, the bar has the same instantaneous rate at the end of the interval whether there is slack or not, but it has less average rate over the interval if there is slack.

DON'T SACRIFICE THE WIN

The difference between WINNING and LOSING is STAYING CONNECTED...

Get Connected!

ADEL WIGGINS GROUP *Flexible Tube Connectors*

SECURE YOUR WIN

Stay connected with Adel Wiggins Flexible Tube Connectors! The difference between winning and losing is in the connection. Do not sacrifice a win to a simple hose blowout or burst. This occurs when conventional hose clamps or barbs fail to secure the hose located between the connections or components. Adel Wiggins Flexible Tube Connectors eliminates these failures. This is why they have caught the attention of so many professional racers today. One of the main reasons for its popularity is its ability to be removed or installed with only one hand quickly and easily, whether they are being used with tubing or hose. Adel Wiggins Flexible Tube Connectors are offered standard in lightweight aluminum and are available in stainless steel or titanium upon special order. They have an operating temperature range from –120° F to 800° F and are able to withstand boost and pressure levels in excess of 125 PSI.

SAFETY-LOCKING, ONE HAND INSTALLATION

The locking latch design eliminates troublesome and time-consuming installation of safety-wire or the necessity of tools to make the connection. The electrical bonding feature eliminates the external clamps, fasteners and jumper wire required in some applications. Elimination of lock wire holes, bolt-on bars, grounding clamps, snake clamps and jumper wires removes what can be a cumbersome and unattractive connection. The W900 series minimizes weight and unit cost, while retaining the proven performance and reliability of other WIG-O-FLEX connectors.

APPLICATIONS

FEATURES: Lightest of all flexible tube connectors

- Saves installation and tear down costs • Full range of stocked sizes: 1/2" to 4"
- Saves time, space, and weight • Easy, one-hand installation • Design flexibility

FCP
Fluid Control Products, Inc.

Australia
C.A.P.A. 088 582 3499
England
Goodridge UK 01392 369090
BMRS 0175 355 3610
Earls UK 0132 785 8221

Germany
Goodridge Deutschland 06321 60168
Kronter 09401 52530

Italy
Tecnauto SRL 02 738 8773
Japan
SIFo Corporation 03 5420 4151
New Zealand
Turbo Vehicles Ltd. 09 525 6696

Toll Free in NA: 800-541-2345
Worldwide: 217-324-3737
www.fluidcontrol.net