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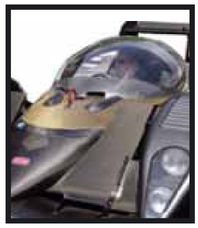

THE LOST PROPHET
The Allard J2X lacked results but it changed prototype design

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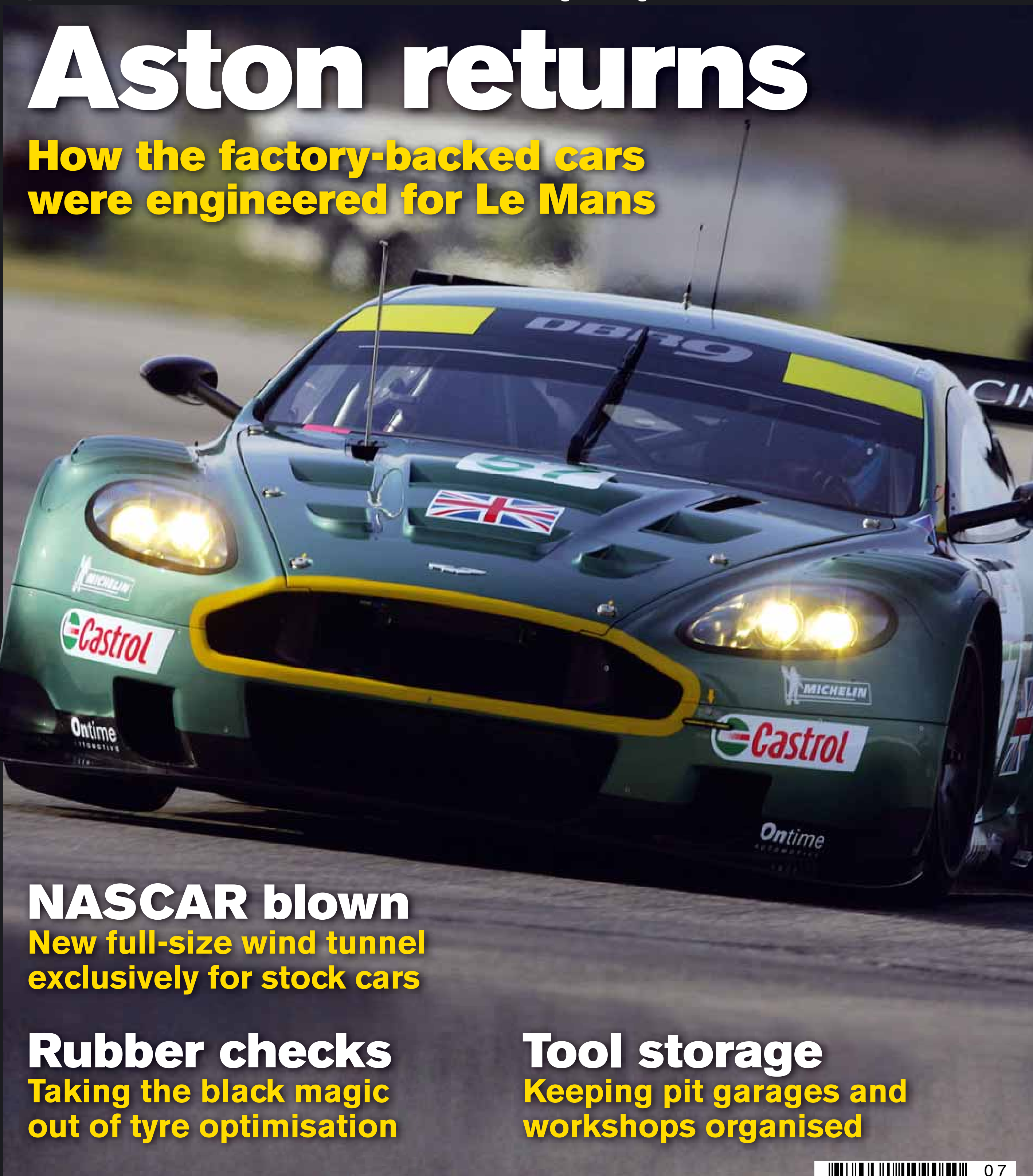
July 2005 · Vol 15 No 07 www.racecar-engineering.com UK £4.50 · USA $8.95



Aston returns

How the factory-backed cars were engineered for Le Mans

NASCAR blown

New full-size wind tunnel exclusively for stock cars

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Taking the black magic out of tyre optimisation

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Write Line

What is the biggest threat to world motorsport? Would you be shocked or outraged if I was to suggest it might be world motorsport itself? How can that be, you may be asking? There are many threats to our favourite activity and all of them are external. Consider for examples, the green lobby, or fuel shortages. How about economic recession or rising population density? Surely all these are threats hanging over the future of the sport and they are the things holding a gun to our heads. True, but only if we let them. None of these will inevitably lead to the death of motorsport. They can all be dealt with if we have the will.

In the UK, a long battle to ban fox hunting was finally successful earlier this year. I don't want to take a stand either way on the rights or wrongs of this decision, but the way it came about offers some sobering lessons for the future of our industry.

By the time the issue was being bounced around in our parliament, it had become a political battle, not an electoral one. There were staunch camps on both sides of the argument, but the vast majority of the voting public had a resigned indifference to the issue. It was unlikely to win or lose the election for any party and, if it went, the vast majority would hardly notice. That left the majority of members of parliament with little reason to resist the onslaught of lobbyists and pressure groups.

> **"SURELY THE FAILURE TO FIGHT THIS IS THE GREATEST THREAT TO MOTORSPORT"**

In fact, the bulk of the work by the anti-hunting groups had been done up to 30 years earlier with well-organised, high-profile protests that succeeded in seeding the public consciousness with one point of view. Meanwhile, the hunt supporters regarded this interference as a nuisance, but not a serious threat. They believed in their indisputable right to their sport and saw no need to justify that outlook to others or actively put their side of the argument. By the time the threat became imminent, it was too late.

Now motorsport is starting to face a similar threat, this time from government. In the UK, the Department for Environment, Food and Rural Affairs (DEFRA) has just passed an act denying subsidies for set-aside agricultural land that occasionally hosts motorsport. At a stroke, thousands of competitors in the UK have had their venues priced out of reach as farmers factor the lost subsidies into their charges. Yet motorsport is the only activity excluded, while car boot sales and static shows have been left completely unaffected. Exactly why motorsport alone has been singled out is unclear, but the fact that it has is something we should worry about

This is a blow to club motorsport and possibly the thin end of the wedge, setting a precedent for other exclusions directed at our industry. If we cannot justify our activities at grass roots level, then we are opening the gates for legislation that could work its way all the way to the top. If we can't rise to this, then what are the chances of dealing with the next attack from the bureaucratic-machine? Surely the failure to fight this is the greatest threat to motorsport. Now is when we need to respond with a justification for our activities and a campaign to educate and involve others.

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Charles Armstrong-Wilson

The International Journal **Racecar engineering**

Pit Crew

Vol 15 **No.7**
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Worldwide News Trade Distribution Marketforce (UK) 5th Floor, Low Rise, Kings Reach Tower, Stamford St, London SE1 9LS, UK
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Worldwide Subscriptions Racecar Engineering Subscriptions, PO Box 272, Hayward's Heath, West Sussex, RH16 3FS, UK
Typesetting & Repro Planart Ltd
Print Text Benham Goodhead Print,
Cover BR Hubbard Printers
Printed in England ISSN No 0961-1096
USPS No 007-969
Racecar Engineering **is a Focus Network publication, published by IPC Country & Leisure Media Ltd**
A part of IPC Media, a TimeWarner company
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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
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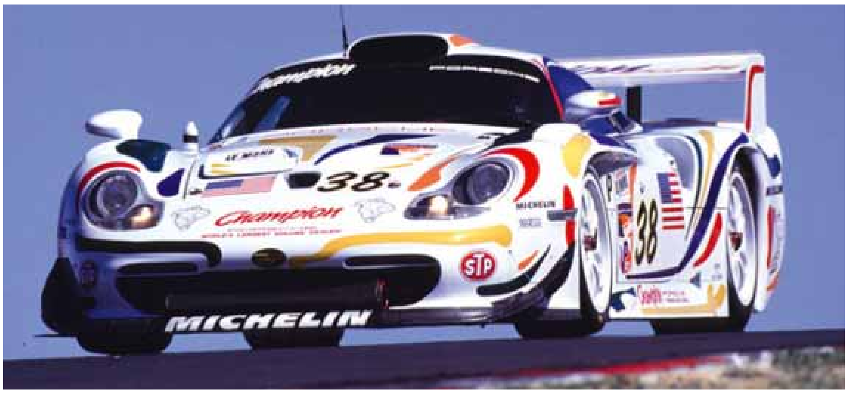
Porsche announces return to prototype racing



Porsche's last major foray into Sportscar racing was in the late 1990s with the 911 GT1

Porsche has announced that it is returning to sportscar racing with a customer-based LMP programme.

A new LMP2 chassis will be run by Penske Racing in the last two races of this year's ALMS. In 2006, Penske will compete in the full ALMS championship and also the Le Mans 24-Hours.

'Our American racing customers have made it clear to us that they would like to move up several levels in ALMS competition, as would we,' said Peter Schwarzenbauer, the president of Porsche Cars North America.

The tie-in with Penske was unexpected, despite strong links between the two, dating back to the 1970s when Penske Porsches won the SCCA Can Am title two years running.

Porsches have won Le Mans 16 times, most recently in 1998, and it has been suggested that a Porsche LMP2 could be a contender for overall victory in 2006. As yet it is unclear whether the firm will develop an LMP1 version.

The Stuttgart-based company designed, constructed and tested an LMP chassis around five years ago but the car never raced.

Zytek LMP awaits DTM decision

Zytek Engineering has revealed that progress on its planned LMP is dependent on the situation with what was the MG DTM project. Continuing work on what was to be the ZT260 DTM car will, said company founder Bill Gibson, 'be dependent on finding another manufacturer.'

Gibson also noted out that, should work on the DTM project cease, the construction of Zytek's projected LMP1 sportscar could be brought forward. He confirmed that plans for the endurance racer have been formulated and work is scheduled to start this winter.

The demise of the MG-Rover group means that, if the DTM car does appear, it will not be a race version of MG Rover's ZT260. However, the amount of work carried out means the DTM's organiser, the ITR, has access to a chassis with which it could attract another manufacturer.

As far as Gibson is concerned though, an LMP1 car is a 'flag waver' for the whole Zytek Group. 'It shows our potential,' he said. Zytek enjoyed its first ever chassis win at this year's Spa 1000kms with the 04S, which will become obsolete at the end of the year. 'I'm not interested in winning a class,' states Gibson.

However, with the ease of converting an LMP1 into an LMP2 he does not rule out building for the latter class, though this would require a potential customer first.

Gavin D Ireland

Zytek set to improve on 04S success

Picchio prototype unveiled

Photos: Picchio

Picchio has released images of its recently completed Daytona Prototype chassis, the DP2. The Italian manufacturer is evaluating the use of a 4.5-litre V8 engine that is approved for use in Grand Am but has not yet been raced. It is also assessing the more common BMW and Infiniti units.

Boom in LMP2

After some doubt last year, the future of prototype racing looks assured by the news of a wave of new interest in the LMP2 category. Of these 'baby' prototypes, 14 have made it onto the entry list for this year's race, but with new cars from Lola, Radical, Riley Technologies and Porsche it seems that the real boom is due in the next two years.

The LMP2s are joined by 14 LMP1s, 10 GT1s and 12 entries in the GT2 class.

LMP1 once again is headed up by a brace of Audis and is reminiscent of the 2004 field, though perhaps a little stronger than before as the Team Jota Zytek and the similar DBA of Creation Autosportif should be able to push the Audis in the early stages of the race.

Oreca has announced that it will be running an Audi R8 this year under the Audi France banner.

Gavin D. Ireland

An Audi R8 has finished in the top three at Le Mans every year since 1999

Withdrawal symptoms blight Le Mans

Gavin D. Ireland

In a blow for 'green' motorsport Team Nasamax will not contest this year's 24 Hours

Team Nasamax withdrew from this year's 24 Hours shortly after the first entry list was released by the ACO. Reasons for the bio-ethanol-fuelled team's withdrawal are as yet unclear, though it should be noted it has also not entered the LMES series yet.

Ameco also withdrew its entry after concern over having to run a smaller rear wing on its Saleen S7R after an ACO clarification. The ALMS regulars are concerned about the high-speed stability of the car when running the smaller wing.

A number of cars withdrew from the reserve list, including the second Racing for Holland Dome and Labre Ferrari. At the time of writing the only car remaining on the reserve list is the second Spyker Squadron Spyder C8.

LMP1

2*	Champion Racing	USA	LMP1 - LMP 900	Audi	3600T
3	Champion Racing	USA	LMP1 - LMP 900	Audi	3600T
4	Audi Playstation Team Oreca	FRA	LMP1 - LMP 900	Audi	3600T
5	Jim Gainer International	JPN	LMP 1	Dome Mugen	4000A
7	Creation Autosportif Ltd	GBR	LMP1 - LMP 675	DBA Judd	3397A
8	Rollcentre Racing	GBR	LMP1 - LMP 900	Dallara Nissan	3600T
9	Team Jota-Zytek Engineering Ltd	GBR	LMP1 - LMP 675	Zytek	3396A
10	Racing for Holland	NLD	LMP1 - LMP 900	Dome Judd	3998A
12	Courage Competition	FRA	LM P1	Courage Judd	3997A
13	Courage Competition	FRA	LM P1	Courage Judd	3997A
16	Pescarolo Sport	FRA	LMP 1	Pescarolo Judd	4997A
17	Pescarolo Sport	FRA	LMP 1	Pescarolo Judd	4997A
18	Rollcentre Racing	GBR	LMP1 - LMP 900	Dallara Judd	4000A

LMP2

20*	Pierre Bruneau	FRA	LMP2	Pilbeam - JPX	3396A
23	Gerard Welter	FRA	LMP2	WR	3367A
24*	Rachel Welter	FRA	LMP2	WR - Peugeot	1999T
25	RML	GBR	LMP2	LOLA MG	3397A
30	Kruse Motorsport Ltd	GBR	LMP2	Courage Judd	3395A
31	Noel Del Bello	FRA	LMP2	Courage - CG	3400A
32*	Intersport Racing	USA	LMP2	Lola AER	1995T
33*	Intersport Racing	USA	LMP2	Courage Judd	3397A
34*	Miracle Motorsports	USA	LMP2	Courage - AER	2000T
35	G-Force Racing / Bokkenrijders	BEL	LMP2	Courage Judd	3400A
36	Paul Belmondo Racing	FRA	LMP2	Courage Ford	2000T
37	Paul Belmondo Racing	FRA	LMP2	Courage Ford	2000T
39	Chamberlain - Synergy Motorsport	GBR	LMP2	Lola AER	1995T
45	Lucchini Engineering SRL	ITA	LMP2	Lucchini Judd	3400A

GT1

50*	Larbre Competition	FRA	LM GT1	Ferrari 550 Maranello	5853A
51*	BMS Scuderia Italia	ITA	LM GT1	Ferrari 550 Maranello	5853A
52	BMS Scuderia Italia	ITA	LM GT1	Ferrari 550 Maranello	5853A
58	Aston Martin Racing	GBR	LM GT1	Aston Martin DBR9	5992A
59	Aston Martin Racing	GBR	LM GT1	Aston Martin DBR9	5992A
61	Cirtek Motorsport	RUS	LM GT1	Ferrari 550 Maranello	5853A
63*	Corvette Racing	USA	LM GT1	Corvette C6-R	6991A
64*	Corvette Racing	USA	LM GT1	Corvette C6-R	6991A
69	JMB Racing	MCO	LM GT1	Ferrari 575 GTC	5993A

GT2

71	Alex Job Racing	USA	LM GT2	Porsche 911 GT3 RSR	3600A
72	Luc Alphand Aventures	FRA	LM GT2	Porsche 911 GT3 RS	3598A
77	Panoz Motorsports	USA	LM GT2	Panoz ELAN	5000A
78	Panoz Motorsports	USA	LM GT2	Panoz ELAN	5000A
80*	Flying Lizard Motorsports	USA	LM GT2	Porsche 911 GT3 RSR	3600A
83	Seikel Motorsport	DEU	LM GT2	Porsche 911 GT3 RSR	3598A
85	Spyker Squadron b.v.	NLD	LM GT2	Spyker C8 Spyder	3800A
89*	Sebah Automotive Ltd	GBR	LM GT2	Porsche 911 GT3 RSR	3600A
90*	White Lightning Racing	USA	LM GT2	Porsche 911 GT3 RSR	3600A
92	Cirtek Motorsport	RUS	LM GT2	Ferrari 360 Modena GTC	3586A
93	Scuderia Ecosse	GBR	LM GT2	Ferrari 360 Modena	3596A
91	S1 T2M Motorsport	JPN	LM GT2	Porsche 911 GT3 RS	3598A
95	Racesport Peninsula TVR	GBR	LM GT2	TVR Tuscan 400 R	3996A

*Automatically selected competitors

INTERCOM

SAM COLLINS

Just a thought... I was pondering the future development of sports racing cars and came up with a new theory – could sports prototypes become faster than F1 cars?

The development of sports racers is soon to become inextricably linked to developments in F1, at least it will if the current rules stand. So in theory LMP2 could become a faster class than LMP1, quicker even than F1. So what is going on?

Currently the V10 engine in a grand prix car has to last two complete meetings – practice, qualifying and the race – without any significant work being carried out. That's a total distance of nearly 1000km per engine. In which case a current specification F1 engine would theoretically last the whole of an LMES race.

But where does LMP2 come into all this? Well, a 3.0-litre V10 is not allowed to be used in LMP2 under the current regulations, but from next year works F1 teams will have to use 2.4-litre V8 engines. A 2.4-litre V8 that lasts two meetings would be compact enough, and reliable enough, to bolt into the back of pretty much any of the current breed of LMP2 – from Radical to Lola. It is also acceptable under the ACO rules.

However, the long-term plan for GP engines is to make them last six meetings – a total distance of around 3000km. Not quite the 5000km required for Le Mans but easily capable of all the other LMES races, and a fair few in ALMS, too.

With the might and facilities of F1 engine development powering LMP2, is it simply a matter of time before the second prototype division becomes quicker than the first? Will BMW, Ferrari and Mercedes all return to sportscar racing, to use it as a test bed for Formula 1? It may also work in the other direction though – Porsche, for example, could develop a 2.4-litre V8 for its newly announced ALMS programme and suddenly we could see a Sauber-Porsche F1 team.

Of course, sports racing car engines breathe through a restrictor, meaning some alterations would have to made, but even so, a works BMW or Ferrari V8 would most likely be more powerful and generally better than anything currently on the market that meets LMP2 regulations.

Is this the beginning of a new Group C? Prototypes that are quick enough to qualify near the front of an F1 grid, works teams developing components for F1 and an alternative to GP2 for talented young drivers, engineers and teams. This is, after all, the way Sauber found its way to Formula 1. As I said, it's just a thought...

BAR-red

LAT

Harsh punishment by the FIA has led to much speculation on the BAR case

LAT

BAR was banned from two grands prix and disqualified from the San Marino round of the Formula 1 World Championship for being underweight when drained of all fuel. Fuel was discovered to be in the car's collector within the main tank on Jenson Button's car in post-race scrutiny.

The team was also hit with a six-month ban suspended for one year, starting after the conclusion of the two-race ban. Nick Fry responded to the ruling by saying 'BAR Honda is appalled at the decision of the FIA court of appeal and asserts that the judgement is contrary to all of the evidence heard. The team proved that it complied with the current regulations and the FIA now acknowledges that the regulations are unclear. We repeat that at no time did BAR Honda run underweight at the San Marino Grand Prix and this was also unchallenged by the FIA.'

● See Insight – page 15

North American Eagle land speed record attempt

The North American Eagle (NAE) land speed record challenger has successfully completed its first tests. The top speed achieved by the Lockheed Starfighter-based machine was an encouraging 312mph, during passes along a 5000ft runway. Next up are tests on a longer runway, possibly the one at Edwards Air Force Base where speeds of up to 500mph should be achieved, with 800mph the ultimate target. The current land speed record stands at 763.035mph, held by Thrust SSC.

However, the NAE team is now presented with the biggest challenge faced by all land speed record attempts – the battle to find sponsorship money. If finance is found then the record attempt could take place this autumn.

North American Eagle

Is it a plane or is it a land speed record car? In fact it's a combination of both

New Minardi breaks cover

Minardi's new PS05 ran for the first time shortly before making its debut at the San Marino Grand Prix. Neither car finished.

LAT

FIA not flexible on wings

The FIA has introduced stricter rear wing flexibility tests after complaints about illegal wings being run in the opening rounds of this season. Teams now have to prove that the trailing edge of the rear wing is able to withstand a downward force of 200N without more than 5mm of distortion. Article 3.17.6 of the F1 technical regs now reads: 'The forward-most aerofoil element lying behind the rear wheel centreline and more than 600mm above the reference plane may deflect no more than 5mm vertically when a 200N load is applied vertically.' Flexible aerodynamic elements are currently banned in F1, as they constitute a moveable aerodynamic aid. They were banned in early 1999 after a spate of high-speed accidents caused by rear wing failures, most notably the BAR of Jacques Villeneuve during that year's Australian GP. More recently, rear wing failure was thought to be the cause of Ralf Schumacher's accident at Indianapolis in 2004.

Teams are now required to demonstrate the ability of rear wings to withstand distortion through downforce

Toyota pit lane fire

One of the Toyota TF105s burst into flames whilst departing its second pit stop at the Spanish Grand Prix. The reason for the fire is unclear, but early speculation suggests a fuel spillage or overfill of oil. However, the fire did not hinder the speed of the car – it finished third.

NEWS IN BRIEF

- Enrique Scalabroni wants to take his GP2 outfit, BCN Compeición, to Formula 1 by 2008. Scalabroni, who was involved in the failed Asiatech F1 bid, revealed his aim at GP2's official launch.
- The Bahrain Grand Prix marked the 250th Formula 1 victory for cars using AP racing brakes. The first car to win using the firm's product was a Ferrari 312B in the 1971 South African GP.
- Midland F1 has bought the Jordan wind tunnel facility at Brackley. As yet it is unclear how this will affect the design of the team's Dallara-built chassis for 2006.
- T-Mobile has been announced as the official mobile 'phone supplier to Jordan Grand Prix.
- Construction of the new 'Cityscape' circuit in San Jose has commenced. The 1.6-mile street circuit will run past a number of the city's better known landmarks.
- Arden International will run A1 team Great Britain in the inaugural A1 Grand Prix series. It was also announced that the British team's car will be painted in traditional green.
- Shell will continue to supply Ferrari with fuel until 2010. The Italian team has been using Shell fuel continuously since 1996.

Renault insures for the future

Renault F1 has signed a new long-term sponsorship deal with Spanish insurance firm Mutua Madrileña (MM). It is the first foray into sports sponsorship for the 75-year old company. Mutua's MM logos will appear on the Renault R25s from the Spanish Grand Prix onwards. The insurance firm's chairman José María Ramírez Pomatta inked the deal with Flavio Briatore at the grand prix team's HQ in Enstone, England.

Engine swaps as Red Bull gets prancing horses

Red Bull Racing has announced it will be switching to Ferrari engines. Red Bull's Christian Horner stated: 'This is an enormous boost for the team and underlines our commitment to compete at the forefront of Formula 1,' speaking on the deal which will see the Italian engine power the Red Bulls in both the 2006 and 2007 seasons.

Ferrari currently supplies engines to the Sauber team, but this looks unlikely to continue into 2006 with BMW firm favourites to supply the Swiss outfit, although a Ferrari deal has not yet been ruled out.

Red Bulls will now run with Ferrari power in 2006 and 2007 seasons

The announcement ends recent speculation that Red Bull would run with Dodge engines.

Red Bull Racing's current engine supplier, Cosworth, has resolved to remain in Formula 1 as an engine supplier, despite the news of the switch, but as yet it is unclear whom Cosworth will supply its new 2.4-litre V8 to. Currently the only team with a Cosworth contract is Minardi, who will be using the V10 unit again next year.

Toyota show in Busch?

Toyota officials are expected to announce during the summer that they will field cars in the Busch Series for the 2006 season. NASCAR has a deadline each year of 1 July for any manufacturer wishing to submit new car models so a decision has to be made before that date. The car of choice will more than likely be the Toyota Solara – a two-door coupé based on the best selling Camry platform – that has already undergone wind tunnel testing with help from Bill Davis Racing. BDR has a strong Toyota bond through its truck racing programme and already shares building space with the manufacturer.

LAT

Toyota's current NASCAR involvement is limited to the Craftsman Truck Series

Split rims

A number of NASCAR teams have suffered wheel failures, most recently the Nextel Cup Chevrolet of Tony Stewart. The Joe Gibbs Racing-run car also suffered a broken centre on its right front wheel at the half-mile Martinsville Speedway on 10 April. This forced many teams to use their 2004 model wheels the following week at the much faster Texas oval. Currently three US manufacturers have steel wheels approved for use by NASCAR, but only two are widely used, the third company only being granted approval in the off season.

$50,000 carburettor

A NASCAR official was released after a carburettor was changed on an impounded car. The James Finch owned Phoenix Racing car was disqualified from the Texas Busch Series race when, during post race inspection, an illegal carburettor was discovered. Apparently it was changed after the car was impounded following qualifying and, when the governing body reviewed how this was achieved, the official was released immediately. The oversize carburettor helped driver Johnny Sauter to a 14th placing but, along with the disqualification, both his prize money and series points were forfeited. Crew chief Joe Shear Jr was suspended for four events and the team was fined $25,000 (£13,000), only for Finch to appeal the penalties and to be hit with an additional $25,000 by the National Stock Car Racing Commission.

LAT

Heavy fines imposed on Phoenix Racing after the discovery of an illegal carb

Track grinding to improve Charlotte

LAT

Diamond cutting the groove at Lowes looks to have improved the outside line

Lowe's Motor Speedway has undergone a track grinding operation in a quest to increase grip in the outside groove. The Charlotte track underwent the work in readiness for two weeks of racing that takes place during May. A diamond grinder was used in the outside groove of the turns to roughen the asphalt surface with the intention of making the outside as fast, or possibly even faster, than the inner racing line. Early results from testing at the 1.5-mile speedway during the end of April and early May were positive.

Caught in the nets

A number of Nextel Cup teams have been accused of using window nets with undersize holes to gain an aerodynamic advantage. Five teams had nets confiscated prior to the May Talladega event. Those caught were the two Roush Fords of Matt Kenseth and Carl Edwards, Jason Leffler's Joe Gibbs Chevrolet, the Mike Bliss Haas Chevy and Jeremy Mayfield's Evernham Dodge.

Fame academy bids

At least six US cities are vying for the NASCAR hall of fame. Among those expected to lodge bids are Charlotte, Kansas City, Richmond, Daytona Beach, Atlanta and Detroit. Many of the cities are looking towards airport, hotel and car rental taxes as a way of paying for the initial structure should they be the winning bidders.

'Superally' slammed by crews

World Rally crews condemned the new 'superally' system after the recent Rally of Italy, Sardinia.

Co-driver Timo Rautiainen stated: 'The superally system – I would use the word ridiculous. A driver who has done a fantastic rally, Harri Rovanpera, had a hold on a podium position but ended with zero points.

Toni Gardemeister, who had a medium rally, retired yesterday and finished fifth today.

If the FIA's purpose was for the spectator to see more cars in the forest, okay, but now we have to find a different solution for the drivers who do two and a half days and then retire: so stupid.'

Of the 20 top classified crews, seven would not have finished the rally had the 'superally' system – in which cars which retire from a leg of the rally are permitted to re-start the following day's leg with a penalty – not been in place.

New Superally regulations, aimed at getting more cars out on stages in front of the spectators, are not proving popular with the crews

LAT

NEWS IN BRIEF

- Entry numbers are expected to increase in the BTCC throughout the season. Both Team Halfords and team Synchro Motorsport are expected to run extra cars.
- Renault has confirmed it will continue to run support races at BTCC meetings. Formula Renault and the Clio Cup are the current series run by the French manufacturer, which has been active in British motorsport for 30 years.
- The NASCAR Brickyard 400 held at Indianapolis Motor Speedway since 1994 will have a new name this year, with the naming rights going to Allstate Insurance and a name change to the Allstate 400.
- The scheduled DTM street race in Avignon, France has been cancelled due to French laws banning street races. Some street races are occasionally granted an exception to these laws, such as those run in Pau, but the Avignon event will not be granted such an exception.
- Chinese manufacturer Brilliance has postponed its debut in the World Touring Car Championship until 2006, due to problems with a contractor.
- Mitsubishi has confirmed that it will again contest the Dakar Rally using a new specification Pajero.

Peugeot Sport – putting a damper on proceedings?

Consistent criticism of the Peugeot 307 WRC's handling from its drivers has pressured team management into considering outsourcing shock absorbers for the car. Peugeot Sport has traditionally used its own-brand units in world rallying, but now team bosses are heeding drivers' complaints that the lack of adjustability in these units contributes to uncompetitive handling.

Peugeot Sport director, Jean-Pierre Nicolas, explained on the Rally of Italy that it is mandatory for the team to use Peugeot damper casings, but that the team is currently investigating substituting internals manufactured by: 'Öhlins, Sachs - anybody.'

It is understood that Dutch firm Reiger is also under consideration for this supply. Reiger already supplies works rally car damping equipment to Ford, Skoda and Suzuki.

LAT

New damper suppliers are being looked at to make Peugeot more competitive

New Focus WRC now planned to rally this year

The all-new, M-Sport-designed Ford Focus WRC for 2006 faces a rushed development schedule to have it ready for a competition debut in September or October this year.

Ford's European motorsport boss, Jost Capito, admitted at the Rally of Italy that the manufacture of parts for the new car was just beginning to take place and that it is too early to confirm whether a 2005 debut will be feasible, but: 'In principle, I think it is good to have rallies before the start of the World Championship next year. Experience in competition is always good,' he said.

Designed under the leadership of Christian Loriaux, the new 2006 car will be different to the outgoing Focus RS WRC04 in a number of ways, principally in that it will feature a different engine and a completely revised location – that being a transverse gearbox in place of the transverse engine/longitudinal Xtrac gearbox of the older car.

Loriaux has selected FFD/Ricardo as suppliers for the new car's transmission parts, part of his decision being based on the fact that World Rally Cars will not be allowed to use active differentials in the 2006 season.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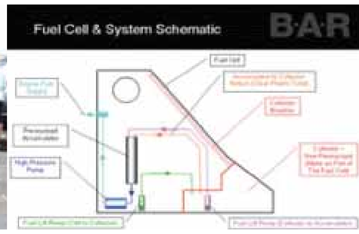
Fuel for thought

BAR Honda's two-race exclusion divided opinions, but what really happened behind the scenes in the episode widely reported as a Formula 1 scandal?

BY CHARLES ARMSTRONG-WILSON





After trying to argue the point on technical grounds, BAR has had to concede and accept that the FIA's ruling regarding a Formula 1 car's minimum weight is clear

When Jenson Button's BAR Honda was declared illegal following the San Marino Grand Prix, the headlines were full of accusations of cheating. However, the team vigorously denied the claims and was willing to defend itself at an appeal hearing in Paris. After presenting its case, the verdict ruled against BAR Honda but the team still denies any attempt to break the rules and feels the two-race ban it received was unnecessarily harsh.

The FIA, on the other hand, has spoken robustly on the subject, claiming the team had got off lightly. So what were the real circumstances and how did this situation come about?

Before the start of the season, uncomplimentary rumours were circulating about BAR's tactics that were said to come from a couple of the team's ex-employees. However, it took until the San Marino Grand Prix for a BAR Honda to make it into the points for the first time this season, with Button taking third and Takuma Sato fifth. Consequently this was the first time the cars were subjected to the full post-race scrutineering process. In fact, Button's car came in for even closer examination than normal.

Unusually, the stewards asked for the fuel tank to be pumped out, and a team member obliged using a lift pump. Only 160g of fuel were initially extracted and he reputedly said, 'that's it', to confirm it was empty. This raised the steward's suspicions, as when using an endoscope they discovered more fuel in the tank. Another 2.46kg was pumped out of the main tank and a further 8.92kg extracted from the forward collector. In its defence, BAR claims the man doing the pumping, Chris Fry, was the truck driver and would not have been clear on the precise construction of the tank and how to empty it correctly.

Neither, it seems, was the FIA, as race director Charlie Whiting began intimating that the stewards had found a secret tank in the BAR. In fact, according to ATL, the company that manufactures all the tanks for the Formula 1 teams, the BAR tank is fundamentally the same as those of all the other teams.

To aid fuel pick-up, the tanks incorporate a two-stage collector system. Fuel is pumped from the main tank to an unpressurised, forward collector. This acts as a reservoir for supply to a pressurised rear collector. Once this was pointed out to Whiting, the secret tank accusation was quickly (and quietly) dropped.

When the tank had been fully drained, the car was weighed again and found to be 594.6kg, 5.4kg below the minimum weight limit. Based on this, the stewards moved to exclude the car on the reasoning that it could have run underweight approaching the first and second pit stops. BAR responded by presenting fuel consumption data from the race showing that at no point did the car actually run below 600kg. On this evidence the stewards accepted the car's legality, but the judgement was overturned by the FIA. It declared that, according to the rules, a car's minimum weight should be without fuel on board. This was the point around which the whole case subsequently pivoted and the main plank of BAR's subsequent appeal.

"THE BAR FUEL TANK IS FUNDAMENTALLY THE SAME AS THOSE OF ALL THE OTHER TEAMS"

In a complex defence citing a number of FIA regulations, BAR contended that it was not clear that the minimum weight of the car could not include residual fuel. It also insisted that for the car to be operational, a certain amount of fuel in the tank was necessary to ensure reliable pick-up. To run significantly less than Button's car finished the race with would have risked fuel surge and cavitation in the pumps, with subsequent damage that would have led to retirement. Therefore, the cars would have been realistically unable to run underweight without risking reliability.

This defence was rejected by the FIA though on the basis that the rules are clear and, if they were not, then it is the responsibility of the competitor to seek clarification as laid out in the rules.

Jenson Button's car was still underweight once drained and was therefore still illegal, and BAR was handed a two-race suspension and docked its points from San Marino.

