



Racecar engineering

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The Allard J2X lacked results but it changed prototype design



TECHNOLOGY CHALLENGE

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How the factory-backed cars were engineered for Le Mans



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Contents

Features

Cover story

- 30 Aston Martin DBR9**
Aston's new GT1 Le Mans contender examined in detail
- 38 Hindsight**
The Allard J2X was a radical car that never fulfilled its true potential
- 44 Tyre optimisation**
Getting the best from a racecar's tyres is crucial. Dufournier Technologies is the expert
- 52 Formula 1 for amateurs**
EuroBOSS is grand prix cars run on a budget. We investigate what it takes to succeed
- 60 NASCAR wind tunnel**
A look at AeroDyn's purpose-built stock car wind tunnel



30



38

Raceworld

- 05 Write line** – Motorsport's worst enemy is motorsport itself
- 06 Debrief** – BAR Honda gets banned and Porsche heads for Le Mans
- 16 Race people** – Adrian Daniels of ADR Engineering is On the Gas
- 21 V-Angles** – Paul Van Valkenburgh discusses psychology and super sensitivity
- 29 Forum** – Patent problems and Supermodified wing issues



44

Raceshop

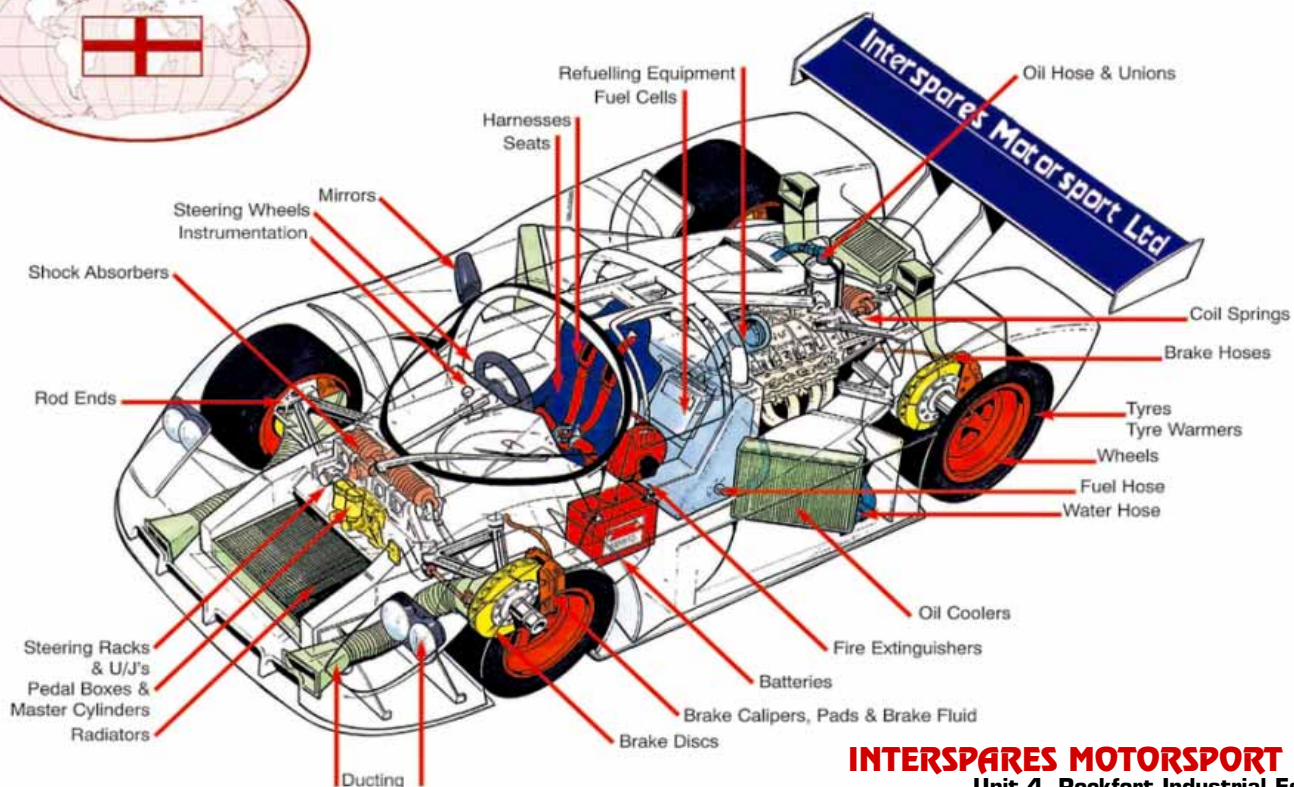
- 77 Racegear** – All the latest products
- 83 Database** – Full motorsport supplier listings
- 93 Aerobytes** – Simon McBeath examines the true role of bargeboards
- 97 The Consultant** – Roll moments and anti geometry discussed



52

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PAGES 68-69
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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.

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.

Editor
Charles Armstrong-Wilson

“SURELY THE FAILURE
TO FIGHT THIS IS THE
GREATEST THREAT TO
MOTORSPORT”



The International Journal
Racecar
engineering

Pit Crew

Vol 15 No.7

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Porsche announces return to prototype racing

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



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

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.

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.



Carlin D Ireland

Zytek set to improve on 04S success

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



Gavin D. Ireland

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

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.

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

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

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

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 be 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

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



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

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.



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.



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



LAT

Toyota pit lane fire



LAT



LAT

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 Scalabrini wants to take his GP2 outfit, BCN Competición, to Formula 1 by 2008. Scalabrini, 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



LAT

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

BMW firm favourites to supply the Swiss outfit, although a Ferrari deal has not yet been ruled out.

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? Split rims

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.



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

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.



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

Track grinding to improve Charlotte



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.

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'Superrally' slammed by crews

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

Co-driver Timo Rautiainen stated: 'The superrally 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 'superrally' 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 Superrally regulations, aimed at getting more cars out on stages in front of the spectators, are not proving popular with the crews



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:



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

'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.

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

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

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

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

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,

main plank of BAR's subsequent appeal.

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

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 naïveté on both sides – BAR Honda with the rules and the FIA stewards with the design of current F1 cars.



Flavio Briatore

● 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



Adrian Newey

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



Yasuhiro Wada

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 be 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



Ryan Dalziel

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

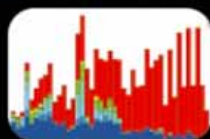
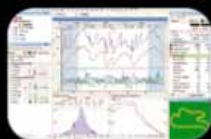
engineering for the teams and manufacturers. Join the both of them together and you get a good result. We get entertainment from engineering by trying to beat our competitors whilst spending similar money.

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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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,



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

as well as confidential work for the Ministry of Defence.

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.

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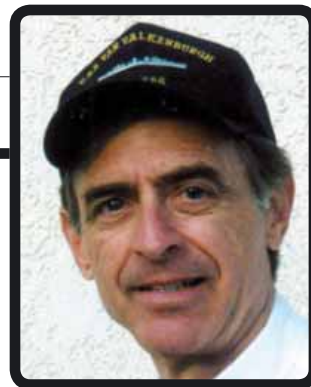
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Perfect harmony

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?

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“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 minuscule 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?

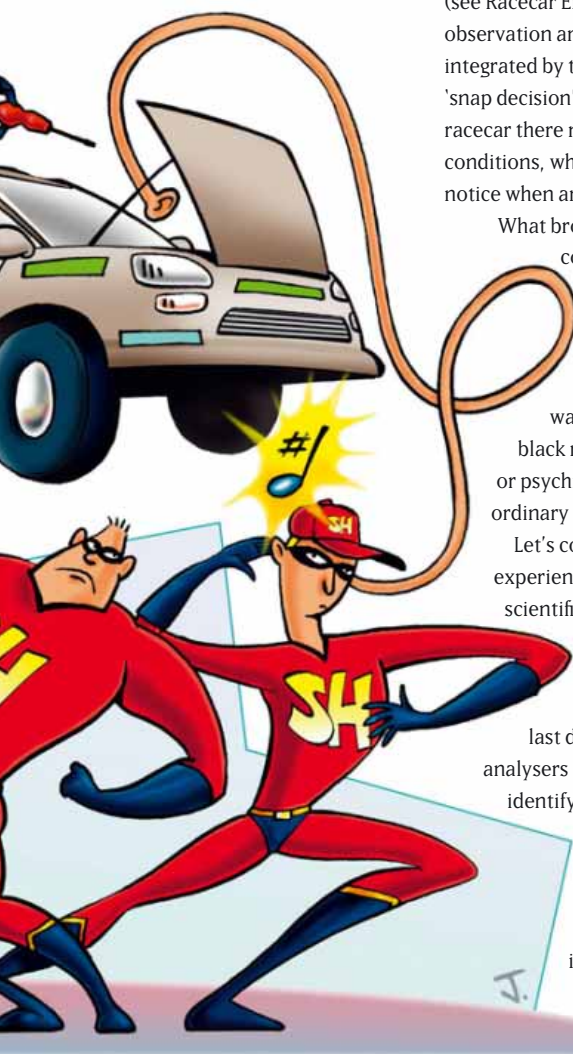
However, when it comes to diagnosing problem sound spectrums, some frequencies may be masked from conscious awareness by louder nearby frequencies. And yet the experienced subconscious may be able to intuitively recognise a condition of 'danger — about to fail' above the apparently random noise. And 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.



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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?

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



Photos: Karsten Balleschmidt

of the sport comprising banger racing and destruction derbys, using minimally modified scrapyards 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 year's 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 through 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.

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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

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Are Formula 1 teams avoiding intellectual property issues?

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 x 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 x 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 Kaufman, 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.

$1\text{cm} \times 1\text{cm} \times \pi/4 = 0.7854\text{cm}^2$ area
 $\text{and } 1\text{cm} \times 0.7854\text{cm}^2 = 0.7854\text{cm}^3$
 volume. $7.85\text{g/cc} \times 0.7854\text{cc} = 6.165\text{g}$. SolidWorks agrees with me, too!

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Return to form

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

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 man-

Words	Ian Wagstaff
Photos	Aston Martin Racing, LAT

ager, 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.'

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

**“RACING IS TO BECOME
ONE OF THE COMPANY'S
CORE ACTIVITIES”**



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.

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

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

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 DBR9'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

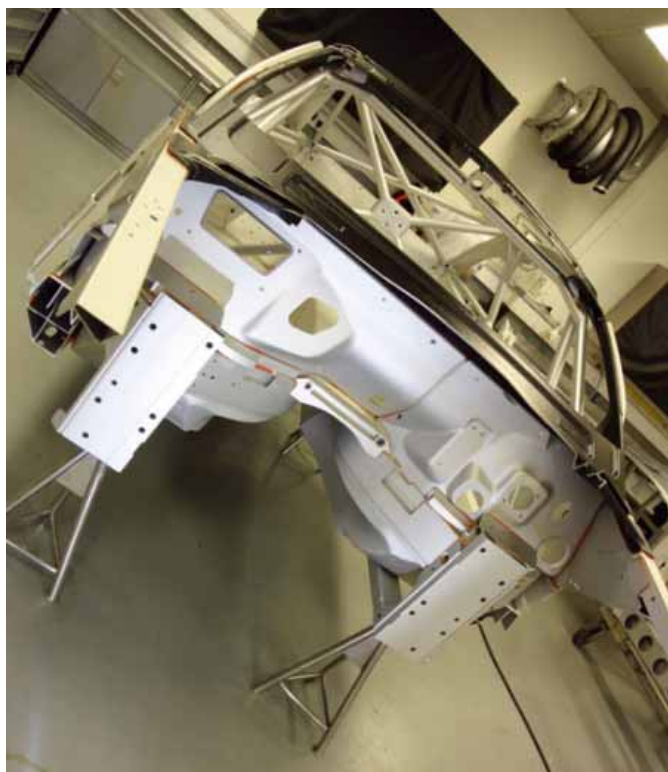
Work on the chassis has been very different from a carbon car or a traditional steel monocoque. With the Ferrari, as with its rallying and touring projects, Prodrive had been used to working with a steel 'shell. 'You weld your rollcage into that and away you go.' But the Aston Martin features a bonded 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.

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

'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



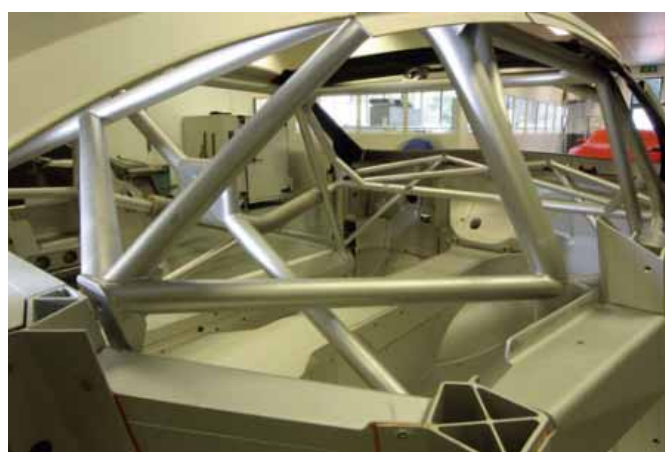
Even the wiring looms are partially made in-house, the rest by Tony James



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



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

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 sus-

pension 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.'

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 x 18in front and 13 x 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. →

“ITS BONDED ALUMINIUM CHASSIS CAB IS USED IN NEAR STANDARD FORM”

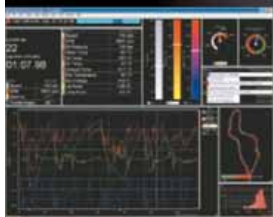
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Double wishbone suspension all round uses proven Koni 2812 series dampers

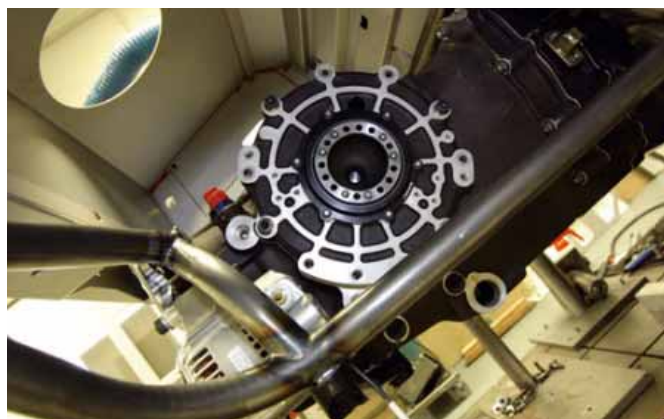
The car features a full MIL-spec loom, some of it made up in-house, the rest by Tony James, mainly because of a question of capacity. Magneti Marelli supplies the sequential injection, while use is made of a Pi data system and a Pectel engine ECU, enabling the team to run traction control, too. It makes 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



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



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

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.

