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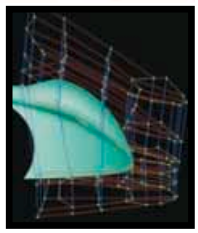

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Contents

Features

Cover story

Raceworld

Raceshop

Subscriptions

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

Write Line

Anyone working in motorsport knows, speed is the essence of the sport. Success is typically measured by the stop watch and, even when it isn't – trialing or drifting for example – then speed of reactions and response from the vehicle are vital. But the ethos of speed extends beyond the public theatre of competition. Formula 1 in the current era is a race of development led by the outfit that can progress faster than the competition. Anyone who stands still, even for a moment, will be found slipping helplessly down the grid order. The race is on to develop faster wind tunnel programmes and faster computational processes that can iterate down to that theoretically ideal machine more quicker than the rivals. Manufacturing is always under pressure too, to turn developments into parts as quickly as possible and maximise their competitive advantage. Lead times become compressed with contracts being awarded on the basis of fast turnaround.

It all amounts to a culture that those within the industry take for granted. So it comes as no surprise that they find the pace of life outside motorsport frustratingly slow. Our own Paul Van Valkenburgh is currently pursuing an interest in psychology and, enthused about his ideas, is finding the pace of the academic establishment in responding unbelievably slow after a life spent in motorsport. Likewise, the Motorsport Industry Association appointed a well known British motorsport figure, John Kirkpatrick, to work with the government on distributing funds assigned to help develop motorsport. A year down the line he looks back at a rate of progress that is, by his standards, geological.

> **"COMMERCIALLY, FEW TEAMS CAN SEE BEYOND THE NEXT 12 MONTHS"**

The leisurely pace of the outside world is widely condemned by the motorsport community but its own fast pace also has its hazards. Commercially, few teams can see beyond the next 12 months. After all, their market value depends greatly on how they perform in the coming season, so making plans two or three years into the future is virtually impossible. Inevitably this generates a short term culture where everything is secondary to results on the track now. It has proved to work for the teams themselves, but it causes real problems when they become involved in regulating a championship. Inevitably a competitive advantage now is a greater prize than the long-term survival of the championship. So often we see one team managing to exert enough pressure on the organisers to manoeuvre a dominant position by allowing in a car or technology that stretches the spirit of the rules. As they proceed to monopolise the silverware, the other teams and the crowds drift away, inflicting terminal damage on the series. This, in turn, damages the industry as championships wax and wane too quickly for development and tooling costs to be recovered in time to yield worthwhile profits.

Long-term prosperity for the sport and the industry comes from stability and that can only be engineered by those with a long-term view – by which I mean a decade or more. Even the most successful and best funded teams struggle to manage that order of objectivity. To involve them in planning for the future is, as the FIA is finding, hazardous at best.

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Charles Armstrong-Wilson

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Racecar engineering

Pit Crew

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Edited by Sally McDonald

Seamless-shift gearboxes given go-ahead by FIA

The FIA has signed off three so-called 'seamless shift' gearboxes for F 1 teams to run during the 2005 season despite initially planning to ban them.

An FIA rule clarification threatened to outlaw the technology considering them too close to continuously variable transmissions, a technology specifically excluded from Formula 1.

Both BAR-Honda and BMW-Williams are expected to race 'seamless shift' gearboxes in 2005, and the teams have both had experience with this technology in the past – Honda experimented with the Weismann system during its partnership with McLaren, while Williams worked with a Weismann-based gearbox in 1993 [see Racecar Engineering V14 N6].

Formula 1 rules require a maximum of seven distinct ratios and the FIA argues that unless there is a clear break in drive between ratios, then it does not conform. The situation may have come under review if the teams are using controlled clutch slip to cushion the shock of changing from one ratio to another, thereby producing a partial CVT effect.

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Only BAR-Honda's 'seamless shift' gearbox is ready to go from the outset, but both Williams and McLaren are working on similar systems

Although the Williams system is not scheduled to appear for some time, BAR-Honda intends to race it from the beginning of the season. 'In our system there is a definite break in power so it does not breach the FIA regulations,' said Otmar Szafnauer, vice president of Honda Racing Development. 'The system is a lot quicker than before but it is not a CVT.'

McLaren too is said to be working on a system that it may race in 2005.

GTs have no problems on 'clean' fuel

Anglo American Oil, the European distributor of Sunoco oil has recently 'come clean' over the fact that it was supplying fuel with 11 per cent bio-ethanol for the British Formula 3 and GT championships and to the Seat Cupra series during 2004. This additive uses renewable sugar beet and no problems at all were experienced during the year. As a result the company will continue to supply the 'green' fuel for the domestic F3 and GT series, as well as a Ginetta championship.

Managing director Anders Hildebrand points out that this move was a direct result of his attending the MIA Clean Racing conference, held in Birmingham, UK, during early 2004. Given the possibility that teams might blame the fuel for any engine problems they might encounter, Anglo American Oil thought it prudent not to announce the bio-ethanol content until a trouble free season had passed.

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The British GT series unknowingly saw its cars fuelled partly by sugar beet during 2004, with no ill effects whatsoever

All teams in the championship have now been made aware of the situation.

Ian Wagstaff

New Turkish GP circuit nears completion

The brand new circuit near Istanbul that will stage the Turkish Grand Prix on 21 August is rapidly taking shape. The racing surface has already been laid and the construction of service roads, tyre barriers, grandstands, and the pit and garage complex is nearing completion. The 5.28km track was designed by Hermann Tilke, who was responsible for Sepang, Bahrain and Shanghai, as well as the new Hockenheim circuit.

The anti-clockwise layout will test drivers' neck muscles and will feature some gradient changes. The 0.64km start/finish straight ends in a sharp left-hander, which feeds into a long sweeping right-hand curve that Formula 1 cars should be able to take flat out. A tight left-right-left complex, followed by a fast stretch to a right-hand hairpin is also included.

The main grandstand will seat 30,000 people, while the overall capacity is close to 150,000. The circuit is located on the Asian side of Istanbul, close to a newly constructed international airport and just off the TEM motorway linking Istanbul to Ankara. It is also situated within a green belt area amid forest and cultivated green fields.

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The testing new circuit will seat 150,000 and have an impressive pit and garage complex

Nasamax to update in 2006

Team Nasamax is to design and develop a new LMP1 car this year to replace its current, bio-ethanol fuelled hybrid for 2006. Work will be carried out in conjunction with Kieron Salter of KW Motorsport, who was responsible for converting the team's Reynard 01Q into the current Nasamax DM139. The team will also continue to develop the latter throughout the year, entering it for Le Mans and for races in the Le Mans Endurance Series.

The new car will again be powered by a Judd V10. Nasamax moved from Cosworth to Judd for the 2004 season and says it is 'very happy' with the working relationship that it has with the latter. It is expected that use will again be made of bio-ethanol fuel, the team pointing out that this is still 'the most available fuel that can provide the necessary performance.'

The Nasamax publicity machine also continues to forge ahead, the team now entering its third season as a flag carrier for the Energy Efficient Motor Sport initiative. Recent television appearances include a six minute feature on BBC Working Lunch and a slot on Meridian TV news, both prompted by its recent MIA Technology and Innovation Award. *Ian Wagstaff*

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Team Nasamax will design and develop a new bio-ethanol fuelled LMP1 car for 2006

One tyre and short meets proposed for F1 in 2008

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Tyre warmers could be banned from 2008 as part of the FIA's cost cutting exercise

Formula 1 could revert to a single tyre manufacturer as early as next year in a further attempt to cut costs and make the sport more accessible. The implementation of one manufacturer would also make it easier to keep cornering speeds under control, as the company could be asked to supply a harder, less grippy tyre to all teams.

The latest list of cost-cutting measures ready to be proposed by the sport's governing body for 2006 also includes the shortening of race weekends to two days. Spare cars may also be banned, and a limitation on the range of materials available for use in chassis construction imposed. Mandatory standard and long-life components – including a further extension in minimum engine life – as well as rev limiters could be introduced and there could be a ban on tyre warmers and telemetry. In addition to the technical changes, the governing body is also thought to be proposing a personnel restriction at race meetings, and salary caps on driver line-ups. These proposed changes would come into effect in 2008.

Unsafe alterations

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WRC driver Sebastien Loeb struggles to get comfortable with his HANS device and helmet during the Monte Carlo Rally

As highlighted in last month's Racecar Engineering there has been uncertainty voiced over the new HANS device introduced for rally driver. This continued after drivers taking part in the 2005 Monte-Carlo Rally – the first World Championship event in which the HANS device was mandatory – complained of devices working loose, becoming displaced and causing discomfort.

The device is secured most efficiently when harness shoulder straps are at 15 degrees from the horizontal – an angle defined by the position of the strap holes in the seat back – and the height of the driver or co-driver's trunk. A HANS expert explained that some teams were not adjusting belts accordingly and that some seats may not be suited to the device.

It was found that competitors were attempting to provide themselves with more head movement by lengthening the straps which tether the helmet to the HANS. This sometimes resulted in the securing straps being effectively shortened during use.

Teams still believe modifications and more testing is required, especially as the devices were not designed specifically for rallying. Re-designed rally seats are a preference of Hubert Gramling, the FIA consultant largely instrumental in the introduction of the collar to rallying, who attended the second 2005 WRC round to investigate these fitting difficulties.

Peugeot power is provocative to Ford

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The engine of the Ford Focus WRC may have help from Pipo Moteurs to power it in 2006

Christian Loriaux, chief engineer for the Ford Focus World Rally Car is to devote his time in 2005 to the design and development of the 2006 car. Next year's challenger will be based on the current Ford Focus WRC which is powered by a turbocharged version of the Zetec four-cylinder, 16-valve unit.

Over the past few years this has been extensively modified by Cosworth but this year sees Malcolm Wilson's M-Sport operation, which already designs, develops and runs the Ford WRC, taking responsibility for the engines. In addition, it is speculated that M-Sport might engage engine specialist Pipo Moteurs to develop the i4 engine for the 2006 season.

The French-based company has previously worked with Peugeot Sports' World Rally Car, the engines of which have proved very powerful over the last few years, but could move over to work with Ford after Peugeot's decision to withdraw from the championship at the end of the year.