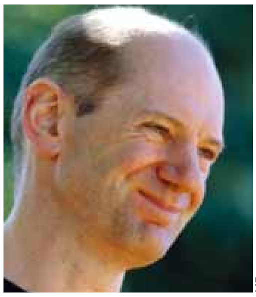
BAR Honda was finally forced to accept the circumstances and issued the following statement in the week following the Spanish GP: 'Having investigated the matter fully, including making extensive enquiries of other teams, BAR Honda now accept that Formula 1 cars must always weigh more than 600kg when completely empty of fuel, and that this applies even if the car's fuel system is such that some of the fuel in the car is unusable. Before making these enquiries, it was the team's honest belief that fuel which could not be used during the race did not have to be removed before the car was weighed.'

Taking a charitable view, the episode seems to have emerged from a degree of naïvety on both sides – BAR Honda with the rules and the FIA stewards with the design of current F1 cars.

Race people

LAT

Flavio Briatore



LAT

Adrian Newey

LAT

Yasuhiro Wada

LAT

Ryan Dalziel

● Renault Formula 1 team boss **Flavio Briatore's** contract with the team has been extended until the end of 2006.

● **Robby Gordon** released his crew chief Bob Temple at the end of April. Temple and Gordon had worked together in motorsport for many years.

● **Greg Erwin**, former Ganassi, Richard Childress Racing and, more recently, Truck Series team Express Motorsports' engineer has replaced Bob Temple.

● Former general manager and vice president of the Milwaukee mile, **Mark Perrone**, has joined the organising team behind Champ Car as the vice president of promoter services. Perrone has previously worked in NASCAR, NHL and organised concerts for musicians such as Faith Hill.

● McLaren has extended its technical director **Adrian Newey's** contract for an undisclosed length of time. Rumours suggest the extension only runs until the end of 2005.

● Current Honda Racing president **Yasuhiro Wada** will replace **Shoichi Tanaka** as Honda Racing Development president when Tanaka retires later this year.

● M-Sport senior designer **Simon Carrier** has been promoted to the role of chief designer. Carrier will be working on the design of the 2006 Ford Focus WRC.

● **Heather Haupt** has resigned from her position as news associate for the Champ Car World Series and joined the Rocketsports team as the public relations representative. She will based at the outfit's HQ in East Lansing, Michigan.

● Champ Car outfit PKV racing has hired **Tom Brown** as the team's new technical director. Brown, who has spent time at HVM, Bettenhausen Motorsport and Penske will replace PKV's previous technical director **Steve Challis**.

● PKV has also reached an agreement with **Ryan Dalziel** that will see the Toyota Atlantic driver act as consultant to the team. He will work with the engineering staff and the drivers, as well as being involved with the team's marketing.

● **David Knight** has rejoined the company his father started, Jack Knight Developments, as senior designer. Knight designed many of the components the firm currently supplies.

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...

ADRIAN DANIELS
Director, ADR Engineering

Daniels heads up the Maidenhead-based sports racing car manufacturer, doing both design and marketing work. A new open-topped prototype is currently under development

How did you first get involved in motorsport?

When I was young my father raced a Mk2 Jaguar, it had an effect on me and in 1996 I started racing in 750 Formula in my own car.

What's the most interesting project you've ever worked on?

I think it must be what we are doing now, but other than that, when I was working for Wokingham plastics I did a lot of work with companies like Reynard and McLaren. The relationships I gained there helped me a lot.

What achievements are you most proud of?

The first time the ADR 1000 raced in the series it was made for – Sports 1000. Although there were only four cars, ours lapped all of them in a short race.

Can you name your favourite racecar of all time?

I could never afford one, but the Alfa Romeo Tipo 33. There's one that still races in historics – it's a gorgeous sounding thing.

Who do you most admire in racecar engineering and why?

Colin Chapman for the innovation. I don't agree with some of the things he did though. The safety of some cars was questionable.

What racing era/formula would you have liked to work in and why?

The late '60s and early '70s in sports racing and GTs. You had great cars like Ford prototypes and Lola T70s. That era of motor racing seemed to be far more about the sport and less about the politics. Even the big teams were turning up with their cars on the back of some old truck. Now even club racers have motorhomes. I still watch videos about racing back then.

What tool/instrument could you not work without?

I reckon the tool we couldn't do without is the Haas CNC machine – we seem to do everything on that at the moment.

What engineering innovation do you most admire?

Carbon fibre, and the development of it to create usable strength and lightness. Of course its amazing the way it has developed, looking at the components that use it today.

Is motorsport about engineering or entertainment?

Both. Entertainment for the competitors and engineering for the teams and manufacturers. Join the both of them together and you get a good result. We get entertainment from engineering by trying to beat our competitors whilst spending similar money.

What new technologies in motorsport are you most excited about?

We are getting into aerodynamics at the moment, our new car is going to the wind tunnel next week as a scale model. Aside from that, the evolution of motorcycle-based engines for racecar applications. We have a new one that we will be trying out soon, that's quite exciting.

Is there a future for high technology in motorsport?

Yes. There must be. A Formula 1 car should be the very best of what you can get from what you have got. Not the current situation of over regulation and capped development. ABS, electronic ignition and tyre technology have all filtered down to the road car market and that's very important. If you stop development then the technology itself cannot filter down.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Autosport International ENGINEERING SHOW

News

The much anticipated Autosport Engineering show is due to take place on 12 and 13 January 2006 and, with seven months still to go, the limited number of stands are already selling out fast.

An impressive 90,000 tickets were sold at the 2005 Autosport Engineering show in January – 26,000 being trade visitors and 64,000 public guests. Yet stand bookings for the next anticipated show in January, with an intended 400 due to exhibit, have already outsold 2005 figures by 20 per cent.

Tickets are not available until the website comes online on 1 July 2005, yet research has found that some of the most prominent figures in the industry secure their tickets to what has been termed as one of the world's most significant motorsport showcases at least six months in advance.

The show receives enormous attention from overseas trade and over 3500 international visitors. Many of the most important players in the business travel to the UK each year to be part of it. Because of this attention, Autosport 2006 Haymarket Exhibitions is working closely with the Motorsport Industry Association to draw in more inward missions with direct concentration on Germany and America.

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 it, then contact Racecar's Tony Tobias. Email expo@tonytobias.com or call him direct on +44 07768 244 880.

On the Pace

Pace Products is just one of the many leading names set to take part in next year's Autosport Engineering show

Specialising in the design and manufacture of remote-mounted oil pumps and dry sump oiling systems, Pace Products continues to contribute to its vast experience within the motorsport industry.

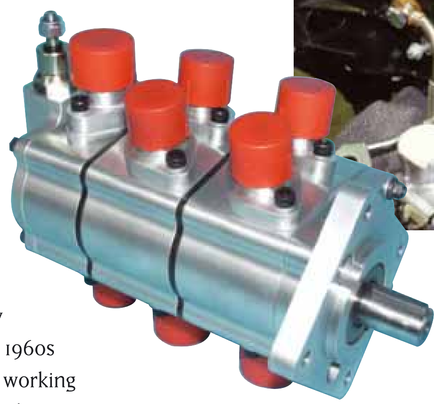
Previous co-owner of Hawk racing and producer of the Hawk DL Formula Ford racecars, David Lazenby, founded Pace over 25 years ago. Lazenby originally worked as chief mechanic to Jimmy Clark at Lotus F1 during the 1960s and honed his design skills working alongside the likes of Colin Chapman.

Since the company's conception, Pace has grown from being a double garage in Lazenby's garden to the 26,000 sq ft factory unit it is today, staffing close to 30 experienced employees.

Pace initially branched out by turbocharging road cars and manufacturing a limited range of specialised parts, but it was when they started supplying oil pumps to companies such as Leyland for the Sunbeam Lotus, TR8 and Vauxhall HSR projects that the company really began to progress.

Technical director Neil Patterson joined the business 21 years ago and since then has worked hard at building strong customer relationships, with a primary focus of treating all customers as equals. These relationships have extended to many BTCC teams, culminating in a point when all of the cars participating were equipped with at least one of Pace's line of products.

Today Pace is also a manufacturer of aluminium water radiators, intercoolers and charge coolers – all created in-house to meet specific design requirements. Remote-mounted pumps and complete dry sump kits are also products now firmly associated with the Pace name. The company's ability to create individual components to meet customer requirements has led to its expansion into the automotive racing and OE world, where it also now offers a consultation service, as well as confidential work for the Ministry of Defence.



Dry sump oil systems and remote oil pumps are a Pace speciality

More recently Pace has been working on tapered/curved water intercoolers and oil cooler cores and cooling units for World Superbikes.

It is currently looking to join the MIA and progress into becoming a key distributor for dry sump fittings, K&N filters, oil hose lines and Setrab oil coolers, to compliment the existing range.

Pace was one of the original players to appear at the Autosport Engineering launch show and has been a regular attendee over the last six years.

It sees the show as an opportunity to interact directly with its buyers as the company strives to create the products required within the motorsport industry without compromise.

With spectators and engineers alike promising to flock to the show in their droves, there is guaranteed to be ample opportunity to grow.

Contact

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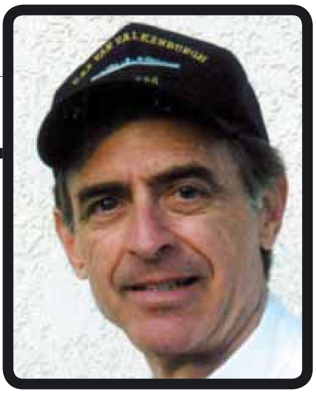
SUSPENSION TECHNOLOGY

By Paul Van Valkenburgh



Perfect harmony

After decades of technological advancement, have machines caught up with humans, or are the gifted few still one step ahead?

We all know of race drivers who seem to have superhuman talents. So why shouldn't we expect to find engineers, crew chiefs, and tuners with apparently superhuman skills, too? While it may be rare to find a driver who also has a valuable 'empathy for machines', in addition to his vehicle control skills, we all know of engineering or mechanical wizards who just seem to 'know' when something is not right, or about to fail. They may say 'That doesn't sound right', and when you put the instrumentation on it, sure enough, a potential disaster becomes apparent. Or maybe it is ignored, and fails, to which they may reply, 'I tried to tell you.'

All that our world is is what our senses perceive. And sometimes I think that intelligence is little more than pattern recognition of those sensations – or in other words how early, how quickly, and how accurately we can identify and predict what those perceptions actually mean.

It's natural to assume that everyone perceives the world with the same average senses we ourselves have. And yet it's obvious that some people are born with deficiencies in vision, hearing, balance, vibration awareness etc.

It therefore shouldn't be any surprise that others could be more sensitive at some perceptions. It's not too uncommon to find people with vision testing at 20:15, or 25 per cent better than the standard average 20:20. That's why they put those smaller letters on the Snellen eye chart. And my younger ears could tell when a so-called 'ultrasonic' burglar alarm had been left on. But so what? How does that relate to racecar engineering?

When it comes to optimising something as complex as a racecar, to a winning level of →

> "CONSIDER SOME OF THE WAYS AN EXPERIENCED ENGINEER MIGHT OUT-PERFORM SCIENTIFIC MEASUREMENTS"

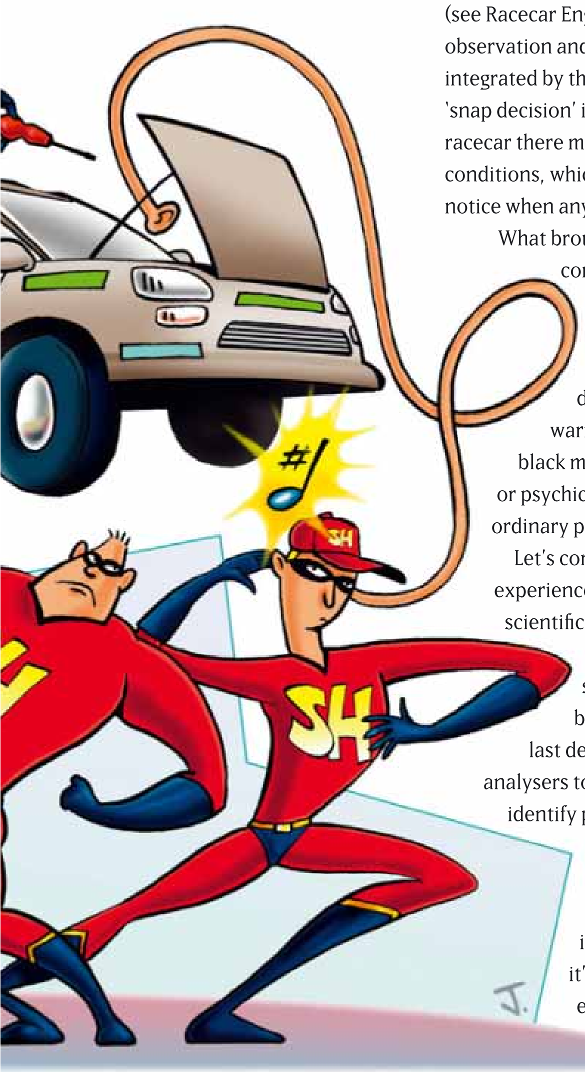
> **“THE LAST I HEARD, SKILLED PROFESSIONAL ENGINEERS STILL HAD THE ULTIMATE SAY”**

precision, sometimes mechanical or electronic data may not be good enough.

Long ago, when I was responsible for setting up lots of cars, I asked a mechanic to re-check a camber angle. He said, 'It's three degrees.' I said, 'Check it again.' Again he said, 'It's three degrees.' So I said, 'Check your gauge.' And sure enough, the bubble level had come loose. That doesn't take x-ray vision but, putting that into perspective, one degree equals an angular displacement of over one inch at five feet.

We are only really conscious of a miniscule fraction of all the sensory inputs we receive, or we might be overwhelmed into paralysis (some people believe that is a symptom of autism). Most interpretations and decisions are made below the level of conscious awareness, they aren't explainable. We either can't explain them, or don't want to try. Sometimes I sit at an intersection, staring ahead, and as cars zoom past, in a sort of 'stop-action' vision, I can perceive whether they have smooth or spoked hubcaps – something I couldn't distinguish if I panned with them. I can't explain that. Maybe it's not uncommon?

We can only hold about seven or eight factors or variables in our minds at one time (think of 'phone number digits), while it's not unusual for scores of them to be required in any decision. As I age, my continually more limited memory is the reason I wanted to develop the PDAdVisor for racecar set-up (see Racecar Engineering V12N9). Many years worth of observation and similar experiences are often integrated by the subconscious, and the resultant 'snap decision' is merely credited as intuition. In any racecar there may be hundreds of possible 'not right' conditions, which we couldn't even list. But we may notice when any one of them is 'not right'.



What brought all this to my mind was being consulted about a screenplay based on the premise of a tuner who seemed to have a 'magical power' of just waving his hand over the engine and determining if it was down on power. I warned that it shouldn't come across as black magic, or paranormal, supernatural ESP, or psychic – but as merely hypersensitivity to ordinary perceptual cues.

Let's consider some of the ways a skilled and experienced engineer might out-perform scientific measurements.

Our hearing is a precise sound spectrum analyser, which has only been equalled by instrumentation in the last decade or so. It's now common for digital analysers to use FFT (Fast Fourier Transforms) to identify problem frequency peaks in sound signals from gear trains and engines. But humans have been 'tuning by ear' using relative pitch, ever since the invention of musical instruments. And it's well known that some super humans even have 'absolute pitch', giving them the power to actually quantify frequency peaks – as in the identification of musical note values – or fractions of error between them. They can tell if a frequency is off by just a few Hertz. The thought just occurred that if they learned what the conversion was between pitch and rpm (based on the number of cylinders firing) that they might also learn to be accurate 'human tachometers.' Maybe some race drivers already have this talent?

However, when it comes to diagnosing problem sound spectrums, some frequencies may be masked from conscious awareness by louder nearby frequencies. And yet the experienced subconscious may be able to intuitively recognise a condition of 'danger – about to fail' above the apparently random noise. And think about locating the source of sounds of interest. I'm not sure science has yet explained how the brain can make the necessary time lag distinction in the short distance between the two ears, which is necessary to identify where sounds are coming from within a few degrees.

Vision may not be quite so valuable in the prediction of mechanical optimisation or imminent failure. And yet, consider that highly experienced racecar engineers (DAS author Buddy Fey, for example) can identify pattern signatures in plotted data that are just now being mathematically understood. We've been using digital data acquisition for decades, without the ability to identify understeer/oversteer as precisely as a good driver. There are still indefinable or unquantifiable subtleties in recognising optimum human performance – whether in athletics, dance, or driving skill – that are still best judged subjectively.

When it comes to the final decision in rating NVH (noise, vibration, harshness) in automotive ride quality, the last I heard was that skilled professional engineers still had the ultimate say. Maybe not in the specifics of absolute frequency or amplitude, but in the acceptability of the overall integration of the total signal.

Then there is the rare and exotic perception of 'synesthesia,' or cross-perception between senses. People with this talent may see colours or patterns which represent touch or sounds. For example, the number four may be visualised by a person with this condition as the colour orange, while a rough texture may be visualised as being brown with white stripes. Consider that composers may think in terms of 'the blues', or 'white noise', and artists sometimes paint to music. Who knows, maybe some engineers see different frequencies of gear whine, for example, as distinguishable patterns? And remember, we don't just have the traditional five senses of vision, sound, touch, smell, and taste either, but many others that are more subtle, such as temperature, acceleration, and balance.

I'm not suggesting that these additions to the master engineer's arsenal can be learned, much less taught, because they are most likely innate neurological distinctions on a continuum for all humans. But maybe we can learn to identify and take advantage of those mortals who are so gifted. RE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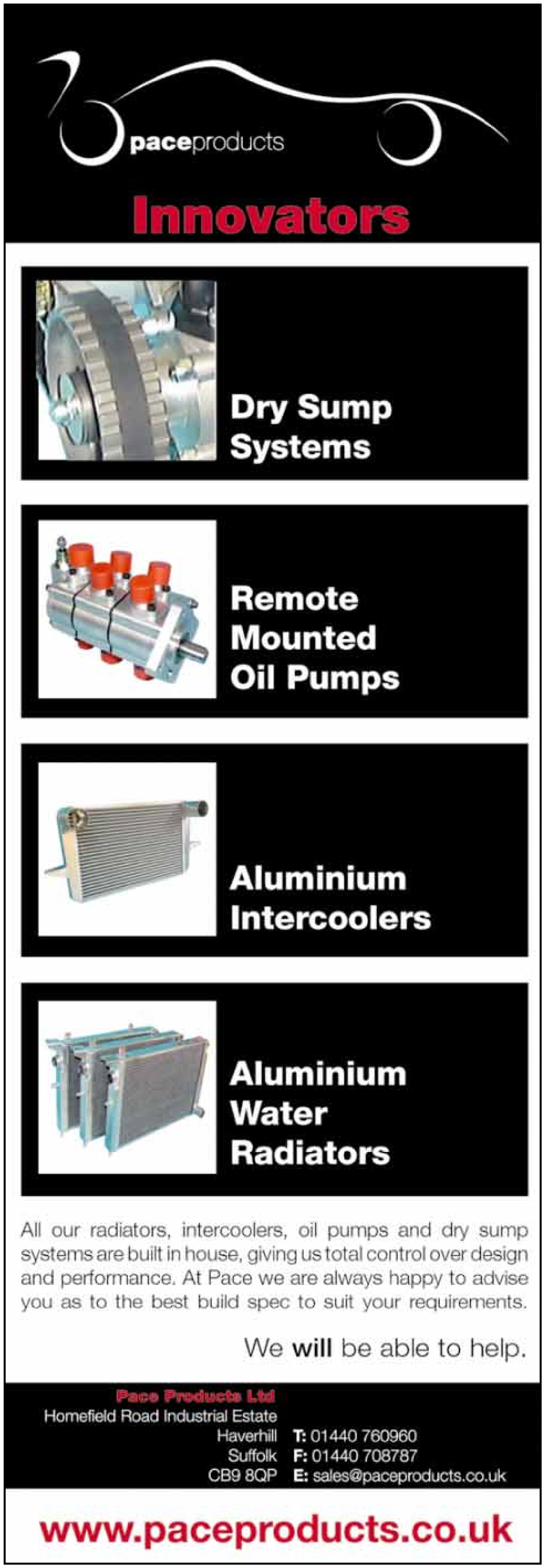
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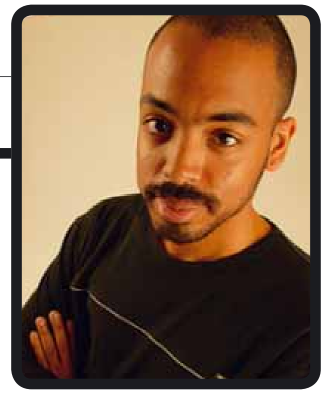
By Sam Collins



Entertainment for the people

With dwindling grid numbers and spectators deserting traditional UK motorsport series, is it time manufacturers looked to other, less glamorous series to promote their brands?

Photos: Karsten Beilschmidt

Whilst Britain is often perceived to be a world leader in motorsport engineering, its national racing scene is in decline – rising costs and poor organisation amongst the factors forcing competitors away. The spectators, too, turned off by over complex and seemingly illogical regulations, are also long gone. At least that's the case for the sections of the sport that come under the reign of the UK's FIA affiliated governing body, the MSA. However, this downward trend has not been seen in the UK's short oval scene. So why is it that the motorsport industry and motor manufacturers totally ignore a largely untapped market and a great marketing opportunity?

There have been two recent abortive attempts to set up a high-powered, high budget silhouette/spaceframe class in the UK, namely SCV8 and Touring One, but neither got much further than a working test hack. A lot of resources were poured into these projects and they both lead to nothing, yet all the while there was a highly successful racing formula already in existence that met all the goals of the two failed attempts.

The European racing drivers' view of oval and stock car racing is often one of suspicion. When the short circuit variant is mentioned in those circles the opinion is universally one of disdain. Perhaps this is the reason that on the whole the motorsport industry ignores the Cinderella of Britain's high-octane scene. But are they just being blinkered? Short oval racing in Britain is a growth sector, no doubt about it, the simple, stadium-based format and proletariat appeal brings in decent crowds by UK standards on a regular basis. Is it quite simply a missed, or perhaps more correctly a misunderstood, opportunity?

Ill perception

The sport can be split roughly in two, contact and non contact, and it is the former that creates much of the ill feeling towards short circuit racing. The perception of the sport comprising banger racing and destruction derbys, using minimally modified scrapyard escapees, does not help – after all, it's hardly what you might call 'proper' racing is it? However, at the top level of Britain's stock car scene, where National Hot Rods operates, there are classes that, as anyone who had ever witnessed it would surely agree, proper racing is certainly taking place.

Regarding this negative attitude towards stock car racing as a whole, there is a definite touch of that oh-so-British trait, snobbery, at play. The short ovals are seen as lower grade and the fans working class, which to be honest is true. But in their masses these working class fans have buying power. The young males in the crowd may aspire to owning the latest Saxo VTS or Fiesta ST, and be well aware of the 'bling' factor of owning the latest sporty hatchback – especially if it's modified with flared wheel arches, rear wings and body kits as National Hot Rods are – but is it not they who actually buy the hatchback cars represented in Hot Rod form? With its interesting racing, drivers with real personalities, family appeal and excellent →

Low ticket prices and city centre locations make oval track racing attractive to the UK's car-orientated youth market

> **"NATIONAL HOT RODS IS BRITAIN'S OWN VERSION OF NASCAR"**

Though often derided as glorified banger racing, National Hot Rods is affordable, close quarter racing at its best

potential for increasing footfall to dealerships, it's time manufacturers started to take note.

National Hot Rods is Britain's own version of NASCAR. The 200bhp cars have steel spaceframe chassis, clothed in silhouette bodywork based on popular mass produced hatchbacks. Citroën, Ford, Volkswagen, Vauxhall, Peugeot and Toyota are all represented, albeit unofficially. Those silhouette shapes are recognisable to even the most casual European motorsport fan as cars they drive on the road, a fact that is not lost on National Hot Rod

"THERE IS NO DOUBT THE NHRPA SERIES IS CHEAPER [THAN BTCC], BUT CAN IT REALISTICALLY OFFER BETTER VALUE TO MANUFACTURERS?"

Promoters Association (NHRPA) chairman Roy Eaton: 'That's important, perhaps the very casual fan might not know some of the cars, but anyone who knows even a little bit will recognise the cars easily.

'£10–20,000 will buy you a good, front-running car, and top drivers will spend about £1000 per outing, across 17 events. A £20,000 season budget would be about right,' he claims. And that's a modest budget in the motorsport world, but it doesn't seem to affect its success as a formula. There are over 150 drivers registered for this years National Hot Rod series alone, and at least a third of them will compete in every event, all desperate to qualify for the honour of taking part in the world final held every year in Ipswich. An event that is a sell out every year.

The peoples' choice

But where does the series go from here? Does it follow the NASCAR model and become the peoples' racing series? If so, manufacturers need to get involved and run works cars. So why don't they? Perhaps because there is a series that already occupies this position, at least as far as manufacturers see it. The British Touring Car Championship – cars that look much like the ones in the showroom, except with some fancy bodykits (sound familiar?), and a £200,000 running cost. There is no doubt the NHRPA series is cheaper, but can it realistically offer better value to manufacturers?

There's no denying the two series are very different. Whereas the BTCC is seen as a premier league event, short oval racing is part of the community, in some places even responsible for keeping the area alive. But with its city centre philosophy, National Hot Rods has the potential to tap into parts of the population no other form of motorsport can. And with its community feeling, any manufacturer in the sport with the right driver is sure to garner brand loyalty from fans.

Stock car racing is also highly profitable for the venues that host it. Crowds of between 2000 and 15,000 turn out to watch the NHRPA series, each paying around £10. Putting on a show is also something that has not been forgotten by those involved. Sometimes the big events are supported by the popular historic stock car class, other times families are entertained by madcap stunts. At one recent event the organisers drove a Reliant Robin though 11 exploding caravans! Like NASCAR the NHRPA is a show, and it is a good one.

Surely it must only be a matter of time before the manufacturers and mainstream media sit up and take notice of the series and its current growth rate. And what will happen then? Will a manufacturer such as MG or Vauxhall realise that for a fraction of its BTCC budget the company could run works cars in the National Hot Rods and reach a greater number of people with more frequency, at least at the circuits, and perhaps in time, also in the media? After all, what sounds better on a press release, winning a British Championship or a World Final?

Without doubt, the BTCC has more presence in the UK at the moment. It's televised live on ITV (one of the UK's main terrestrial channels) whereas Hot Rods can only currently be found on Sky Sports, so any change in perception is clearly going to be a gradual process. However, this season the BTCC grid looks fairly weak, and it only has a few events near any major population centres. With BTCC budgets now running into millions of pounds you have to question how long Britain's premier saloon series can stay thus. Perhaps the future really is Oval. RE

The key to success is giving the public what it wants to see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LAT

Are Formula 1 teams avoiding intellectual property issues?

Pat pending

Having patented an engine component, I would like to add to your reasons why F1 teams avoid intellectual property matters. Secrecy is part of racing, and a patent is a public document published by the government. Outside inventors are at a disadvantage thinking a patent will protect them in an environment better protected under 'trade secrets'.

In the US, the patent office does not grant patents because it feels benevolent toward the inventor. They grant an inventor the right to control both the use and sale of their idea, in exchange for that inventor showing due diligence in getting the invention to the marketplace in order for the whole of society to benefit. Treating a patent as a secret is in opposition to that purpose.

Additionally, many inventors have only a paper patent and they are naïve about the concept of 'shop right'. This is where an inventor persuades a company to fund the prototype, not realising they may be giving them a 'shop right' to use that design within their environment. RE's article on the Weismann transmission design (V14 N6) might serve as an example. If Wiesmann, paper patent in hand, persuaded McLaren-Honda to fund and build the prototype, they may have given McLaren-Honda a 'shop right' to use that design within their company. Development is only one stage in getting the idea into the marketplace. If the purpose of the inventor is to keep it secret, and thus out of the marketplace, they should not be surprised that the patent office (US) does not defend them.

George Stamps, while working for Bell Labs, invented the fax machine. A very tall man, he leaned over to me and said, 'Son, get yourself a good lawyer.'

Ken Towler
US patent #6,651,607

Ray's sore head

In Simon McBeath's excellent article on end plates (V15 N4) I found some intriguing information that may directly relate to my own programme. I have an asphalt Supermodified with a 2500sq.in free standing, two-element main wing (much like the profile depicted in the article). The endplates are roughly 24in × 36in. This is a fixed wing class, without the flip-up wing mechanisms used in other parts of the country.

While we were running this car in 2001, we tried out some 12in × 36in Lexan extensions on the bottom of the endplates. Initially, we saw no real improvement in either lap time or driver feel, *until* I decided to dramatically reduce the wing angle of attack.

Apparently, we had been running very close to stall, and the extensions had the effect of separating the flow under the wing(?). With the lower wing angle, we immediately noticed that the Lexan strips were being bent nearly horizontal by the pressure drop under the wing! The driver reported improved 'stick' and we saw some improvement in free air lap times. My thoughts at the time were that we were seeing some 'venturi' airflow acceleration as the Lexan sheets folded up toward the wing. We later removed the extensions as the number of head wounds suffered by the crew outweighed any benefit in performance.

Is there some theoretical or empirical explanation for what we were seeing? Are curved or flexible lower endplates an area worth investigation? I'm thinking about getting hard hats for the team and putting those Lexan strips back on...

Ray Kaufmam, by email

Steely Dave

Regarding the Vibration Free article in V15 N5, I'm sure I'm not the first to point this out, but a 10mm length of Ø10mm steel (typically 7.85g/cc) cannot represent 10g.

1cm × 1cm × Pi/4=0.7854cm^2 area and 1cm × 0.7854cm^2 = 0.7854cm^3 volume. 7.85g/cc × 0.7854cc = 6.165g. SolidWorks agrees with me, too!

Dave, chief designer
Engine Developments Ltd.

Return to form

A purpose-built GT car designed with the customer in mind heralds Aston Martin's spectacular return as a racing marque

Words	Ian Wagstaff
Photos	Aston Martin Racing, LAT

It could be said that the Aston Martin DBR9s being built at Prodrive's Banbury operation are 'production' cars, in the same way as any DB9 coming off the line at Gaydon. The main difference, apart from the obvious fact that one is destined for the track and the other for the street, is in numbers. Production of the DBR9 will cease at 32, while as many as 2500 road cars were sold last year.

Much is changing at Aston Martin. Thanks to the V8 Vantage, and with the addition of a Volante version of the DB9 being added to the line-up, production is expected to double this year. And importantly, according to Aston CEO Ulrich Bez, racing is to become one of the company's core activities, underlining the marque's respect for new technology.

Aston Martin's motorsport business manager, Sarah Durose, points out how dissimilar its aim is to that of the other famed British marque to have returned to Le Mans in recent years. 'The reason our programme is different to the Bentley programme is that from the start their objectives were clear in that it was only ever going to be a three-year programme, where as we would like motorsport to become an integral part of our strategy.'

> "RACING IS TO BECOME ONE OF THE COMPANY'S CORE ACTIVITIES"

Aston already has a history at Le Mans, having won the 24-hour race in 1959 with the DBR1. The new car even has an appearance

Initial testing at Sebring highlighted very few problems, while the race result proved reliability isn't a problem

that reminds one of the DB4 GT, or the magnesium-aluminium alloy bodied DP212 developed from it over 40 years ago. Now it is to take on the Ferraris and Corvettes in the GT1 class with a 600bhp carbon fibre and aluminium version of the DB9. The latter is said to be an ideal base for a racecar as its bonded aluminium chassis cab is used in near standard form.

"A GT1 CLASS VICTORY THE FIRST TIME OUT AT THE SEBRING 12-HOURS"

The cars are being built by Aston Martin Racing – a joint venture between the vehicle manufacturer and Prodrive. The latter, which has already created the 2003 Le Mans GTS-class winning Ferrari F550 Maranellos, has a five-year contract with Aston that looks likely to be extended. 12 works and 20 customer DBR9s are to be constructed, with the company giving preference to teams likely to race the cars rather than lay them up as part of a collection. The first customer cars will be delivered by the end of the year. The total of 32 harks back to the production of the DB3S.

Ian Ludgate, Aston Martin Racing drawing office manager, and his team, started looking at how to convert a DB9 into a racecar about 18 months ago. He had previously been working for Aston itself and for three years had been examining ways that the company could go racing. At one stage there was even a possibility that a programme could be run in-house. However, a number of other companies were considered and Prodrive 'offered the best all round experience and package.'

This year was heralded as a learning exercise for the DBR9, with two Prodrive-run cars testing the waters in such a way that the customers could expect to have a competitive car for 2006. A GT1 class victory the first time out at the Sebring 12-hours might almost be said to have left Aston Martin in a state of pleased embarrassment. Expectations for the Le Mans 24-hours must therefore now be high, particularly after a post-Sebring endurance test saw the car run for over 23 hours before even a small problem arose.

In addition to Sebring and Le Mans, the two works cars should, by the time of publication, have also competed in the FIA GT round at Silverstone. In this way, Aston will have demonstrated it in its three key markets – ALMS/LMES, FIA GT and Le Mans itself. Next year there will still be so-called 'works' cars, but these will be different from the current works cars in that they will be privately owned but raced under strict factory conditions by independent teams. The rest of the cars from next year on will be conventional private entries.

Customer cars

This year's programme, however, is based around showing that the car is both fast and reliable in all prospective markets. The ultimate programme is about providing customers with cars, rather than Aston Martin Racing works racing cars.

In describing how the company approached developing the DB9 into a GT1 racecar, Aston Martin Racing technical director, George Howard-Chappell, stated: 'As with rallying and touring cars, you tend to look at the production car with a view to the parts you have to carry over and what it offers you as a donor car. What you get with the Aston Martin is a very nice V12 →

GT regulations forbid moving the bulkhead itself but the DB9's favourable engine bay layout means engines can be located further back and lower in the chassis than some of its competitors

normally aspirated engine and a very stiff, relatively light, aluminium chassis. You get double wishbone suspension and a shape that has some aerodynamic potential, although clearly it does not have the same aerodynamic potential as some other cars in its class. What you carry over essentially is the main structure of the car and the chassis, the castings of the cylinder head and the block, and the shape of the car above wheel centre line. Almost everything else is free.'

In addition to the fact that the chassis has been modified in a number of ways that are allowed by the regulations, Ludgate points out that there have also been a couple of dispensations from the FIA and ACO to make it suitable. For example, the tunnel top has been modified so that a fuel cell can be fitted.