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 ver-



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

sions will be forged and machined. A cast sump panel separates the bays with each pair of cylinders separated from its adjacent partner.

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.'



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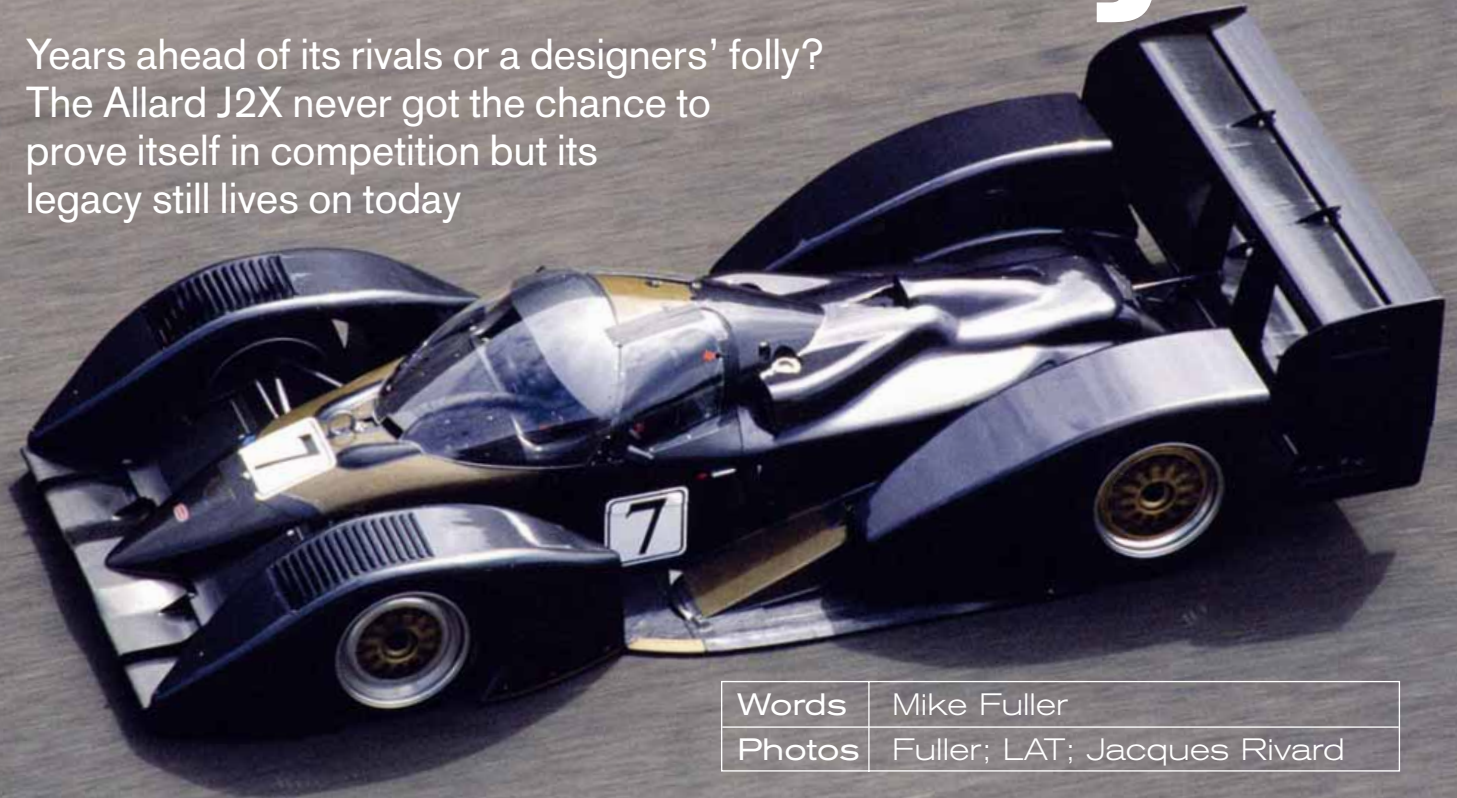
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Evolution theory

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.'

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



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

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 anhedral, 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.'

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.

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



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

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. Anhedral 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.'

Robb 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

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.'

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.

“THE ALLARD WAS PLAGUED BY ONE FUNDAMENTAL PROBLEM – IT HAD NO BUYERS”

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



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



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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.

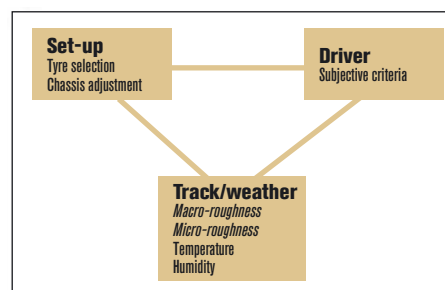
Adhesion Monitoring System

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 Waals 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 ($d < 100\mu\text{m}$). Micro-hysteresis is due to the effect of micro-roughness on the surface of the rubber. In fact micro-hysteresis and Van der Waals 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 Waals 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 $5.0\mu\text{m}$), 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 →

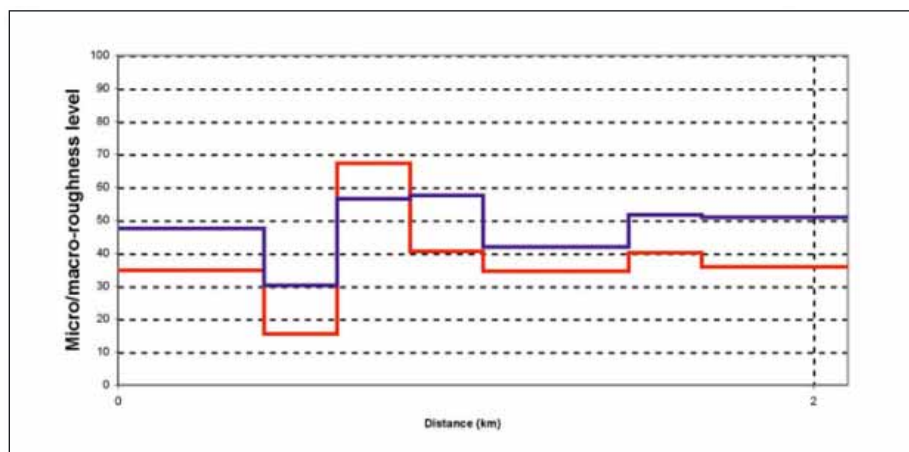


Figure 1: macro- and micro-roughness data assist with the objective selection of suitable tyres

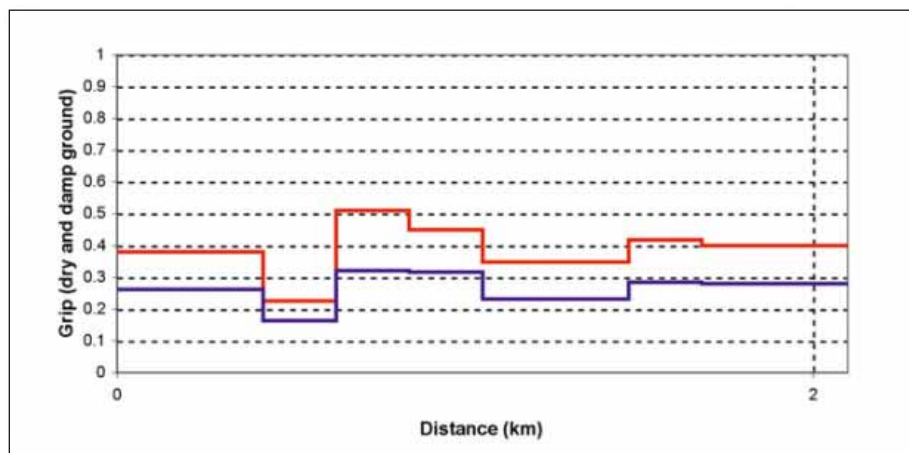


Figure 2: grip levels in dry and damp conditions determined from macro- and micro-roughness data

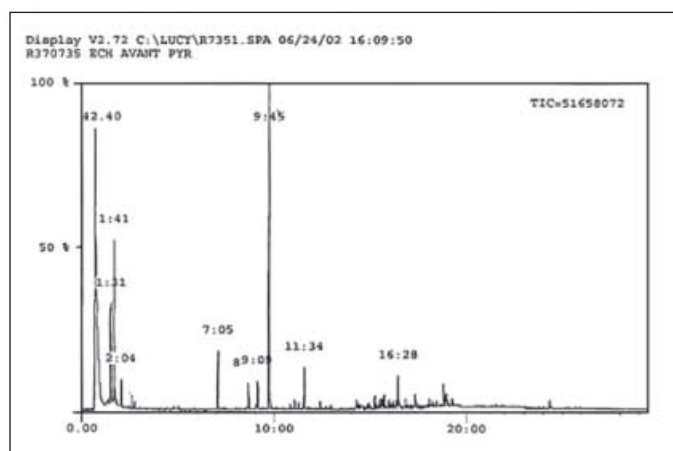


Figure 3: GC/MS chromatogram of the front tyre in the example project

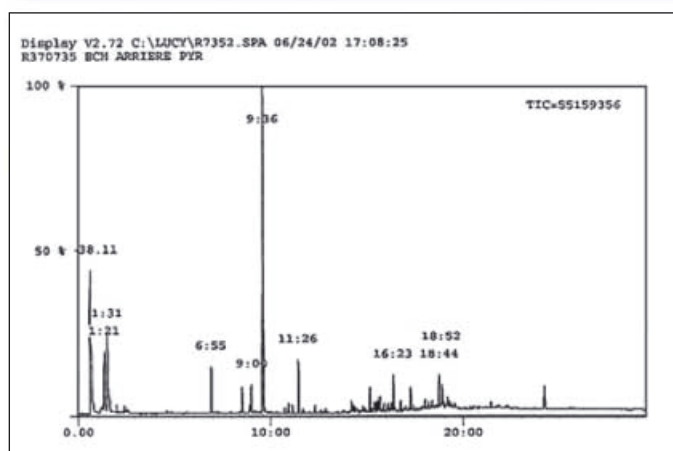


Figure 4: GC/MS chromatogram of the rear tyre in the example project

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 ($\tan \delta$) 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

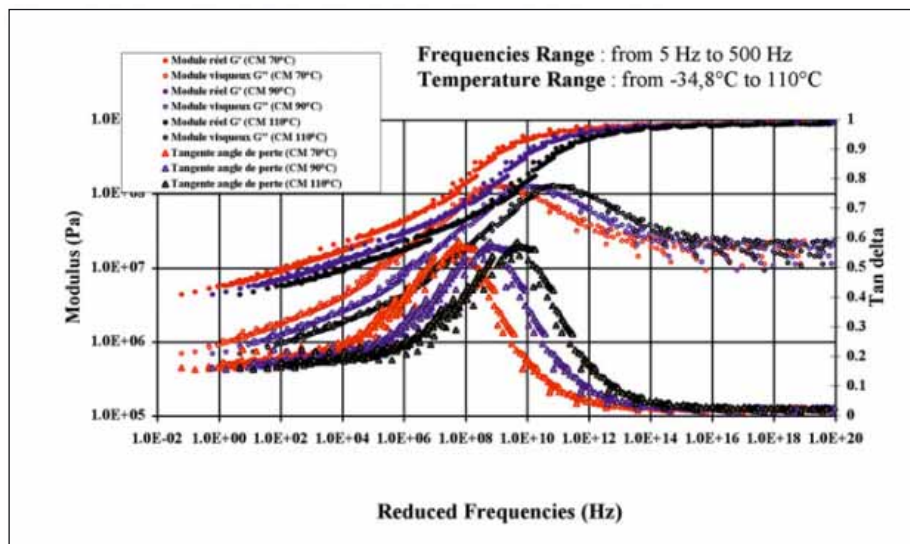


Figure 5: a typical thermo-mechanical analysis plot from a test subject tyre

“A GOOD SET-UP DEPENDS ON A TRIANGULAR RELATIONSHIP BETWEEN A SPECIFIC DRIVER AND THE SPECIFIC WEATHER AT A SPECIFIC TRACK”

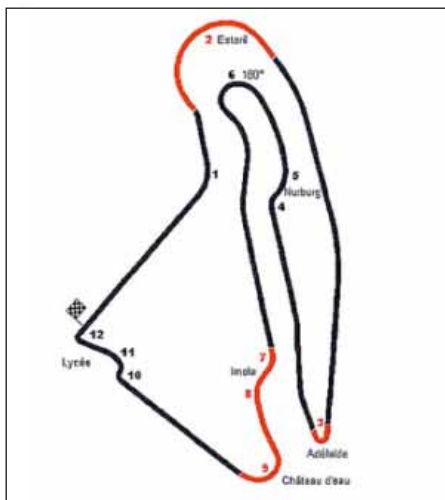


Figure 6: track map of Magny Cours circuit, France

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.'