However, it has been Malcolm Wilson's ambition for some time to build World Rally Cars in their entirety, including the engines, at M-Sport's Cumbria-based premises, and Ford itself has played down the Pipo Moteurs rumour.

Cages rattled for 2006 WRCs

Further complications to the design of the 2006 WRC cars have arisen as a result of new regulations. The proposed technical regulations required initially that rollcage tube wall thicknesses be a minimum of 1.6mm in the area of the main, occupant enclosing cage while other tubes should be no thinner than 1.2mm. Works teams agreed on this measure in response to the massive g-forces generated in particular to accidents which befell Markko Märtin's Focus and Petter Solberg's Impreza last year, and Ford and Subaru had hoped to finalise their 2006 rollcage designs early in 2005 and get on with developing the rest of the new cars.

However, the FIA World Council subsequently made the decision to make a further proposal that the wall thickness of all WRC rollcage tubes for 2006 should be a minimum of 1.6mm thick. It is estimated that this measure alone will add 20kg to the overall weight of a 2006 World Rally Car, which must also use passive front and rear differentials, as opposed to the active variety allowed this year.

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The Subaru Impreza will have to be altered further for the 2006 WRC as a result of major accidents which took place in 2004

Engineers believe that this later rollcage ruling would make a 2005 – or even a 2004 – World Rally Car more competitive in 2006 than a car built to the rules for next year, and are pushing for a hasty change to the originally proposed rollcage thickness dimensions.

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IAN WAGSTAFF

Jonathan Neale, managing director of McLaren Racing, had just started his lunch when I interrupted with what has become a 'beef' of mine. Why can't motorsport component suppliers trumpet their illustrious customers? Is it technical confidentiality or F1 paranoia? The industry contains some fine companies that would benefit if they could herald their clientele, thus gaining credibility, and extra business, not just in the motorsport world but elsewhere.

I do not wish to single out McLaren, it was just that Neale was fair game at the time and I had recently visited a number of component manufacturers all of whom had told me 'off the record' who their customers were.

Neale did point out that he was happy for suppliers to boast in the pub that they made components for McLaren, but would rather they did not go into print. There were those, he pointed out, who paid good money to be known associates of McLaren and they might not be too amused if every widget supplier rode off the back of its involvement. Alex Burns, Williams' general manager, has since made the same point to me.

I contend that the F1 world should be sufficiently proud of its suppliers that it allow them to publicise their involvement. There is precedence. Years ago, conventional vehicle manufacturers liked to pretend that they made the whole car. There was a story, perhaps apocryphal but told by a Ford purchasing director, that one castings manufacturer insisted that its own brand be on every casting supplied. Ford would then grind off the name once it had arrived at the plant. If you asked a component manufacturer who it supplied to, it would usually say that it dare not tell you for fear of losing the contract. All that changed as the manufacturers realised they could benefit from listing the prestigious component manufacturers they were using.

Technical confidentiality is not an issue. Nobody is asking that such secrets should be given away. That the road car industry has become 'cool' with this is illustrated by the way the major tier one suppliers operate.

I realise that motorsport is about competitive edges, however, many of the suppliers are used by more than one F1 team. Village gossip will usually tell you who does what. I contend that they should be able to broadcast this to the wider world and benefit from reflected charisma.

Formula Ford entry fee package trimmed

The UK Formula Ford Championship is set to support the British Formula 3 series again this year, and is hoping that a recently-revealed cost reduction will attract a larger field than of late.

The Ford-backed championship will share all six of the F3 series' confirmed UK dates, while non-supporting events will take the campaign to 20 rounds in all, spread over a total of 10 double-header meetings.

Series co-ordinator Barbara Armstrong said she was delighted that UK Formula Ford will be alongside F3 at all six of its British dates, adding that it was important as F3 team managers keep a much closer eye on Formula Ford than they do on other formulae, something which prospective competitors have said is important.

Armstrong's team has announced too that entry fees will be trimmed significantly for 2005 to attract new drivers into Formula Ford. The championship registration and race entry fee package is now under £5000 for the year which is real value for money when compared with other junior single-seater series. The 2005 fees also include a reduced price one-off entry fee for guest drivers seeking to contest occasional rounds as respite from other series.

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The UK Formula Ford Championship will once again support the British Formula 3 series this season, sharing all six of the series' confirmed dates, and with a total of 20 rounds

New junior team announced in Jordan-Midland package

The Midland-owned Jordan team will also run a junior outfit in the Formula 3 Euroseries, following the Kolles squad's re-branding.

Following Alex Shnaider's takeover of the team in January, F3 team boss Colin Kolles was appointed as Jordan managing director. This move gave Alex Zoechling control of the F3 team which has in turn led to the creation of the category's first junior team since Jaguar Racing ran its British championship squad in 2001.

Kolles has also merged its TME satellite F3 squad into the main team and could run three Dallaras this season. Last year Kolles ran Mercedes engines, but Jordan's deal with Toyota in Formula 1 may see the team going to the Japanese manufacturer for its F3 engines as well.

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All new – the Jordan-Midland Formula 3 junior team, now under the leadership of Alex Zoechling and ready to contest the 2005 series

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Champ Car rule changes aim for increased activity

The Champ Car World Series is set for a number of rule changes in the 2005 season. Organisers of the series believe that the changes will boost the competitive environment of the series and give teams more leeway to make their own racing decisions, rather than being restricted by official directives.

Pit intervals and mandatory pit stops have now been abolished so that teams will be able to pit when they choose and will not necessarily have to change a full set of tyres when they do. The rules around full-course caution periods have also changed – the pits will now be automatically closed during full-course yellow flag conditions, with the pace car slowing the field down as soon as possible after the caution flag has been waved.

Other rule changes are designed to increase activity across the race weekend to encourage more on-track action. Teams are likely to spend more of their morning hour on track working on their racecars as the Friday and Saturday morning practice sessions are to be shorter, while the wet track rules have been abolished – teams formerly had unlimited qualifying laps on a wet track, now they will have only 15 laps at their disposal. The pit selection order is to be set by the previous event's results, instead of by qualifying order.

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Mandatory pit stop regulations in Champ Car have been dramatically changed, giving the teams more flexibility and choice with their tyres

French-based Zulltec to join LMP2 runners

The growing ranks of LMP2 contenders could increase further by the end of the season with a new car from French newcomer, Zulltec. This industrial operation, based 45km east of Paris, formed a company two years ago to develop a car for Le Mans. The construction of the car's carbon chassis has now been completed and the team has recently announced its plans.

While Zulltec itself is only a five-man operation, it has developed the car with the assistance of outside contractors including ACE (Aero Concept Engineering), the Magny Cours-based wind tunnel run by former Prost Grand Prix aerodynamic engineers. ACE carried out all the CAD design of the car using CATIA software, as well as the CFD work.

Rivoyre Ingéniere, a company based in the south of France, was responsible for the design of the chassis' carbon structure.

The manufacturing of the masters and car body moulds was in process at the time of writing with chassis crash testing scheduled for March.

Project leader Yves Cazard states that the car should be finished in June, ready for testing in July and August. After that it is expected to appear as a works entry at the two final LMES rounds of the year, Monza and Istanbul.

Further evidence of the current healthy state of endurance racing in Europe is newcomer Zulltec, already close to completion of a new LMP2 car and with plans to build an LMP1 variant also

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Cazard also points out that the car is being offered in two packages, one being a complete car with a MCT 3.4-litre V8 engine and Ricardo six-speed gearbox, being offered for sale at 480,000 Euros. No other engine options are being offered as he believes that a complete unit is the secret to success. However, he states that it will be possible for another manufacturer – he cites Pescarolo as an example – to take the chassis design as its own and to develop it accordingly. It is thought this is the most likely way that the car will be able to compete at Le Mans next year. Zulltec is also interested in building an LMP1 version of the car, again to be powered by an MCT engine.

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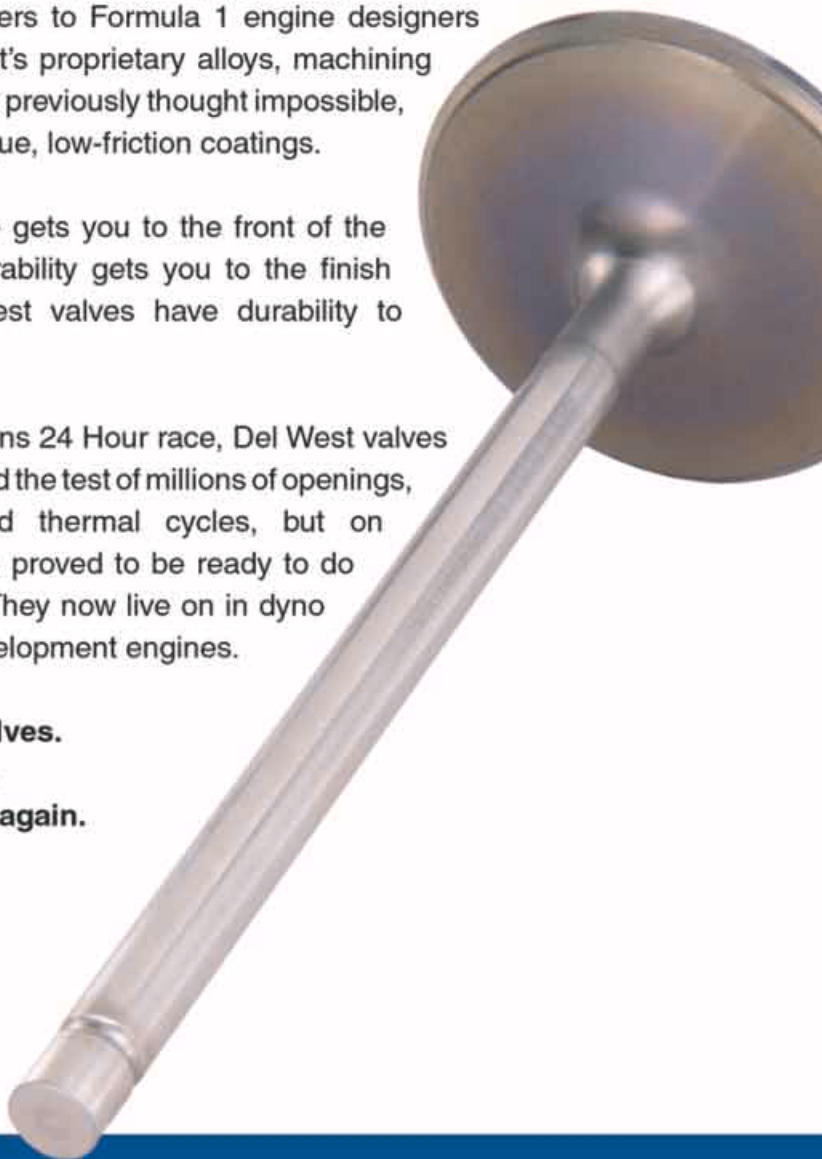

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Porsche invites GruppeM as factory support team for GT Championship

For the first time since 1971 Porsche Motorsport has selected a British outfit as its partner in the FIA GT Championship. GruppeM Racing, who last year won both the team and drivers awards at the British GT Championship, will race two factory supported Porsche GT3 RSR cars in the 2005 FIA GT Championship beginning at Monza on 18 April.