Howard-Chappell admits that work carried out on developing the Ferrari has also helped enormously. 'Clearly, it is a car running in the same class with a similar engine so we knew the key things to look at and where the performance is derived from. That said, there are very few parts that are a straight carry over.' In fact he calculates that less than 20 components are the same on the two cars. 'However, there is certainly a theme there and in some areas the Aston Martin is essentially an evolution of the Ferrari. We learnt things that we needed to improve.' As an example, Howard-Chappell cites the gearbox, which is basically the same Xtrac six-speed sequential unit as that run in the Ferrari but improved 'in certain areas.' The result is a lighter unit with a longer life.

The Ferrari was essentially a privateer programme with limited funds. Therefore, there was no opportunity to carry out an evolution of the car each year, as there might have been had it been a major manufacturer's project, and the mechanical side of the Ferrari has been fixed since it first appeared. The Aston has given the Banbury operation the opportunity to evolve some of the ideas that had been started on the Ferrari.

A comprehensive aerodynamic programme was carried out using Advantage CFD. This was very different to the Ferrari where there was no model programme, just a couple of full-scale wind tunnel tests and then straight line testing. However, the Ferrari was developed in 16 weeks, the DBR9 took around nine months. 'If you put the two cars side by side you can really see that in the detail and the quality.' The Aston Martin was fully tooled and the whole car drawn in CAD. The bodywork was fully surfaced and all of the patterns milled, carbon tooling taken and then the component produced, whereas the Ferrari was foam and filler to get the shape and then wet laid moulds taken from it. 'It was rough and ready in that department, whereas the Aston is a nicely done car.'

Construction and use

Work on the chassis has been very different from a carbon car or a traditional steel monocoque. With the Ferrari, as with its rallying and touring projects, Prodrive had been used to working with a steel 'shell. 'You weld your rollcage into that and away you go.' But the Aston Martin features a bonded aluminium chassis. Fortunately, Howard-Chappell had some experience of this before as he was technically in charge of the Lotus Elise-based GT car in 1997. 'I knew a little bit about producing a competition chassis from a bonded aluminium structure,' he told us modestly. The challenge was that the rollcage had to be made outside of the car as a single unit, it being impossible to weld the 'cage in place. The 'cage is then dropped into the chassis tub while it is still on the jig and before the top assemblies are glued and riveted in place. It is initially fitted in loose because of the different coefficients of expansion, as the chassis is placed in the oven afterwards with the rollcage already inside. This results in an extremely sound structure with the rollcage integrating well with the chassis itself.

'Essentially the chassis is a bit like an Airfix kit – a load of aluminium extrusion, glued and riveted but primarily glued together.' This work is carried out at Hydro Aluminium's plant in Worcester.

Ludgate pays tribute to the co-operation of Aston Martin itself with regard to the rollcage. 'Obviously it had knowledge of the chassis, and we wanted to make sure the 'cage was well integrated. I gave Aston Martin my idea for the design of the 'cage and its integration into the chassis and it

"THERE HAVE ALSO BEEN A COUPLE OF DISPENSATIONS FROM THE FIA AND ACO TO MAKE IT SUITABLE"

Even the wiring looms are partially made in-house, the rest by Tony James

Rollcage is integrated into DBR9's bonded aluminium structure at build stage

A close association between Aston Martin Racing and Prodrive means that as much as 90 per cent of the DBR9 racecars can be manufactured in-house

Above: technical director George Howard-Chappell and (right) Ian Ludgate, drawing officer manager – the men on the inside at Aston Martin Racing who have made this programme happen

carried out analysis, making recommendations as to where it could be made lighter and stiffer.' Howard-Chappell also points out that, with Prodrive's manufacturing and composite facilities, the joint venture makes over 90 per cent of the car on site. The Inconel exhaust system, for example, is currently fabricated in-house.

The DBR9 has had very few evolutions, essentially it is as designed. A small number of initial teething problems with the engine and the gearbox set-up were experienced, but otherwise the development has been trouble free. A four-day, 17-hour test at Sebring earlier in the year highlighted a few problems that were quickly sorted out.

'The race itself [the Sebring 12-hours] was unbelievable. It was like running a car that had been under development for a couple of years,' recalls Howard-Chappell.

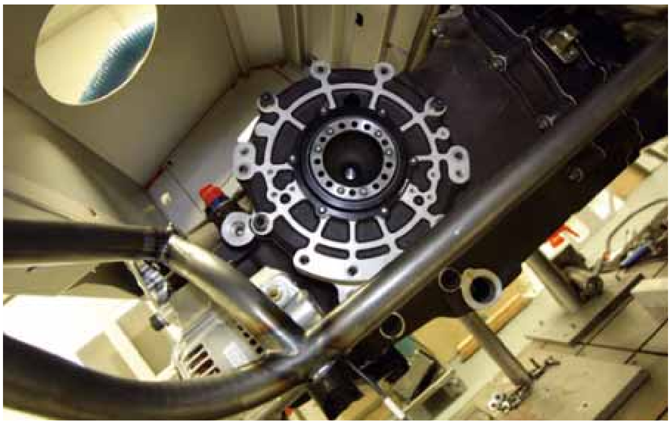
The road car specification means the DBR9 uses double wishbone suspension all round – described by Howard-Chappell as 'highly desirable.' The pick-up points are free and here Prodrive relied heavily on its Ferrari experience with regard to geometry, but 'with a few new ideas' added. The dampers are Koni 2812 series double adjustable, multi-tube units – a widely used product found, for example, on all Dallara F3 cars. Prodrive and Koni are said to have enjoyed a good relationship for some time now and Howard-Chappell describes the units as 'simple and straightforward, giving us the level of control and ride that we need.' The springs are from Eibach.

Brembo, also the OE supplier to the road car, manufactures the six-pot calipers with 330mm diameter carbon discs – a change from the Ferraris where the brakes came from AP Racing. A steel option will also be available for customers. 'It's great to have brakes that are no problem and that the drivers like the feel of. We don't have any cooling issues and they seem to be very consistent throughout the wear range.'

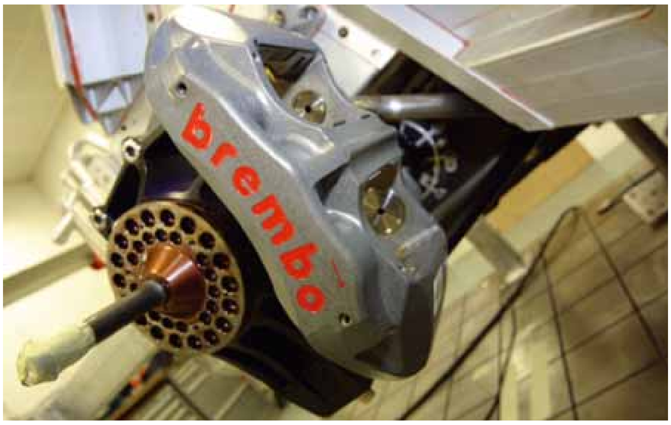
"ITS BONDED ALUMINIUM CHASSIS CAB IS USED IN NEAR STANDARD FORM"

The forged magnesium wheels are from OZ, the same Italian company that the Ferraris also used, but with a different design (primarily for aesthetic reasons) and revised sizes – 12 1/2 × 18in front and 13 × 18in rear. Prodrive has been close to Michelin since swapping to the French tyre manufacturer in 2001, so it comes as no surprise that the Aston Martin also uses tyres from the company currently to the fore in endurance racing. Another supplier is near neighbour CTG, which makes a habit of providing the GT1 field with its filament wound propshafts. →

Double wishbone suspension all round uses proven Koni 281 2 series dampers



Six-speed, sequential Xtrac gearbox is mounted longitudinally at the rear axle



Six pot calipers and carbon discs as standard, though a steel option is offered

The car features a full MIL-spec loom, some of it made up in-house, the rest by Tony James, mainly because of a question of capacity. Magneti Marelli supplies the sequential injection, while use is made of a Pi data system and a Pectel engine ECU, enabling the team to run traction control, too. It makes sense to combine these as they come from the same group. It may also be relevant that, although Pi has since been sold, it, like Aston Martin, was then Ford owned. The Ferrari had what Howard-Chappell describes as 'a decent traction control already, and we just evolved that.'

Between the axles the car features a flat bottom, while rearward of the rear axle the regulations permit a flat diffuser. There is a choice of where the break point is, as long as it is not forward of the rear axle. It is not permitted to have more than 150mm change between the flat bottom and the top of the diffuser. The splitter forward of the front wheels is free. How the manufacturer blends the bumpers to the wheelarches is basically free, as long as it is sympathetic to the road car. The sides of the cars below the doors are free as long as they do not encroach on where the original bodywork was. The rear wing is completely free as long as it fits within a 'box', and is not higher than the roof and further back than the rearmost part of the car. The majority of the cooling is essentially free. 'It's definitely an aero formula. It's a key part of the performance of the car.' Two aero packages are to be used, one suitable for Le Mans and Monza, the other for all other tracks where the DBR9s can run all the downforce available.

Driving force

Howard-Chappell acknowledges the work done on the F550 as having an influence on the DBR9's engine, too: 'We learnt a lot about making one of these engines go well from the Ferrari but I don't think that there is a component in the engine that is the same. The Aston Martin is quite a different beast and gave us its own challenges.'

GT1 regulations state that the original cylinder block and head have to be retained. They also say that you can only move the engine back in the engine bay as far as is possible without changing the internal dimensions of the cockpit. In other words, you cannot move the engine bay bulkhead. Because of the way in which the engine bay is laid out, Aston Martin Racing was able to move the engine further back and lower than in the Ferrari.

“THE ENGINE WAS DEVELOPED ‘WITH A CHEQUE BOOK RATHER THAN A RULE BOOK’ IN HAND”

Aston Martin Racing's chief engineer – engines, Jason Hill

Jason Hill, Aston Martin Racing chief engineer – engines, points out that the engine was developed 'with a cheque book rather than a rule book in hand.' It was also designed so that it could be manufactured in reasonable numbers and to a consistent quality. It was additionally essential that the performance target should exceed that of the Ferrari. The design philosophy has been very different from the Ferrari, for the Aston Martin has been developed to be made in numbers. As Hill points out, it is only when you intend manufacturing for as many engines as the DBR9 programme will use that you put down tooling for items such as the sump.

Prodrive converted the block from a dry liner to a nicosil steel wet liner and increased the bore size up to 94mm from 89mm. The road car's steel bearing caps have been retained, albeit slightly modified, and material →

Tech specs: Aston Martin DBR9

Configuration:	Front engine, rear-wheel drive
Chassis:	Modified DB9 aluminium chassis, aluminium roof, all other body panels in carbon fibre composite, steel rollcage
Dimensions	
Length:	4687mm +80mm
Width:	1978mm
Wheelbase:	2741mm
Weight:	1100kg
Engine:	Aston Martin Racing V12 based on Aston Martin DB9 aluminium block and cylinder heads, dry sump, double overhead cam, four valves per cylinder, two 31.2mm air restrictors
Capacity:	6.0-litres
Power:	approximately 600bhp
Torque:	approximately 700Nm
ECU/data system:	Pi Research data system, Pectel engine ECU
Transmission:	Xtrac six-speed sequential gearbox longitudinally mounted at the rear axle
Clutch:	Four plate carbon clutch
Suspension:	Double wishbone suspension front and rear with adjustable Koni dampers and Eibach springs
Wheels:	OZ forged magnesium
Brakes	
Front and rear:	Brembo six-pot calipers with 330mm diameter carbon discs

Carbon fibre composite panels laid out ready for use – only the roof of the DBR9 is still made from aluminium

has been machined off the lower deck of the deep-skirted block in order to lower its position in the car and to reduce weight. Material has also been removed from the fire face deck and an o-ring groove added on top as part of the cooling package.

Aston Martin Racing uses its own design of crankshaft and bearings. The crankshaft, eight rather than 12 web, is not dissimilar in its counterbalance to the road car. The pistons, which feature a cross web design similar to the Ferrari, are currently machined from solid, although the production versions will be forged and machined. A cast sump panel separates the bays with each pair of cylinders separated from it adjacent partner.

DBR9 V12s will be made in numbers, with the emphasis firmly on reliability

One of the few pieces of the original engine that has been retained is the chain drive for the camshaft, although the hydraulic adjuster has been dispensed with. The camshaft is machined from bar and nitrided, while the valve train is bespoke, with the valve head diameter slightly increased and the stems decreased. The valve angles are positioned as standard, much wider than the Ferrari, and valve control is via a single wire spring. A major feature is the finger follower actuation.

Unusually for a GT engine, use is made of a carbon cam cover. Also made of carbon are the intake and port ducts, as well as all the air box intake components and the oil inlet pipe.

'Clearly there will be people of different levels operating these cars,' says Hill. His team used the robustness of the Porsche 996 GT3 as an inspiration in order to overcome this. 'We tried to head further in that direction than we did with the Ferrari,' adds Hill, who was in charge of both programmes. 'The F550 needed a certain amount of attention all the time, although it has proved to be a very successful customer car. With the Aston we have gone further and created a car that can be operated without an awful lot of assistance. This comes down to details in the design.'

The engine life is being set at 5000kms, effectively a Le Mans distance, though a sprint package will also be offered. All the parts are bespoke, with the engines having to be returned to Aston Martin Racing for rebuild (the same as with the Ferrari). The mileage is guaranteed and all parts controlled by the company.

The Aston Martin DBR9 should bring a new dimension to the GT field by the start of the 2006 season. It is designed and built within the spirit of the regulations – being based on a genuine existing road car – and it brings a famed name back to the sport. Ian Ludgate is just one of those at Aston Martin Racing who believe that the GT classes are where the future lies. 'Sportscar racing now has an opportunity to get its house in order,' he says. 'If you can bring yourself to look away from the LMPs then you will find much better racing.' RE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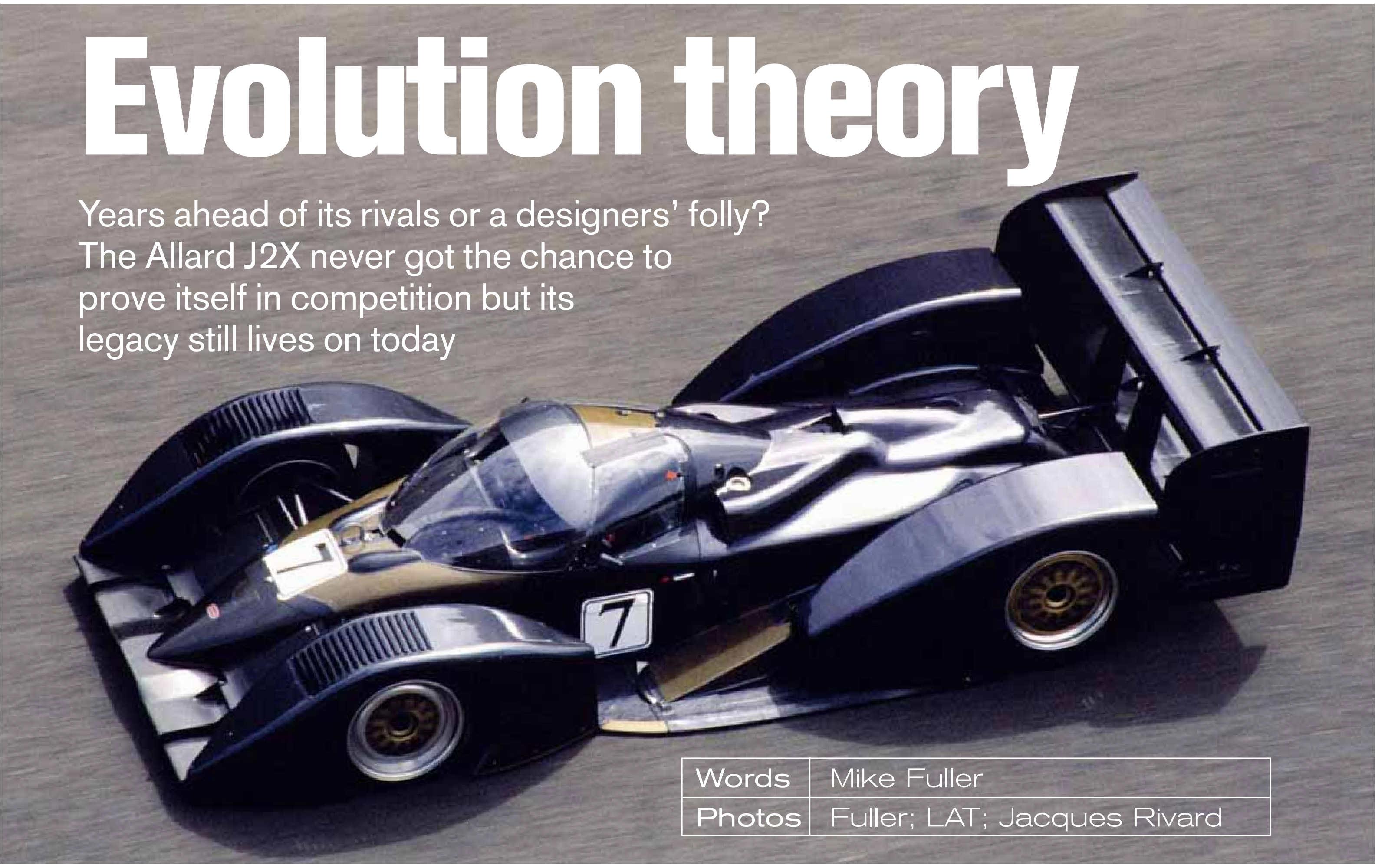


Evolution theory

Years ahead of its rivals or a designers' folly? The Allard J2X never got the chance to prove itself in competition but its legacy still lives on today

Words	Mike Fuller
Photos	Fuller; LAT; Jacques Rivard

Some of the most advanced sports prototypes ever designed were born out of the 3.5-litre Group C championship. The 3.5-litre cars relied on superior aerodynamic efficiency and ever increasing downforce to produce lap times eclipsing those of the previous Group C era and it was into this environment that the independently designed Allard J2X was born – a car that accelerated the pace of thinking at a time when the development graph was already quite steep.

In the late 1980s, a designer named Chris Humberstone revived the Allard name. Humberstone had a flair for tackling and managing complex engineering projects, having previously worked with various racing teams and manufacturers, including Beatrice/Force F1, Benetton, and Brun Technics. He approached Alan Allard, the son of company founder Sidney Allard, about licensing the family name for a future road car project. Though delayed a number of years, in the early '90s Humberstone finally formed Allard Holdings with the intent of moving forward.

Starting late in 1990 he quickly amassed a group of young, enthusiastic (if somewhat inexperienced) designers and engineers for the project, starting with Brun Technics' Hayden Burvill. The Australian born Burvill became chief designer for the J2X, with John Iley, also from

Testing at Le Mans in '93 proved the J2X unsuitable for the race itself, due to its clear performance deficit

Brun, joining him as the car's aerodynamicist in early '91, and conceptualisation began straight away. 'We had seen people do maximum cross section for chassis stiffness (Brun C91) and we knew about the XJR-14 being very low profile. Our approach was to optimise the package to allow maximum volumes for investigating the aero solution,' says Burvill. John Iley adding, 'you always look for targets, areas for improvement, areas of strength with existing designs and ways to get the most from the category's regulations… There is also the difficulty of striking the right balance during development of very original new concepts versus iterative steps.'

From the start, the primary goal was minimal frontal area and the maximisation of aero development area, and the J2X's radical look was a direct result of this. Some 1/10 scale study models were built to evaluate ideas, with Burvill and Humberstone contributing and Iley joining a few months later. What began to emerge was a combination of all the best elements – a narrow tub and bubble canopy, detached front pontoon wings, a complex front wing, and very low profile rear bodywork.

Two 1/3 scale wind tunnel models were used to evaluate as many ideas as possible. It would have been preferable to use the Imperial College wind tunnel in London, but McLaren was the favoured customer and there wasn't any tunnel time available for the Allard group. Clearly the J2X concepts were unlike anything that was racing at the time, and there was some question over whether they would produce results in the wind tunnel. The MIRA wind tunnel in Warwickshire, England, was chosen instead and testing began in earnest. Iley: 'We tested in regular short and intensive three-day test sessions, starting from the very first test with the radical minimal layout, to see if we could get it to work. It showed sufficient promise to persevere, with gradual improvements being made test by test, to produce a strong, distinctive and legal aero platform.'

Front wing design, with its secondary flaps between the wings, was way ahead of its time, and worked too

Eliminating understeer

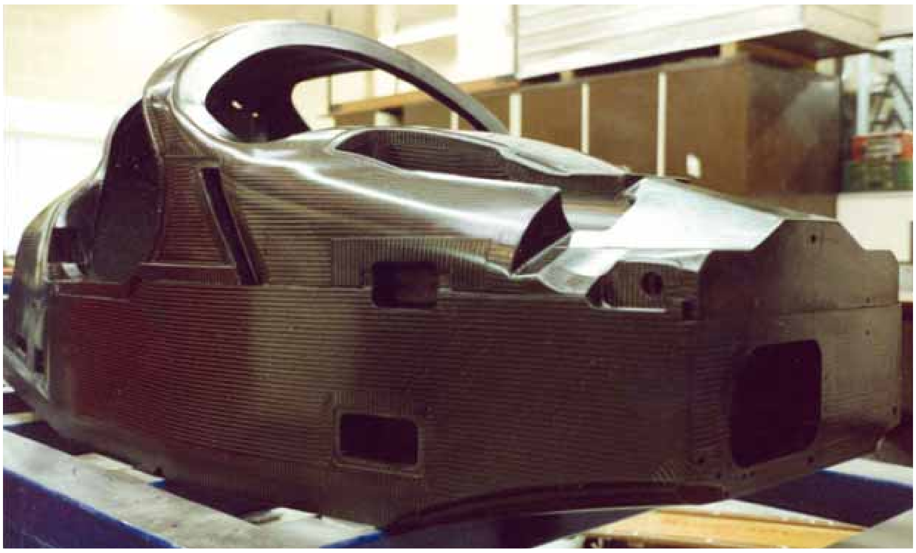
The quest for front-end downforce was nothing new in a closed bodied prototype, as sportscars have historically been hampered by a lack of front grip. The design goal has always been to dial in as much front grip as possible to reduce or eliminate the car's understeer without affecting airflow to the rear wing. Splitters had been the predominant device used to increase front load throughout the Group C and GTP era and were proved effective, if somewhat limited in their scope of adjustment, while early experiments with front wings on sportscars gave less than satisfactory results. The March GTPs actually ran an adjustable wing element between the so-called 'lobster claws' and below the radiator. The Grid S1 further accentuated the idea by mounting a front wing, again between the front fenders, but well ahead of the intake ducting and various Porsche 962 teams mounted ungainly wings on the noses of their cars, also in the search for downforce. The concept had been revived most recently by the Jaguar XJR-14 and was also subsequently used on the rival Peugeot 905 Evo 1.

Typically, the front wing element spoiled the airflow to the rear wing, though ironically this produced the desired result – a forward balance shift – but was undeniably detrimental to overall downforce, especially at the rear. The J2X's complex front wing, with its secondary flaps situated between the front pontoon fenders, was squarely aimed at eliminating the historical sportscar understeer condition.

'We could generate up to 43 per cent front aero balance if we wanted to. This was a combination of having clean airflow between the chassis and the front wheels and careful treatment ahead of the wheels,' says Iley. Burvill: 'The front wing definitely worked in isolation. The impressive L/D figure would not have been achievable otherwise. What you cannot see is some quite sophisticated air management under the nose.' The J2X features a raised front nose and tub that the front wing drooped from. Burvill admits to being influenced by the Tyrrell 019 F1 car when it came to the drooped, or anhederal, front wing. 'It seemed logical to increase the air gap under the nose to reduce the volume change under the nose with pitch and ride height change, the Tyrrell offered the first working version of that.' The raised nose and subsequent air management aft of the front wing allowed air to flow onto the top surfaces of the floor just behind the front wheels. Burvill continues: 'This air was then managed rearward over the extremely low profile rear deck. This was to make the rear wing work harder, not suffer.'

"THE PRIMARY GOAL WAS MINIMAL FRONTAL AREA AND THE MAXIMISATION OF AERO DEVELOPMENT AREA"

Additionally, the front wing flaps performed a rules compliance function by masking the suspension components, as seen from the front. 'The launch version of the car, which was in a maximum downforce configuration, had probably about 10 settings, the problem being to keep the suspension covered in elevation at the same time.' The rules function of the front wing flap did limit its amount of travel somewhat, in that at lower flap angles it would have been possible for suspension components to be seen (thus rendering the car illegal), but within the practical range of flap angle versus balance, it was not an immediate issue.



Full length monocoque had bonded in roll hoop and, without its gearbox sub structure, weighed just 85kg

Interestingly enough, additional front downforce could be dialled in by adjustments made at the rear of the car. The Allard's twin-tier rear wing was found to be a powerful device to tune aerodynamic balance front and rear. With the primary suction peak of the diffuser being forward in the underbody, any increase in flap angle of the lower wing at the rear of the car would increase overall downforce and in turn increase front downforce as well. →

The pontoon fenders were perhaps the most unique element of the entire design and also an integral part of the aerodynamics package. Perhaps surprisingly, the Allard's design didn't evolve towards that solution, it started there: 'Quite simply, I shaped up the first version based on experience. We tested it, it worked great and we never discarded it,' says Burvill. To cover their bases the Allard team did try a much more conventional front end but found it seriously lacking when compared to the direction they had initially headed in. By encouraging airflow around the fenders instead of over them (simply by the nature of its planform shape) helped reduce top surface lift generation.

It should be noted that the Allard is streamlined in plan view, to encourage air to go around and not over the bodywork. There was also thought to be a functional benefit of the pontoon fenders in the case of a tyre failure as damage would be limited to the pod and not the surrounding bodywork, making repair easier.

As previously mentioned, the achievement of the ultra low rear deck height of the Allard was driven by the desire to feed the rear wings with airflow as unobstructed as possible. Additionally, the exhaust gas was piped into the trailing edge of the tunnel exit, but for a purpose other than aerodynamics. Iley: 'As a rule I am not a supporter of such a system [exhaust activated diffusers] as it makes the car's performance too throttle dependant, which does not provide the basis for a stable platform. However the location on the J2X was far enough rearward that its effect was greatly reduced. The main drive to route the exhausts this way on J2X was just to achieve an incredibly low and tidy rear deck for the lower rear wing, not to utilise a blown diffuser principle.' Ultimately the designers were able to achieve a rear deck height just 10mm above the rear tunnel exit.

According to John Iley, the J2X developed approximately 5500lbs of downforce for 916lbs of drag at 150mph (L/D 6.0:1). 'Yes, our loads were huge and what little correlation work we did to the tunnel numbers seemed to agree with them well.' The anticipated downforce loads also called into question the viability of tyres and wheels, as well as overall car structure, in the end driving the design of the car's monocoque. That 5500lbs equates to a theoretical 9778lbs of downforce at 200mph. With so much downforce on hand 200mph would have been a very optimistic speed given the drag consequence. Peak downforce was achieved at a 35mm front ride height and a 48mm rear ride height, with good high ride height performance and low overall pitch sensitivity. With only 560-580bhp on tap from its 3.5-litre

J2X design was driven by aerodynamics – dramatic pontoon wings were always part of the package, as was the low rear deck height. Anhederal front wing was influenced by the Tyrrell 019 and the car could generate up to 43 per cent frontal aero if needed

Ford DFR, a low downforce package would have eventually been developed, though it was clear that a more powerful engine would have greatly benefited the project.

With such high aerodynamic downforce, a power steering system was also deemed a necessity, though it was never developed or installed, as the front suspension would have required re-working to allow for fitment. Instead it became a future project and a simple active suspension system was installed for the J2X's testing, though it was never optimised.

It was the anticipation of the car's massive downforce that led to the design of its full-length monocoque structure, incorporating a rear composite chassis that housed the gearbox. This rear chassis was designed so that the gearbox could be swivelled within the structure to allow for easy change of the gear cluster. The entire tub, minus the gearbox sub structure but including the FIA mandated steel rollover hoop, weighs around 85kg. Burvill: 'The chassis comprised a closed box section 100mm wide on each side, running the full length of the footbox and sills. The roll hoop could not be fully integrated or made of anything but certified diameter and wall thickness steel, unless we had subjected the tub to a potentially destructive crash test. We had the roll hoop inspected and then bolted and bonded it into the chassis before the top section of the chassis was bonded – so it did become fully integrated.'

Unfortunately, the rear composite chassis turned out to be a potential liability, compromised by the use of an off-the-shelf gearbox (Leyton-March). According to Paul Burgess, detail designer engineer for the J2X's rear chassis, the design was 'constrained by using an existing single-seat gearbox with integral rocker and suspension mounts. It was complicated to mount and access the gearbox internals. A much neater solution would have been to design and build a separate and easily changed gearbox, without any suspension mounts on it.' On-track testing would later bear out the need to re-think the gearbox housing, if not the need to re-design it.

A 3.5-litre Cosworth (Ford) DFR engine was chosen for the Allard, given the commonality of the engine in Group C at the time. The first J2X

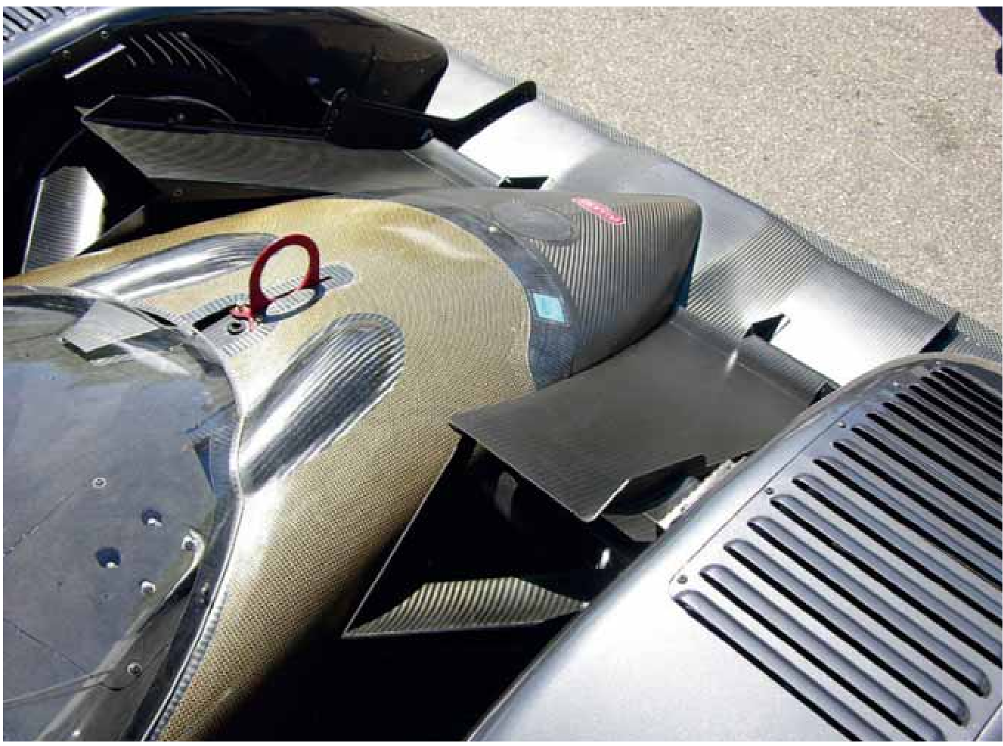
> **"IT STILL WAS MERELY DESIGN EVOLUTION AND NOTHING WAS PARTICULARLY REVOLUTIONARY ABOUT IT"**

was actually intended to use a small block Chevy, but when a potential customer showed interest in a Group C version of the car, the DFR went in instead. The Chevrolet engine would have required a Hewland DGC gearbox to replace the Leyton-March sourced one – a task that would have been welcomed by the design staff given the problematic March gearbox. Mazda and Porsche engines were also considered and rejected, due to the difficult packaging requirements, even though potential customers in IMSA may have wanted those engines options. Ryan Falconer had even been contacted about the use of a big block Chevy. The Allard's full length monocoque chassis, while appearing to lend itself to the installation of various engines, was actually somewhat compromised by the tight packaging at the rear, meaning that all engines would have to be highly scrutinised in order to determine their suitability, or even whether or not they would fit!

Driving impressions

Finally, on 9 July 1992, the Allard J2X was shaken down at Pembrey in Wales. Test Driver Costas Los was at the wheel: 'The J2X felt very different to a regular Group C car. It had a different driving position to what I was used to, and an unusually small cockpit… I recall in particular how pointy the car could be made to be, and how it was possible to wind on an extraordinary amount of front-end grip with that wing. Contrary to most group C cars I had driven, it was a lot more tuneable than I was accustomed to.' The J2X required tremendous physical effort to drive and Los re-affirmed the eventual need for power steering. 'Imagine loading a Spice GTP with all the gizmos we developed for it on street tracks, and that's how it started off on the Allard, without having even attempted to get a street circuit type of set-up – no appendages or anything, wings set neutral. On all the Group C cars I drove except the Allard, if you loaded both ends to the maximum you would get an understeering car. It was quite an eye-opener,' he went on to say.

But the Allard was plagued by one fundamental problem – it had no buyers. After feints from the likes of Honda North America (who considered the chassis for the IMSA GTP series, even going as far as testing at three different circuits in the US in late 1992) and Gianpiero Moretti (again →



Twin-tier rear wing allowed adjustments to be made to front/rear aerodynamic balance and also to frontal downforce

looking at the IMSA GTP series), the prospects were grim, especially with the IMSA GTP series in its death throes, as it were. Allard quickly slid downhill as funding and prospects dried up, only lasting until the end of the first quarter of 1993. Allard Holdings and all its assets were auctioned to pay the company's debtors. John Iley: 'I went to watch the auction of the car in London to close the chapter; £76,000 ($145,000) seemed a small price for all those hours of effort put in by the team.'

Robs Lamplough was the purchaser of the car and he took it to the 1993 Le Mans test days, which just verified the car's lack of suitability for the high-speed circuit. After the test days it was decided not to run at the race, given the obvious performance deficit. The Laguna Seca round of the IMSA GTP Championship came next and, at this point, Lamplough simply wanted to race the car. The J2X went on to qualify 12th and finished in 9th place overall. The Allard was then shipped back to England and there the car's racing history ended. Eventually Lamplough did sell the J2X and it went through a succession of owners during the '90s, ending up in Montreal, Canada, where it is presently completing restoration, including the installation of a new Ford DFR engine.