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	Creffr	Treff	Treffr	Breff	Breffr	ARBreff	ARBreffr	Diffref	Ref
2	Creff-0.5°	Creffr	Treff	Treffr	Breff	Breffr	ARBreff	ARBreffr	Diffref	C-
3	Creff	Creffr	Treff+10'	Treffr	Breff	Breffr	ARBreff	ARBreffr	Diffref	T+
4	Creff	Creffr	Treff	Treffr	Breff	Breffr	ARBreff	ARBreffr	Diffref	Ref1
5	Creff	Creffr	Treff	Treffr	Breff-5	Breffr	ARBreff	ARBreffr	Diffref	B-
6	Creff	Creffr	Treff	Treffr	Breff	Breffr	ARBreff-2	ARBreffr+	Diffref	ARB+
7	Creff-0.5°	Creffr	Treff+10'	Treffr	Breff	Breffr	ARBreff-2	ARBreffr+	Diffref	Synth
8	Creff-0.5°	Creffr	Treff+10'	Treffr	Breff	Breffr	ARBreff-2	ARBreffr+	Diffref+2	Dff+

Reference set-up	
Front tyre pressure	1.6bar
Rear tyre pressure	1.6bar
Camber front, Creff	3.5deg.neg
Camber rear, Creffr	2.75deg.neg
Toe out front, Treff	20'
Toe in rear, Treffr	10'

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

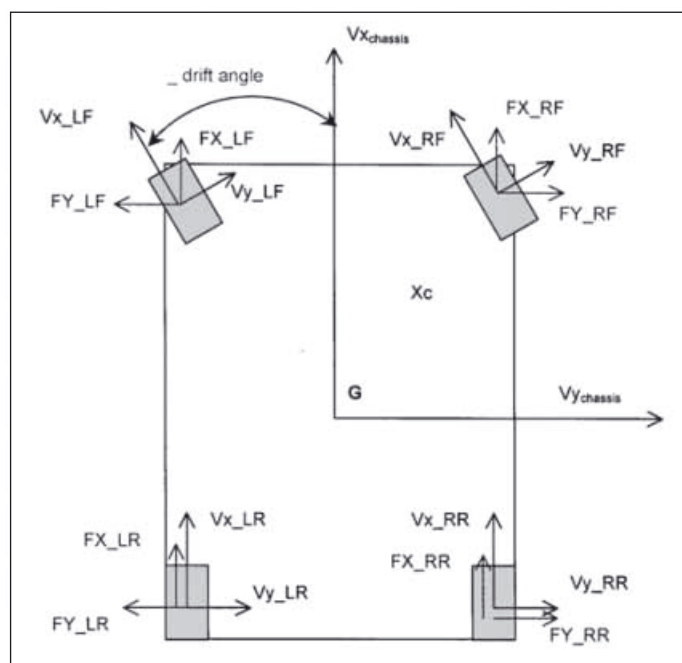
Results and analysis

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

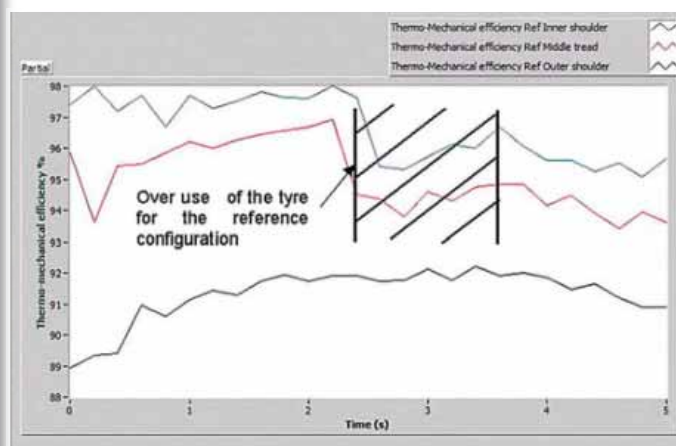


Figure 9: measurements of the thermo-mechanical efficiency of the loaded front tyre in the reference set-up

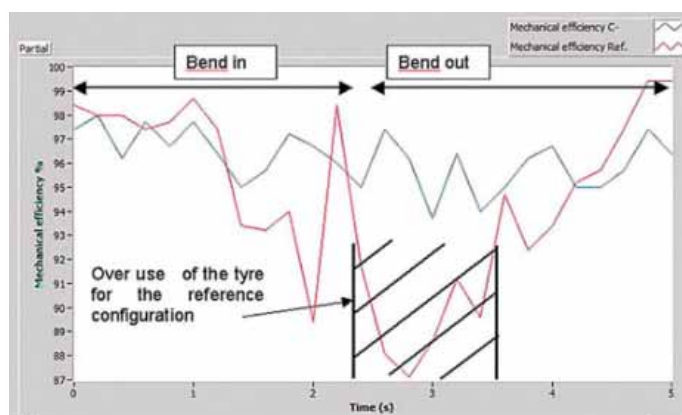


Figure 8: mechanical efficiency of the loaded front tyre after camber reduction

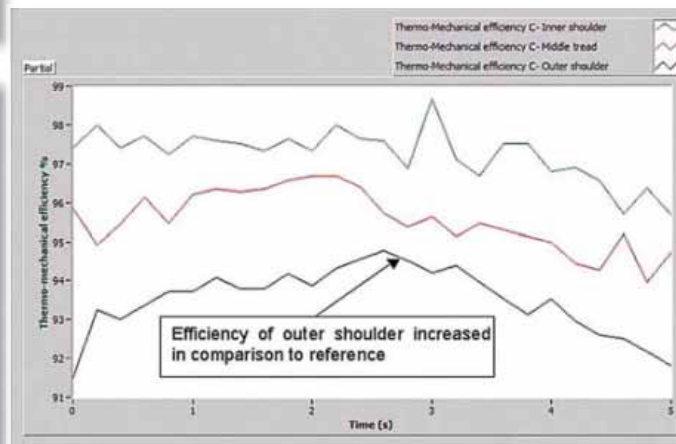


Figure 10: measurements of the thermo-mechanical efficiency of the loaded front tyre after camber reduction



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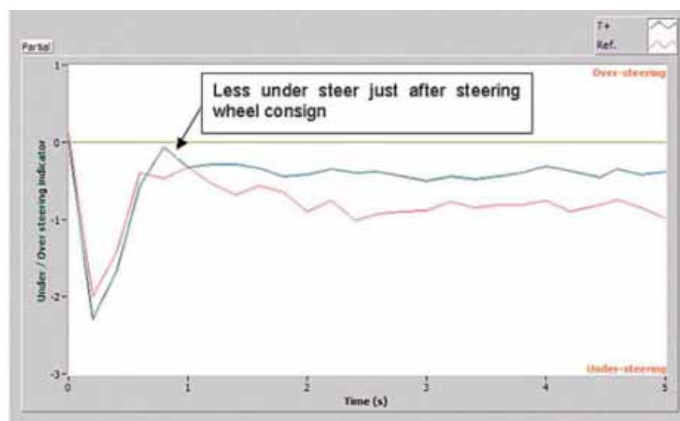


Figure 11: oversteer/understeer (USOS) indicator showing relative effect of front toe-out reduction

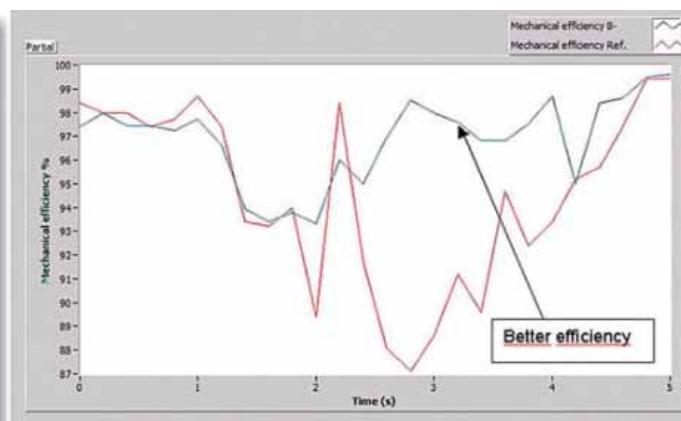


Figure 13: the gain in front tyre mechanical efficiency following the front damper compression softening

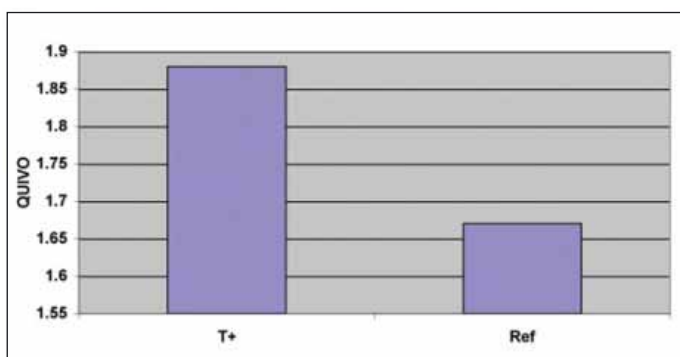


Figure 12: 'QUIVO' indicator showing the gain in front axle behaviour following the front toe-out reduction

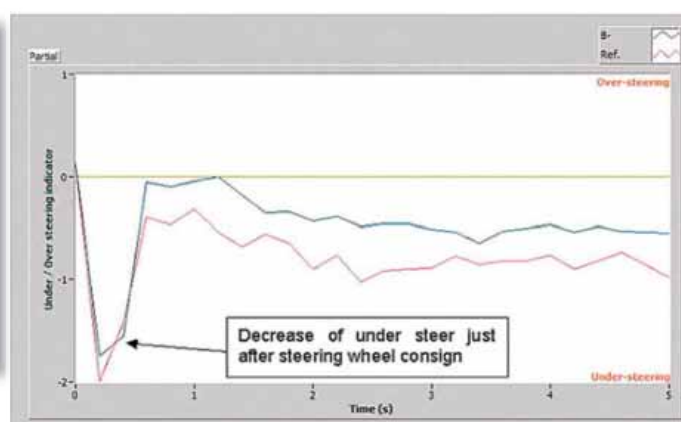


Figure 14: USOS indicator shows reduced understeer after front damper compression softening

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.

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

Dufournier 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.

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.

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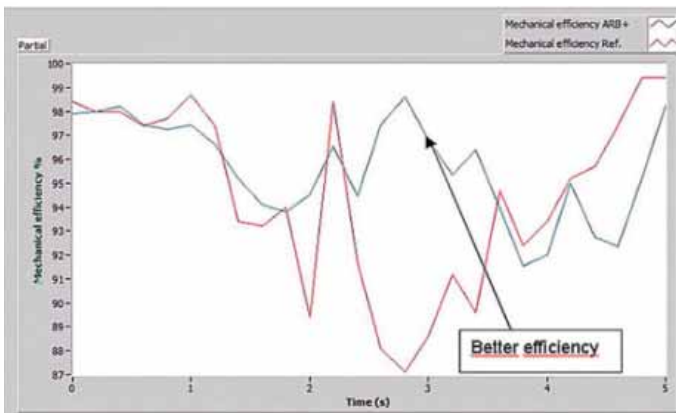


Figure 15: improved front tyre efficiency after roll stiffness shift to the rear

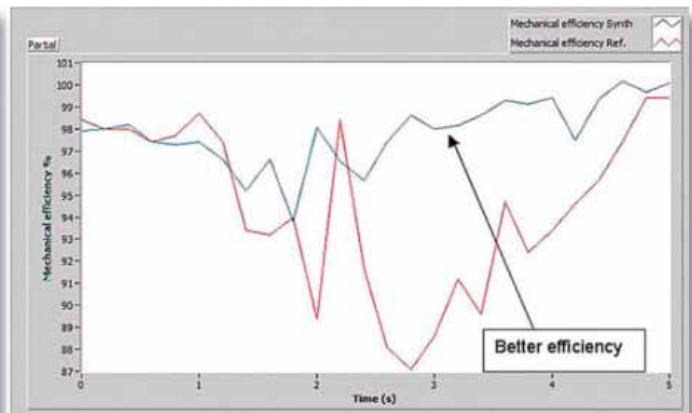


Figure 17: better front tyre efficiency in the 'synth' configuration

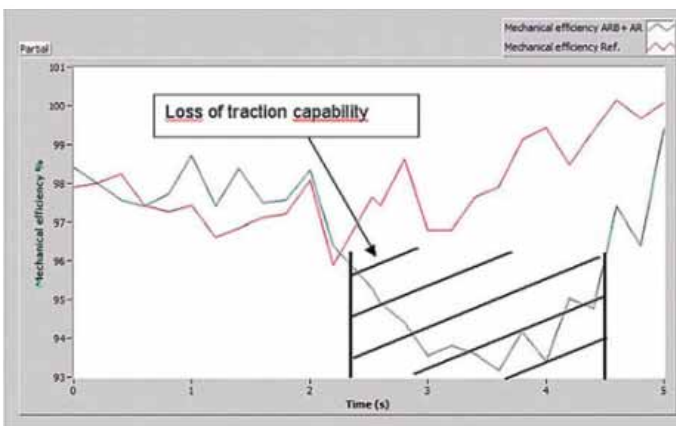


Figure 16: worsened rear tyre efficiency after roll stiffness shift to the rear

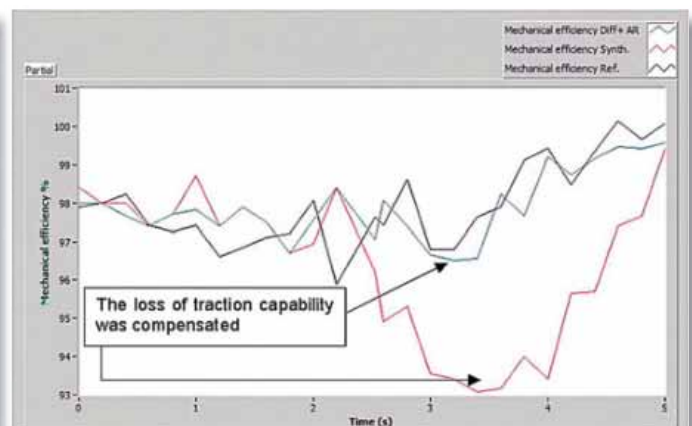


Figure 18: improved rear tyre efficiency after the differential was tightened

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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



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

Scott Mansell's Mansell Motorsport Benetton B197

(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 Lausitz 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 Ascaris runs its modified Benetton B197s as Ascasis. 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**



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 →



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



Mansell's engine data man Andy Barnsley warms up

What's in a name?