The deal will allow GruppeM access to Porsche's GT know how, as well as its Michelin tyres. Kenny Chen, team principal of GruppeM Racing, said that he was very excited about the deal, as it was a validation of the commitment of everyone at GruppeM Racing that Porsche is wanting to work with them. 2005 will be only the third full season of competition for the GruppeM team in the FIA GT Championship.

This new partnership will also extend to the 2005 LMES and the 2005 Porsche Infineon Carrera Cup Asia.

Hartmut Kristen, director of motorsport at Porsche, has worked closely with GruppeM for the last few years and is impressed with the team's results and technical proficiency and is said to be delighted to have secured a long-term partnership with GruppeM.

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UK-based GruppeM Racing won both the team and driver awards in 2004 and will race two Porsche factory backed GT3 RSRs this season

ON THE GAS...

PROFESSOR GARY SAVAGE
Deputy technical director, BAR Honda

Gary Savage has worked with BAR Honda since the end of 2003 and was involved with the team's recent success in achieving the Simms Medal for development of its carbon fibre gearbox.

How did you first get involved in motorsport?
After completing my PhD I worked for several years for ICI Advanced Materials, primarily on military projects. Some work however was done in conjunction with the Williams F1 team which we sponsored at the time. When an opportunity arose with McLaren to move into Formula 1 I took it. That was over 15 years ago, so I guess I'm hooked now.

What achievements are you most proud of?
Being part of the team that took BAR Honda from the back of the grid to second position in the 2004 Formula 1 World Championship.

What's the most interesting project you've ever worked on?
Composite suspension and gearboxes.

Can you name your favourite racing car of all time?
Definitely the Tyrell 019 – it was years ahead of its time.

Who do you most admire in racecar engineering and why?
Alan Jenkins and John Barnard. Alan is a very shrewd strategic thinker. Not only does he understand the engineering of racecars, he can see where things are going and how to implement and manage change. Many of the procedures I have implemented in BAR Honda are based on discussions with him when we worked together and subsequently.

A single word describes John Barnard – brilliant! So much of the engineering we now take for granted in F1 began as JB's innovations. Furthermore, his ability to get a grip of a team and drive it on to better things is second to none. I make no attempt to disguise the fact that much of my management style and approach to racecar engineering is based on what I learned from him. The man is a legend, and rightly so.

What tool/instrument could you not work without?
The key 'tools' in Formula 1, particularly in my position, are people. There are a number of key individuals within BAR Honda whom without, both the team and I would be lost.

What racing era/formula would you have liked to work in and why?
The present! I despair of all those, particularly in the media, who drone on about 'the good old days', trying desperately to hold back the tide of progress like some latter-day King Canute. The world moves on, we have to accept that and move with it.

What engineering innovation do you most admire?
John Barnard's original carbon fibre chassis. A very brave step at the time, which has kept many engineers employed (myself included!) and saved countless drivers' lives. It was without doubt the catalyst in the transformation of the sport to the technological excellence and esteem it enjoys today.

Is motorsport about engineering or entertainment?
Motorsport is entertainment through engineering.

What new technologies in motorsport are you most excited about?
Full scale wind tunnel testing.

Is there a future for high technology in motorsport?
Motorsport in general and Formula 1 in particular have no future without high technology – they are inextricably linked.

Race people

Professor Sid Watkins

Henri Durand

David Brabham

Jean-Pierre Nicolas

Mark Smith

Corrado Provera

Fujio Cho

Gemma Briggs

● Sportscar racer **David Brabham** has been confirmed as official ambassador for the UK Government-backed Energy Efficient Motorsport programme. Brabham's role will be to actively promote and encourage the greater use of alternative fuels and energy efficient materials within all forms of motorsport.

● **Katsuaki Watanabe** has been employed as the replacement for **Fujio Cho** as president of the Toyota Motor Corporation.

● **Mark Smith** has once again left his position at Jordan as returning technical director, after a spell at Renault F1, only weeks after accepting the position. Smith is currently linked with Mike Gascoyne at Toyota but, at the time of going to press, this rumour had not been confirmed.

● Former Jordan technical director **Henri Durand** has joined Red Bull Cheever Racing in the Indy Racing League.

● Lotus Cars Ltd has appointed **Clive Dopsom** as managing director of its sportscar division. Dopson has held the position of manufacturing director since 2000 and his new role will involve the overseeing of both the manufacturing and the commercial sides of the business.

● Formula 1 medical expert **Professor Sid Watkins** has decided to end his active involvement as FIA Formula 1 medical delegate at grand prix weekends after 30 years He will however continue his involvement with the FIA as president for the Institute of Motorsport Safety.

● Designer **Gordon Murray** is leaving McLaren after 18 years with the team. The 60-year old South African engineer was a major player in F1 in the 1970s and '80s with the Brabham team, winning two world championships for Nelson Piquet. He stayed with Brabham until the end of 1986 and then joined McLaren where he took on the role of chief designer.

● Citroën Sport chief engineer **Jean-Claude Vaucard** retired at the end of February. Vaucard has been responsible for some of the most competitive competition rally cars in recent times. He is replaced by **Jean-Pierre Nicolas**. Together, Provera and Nicolas saw Peugeot Sport through the WRC Manufacturers' Championships from 2000 to 2002 in the days of the works 206 WRC.

● **Corrado Provera** retired from his post as head of Peugeot Sport and Peugeot Communications at the end of February. Provera maintained a particular enthusiasm for world rallying throughout his career and his Chrysler, Peugeot, Talbot, then PSA-Peugeot marketing and public relations background equipped him with a unique understanding of the relationship between motorsport and selling motor cars.

● **David Watson** has joined Rocketsports Racing as engineer to Alex Tagliani. Watson brings more than 16 years of experience to the Rocketsports organisation, having previously been employed by Dale Coyne Racing, Fernandez Racing, Mo Nunn Racing and Team Rahal.

● Former deputy editor on ***Racecar Engineering***, **Gemma Briggs**, has been named as best young motorsport journalist of 2004 at the Renault/MSA Young Journalist and Photographer of the Year awards.

● Champ Car has named motorsports veteran **Paul Harcus** as its director of operations. Previously team manager at Kelley Racing, Harcus will be primarily responsible for running technical inspection for the Champ Car World Series.

● Indianapolis Motor Speedway boss **Tony George** has bought the Kelley Racing Indy Racing League team.

Tony George

● Seven students from Cranfield University have won awards for their studies in Motorsport Engineering and Management. The awards were presented to them by Sir Jackie Stewart. Racecar Engineering would like to congratulate the following:

Darren Freeman who won the BRDC Trophy and prize for his outstanding contribution to the course; **Pierre Defays**, for obtaining the Sir Jackie Stewart OBE trophy and prize; **Duncan Dunbar** who achieved the Professor Adrian Reynard prize for the best thesis project and the Le Dis team, which consisted of **Dario Deutsch**, **Darren Freeman**, **Jean-Philippe Granger**, **Roel Sourbron** and **Ian S Turner**, for winning the group design project.

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

By Mike Breslin

Ford's winning formula

Ford has pledged greater support for the formula that bears its name – and that's good news for racecar producers, engineers and drivers alike

They used to save the best 'til last. November, Brands Hatch: the Formula Ford Festival. For two and a bit decades, it was the place to be come the end of the season – an autumn harvest of that year's crop of Formula Ford racers and racecars from right across the globe. Entry lists of 200 plus and plenty of races in a hugely enjoyable knockout format. The action was hot, the weather was cold, but we would all head for home warmed by the fact that we had seen some real racing, while ticking the names in our programmes we thought would go further – didn't think that fellow M Schumacher, punted out of his heat by Andrew Guye-Johnson in 1988, would amount to much though...

These days the festival is a pale shadow of its former self, just 30 entries for last year's event, and sadly that's a fair barometer of the state of Formula Ford in the UK as a whole. The reasons for this are manifold. Some point to the proliferation of other formulae cluttering the lower reaches of the single-seater ladder. Others blame the 'new' Zetec 1800 formula introduced in 1993 which, they say, has detrimentally affected the quality of the racing (always a hallmark of the 1600 Kent-engined cars) thanks to heavy engines, excessive grip and over-stiff chassis.

But whatever the reason, it's sad to see an old friend fade away. Sadder still if you've an emotional investment – for my part peddling outdated Lolas and Van Diemens back in the 1980s. So it was with no little cheer that I heard Ford has stepped in with a much needed rescue package for the formula that has kept its name at the forefront of national and club level motorsport for the past 38 years.

The blue oval announced its new 'full' financial and promotional support package for the UK Formula Ford championship last October, which allowed teams, drivers and sponsors to commit to 2005 in the sure knowledge that there would be a championship to race in. And the long term thinking didn't end there, with talk of broad changes that are set to sweep the formula in 2006. Chief among these is a muted switch to lighter 1600 Duratec or Sigma engines, which could go some way towards getting the formula back to where it was in the Kent days.