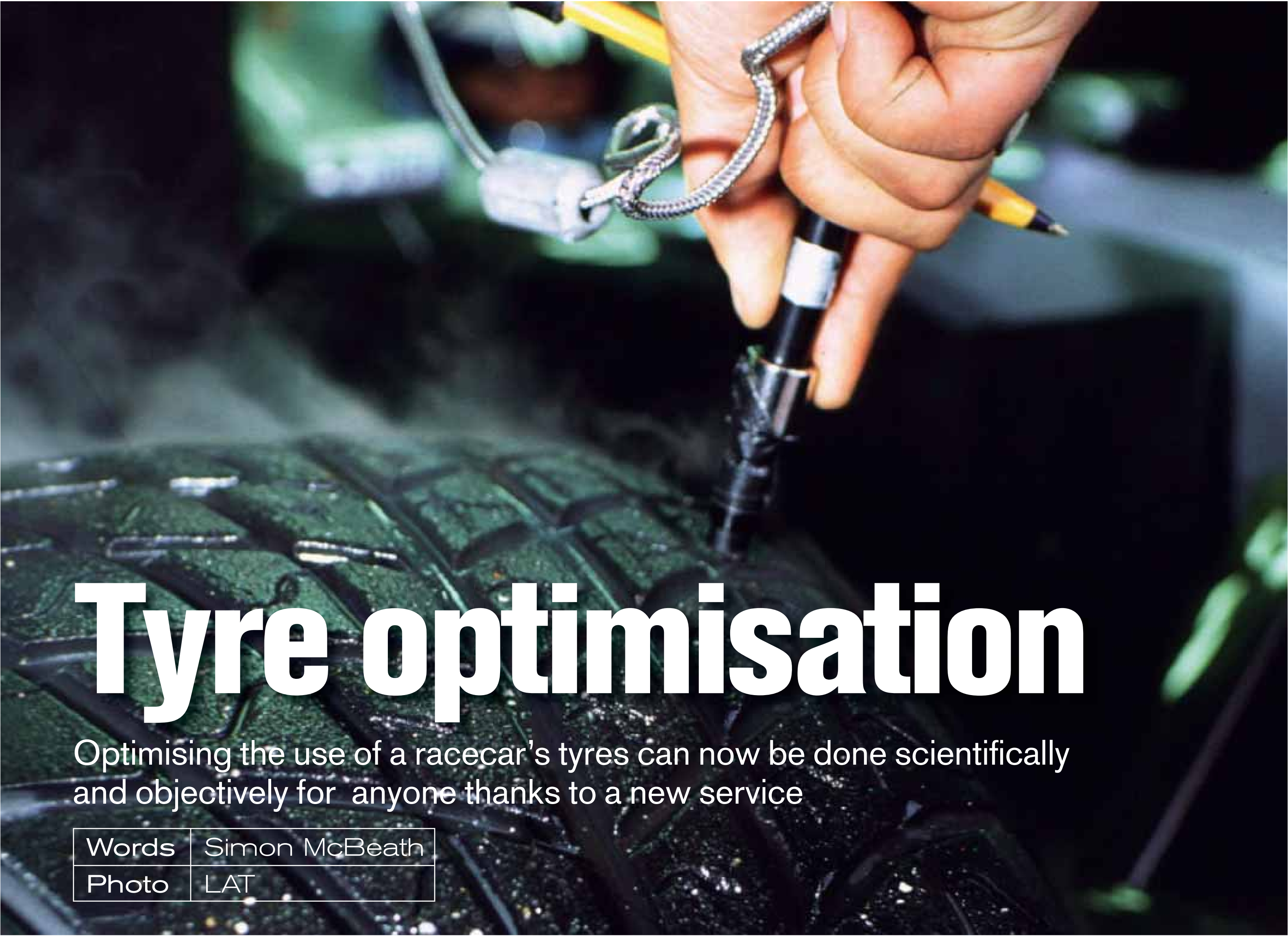
As radical as the Allard was, it was still merely design evolution and nothing was particularly revolutionary about it. In terms of aerodynamic performance, it certainly was impressive, but even the much more conventional Toyota TS-010 was generating over 9500lbs of downforce with a lift-to-drag ratio also in the 6+ region. Though Burvill admits the Allard was far from optimised aerodynamically, there was more to come and more potential over conventional designs given the use of volumes on the Allard. But Costas Los offers this interesting encounter: 'I ran into Tony Southgate at Le Mans a few years after I retired, and he told me that all the major sportscar manufacturers had toyed with the concept of the Allard. For an independent designer being paid by a manufacturer to design a winning car for such a key race, it was risky to propose an Allard-type car.' Graham Humphries, lead designer at Spice Engineering, also indicated that the idea was considered: 'We developed a 40 per cent wind tunnel model which initially showed promise. The model had a high pointed nose, low front wing and extremely low delta-shaped pods to enclosed rear arches. It was extremely elegant and, whilst it produced the required downforce, drag was just too high. With limited resources, it was decided instead to follow the more conventional route of further developing what we knew.' So while many companies were working towards Allard-esque solutions, it all came down to who was willing to take the risk. Hayden Burvill: 'I am sure many had considered it, perhaps even sketched it, but no one had the guts to step up and design it. I had nothing to lose, nobody knew who I was.'

> **"THE ALLARD WAS PLAGUED BY ONE FUNDAMENTAL PROBLEM – IT HAD NO BUYERS"**

It is perhaps contentious to say that the Allard J2X had direct influence on chassis design trends, but only so much as its design was evolutionary. Rival groups were working towards similar solutions at about the same time but the fact is no one else got their car to the track. Certainly the design brief for the Allard was no different than that of its rivals but the 'nothing to lose' attitude of the J2X project allowed them to contemplate and adopt design ideologies that others were also considering but were unable to execute in their more conventional design environments.

While the J2X never had the opportunity to validate its design on the track, its success can be judged solely by the emulation that occurred after it faded from the scene. One only needs to look at today's Audi R8s, Lola B01/60s and B05/40s and Dallara LMPs to see that emulation still continuing all these years later. RE

Originally designed to use a small block Chevy, the J2X was built with a Group C compliant Cosworth DFR



Tyre optimisation

Optimising the use of a racecar's tyres can now be done scientifically and objectively for anyone thanks to a new service

Words	Simon McBeath
Photo	LAT

For many racers the only scientific way to tell how well tyres are functioning is to take temperature readings from the treads when the car comes into the pits or service area. This data will be supported by a visual inspection of the tyres. But forgetting for a moment the debatable usefulness of delayed, static temperature readings, how many people know whether the temperatures recorded are right for the tyres we are using? In other words, how is it possible to tell if we are anywhere near making best use of the tyres? And what about the temperatures that the tyres reach dynamically, out on the track?

Wouldn't it be better to first find out in what temperature range the tyres should be operating? And then log some dynamic data to see whether they were operating within this range? And if not, make some changes to optimise the use of the tyres – or possibly even change to different tyres altogether? Well, now a French company called Dufournier Technologies can provide all this and more, and already teams in F1, F3000, F3 and WRC have been seeking out its services.

But why exactly are Dufournier's services being sought out by high profile race and rally teams? The basis is a sound understanding of how tyres function but, as the company says, 'it's more than just our general knowledge of tyres from the physical, thermal and chemical point of view. We also generate knowledge about the thermo-mechanical behaviour of tyres. This deals with the thermal and mechanical behaviour of both the tread and the carcass. It leads to a unique approach to analysing the tyre through objective and physical criteria, using very accurate tools and numerical models.'

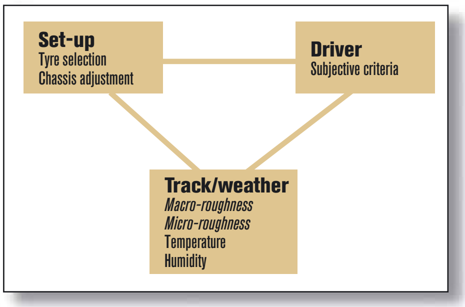
A key feature of Dufournier's approach is considering the tyre as one element of the suspension. 'We analyse the tyres' function with respect to the whole suspension system, and with this global approach we look for a set-up for each part of the chassis/suspension system in order to attain or maintain the tyres in their optimal functioning ranges.' This includes taking into account suspension geometry, dampers, springs and anti-roll bars and the differential.

Adhesion Monitoring System

Ordinarily, analysis would commence in the laboratory, but a unique feature of Dufournier's capability is its patented Adhesion Monitoring System (AMS). Combined with the founder's knowledge of the ground-tyre contact mechanisms, the AMS provides real measurements of the macro and micro-roughness characteristics of the track surface. And it does so quickly enough for regular updates or large distances to be rapidly achieved (up to 200km a day). With data from the AMS, Dufournier can then accurately model the real contact patch with a longitudinal accuracy of 5.0μm and vertical accuracy of 1.0μm. It can also simulate grip and tyre wear, optimise suspension set-up and select tyres according to actual ground characteristics.

One of Dufournier's dictums is that a good set-up depends on a triangular relationship between a specific driver and the specific weather at a specific track, as depicted in the diagram below.

The only aspect that teams cannot generate information about is the ground characteristics, which is where AMS comes in. Tyre grip is generated by two independent mechanisms, as Dufournier explains: 'there is what we call adhesion and indentation. Adhesion arises from micro phenomena and is constituted of both Van der Walls forces and micro-hysteresis. Van der



"A UNIQUE APPROACH TO ANALYSING THE TYRE THROUGH OBJECTIVE AND PHYSICAL CRITERIA, USING VERY ACCURATE TOOLS AND NUMERICAL MODELS"

Walls forces are intra-molecular, and to exist they require a very close contact between the tread and the local ground (d<100μm). Micro-hysteresis is due to the effect of micro-roughness on the surface of the rubber. In fact micro-hysteresis and Van der Walls forces are very low, but they are very numerous, too. As a result, their effect is dominant in global grip.

Indentation is essentially composed of hysteretic forces between the rubber and macro-roughness. It requires macro-roughness on the ground, hysteretic rubber and periodic constraint (the 'slip-grip' phenomenon). As soon as a tyre begins to slip on roughness, hysteresis is transformed into friction energy that creates indentation forces. In fact macro-hysteresis generates quite substantial forces, but not numerous. As a result their impact on global grip is less important (around 25 per cent) than that of micro-hysteresis and Van der Walls forces (around 75 per cent).'

So AMS generates data on macro-roughness (1.0cm down to 1.0mm amplitude) and micro-roughness (1mm down to 5.0μm), and using this data a ground surface profile for the track in question can be generated (see figure 1). From there, what Dufournier calls a 'spatial frequencies distribution', or spectrum, can be generated, and using proprietary methods that it unfortunately can't explain in detail it then calculates grip levels in different weather conditions for a known tyre (with reference to a lab rubber qualification) on the track evaluated (figure 2).

Problem solving

Some extracts from a recent Formula 3 project throw more light on the possibilities. A structured project process first defines the customer's needs, and then designs an appropriate experiment with the required instrumentation. If relevant, laboratory tools to characterise the tyres will be used, which can include physical, chemical and thermo-mechanical analysis. And if applicable, the AMS will be used to evaluate the track surface. In this instance a known venue – Magny Cours – was used. Representative track sectors in which the customer's problem symptoms manifest themselves are then selected, and a set of objective criteria are generated from logged →

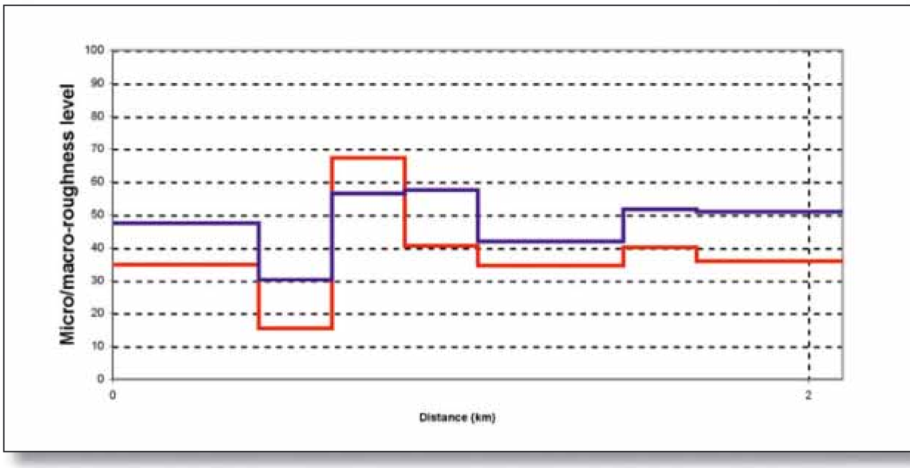


Figure 1: macro- and micro-roughness data assist with the objective selection of suitable tyres

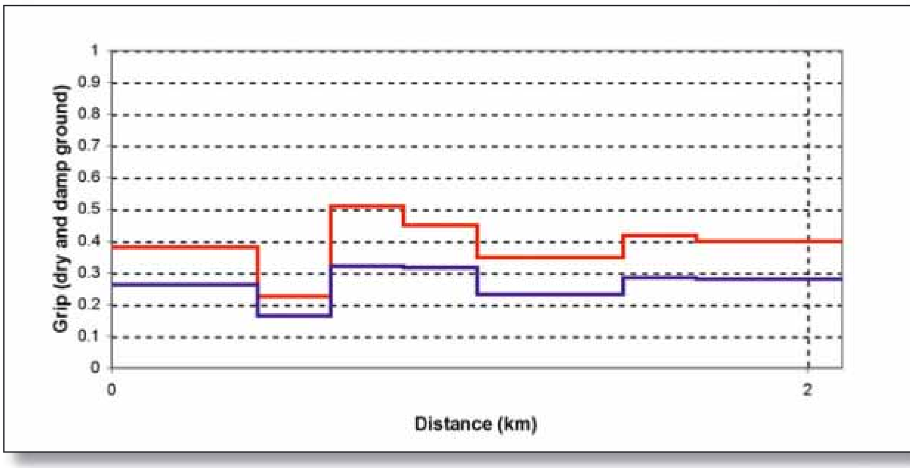


Figure 2: grip levels in dry and damp conditions determined from macro- and micro-roughness data

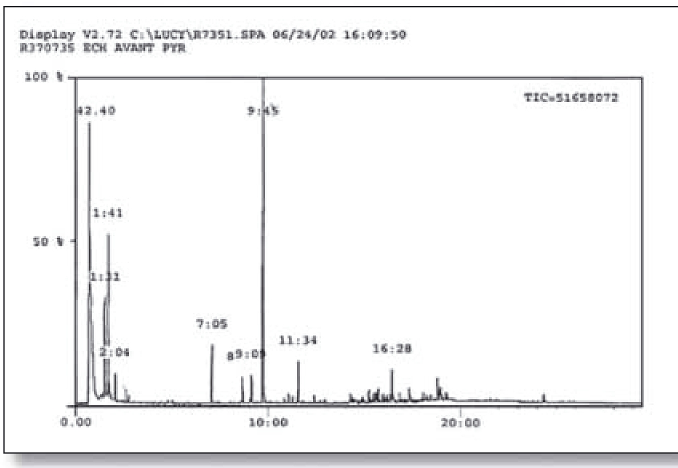


Figure 3: GC/MS chromatogram of the front tyre in the example project

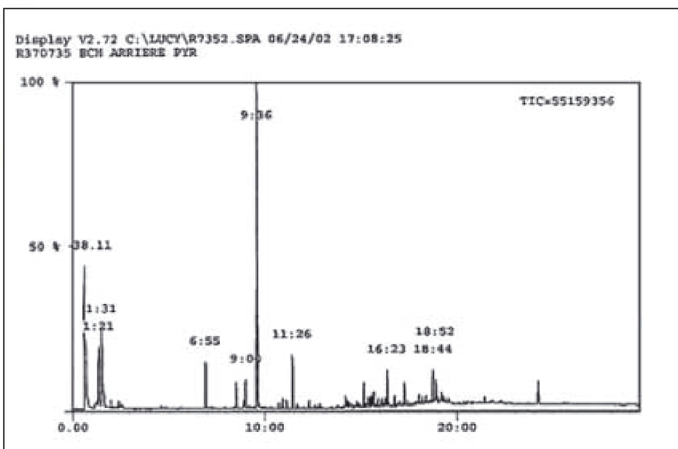


Figure 4: GC/MS chromatogram of the rear tyre in the example project

data to enable analysis and refinement.

In this instance the customer had an acute corner-exit understeer problem that was particularly bad in slow to medium speed corners. Dufournier devised a three-phase project to reach a solution: the first phase determined the 'functioning domain' of the tyres in the laboratory; following that a track test and analysis programme, with the final phase being the delivery of new, improved set-up guidelines.

Tyre properties

The laboratory programme first checked that the front and rear tyres were the same compound and secondly, through thermo-mechanical analysis of tread samples, what the optimum operating temperature range for the tyres actually was. The tread was analysed using gas phase chromatography coupled to mass spectrometry to determine the chemical 'signature' of the elastomers present. Figures 3 and 4 show the chromatograms of the front and rear tyres respectively, and demonstrate that the key components and their proportions were basically the same (the elastomer present was a styrene butadiene co-polymer commonly used in racing tyres). It was concluded then that the front and rear compounds were identical.

Next, thermo-mechanical testing was carried out on tread samples. Dufournier maintains that classic measurements using methods such as pendulum skid resistance testers are not representative of tread function. And Shore hardness values apparently do not provide information that is reliably correlated to the adhesion coefficient.

So the company's own approach uses a relationship, at a range of stress frequencies and at various temperatures, between the damping coefficient (tan ▯) of the elastomer, and its shear modulus to ascertain the adhesion potential of the tread. Attaining maximum adhesion from elastomers such as that used in these tyres means seeking the lowest shear modulus for the highest damping coefficient.

Apparently this method has been widely used in recent years, especially in motorsport, with the proviso that measurements remain within elastic limits. Dufournier has a bespoke test rig to perform these measurements, and a typical plot is shown in figure 5. Although specific results cannot be disclosed for this project, the data generated is used later in determining the thermo-mechanical efficiency of the tyres on track.

The next stage in characterising the tyres was to carry out a structural analysis. This deals with the carcass, the ply assembly, the sidewall construction and so on, and can establish which parameters of tyre set-up are liable to be the most sensitive, such as pressure, camber or toe. As Dufournier says in this recent Formula 3 report when comparing the new tyres used with the older: 'for example, if the sidewall is very stiff vertically then the tyre will be sensitive to camber. If the tread is very flexible then the tyre will be sensitive to pressure.

'Conversely, a certain level of pressure may be necessary to achieve the desired lateral stability. Sufficient pressure is also required to achieve good load distribution in the contact area and compensate for overpressure in the shoulders, yet this goes against common sense which says that high pressure can lead to high temperatures and this in turn to reduced tread performance. So it is necessary to find a compromise between holding the sidewalls transversely, maximising contact area and keeping tread temperature at an optimum level. Toe offers a further degree of freedom.'

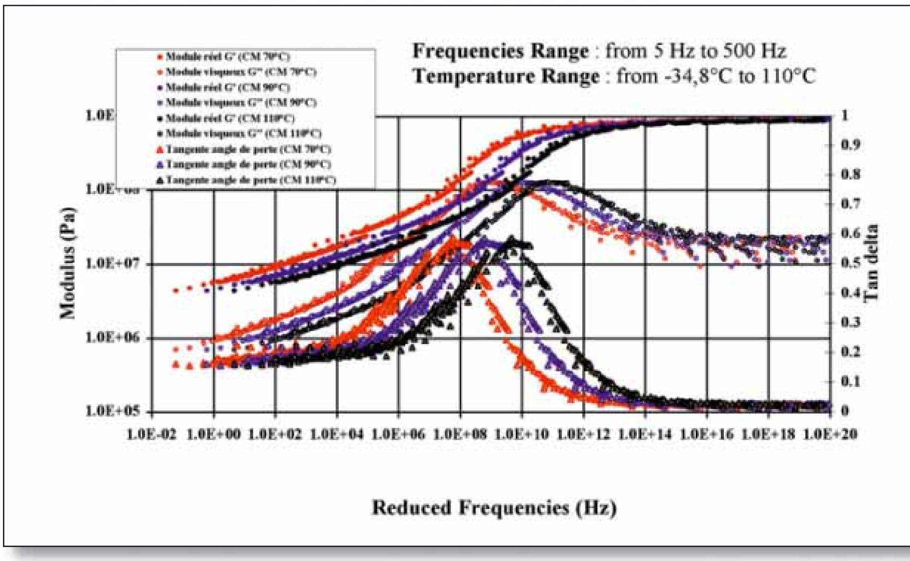


Figure 5: a typical thermo-mechanical analysis plot from a test subject tyre

> **"A GOOD SET-UP DEPENDS ON A TRIANGULAR RELATIONSHIP BETWEEN A SPECIFIC DRIVER AND THE SPECIFIC WEATHER AT A SPECIFIC TRACK"**

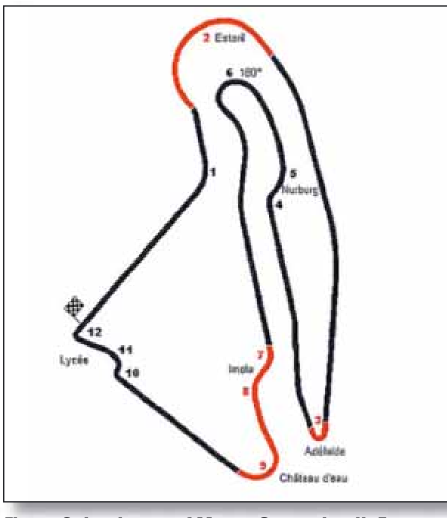


Figure 6: track map of Magny Cours circuit, France

Track testing

The aim of the track test was to determine the effect of the different parameters (toe, camber etc.) relative to the reference set-up, and so recommend a new set-up. The project actually investigated the car's behaviour in three sectors of the Magny Cours track (see figure 6). For brevity we'll just look at the low speed study by analysing data and behaviour from the Adélaïde Hairpin – bottom right on the circuit map.

To ascertain the tyres' thermo-mechanical efficiency, a row of six infrared pyrometers were fitted to the front and rear left side tyres. These monitored temperatures across the tread. The attachment system used at the front enabled the pyrometers to move with the tyre as steering lock was applied. Other data sensors fitted included yaw velocity, wheel speeds, lateral and longitudinal '*g*', slip angle and 'drift' angle (see diagram opposite). A range of tests was then designed that would hopefully provide trends towards an improved set-up (figure 7). In each configuration the data from the second lap out of the pits were analysed, after checking there were no problems such as wheel locking that would interfere with calculations (shown above right).

A range of data analysis tools is used by Dufournier, but the most frequently used are:

- 'Delay' or response time between the application of steering lock and the occurrence of yaw velocity.
- 'QUIVO', French for 'Qualité d'information Volant', translating roughly as 'quality of steering wheel information', and a measure of the relationship between steering angle and yaw velocity in steady state.

- 'USOS' or understeer/oversteer indicator, derived from the relationship between front and rear lateral *g*, and complemented by driver feedback.
- Mechanical efficiency of the tyres.
- Thermo-mechanical efficiency of the tyres.

Precise details of the latter two parameters were not available for discussion, but Dufournier allowed that mechanical efficiency is assessed independently without reference to temperature, and it describes the effective mechanical potential of the tyres relative to a reference or maximum value.

Data used for this assessment appears to include longitudinal and lateral slip in reference to the forces (*g*) being generated in those directions and it leads to a 'global qualification of the tyre as a mechanical object.' Thermo-mechanical efficiency takes into account tread temperature mapping, and helps to understand the effects of camber, toe and tyre pressure. This tool complements the previous one with a local and accurate view of the functioning of the tread.

Run	Camber		Toe		Shock Absorber		Anti Roll Bar		Differential	Label
	Front	Rear	Front	Rear	Front	Rear	Front	Rear		
1	Creff	Crefr	Treff	Trefr	Breff	Brefr	ARBreff	ARBrefr	Diffref	Ref
2	Creff -0.5°	Crefr	Treff	Trefr	Breff	Brefr	ARBreff	ARBrefr	Diffref	C-
3	Creff	Crefr	Treff+10'	Trefr	Breff	Brefr	ARBreff	ARBrefr	Diffref	T+
4	Creff	Crefr	Treff	Trefr	Breff	Brefr	ARBreff	ARBrefr	Diffref	Ref1
5	Creff	Crefr	Treff	Trefr	Breff-5	Brefr	ARBreff	ARBrefr	Diffref	B-
6	Creff	Crefr	Treff	Trefr	Breff	Brefr	ARBreff-2	ARBrefr+	Diffref	ARB+
7	Creff -0.5°	Crefr	Treff+10'	Trefr	Breff	Brefr	ARBreff-2	ARBrefr+	Diffref	Synth
8	Creff -0.5°	Crefr	Treff+10'	Trefr	Breff	Brefr	ARBreff-2	ARBrefr+	Diffref+2	Diff+

Reference set-up

Front tyre pressure	1.6bar
Rear tyre pressure	1.6bar
Camber front, Creff	3.5deg.neg.
Camber rear, Crefr	2.75deg.neg
Toe out front, Treff	20'
Toe in rear, Trefr	10'

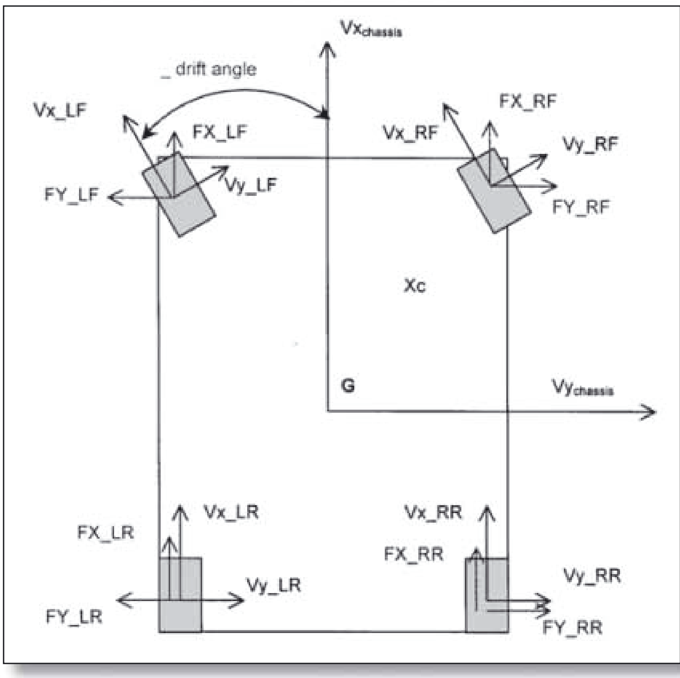
Figure 7: experimental design for the example Formula 3 project to cure corner exit understeer

Results and analysis

C- configuration

The front camber was reduced from -3.5 degrees to -3.0 degrees and the changes to the mechanical and thermo-mechanical efficiencies of the loaded front tyre are shown in figures 8, 9 and 10. Figure 8 shows how the front tyre in the reference set-up configuration lost mechanical efficiency early in the corner exit ('bend out') phase, indicative of the understeer problem the team was attempting to solve. However, although tread efficiency was improved by reducing camber, the thermo-mechanical efficiency plots shown tell a more complete story.

Figure 9 shows the thermo-mechanical efficiency across the tread in the baseline reference configuration. Here we can see that the outer shoulder of the tyre is being under used, while the centre and particularly the inner shoulder are being over used, with efficiency falling off rapidly as the corner exit phase begins. Figure 10 demonstrates the improvement in thermo-mechanical efficiency of the outer shoulder, and corresponding lessening of the →



Left: diagram to illustrate the various data sensors fitted to the test project

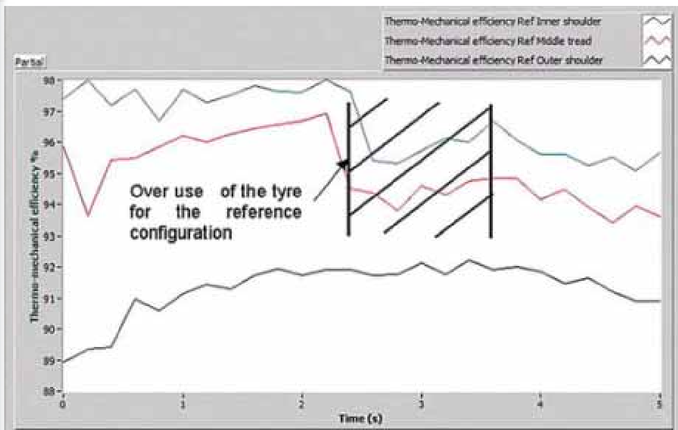


Figure 9: measurements of the thermo-mechanical efficiency of the loaded front tyre in the reference set-up

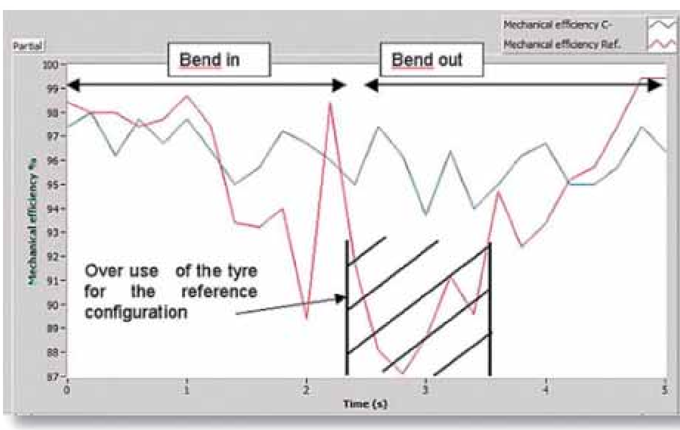


Figure 8: mechanical efficiency of the loaded front tyre after camber reduction

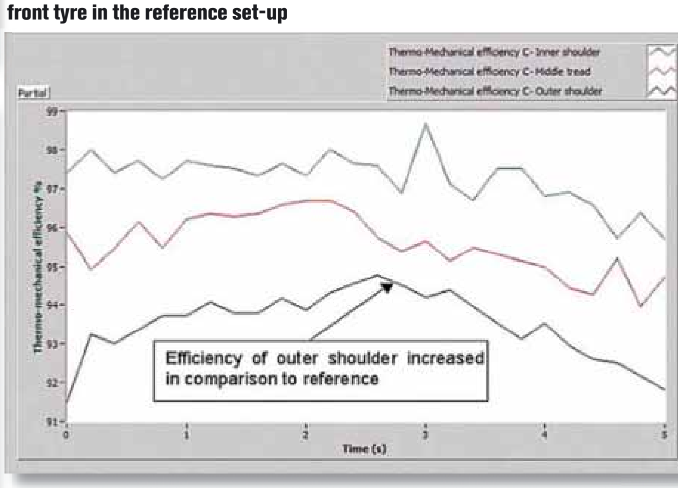


Figure 10: measurements of the thermo-mechanical efficiency of the loaded front tyre after camber reduction

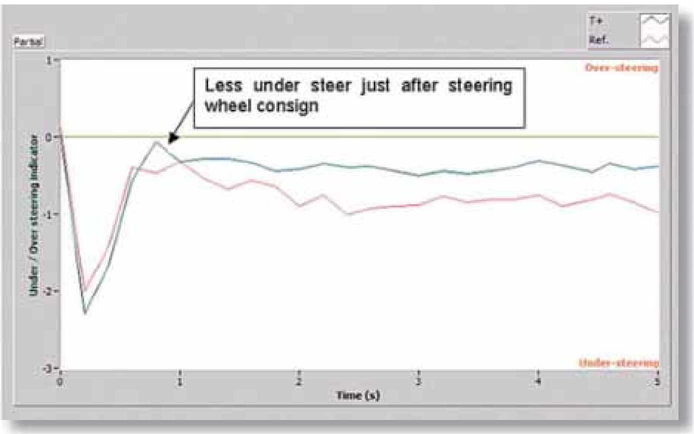


Figure 11: oversteer/understeer (USOS) indicator showing relative effect of front toe-out reduction

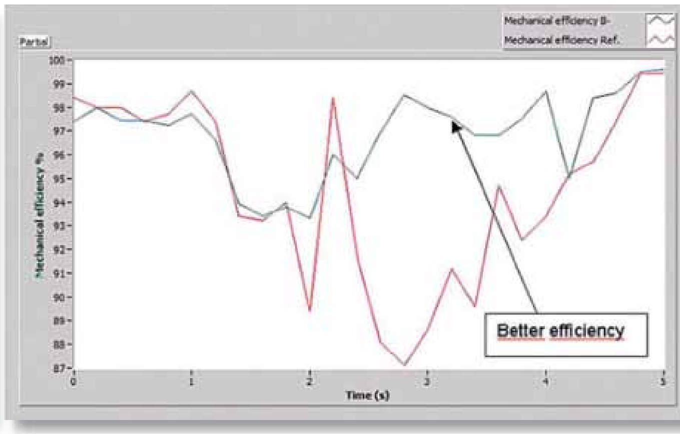


Figure 13: the gain in front tyre mechanical efficiency following the front damper compression softening

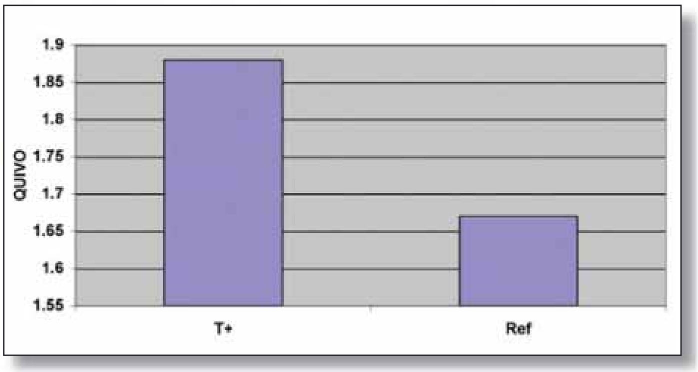


Figure 12: 'QUIVO' indicator showing the gain in front axle behaviour following the front toe-out reduction

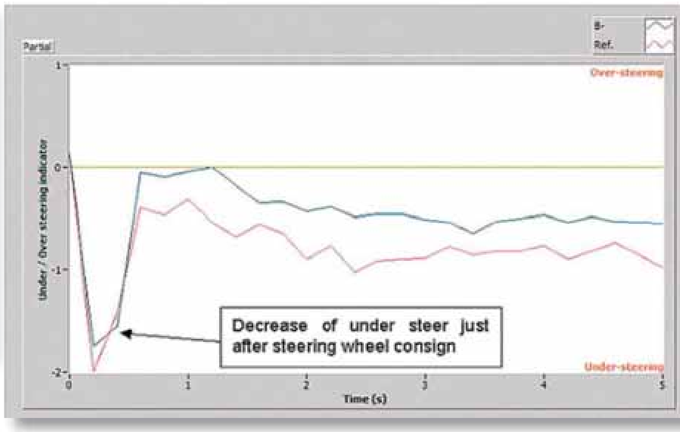


Figure 14: USOS indicator shows reduced understeer after front damper compression softening

fall off in the centre and inner shoulder regions, after the camber change. This is clear evidence of a more optimally used contact area, which will not only enhance grip but also reduce wear rate.