'Any relation?' It's a question the Mansells have been asked 1 001 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.

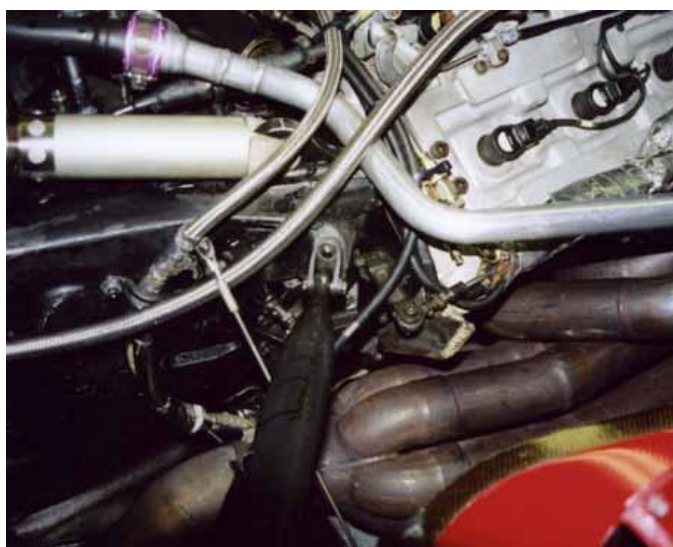
Running Scott in EuroBOSS in 2004 was a gamble. It's not your normal stepping stone to grand prix stardom after all, but the championship crown, the McLaren Autosport nomination and subsequent successful tests with GP2 team Arden seems to suggest the gamble paid off. Just perhaps, in the future, when 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



740bhp, 4.0-litre Judd V10 sports car unit has proved itself to be low maintenance and very reliable in the re-born B1 97



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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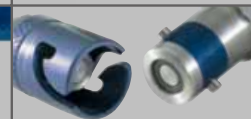
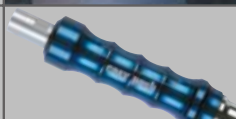
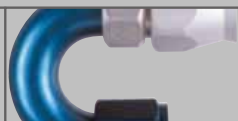
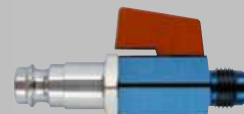
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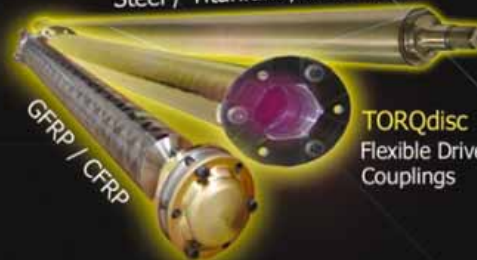
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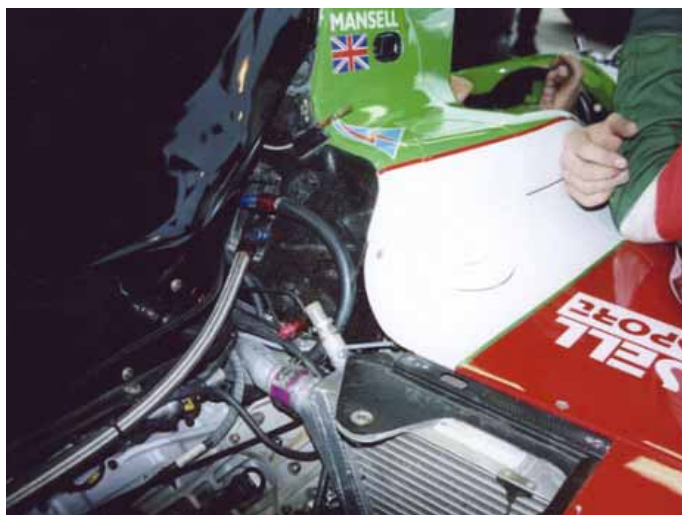


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One of many less significant changes is the use of a smaller capacity fuel tank



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

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

operation, with Judd present at every round of the championship to support its teams.

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.

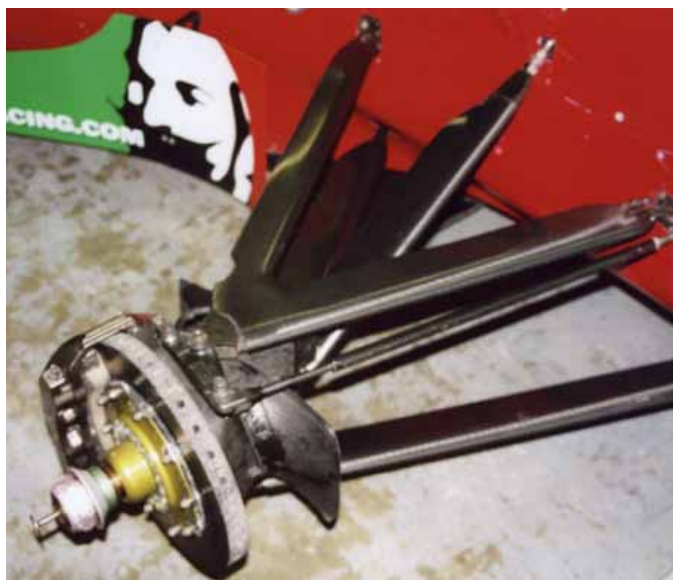
That paddle shift has been replaced by a conventional sequential system, which although a simplification also needed plenty of thought: 'The problem is that when you're going to be in high g corners you need to work out the rack weight so you can spring it to control it in the turn, otherwise it would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



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

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.

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.



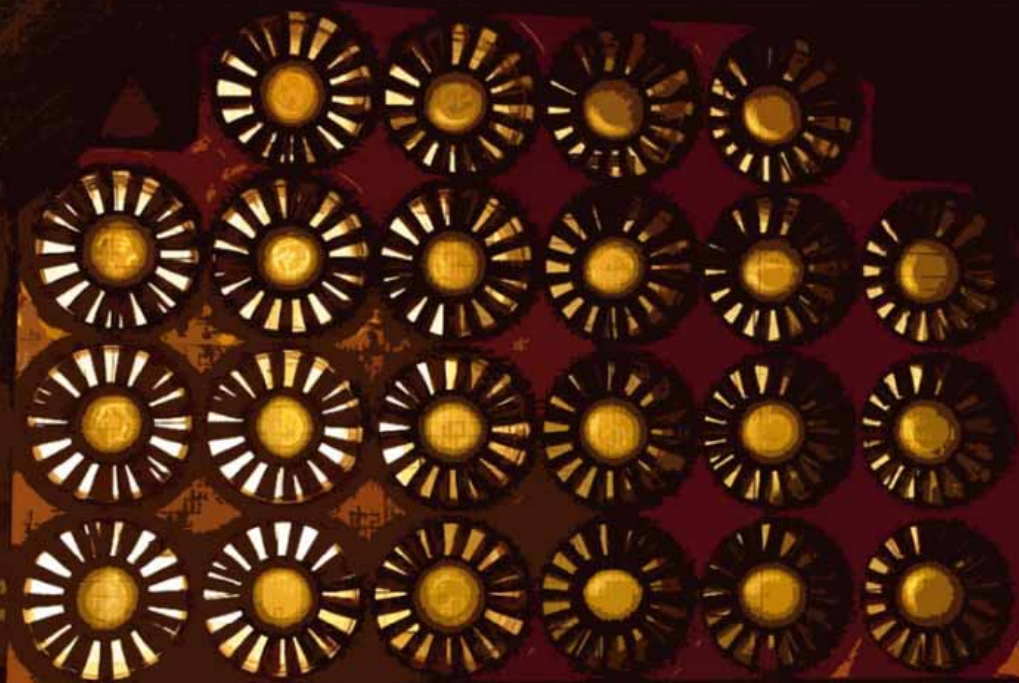
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Building your own wind tunnel and limiting it to one style of racecar sounds like a recipe for disaster, but not if your customer is NASCAR

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

“WE’VE FINE TUNED IT TO EXACTLY THE SHAPE WE NEEDED”

results,' says Eaker on a walking tour. 'That means you've got brains and brawn.'

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”

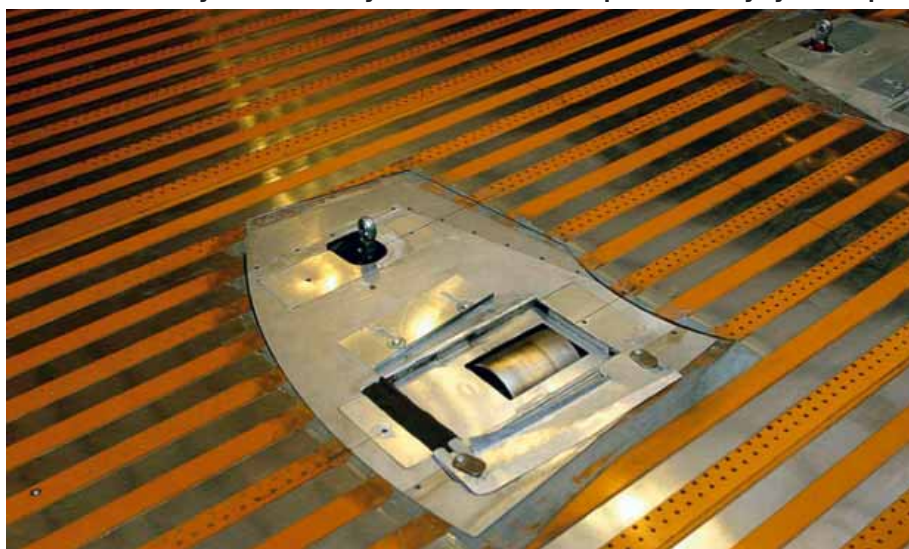
have large chambers to accommodate a wide range of tests. The same is true of those owned by manufacturers. There's enough space in these traditional tunnels' chambers to account for any blockage problems — as opposed to the use of contoured walls.

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**



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Mr. Mike Holzapfel
President

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Robert S. Clarke
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December 9, 2004

ARP
Mr. Mike Holzapfel
President

In 1985, at the biggest race of the year - the Daytona 500 - with a great race car driver, Tim Richmond and high expectations, we had a problem. Early in the 500 we broke the wheel studs on the left front of our Old Milwaukee Pontiac. NASCAR has always been a family. With the help of some great friends, the Wood brothers - Eddie and Lynn - they said if you run the wheel studs we run on our car, you'll never break another one. I asked, "What are they and where do we get them?"

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As recently as last year when Rusty Wallace started RWI Racing, my suspension guys wanted another product. I said no, but they didn't know why. Being a past champion was part of the reason.

In the fall of this year, with 57 laps to go, we left four nuts loose on the right front wheel leading the race at Darlington. Jamie said it would never make it. The wheel made it on one stud. We owe the first win at RWI Racing to ARP.

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Barry Dodson
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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.

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

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



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 $\frac{3}{8}$ in 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 $\frac{3}{4}$ in. 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.

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71 Storage solutions

Toolboxes say more about you and your team than you might think

77 Racegear

Our review of the latest products and components for racecar engineers

83 Database

Racecar's comprehensive, easy to use directory of contact details for motorsport engineering companies, manufacturers, suppliers, teams and much, much more – exclusive to **Raceshop**

93 Aerobytes

Simon McBeath explains what really happens to the air around bargeboards

97 The Consultant

This month our resident chassis guru Mark Ortiz explains anti geometry

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 prod-

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

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

ucts that first brought the company's systems to his team's notice.

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 →



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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.

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 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 →



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



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

Tool storage

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.

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 Naguales 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.

“PRODUCTS THAT ARE MODULAR IN DESIGN ARE THE MOST SUITABLE”

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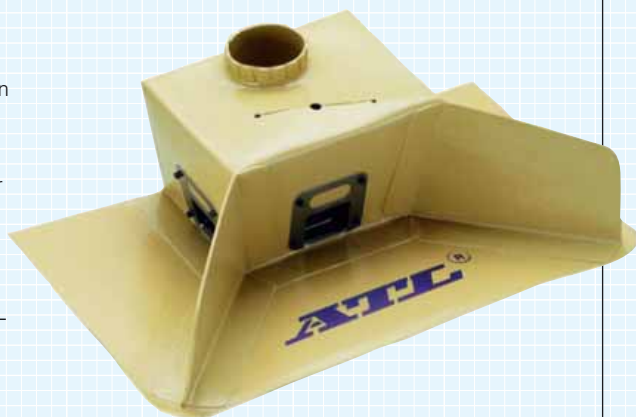
Lifeline Fire & Safety Systems Ltd Burnsall Road Coventry CV5 6BU UK
Tel +44 24 7671 2999 Fax +44 24 7671 2998 www.lifeline-fire.co.uk

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.



● Call +44 (0) 1908 351700 email atl@atlltd.com or visit www.atlltd.com



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

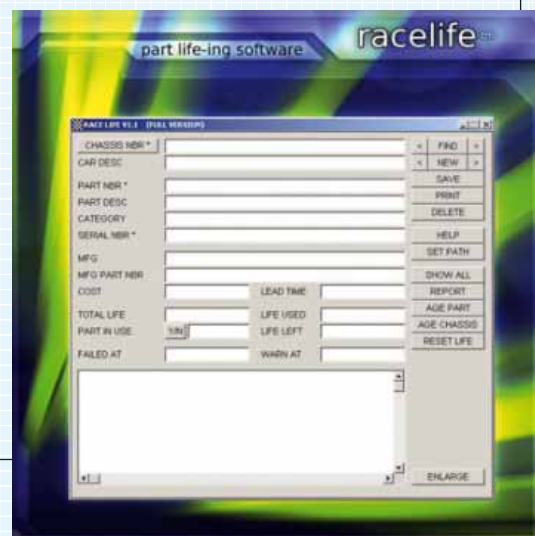
RaceLife software has designed a new program to assist teams in recording vital statistics on all car components. The software, also named RaceLife, enables the user to record how long each component on the car's chassis has been in use and the distance accrued.