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The switch to 1800cc Zetec engines in 1993 has had a detrimental effect on Formula Ford grids, but a potential change to the 1600cc Duratec or Sigma engine and confirmed manufacturer backing may herald a new dawn for the ever-popular series

But why bother? Brutal, maybe, but that's what you're asking isn't it? Why should Ford make the effort? After all, even if the motor giant does owe Formula Ford a debt of gratitude for past publicity, do we really expect it to pump in cash when it's all but dead and buried? No, of course not, but luckily Ford has realised there is life in the old dog yet and has seen the sense in keeping it going while it still can – no doubt partly prompted by BMW and Renault's commitment to, and subsequent publicity from, its national level single-seater series.

> "FORMULA FORD OFFERS SOMETHING TO THE WORLD OF RACECAR ENGINEERING A SPEC FORMULA CANNOT. VARIETY"

And that's a good thing, for Formula Ford offers something to the world of racecar engineering that a spec formula cannot. Variety. From Alexis to Zeus, with just about every letter in the alphabet in →

between. Here's a few of them just off the top of my head: Crossle, Hawke, Reynard, Image, PRS, Titan, Merlyn, Mygale, Swift, Lola, Royale, Quest, Martlett, Jamun, Getem, Ray, Van Diemen, Vector, Laser, Lotus, Palliser, Mondialle, Tiga, Lanan, Dulon, Elden...

Some of those racecar makers were already great names (Lotus and Lola), a few found greatness within Formula Ford (Van Diemen), while others still (sadly many) have disappeared without a trace. But the point is they all had the opportunity, they all had a way into racing – a good Kent lump, a nicely engineered spaceframe and someone quick behind the wheel, then do well and you might sell a few more. This is how racecar manufacturers are born.

Sadly, these days few new cars arrive on the FF scene, the market is much smaller and with the Zetec cars there's no strata of junior and regional championships in which to prove a chassis. Also, drivers in the UK championship are often scared to risk hard-won budgets of £100,000 (US$185,000) and more on unproven machinery. That's understandable perhaps, at a time when one bad year can ruin a driver's career. But, all that said, the fact remains that this avenue is still there, and with a lack of aeros and monocoques it's still a relatively cheap way to get a new single seater on the grid. And every now and then something nice comes along (witness the Spirit unveiled at the end of last year) that makes its existence worthwhile.

"DRIVERS NEED TO UNDERSTAND THE DIFFERENCE BETWEEN AERODYNAMIC AND MECHANICAL GRIP"

But Formula Ford is not just a showcase – arguably the only showcase – for new single seater manufacturers. It's also an academy of race engineering and driving like no other. After all, where else these days can a serious racing driver learn about mechanical grip without the confusion of wings? Drivers need to understand the difference between aerodynamic and mechanical grip, they need to recognise mechanical grip and they need to be able to communicate that to their engineers. Lack of downforce means Formula Ford remains one of the best training formulas around, for drivers and engineers alike. It also means there's plenty of overtaking too, which can't be bad.

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Devoid of downforce, Formula Ford remains a true training ground for drivers and engineers alike

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A varied field means plenty of overtaking and great entertainment

New-found enthusiasm

So Ford's new-found enthusiasm for its formula is a good thing then. Yet I can't help feeling that perhaps, just perhaps, if Ford hadn't meddled in the first place things might be so much better anyway. I mean, let's go back to that barometer at the start of this piece, the Formula Ford Festival. A couple of weeks after 30 Zetec cars turned out at Brands, around 90 Kents were racing for the Walter Hayes Trophy at Silverstone.

And that's the thing, over a decade after Formula Ford switched from Kent to Zetec motivation, it's the older configuration that's still drawing the biggest and most diverse fields. It's also producing the better racing, too. There's a huge pool of cars out there – while estimates for Zetecs in the UK are around the 50 mark – and a growing trend of converting Zetec cars to Kent, while the supply of the venerable Kent engines shows no sign of drying up.

Ford might argue that things must move on, that it's progress and it needs to showcase its technology, but surely that's what F1 and the WRC are for? Anyway, Ford spends millions of dollars on those antiquated taxi-cabs they call NASCAR racers, so surely a little bit here and there to keep an old legend going wasn't so much to ask for?

Whatever, the important thing is that Ford is sticking with a non-spec formula and for that we should all be grateful. Long term, let's hope the new engine will be readily interchangeable with the Kent, for then there will be a place for the superannuated national racers to go in the regional 1600 championships and the new MSV-backed championship. And that can only be for the good. Either way, come the autumn I'll be at Brands for the Festival again. Unless it clashes with the Walter Hayes Trophy at Silverstone, that is...

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Loaded question

I just read your Consultant column on load transfer in this February's Racecar Engineering [V15 N2], and found it quite interesting. I completely agree with the load transfer arguments presented therein, however, it seems an important part of the discussion has been missed.

Tyres, like vehicles themselves, are directionally constrained in pointing their force vector. So when a tyre is producing the braking forces necessary to induce the forward load transfer as mentioned, their ability to produce a simultaneous lateral force is also diminished. This effect will lead to understeer, fighting the oversteer effects of the load transfer.

Who wins out in this battle is beyond me, so I'll put it to you. The result is probably quite vehicle and tyre specific.

Jeremy Neubauer
Washington University,
St Louis, USA

Mark Ortiz replies:
It certainly is true that the amount of grip available for cornering diminishes when we are braking at the same time. However, this effect is not confined to the front wheels. The rears also brake, so the rearward force component is present at all four contact patches, and it doesn't necessarily add understeer. It adds more understeer the more front brake we add, and it adds oversteer the more rear brake we add. It is possible to have understeer on entry, via brake bias and other means. But the effect of forward load transfer, in itself, is to add oversteer.

Email the Editor: racecar@ipcmedia.com
or send your letters to: The Editor, Racecar Engineering, IPC Media, Leon House, 233 High Street, Croydon, CR9 1HZ, England Fax: +44 (0) 20 8726 8399

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Is the advent of five-way adjustable spec shocks in the Toyota Atlantic Championship a disaster waiting to happen?

Less is more

I read with some interest and trepidation about the Atlantic racecar series running a 'spec shock' with five adjustments [Racecar Engineering V15 N3 p10]. Presumably this is high and low-speed rebound and three bump adjustments.

I would hazard a guess that most teams will get lost with all that and, without a shock dyno to calibrate settings, a disaster is waiting to happen. The best of engineers get lost with high and low-speed rebound in there own admission, so why complicate issues when it is unnecessary and a simple two way adjustment would be very applicable.

I wouldn't mind betting the top teams are heading for the shaker rig and that will increase budgets even more, not cap them.

Common sense does not always seem to prevail.

Richard Barnes, Spa Group
Lichfield, Staffs, UK

Go with the flow

I want to know why water ballast has not been used in a more constructive way in racing applications? Weight transferred properly across a vehicle's axle may be beneficial towards traction control.

I realise that such a free moving fluid would be hard to control, but I'm sure there are safe, thicker density fluids available. Would you please explain, if possible, what happens at high speed if fluid dynamics are used to balance out traction? Is it more a matter of controlling the side-to-side inertia verses the dampening of gravity forces against the suspension? Or could it be something to do with evaporation techniques that would lighten the car and make it go faster that is keeping this odd idea off the tracks?

I'm a swimming pool technician by trade, but fascinated by the laws of physics in racing as a hobby. So maybe my ideas are all wet and I should keep looking for little bikinis to pass the time. Either way, this Pennsylvanian Dutchman will continue to race around looking for trouble.

Thanks for the good articles.

Speedy Petie,
Pennsylvania, USA

Book 'em Danno...

I have in times past purchased books from the Racecar →

Forum

Engineering bookstore, and I was wondering if you still provide a book sales service?

Specifically, I am in need of two copies of Giorgio Piola's Technical Analysis 2004/2005. My concern with contacting NADA Editore directly is that they accept only faxed credit card orders, attendant with its obvious security concerns. I have also researched several other sources (Amazon, EWA etc.) with no luck.

Do you still sell books through your own magazine outlet, or can you suggest (other than the NADA Editore website) another source for these books?

Dave Gaddis
Greenville, Texas

Unfortunately, this is a service we are no longer able to offer through the magazine. However, I would refer you to any of the specialist bookshops like Chaters in the UK [www.chaters.co.uk] or Autobooks-Aerobooks in the US, as recommended by Paul Van Valkenburgh in his column last month – Ed.

Cellular telemetry

I hope that you can help me. I have misplaced an issue that contains an article that I would like to have. The article was about the results of a masters thesis regarding the use of cellular phone technology to send/receive racecar telemetry. I need to contact the people involved in the research and would be happy to purchase another copy of the article. Any help that you can provide would be appreciated.

Mike Kaler
Motocoolstuff Inc. USA

The article you are looking for is Straight Talk from Racecar Engineering V14 N7. It was written by a team of Cranfield students who developed the idea as a part of their Motorsport Engineering and Management MSc – Ed

Bright idea

The size of run-off areas and the design of some modern circuits has made it very obvious that the safety flag has lost its visual importance, and is now largely symbolic. Perhaps then the time is right for the FIA to upstage these clearly inadequate safety arrangements, and make more of an effort to bring vital safety information out of the unsafe middle distance, and place it directly in front of drivers' immediate field of vision instead.

If the driver can have any parameter of the car available to him at all times in the most recognisable form possible, which he or she cannot miss under any circumstances, why do they have to visually scan the distance around them to recognise this important safety code information?

While we are waiting for safety officialdom to come out of hibernation and start thinking about this matter, I have a simple suggestion to address it.

How about a single row of high density LED lights in the colour responding to the flag (the black flag could appear on the main board screen), right in front of the drivers' immediate visual field. These could be triggered by a series of sensors positioned around the circuit, under the race steward's control.

Positively ancient marshal's flag sticks would see the greatest transformation, and should be totally re-designed. The former stick should still contain the flag as the visual symbol, but it should also become a sophisticated electronic unit that contains all relevant electronic and communication links like continuous GPS, data and voice link with central control unit, facility to activate or deactivate circuit safety sensors etc. This would enable race marshals to perform this noble duty both more efficiency and more safely.

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Marshal's flags play a vital role in communicating safety information to the drivers. Isn't it time they were brought into line with modern technology?