T+ configuration

This run involved reducing toe out at the front from 20' to 10'. The thermo-mechanical plots were said to show a similar gain to the camber adjustment, with the loads being better distributed across the contact area. Figure 11 though shows a plot of the understeer/oversteer (USOS) indicator, which shows that although the change to less toe out gave a little more initial corner entry understeer than the reference set-up, for the majority of the corner there was significantly less understeer. There was thus a corresponding gain shown by the QUIVO analysis in the middle phase of the bend, as figure 12 depicts, demonstrating better front end behaviour, essentially meaning less steering angle was required to hold the car at steady state in that part of the corner.

B- configuration

This run involved a reduction of the front compression damping, and figure 13 shows the mechanical efficiency of the front loaded tyre arising from this adjustment, relative to the reference set-up. Interestingly, the two curves are initially similar, but clearly later on in the corner the mechanical efficiency has been improved. Figure 14 is the USOS indicator for this change, relative to the reference set-up. It can be seen that the handling has improved from the moment of steering lock application, and that there is less understeer throughout the rest of the corner, presumably as the result of efficiency being improved in the later phases. However, feedback from the driver was less favourable because of excessive bump movement, especially on high-speed sectors of the track.

ARB+ configuration

In this configuration front anti-roll stiffness was increased and rear anti-roll stiffness was simultaneously decreased to maintain equivalent overall anti-roll stiffness while shifting the balance from the front toward the rear. Figure 15 shows the mechanical efficiency of the loaded front tyre relative to the reference set-up, and it is apparent that the gain in front tyre efficiency is very similar to that achieved by the damping change. An important difference though was that there were no excessive bump movements with this change in anti-roll stiffness. Overall the driver reported a marked preference for this set-up over the reference configuration.

However, as might be expected, there was a noticeable loss of traction on corner exit from this set-up, and this is evident in figure 16, which plots the mechanical efficiency of the loaded rear tyre in this configuration versus the reference set-up. There has been a clear reduction in the efficiency of the loaded rear tyres during the exit phase of the corner.

Synth configuration

This set-up involved the camber change, toe change and anti-roll stiffness change in combination but left out the damping change because of its adverse effect on vertical movement of the car at high speed. Figure 17 shows the mechanical efficiency of the front tyre and clearly there has been a cumulative gain →

> "ATTAINING MAXIMUM ADHESION... MEANS SEEKING THE LOWEST SHEAR MODULUS FOR THE HIGHEST DAMPING COEFFICIENT"

from this combination of set-up changes. The loss of rear traction capacity remained, but overall the aim of the study – to improve the mechanical efficiency of the front axle – was achieved. However, the original experiment design included a change to the differential setting.

Diff+ configuration

This set-up retained the 'synth configuration' above but in addition the differential was tightened up. The efficiency of the front end of the car remained very similar to that attained with the synth configuration, and corner exit understeer retained its much-improved level. Now however the efficiency of the rear tyres, which had fallen in the corner exit phase following the anti-roll stiffness adjustment, returned virtually to the level of the reference set-up. So not only had the front end of the car been much improved by this programme, but that improvement was ultimately achieved with no loss at the rear of the car.

Dufornier Technologies

Arnaud Dufournier established his company in 1999 after nearly 10 years in Michelin's tyre research centre at Ladoux, France. As his company's information states, great progress has been made with engines, chassis and aerodynamics in many categories in recent years, but the tyre – the sole contact with the ground – is generally considered to be an invariable. Dufournier believes that the tyres have not been properly exploited to attain advantage over the competition.

So, Arnaud Dufournier decided to make his knowledge and understanding of the internal functioning of tyres, and also of suspension system metrics and adjustment, more widely available with a range of commercially accessible professional services. As far as he is aware there are currently no competitors in this technical area with the exception of the tyre manufacturers, who don't offer these services on a commercial basis.

Though still a compact company, Dufournier Technologies has recently completed its third move into larger premises where it works in motorsport and also on automotive and truck projects. Its areas of expertise applicable to motorsport include: tyre and suspension analysis; static and dynamic thermo-mechanical analysis of tyres; numerical modelling of tyres; numerical modelling of track surfaces; Tyre Selection Device (TSD, enables selection of matched tyres according to physical and chemical properties); Tyre Monitoring System (TMS, which continuously monitors the tyres' physical integrity, not just pressure); and electronics and instrumentation.

Among short-term development projects are the development and improvements of ABS and anti-skid software for motorsport use, and assistance and advice in design, with respect to the influence of settings on tyre performance and driver feel. In addition to these technical services, Dufournier also offers training on the tyres, elastomers, mechanical and thermo-mechanical function of tyres, and adhesion and wear in operation.

Summary

While there may have been nothing surprising in the programme of adjustments here, or indeed the results obtained, what was very different was that at each step there was hard, objective data with which to analyse and make judgements to back up the driver's subjective feedback. Some of the data, and the calculated indices that were based on it, can be logged conventionally. But the manner in which Dufournier is able to supplement those methods with direct physical measurements of the behaviour of the tyres and the track surface surely offers a much more targeted means of deriving an optimum set-up than anything else currently available. RE

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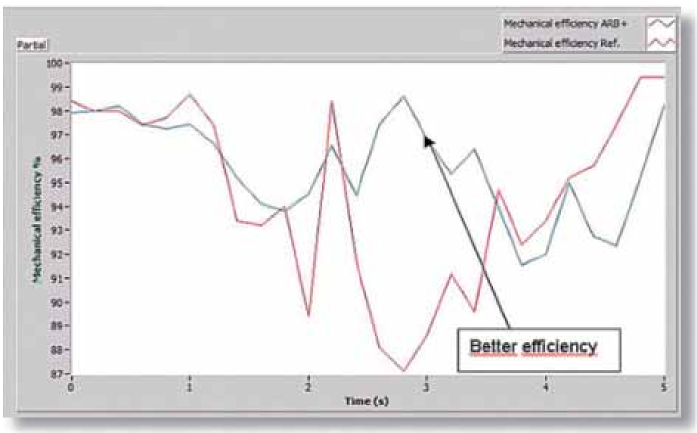

Figure 15: improved front tyre efficiency after roll stiffness shift to the rear

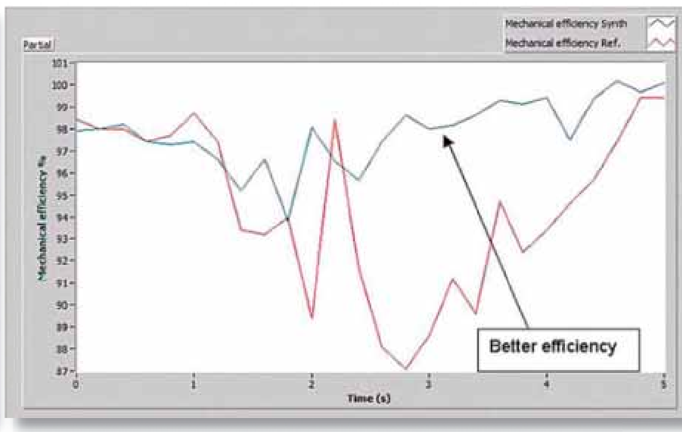

Figure 17: better front tyre efficiency in the 'synth' configuration

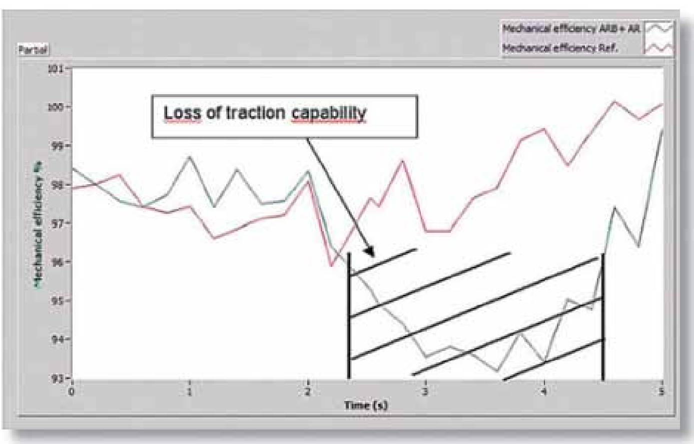

Figure 16: worsened rear tyre efficiency after roll stiffness shift to the rear

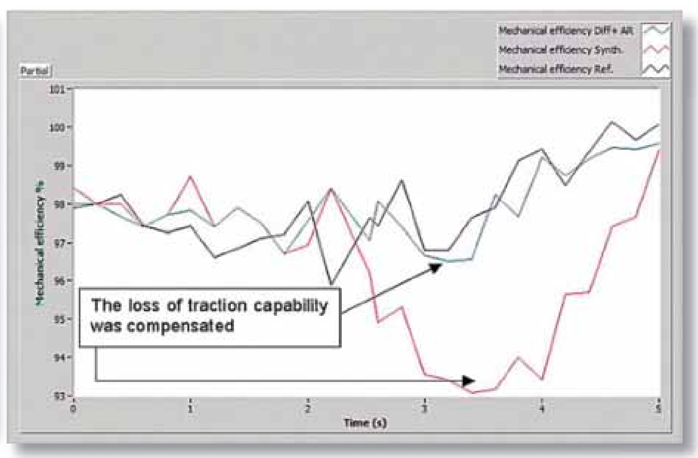

Figure 18: improved rear tyre efficiency after the differential was tightened

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BOSSing around

Can you really run a Formula 1 car, and even win a championship, on four per cent of Ferrari's corporate entertainment budget? Welcome to F1 the EuroBOSS way

Words	Mike Breslin
Photos	Breslin; LAT

Scott Mansell's Mansell Motorsport Benetton B197

It's not often you talk to a Formula 1 boss in the cab of the team transporter. Rarer still will he be munching on a fried egg sandwich. But then Mansell Motorsport is no ordinary F1 outfit, and Kevin Mansell is no Flavio Briatore. In fact, perhaps the only thing the down-to-earth midlander and the flamboyant Italian have in common is the Benetton B197 that Mansell Motorsport ran in last year's EuroBOSS championship – a car that the Briatore-run Benetton team built for Jean Alesi in 1997, for what was (for the team that was to evolve into Renault) a fairly unremarkable season.

Unremarkable is definitely not an adjective that could be applied to Mansell Motorsport's 2004 race campaign though. From a total of eight races with the B197 the team scored seven poles and four wins and also scooped four outright lap records, a feat that helped 19-year old Scott Mansell (son of Kevin) line up as one of the nominees for the coveted McLaren Autosport BRDC Award at the close of the season.

But the statistic that will really grab you is this one: all this was achieved on a budget of something close to £200,000 (US$378,000). Which puts things a little more into perspective, as that's about half of what a year in Formula 3 will cost these days. Best of all though, it's a mere particle of a drop in the ocean compared to the almost obscene amounts being spent in contemporary F1. For instance, perennial minnow Minardi is said to spend around £22m (US$41m) a year on its tail-end-Charlie efforts, while championship winner Ferrari is reputed to have committed £243m (US$459m) to its 2004 campaign. Of that, £5.4m (US$10.2m) was spent on corporate entertaining...

Of course, Mansell Motorsport is not competing in real Formula 1, and no-one is trying to pretend it is. But nevertheless it is real racing and at the sharp end of the EuroBOSS grid the competition is as fierce as it is in many an international race series (see panel). The cars are very quick too – Scott Mansell's Brands Hatch record eclipsed the ChampCar mark from 2003 – and they're also great to watch, thanks in no small measure to up to 740bhp and a lack of driver aids. Lack of driver aids? Yes, you see this is Formula 1 – just not as we know it.

Skin deep

In fact, the current specification of this B197 differs quite markedly from that in which Alesi raced it to second at the 1997 British Grand Prix. Changes have had to be made, for operational, financial and engineering reasons, and also to make it a better car – or 'bossing it', as Mansell puts it. And that's an important point. EuroBOSS is not an historic race series. It's not about racing in the original livery for the sake of authenticity, it's about racing, full stop. 'We don't really care if it looks like it did in 1997, we would do anything for a 10th,' says Kevin Mansell, 'what's important to us is that it's quick. And this is very quick.' Thanks in no small part to the improvements the small

The Mansell Motorsport team has not made many changes to the above-ground aeros on its B197 racecar

BOSSmen

BOSS: Big Open Single Seaters. The 'Euro' bit came later. And it fits well, for now EuroBOSS is a fully-fledged FIA international race series, with rounds at high profile circuits across the continent, from Lauzitz to Le Mans.

As for the cars themselves, the regs for EuroBOSS are as close to Formula Libre – or a free formula – as you're likely to find, the championship open to pre-December 2001 Formula 1 cars (it was pre-'98 until this year), Formula 3000s, 5000s, Formula Nippons, ChampCars, IRL etc. and of any vintage.

The cars run on Avon control rubber supplied by BMTR, but as far as other modifications are concerned pretty much anything goes, except for active suspension, traction control (no bad thing) and ABS brakes. Engines are limited to 4.0-litres – hence the Judd that sits in the back of the Mansell Benetton.

All this makes it so much more than an historic race series. Indeed, Le Mans entrant and EuroBOSS mainstay Ascari runs its modified Benetton B197s as Ascaris. But that doesn't mean the championship doesn't attract a welter of mouth-watering historic machinery too, with everything from a '95 F1 Ferrari V12 to a G-Force Indycar seen out in 2004. Meanwhile, there's even been talk of a trio of 2001 F1 Ferraris turning out this year. Racecar heaven if you're a fan of those Big Single Seaters then.

Right: Jean Alesi's 1997 Benetton B197 Renault at Monza. This is now Scott Mansell's car, seen left

"EUROBOSS IS NOT AN HISTORIC RACE SERIES"

A more fundamental change at the rear on the Mansell Motorsport car is the use of a B194 rear diffuser

The rear wing also now sits 10mm higher than in '97, while 'flat flooring' helps generate more downforce

team has made, particularly on the aerodynamic side of things. But this is not about hours in a wind tunnel – it's a long time since this particular car has been near one of those – it's about where the car was when it was original designed, and where it might have been had the regulations differed. Post 1994, in the wake of the Senna tragedy, F1 cars were required to have a stepped-bottom, so fitting a flat floor to one of these cars is an obvious way to find some extra downforce.

'Putting a flat floor on the car (coupled to a B194 rear diffuser) has really been a step forward,' says Mansell. 'We are in a position with this now where it's pre-grooved tyres, but it has all the above ground aero development work done on it after 1994. To put that in perspective, in F1 in '95 they had the stepped bottom and went slower, in '96 they matched '94 times and in '97 went quicker still. We have that plus the flat floor, which moves it on again.'

Not that Mansell underestimates the complexities of F1 aeros: 'We haven't really got the resources to sort the aero, and we have to rely on Scott's feedback – which is very good. But when we flat floored it we didn't really know where the centre of pressure was going to go, and you can have a sliding centre of pressure, so →

"FITTING A FLAT FLOOR IS AN OBVIOUS WAY TO FIND SOME EXTRA DOWNFORCE"

"CHANGES HAVE HAD TO BE MADE FOR OPERATIONAL, FINANCIAL AND ENGINEERING REASONS"

as the speed increases the centre of pressure is moving along the car.'

So while the rear wing has been lifted 10mm to get it into the clear air, on the whole the policy is not to mess too much with the above-ground aeros, largely because it was originally designed as part of a package, and small changes can have a knock-on effect, as Mansell explains: 'One time we tried our own little aluminium winglets on the front, which gave it more bite in the high speed corners, but it also made the engine run hot because it directed the air away from where it's supposed to go.'

Yet while Mansell Motorsport is happy to →

What's in a name?

'Any relation?' It's a question the Mansells have been asked 1001 times. The answer's no, by the way, but Scott and manager Richard Barrow are aware of the PR boost the coincidental link with former F1 and Indycar champion Nigel gives them – especially at a time when they're competing for race seats, and sponsorship Euros, with the offspring of Piquet, Lauda and Rosberg.

Funnily enough, Kevin Mansell (45) started in motor racing at about the same time as 'our Nige' did, back in the mid 1970s, first competing in grasstrack racing and then on short ovals. After that, following a spell building up his own garage business, he started racing a Lotus Cortina in Classic Saloons.

Success with the Cortina led to him selling the garage business and becoming involved with historic race engineering, firstly through buying into Twin Cam Techniques, and then through running a fleet of Cortinas across Europe under the Mansell Motorsport banner.

In the mid 1990s the company moved into single seaters, looking after the engines for the Formula Honda championship in the UK, and then a couple of cars in that championship. The move to EuroBOSS came when one of the team's Honda drivers wanted to step up to drive a 1991 Reynard Formula 3000 – an ex Christian Fittipaldi car.

The team consists of the family, and up to four part-time, fully qualified racecar engineers, 'depending on where we're running,' says Kevin, with driver Scott pitching in on the mechanical side between stints on the track. But as far as working on the car full time is concerned, that's pretty much down to Kevin.

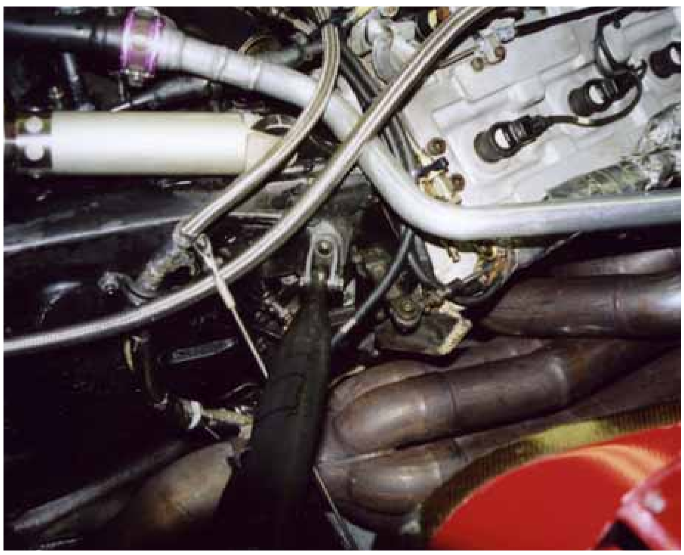
Running Scott in EuroBOSS in 2004 was a gamble. It's not your normal stepping stone to grand prix stardom after all, but the championship crown, the McLaren Autosport nomination and subsequent successful tests with GP2 team Arden seems to suggest the gamble paid off. Just perhaps, in the future, when the name Mansell is uttered, it will not only be the once-moustachioed one that springs to mind. Only time will tell.

Kevin Mansell – no relation to Nigel Mansell

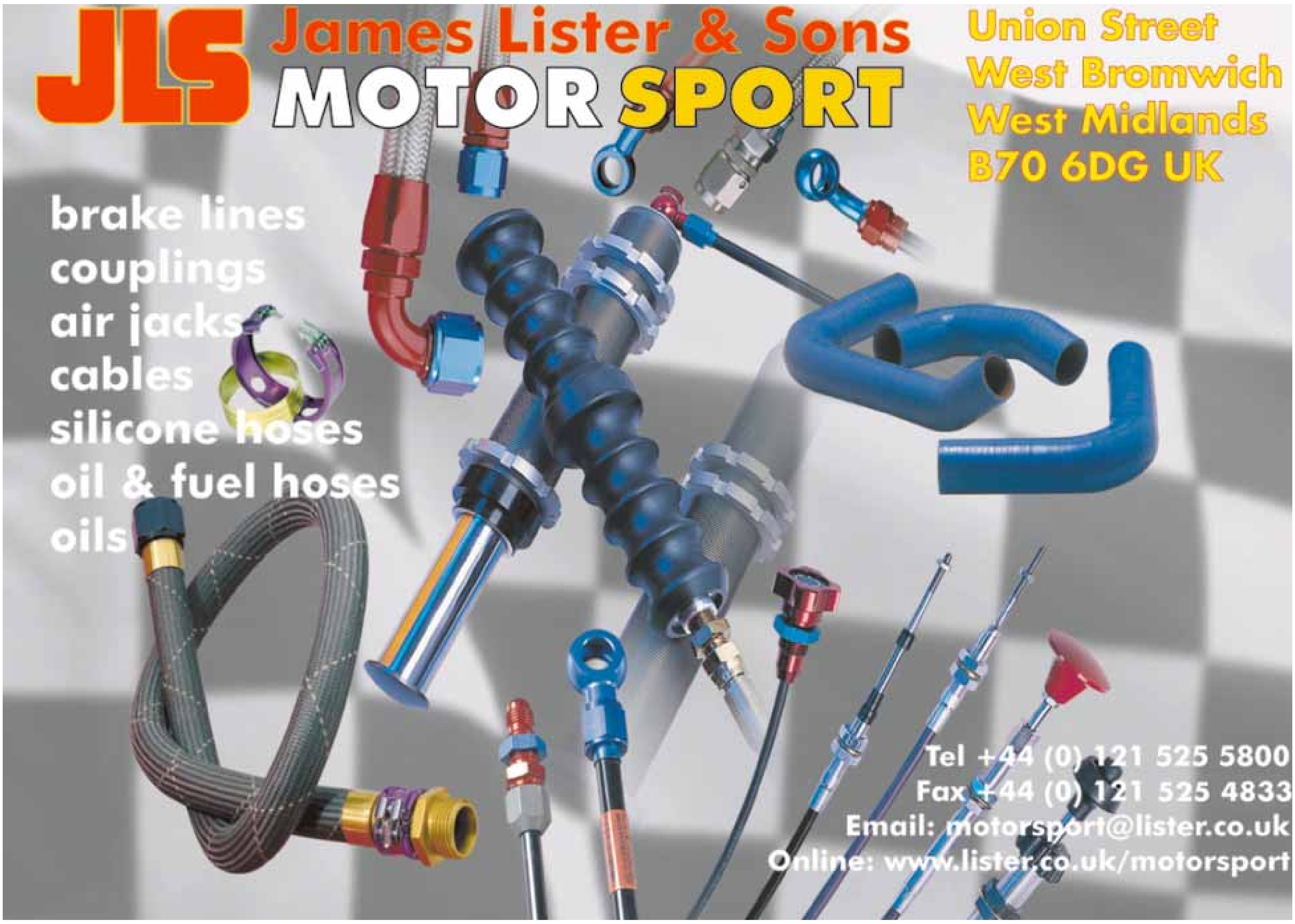
There are no hydraulic and electronic systems on Mansell car, so paddle shift has been replaced with conventional mechanical sequential shift

740bhp, 4.0-litre Judd V10 sportscar unit has proved itself to be low maintenance and very reliable in the re-born B197

Mansell's engine data man Andy Barnsley warms up



Mounting the Judd engine necessitated the use of a special gearbox adapter, which in turn forced some re-engineering of the rear suspension pick-ups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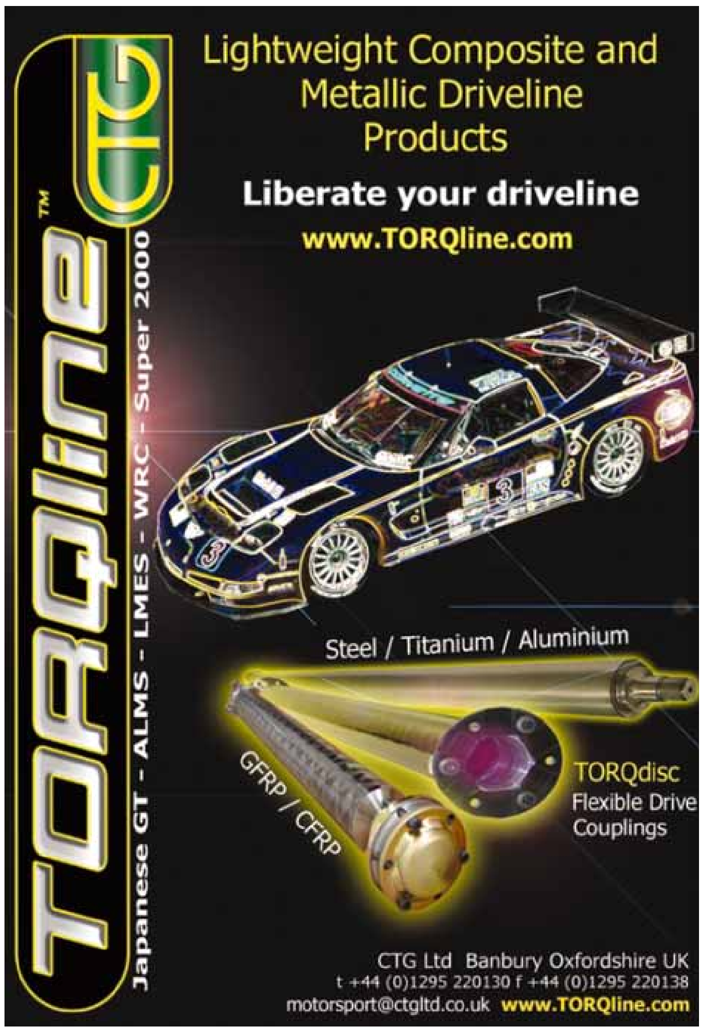
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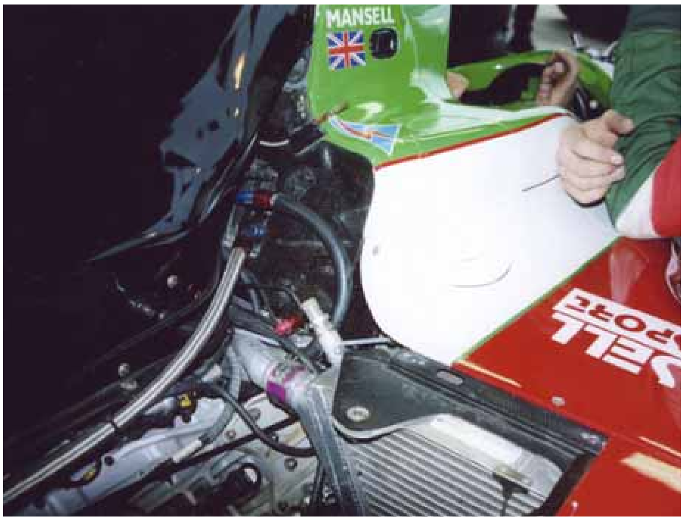
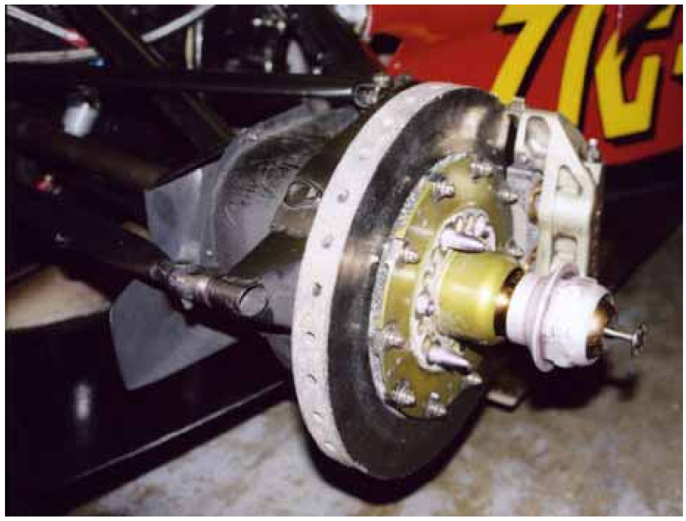


One of many less significant changes is the use of a smaller capacity fuel tank

Rear suspension pickups had to be re-engineered to fit the relocated gearbox

The team has been impressed by the refinement of the engineering on the car



Carbon brakes leave little time for downshifts on the non-paddle shift gears

reap the benefits of Benetton's mid-1990s aero expenditure [incidentally, this was the last Rory Byrne designed Benetton before he left for Ferrari] some of the inherited traits of the car are less welcome, in particular its lack of mechanical grip on low-grip surfaces, the very problem that blighted its 1997 world championship campaign.

'We really suffered with that at Zolder, which has a pretty poor surface with eroding Tarmac and little stones everywhere. Scott came in and said "the car is awful, it's like driving a rally car." But we sorted it... I don't want to say how because we took two seconds off Ascari's lap record thanks to that, and they're using B197s, too...' Just in case you doubted this EuroBOSS racing was anything less than competitive.

Filling the gap

There is of course a far more obvious, and inherent, problem with running Formula 1 cars from the manufacturer era of the sport. You just can't get the engines – as the manufacturers invariably took them back at the end of a season's racing. Luckily, renowned engine builder Judd has filled the gap with its fantastic sportscar 4.0-litre V10. The engine, which is said to give 740bhp, has been pretty much a bulletproof part of the car since Mansell started using it three years ago and, apart from Mansell Motorsport's engine man Andy Barnsley checking the data, the powerplant is effectively a low maintenance part of the operation, with Judd present at every round of the championship to support its teams.

"THE 740BHP 4.0-LITRE JUDD HAS BEEN A BULLETPROOF PART OF THE CAR"

Fitting the Judd was a little bit more of an issue though, particularly as it had to be eased into a space once occupied by one of the first of the new compact breed of F1 engines, the Renault RS9, but Mansell has done a remarkably good job of it. 'We've managed to machine the rocker cover so we can use the top mounts in the original position, while there's a steel block in the floor of the tub, which means we're able to locate the engine pretty close to its original position.'

All of which is important to the torsional rigidity of the car, of course, because the tub has been designed with the original loading points in mind. But Mansell says this has caused its own knock-on problems because of the higher crank height. This, along with the fact the 4.0-litre has a bigger throw, means that locating the gearbox was not the work of an afternoon, and has involved the manufacture of a clever adaptor plate – designed in conjunction with Ascari – which has enabled the Benetton 'box to mate with the Judd. This has had its own knock-on effect of raising the 'box by 16mm, which in turn picks the rear suspension up with it. Consequently, the rear suspension pick-ups had to be redesigned, and this dialled out 14mm of this... As you can see, engineering an older F1 car has more than an element of compromise about it.

But it's not just the mating of the six-speed Benetton gearbox to the engine that caused problems initially: 'The Judd has got massive torque, and to begin with it drove the dogs off →

the face of the gear! So what we did was add 20thou to either side of the dog. The problem with that is that when Scott got in the car and the braking distances were shortened (from that of a previous pay driver) he found it difficult to get down the gears, as we had reduced the window of opportunity by widening the dog.'

The team has worked on that (it's now 20thou/10thou either side), but with carbon-carbon brakes there remains a sort of technical discrepancy between some parts of the car and others, particularly when it comes to driving it.

For instance, while a driver of Scott's undoubted calibre can get the best out of the staggering performance of modern F1 braking systems, the lack of a paddle shift and related electronics means there's no throttle blip on the downchange, and there is simply not the time to heel and toe as he goes through the gears.

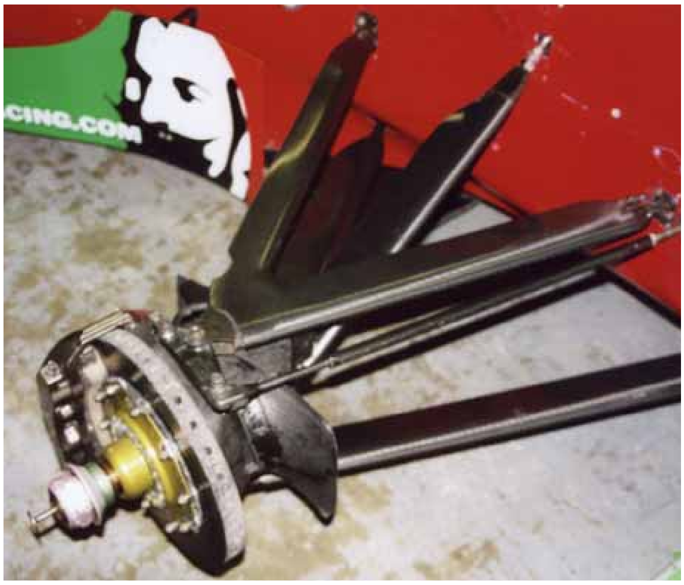
That paddle shift has been replaced by a conventional sequential system, which although a simplification also needed plenty of thought: 'The problem is that when you're going to be in high g corners you need to work out the rack weight so you can spring it to control it in the turn, otherwise it would simply pull the car out of gear,' says Kevin Mansell.

The B197 has lost other accoutrements of its glamorous past, too. Gone are the complex electronic software and the hydraulics, the power steering, and the fly-by-wire throttle and clutch. 'The hydraulics would be a technical nightmare,' says Mansell, 'and that's why we run without these systems. Think about it, what's the most common reason for an F1 car to retire from a grand prix? Hydraulics. To run with it we would need an hydraulics expert, and then someone to run the software, and with that added expense we simply would not be able to race.'

Yet the hydraulic diff remains – even if the software to make it work doesn't, and they've been running it as a normal diff. 'It would be great if we could make it work as it did,' Mansell says, 'but that sort of technology is pretty much pie in the sky as far as we're concerned, and I've actually found a normal plated LSD that we can use from now on.'

Attention to detail

Parts can obviously be difficult to come by, and like many teams running older single seaters there is a lot of component re-fabrication involved, although the proximity of East Midlands Airport to the team's base also means there are plenty of aerospace testing companies within easy reach, which is handy. All that said, Mansell is often amazed at the strength of this car, as he is with the exquisite design detail: 'When you look at some of the things on this car, even something simple like the radiator supports for instance, they are just a work of art. The way they are designed… And yet you pick them up and they weigh absolutely nothing. You should pick the engine cover up, you'll be amazed at how light it is.' We did, and we were.



Mansell's Benetton came with a decent supply of spares so suspension breakages are not a concern

While there has been no need so far, the team is not fazed by the prospect of making alterations to the tub

Gearbox gear dogs needed re-machining to cope with the Judd's phenomenal torque characteristics

The team was lucky in that the car came with plenty of spare bodywork, including engine covers and side pods, and while Mansell has not needed to touch the carbon-honeycomb tub for any reason as yet, the prospect of fixing it doesn't seem to daunt him too much.