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@racelivesoftware.com or visit www.racelivesoftware.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

RACE GEAR

New products and services for racecar engineers

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

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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

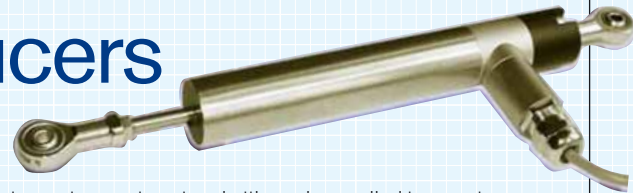


Programmable transducers

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



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RACEGEAR

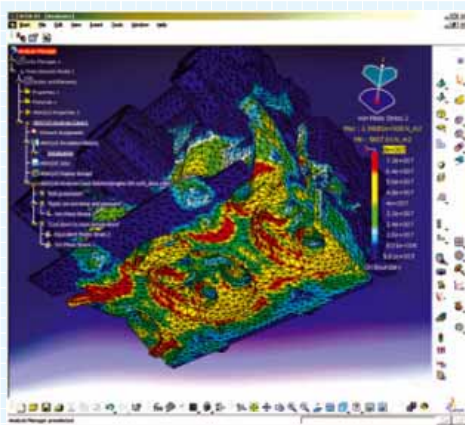
New products and services for racecar engineers

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

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>CLUBMAN 04

This machine is designed to bring features of higher end machines to racers with limited budgets. The standard windows based software supplied with this machine enables the user to access data of both velocity and displacement. The machine is an economy evolution of the wide range of capabilities available with SPA Dynamometers.



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>PSD 04

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Database

Section 1 lists manufacturers of Brand-Name Racecars.

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

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

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

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

Costs listed below:

Name and number £50 - 12 issues

Name and number bold

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£210 - 6 issues

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andy_king@ipcmedia.com

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1.1

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ASCARI	Tel 01295 254800 Fax 01295 255944 Overthorpe Road, Banbury, Oxfordshire OX16 4PN England
APOLLO RACING DESIGN LTD	Tel 01280 813580 Fax 01280 823015 Email info@apolloracingdesign.com Website www.apolloracingdesign.com Millgate Barn, Radcliffe, Bucks MK18 4AB, England
BARRELLI	Italy (39) 02 782427 Flli Barrelli, Via La Spezia 5, 20156 Milan, Italy
BRD Race Cars Inc.	Tel (1) 716 637 9467 16 Hollybrook Road, Brockport, NY 14420, USA
BODOLA	Tel Sweden 46 171 27690 Fax Sweden 46 171 27690 Bodin Chassiteknik, Skalbysgatan 8, 745 37 Enköping, Sweden
BREDA	Italy (39) 049 900895 Fax (390) 49 900 2821 Breda Racing s.r.l, via Buonarroti 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, Flatebyvyn 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, Piddie Trenthide, Nr Dorchester, Dorset DT2 7RF, England
US Importer Continental Crossle	Tel (1) 513 777 4545
DALLARA	9000 Debbie Drive, West Chester, OH 45069, USA Italy (390) 525 550711 Fax (390) 525 53478 Dallara Automobili, Via Provinciale 33, 43040 Varano Melegari, Parma, Italy
DEBORA	France (33) 381 52 02 10 36 Fax (33) 381 51 18 51 bis Rue du Docteur Moras, 25000 Besancon, France
DAN GURNEY'S ALL AMERICAN RACERS, INC	Tel USA 714 540 1771 Fax USA 714 540 3749 2334 South Broadway PO BOX 2186, Santa Ana, CA 92707, USA
DJ RACECARS	Tel 01663 734518 Fax 01663 732 130 Email del@djracecars.fsnet.co.uk Unit 10, Britannia Rd Est, Buxworth, Nr Whaley Bridge, High Peak, SK23 7NF
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DOWNES ENGINEERING	Tel USA 707 938 1001 Fax USA 707 935 0481 19564 8th St. East, Sonoma, CA 95476 USA
DRAGON	USA (1) 413 267 0904 Small Fortune Racing, 77 Stafford Hollow Road, Monson, MA 01057, USA
ELISE	France (33) 1 47 49 15 66 1 Rue Pierre Cassin, 92500 Rueil Malmaison, Paris, France
EUROCAR	Tel 01353 861687 Fax 01353 861687 SHP Motorsport, Unit 7 Farraday Business Park, Littleport, Ely, Cambridgeshire CB6 1SE, England
EXTREME CARS	Australia (61) 396 822225 (61) 396 821119 (61) 396 900809 Email mrproot@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 69817 Clyse Farm, Stathe, Nr Bridgwater, TA7 0JN England
GRAN TOURING CLASSICS	001 562 596 9242 Tel 01635 44466 Fax 01635 30056 Gould Engineering Services, Unit 7, Arnhem Road, Newbury, Berks, RG14 3RU
GOULD	USA (1) 317 273 0089 Indianapolis Competition Products, 1717 Expo Lane, Indianapolis, IN 46214, USA
ICP/CITATION	Tel 01883 744 443 Fax 01883 744 443 Address Jade Motorsport Engineering, Unit 2 Pendell Farm, Pendell Road Bletchingley Surrey RH1 4QH
JADE	Tel 01932 440774 John Corby Motors, 36A Stanley Road, Wellingborough, Northamptonshire NN8 1DY, England
JEDI	USA (1) 909 355 4800 Fax (1) 909 355 5933 KBS Engineering, 8296 Fremontia, Suite B, Fontana, CA 91040, USA
KBS	USA (1) 404 457 6300 Fax (1) 404 458 6018 5096 Peachtree Road, Atlanta, GA 30341, USA
KUDZU	USA (1) 906 861 5003 Campbell Motorsport, W7719 Fernwood Drive, Menominee, MI 49858, USA
LAZER	Tel 01480 453101 Fax 01480 456722 Lola Cars International, Glebe Road, St Peters Hill, Huntingdon, Cambridgeshire PE18 7DS, England
LOLA	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 Valseggio 2, 45100 Mantova, Italy
LYNCAR ENGINEERING	Tel 01635 860066 Fax 01635 860066 Email: lyncar@abdnorthamptonworld.com Briff Lane, Bucklebury, Reading, Berkshire RG7 6SN
MAGNUM	Tel 01933 428661 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 NN9 2QT, England
MARK BAILEY RACING	Tel 01380 85030 Fax 01380 850410 MBR Building, 8A Jockey Lane Bromham, Chippenham, Wiltshire, SN15 2EZ
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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 60075, USA
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RAY	USA (1) 215 775 1938 Performance Engineering, RD5 Box 5435, Mohnton, PA 19540, USA
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TAMPOLLI	Italy (39) 055 882368 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 Tel 01953 888195 Fax 01953 888178
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US Importer

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Lola Cars Inc, Suite B, 2801 Fortune Circle East,

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Australia (61) 2 791 9899
0208 568 1172
01684 891898
01392 369090
France 33 3 20997510
01327 359912
USA (i) 216 232 2282



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

FUEL VALVES

AN MOTORSPORT DESIGN
ATL
EXACT ENG
KINSLER
PRONALS
SPECIALTY FASTNERS

01628 776320
USA (i) 201 825 1400
UK 01908 357700
01803 866646
USA (i) 248 362 1145
France 33 3 20 997510
01803 866371

HOSES & HOSE-ENDS

AEROQUIP
AN MOTORSPORT DESIGN
BMS

USA (i) 419 238 1190
01628 776320

BROWN AND MILLER

UK Tel: 01753 553610
Fax: 01753 571477
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

EARL'S
EXACT ENG
FASTENER FACTORY
FHS MOTOR RACING
FLUID CONTROL PRODUCTS INC
GOODRIDGE UK
GOODRIDGE CA
GOODRIDGE INDY
GOODRIDGE EAST
HCL FASTENERS
HENRY'S ENG
JLS MOTORSPORT
KINSLER
SAMCO SPORT

01926 474742
USA (i) 310 609 1602
01803 866646
01327 311018
01753 570863
USA (i) 217 324 3737
Fax (i) 217 324 3717
01392 369090
USA (i) 310 533 1924
USA (i) 317 244 1000
USA (i) 704 662 9095
01282 411992
USA (i) 410 435 3142
0121 525 7733
USA (i) 248 362 1145
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
SPEED FLOW
THINK AUTOMOTIVE
UNICLIP AUTOMOTIVE
XRP INC

01803 866371
0208 530 6664
0208 568 1172
01932 355277
USA (i) 562 861 4765

INTERCOOLERS

AH FABRICATIONS
FLUID CONTROL PRODUCTS INC
PACE PRODUCTS
SERCK MARSTON
SFS PERFORMANCE

01432 354704
USA (i) 217 324 3737
Fax (i) 217 324 3717
01440 760960
0208 965 2151
01582 412 697

OIL COOLERS

AEROQUIP
CV PRODUCTS
DOCKING & CO
EARL'S
EXACT ENGINEERING
FAE MACHINE
FLUID CONTROL PRODUCTS INC
GOODRIDGE UK
GOODRIDGE CA
GOODRIDGE INDY
GOODRIDGE EAST
LAMINOVA
PROCOMP
SECAN
SERCK MARSTON
SETRAB
SPECIALTY FASTNERS
SPV RACING
THINK AUTOMOTIVE
TREVOR MORRIS ENG

USA (i) 419 238 1190
USA (i) 910 883 4096
01372 857164
USA (i) 310 609 1602
01803 866646
USA 317 243 3092
Fax (i) 217 324 3737
01392 369090
USA (i) 310 533 1924
USA (i) 317 244 1000
USA (i) 704 662 9095
Sweden (46) 85 907 4045
0121 350 3258
France (33) 14 790 6512
020 8965 2151
Sweden (46) 0158060
01803 866371
Australia (61) 2 791 9899
020 8568 1172
01547 530289

OIL FILTERS

AN MOTORSPORT DESIGN
COSWORTH
EARL'S
ED PINK ENGINES
EXACT ENGINEERING
FLEXIBLE HOSE
FRAM FILTERS
KINSLER

01628 776320
01604 752444
USA (i) 310 534 1390
USA (i) 310 609 1602
USA 818 785 6740
01803 866646
01753 570863
01433 223000
USA (i) 248 362 1145

OIL PUMPS

ED PINK RACING ENGINES
KENT CAMS
PACE PRODUCTS
PACET
SPV RACING
SWINDON RACING ENGINES
TITAN MOTORSPORT

USA 818 785 6740
01392 248666
01440 760960
01628 526754
Australia (61) 2 791 9899
01793 531321
01480 474402

OIL SEALS

RACE-TEC NAK
PIONEER WESTON (WYKO)

02380 246986
0161 703 2011

OIL SUMPS

AH FABRICATIONS
ARE RACING ENGINE SYSTEMS

01432 354704
USA (i) 916 987 7629
www.drysump.com
01795 843802
01746 768810
USA (i) 818 407 1211
01440 760960
0208 853 4648
01793 531321
01480 474402
01547 530289

OS TANKS

BS ENGINEERING
GARTRAC
GOMM METAL DEVELOPMENTS
KS MOTORSPORT
MIDAS METALCRAFT
PACE PRODUCTS
THINK AUTOMOTIVE

01908 618080
01248 682263
01483 764876
Germany (49) 2271 44905
01933 355512
01440 760960
020 8568 1172

RUBBER & ELASTOMERIC COMPONENTS

BUTSER RUBBER LTD
Tel: 01730 894034

STARTER MOTORS

ARK RACING
EARL'S
RTRAC
STARTLINE UK LTD

01785 715234
USA (i) 310 609 1602
Germany (49) 9725 5075
01933 665752

THROTTLE BODIES

JENVEY DYNAMICS
KINSLER
LINGENFELTER
LUMINATION
SWINDON RACING ENGINES
TWM INDUCTION

01746 768810
USA (i) 248 362 1145
USA (i) 219 724 2552
0207 403 4334
01793 531321
USA (i) 805 967 9478

THROTTLE VALVES

JENVEY DYNAMICS
KINSLER
LUMINATION
TREVOR MORRIS ENG
TWM INDUCTION

01746 768810
USA (i) 248 362 1145
0207 403 4334
01547 530289
USA (i) 805 967 9478

TURBOCHARGERS

GARRETT AUTOMOTIVE
HOLSET ENG
INTERPRO ENGINEERING
QINETIQ
TURBO TECHNICS

01695 22391
01484 422244
01454 412777
01800 100942
01604 764005

WATER COOLERS

AH FABRICATIONS
DOCKING & CO
DENSO MARSTON
NIPPON DENSO

01432 354704
01327 857164
01274 582266
Japan (81) 56 625 5511
UK 0208 591 7700
01440 760960
0208 965 2151

WATER INJECTION

ERL

01273 581007

WATER PUMPS

DAVIES, CRAIG
ED P

3.3 Engine Electronics

COMPUTER SUPPLIERS

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

DATA-ACQUISITION

ACTIVE SENSORS	Tel 01202 480620
	Fax 0120 2480664
ADVANCED AUTOMOTIVE B&G RACING	01753 642019
BOSCH	USA (i) 602 274 2537
	01895 834466

COMPETITION DATA SYS	Germany (49) 711 8111
COMPUTECH SYSTEMS	USA (i) 312 865 5200
COMPUTERACE TIMING	USA (i) 716 631 2880
CORSA INSTRUMENTS	USA 800 876 8383
2D DEBUS	01905 796090
DATAPARES ACQUISITION	USA (i) 313 761 1545
DATRON TECHNOLOGY	Germany (49) 721 944850
DIGICON ENGINEERING	0208 463 9222
FORERONT	01908 261655
	Canada (i) 604 984 9337
	USA (i) 404 448 9550