To make the flag wearing marshal more visible, the electronic flag stick should have on its top a highly visible and dynamically reflected flashing LED unit in the corresponding colour. To make absolutely sure that drivers, the public, the TV viewers, and everyone else knows exactly what is happening, the safety fence poles containing sensors should also incorporate a set of lights in flag colours, again with high visibility light and dynamic reflection facility.

Adopting something as simple as this would bring far more certainty that the important safety information has been transferred to the drivers, and that safety personnel are better protected, both because they are more visible and because of the distance they can keep, knowing their flag wasn't the only signal sent to the drivers.

I find myself asking why I have to spend my coffee break coming up with something like this, while well paid official 'safety gurus' are seemingly inactive for years. I don't know the answer, maybe the FIA is waiting for all the team directors, principals, drivers and marshals to complain officially at the same time to have an effect. Whatever it is, its obvious that the FIA is short on creativity and that the safety structure is not performing to accepted standards. That could cost lives and that is not acceptable.

Ado Sigal

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Words | Charles Armstrong-Wilson
Photos | Ian Harris; Sutton Images

F1 2005

Have late rule changes upset the established order or will the teams with more resources to throw at the problem simply pull out a bigger lead?

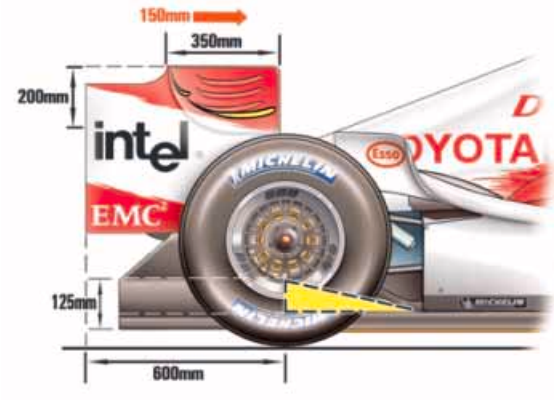
For the new season the Formula 1 teams have had a raft of new rules foisted on them and many have been critical of the changes. In the main they felt they were confirmed too late at a time when the design of the new cars was well underway. Jaguar was very outspoken and it may have been a contributing factor to the manufacturer pulling out. BMW's Dr Mario Thiessen also criticised the changes, claiming it was too much too late.

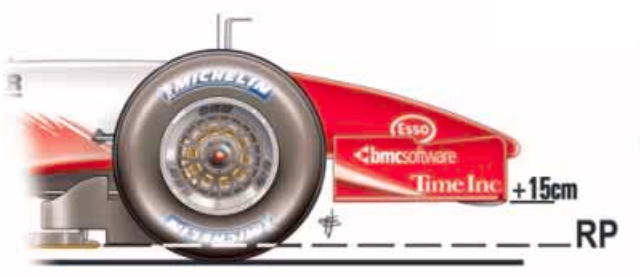
Nevertheless, the changes were implemented, and everyone who has stayed has had to cope with them. And as ever, the less well-funded outfits have seen it as handing an advantage to the front-runners who, with greater resources to throw at the problem, will pull out a lead in the development of the new style cars that the others will take time to close up again.

The three main areas the changes cover are engines, tyres and aerodynamics. All are aimed at reducing speeds, while the engine rule also targets costs. All teams now have to use their engines for two entire race weekends and failure to do so will incur a 10 grid-position penalty. This brings issues for the engine builders to do with heat cycling on components. However, an engine that can run for up to 1500km can accumulate many more bench and track testing miles, making savings that are disproportionate to the number of engines saved at race weekends.

Tyres must also complete final qualifying and the whole race and can only be changed if they puncture or the weather changes.

Aerodynamically, the rules are geared to reducing downforce, thereby slowing the cars. The height of the front wing now has to be 150mm rather than 100cm above the car's reference plane





For 2005 front wings must now be 150mm above the reference plane, while rear wing elements have been brought 150mm further forward

Images: Toyota

BAR-Honda 007

For the 2004 season, BAR managed to coordinate all its areas of excellence into a coherent whole that brought the team second in the World Championship from fifth the previous year. Its success is commendable yet to make a leap of the same order this year will be many times harder. The team seems well aware of this and, feeling the frustration of achieving so many podiums without a win last year, is reconciled to aiming at some ambitious targets to raise its game again. 'What choice do we have but to set ambitious targets,' asks technical director Geoff Willis. 'Our development matched Ferrari's last year, but the gap remained the same at the end of the season. Only by pushing in every area can we hope to catch them.'

Improved packaging has reduced the size of the car significantly in pursuit of efficiency. 'One of our biggest deficits to Ferrari last year was aerodynamic efficiency,' says Willis, 'not total downforce, which was similar, but the amount of drag we incurred to get that downforce.'

Significant weight savings have also been made across both the chassis and engine. The gearbox is a development of the successful carbon fibre-cased unit introduced last year [Racecar V14 N9]. Its seven-speed internals were developed entirely by Honda and features the seamless shift technology that shifts with such speed and quality that the drivers have found it a revelation. However, the FIA considered banning it on the basis that it constitutes a form of constantly variable transmission.

Despite the rule imposing longer engine life on the teams, engine chief Takeo Kiuchi was adamant in his refusal to compromise in the new 90-degree V10. 'The new regulations set us an even greater challenge than we faced for 2004 when we produced a top class Formula 1 engine,' he observed. 'This year we have concentrated on three areas. We have made the engine more compact and lowered the centre of gravity to improve the performance of the overall package. We have increased mid to low-speed torque to improve acceleration at the start and exiting corners. Finally – and this is our biggest challenge – we are aiming to maintain top power despite the new regulations.'

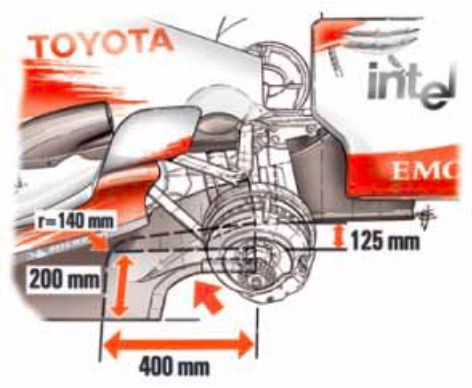
To improve efficiency, aerodynamic changes are focussed on lessening drag

BAR's new 007 car has been developed specifically around Michelin's tyres

Significantly, the team's success last year has had a bearing on its relationship with its tyre supplier, as Willis notes: 'Following a very successful first year with Michelin, we have been able to design the 007 specifically around their tyre characteristics, as well as being able to drive the development programme for the demands of the new regulations.' This agenda-leading partnership with Michelin could put the team on a par with Ferrari and its successful technical tie-up with Bridgestone.

In all, the mood of the team is brimming with confidence in its new challenger, as Willis confides: 'The numbers tell us this car is a pretty big step.' It will however be a test of the new management structure at Brackley following the termination of its relationship with Dave Richards and Prodrive. However, Honda seems to be the future for the team, with talk of a 'total integration' philosophy born of ever closer ties in the BAR/Honda partnership. Certainly the team lining up to be Ferrari's strongest challenger again this season. There is just the matter of where the Maranello team has left the goalposts during the winter lay-off.

reducing the amount of ground effect it can generate. At the rear the wing end plates and wing elements must begin at the rear axle line, 150mm further forward than before. The side diffusers have also been subjected to a height limit of 125mm whereas before they were unlimited. Also the underbody must now end 400mm ahead of the rear axle line while under the old rules it could extend right up to the profile of the tyre.



Side diffusers now have a 125mm height restriction and underbody base plates must end 400mm ahead of the rear axle line. The result of all these changes is typically a 25 per cent loss in downforce

Most teams seem to have experienced at least a 25 per cent loss of downforce under the new regulations and have since been fighting to recover the lost downforce in other ways.

The tyre rule has also influenced the design of the cars with teams talking of attention to suspension geometry and kinematics to get the most out of the tyres – areas that were long regarded as of little relevance to modern F1 cars with stiff suspension and high aero loads. Certainly efficient use and conservation of the tyres will be key to success in 2005.

As Racecar went to press, eight of the 10 cars had been rolled out, with the exceptions of Ferrari which is running an evolution of its F2004 car for the first few races and Minardi, due to be unveiled in Melbourne. →

Renault R25

Technical directors Bob Bell (left) and Rob White

Enlarged chimneys over 2004 car re-direct airflow more effectively from the radiators up over the intermediate and rear wings

Renault's 2004 challenger, the R24, was born into some disarray as engine man Jean-Jacques His departed and his 111-degree engine concept was hastily dropped in favour of a safe compromise 72-degree unit. For the R25 the engineers had a clear two year run at the design (Renault designs its cars over concurrent two-year timescales) and one would rightly expect no compromise. So it was a surprise to most that the team has stuck with a 72-degree bank angle for the RS25, rather than opting for the otherwise universal 90-degree route.

This all new engine, sharing no major parts with the original, is no compromise though, insists Rob White, technical director at Renault's Viry-Chatillon engine plant. 'The engine's centre of gravity is significantly lower, recovering nearly 70 per cent of the difference relative to the previous generation of wide angle engines.' This relatively minor compromise on a car-wide scale is more than offset in two areas. With the new two race engine rules, having an ideal bank angle for a V10 will ease the stresses on the unit, and its taller, slimmer design helps produce a slim tail, helping airflow between the rear wheels.

Renault has also put great emphasis on power delivery characteristics, betrayed by its exceptional standing start performance and the team's unique attachment to a six, instead of a seven-speed, gearbox. Despite theories about the blue cars running a greater rear weight bias than others, White attributes their startline performance to simply a 'good understanding of the physics involved', implying others are missing a trick in this area.

The rest of the car follows an evolutionary philosophy, again benefiting from the conceptual stability denied the R24. 'Last year, the mechanical architecture of the car was compromised by the late change of engine angle, recalls technical director Bob Bell. There are innovations on the car, however, including what Bell describes as 'a number of elegant engineering solutions in the suspension', the most visible of which he describes as a 'v-keel.' This is an attempt to reconcile the aerodynamic penalty of a single keel lower front wishbone mount with the trade-off from a twin-keel arrangement. 'It combines the virtues of both systems,' says Bell. 'We have obtained an aerodynamic advantage for minimal structural penalty, while maintaining our preferred mechanical configuration for the front suspension.' His comments suggest that front suspension kinematics in F1 are not as irrelevant as many would have us believe.