On the outside, the main sponsor's livery, colours and signwriting aside, echoes that of the 1997 spec car, for a reason. As graphics man and Scott's manager, Richard Barrow, reasoned, why waste a perfectly good design that works well at speed and possibly cost the fashion-conscious Benetton works team quite a bit to come up with?

It's this sort of no-nonsense reasoning that's a hallmark of this down-to-earth yet professional team and one of the secrets of its success, too, along with attention to detail and realising that running an F1 car is so much more than turn-key motorsport. 'There's not one thing you need to do,' says Mansell, 'it's everything. Look at the way we start it up, it's in the detail: we get the engine up to temperature, it doesn't turn a wheel until the oil's up, the water's up… We have a group of lads who each have their part in a set sequence: one looks after the wheels, one looks after the fuel, one looks after the engine, and so on.' And Kevin Mansell's part? 'I tend to oversee everything and do the set-up – I'm team manager, chief engineer, technical director… and truck driver!' Just like Flavio Briatore then.

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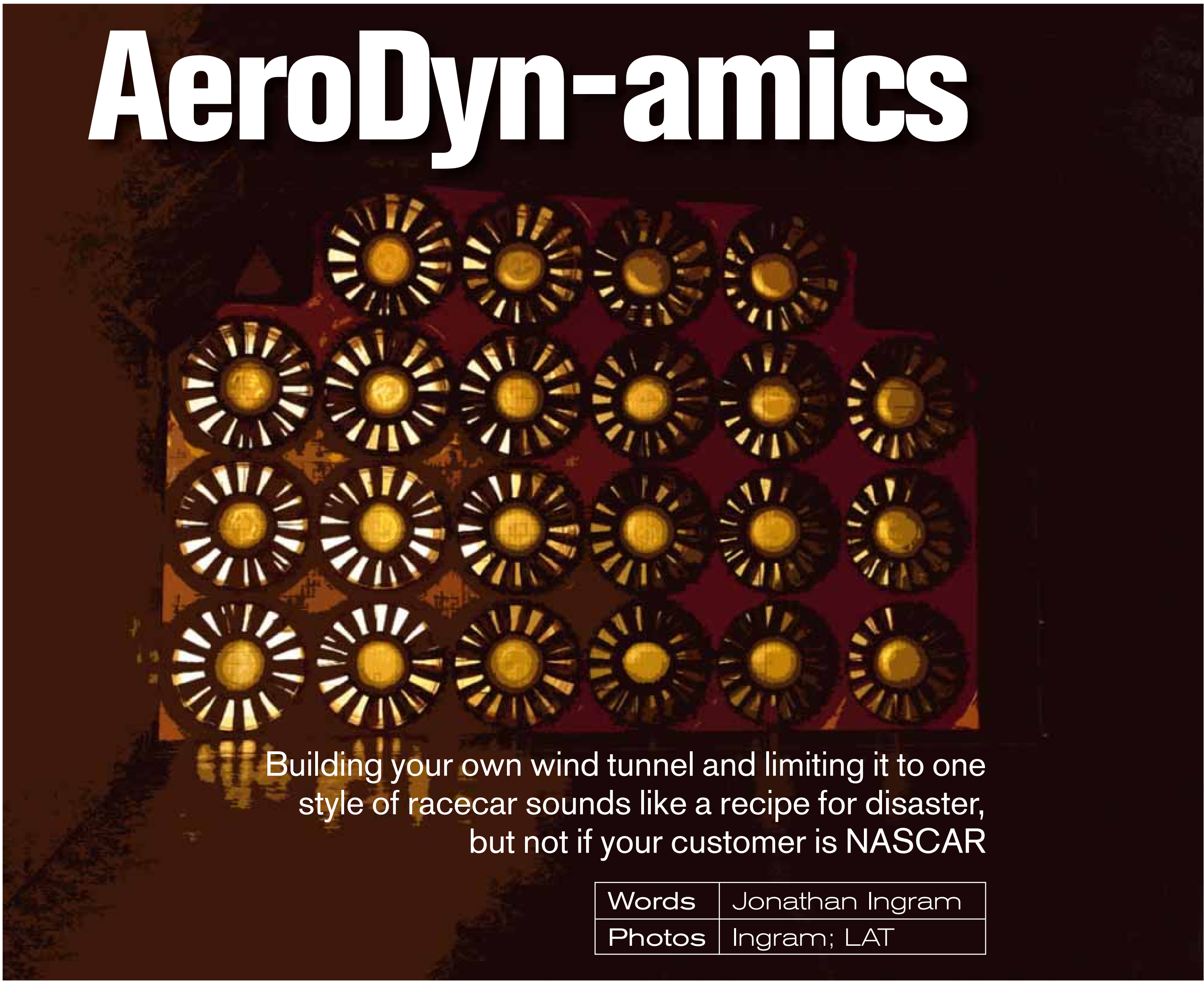


Building your own wind tunnel and limiting it to one style of racecar sounds like a recipe for disaster, but not if your customer is NASCAR

Words	Jonathan Ingram
Photos	Ingram; LAT

When Smokey Yunick snookered the Ford and Chrysler factories with his privateer Chevelle to win the Daytona 500 pole nearly four decades ago, he used a rotisserie-style jack in his Daytona Beach garage to work on the aerodynamics. To get from the topside of his Chevelle to the bottom, the pipe-smoking garage philosopher just flipped it over. But things are radically different these days, and the majority of the cars in every starting Nextel Cup field now do time in a wind tunnel – most before the race and some afterwards as well.

This development is due in no small part to Gary Eaker. Introduced to NASCAR while employed by GM Racing, Eaker jumped into stock car racing in a big way when he signed up as aerodynamicist for the Hendrick Motorsports team. Then in 2003 he went out on his own, opening his own wind tunnel in sleepy Mooresville, North Carolina, the heart of stock car racing country. His ingenious tunnel which is known as AeroDyn, or more colloquially as Eaker's place, is a one-of-a-kind original that has changed the modus operandi of NASCAR's Nextel Cup, not to mention the bodywork, from top to bottom, of many a stock car.

Eaker's closely shaved head gives him a youthful look, not to mention an aerodynamic one and, like so many veterans of NASCAR garages, he's outgoing and proud to show off his creation. His tunnel is custom-built for NASCAR-size cars and trucks, its first distinction, and the vehicles experience a simulated 130mph while the wheels and tyres spin on four steel rollers, its second distinction. 'It's intuitively obvious that spinning wheels are closer to the actual process on the track than stationary ones,' says Eaker.

> **"WE BUILT THE WALLS EXPRESSLY FOR STOCK CARS"**

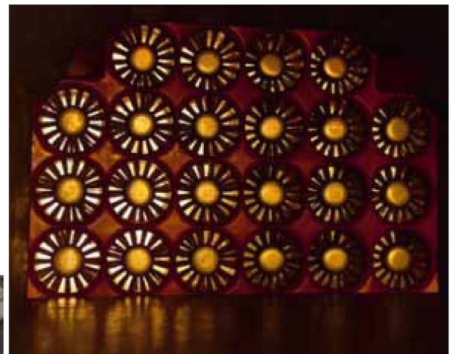
This process not only better simulates airflow on the track, it also provides a unique opportunity for testing at yaw, yet another distinction crucial to racing on banked superspeedways. As importantly, the Eaker methodology includes a clever resolution to the boundary layer issue that literally crops up like bad air growing from the floor in any wind tunnel programme.

When it comes to current aerodynamics, the standard templates used by NASCAR for all car brands has put an even higher premium on the bodywork and underside areas that are not controlled, and exploiting even the tiniest loopholes to the maximum means gathering a lot of data: 'If you start with the information you get from the wind tunnel, and then include the springs, shocks and sway bars and take all those complex interactions, the combinations are infinite,' comments Eaker. 'It's never going to end either. It's always going to be a continual process of development.'

Because Nextel Cup teams build so many cars

Standing alone in a large warehouse the AeroDyn facility works as an open return system

22 fans, with a total power of 2200bhp, draw air through angled inlets and into the tunnel itself



Eaker's AeroDyn tunnel is designed specifically for aerodynamic work on both NASCAR cars and trucks

for the 22 different circuits on the schedule (which comprises 36 races in all) the first preference is to work with de facto information versus sources like 40 per cent scale models or computational fluid dynamics. The latter methods are rapidly gaining footholds as more teams build databases, but the practical continues to trump the theoretical in NASCAR, especially since AeroDyn makes it both relatively easy and rewarding to run a full-scale test at $1250 (£660) per hour.

Brains and brawn

AeroDyn is housed in a large building, and the tunnel – its external structure entirely in view beneath a high ceiling – is an enclosed chamber within a larger warehouse-style room. The encompassing room's vault is big enough to allow the air to re-circulate to the open chute at the front of the tunnel after the 2200bhp fans pull it through, hence the open return designation. 'It's a machine that blows a very controlled wind over a test object and then very carefully measures the results,' says Eaker on a walking tour. 'That means you've got brains and brawn.'

> **"WE'VE FINE TUNED IT TO EXACTLY THE SHAPE WE NEEDED"**

The advantage of Eaker's approach is he concentrates on only one size and type of vehicle – those found in NASCAR's three major touring series: the Nextel Cup, Busch Series and Craftsman Truck Series. The relatively small size of the tunnel chamber provides reliable accuracy as well as the benefit of reduced construction cost. The accuracy comes first from consistent air speed due to walls contoured to accommodate the usual slipstream of air buffeting around a stock car. 'We built the walls expressly for stock cars, not everything from Formula 1 cars to go karts and a range of vehicles in between. Since we've defined that we deal with stock cars and trucks only, we lock these walls in place and leave them where they're at.'

Borrowing from NASA technology, Eaker also built the chamber with slotted walls, which can be adjusted to allow air to escape if necessary to prevent blockage. But after tuning the walls using jack screws, such as those found on a stock car suspension, Eaker achieved contours that resulted in a consistent speed without blockage. A quick walk back into the larger chamber reveals the jack screws, which stick out from the mid-section of the external side of the tunnel walls like a well-mannered row of porcupine quills, their gradually staggered line providing a mirror image of the contours of the tunnel walls inside. 'There's an outer wall and an inner wall and the screws are attached to a linkage,' Eaker explains. 'We actually moved the contour around from the starting point and fine tuned from there. The way the tunnel was originally built was like the way the racecar shows up at the track Friday morning and what we wound up with is something →

we're ready to race with on Sunday morning. Over time we've been able to fine tune it to exactly the shape we needed.'

In fact, so close did Eaker get with his original contours, after first building a scale model tunnel and with the use of CFD modelling, that the slotted wall system is not in use at all. 'We started testing with the open slots and then started closing up the slots and saw that the quality of the air flow wasn't changing, but the air speed was – the slots are an actual loss to the air speed. Ultimately, we can run it either way, and since we don't need the slots we picked up a little more air speed. Theoretically we can run at 147mph (236km/h), but the tunnel was designed to work at 130mph. The rollers spin at 130mph (209km/h) and the boundary layer management system in the floor is mapped to 130mph.'

All this stands in contrast to more traditional full-scale tunnels used by airplane and car manufacturers, as well as NASCAR teams. Tunnels such as the Lockheed-Martin facility in Georgia or the National Research Center in Ontario, Canada

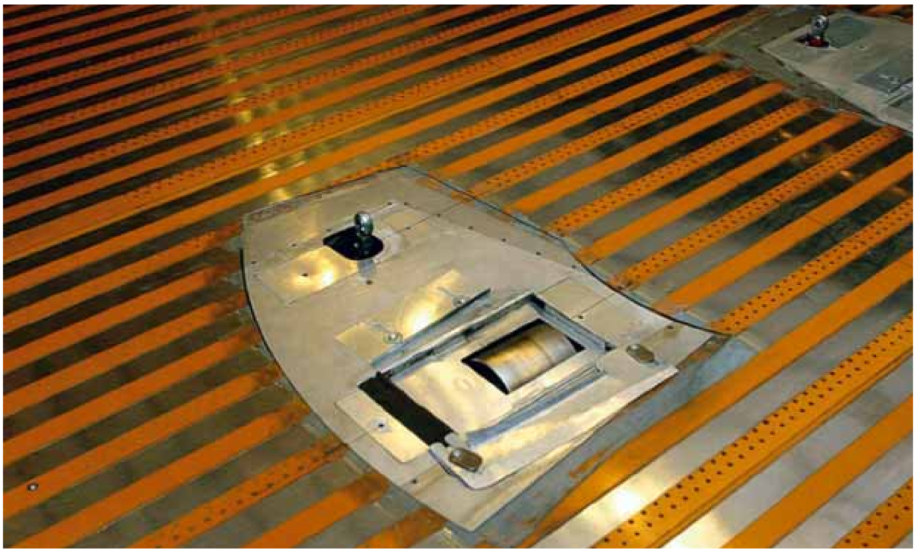
"BORROWING FROM NASA TECHNOLOGY, EAKER ALSO BUILT THE CHAMBER WITH SLOTTED WALLS"

have large chambers to accommodate a wide range of tests. The same is true of those owned by manufacturers. There's enough space in these traditional tunnels' chambers to account for any blockage problems – as opposed to the use of contoured walls.

To prepare for a session at AeroDyn, teams first remove the springs and shocks from the chassis. Each of the frame's four corners is then fixed to a two-inch diameter hydraulic ram. The contact patch for the tyres are metal rollers that can spin the wheels at the maximum of 130mph, each requiring a 20hp electric motor that turns it to 7000rpm. Eaker: 'The rollers are mechanically attached to the scales and are only there to spin the tyres. They support only the unsprung weight of the tyre and the suspension. 95 per cent of the weight is on the hydraulic rams fixed to the chassis. Instead of sitting on four pneumatic springs called tyres that have to be bolted down, we're fixing it to the chassis itself. So we have a more rigid mounting system and the car shouldn't be moving at all.'

Just as the size of the tunnel is designed for one car, the tunnel is also designed for vehicles that turn left. The ram at the right front corner is fixed in all three axes (up and down, sideways, back →

Above: internal tunnel dimensions have been honed to perfectly suit the shape of the NASCAR racecars
Below: four individual rollers support unsprung weight only and spin the wheels at 130mph, while the vehicle chassis is firmly attached to four hydraulic rams. Perforations prevent boundary layer build-up



Boundary layer system uses suction and tangential blowing through precise holes and sprung steel strips

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29 October 2004

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Mr. Mike Holzapfel
President

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Mike, I wanted to take this opportunity to thank you and everyone at ARP for their dedication, commitment and hard work this past season. As you know, Honda takes its racing very seriously and expects the same level of product quality and customer service from our suppliers as we expect of ourselves. It's a pleasure to do business with ARP - a company that clearly lives up to our expectations.

Sincerely,

Robert S. Clarke
Vice President & General Manager

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December 9, 2004

ARP
Mr. Mike Holzapfel
President

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Above: underside of NASCAR racecars shows how limited underside ground effects are

Left: with such tight regulations and so few differences in silhouette shapes, specific aero details such as the front splitter shown on the Dodge (left) are vital to front running teams

> **“NASCAR TEAMS USE FULL-SCALE WIND TUNNELS IN THREE WAYS TO IMPROVE PERFORMANCE”**

and forth). The left front is fixed in two axis (sideways, back and forth) and the two rear mounting points are fixed in one axis only (back and forth). 'That way the car is firmly fixed, but it doesn't bind up.'

To test for turns – or yaw – the metal platform holding the rollers that spin the rear wheels can be laterally moved either to the left or right while the front wheels continue to spin on rollers mounted in a fixed position – in effect simulating the yaw angles of cornering.

By contrast, at Lockheed a car is mounted on a round plate, or turntable, which is rotated. At AeroDyn, the pivot point is between the front tyres. The car is pivoted around the engine, in effect, and keeps the nose of the car centred in the tunnel, giving the AeroDyn system a dynamic and accurate testing opportunity.

With recent alterations to rear wing height regulations, wind tunnel testing is vital for top teams to attempt to reclaim lost speed

Breaking boundaries

All wind tunnels have problems with a boundary layer of static air that clings to the floor, which builds gradually and slows the air down. Eaker's system reduces the layer itself instead of using calibrations. Again, this is a benefit of a tunnel designed for one type of vehicle. 'In the real world you're moving the car over stationary ground, so there isn't a boundary layer, but in a wind tunnel you have air that is accelerated. Street car tunnels are less concerned because the car is six inches above the ground instead of one or two inches. It's an issue of clearance and how dependent the racecars are in using ground effects to make the car stick to the racetrack.'

In Eaker's system, there's a compromise →

Tunnel overview and specifications

Tunnel design:	Full-scale, closed-jet, contoured and optionally slotted wall test section, with an open return. Optimised for stock-bodied racecars (open-wheel applicability not determined)
Test section size:	11.9ft high by 19ft wide by 56ft long
Air flow:	125-130mph, using 22 individually speed-controlled 100hp AC electric fans
Boundary layer control:	Continuous blowing/suction groundplane ahead and under the car, plus spinning tyres
Balance:	External six component strain gauge balance, vehicle frame rail end fixturing, integrated vehicle height control, spinning tyre mechanisms, +/- three degrees yaw
Wheelbase range:	103-112in
Track range:	60in
Data acquisition system:	3x64 channel 16 bit, 2x32 channel 16 bit, 2D aero pressure grid built into floor beneath the car. Output to Excel, with default layout or customer supplied layout

Source: www.aerodynwindtunnel.com

"TEAMS CAN BLOW A CAR AFTER A RACE TO FIND CORRELATIONS BETWEEN ITS ACTUAL PERFORMANCE AND THE DATA FROM THE WIND TUNNEL"

between the two ways of dealing with the boundary layer – either by removing air through sucking or adding air through tangential blowing. 'In a perfect world, the boundary layer is only an energy loss because the air is slower. My premise is to only add energy instead of air flow.'

To accomplish this goal, a porous surface to suck the air is followed by, or combined with, tangential blowing. There are five segments to the system, starting with a strip of 3/8in suction holes 14ft in front of the vehicle's nose. 'Almost half the air from the boundary layer is sucked away here,' Eaker explains, 'pulling it down and getting rid of the boundary layer that is built up from the beginning of the tunnel.'

Because the boundary layer is relentless, the fight to make it as thin as possible continues shortly afterward. Sprung stainless steel strips convert forced air from a channel underneath the floor into tangential blowing. That in turn energises the airflow and also realigns the air, whose angularity has been disturbed by the first set of suction strips.

The third segment is located two feet in front of the valance, or air dam, of the vehicle, where another porous surface sucks the air from the boundary layer, enabling faster air from above to come down and fill the area. 'You have to be careful because anything you do to the boundary layer is adding an artificial change in the streamline,' said Eaker of his carefully laid out pattern of suction holes.

Just in front of the valance is a combined suction and tangential blowing segment. 'The amount of air is unchanged, because you're blowing and sucking at the same time, but the valance has an extremely high velocity change – the pressure goes from very, very positive in front of the valance to very, very negative behind it.

'Distributed suction was a good compromise under the valance area,' Eaker continued, 'because it was a predictable low pressure area. There is just enough sucking to keep the air thin. Once the air gets past the valance, to about where the engine's radiator is, that's where the tangential blowing slots and suction holes start again. In a perfect world that would go all the way back to the rear of the vehicle, but because of all the physical mechanisms back there, I lost some of the real estate.' The leading minds in the Nextel Cup garage aren't lamenting the fact Eaker's system doesn't go all the way to the rear bumper. When teams want to work on the trail originally blazed by Yunick, enhancing ground effects anywhere possible on the underside of the stock cars, the Eaker tunnel has all the fixings.

Gary Eaker, the man behind AeroDyn

Right: data acquired is output to Excel in a standard or customer supplied format

And because of its practicality and proximity, teams keep AeroDyn busy around the clock six days a week, and estimates reckon that 80 per cent of the cars in any starting field at a Nextel Cup race see tunnel time at AeroDyn.

NASCAR teams use full-scale wind tunnels three ways to improve performance. They can use a previously established profile, in the form of data from the wind tunnel or instrumented track testing, to find out how a newly built or recently modified car stacks up. Being able to determine how a car responds to changes such as rear spoiler angle is especially handy before actual qualifying. Alternatively, teams can blow a car after a race to find correlations between its actual performance and the data from the wind tunnel.

The third method emphasises research and development, and can be achieved in either a full-scale or a model tunnel. Teams use R&D cars to test before building new cars or to anticipate rule changes such as the 2004 reduction of the rear spoiler by 3/4in. Whether a full-size car or a scale model, in either case the cars are outfitted with a multitude of taps to measure the aerodynamic pressure at key points on the body and chassis.

At AeroDyn teams are relying mostly on Eaker, who designed every major component in his tunnel, including the scales attached to the rollers. This is a pretty amazing feat, given that some of the toughest taskmasters in racing have found AeroDyn to be so useful, but this is also still racing. Out of concern that a competitor might try to squeeze another tunnel into the busy NASCAR market, Eaker remains understandably tight lipped on the construction cost of his relatively small, open-return type tunnel, which was financed privately from sources outside racing. Right now though, AeroDyn is so distinctively stamped by Eaker's own work and experience, it would be hard to imagine anyone else building a replica of it. RE


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Boxing clever

More than just a place to store your spanners, effective and good looking tool storage is a vital part of any race teams armoury

Words | Ian Wagstaff

When choosing a tool storage system, it is more than just a question of convenience, it is also one of image. Every technician needs somewhere to store tools in such a way that they are easily accessible and do not get mislaid. That much is obvious. However, Toolstars marketing services manager Daniel King reckons there is more to it than just that. 'It's one of the first things sponsors see when they walk into the pits.'

King contends that 'it is the impression they give', particularly at the start of the season when there is no excuse for a battered cabinet. 'It has to look good,' agrees Dura's managing director Dominic Wishlade. The same, of course, must be true in the workshop. K2 Race Engineering director Mark Winsor reckons it may have been the understated grey hue of Dura's products that first brought the company's systems to his team's notice.

"IT IS MORE THAN JUST A QUESTION OF CONVENIENCE, IT IS ALSO ONE OF IMAGE"

That said, a cabinet is a basic piece of kit that has to suit the needs of the technician. Quite how far it goes to meet those requirements will depend upon the budget available. 'It comes down to money,' says Beta Utensili country manager Steve Morgan. It may be that smaller teams do not require a top or middle box. Just one size of cabinet in the Beta range can have a wide variety of specifications – how it is fronted, whether the top box is →

British-made Dura storage systems are fully modular and look purposeful in its trademark grey colour


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Systems have to look good too, as in motorsport professionalism is everything

wood or metal, what weight it is and what it will withstand. Beta, like many others including Teng, also supplies the hand held barn-style toolboxes. The Italian company is currently an official supplier to Ferrari, while also providing product for a number of other Formula 1 teams. It is also to supply to the new Silverstone-based National College for Motorsport.

Snap-On, which suggests its five drawer roll, double wall construction cabinet for motorsport, has an even longer association with racing, one that dates back over 70 years. Its current involvement started in the early 1980s with Rick Mears. Now it sponsors 19 NASCAR drivers, four IRL racers and a number of NHRA contestants.

The manufacturers understand the matter of image, and their logos can often be seen on racecars. Indeed, the 1975 Austrian Grand Prix winning March of Vittorio Brambilla was totally in Beta's orange livery while, more recently, MAC Tools has been using its technical partnership with BAR to help expand its distribution network. These two use their associations with F1 teams to sell to the outside world, and perhaps even technicians in lesser formulae who might fancy a Ferrari or BAR-liveried cabinet. However, such special edition cabinets are more likely to appeal to the average garage mechanic than to the motorsport technician. Remember, when choosing, that most toolboxes on the general market have been designed to remain static in the workshop.

Special edition toolboxes, such as this BAR liveried example from US company MAC, generally appeal more to garage mechanics than racecar technicians

Teng Tools is another to have issued a special liveried 'box, having used its association with Morgan at Le Mans. Perhaps more pertinent to the small motorsport team is that it also offers a toolbox personalisation service with transfer sticker sets that can be made up with the user's name or message. It has also liveried up for certain teams.

The tool storage equipment used in motorsport has evolved from products used in industrial storage and handling. However, the requirements of the racing sector are likely to be more demanding. Colin North, managing director of Toolstars (UK), the company responsible for the Swedish-owned Teng Tools in Britain, points to the need for mobility – that could mean wheeling a cabinet across uneven ground to a far-flung corner of the paddock. The quality of the wheels is therefore crucial and motorsport technicians should avoid cabinets where these are mainly cosmetic. The welding points need to be strong, too. The drawer runners should feature ball bearing slides as regular friction slides just will not stand the ravages of a season's racing. The gauge of steel is also important – too light and the cabinet will be fragile, too heavy and it will be difficult to transport and move around.

Snap-on products mainly find favour in NASCAR, IRL and NHRA

Trays are also an important matter. Steve Wallis, sales and marketing manager for Serenco (UK), distributor for the German brand KS, points out how his company's are all foam profiled. The last thing a race technician wants to be doing is searching for his tools. Steve Morgan refers to Beta's thermo-formed trays that indicate immediately if any tool is missing.

David Kendall, key account manager motorsport for Lista (UK) concurs with much of the above. Buy a cheap solution and the chances are the trays will no longer slide, nor the lock work properly once the season is over. Swiss-owned Lista supplies product for a host of non-automotive markets, but it is Formula 1 that it uses most in its marketing because of the harsh environment the cabinets have to work in. Having said that, Kendall points out that it is the lesser formula teams that have to park in the outfield, meaning that they going to need even stronger product that than used by the F1 outfits.

The equipment of choice for the top end of the market appears mainly to come from Lista. While supplying product for a whole variety of workshop applications, there is a motorsport ethos in the company led by its owner Fredy Lienhard. A former Daytona 24-Hours winner, Lienhard has recently purchased one of the latest Lola B05/40 LMP2s. His company claims that →

Sponsoring motor racing is also important, as shown by Swiss company Lista

Swedish-owned Teng Tools prides itself on offering a fully interchangeable tool tray system so engineers can equip with exactly the tools they require

virtually every F1 team uses its products. To these can be added most of the teams in CART and a sizeable number in NASCAR, too.

Lista's storage systems cover the whole spectrum. Its mobile tool caddies, drawer cabinets and drawer storage walls are to be found in production facilities (the company was called upon to kit out the new McLaren building), workshops, transporters and in the pits. The company states that its products are easy to plan and assemble and lend themselves perfectly to the temporary set-ups so often found in motorsport. Its drawer storage systems can be installed in transporters, unloaded on arrival at the track and wheeled into the pits. As Lienhard's fellow Swiss, Peter Sauber states, 'In the race pits the immediate access to spare parts is of utmost importance.' He reckons that there is 'no better workshop system in the world to create order.'

A workshop design should feature a high degree of versatility and products that are modular in design are the most suitable. Dividers, drawers and drawer storage should be combined with a minimum of restriction. You may also have specialised requirements. Lista, for example, offers an electronic locking system, e-Lock, that prevents unauthorised access to drawers.

British company Dura is another that supplies fitted workshop systems, as well as tool cabinets. An example of its work having been the Foggy Petronas motorcycle racing team based in Staffordshire. As part of a complete workshop solution that included flooring, overhead gantry and lighting, Dura provided a modular cabinet system. K2 Race Engineering is another to have fitted its workshop with a Dura system. K2, which currently campaigns an LMES Pilbeam, has used Dura for its two-car preparation bay and also for its race transporter. Dominic Wishlade states that the modular nature of any system is important for motorsport. Dura's units come in three base sizes and are compatible with wall cabinets and back panels. In addition, the company offers a range of associated items, such as component trolleys and benches that co-ordinate the whole system. Wishlade is also another to emphasise the need for a quality product, pointing to the heavy gauge header rail of Dura's cabinets as an example. The company's 1200 series RC range is said to be particularly appropriate to motorsport needs.

"PRODUCTS THAT ARE MODULAR IN DESIGN ARE THE MOST SUITABLE"

The distinctive Teng Tools logo is familiar throughout motorsport. This season the company moved up with Hitech Piquet from involvement in Formula 3 (just one series in which it supplies both tools and cabinets) to GP2. The team has built a pit vehicle based around two of Teng's roller cabinets, underlining Colin North's comments about mobility.

Teng has its own web-based computer programme that enables users to design their own tool kit using any combination of trays, top boxes, middle boxes and roller cabinets. The programme includes several suggested tool kits than can be changed by adding or removing tool trays to suit personal needs. The programme is found on the www.tengtools.com web site.

An appropriate new product from the company is its 13 drawer, 8 series roller cabinet with ball bearing slides. Its overall 'double' length of 1348mm provides a suitable workbench, too. Also new is a 'one and a half' size cabinet – a 13 drawer, 7 series roller cabinet with a width of over 900mm.

Iowa-based Waterloo Industries is said to be the largest tool cabinet supplier in the world, manufacturing for a large number of brands including Snap-On. Manufacture takes place at Sedalia, Missouri and Nagulaes in Mexico. Brad Reinhardt, the company's senior manager, international sales, states that it has ceased its actual association with racing. However, it does still offer appropriate product. Recently it announced that two of its storage lines, Traxx and ProMaxx – both of which feature quick-release ball-bearing slides – had become available in a choice of three colours: Baltic Sea Black, Crimson Red and Iron Blue. Back to that question of image again then. RE

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Anti-surge cells

ATL is launching its new range of internal fuel collectors, purpose built for installation in either one or two Bosch high-pressure fuel pump applications.

Designed to be fitted into the internal foam baffling, each unit is fixed with two fuel guiding vanes to steer the fuel towards the collector when either accelerating or under cornering forces. Three one-way trap doors allow fuel to pass through into the collector chamber when open and prevent the possibility of fuel surge problems by tightly closing when braking or turning.

The fuel collectors have a capacity of three litres and can be mounted into every ATL Saver cell over 60 litres capacity.

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The truth about torque

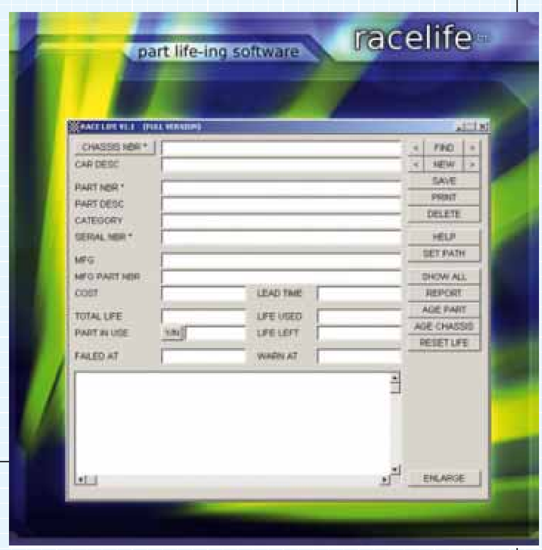
Norbar has released its new 'TruCheck' torque tester to ensure simplicity and remove common problem areas when calibrating torque measuring tools.

The 'TruCheck Plus' tester, which can be adapted to work on either 'click' or 'dial' type torque wrenches, works across the range of 35-350Nm For those working in Imperial units, there is also a version available calibrated from 25-250lb.ft.

The tester provides readings with +/- one per cent accuracy, meeting ISO 6789:2003 standard torque wrench requirements. Tolerance bands can be set when testing and the unit also provides an RS232 output in order to download information onto a PC.

● **For more information call +44 (0) 1295 270333 or email pbrodey@norbar.com**

Component lifespan



RaceLife software has designed a new program to assist teams in recording vital statistics on all car components. The software, also named RaceLife, enables the user to record how long each component on the car's chassis has been in use and the distance accrued. Teams then receive detailed notification of when parts are due to be repaired or replaced.

The software also allows the user to include additional information about the components such as place of purchase, price and part numbers.

A five-part demo version of the software can be downloaded from the website and purchasers will qualify for free updates as and when they become available.

● **Email info@racelifesoftware.com or visit www.racelifesoftware.com**

MSF Safety DVD

The Motorsport Safety Fund has released a DVD compilation of its five previous video guides. 'First Aid in Motorsport'; 'Motorsport Rescue'; 'Motorsport Marshalling'; 'Motorsport Firefighting' and 'It Could Happen To You' are now all available as one on the new DVD.

Run by volunteers since 1974, the Motorsport Safety Fund was created to improve safety within the motorsport industry and continues to do so through its own range of specialist publications, videos and the highly acclaimed annual Watkins lecture.

The DVD is priced at £10, including postage and packaging.

To order your copy send your cheques, made payable to 'Motorsport Safety Fund', to Motorsport Safety Fund, PO Box 239, West Malling, Kent ME19 4BL, UK.

● **For more details visit www.motorsportsafetyfund.com**

New Mitsubishi gears

Ricardo Motorsport, official transmission partner to Mitsubishi Motor Sport for the World Rally and Rally Raid Cars, has released the new Mitsubishi Evo VIII MR Group N gearkit.

The gearkit is a progression from Ricardo's existing and successful model for the Mitsubishi Evo VI, VII and VIII Group N rally cars. The five-speed, straight-cut dog engagement gearbox conversion provides a maximum of 560Nm engine torque alongside the five homologated ratios and offers a consistent answer to complications in Group N rallying. Due to being fitted directly into standard gearbox casings, is supplied in kit form.

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

Technicians little helper

Agriemach continues its stance on creating products that save time and money by launching the new PM66400 steering wheel holder and pedal depressor.

Intended to cut down the costs of extra technicians, the tool is simple to use and install. As a steering wheel holder, the product secures the wheel into position whilst the wheel is centred or any toe in/toe out work is carried out, while the pedal depressor aspect can be operated in a number of circumstances ranging from fuel injection cleaning, clutch work, engine diagnosis, tune-ups and brake jobs.

● **For more details call +44 (0)1342 713743, email info@agriemach.com or visit www.agriemach.com**

Contamination fighters

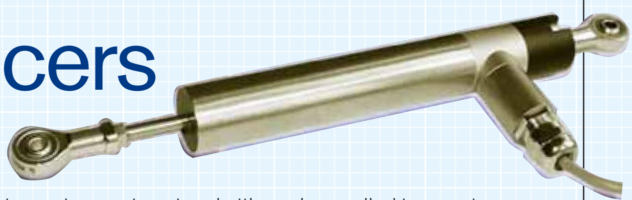
Lee Products, specialist in miniature filter components, has introduced a new range of 'last chance' safety screens to protect vital components from contamination.