INTERCOMP	USA Tel (i) 763 476 2531
	Fax (i) 763 476 2613
14465 23rd Avenue N, Minneapolis, MN 55447, USA	
ISACA 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 (i) 425 485 0620
MCLAREN ELECTRONICS	01483 261400
MM COMPETITION SYSTEMS	08707 444666
MOTEC	Australia (61) 3 9761 5050
MOTEC (EUROPE)	UK 08700 191001
MOTEC JAPAN	Japan (81) 489 46 734
MOTEC SYSTEMS USA	USA (i) 714 897 6804
MOTEC	USA (i) 804 973 1399
MOTOR SPORT ELEC	01327 31011
MOTORSPORTS INTERFACE	Tel 01932 351516
MTS Powertrain Tech	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 253091
PENNY & GILES	01202 409409
PERFORMANCE TRENDS	USA (i) 248 473 9230
PI RESEARCH	01954 253600
POLY LOGIC	01462 621066
QINETIQ	08700 100942
QUANTUM SUSPENSION	01243 885058
RACE DATA ENGINEERING	USA (i) 714 449 1445
SAKATA MOTORSPORT ELEC. INC.	(714) 446 9473
STACK	Tel 01865 240404
	Fax 01865 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
CONNAUGHT	USA (i) 312 865 5200
DATAPARES	01795 843862
SBD MOTORSPORT	0208 463 9229
MCLAREN ELECTRONICS	0208 391 0121
MM COMPETITION	01483 261400
	08707 444666



MOTEC PTY LTD	Aus Tel: 613 9761 5050
	Aus Fax: 613 9765 9091
	Japan -81 489 461 734
	121 Merringdale Drive
	Croydon South Victoria Australia
	UK: +44 8700 191001
	USA: +1 714 895 7001

PECTEL CONTROL SYSTEMS	+44 (0)1954 253610
PRECISION RACE SERVICES	USA (i) 248 844 1060
SAKATA MOTORSPORT ELEC. INC.	(714) 446 9473
STACK	01869 240404
SUPERCHIPS	01280 816781
TERRY SHEPHERD TUNING	01605 574454
WALBRO ENGINE MANAGEMENT	USA (i) 0989 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	
DATAPARES	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
MCLAREN ELECTRONICS	01483 261400
THE STRAIN GAUGING CO	01256 320666
VARIOHM	01327 351004

REV-LIMITERS

LUCAS ELECTRICAL	0121 536 5050
LUMINATION	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 7JN	



AP RACING	(0)24 7663 9595
	Fax (0) 24 7663 9559
Wheler Road, Coventry, CV3 4LB	
	0208 654 8835
FICHTEL & SACHS	01392 369090
GOODRIDGE	Tel 01480 451301
LOLA	Fax 01480 450722
QUARTER MASTER	USA (i) 847 540 8099
	Fax (i) 847 540 0526
510 Telser Road, Lake Zurich, IL 60047, USA	
SUPER CLUTCH	UK 01926 812136
RTRAC	Germany (49) 9275 5075



SACHS RACE ENGINEERING GmbH	Tel +49 9721-984300
	Fax +49 9721-984299
Email: service.sachs@sachs.de	
Website: www.sachs-race-engineering.de	
Ernst-Sachs-Strasse 62, 97424 Schweinfurt, Germany	
SACHS BOGE	UK 01788 822353
TILTON ENGINEERING	USA (i) 805 688 2353
	Fax (i) 805 688 2745
25 Easy Street, Buellton, CA 93427 USA	
WILWOOD ENGINEERING	USA (i) 805 388 4938
	USA (i) 805 388 1138
416 Calle San Pablo, Camarillo, CA 93012, USA	

COMPLETE TRANSMISSIONS



RICARDO MIDLANDS TECHNICAL CENTRE	Tel: 01926 319399
	Fax: 01926 319322
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 (i) 313 778 0540
JCM TRANSAXLES	USA (i) 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 (i) 303 695 6093
MARK BAILEY RACING	01380 850130
QUAIFE ENGINEERING	01732 741444
RICARDO	01273 455611
RICARDO MIDLANDS TECHNICAL CENTRE	01926 319399
TOM'S DIFFERENTIALS	USA (i) 310 634 8431
TRAN-X GEARS LTD	02476 659061
XTRAC LTD	01635 293800
ZEXEL-GLEASON	USA (i) 716 404 5000

DRIVESHAFTS

TORQLINE	Tel: +44 (0)1295 220130
Composite Driveline Products	Fax: +44 (0)1295 220138
CTG	Email: motorsport@ctg.co.uk
	www.ctg.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 (i) 310 643 0760
PANKL	0043 3862 33999
TEX RACING	USA (i) 910 428 9522
TRAN-X GEARS LTD	02476 659061

GEARS



BGM	oor 818 882 6422
	www.bmracing.com
	Chatsworth CA 9311 USA
COLLEDGE & MORLEY	02476 462328
COMPTech USA	USA (i) 916 933 1080
DAVID BROWN	01484 422180
GEARACE LIMITED	01869 277563
HEWLAND ENG	01628 827600
JCM TRANSAXLES	USA (i) 303 695 6093
KERSCHBAUMER	Ger (49) 6074 47 663
MARK BAILEY RACING	01380 850130
PANKL	0043 3862 33999
TEX RACING	USA (i) 910 428 9522
RICARDO MIDLANDS TECHNICAL CENTRE	01926 319399
TRAN-X GEARS LTD	02476 659061
XTRAC LTD	01635 293800

UNIVERSAL JOINTS

FLAMING RIVER	USA (i) 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 (i) 310 533 1924
GOODRIDGE INDY	USA (i) 317 244 1000
GOODRIDGE EAST	USA(i) 704 662 9095
INGERSOLL RAND	01204 606060
JLS MOTORSPORT	0121 525 7733
KRONTEC	Germany (49) 9401 703062
REGEN	01908 612662
ROTTOTEST	Sweden 46 8532 55890
THINK AUTOMOTIVE	0208 568 1172

AIR TOOLS

DESOUTTER AUTOMOTIVE	0208 205 4884
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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 606060
JLS MOTORSPORT	0121 525 7733

CNC MACHINING CENTRES

ABSOLUTE MACHINE TOOL	USA (i) 440 324 5133
BOSTON DIGITAL	USA (i) 508 473 4561
BRIDEPORT MACHINE	USA (i) 248 299 1750
DEREK ROBINSON	0116 266 2222
DEWCO	USA (i) 765 962 7201
MACHINERY SALES	USA (i) 510 490 4000
MAKINO	USA (i) 800 552 3288
MEDDINGS MACHINES	01752 893277
MILLS ENGINEERING	01603 745531
MILLSITE ENGINEERING	USA (i) 304 273 5353
RGS PERFORMANCE	USA (i) 716 434 2509
RMT MECHATRONICS	01505 650411
SERDI	01805 232215
SOUTHWESTERN IND	USA (i) 310 608 4422
SPA AEROFOLDS LTD	01827 260026
TGS	USA (i) 940 668 1002
TOYODA EUROPE	02476 547200

CRACK DETECTION

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

CRYOGENIC TEMPERING

FROZEN SOLID	01449 674914
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DUST EXTRACTION EQUIP

DENCER	01789 470198
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DYNAMOMETERS: CHASSIS

FROUDE CONSOLE	01905 856800
International Dynamometers LTD/Dynapack	
USA 001 559 292 3800 New Zealand 64 4587 0484	
LAND & SEA	USA (i) 603 329 5645
KISTLER Instruments Ltd	01420 544477
ROTTOTEST	Sweden (46) 8 322 55890
SUPERFLOW	USA (i) 800 471 7701
	Belgium 3215 216300
	01908 260000

UNICO (UK) LTD

DYNAMOMETERS: DAMPER

BEHRENS SPEED CENTER	USA (i) 914 651 7389
CZECH MATE	USA (i) 800 819 7223
DYNAMIC SUSPENSIONS	Can (i) 905 470 8778
	UK 01842 755744
ND TECH SHOCK DYNOS	USA (i) 520 624 3907
SCHMITT EUROPE	UK 02476 697192
SPA DESIGN	01827 260026
SPA TECHNIQUE	USA (i) 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 CONSOLE	01905 856800
LAND & SEA	USA (i) 603 329 5645
KISTLER Instruments Ltd	01420 544477
PERFORMANCE TRENDS	USA (i) 248 473 9230
QUADRANT SCIENTIFIC	USA (i) 303 666 8414
ROEHRIG ENGINEERING	USA (i) 336 431 1827
SUPERFLOW	USA (i) 800 471 7701
	Belgium 3215 216300
	Germany (49) 7252 84258

DYNAMOMETER INSTRUMENTATION

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

TAT

ENGINE BALANCING EQUIP

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

GENERATORS: PORTABLE

HANCO GENERATING USA (i) 800 413 6688
LINCOLN ELECTRIC USA (i) 216 481 8100

HORIZONTAL/VERTICAL MACHINING CENTRES

MAKINO USA (i) 800 552 3288
MILLS 01603 745531
MITSUBISHI-YAMAZEN 0208 549 9161
RGS PERFORMANCE USA (i) 716 434 2509
TOYODA 02476 542020

LATHES

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

RAPID PROTOTYPING

CRP TECHNOLOGY Italy (39) 059 821135
3D SYSTEMS UK 01442 826000

TOOL CABINETS

DURA 01295 712800



GWS Systems Oy

Tel: 01403 276445

Fax: 01403 276424

Email: sales@gwsystems.co.uk

Website: gwsystems.co.uk

Units 10-12 Horsham Court, City Business Centre, 6
Brighton Road, Horsham, West Sussex RH13 5BA

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

WELDING EQUIPMENT

AMILLER ELECTRIC MFG USA (i) 800 426 4553

4.2 Factory Software

CAD & CAM SOFTWARE

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

PARTS USE LIFING

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

PERF SIMULATION

D.A.T.S 01603 506526
PI RESEARCH 01954 253600
PERFORMANCE TRENDS USA (i) 248 473 9230
RICARDO USA (i) 734 397 6666
SERVOTEST 0208 707 1400
VEHICLE DYNAMICS PERFORMANCE USA (i) 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 (i) 310 533 1924
GOODRIDGE INDY USA (i) 317 244 1000
GOODRIDGE EAST USA (i) 704 662 9095
JLS MOTORSPORT 0121 525 7733
KRONTEC Germany (49) 9401 703062

Fax (49) 9401 70 24 76
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, WPA 7NX
01327 857822

TRIDENT CAMBER GAUGES

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

HARRISON AUTO USA (i) 602 254 0024
LONGACRE RACING USA (i) 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

01327 857822

CHASSIS STANDS

DEMON TWEETS 01978 664466
SMR COMPONENTS USA (i) 708 949 9100

COMPUTER HARDWARE

ADVANCED AUTOMOTIVE 01753 642019
CALEX INSTRUMENTATION 01525 373128
CRANFIELD 01234 753161
DYNOLAB USA (i) 206 243 8877
FASTER SYSTEMS USA (i) 415 332 6064
FUELTRONICS Australia (61) 0883632199
FUJITSU 0208 573 4444
GENESIS 01635 582255
KISTLER Switzerland (41) 52 224 111
NOVA USA (i) 615 832 6355
OLIVETTI 0208 785 6666
PERFORMANCE TRENDS USA (i) 248 473 9230
RACING CAR COMPUTERS 01279 812496
STACK 01869 240404

CORNER SCALES

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

DAMPER DYNAMOMETERS (PORTABLE)

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

EAR DEFENDERS

DEMON TWEETS 01978 664466
FASTENER FACTORY 01327 311018
RACING RADIOS USA (i) 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 (i) 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 (i) 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 (i) 414 656 5372
0161 969 0126
0208 310 6666

HAND TRUCKS

OMS RACING 01322 575956
SILVERSTONE RACE SERVICES 01327 858441

HEAD TORCHES

ESSEX RACING USA (i) 404 889 4096
HELLA 01295 272233

JACKS

ARGO MANUFACTURING USA (i) 630 377 1750
DEMON TWEETS 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 (i) 303 828 4546
REDLINE MOTORSPORT Tel 01606 737500
SLINGSBY 01274 721591
DEMON TWEETS 01978 664466
KS MOTORSPORT Germany (49) 2271 44905
MARDI GRAS MOTORSPORTS 01327 858 006
MECHANIX WEAR USA (i) 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 TWEETS 01978 664466
GRAND PRIX RACEWEAR 0208 897 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 TWEETS 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 (i) 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 TWEETS 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 TWEETS 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 (i) 914 889 4499
CYBER DYNAMICS 01869 347812
DEMON TWEETS 01978 664466
JLONACRE RACING USA (i) 206 885 3823
ME MOTORSPORT 01884 253070

REDLINE MOTORSPORT THE STRAIN GAUGING CO

Tel 01606 737500
01256 320666

SPACE HEATERS

FASTENER FACTORY 01327 311018

STOPWATCHES

CASIO 0208 450 931
DEMON TWEETS 01978 664466
GRAND PRIX RACEWEAR 020 8987 5500
KS MOTORSPORT Germany (49) 2271 44905
RACING RADIOS USA (i) 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 TWEETS 01978 664466
CLARENDON 01455 841200
DRC RACE CAR USA (i) 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 450 931
CONTINENTAL SPORT USA (i) 513 459 8888
ME MOTORSPORT 01884 253070
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 19100
MOTEC JAPAN Japan (81) 489 46 1734
MOTOR SYSTEMS USA USA (i) 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 (i) 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 (i) 914 889 4499
DEMON TWEETS 01978 664466
GMD COMPUTRACK Austra (61) 2 9644 1946
REDLINE MOTORSPORT Tel 01606 737500
THE STRAIN GAUGING CO 01256 320666

TYRE PRESSURE GAUGES

BERU Fi 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 01324 575956

TYRE WARMERS

BANDIT Australia (61) 3 9318 0644
DEMON TWEETS 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 763616
AWNING COMPANY 01204 363463
BARKERS 020 8653 1988
DEANS AWNINGS 01942 241399
MAYFLOWER 01494 712131
PIT BITS 01727 858297
TOP MARQUEES 01623 740777

MOTORHOME HIRE

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

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COMPETITION CAR CHASSIS COMPONENTS

6.1 Driver's Equipment

ANTI MIST FLUIDS

DEMON TWEAKS

Hugmore Lane, Llan-y-Pwll, Wrexham, Clwyd LL13 9YE, Wales
GRAND PRIX RACEWEAR
 Fax 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 TWEAKS