Perhaps the innovation the team is most excited about is the new Step 11 electronic system, developed in association with Magnetti Marelli. By integrating the chassis and engine controllers into one system the size and weight of the electonics has been reduced. With fewer boxes around the car it has contributed a quarter of the total weight saving on this year's challenger. It also offers four times as much processing power and 10 times more data acquisition capacity.

Bearing in mind Renault won a race and came third overall last year with a compromise car, the R25 may be the step the team needs to be regular winners in 2005.

Aside from an innovative 'v-keel' arrangement, car is an evolution of R24

Renault sticks with a 72-degree bank angle but otherwise the RS25 is new

Williams FW27

Patrick Head, now director of engineering (far right) and Sam Michael, technical director (second right)

The FW27 is the first grand prix car to come out of the Williams factory since the management restructure that saw Sam Michael take over the role of technical director and Patrick Head consigned to research and development as director of engineering. In this it signifies the start of a new era, but we will have to wait to find out whether it proves to be a better one.

Its predecessor, the FW26, was the most eye-catching car on the grid with its distinctive short nose and 'tusk-style' front wing mounts. However, when the team lost faith in the concept it ultimately cost aerodynamicist Antonia Terzi her job. Not only did it compromise suspension geometry but the shorter nose had to be heavier to provide the necessary crash protection, putting significant weight higher than was desirable. The aero work on the new car has been managed by Loic Bigois who has resorted to a more conventional arrangement and the pre-'04 style single keel lower front wishbone mounts.

By the team's own admission, changes to the new rules cost 30 per cent of the car's downforce under the old rules – more than other teams are claiming. Since then, much of the team's resources have been devoted to clawing back as much of this as possible, helped by the team's acknowledged cutting edge computational fluid dynamics facility. Its Linux cluster has recently been upgraded to speed the task.

Another casualty of the late rule changes was the all new P85 engine. When the two-race rule was announced, this unit was already being tested and had to be shelved after being deemed an unsuitable base for the longer life requirement. BMW's motorsport director Dr Mario Thiessen was outspoken about the changes, saying: 'the move to two-race engines is a radical and late change to the rules which has caused significant extra development costs, rather than saving money.'

Instead BMW opted for a development of last year's unit, designated the P85/5, and describes the impact of the new rules on its size and weight as 'minimal'. The company still anticipates engine speeds of 19,000rpm and power output in excess of 900bhp. To offset losses, BMW's Formula 1 engine team – working under director of Formula 1 engine development Heinz Paschen – collaborated closely with FIZ, the car company's research and innovation centre, and attributes much of its success to new surface treatment processes.

Like BAR-Honda, Williams is hoping to run its seamless shift seven-speed gearbox in the new car. For a while, under a clarification of the rules by the FIA, the system was deemed a form of continuously variable transmission (CVT) and therefore illegal but under consideration has now be cleared to race. In every other respect, the team has all the signs of an organisation regrouping after internal change and on the back foot following rule changes. ➔

Gone is the FW26's 'tusk' nose, now replaced by a more conventional design

Williams admits a 30 per cent loss of downforce under new rules so much of the development work has been aimed at clawing this deficit back

McLaren MP4/20

Last season's fifth place overall left McLaren with a lot of work to do, and continued doubts over key members of its management mean its far from an easy road ahead for the Woking-based team

After a series of embarrassing engine failures last season further management changes claim to have brought 'proper focus' to McLaren's 2005 programme and a car that is already being praised for its ease of adjustability

For the multiple world championship-winning team, finding itself fifth at the end of last season seems to have come as something of a shock to everyone in Woking. However, this position is not all bleak as its lowly position in the pecking order does bring the right to run a third car on Friday practice. This would be a benefit to any second order team trying to play catch up but, should one of those teams suddenly find itself wielding a potentially race-winning car, then the combination could be devastating. Yet this could be the position the team finds itself in this year.

Since its introduction with the unraced MP4/18, the current McLaren GP car concept has been problematic, as has the engine, and flashes of speed were masked by reliability and driveability problems. However, the new car is believed to have addressed all these and chief designer Mike Coughlan has been praised by everyone down to the mechanics who are finding it easy to work on and set-up. CEO Martin Whitmarsh said, 'He's overseen a design that can be put together and adjusted more easily.'

The engine failures were particularly embarrassing, considering DaimlerChrysler is a part owner of the team and a major shareholder of Mercedes Ilmor. Now the engine concern has a new MD, Ola Kallenius, who, as part of a programme of management changes, is said to have brought the 'proper focus' to the operation. According to Whitmarsh, the two-race engine rule would have been a worry for the team before the management re-structure. 'We were behind,' he admitted, 'but we are now starting to do long runs.'

The McLaren transmission is still shrouded in mystery, amid stories of the team working on a radical new system. Theories range from twin clutches to seamless shift technology but there is no confirmation of either making it onto the MP4/20.

Aerodynamically, technical director Adrian Newey said that since the car's spec was set in May 2004, 3600 hours of wind tunnel work have gone into it.

Having two smaller drivers to draw the car around has reputedly resulted in a more compact cockpit that is causing six-footer Alex Wurz some problems, but will inevitably bring a small dynamic benefit in the races. The quality of the tyres, however, and the ability to rise to the challenge of the new rules has been questioned following a closed-season re-shuffle within Michelin. Team principle Ron Dennis is certainly said to have reservations about the changes. Rumours of change also continue to dog both him and technical director Newey. Talk of tensions between Dennis and 40 per cent McLaren owners DaimlerChrysler persist and, whatever the truth, cannot be good for long term confidence. Likewise, Newey's contact with McLaren expires in July and there are rumours of him returning to Williams. However keen Dennis is or is not to keep him, he will be more keen to prevent him designing F1 cars for anyone else. ➔

3600hrs of wind tunnel work has gone into the MP4/20 since May 2004

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Sauber C24

Running on Michelins for 2005 means Sauber will not be able to share vital tyre data with Ferrari this season

Canny management and the cultivation of a close relationship with dominant Ferrari have helped Sauber survive and prosper as other independent teams have struggled or gone under. Against that, few expect the blue cars to pitch their drivers to the top step of the victory podium either. Last year's C23, however, proved a sound base for development and, as the team's new 100 per cent wind tunnel came on line, the Saubers showed a corresponding climb up the field. Since then Sauber has unveiled its all new super computer, designed to help tackle aero development through computational fluid dynamics. Christened ALBERT, it boasts 530 AMD Opteron processors installed in high-density cooling enclosures. At 30 times more powerful, the new machine is a big step over the team's previous resource and fields 1 terabyte of RAM and 11 terabytes of hard disk space. Running Fluent CFD software, it too will accelerate the team's aero development programmes significantly.

In the past Sauber ran Bridgestone tyres, the same as Ferrari, which not only allowed it to align its own data with the Italian team's wherever the engine programme made it available, but also, in the eyes of some cynics, effectively gave Ferrari a second source of data at race meetings. That synergy will not exist in 2005 but those same cynics are now alleging that the relationship will give Ferrari access to a source of data on the Michelin tyres also worn by its main competitors.

The Petronas 05A V10 is identical to the Ferrari unit, parity being necessitated by the two-race engine rule. It shares its architecture with last year's unit but has had its working life extended by judicious use of coatings and heat-resistant materials to overcome issues associated with repeated heat cycling.

Despite the reliance on hardware from Ferrari, Sauber has never been shy of introducing its own innovations. The team was the first to run the twin keel lower front wishbone mounts, although last year it reverted to a single keel arrangement which has been retained for 2005. The C23 of 2004 also saw the introduction of 'folded' radiators to improve packaging in the sidepods and reduce the size of the structure. This idea has been used again for '05 although they are now folded horizontally not vertically.

Sauber again utilises its 'folding' radiators, with extreme sidepod undercuts

Sauber's Petronas 05A V10 engine is identical to that being used by Ferrari

For the C24, Sauber has stopped using the Ferrari gearbox, which it has previously referred to as good but too expensive. Instead it has developed its own titanium-cased, seven-speed unit, saving costs on the manufacturing techniques involved. This unit does, however, still accommodate the Sachs rotary rear dampers incorporated into the gearbox-mounted suspension rockers. This is a technology used by Ferrari since 2003 and acquired by Sauber through the use of the Ferrari gearbox.

Overall the car is an evolution of the C23 model, incorporating all its good points but with improved packaging to aid airflow. As technical director Willy Rampf points out, 'Conspicuous about the C24's design is its sidepods, which have an extreme undercut to achieve optimum airflow,' especially around the particularly important rear.

Red Bull Racing RB1

Despite a great many changes in the team, designer Ben Agathangelou (left) and ex-Jaguar technical director Günther Steiner are confident that development work on the new RB1 car has not suffered

Considering most of Red Bull Racing's Milton Keynes-based staff didn't even know if they would have a job beyond the end of last season, making it to the first round of 2005 is a blessing in itself. The fact the team has been bought by an investor with clear goals and the funds to pursue them must be seen as a definite bonus.

There are downsides to the package though – the uncertainty that hung over Jaguar Racing also afflicted Cosworth, distracting focus and funding from the Formula 1 engine programme. But the team has emerged re-branded, re-structured and revitalised.

Soon after the soft drinks manufacturer's acquisition of Jaguar Racing, changes were implemented to the staff. After initially receiving a vote of confidence, Tony Purnell and David Pitchforth were dropped and the dynamic young head of F3000 team Arden, Christian Horner, was appointed team principle. Also, one-time Jaguar technical director Günther Steiner returned to the same post in the new outfit from his most recent position at Opel's DTM team.

However, for all the upheaval, the RB1's designers, Ben Agathangelou and Rob Taylor, insist it did not affect their focus. They point to a 15 per cent weight saving on the tub alone and claim everything on the car has been improved. With the new tyre restrictions, the last Jaguar's appetite for rubber on the rear needed addressing. The designers also claim some genuine innovations around the car. 'We've got components on the car that are a first in terms of design,' said Taylor, 'As far as I know, nobody in the pitlane is using some of the components we have in the cooling system.'