The Industrial Microhydraulic (IMH) safety screen range was developed to work alongside standard in-line industrial or automotive filters to provide an extra precautionary barrier to prevent contaminants from attacking critical fluid control components. Made from stainless steel wire mesh, the screens can be positioned directly next to the protected components and require a minimal amount of space. Bonding the screens together using a propriety procedure ensures extended life and reliability.

Screens are available in 5.5mm, 8mm 10mm and 12mm diameters.

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

Programmable transducers



The recently released SM41/43 measurement sensor is the latest model to be included to Schreiber Messtechnik's supply of inductive displacement sensors.

The new sensor has a scale of 20-360mm, and fixed electronics in the programmable transducer allow the user to adapt the displacement range within the given measurement scale to their configurations.

Normal accuracy is 0.25 per cent or can be adjusted to 0.1 per cent and set to give an increasing signal either when pulled in or out.

● **For more information call Techni Measure UK +44 (0) 1527 854 103, email sales@techni-measure.co.uk or visit www.techni-measure.co.uk**

RACEGEAR

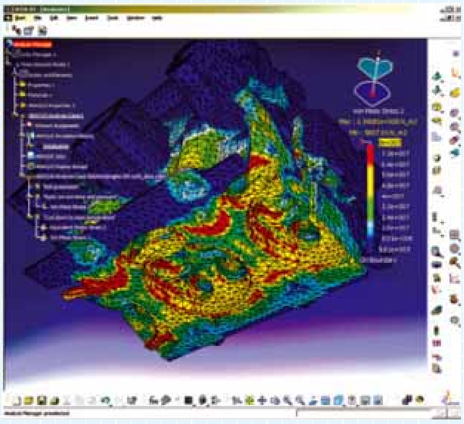
New products and services for racecar engineers

Easy to see socket tags

Facom precision tools has come up with the industry's first socket tagging system, aimed at making life easier for the busy technician by clearly marking sockets with easy to read red on silver tags. The company claims this new innovation will save time by ensuring sockets are always placed correctly in their holders and making their size instantly obvious, wherever they are.

The hard-wearing, laminated tags have been designed to be readily visible, even in bad lighting conditions, and to be an interference fit so they stay where they are placed. The tags are available in a range of sizes from 5-34mm in 1mm increments.

● **For more information call +44 (0) 1922 702000 or visit www.facom.com**



New assembly software

Advanced finite element analysis software provider Abaqus Inc has launched the new Abaqus for Catia V5, Version 2.1.

Complex technology is essential when modelling joining procedures in order to estimate product resilience and guarantee high standards of reliability and performance. The software provides new simulation potential with extra utilities for structural assembly techniques and complex materials and is fully integrated with the Catia V5 Product Lifecycle Management solution from Dassault Systemes, designed to assist engineering workflows in both ground vehicle and aerospace models.

● **For more information call +1 401 276 4400 or visit www.abaqus.com**

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
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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 Crosslé **Tel (1) 513 777 4545**
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Fax (390) 525 53478
Dallara Automobili, Via Provinciale 33, 43040 Varano Melegari, Parma, Italy

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bis Rue du Docteur Moras, 25000 Besancon, France

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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

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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 OJN England

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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

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

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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 SRD, England
US Importer
Tel (1) 310 533 1144 Fax (1) 310 530 0139
Ralt American, 23110 Kashiwa Court, Torrance, CA 90505, USA

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TPG **0039 682 32225**

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

Database 2
COMPETITION CAR CHASSIS COMPONENTS

2.1 Chassis/BodyWork Ancillaries

AEROFOILS
ACTIVE ENG USA (1) 714 637 1155
AERODINE USA (1) 317 271 1207
ANDREAM LTD
CUSTOMIZED COMPOSITE WINGS
Tel: 01953 885775
Fax: 01953 884176
Email: dave.greenwood@eidisnet.co.uk
Unit 12 Norwich Road Industrial Estate, Watton, Norfolk IP25 6DR
C&B CONSULTANTS 01202 661707
DJ RACECARS LTD 01663 734518
JANUS TECHNOLOGY 01753 869996
PROTECH COMPOSITES LTD
Tel: +44(0) 1420 471 400 Fax: +44 (0) 1420 487 047
www.protechcomposites.co.uk
Unit 62, Woolmer Trading Estate
Bordon, Hampshire, GU35 9QF, UK
LOLA **Tel 01480 451301**
Fax 01480 456722
Lola Cars International, Glebe Road, St Peters Hill, Huntingdon, Cambridgeshire PE18 7DS, England
US Importer
Tel (1) 317 244 2277 Fax (1) 317 390 2121
Lola Cars Inc, Suite B, 2801 Fortune Circle East, Indianapolis, IN 46241, USA
ROAD & STAGE M/SPORT 01524 844066
SARDOU France (33) 1 60 01 03 67
THE WING SHOP **Tel: 01258 860716**
Fax: 01258 860716
E-mail: info@wingshop.co.uk
Web: www.wingshop.co.uk
SPA AEROFOILS LTD 01827 260026
UNI OF MARYLAND USA (1)301 405 6861
QINETIQ 02700 100942
ZEUS MOTORSPORT 01604 878101

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

FIRE EXTINGUISHERS
LIFELINE **02476 712999**
LINREAD NORTHBRIDGE MOTORSPORT 01162 572924
RALLY DESIGN 01795 531871
SAFETY DEVICES **01353 724202**
SPA DESIGN **01827 288328**
SPA TECHNIQUE **USA (1) 317 271 7941**
ATL **USA (1) 201 825 1400 Fax (1) 201 825 1962**
Aero Tec Laboratories Inc, Spear Road Industrial Park, Ramsey, NJ 07446-1221, USA

FUEL CELLS
ATL **UK 01908 351700 Fax 01908 351750**
Aero Tec Laboratories Ltd (Europe), 1 Patriot Drive, Rooksley, Milton Keynes MK13 8PU
FUEL SAFE SYSTEMS USA (1) 714 842 2211
GOMM METAL DEVELOPMENTS 01483 764876
KS MOTORSPORT Germany (49) 2271 44905
PRONALS France (33) 320 99 75 10
TRANSAUTOSPORT **01772 454647**
ACTIVE ENG USA 001 714 637 1155
GARTRAC 01428 682263
ROLLCENTRE 01480 464052
SAFETY DEVICES **01353 724202**
SIGMA **Switzerland (41) 61 9717600**
CORBEAU 01424 854499
GRAND PRIX RACEWEAR 020 8987 5500
MOMO USA 001 714 637 1155
EARS MOTORSPORTS 01625 433773
KS MOTORSPORT Germany (49) 2271 44905
OMP USA (1) 973 361 0508
MOMO USA 001 714 637 1155
LUKE 01323 844791
Total Restraint Systems 01722 326080
TRW SABELT 020 7736 2881
WILLANS **01264 810712**

RUBBER & ELASTOMERIC COMPONENTS
BUTSER RUBBER LTD Tel: 01730 894034

2.2 Electrical Systems

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

ALTERNATORS
BOSCH 01895 834466
Germany (49) 711 8111 USA (1) 312 865 5200
BRISE AUTO ELECTRICS **01322 277622**
MM COMPETITION **08707 444666**
McCLAREN ELECTRONICS 01483 261400

CABLES
CENTURY CABLES **Tel 01733 211600 / Fax 01733 211082**
Email kwhincup@yahoo.com / web www.centurycables.com
IS MOTORSPORT USA (1) 317 244 6643
PERFORMANCE WIRING SOLUTIONS +44 (0)1954 253620
SPEEDY CABLES 020 7226 9228
SPOT ON CONTROL 0118 979 0682
TRIDENT RACING 01327 857822
CONTINENTAL USA (1) 513 459 8863

CONNECTORS
BERU F1 SYSTEMS 01374 646200
DEUTSCH 01424 852721
IS MOTORSPORT USA (1) 317 244 6643
MAGNETI MARELLI **Italy (39) 02 972 27570**
MM COMPETITION **08707 444666**
PERFORMANCE WIRING SOLUTIONS +44 (0)1954 253620
SAKATA MOTORSPORT ELEC. INC. (714) 446 9473
SERVO & ELECTRONIC SALES LTD 01797 322500
SPECIALITY FASTENERS 01803 868677
RAYCHEM 01793 572217

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

IGNITION SYSTEMS
BOSCH **UK 01895 834466**
Germany (49) 711 8111 USA (1) 312 865 5200
SBD MOTORSPORT 0208 391 0121
EFI TECH USA (1) 310 793 2505
HELLA UK 01295 272233
LUMENITION 020 7403 4334
MAGNETI MARELLI Italy (39) 02 972 27570
MM COMPETITION **08707 444666**
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
MSD IGNITION USA (1) 915 857 5200
PI RESEARCH 01954 253600
PIAA (UK) 01934 814812
STACK 01869 240404
McCLAREN ELECTRONICS 01483 261400

THE STRAIN GAUGING CO 01256 320666

LIGHTS
HELLA 01295 272233
PRODRIVE 01295 254400

LOAD CELLS
NOVATECH MEASUREMENTS 01424 852 744

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

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

WIRING HARNESSES
A.N. MOTORSPORT DESIGN 01628 776320
COMPETITION DATA SYS USA (1) 716 631 2880
DC ELECTRONICS 01621 856451
SBD MOTORSPORT 0208 391 0121
EFI TECH USA (1) 310 793 2505
BERU F1 SYSTEMS 01374 646200
MAGNETI MARELLI **Italy (39) 02 972 27570**
MM COMPETITION **08707 444666**
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
PALLAS CONNECTIONS 01869 277053
PERFORMANCE WIRING SOLUTIONS +44 (0)1954 253620
RAYCHEM 01793 572217
SAKATA MOTORSPORT ELEC. INC. **Tel (714) 446 9473**
Fax (714) 446 9247
Website www.sakatamotorsport.com
689 S. State College Blvd, Unit F Fullerton, CA 92831
SERVO & ELECTRONIC SALES LTD 01797 322500
THE STRAIN GAUGING CO **01256 320666**
TONY JAMES **01379 854485**

2.3 Controls

GEARSHIFT SYSTEMS
CENTURY CABLES **Tel 01733 211600 / Fax 01733 211082**
Email kwhincup@yahoo.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
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

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

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

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

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 COMPS 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

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

2.9 Tyres

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

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

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

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

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

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 0116 572924 Fax 0116 572901
Viking Road, Wigston, Leicester, LE18 2BL
PANKL **Austria (43) 386 251 2500**
ATECH MOTORSPORTS USA (1) 330 630 0888

DKE 01455 273738
EAGLE USA (1) 901 345 5886
FARNDON ENG 02476 366910
GRAINGER & WORRALL 01902 324460
LAYSTALL ENGINEERING 01902 451789

MILLINGTON 01746 789268
SWINDON RACING ENGINES 01793 531321

CRANKSHAFTS

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 84380
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 01799 541955
USA (1) 714 842 2211
GOODRIDGE CA **USA (1) 310 533 1924**
GOODRIDGE INDY **USA (1) 317 244 1000**
GOODRIDGE EAST **USA (1) 704 662 9095**

GOODRIDGE UK **Tel 01392 369090**
Fax 01392 441780
Exeter Airport Business Park, Exeter, EX5 2UP
HENRY'S ENG USA (1) 410 535 3142
JLS MOTORSPORT **Tel 0121 525 7733**

KRONTEC MASCHINENBAU GmbH
Fitting & Hose Systems
Pommernstraße 33 93073 Neutraubling
Tel: 09401 5253-0
Fax: 09401 5253-10
KS MOTORSPORTS Germany (49) 2271 44905
PRONAL'S France (33) 320 99 75 10
SPECIALTY FASTENERS 01803 866371
SPV RACING Australia (61) 2 791 9899
THINK AUTOMOTIVE 0208 568 1172
FLEXOLITE **01684 891898**
GOODRIDGE 01392 369090
PRONALS France 33 3 20997510
RACETECH 01327 359912
WELDON RACING PUMPS USA (1) 216 232 2282

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

FUEL VALVES

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

HOSES & HOSE-ENDS

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

BROWN AND MILLER **UK Tel: 01753 553610**
Fax: 01753 577477
Unit 7-7A, Langley House, Middle Green Trading Estate, Langley, SL3 6DF USA Tel: 704 793 4319
Fax: 704 793 4321
4005 Dearborn Place NW, Concord, NC 28027
DELPHI BRAKES SYSTEMS **01926 472472**
EARL'S **USA (1) 310 609 1602**
EXACT ENG **01803 866464**
FASTENER FACTORY **01327 311018**
FHS MOTOR RACING **01753 570863**
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 USA Tel (1) 763 476 2531
Fax (1) 763 476 2613
14465 23rd Avenue N, Minneapolis, MN 55447, USA
ISAAC INSTRUMENTS INC. Tel: (450) 658 7520
Fax: (450) 658 3322
Email: isaac@isaac.ca
Website www.isaac.ca
25 Robert, Chamby, Quebec, Canada J3L 1S2
LONGACRE USA (1) 425 485 0620
McCLAREN ELECTRONICS 01483 261400
MM COMPETITION SYSTEMS 08707 444666
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
MOTECH USA (1) 804 973 1399
MOTOR SPORT ELEC Australia (61) 7 3290 1309
MOTORSPORTS INTERFACE 01327 311011
MTS Powertrain Tech **Tel 01932 351516**
Fax 01932 351517
7 Glen Court, Canada Road, Byfleet, Surrey KT14 7JL
NIPPON DENSO Japan (81) 56 625 6951
PECTEL CONTROL SYSTEMS +44 (0)1954 253610
PENNY & GILES 01202 409409
PERFORMANCE TRENDS USA (1) 248 473 9230
PI RESEARCH **01954 253600**
POLY LOGIC 01462 621066
QINETIQ 08700 100942
QUANTUM SUSPENSION 01243 865058
RACE DATA ENGINEERING USA (1) 714 449 1445
SAKATA MOTORSPORT ELEC. INC. (714) 446 9473
STACK **Tel 01869 240404**
Fax 01869 245500
email: sales@stackltd.com
Wedgewood Road, Bicester Oxfordshire, OX26 4UL
STEVE BUNKHALL 01223 303025
VARIOHM 01327 351004

ENGINE MANAGEMENT SYSTEMS

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

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

ENGINE SENSORS

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

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

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

REV-LIMITERS

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

3.4 Transmission Components

CLUTCHES

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

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

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

COMPLETE TRANSMISSIONS

RICARDO MIDLANDS TECHNICAL CENTRE
Tel: 01926 319399
Fax: 01926 319352
Email: rasimmonds@mtc.ricardo.com
Website: www.ricardo.com
Southam Road, Radford Semele,
Leamington Spa CV31 1FQ

CWP'S

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

DIFFERENTIALS

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

DRIVESHAFTS

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

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

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

GEARS

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

UNIVERSAL JOINTS

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

Database 4

FACTORY EQUIPMENT

4.1 Factory Hardware

AIR LINES & FITTINGS

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

AIR TOOLS

DESOUTTER AUTOMOTIVE 0208 205 4884

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

CNC MACHINING CENTRES

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

CRACK DETECTION

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

CRYOGENIC TEMPERING

FROZEN SOLID 01449 674914

DUST EXTRACTION EQUIP

DENCER 01789 470198

DYNAMOMETERS: CHASSIS

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

DYNAMOMETERS: DAMPER

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

DYNAMOMETERS: ENGINE

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

DYNAMOMETER INSTRUMENTATION

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

ENGINE BALANCING EQUIP

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

ENGINE HOISTS

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

ENGINE STANDS

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

FLOW BENCHES

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

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

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

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

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

TOOL CABINETS
DURA 01295 712800
GWS Systems Oy Tel: 01403 276445
Fax: 01403 276434
Email: sales@gwssystems.co.uk
Website: gwssystems.co.uk
Units 10-12 Horsham Court, City Business Centre, 6 Brighton Road, Horsham, West Sussex RH13 5BA
LISTA 01908 222333
MAC TOOLS USA (1) 614 755 7000

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

4.2 Factory Software

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

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

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

Database 5
CIRCUIT EQUIPMENT

5.1 Pits Equipment

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

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

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

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

HARRISON AUTO USA (1) 602 254 0024
LONGACRE RACING USA (1) 425 885 3823
OMS RACING 0113 2575956
PACE PRODUCTS 01284 850960
REDLINE MOTORSPORT Tel 01606 737500
Fax 01606 737683
E-mail info@redlinemotorsport.co.uk
TRIDENT 01327 857822

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

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

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

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

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

ELECTRIC STARTERS
POWER TRANS SOLUTIONS 01722 332126

ENGINE HOISTS
DUNLOP AUTOMOTIVE 0121 384 4444
FACOM UK 01932 566099

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

FIRE EXTINGUISHERS
CHUBB 01932 785588
FEV Tel 01243 555566 Fax 01234 555660
Email sales@f-e-v.co.uk
www.f-e-v.co.uk
Unit 10 Ford Lane Business Park,
Ford, West Sussex BN18 0UZ
FIREMASTER 0208 852 8585
LIFELINE FIRE SYSTEMS 02476 712999
Mardi Gras Motorsports 01327 858 006
OMP 0208 656 7031
Italy (39) 10 680 851
QINETIQ 08700 100942
SILVERSTONE RACE SERVICES 01327 858441
SPA DESIGN 01827 288328
SPA TECHNIQUE USA (1)317 271 7941
TRIDENT 01327 857822

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

FUME EXTRACTORS
DENCER 01789 470198
INGERSOLL RAND 01204 690690

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

HAND TRUCKS
OMS RACING 01132 575956
SILVERSTONE RACE SERVICES 01327 858441

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

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

NOISE METERS
CIRRUS RESEARCH 01723 891655

PIT BARRIERS
KAISER & KRAFT 01923 233312
SLINGSBY 01274 721591

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

PIT CANOPIES
PIT BITS 01727 858297

PIT LANE MARKERS
KAISER & KRAFT 01923 233312
SLINGSBY 01274 721591

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

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

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

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

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

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

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

SCISSOR PLATFORMS
SLINGSBY 01274 721591

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

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

REDLINE MOTORSPORT Tel 01606 737500
THE STRAIN GAUGING CO 01256 320666

SPACE HEATERS
FASTENER FACTORY 01327 311018

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

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

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

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

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

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

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

TYRE PRESSURE GAUGES
BERU F1 SYSTEMS 01374 646200
GRAND PRIX RACEWEAR 0208 987 5500
THE STRAIN GAUGING CO 01256 320666
TRIDENT 01327 857822

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

TYRE TROLLEYS
OMS RACING 01132 575956

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

5.2 Paddock Equipment

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

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

Database 6
COMPETITION CAR CHASSIS COMPONENTS

6.1 Driver's Equipment

ANTI MIST FLUIDS

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

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

BOOTS & GLOVES

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

COOL CAPS & SUITS

DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 020 8987 5500
REDLINE MOTORSPORT Tel 01606 737500

DRIVING SUITS & ACCESSORIES

DEMON TWEEKS 01978 664466
GRAND PRIX RACEWEAR 020 8987 5500
REDLINE MOTORSPORT Tel 01606 737500

HELMETS & ACCESSORIES

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

Database 7
CHASSIS ENGINEERING SERVICES

7.1 Chassis Services

BODYWORK SPECIALISTS

ABBEY PANELS 02476 644999
ADVANCED COMPOSITES 01773 763441
ANDY ROUSE ENGINEERING 02476 635182
AERO APPLICATIONS USA (1) 562 597 0001
AERODYNAMIC CONSULTANTS (661) 729 5628
APPLIED FIBREGLASS 01842 765339
ASQUITH BROTHERS 01924 402001
C&B Consultants Aerodynamics 01202 617 1707
CML GROUP 0151 647 5531
COMPOSITE DESIGN USA (1) 727 539 0605
CRANFIELD UNIVERSITY 01234 754152
CROPREDY BRIDGE GARAGE 01295 758444
DEREK PALMER ENGINEERING 01555 893315
DON FOSTER France (33) 470 580308
EARS MOTORSPORT 01625 433773
FIBRESPORTS 01268 527331
GRAHAM HATHAWAY RACING 01621 856956
GTC COMPETITION 01483 272151
GTI ENGINEERING 01280 700800
HAMLYN MOTOR SERVICES 01582 841284
HEDDINGTON COACHWORKS 01380 850198
INTAPORSCH 01273 834241
LOTUS ENGINEERING 01953 608000
LYNX MOTORS 01424 851277
MERLIN BODYCRAFT 01280 705156
MITCHELL NZ (64) 78236188
PODIUM DESIGN 07000 763486
SPA COMPOSITES 01543 432904

COMPOSITES SPECIALISTS

Active engineering USA 001 714 637 1155
ACTIVA TECHNOLOGY 020 8974 1615
ÆOLUS TECHNOLOGY USA (1) 970 472 1288
APPLIED FIBREGLASS 01842 765339
ASTEC 01332 875451
B&K RESINS 0208 464 7734
C&B CONSULTANT AERODYNAMICS 01202 661707
CARBON FIBRE TECHNOLOGY 01508 488257
CARBONE INDUSTRIE France (33) 14 972 2305
COMPOSITE AUTOMOTIVE TECH 01249 443438
COMPOSITE DESIGN USA (1) 727 539 0605
COMPOSITE WINGS 01953 885478

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

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

KOMPREX Tel 0191 416 8200 Fax 0191 415 5962
Website www.komprex.com
Email sales@komprex.com
58-59 Hutton Close, Crowther Ind Est,
Tyne & Wear 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 CORNERY ENGINEERING 01285 860295
UNICLIP AUTOMOTIVE 01932 355277
VAN DYNE ENGINEERING USA (1) 714 847 4417
VIN MALKIE RACING 01565 777395

MOULDING

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

SPACEFRAME DESIGN

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

Database 8
DRIVETRAIN & SUSPENSION ENGINEERING SERVICES

8.1 Engine Services

RACE PREPARATION

ALDON 01384 572553
ANDY ROUSE ENGINEERING 02476 635182
AUTOKRAFT 0121 777 2083
AZTEK 01509 261299
BJ MOTOR ENGINEERS 0161 748 8663
BR MOTORSPORT 01926 451545
DAVE CROSS MOTOR SERVICES 01246 477566
SBD MOTORSPORT 0208 391 0121
CLEM COMPETITION USA (1) 214 503 8044
CONCEPT MOTORSPORT 0208 568 0293
CONTINENTAL M/SPORT USA (1) 513 459 8888
DBR MotorSport Tel 0161 627 4189 Fax 0161 627 4189
Unit 4 Forge Ind Estate, Green Acres Road,
Oldham Lancashire, OL4 7LE
DJ RACECARS 01663 734518
DTM POWER 01865 407726
DUNNELL ENGINES 01449 677726
EARS MOTORSPORT 01625 433773
EDS 01708 857108
ELABORAZIONE COLASUNO 0207 738 8331
ENGINE DATA ANALYSIS 01977 516622
ENGINE SHOP 01280 812199
FISCHER ENGINEERING USA (1) 818 767 8840
FORWARD ENGINEERING 01676 523526
GEMINI ENGINEERING 01474 534779
GEOFF RICHARDSON ENGINEERING 01480 861599
GF BECK MOTORSPORT PREPARATION 01646 621184
GOLDFLOW 01491 875554
GOODMAN RACING ENGINES 01327 300422
GRAHAM HATHAWAY RACING 01621 856956
GRIFFIN MOTORSPORT 01793 771802
HARPERS PERFORMANCE 01642 818188
HARTWELL 01202 556566
HAUS OF PERFORMANCE USA (1) 714 545 2755
HT RACING 01474 872888
IRMSCHER 01543 414466
IVAN DUTTON 01923 816277
JANSPEED MOTORSPORT 01722 321833
J MATTIS ENGINETECH Greece 003 019 512 761
JOHN WILCOX COMPETITION ENG 01455 230576
JONDEL 01933 411993
KENT AUTO DEVELOPMENTS 01303 874082
KREMER RACING Germany (49) 221 171025
LE SPORT France (33) 14 582 4400
LIGHTNING PERFORMANCE USA (1) 904 439 5283
LINGENFELTER USA (1) 219 724 2552
MARDI GRAS MOTORSPORTS 01327 858 006
MATHWALL ENGINEERING 01252 703191
MATRIX ENGINEERING USA (1) 888 249 0013
MAXSYM ENGINE TECH 01608 685155
MERLIN DEVELOPMENTS 01283 511184
MILLINGTON 01746 789268
MINERVA MOTORSPORT 01509 233970
MINISTER RACING ENGINES 01634 682577
MIRKO RACING USA (1) 408 776 0073
MIS M/SPORTTECHNIK GERMANY (49)263680394
MOUNTUNE RACE ENGINES 01621 854029
NEIL BROWN ENGINEERING 01775 723052
PHIL JONES ENGINE DEV 01454 310936
PHIL MARKS ENGINE DEV 01564 824869
PRICE MOTORSPORT USA (1) 812 546 4220
PRIMA RACING 0115 9491903
PRODRIVE 01295 273355
QUICKSILVER RACE USA (1) 301698 9009
QUORN ENGINE DEVELOPMENTS 01509 412317
RACE ENGINE DEVELOPMENT USA (1) 760 630 0450
RACESPEC 01925 636959
RACE TECHNIQUES 01242 245640
RACING BENT USA (1) 714 779 8677
RANDLINGER Germany (49) 761 16373
ROAD & STAGE MOTORSPORT 01524 844066
ROADSPEED PERFORMANCE 01453 750864
RPM FRANCE (33) 3 86 66 00 08
SCARBOROUGH Canada (1) 416 759 9309
SEARLE 0208 305 2250
STEVE CARBONE RACING USA (1) 918 835 6596
SWAYMAR 01932 868377
SWINDON RACING ENGINES 01793 531321
TECNO 01268 764047
TERRY SHEPHERD TUNING 01695 574454
THINK AUTOMOTIVE Tel 0208 568 1172
Fax 0208 847 5338
Email matt@thinkauto.co.uk
292 Worton Road, Isleworth, Middlesex, TW7 6EI
THUNDERBIRD RACING INT LTD 01623 622848
VAN DYNE ENGINEERING USA (1) 714 847 4417
WARRIOR 01825 764833
ZYTEK ENGINEERING 01332 48974
ZEUS MOTORSPORT ENGINEERING LIMITED
Tel 01604 878101 Fax 01604 878111
The Racing Stables, Blisworth Hill Farm,
Stoke Road, Blisworth, Northants NN7 3DB

8.2 Engine Services

REBUILDS

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

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

8.3 Suspension Services

SETUP SPECIALISTS
ACTIVE ENGINEERING USA (1) 714 637 1155
ANDREASON RACING 01300 348499
ATHON MOTORSPORT 0114 2490 272
AZTEK 01509 261299
BEAUFORT RESTORATION 01795 830288
DAVID POTTER CONSULTING 0033(0)494 339090
BRADY FABRICATIONS 01869 252750
CRANFIELD UNIVERSITY 01234 754152
DON FOSTER France (33) 470 580308
EARS MOTORSPORT 01625 433773
GEOSCAN (G.I.L. Design) 01225 790568
LOLA Tel 01480 451301
Fax 01480 456722
HAUS OF PERFORMANCE USA (1) 714 545 2755
INTERPRO ENGINEERING 01454 412777
LOTUS ENGINEERING 01953 608000
MARDI GRAS MOTORSPORT 01327 858006
MARK ORTIZ USA (1) 704 933 8876
PILBEAM RACING DESIGNS 01778 424838
PODIUM DESIGNS 07000 763 486
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
FSUSPENSION TECHNOLOGY 01327 858558

SHOCKBOX DAMPER SERVICES Tel: 07919 340550
Website: www.shockbox.co.uk
Email: ghbj@compuserve.com
67 Blackthorn Road, Attleborough, Norfolk, NR17 1YJ UK
THE STRAIN GAUGING CO 01256 320666
UNIVERSITY OF HERTFORDSHIRE 01707 284270

ENGINEERING SERVICES
RACING INDUSTRY TECHNICAL SERVICES USA (1) 248 645 1724

8.4 Metal Services

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

COATINGS
CAMCOAT PERFORMANCE COATINGS 01925 445003

CTG Tel: +44 (0)1295 220130 Fax: +44 (0)1295 220138
E-mail: motorsport@ctgltd.co.uk
www.ctgltd.co.uk
Thorpe Park, Thorpe Way, Banbury, Oxfordshire OX16 4SU United Kingdom
LURO COTE USA (1) 909 885 3223
KENT MOTORSPORT CASTINGS 01795 662288
POETON 01452 300500
POLYMER DYNAMICS USA (1) 713 694 3296
QINETIQ 0 8700 100942
SWAIN TECH USA (1) 716 889 2786
WALLWARK HEAT TREATMENT 0161 7979111

ZIRCOTEC PERFORMANCE COATINGS
Tel: 0870 190 8480 Fax; 0870 190 8488
E-mail: enquiries@zirotek.co.uk
www. zircotek.com
528.10 Unit 2 Harwell business Centre, Didcot, Oxfordshire OX11 0QJ United Kingdom

FINISHING
ALUMINIUM SPECIAL 01384 291900
APPERLEY HONING 01242 525868
ARMORALL PRODUCTS 01799 513130
CML GROUP 0151 647 5531
GRIFFITHS ENGINEERING 01582 600629
HEPWORTH INTERNATIONAL 01484 711720
JENVEY DYNAMICS 01746 768810
KENT AEROSPACE CASTINGS 01795 476333
QUAIFE ENGINEERING 01732 741144
QINETIQ 0 8700 100942
RICHARD BARRETT MOULDS USA 353 282 9842
ZEUS ALUMINIUM PRODUCTS 01384 482222

FOUNDRIES
AEROMET 01795 415000
BA HARRISON 0116 2769351
GM DESIGN 0117 985 9964

FINECAST 01903 765821
H GRIFFITHS ENGINEERING 01582 600629
JENVEY DYNAMICS 01746 768810
KENT AEROSPACE CASTINGS 01795 476333
KENT MOTORSPORT CASTINGS 01795 662288
QUALCAST 01332 760260
UK RACING CASTINGS 01227 750877

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

MACHINING
ABBEY PANELS 02476 644999
ACTIVE ENGINEERING USA (1) 714 637 1155
APPERLEY HONING 01242 525868
ATHENA MANUFACTURING LP USA (1)512 928 2693
AVONBAR 01932 840058
AZTEK 01509 261299
BEAUFORT RESTORATION 01795 830288
CML GROUP 0151 647 5531
COLEMAN MACHINE USA (1) 906 863 8945
DATUM ENGINEERING 02476 383032
FORMULA FABRICATIONS 01953 605490
DONCASTERS LTD 01332 864900
JENVEY DYNAMICS 01746 768810

KRONTEC GMBH Tel Germany (49) 9401 5253-0
Fax Germany (49) 9401 5253-10
Pommernstrabe 33, 93073 Neutraubling, Germany
LANGSTONE ENGINEERING LTD 02392 452430
LINGENFELTER USA (1) 219 724 2552
LOTUS ENGINEERING 01953 608000
MACDONALD RACE ENG 0208 889 1633
MASON ENGINEERING USA (1) 805 527 6624
METAL SPINNERS 0191 267 1011
MILSPEC PRODUCTS USA (1) 407 814 8997
QINETIQ 0 8700 100942
PANKL AUSTRIA (43) 386255122500
PERFORMANCE MACHINE USA (1) 303 828 4546
PREMIER AEROSPACE 01332 850515
PREMIER FUEL SYSTEMS 01332 850515
QUAIFE ENGINEERING 01732 741144
RICARDO INC USA (1) 734 397 6666
RICHARD BARRETT MOULDS USA 353 282 9842
TITAN MOTORSPORTS 01480 474402
TREVOR MORRIS ENGINES 015474 289
TRICK MACHINING 01493 751666
VIN MALKIE 01565 777395

METAL MATRIX COMPOSITES
BP METAL COMPOSITES 01252 37

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

METAL SUPPLIERS
ADVANCED METALS INTERNAT 01923 210250
AIRCO METALS LTD 0118 973 0509
ALUMINIUM SPECIAL 01384 291900
APPERLEY HONING 01242 525868
BRADY FABRICATIONS 01869 252750
BRITISH ALCAN ALUMINIUM 01753 887373
AVESTOPOLART LTD 0114 2443311
BYWORTH MATERIAL SERVICES 01453 821609
COLUMBIA METALS 01604 810191
CROMPTON TECH GROUP 01295 220130
MASON ENG USA (1) 805 527 6624
RICHARD BARRETT MOULDS USA 353 282 9842
RGB STAINLESS 0121 558 3111
SPA AEROFOILS LTD 01827 260026

Tel: +44 (0) 1908 260707 Fax: +44 (0) 1908 260404
Email: sales@superalloys.co.uk
Number 1 Garamonde Drive, Wymbush Milton Keynes MK8 9DF UK.