GRAND PRIX RACEWEAR

MECHANIXWEAR

REDLINE MOTORSPORT

01978 664466
 0208 987 5500
 USA (1) 805 257 9474
 Tel 01606 737500

COOL CAPS & SUITS

DEMON TWEAKS

GRAND PRIX RACEWEAR

REDLINE MOTORSPORT

01978 664466
 020 8987 5500
 Tel 01606 737500

DRIVING SUITS & ACCESSORIES

DEMON TWEAKS

GRAND PRIX RACEWEAR

REDLINE MOTORSPORT

01978 664466
 020 8987 5500
 Tel 01606 737500

HELMETS & ACCESSORIES



QINETIQ

Tel 44 (0) 8700 100942
 www.qineti.co.uk
 Cody Technology Park,
 Ively Road, Farnborough, Hampshire, GU14 0LX

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 (666) 729 5628
 APPLIED FIBREGLASS 01842 765339
 ASQUITH BROTHERS 01924 402001
 C&B Consultants Aerodynamics 01202 617 1707
 CNL GROUP 0151 647 5531
 COMPOSITE DESIGN USA (1) 727 539 0605
 CRANFIELD UNIVERSITY 01234 754152
 CROPPEDY BRIDGE GARAGE 01205 758444
 DEREK PALMER ENGINEERING 01555 893315
DON FOSTER France (33) 47 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) 78236888
 PODIUM DESIGN 07000 763486
 SPA COMPOSITES 01543 432904

COMPOSITES SPECIALISTS

Active engineering USA 001 714 637 1155
ACTIVA TECHNOLOGY 020 8974 1615
AOLUS TECHNOLOGY USA (1) 970 472 1288
 APPLIED FIBREGLASS 01842 765339
 ASTEC 01832 765451
 B&K RESINS 0208 464 7734
 C&B CONSULTANT AERODYNAMICS 01202 661707
 CARBON FIBRE TECHNOLOGY 01508 488527
 CARBONE INDUSTRIE France (33) 14 972 2305
 COMPOSITE AUTOMOTIVE TECH 01249 443438
 COMPOSITE DESIGN USA (1) 727 539 0605
 COMPOSITE WINGS 01953 885478



CRANFIELD UNIVERSITY

Tel 01234 754902
 Fax 01234 751671
 Cranfield, Bedfordshire, MK43 0AL
 www.motorsport.cranfield.ac.uk
 motorsport@cranfield.ac.uk

CROSBY GRP

CTG 01327 857042
 CTG 0101295 220130
 CTS 01480 459378
 DELTA COMPOSITES 01280 824498
 DEREK BENNETT 01565 777395
 ELAN COMPOSITES 01706 658 2853
 DU PONT UK 01438 734000
 Switzerland 012 717 5111
 USA (1) 302 774 1009
 0208 568 0293
 01243 544192
 01453 750491
 HITCO USA (1) 213 516 5707
 JANUS TECHNOLOGY 01753 869996

FIBREGLASS FABRICATIONS

G FORCE COMPOSITES 01243 544192
 HEYES ENGINEERING 01453 750491
 HITCO USA (1) 213 516 5707
 JANUS TECHNOLOGY 01753 869996



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 Email sales@komprex.com
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 Tyne & Wear NE58 0AH

LOTUS ENGINEERING

MICRO CRAFT 01953 608000
 MIRA USA (1) 909 947 1843
 NERO 0247 6355 9090
 PANKL 01254 202085
 PODIUM DESIGN Austria (4) 3862 512500
 PRONAL'S 07000 763486
 QINETIQ France (33) 20 99 75 10
 RICHARD HINTON RACING 08700 100942
 RMCS (CRANFIELD) 01279 771667
 SAMCO sport 01793 785359
 SECART 01443 238 464
 SCOTT BADER 01933 663100
 SPA COMPOSITES 01543 432904
 SQUARE ONE MOTORSPORT 01825 723425
 STRAND GLASSFIBRE 0208 568 7191
 TAG EQUIPMENT 01871 477790
 TECHLEK USA (1) 201 729 6253
 TECHNICAL RESIN BONDERS 01480 52381
 TONY THOMPSON RACING 01664 812454
 TURBO HEAT 01535 664993
 UNIVERSITY OF HERTFORDSHIRE 01707 284270
 VIN MALKIE RACING 01505 777395
 ZEUS M/SPORT ENG LTD 01604 878101

DESIGN AND ANALYSIS

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 Web enablingtechnologies.co.uk
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 Monks Brook, New Port, Isle of Wight PO30 5WB, England
 LOMA Tel 01480 453101
 Fax 01480 450722



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 Southam Rd, Radford Semele, Leamington Spa CV31 1FO

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
 BRISSE ALLOY FABRICATIONS 01322 222343
 BSS PARTS 01772 601602
 CHEVRON RACING 01565 777395
 CHIP GANASSI RACING 01243 544192
 CNL GROUP 01296 081058
 COLMET PRECISION 01202 871102
 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

FOX CRAFT 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
 MURKO 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
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 Fax: 01926 319352
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SNAPDRAGON MOTORSPORTS USA (1) 413 2560861
 SPA AEROFOLDS LTD 01827 260026
 SOUTH CERNEY ENGINEERING 01285 866025
 UNICLIP AUTOMOTIVE 01932 355277
 VAN DYNE ENGINEERING USA (1) 714 847 4417
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ADVANCED COMPOSITES 01773 763441
 AERODINE USA (1) 317 271 1207
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 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 0101295 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 9OF, UK
 ROSS COURTNEY 01384 291919
 STARTLINE UK LTD 01933 665752
 SECART ENGINEERING 001 203 798 6698

SPACEFRAME DESIGN

AOLUS 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 01595 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 455415
 DAVE CROSS MOTOR SERVICES 01246 477566
 SBD MOTORSPORT 0208 391 0121
 CLEM COMPETITION USA (1) 214 503 8044
 CONCEPT MOTORSPORTS 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 525256
 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 ENGINEERING 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 01525 703191
 MATRIX ENGINEERING USA (1) 888 249 0013
 MAXSYM ENGINE TECH 01608 685155
 MERLIN DEVELOPMENTS 01283 511814
 MILLINGTON 01746 789268
 MINERVA MOTORSPORT 01509 233970
 MINISTER RACING ENGINES 01634 682577
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 MOUNTUNE RACE ENGINES 01621 854029
 NEIL BROWN ENGINEERING 01775 723052
 PHIL JONES ENGINE DEV 01454 310936
 PHIL MARKS ENGINE DEV 01504 824869
 PRICE MOTORSPORT USA (1) 812 546 4220
 PRIMA RACING 015 9491903
 PRODRIVE 01295 273355
 QUICKSILVER RACE USA (1) 301698 90099
 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
 ROADSPED 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 01695 574454
 TERRY SHEPHERD TUNING Tel 0208 568 1172
 THINK AUTOMOTIVE Fax 0208 847 5338
 Email matt@thinkauto.co.uk

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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 878101

The Racing Stables, Blisworth Hill Farm,
 Stoke Road, Blisworth, Northants NN17 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



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 Fax 01628 829706
 Waltham Road, Maldenhead, Berks, SL16 3LR
 JACK KNIGHT 01483 764326
 JP RACE CENTRE 01327 858151
 KRENSPEED 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 741444
 Fax 01732 741555
 Email info@quaife.co.uk
 www.quaife.co.uk

Vestry Road, Sevenoaks, Kent, TN14 5EL

ROADSPED PERFORMANCE 01453 750864

TONY THOMPSON RACING 01664 812454d

ZF Germany (49) 7541 77 2543

UK 015 9869211



8.3 Suspension Services

SETUP SPECIALISTS

ACTIVE ENGINEERING USA (i) 714 637 1155
ANDREASON RACING 01300 348490
ATHON MOTORSPO 0114 2490 272
AZTEK 01509 201299
BEAUFORT RESTORATION 01795 830288
DAVID POTTER CONSULTING 0033(0)494 330090
BRADY FABRICATIONS 01869 252750
CRANFIELD UNIVERSITY 01234 754152
DON FOSTER France (33) 470 580308
EARS MOTORSPO 01625 433773
GEOSCAN (G.I.L. Design) 01225 790568
LOLA Tel 01480 451301
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INTERPRO ENGINEERING 01454 412777
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MARK ORTIZ USA (i) 704 933 8876
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Fax 01933 676519
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FSUSPENSION TECHNOLOGY 01327 858558



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Website: www.shockbox.co.uk
Email: gbj@compuserve.com
67 Blackthorn Road, Attleborough, Norfolk, NR17 1YJ UK
THE STRAIN GAUGING CO 01256 330066
UNIVERSITY OF HERTFORDSHIRE 01707 284270

ENGINEERING SERVICES

RACING INDUSTRY TECHNICAL SERVICES
USA (i) 248 645 1724

8.4 Metal Services

BEAD & SAND BLASTING

BLAST-IT-ALL USA (i) 800 353 2612
CAMCOAT PERFORMANCE COATINGS 01925 445003
COMPAIR AUTOPAPER 01494 465000
HANKOE MOTORSPO 01753 522779
MACDONALD RACE ENG 0208 889 1633
SWAYMAR CASTING 01932 868377
AEROMET 01795 415000
CG DESIGN 017 985 9964
GRIFFITHS ENGINEERING 01582 600629
HILLGARD Sweden (46) 300 60590
JENVEY DYNAMICS 01746 768810
KENT AEROSPACE CASTINGS 01795 476333
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QDF COMPONENTS 01332 760260
QUARTMASTER USA (i) 847 540 8909
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www.QinetiQ.com

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Hampshire, GU14 0LX
ZEUS ALUMINIUM 01384 482222

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CAMCOAT PERFORMANCE COATINGS 01925 445003
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CTG Tel: +44 (0)1295 220130 Fax: +44 (0)1295 220138
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www.ctgtd.co.uk
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KENT MOTORSPO CASTINGS 01795 662288
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Tel: 0870 190 8480 Fax: 0870 190 8488
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528.10 Unit 2 Harwell business Centre,
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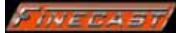
FINISHING

ALUMINIUM SPECIAL 01384 291900
APPERLEY HONING 01242 525868
ARMORALL PRODUCTS 01799 513130
CML GROUP 0151 647 5531
GRIFFITHS ENGINEERING 01582 600629
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QINETIQ 08700 100942

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BA HARRISON 0116 2769351
GM DESIGN 017 985 9964



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QUALCAST 01332 760260
UK RACING CASTINGS 01227 750877

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AUTOSPRINT 01675 464857
AVONBAR 01932 840058
BEAUFORT RESTORATION 01795 830288
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QUANTUM HEAT TREATMENT 01908 642242
TEVCAC 01954 237000
ZEUS MOTORSPO 01604 878101

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APPERLEY HONING 01242 525868
ATHENA MANUFACTURING LP USA (i) 512 928 2693
AVONBAR 01932 840058
AZTEK 01509 261299
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COLEMAN MACHINE USA (i) 906 863 8945
DATUM ENGINEERING 0246 378032
FORMULA FABRICATIONS 01953 605490
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Pommernstrabe 33, 93073 Neutraubling, Germany
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LINGENFELTER USA (i) 219 724 2552
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TREVOR MORRIS ENGINES 015474 286
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Cranfield, Bedfordshire, MK43 0AL
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Austria (43) 3 8625 12500

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AIRCOT METALS LTD 01818 973 0509
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APPERLEY HONING 01242 525868
BRADY FABRICATIONS 01869 252750
BRITISH ALCAN ALUMINIUM 01753 887373
AVESTOPOLAR LTD 0114 244331
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CROMPTON TECH GROUP 01295 220130
MASON ENG USA (i) 805 527 6624
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RGB STAINLESS 0121 558 3111
SPA AEROFOLLS LTD 01827 260026



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CML GROUP 0151 647 5531

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DATUM ENGINEERING 02476 383032
DONCASTERS LTD 01332 864900
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SPA AEROFOLLS LTD 01827 260026



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Fax: 0121 784 6054
Email: rnhoskison@titled.co.uk
Keys House, Granby Avenue, Garretts Green,
Birmingham B33 0SP

TUBE FORMING

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

8.5 Race Preparation

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AMT MOTORSPO 01444 483477
ANEX SYSTEMS 01869 345038
AUTOMECH 0161 775 1851
AVONBAR 01932 840058
BARWELL MOTORSPO 0208 397 4411
BR MOTORSPO 01926 451545
BRK MOTORSPO 0127 858055
CHRIS LEWIS MOTORSPO 01677 422623
DEREK BENNET ENG 01565 777395
POM MOTORSPO 01555 893315
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HAWKINS RACING 0208 579 1438
INTERPRO ENGINEERING 01454 412777
JACK CRONE RACING USA (i) 909 371 6090
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MACDONALD RACE ENG 020 8889 1633
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MELTUNE PX MOTORSPO 01923 242536
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01403 891553
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QINETIQ 08700 100942
RACECRAFT INTERNATIONAL 01789 297000
RACE TEC DESIGN & ENGINEERING 01386 871292
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SANTIZER Germany (49) 8654 2034
SHENPAR PRODUCTS 01322 863901
STARTLINE UK LTD 01933 665752
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TECH-CRAFT MOTORSPO 01926 496075
TOLLBAR RACING 01433 631698
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VIN MALKIE 01565 777395
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9.1 Chassis Testing

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THE STRAIN GAUGING CO 01256 320666
TORQUE FAST CALIBRATION 01787 744212
UNIVERSITY OF HERTFORDSHIRE 01707 284270

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CRANFIELD IMPACT CENTRE 01234 751361
KISTLER INSTRUMENTS LTD 01420 544477
MIRA LTD 0247 635 5000
QINETIQ 08700 100942
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THE STRAIN GAUGING CO 01256 320666

MEASUREMENT EQUIPMENT

AUTOSPRINT 01675 464857
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BERU Fi 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 (i) 425 485 0620
LOTUS ENGINEERING 01953 608000
MICROLEASE 0208 427 8822
MIRA LTD 0247 635 5000
MOTORSPOITS INTERFACE 01788 890412
QINETIQ 08700 100942
ROEHRIG ENGINEERING Tel USA (i) 336 431 1827
ROTO TEST AB Sweden (46) 85 325 5890
THE STRAIN GAUGING CO 01256 320666