Perhaps the team's biggest concern will be over the 90-degree V10 supplied by Cosworth. Formula 1 engine boss Nick Hayes departed suddenly last year, and the programme is now led by head of development Alex Hitzinger and head of race engineering Simon Corbyn. This year's engine is designated TJ2005, a naming convention previously only used internally but now replacing the old CR tag, and is a development of the CR6 which was, itself developed from the CR5, which in turn can trace its roots back to the CR1 used by Stewart in 1999. However, despite the age of the concept, Cosworth is reckoning on a 25bhp power increase, despite the longer life regulation. In this area, the robustness of the more elderly architecture may not be such a handicap.

Expect to see aero changes when the team's Bedford facility is back on line

The team claim a 25bhp power gain and some genuine innovations on RB1

The aero work on the RB1 was carried out in the team's Bicester wind tunnel, but from June the team will have its revamped Bedford facility back on line, helping accelerate its development programme. The car will be racing on Michelins again this season and, despite the break-up of Ford's Premier division, the association with Pi Research remains.

At just 31 years old, Christian Horner has had a meteoric career in motorsport, but Red Bull Racing will be the acid test, as he tries to make it in the Piranha Club, as Formula 1 is known.

Toyota TF 105

Toyota's new car represents the first design to come out of Cologne under the administration of Mike Gascoyne, encouraging onlookers to anticipate an all new direction for the team. The latest car, though, incorporates much of the design elements from the TF 104, revealing a demonstration of faith by Gascoyne in what had been achieved previously by Toyota engineers. However, the resources in the chassis department have been re-structured to free up more capacity for aerodynamic development. This seems to be the main thrust of his influence on the team since his arrival – the re-definition of priorities and internal re-organisation to encourage a better synergy between separate departments. In sticking with a proven chassis concept, more resources have been released for areas where change is more pressing.

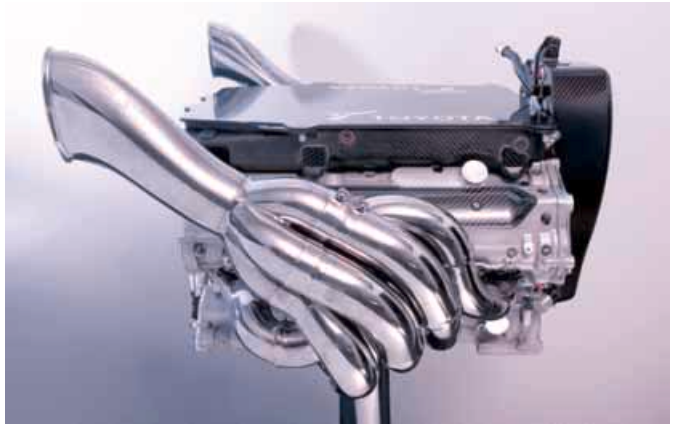
The evolution of the chassis has brought benefits, though, as Gascoyne explains: 'Whilst further reducing the combined weight of the car and its centre of gravity [height], Gustav [Brunner] and his team have looked at the entire mechanical package and put in a large effort, particularly on the rear end of the car, something we feel was one of our weakness last season. We have greatly enhanced stiffness and damping characteristics at the rear of the TF 105.' Much of the work has concentrated on an improved version of the seven-speed gearbox's cast titanium casing.

Power and reliability have never been a big issue for Toyota's RVX family of engines but, with the new rules, retaining that track record for two races on each engine will be a challenge. The RVX-05 is an evolution of the RVX-04 which, itself, had its lifespan doubled from 400 to 800km during its development for last year. Now this design life has been increased again to 1500km to last two races. By working with an existing design, Toyota engineers were able to have a hybrid version of the 2004 engine on the dyno by July last year. The result is a unit developed to the new rules that delivers the same horsepower as the RVX-04.

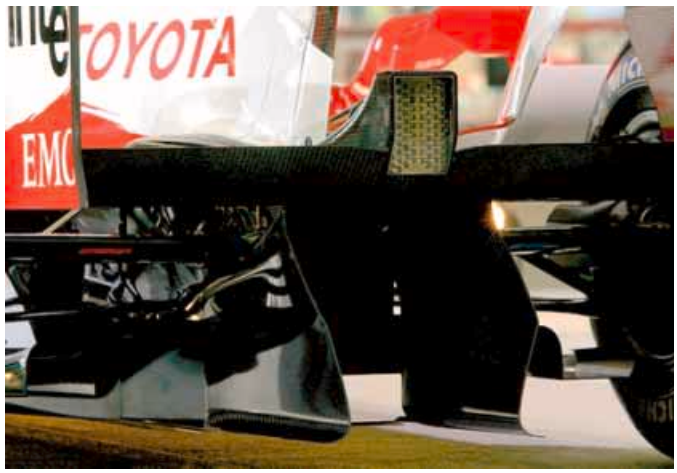
If Toyota does make a leap up the field from its lowly eighth in the championship last season, it will be predominantly down to a much more aggressive aerodynamic programme. When Gascoyne arrived at Toyota he was heartened to find a car with a 15 per cent lift:drag deficit over the frontrunners, which gave him a clear target to attack. The problems seemed to stem from inaccuracies in the Toyota wind tunnel procedure and a lack of repeatability. These were masking the small improvements that cumulatively would have put the team on track for success.

Already the new car is slimmer around the rear than last year's model but, being launched so early (on January 8) much of the aero elements unveiled will have been changed for development parts by the first race.

Toyota is being bullish about its chances but, with a top team budget of around $400 million, there is much expectation and results are overdue. According to team principle Tsutomu Tomita, 'If we don't succeed with our goal of scoring podiums, my head will be chopped off.'



Toyota's RVX-05 engine is an evolution of its RVX-04 and has the same power



Much development has gone into the rear, enhancing stiffness and control

Luca Mamorini, head of engines (left) and technical director Mike Gascoyne

Jordan Midland EJ15

While there has been unrest in Jordan Midland management, new sporting director Trevor Carlin is a definite asset to the team. How well the car performs and how much backing it gets from Midland though in 2005 remains to be seen

One has to sympathise with the engineering staff at Jordan Midland. While everyone in Formula 1 is struggling to cope with the de-stabilising effects of the new rules, the Silverstone-based crew are also having to deal with a new owner, a new engine and the loss of key personnel. No sooner had Eddie Jordan cleared his desk than new technical director Mark Smith walked out. He had been tempted back to Jordan last December after a spell as one of Renault F1's two chief designers. However, following the Midland takeover of the team, he departed over a disagreement with the management on the future technical direction of the team.

It seems clear that Smith had expected to initiate a design programme for next year's Jordan that would apply much of the knowledge he had acquired while working for a leading team. Midland, though, had already commissioned its own 2006 contender from Dallara in Italy and confirmed its intention of sticking with this plan, leaving Smith with a radically different role in the team. Next year's car is being overseen by one-time Jordan technical director Gary Anderson.

Uncertainty over the engine supplier for this year's car has also handicapped the design process. With Cosworth up for sale, supply of engines hung in the balance until, perhaps with some coercion by Bernie Ecclestone and the FIA, Toyota agreed a supply of engines for the privateer team. However, this news came very late in the car's design cycle and will have enforced many late changes to the layout of the internal systems.

So it was no surprise that, before departing, Smith described the EJ15 as, 'essentially a development of the EJ14 with a Toyota engine installation and to the new regulations.' As a result, the car will be operating very much as a mule, with little development during the season while efforts concentrate on the new car for 2006 – the time when Midland intended to enter Formula 1 before acquiring Jordan.

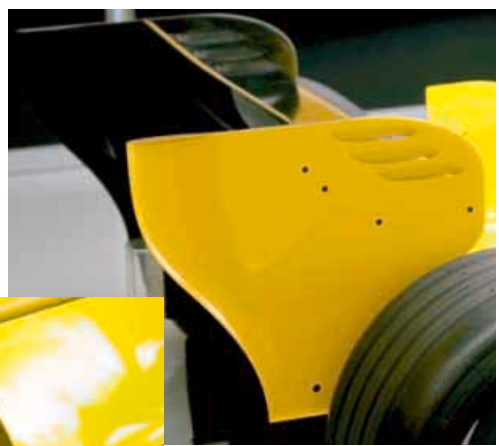
Currently Jordan's established design team – Mike Wroe, head of electronics; Simon Phillips, head of aerodynamics and John McQuilliam, head of design – is still in place though no announcement has been made about their involvement with the team's next generation of racecars.

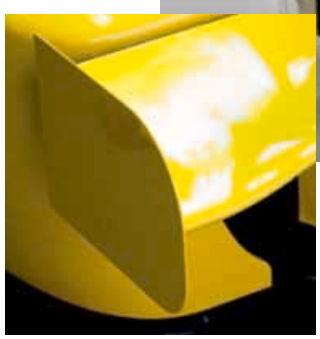
A key member of the new management team is sporting director Trevor Carlin who has a substantial reputation operating teams in lower single-seat formulae. He has already brought with him two race engineers, Bradley Joyce from Carlin Nissan and Paul Monahagn from Renault F1, and chief mechanic Ricky Taylor.

As the car appeared in testing at Silverstone it was sporting some unusual approaches to the problems inflicted by the new rules for 2005. The rear wing endplates are much smaller than other teams' take on the problem, while a pair of winglets are mounted just above the radiator inlets in the sidepods.

Unusual winglets above the radiator intakes seen at Silverstone in practice

Aerodynamic changes made to the EJ15 to comply with the new rules appear initially at least to be quite different to the competition





Examples are smaller rear end plates and unusual winglets above the radiator intakes (shown left)

Just how difficult the team finds this year will depend on how much of its resources Midland is willing to devote to this year's effort, or whether it regards the £16million purchase of the team as a cheap way to avoid the £25.5million ($48 million) deposit required and puts all its efforts into preparing for next season.

Just deserts

Recent rule changes have brought manufacturer backed specials back into raids, and into a school of technology peculiar to this most testing of motorsport disciplines

Words	Martin Sharp
Photos	Bothwell Photographic/Nissan; Sharp

The FIA prefers the term cross-country rally to describe Dakar-type events, yet many people still use rally raid, or the raid abbreviation (a French word meaning long-distance run or flight, endurance test). Dakar is the daddy of them all, and has attracted vehicle manufacturer interest since it first ran from the French capital on Boxing Day 1978, arriving in the capital of Senegal on the West African coast on 14 January 1979. Hence why early events were called Paris-Dakar.