TITANIUM SPECIALISTS
AIRCO METALS LTD 0118 973 0509
A.N. MOTORSPORT DESIGN 01628 776320
APPERLEY HONING 01242 525868
ATHENA MANUFACTURING LP USA (1)512 928 2693
CML GROUP 0151 647 5531
COAST FABRICATION USA (1) 714 842 2603
DATUM ENGINEERING 02476 383032
DONCASTERS LTD 01332 864900
PANKL Austria (43) 3 8625 12500
QINETIQ 0 8700 100942
SPA AEROFOILS LTD 01827 260026

TITANIUM INTERNATIONAL Tel: 0121 789 5764
Fax: 0121 784 8054
Email: nhoskison@tiltd.co.uk
Keys House, Granby Avenue, Garretts Green, Birmingham B33 0SP

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

8.5 Race Preparation

CHASSIS
ACTIVE ENGINEERING USA (1) 714 637 1155
AMS 01831 501363
AMT MOTORSPORT 01444 483477
ANEX SYSTEMS 01869 345038
AUTOMECH 0161 775 1851
AVONBAR 01932 840058
BARWELL MOTORSPORT 0208 397 4411
BR MOTORSPORT 01926 451545
BRR MOTORSPORT 01327 858055
CHRIS LEWIS MOTORSPORT 01677 422623
DEREK BENNET ENG 01565 777395
PRO MOTORSPORT 01555 893315
DOME CARS LTD Japan (81) 75 744 3131
DON FOSTER France (33) 470 580308
FOXCRAFT ENGINEERING 01264 810110
FRP RACING 01494 771609
GRAHAM WISEMAN 01278 685349
HAUS OF PERFORMANCE USA (1) 714 545 2755
HAWKINS RACING 0208 579 1438
INTERPRO ENGINEERING 01454 412777IVAN
JACK CRONE RACING USA (1) 909 371 6090
JOHN VILLAGE AUTOMOTIVE 01246 450580
K2 RACE ENGINEERING 01825 766728
MACDONALD RACE ENG 020 8889 1633
MARDI GRAS MOTORSPORT 01327 857246
MARK BAILEY RACING 01380 850130
MARK DUNHAM RACE ENG 01353 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.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
ROY KENNEDY RACING 01327 858055
SCHNITZER Germany (49) 8654 2034
SHENPAR PRODUCTS 01332 862901
STARTLINE UK LTD 01933 665752
STORM MOTORSPORT 01474 85 4367
TECH-CRAFT MOTORSPORT 01926 496075
TOLLBAR RACING 01433 631698
TT AUTOMOTIVE RACING 0147 485 3456
VIN MALKIE 01565 777395
ZAKSPEED Germany (49) 2636 87923

9.1 Chassis Testing

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

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

MEASUREMENT EQUIPMENT
AUTOSPRINT 01675 464857
BEAUFORT RESTORATION 01795 83288
BERU F1 SYSTEMS 01374 646200
CCA DATA SYSTEMS 01525 378938
CRANFIELD INSTITUTE 01908 694134
GENESIS ELECTRONIC SYSTEMS 01923 893 999
INSTRON SCHENK 01494 456789
INTERCOMP USA -763 476 2531
KISTLER INSTRUMENTS LTD 01420 544477
LONGACRE USA (1) 425 485 0620
LOTUS ENGINEERING 01953 608000
MICROLEASE 0208 427 8822
MIRA LTD 0247 635 5000
MOTORSPORTS RESEARCH 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 1111
Fax Switz (41) 52 224 1414
Email info@kistler.com
PO Box, CH-8408 Winterthur, Switzerland
MIRA LTD 0247 635 5000
WILWOOD ENG USA USA (1) 805 3881188
UNICO (UK) LTD 01908 260000

TESTING SERVICES

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

9.6 Metal Testing

CRACK TESTING

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

STRENGTH TESTING

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

Database 10

SERVICES - GENERAL

10.2 Paddock Services

AIR FREIGHT FORWARDERS

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

MOTORHOME

ATLANTIC COAST 01297 552222

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

TRAILER HIRE

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

AEROBYTES

With Simon McBeath

Bargeboards

Much has been said and written about the purpose of bargeboards. This is what really happens...

Coming in a wide range of shapes, sizes and specific locations, bargeboards can simplistically be described as vertical plates, curved in plan view, located close to the chassis sides, usually – though not always – aft of the front wheels, and ahead of the sidepods. Superficially they appear to be turning vanes that one might reasonably assume 'manage' the airflow in the region between the front wheels and the chassis, in particular 'steering' the front wheel wakes. However, recent developments, including their increasingly three-dimensional shape, the appearance of 'saw-tooth' lower lips and so forth, suggests they may be exerting other influences. As always the story is complex.

This month we can reveal what was found in a study of a bargeboard configuration performed by Advantage CFD for its owning team, BAR Honda. This particular project was carried out on a full-scale virtual model of the BAR in 'Melbourne specification' a few years ago, before the recent raft of aerodynamic restrictions was imposed (see figure 1). The aim was to investigate the changes in the flow around the car, and the re-distribution of aerodynamic forces caused by removing the bargeboards.

“A SIGNIFICANT EFFECT ON DOWNFORCE, DRAG AND EFFICIENCY”

For obvious reasons, actual force measurements cannot be quoted, but we are privy to the percentage changes that were determined. As a footnote, this exercise was also correlated with the physical model in the BAR wind tunnel, and trends and force magnitudes were very closely matched between tunnel and computer.

Figure 2 summarises the percentage changes to some major aerodynamic parameters following removal of the bargeboards. Clearly the bargeboards had a significant effect on downforce, drag and efficiency (lift over drag, L/D), and the change to the forces was described by Advantage as 'dramatic'. In short, removing the bargeboards reduced the overall downforce by 3.6 per cent while also reducing drag by 0.6 per cent. Cooling efficiency, shown as H_2OCp (pressure at the radiator), actually improved by 6.8 per cent when the bargeboards were removed.

Of more value perhaps is to look at these results the other way around. In other words, to look at the effects of fitting the bargeboards, and obviously increases would approximate the decreases shown in the graph but with negative and positive signs reversing. As such, there was a 3.6 per cent or so increase in overall downforce (given as 'body downforce' which omits wheel lift/downforce) and a forward shift in the distribution of downforce with these bargeboards fitted. Although there was also a gain in drag of 0.6 per cent with the bargeboards fitted, L/D improved by three per cent.

Breaking down the force re-distributions further helps to work out where the changes were taking place. For instance, figure 3 shows the percentage changes to wheel and wing forces when the bargeboards were removed. There were small increases in front wing forces, but more significant →

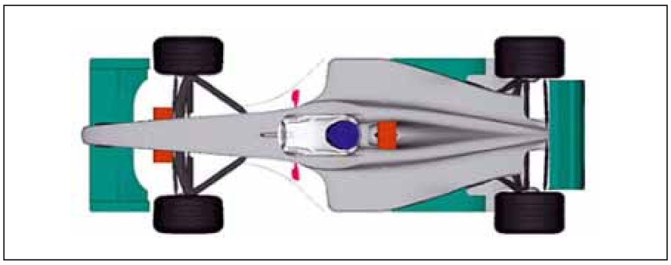


Figure 1: plan view of the BAR model and its bargeboards

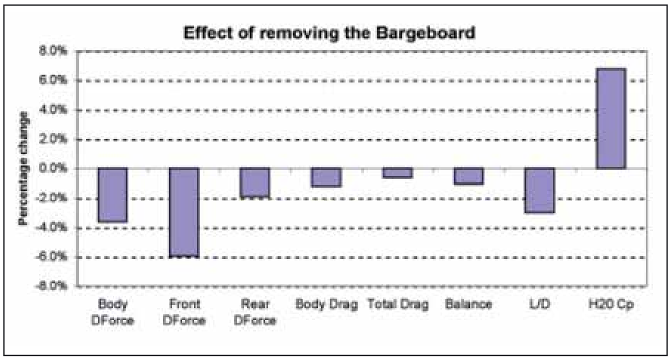


Figure 2: percentage changes to overall aerodynamic forces

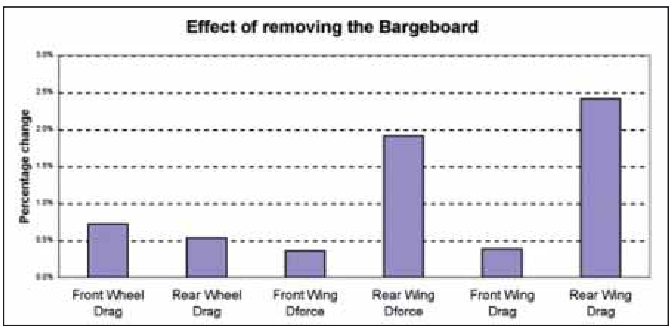


Figure 3: percentage changes to aerodynamic forces on wheels and wings

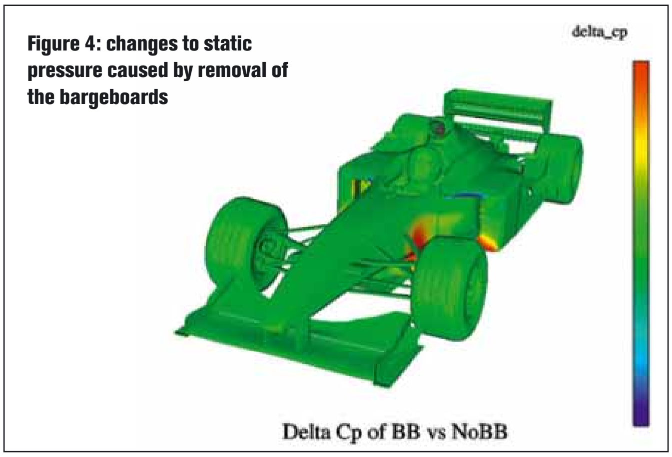


Figure 4: changes to static pressure caused by removal of the bargeboards

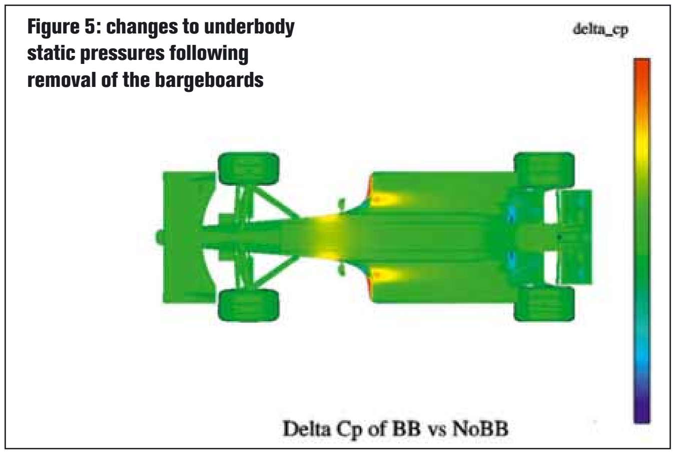


Figure 5: changes to underbody static pressures following removal of the bargeboards

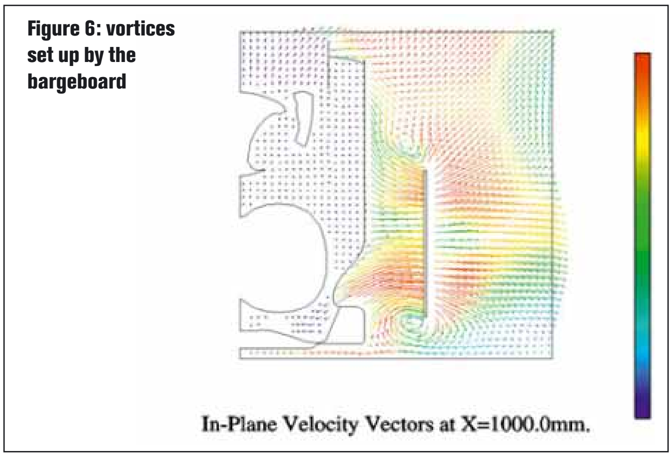


Figure 6: vortices set up by the bargeboard

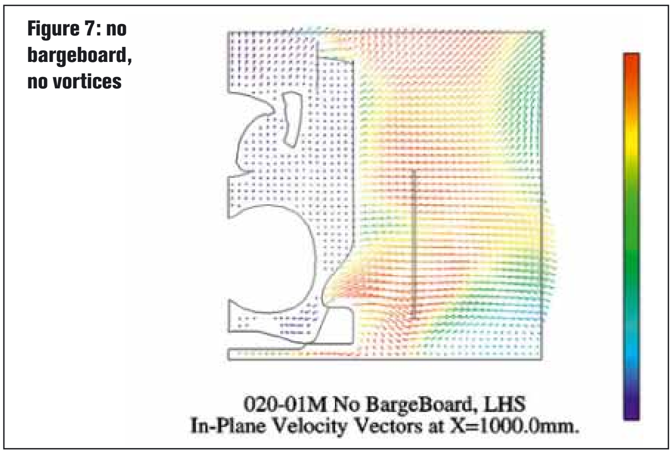


Figure 7: no bargeboard, no vortices

increases in rear wing downforce and drag. Since these increases when bargeboards were removed would equate to decreases when bargeboards were fitted, clearly the overall gain in downforce achieved by fitting the bargeboards must have come from somewhere other than the wings. We must therefore look to changes around the body.

The wheel drag also increased in the absence of the bargeboards, equating to drag decreases with bargeboards, and since wheel drag is a significant proportion of overall drag these apparently small changes should not be overlooked. This comment could also be applied to the rear wing, also a major contributor to overall drag, so the change in rear wing drag here could be important, too.

Further visualisation of changes caused by the removal of the bargeboards is required to begin to see the mechanisms at work. Figure 4 is a delta_Cp plot that shows the changes to surface static pressures when the bargeboards were removed. Reds and yellows indicate removing the bargeboards caused increases in static pressure, while pale and dark blues show decreases in static pressure. The influence of the bargeboards can be clearly seen on the chassis sides and leading edge of the sidepods.

Figure 5 shows the change to static pressures on the underbody. Clearly there was a significant static pressure increase at the front of the underbody and a decrease in the diffuser when the bargeboards were removed. Turned around, fitting the bargeboards created a decrease in static pressure at the front of the underbody and an increase in the diffuser, with an overall reduction in underbody static pressure that produced the increase in (forward-biased) downforce with bargeboards fitted. Also apparent in this plot is the reduction in static pressure on the rear wing's lower surfaces with the bargeboards removed, equating to the loss of rear wing downforce with the bargeboards fitted. This explains the change to overall downforce and its distribution, but what caused this pattern of change?

A different visualisation technique demonstrates. Figures 6 and 7 show a slice taken one metre back from the front axle along the left hand side of the car. Velocity vectors in the transverse, vertical plane of the slice are shown. Figure 6 illustrates the airflow pattern with the bargeboard and figure 7 without the bargeboard. It is apparent that by turning the airflow the bargeboard has initiated a pair of vortices, one from its top edge and one from its bottom edge. This lower vortex subsequently travels downstream (Figure 8 is a slice 200mm further on) causing an increase in velocity and hence the decrease in static pressure in the forward section of the underbody, and its influence is what we saw in figure 5.

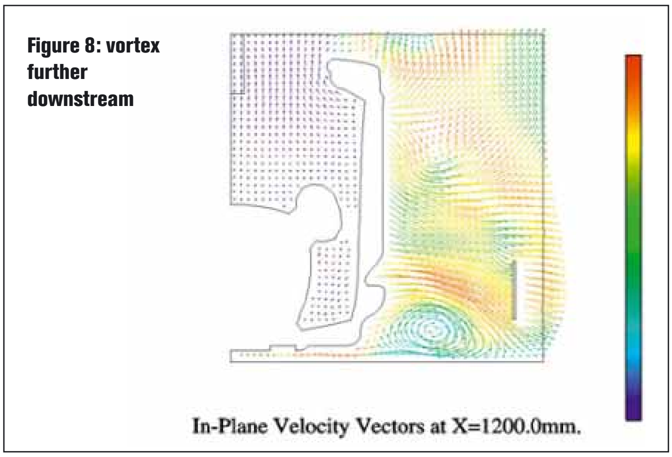
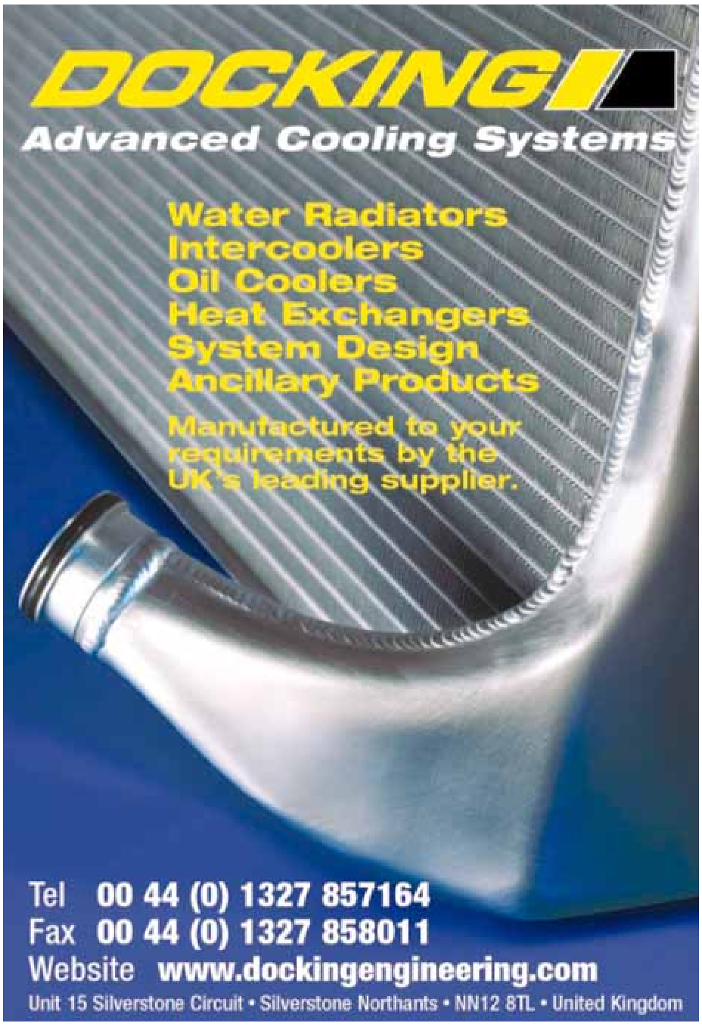


Figure 8: vortex further downstream

But why is there an increase in static pressure in the diffuser with bargeboards fitted? Because the airflow only has so much energy, and by being worked harder in the forward part of the underbody it has now lost energy here compared to the no bargeboard case. The velocity here is now less, and so the static pressure is slightly higher.

So that's what these bargeboards really did. Clearly cars with different shape bargeboards in alternative locations will be exploiting the airflow in slightly different ways, but similar mechanisms will be at work. RE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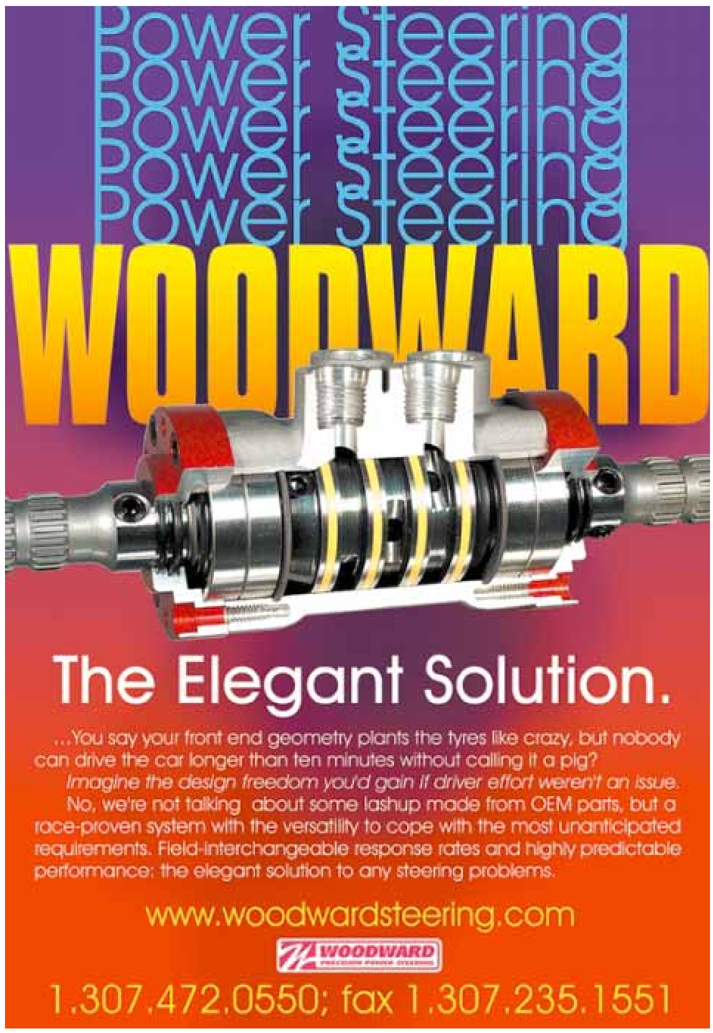
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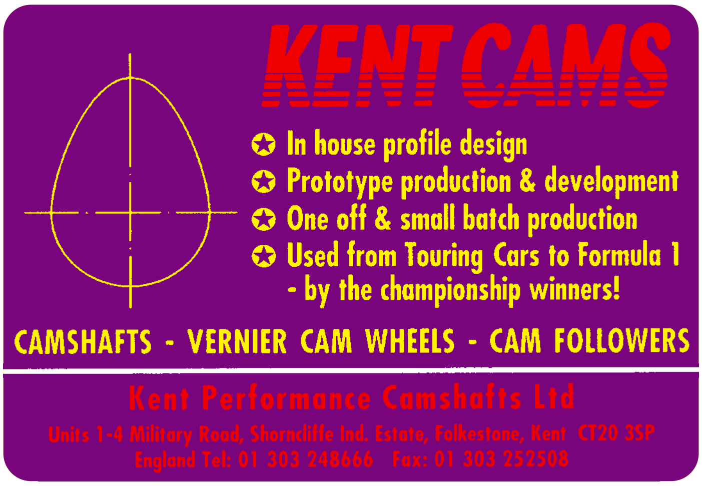
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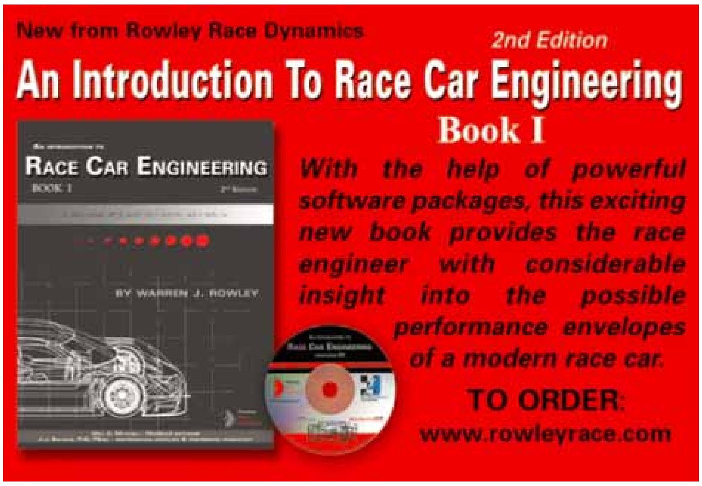
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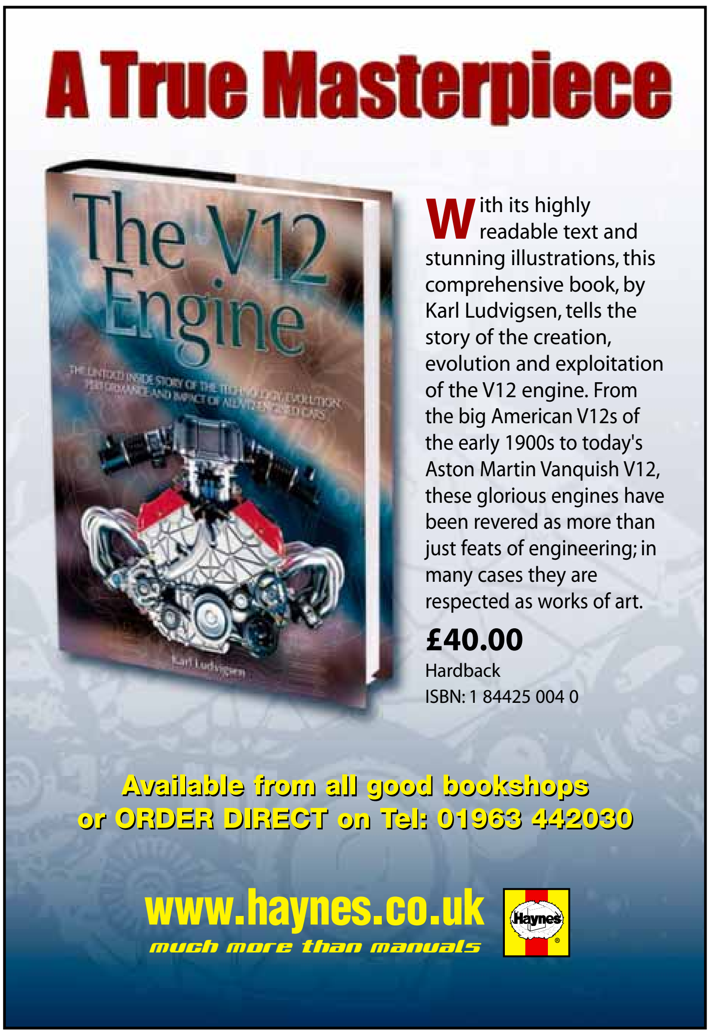
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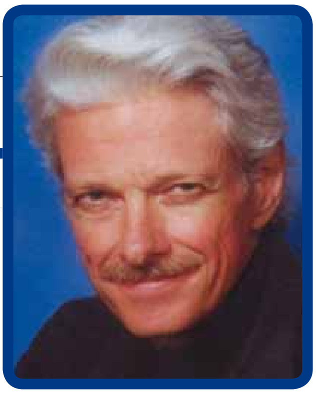

Roll moments from longitudinal anti

Photos: Jeff Bloxham

Formula Vees, with their VW Beetle front suspension, exhibit the more uncommon situation of longitudinal and lateral anti increasing with suspension compression

Q Some people tell me that anti-dive and anti-squat act to stiffen the suspension when forward or rearward forces are present at the wheels. Does that mean these effects add roll resistance? How does this really work?

A Anti-dive at the front wheels does impose a bit of a roadholding penalty, because it requires the contact patch to move forward as the suspension compresses. We might view this effect as requiring an increase in wheel rotational speed with respect to the caliper, as the suspension yields to a bump. The effect varies with the abruptness and height of the bump, the outside diameter of the tyre, whether the hub moves forward in compression or not, and how hard we're braking. However, anti-dive does not completely lock up the suspension as some authors have suggested. It merely acts counter to the desire to have the wheel move backward relative to the car, as well as upward, when the wheel hits a bump.

At the rear, things are a bit different. Anti-lift in braking and anti-squat in forward acceleration cause the contact patch to move rearward in compression, while the bumps still come at the wheel from the front. So rear longitudinal anti improves the system's ability to yield to a bump.

Jacking forces do not in themselves add to wheel rate or subtract from it, provided they do not change with wheel movement. The jacking force simply acts in parallel with the wheel rate or elastic forces, which are displacement dependent. That doesn't mean the jacking forces can't create roll moments or affect wheel loads though – they definitely can.

While anti effects do not necessarily vary as the suspension moves, it is very common for both longitudinal and lateral anti effects to vary with suspension displacement. Most often, both diminish as the suspension compresses, and increase as the suspension extends. But this is not so in all cases. A counter example would be the trailing arm front suspension on a VW Beetle. The arms are equal length and parallel, and at static condition slope down toward the rear. As the suspension compresses, the arms quickly reach horizontal, then begin to slope upward to the rear. The suspension goes from decreasing pro-dive to increasing anti-dive. The direction of change is consistently toward anti-dive as compression increases.

A NASCAR front end is an extreme case of the opposite, and more common, tendency. It changes rapidly toward pro-dive with compression, because the lower control arm is a semi-leading arm, while the upper control arm is almost a purely transverse arm.

If the slope of the suspension's longitudinal force line varies with suspension displacement, then assuming a constant longitudinal force at the contact patch, the jacking effect can act in a manner analogous to a spring force: it may increase or decrease according to displacement. However, →

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it won't necessarily increase with compression. If it does increase with compression, as in the case of the VW, it can loosely be thought of as adding wheel rate. If it decreases with compression, as with the NASCAR suspension, it can be similarly thought of as subtracting wheel rate.

On the face of it, we might suppose that if the front wheels have the same amount of anti-dive – that is, the same longitudinal force line slope – then their longitudinal force-induced jacking forces will lift both the right front and the left front corners of the car with the same force, and this will not create any roll moment. Therefore the anti will neither wedge nor de-wedge the car. This is true, but remember that the longitudinal forces at the contact patches may not be equal. In fact, if cornering, they are unlikely to be.

The longitudinal forces at the front contact patches actually come from two sources. One is braking, the other is the induced drag that a tyre produces when running at a slip angle, which is present any time we're cornering. That induced drag varies with the load on the tyre and is affected to some degree by camber and toe. Generally though, it is safe to say that the induced tyre drag is greater on the outside wheel. Therefore, the jacking force on the outside wheel will be greater for a given force line slope than on the inside wheel. That will tend to wedge the car (add diagonal percentage), and tighten it (add understeer).

Braking forces, on the other hand, tend to be more nearly equal. Theoretically, if we are short of the point of lock-up, with no front tyre stagger, and the brakes are as identical as we can make them, the braking forces will be identical at the two front wheels. With no tyre stagger, the outside tyre will act slightly smaller if we are braking while cornering, because it will deflect more vertically and therefore have a reduced loaded radius. Reducing the loaded radius reduces the effective radius too, though not by the full amount of the deflection change. This effect will make the braking force slightly larger on the outside wheel.

Suspension jacking can in fact add wheel rate if it increases with compression

If braking and cornering at the same time, we will have both a drag component and a braking component. If braking hard and cornering gently, the rearward forces at the front contact patches may be fairly equal. If we are braking gently and cornering hard, the rearward force may be substantially greater on the outside wheel. When off the brakes entirely, and cornering hard, we can say fairly confidently that the rearward force will be greater on the outside front.

Can we therefore say that adding anti-dive makes the car tighter? Well, almost. If we add anti-dive only on the outside wheel, that will tighten the car and it will do this even when not braking. If we add anti-dive evenly on both front wheels, that may also tighten the car, due to the greater rearward force on the more heavily loaded tyre. Any such effect will tend to be more pronounced in hard cornering than in hard braking. However, if we increase anti-dive only on the inside wheel, that will loosen the car (add oversteer). This effect will be present whether braking or just cornering. This would be a situation where we'd increase overall anti-dive yet add oversteer.

One might suppose that adding anti-dive on just the inside or outside wheel is impossible for road racing but, as we have noted, suspension layouts vary as regards how anti-dive changes with suspension movement, and such effects can be used to control the left/right balance of anti-dive when the car is in a rolled condition. Such effects are hard to manipulate on an existing car, but they deserve consideration in the design phase.

All of the above is based on the principle that adding diagonal percentage tightens the car and reducing diagonal percentage loosens it. When applying these principles, it is also important to bear aerodynamics in mind. More anti-dive will cause the front of the car to ride slightly higher through the turns, particularly with soft front springs. If static ride height or valance height are not adjusted for this, the greater ride height when cornering may add understeer purely by reducing downforce.

Now, what about anti-lift and anti-squat at the rear? As at the front, the jacking forces will depend on both the force line slopes and the magnitude of the forces at the contact patches. And, as at the front, any roll moments created will depend on the difference in jacking forces at the right and left sides. Two things are different at the rear: we can have forces forward or rearward (this whole discussion assumes the car to be rear-wheel drive), and we have various kinds of differentials (or lack of) that can influence the relative magnitude of the longitudinal forces, and in some cases even their relative direction.

Like the front tyres, the rears generate drag when running at a slip angle. However, it is unusual for that to be the only longitudinal force. The rear tyres are almost always either propelling the car or retarding it. Even in roughly constant-speed cornering, the rear tyres are making enough forward force to overcome the front tyre drag and the aerodynamic drag.

The rearward forces at the rear contact patches when braking or trailing the throttle will tend to be fairly equal if we have an open differential. If we have a spool or a limited slip diff, however, any rearward force will be greater on the faster (usually the outside) wheel. When under power, again the forces will be fairly equal with an open diff, but any locking effect will result in more force at the slower (usually the inside) wheel. At least, that holds true up to the point of inside wheelspin. Then the outside wheel may make more forward force than the inside.

All of this makes it fairly complex to predict the distribution of longitudinal force at the rear. However, we can say this much: in braking, more anti-lift or less pro-lift on the inside rear loosens the car (adds oversteer) while more anti-lift or less pro-lift on the outside rear tightens the car (adds understeer). Under power, more anti-squat or less pro-squat on the inside rear tightens the car (adds understeer) and more anti-squat or less pro-squat on the outside rear loosens the car (adds oversteer). Effect of more anti-lift or anti-squat geometry added evenly on both sides depends on the distribution of longitudinal force between the two rear contact patches.

Distribution of longitudinal force also affects handling balance because it creates yaw moments. In general, we can state that more longitudinal anti of any type intensifies these effects. For example, more induced drag at the outside front creates a yaw moment promoting understeer. If there is more anti-dive, there is also an increase in diagonal percentage, which intensifies the tightening. If there is more forward force at the inside rear, that creates an understeer-adding yaw moment. If there is ample anti-squat, again we get an increase in diagonal percentage, intensifying the effect. More rearward force at the inside rear creates a yaw moment that adds oversteer. More anti-lift there reduces diagonal percentage, again intensifying the effect. So, in general, we may say that increased longitudinal anti geometry makes a car more sensitive to its tyres' load and force distribution. RE

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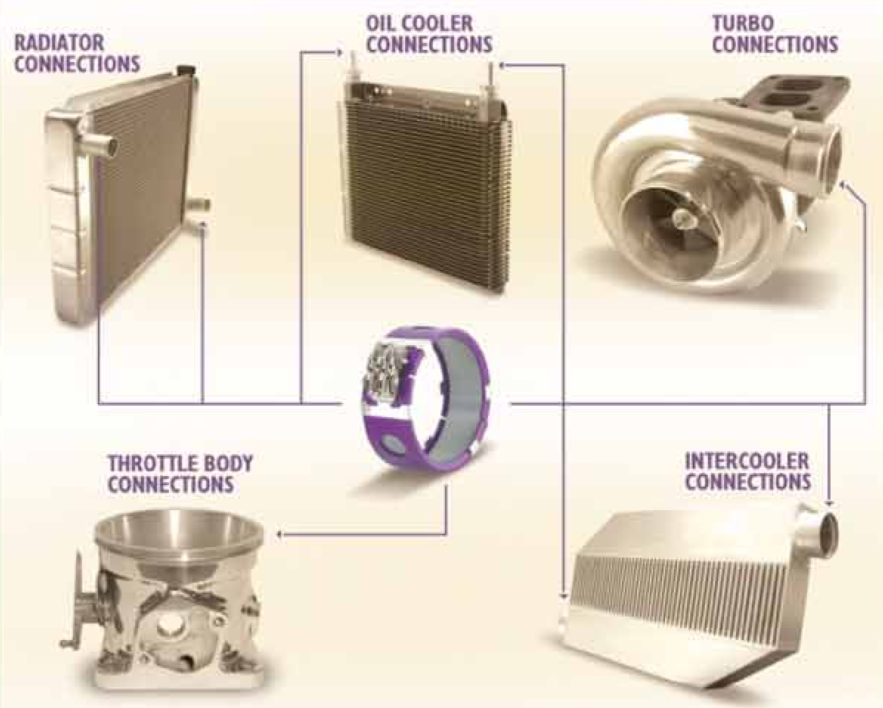

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