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AUTOMECH 0161 775 1851
AUTOPINT 01842 766226
AUTOSPRINT 01675 464857
BD ENGINEERING 01795 843980
PIT STOP 01993 850654
BEJ MOTOR ENGINEERS 0161 748 8663
BOSCH 01895 834466
BBR GTI LTD 01280 702389
BIRNO HANSON Denmark (45) 65 99 1616
CARBURRETOR 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 CONSOLE 01905 856800
INTERPRO ENGINEERING 01454 412777
JANSPEED MOTORSPO 01722 321833
MACHTECH 01923 269788
MATRIX ENGINEERING USA (i) 888 249 0013
MIRA LTD 0247 635 5000
MOTORSCOPE 01609 780155
OHIO STATE UNIVERSITY USA (i) 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 32111
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TIM STILES RACING 01278 453036
TIPTON GARAGE 01404 812091

STRESS ANALYSIS

COSINE TECHNOLOGY 01706 378851
LOLA Tel 01480 451301
Fax 01480 456722

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www.candbconsultants.com
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email candbaero_indy@email.nsn.com
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CRANFIELD UNIVERSITY 01234 754152
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IMPERIAL COLLEGE LONDON 0207 589 5111
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MARCH 01280 704160
MICRO CRAFT USA (i) 909 947 1843
MIRA LTD 0247 635 5000
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RMCS (CRANFIELD) 01793 785159
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UNIVERSITY OF MARYLAND USA(i) 301 405 6861
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CAPITAL PATTERNS 0208 777 9276
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MARTIN FLEWICK 01603 712611
MIRA LTD USA (i) 909 947 1843
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



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01372 360000
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01273 794444
USA (i) 734 397 6666
0 8700 100942
01273 45561
0154 74289

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DEPAC DYNO
DYNAMIC TEST
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USA (i) 315 339 1265
USA (i) 800 243 3966
USA (i) 603 329 5645
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01905 856800
01953 608000
01923 269788
(49)263680394
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BERTHUS ENGINES
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BOB WIRTH RACING
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01403 784022
01539 732500
0121 777 2083
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0207 703 2225
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0161 748 8663
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0121 458392
01296 435389
0208 568 0293
01795 843802
01246 477566
01327 857729
01695 574454
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01449 677726
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0207 738 8331
01306 71275
01708 857108
01977 516622
01274 759564
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01905 856800
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01474 534779
01480 861599
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01327 300422
01621 856056
01642 818188
01202 556566
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0208 951 4923
01732 463958
01473 623000
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01270 665405
01908 278600
01454 412777
Belgium (32) 473 96932
01923 816277
01722 321833
01903 891776
01491 680719
01903 773022
Germany (49) 221 17 1025
01933 441661
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01372 377474
01953 608000
01424 851277
0208 889 1633
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01634 682577
01621 854029
01775 723052
01249 815929
01865 248100
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01454 310 936
01564 842869
01233 7327377
USA (i) 812 546 4220
015 9491903
USA (i) 616 847 5000
01295 273355
01732 741144
USA (i) 301 698 9009
01509 412317
USA (i) 714 779 8677
USA (i) 734 397 6666
01273 794444
01524 844666
Sweden (46) 8 532 55890
Canada (i) 416 759 9309
0208 305 2250
USA (i) 248 689 9000
01285 860295
01375 378606
USA (i) 2609 267 5081
0159 5867311
01793 533121
0154 74289
USA (i) 714 847 4417
01825 764833
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01908 278600
USA (i) 219 724 2552
01953 608000
01608 685155
CANADA (i) 450 647 1890
01204 71636
USA (i) 760 630 0450
01242 245640
USA (i) 734 397 6666
01273 794444
0154 74289
01784 439771

FUEL ANALYSIS

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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 $H_2O C_p$ (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

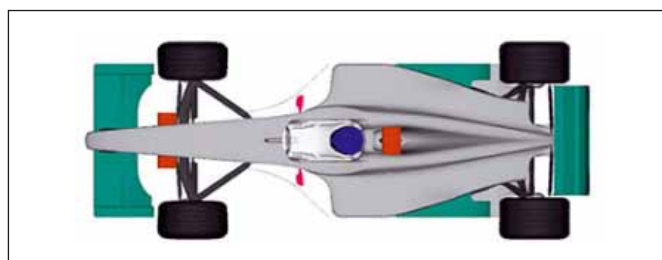


Figure 1: plan view of the BAR model and its bargeboards

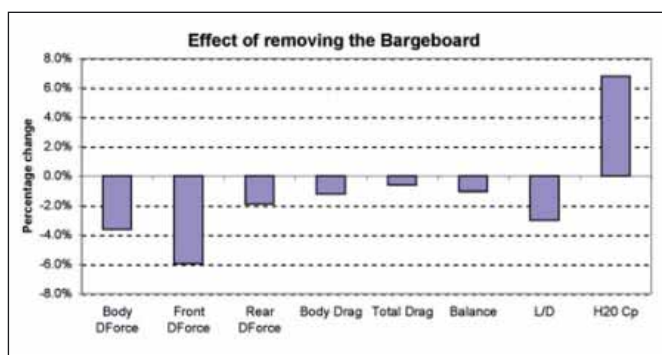


Figure 2: percentage changes to overall aerodynamic forces

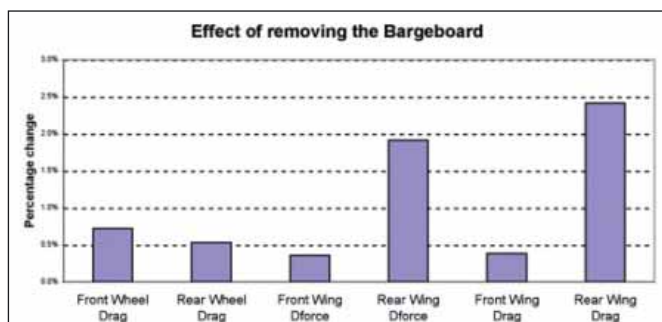


Figure 3: percentage changes to aerodynamic forces on wheels and wings

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 →

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

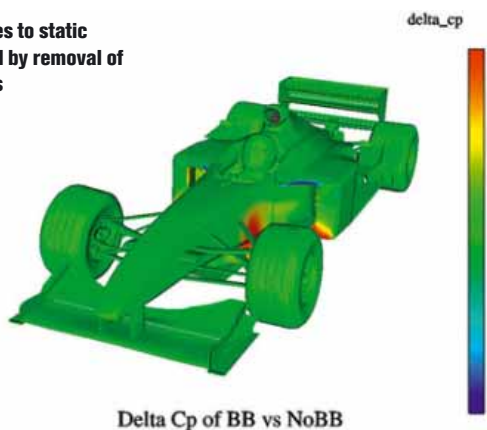


Figure 5: changes to underbody static pressures following removal of the bargeboards

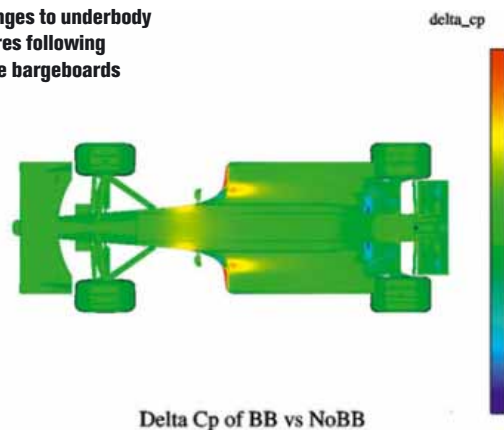


Figure 6: vortices set up by the bargeboard

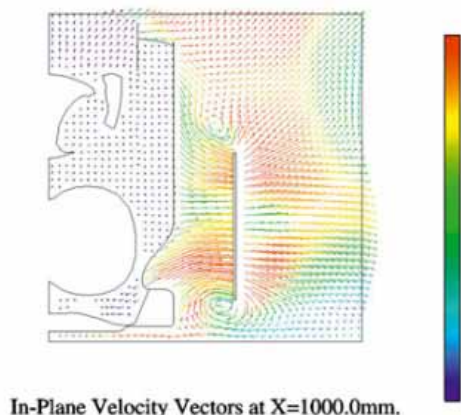
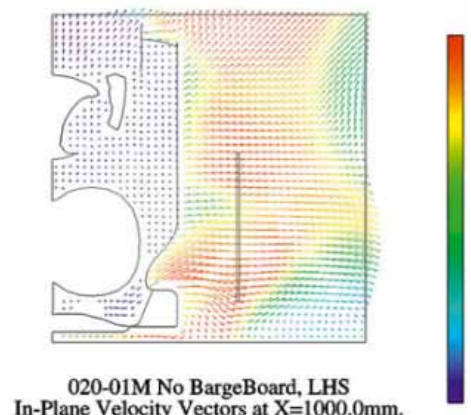


Figure 7: no bargeboard, no vortices



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.

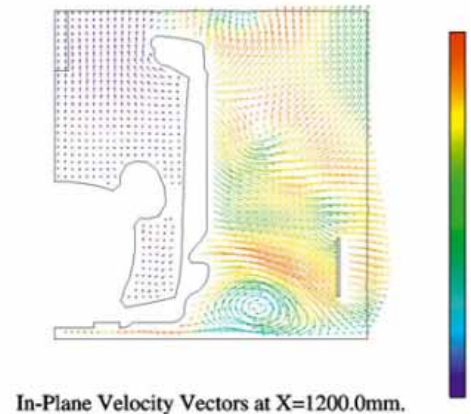
The wheel drag also increased in the absence of the bargeboards, equating to drag decreases with bargeboards, and since wheel drag is a significant proportion of overall drag these apparently small changes should not be overlooked. This comment could also be applied to the rear wing, also a major contributor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

Figure 8: vortex further downstream



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.

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.

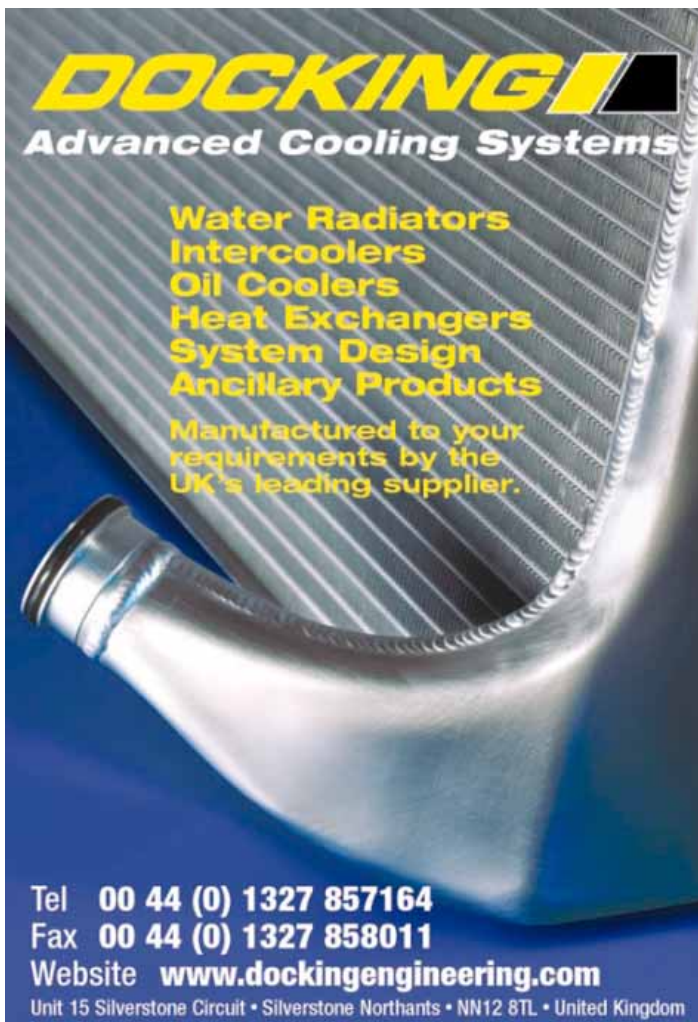
So that's what these bargeboards really did. Clearly cars with different shape bargeboards in alternative locations will be exploiting the airflow in slightly different ways, but similar mechanisms will be at work. RE

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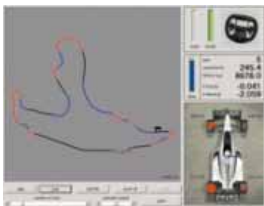
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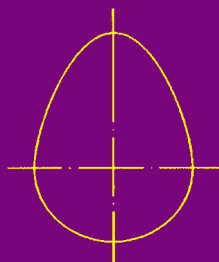
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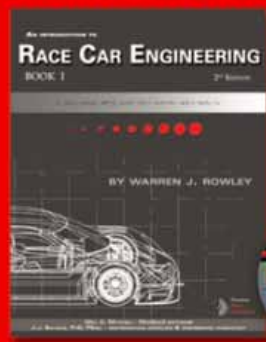
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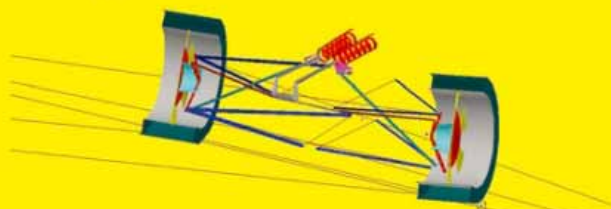
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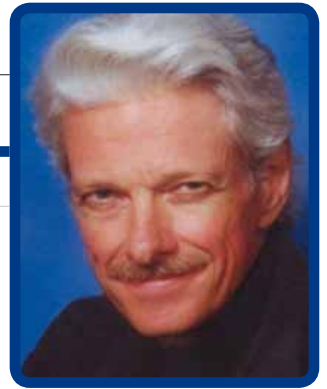


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Formula Vees, with their VW Beetle front suspension, exhibit the more uncommon situation of longitudinal and lateral anti increasing with suspension compression



Photos: Jeff Blumham

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.

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.



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

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. RLE

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