Early Dakars were predominantly for amateur adventurers, and many competing vehicles reflected this. By 1984 an official Porsche 959 won, with Andrew Cowan's works Mitsubishi third overall. Mitsubishi had made a fact-finding entry the previous year, but 1984 represented the beginning of its capitalisation on promoting a rugged image for its vehicles through 'official' involvement in the event.

The following year there were two works Mitsubishis and two 'official' Toyotas in the first four places. Manufacturer involvement was on the increase. In 1986 Porsche took the top two honours, but major change was brewing.

The Group B 'supercars' were banned from the beginning of the 1987 WRC, and Group A was to be the top rank. Peugeot didn't have a suitable production model on which to base a Group A car, so instead took its 205 T16 to rally raids and won Dakar first time out.

During the 1990s Hubert Auriol had taken over as boss of the Thierry Sabine Organisation (TSO) to run Dakar. A previous Dakar winner both on two and four wheels, he considered it his duty to return the event to its original status as a motorsport endurance adventure in which amateurs had a good chance of winning.

The Dakar technical regulations were changed to forbid manufacturers from fielding prototypes. Wily old Jean-Louis Schlesser noticed the remaining

freedom in the buggy rules though and his buggy began to dominate, winning the event in 2000. The first Schlesser buggy had Buick power, then went via Renault V6 to Ford power and managed third last year, By then though 'Schless's' regulation advantage was significantly diminished.

Hubert Auriol's reign had come to an end. TSO had become ASO — Amoury Sport Organisation (the Amoury Group publishes the French national daily sports newspaper l'Equipe), which had soon realised the burgeoning fresh manufacturer interest in the sport, and particularly Dakar. Another rule revamp saw manufacturers allowed to run 'specials' again, yet with more severe performance-sapping restrictions than the essentially free old prototype rules.

Mitsubishi continued its winning ways, developed the Pajero Evolution from a styling exercise into a cross country winner and became the first car manufacturer to win a record 10 Dakars. Volkswagen came back with the Race-Touareg, Nissan with its Pick-up and BMW with its X5 lookalike, the X-Raid — all spaceframe hybrids, but with restrictions.

"HE [HUBERT AURIOL] CONSIDERED IT HIS DUTY TO RETURN THE EVENT TO ITS ORIGINAL STATUS AS A MOTORSPORT ENDURANCE ADVENTURE IN WHICH AMATEURS HAD A GOOD CHANCE"

Nissan Pick-up

Originally developed in South Africa, the Pick-up was revised substantially for the 2005 Dakar. A new team was formed in France in February last year and built up from a core of two ex-Prodrive engineers, Christophe Chatelain and Richard Thompson. First steps were to engage Sadev for the transmission and Don Foster to undertake the manufacture of chassis modifications and suspension components. The primary objective was to improve the car's reliability, and just the central cabin and the fuel tanks were retained from the previous design.

A brand new 3960cc, all-aluminium alloy V6, with controlled timing and four valves per cylinder was available to the team, requiring extensive modifications to the chassis architecture, tunnels and so on. The main problem with the previous car had been propshaft and driveshaft reliability, and with more torque available in the new car (an official maximum figure of 430Nm) these were re-engineered to suit.

Design began in March 2004, with the objective of running a car in June. The previous car was first tested in October 2003, a time when parts for Dakar are already in →

Works entries are little more than silhouettes of the vehicles they represent, with pure race underpinnings

The reprise of major manufacturer involvement means big budgets and impressive on-raid servicing facilities

As with mechanical components, on-board navigation and timing equipment is state-of-the-art in works entries

On-the-move tyre inflation/deflation systems are no longer allowed, these activities having to take place when stationary

manufacture, and Chatelain stressed that major re-designs are not feasible in that timescale. This factor implied an off-the-shelf gearbox, and the price and torque capacity – as well as availability – of Sadev's six-speed sequential 'box fitted the bill. Sadev doesn't make specific rally raid diffs, just fronts and rears for the autocross category, and Chatelain admits that choosing these in place of the earlier Hewland diffs was the only real initial gamble taken. Propshaft and driveshafts are also Sadev, and the team has taken the opportunity to decrease the propshaft angle for reliability.

Locking the centre diff is an entirely mechanical operation, while the front and rear diffs are mechanically locked via hydraulics. Chatelain and Thompson have much experience with active differentials from their days engineering World Rally Cars at Prodrive. Chatelain considers handling to be 'quite important' in a rally raid car and that diff tuning would pay dividends, but time constraints on the project saw them settle on passive diffs.

"DESIGN BEGAN IN MARCH LAST YEAR, WITH THE OBJECTIVE OF RUNNING A CAR IN JUNE"

June was the target date: 'We were 10 days late compared to our planning, and we first ran on tarmac on 30 June. The first real test was 10 days in Tunisia from 17 July.' All 10 days were used, nothing major broke, just some diff cradles, which were re-welded during the night.

Interestingly, the team uses two different makes of dampers. The previous car ran on Donner units, of which the team has retained a plentiful stock. The three drivers tested both Donner and Reiger units in Morocco and chose the type they preferred: Colin McRae and Giniel de Villiers chose Reigers, while Ari Vatanen settled on Donners, having some concern over the (unknown) reliability of the Reiger units.

With full tanks the Pick-up carries 450 litres of petrol. The tanks sit below and immediately behind the drivers' and co-drivers' seats, in the centre of the car. Weight distribution over the axles between full and empty tanks is not a concern as the team calculates the variation at three per cent.

Future developments involve improvements to detail problems discovered on Dakar and some work on aerodynamics to help improve an inherent 'tail-kicking' characteristic.

Volkswagen Race-Touareg

Winners of the first ever Dakar in 1979, Volkswagen returned last year with a turbo diesel machine to pit against the normally aspirated petrol works opposition. A steel tube frame with wishbone suspension front and rear, using two coilover Donner dampers per wheel, is clad in a 50kg carbon Kevlar body, supplied from outside. Some 1200 components make up the welded frame, which weighs around 300kg and boasts a rigidity of 700Nm/mm². VW's philosophy of turbo diesel endurance vehicles carries potential advantages for an event in which a day can include 600 competitive kilometres. A smaller fuel load reduces overall weight and minimises front/rear weight distribution variance between full and low levels in the centrally located fuel tank, not to mention potentially reducing tyre attrition. Fuel consumption was also optimised by making the car's lookalike shape as slippery as possible in the Wolfsburg wind tunnel, where driver cooling was also taken into serious consideration.

The engine is based on the five-cylinder TDi from the production Touareg, stretched by 200cc for the 2005 Dakar to 2.5-litres, taking the output from 238bhp to 260bhp. VW likes to pride itself on using many production parts in its competition engines and, although the team is coy about the number of specific competition engine parts used, it does concede that it delivers 'in excess of 500Nm' of torque.

The FIA equivalence factor brings the notional capacity to 3750cc, which equates to a minimum vehicle weight of 1787.5kg, which means that the VW raider can be 62.5kg lighter than its normally aspirated petrol works rivals.

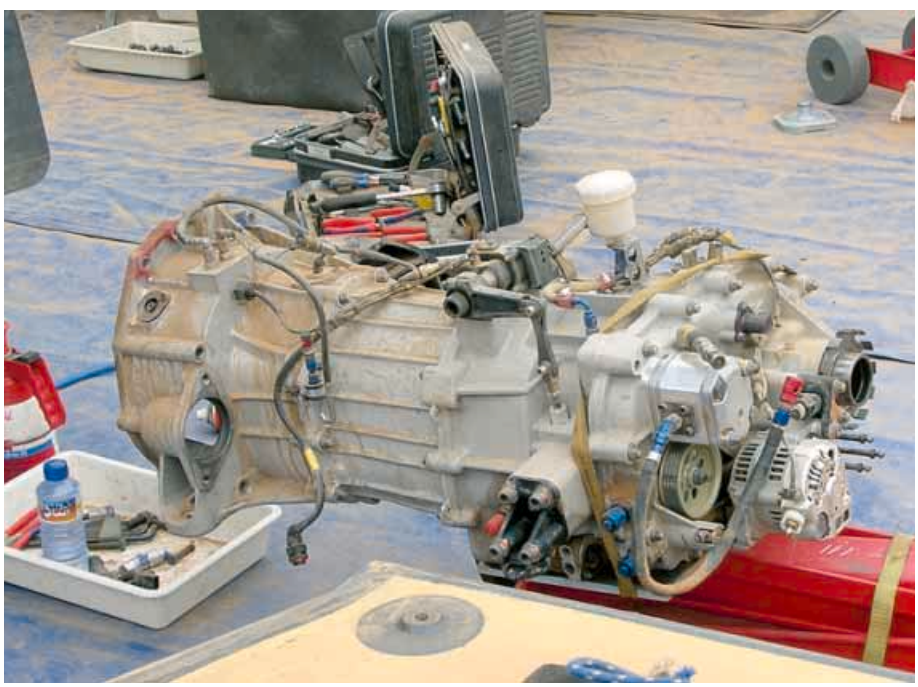
A particular asset to the team on the engineering side is the experience of Christian Tzceherit, a Frenchman in a predominantly German team. Before joining VW Motorsport, Tzcecherit worked for Citroën Sport, during its rally raid years.

His experience has contributed much, particularly to the settings of the Xtrac differentials. Christian was fully aware that you don't score results in the Dakar if you don't get there, and eschewed 'performance handling' settings in favour of those which would ensure the vehicles would be able to claw their way out of soft sand, for example. It worked last year, the team's best result being sixth. This year, with different settings, yet essentially the same philosophy, Jutta Kleinsschmidt got her Race-Touareg to Dakar third overall, while team mate Bruno Saby was fifth.

The centre diff can be locked mechanically, predominantly to keep the car going if a driveshaft breaks (the team specified driveshafts on the safe side from the outset and has only broken them in tests). All three diffs operate on a passive, mechanical basis 'with possibilities of locking via a viscous coupling,' according to official Volkswagen technical information. One might speculate that this could help facilitate handbrake turns... and offer a 'fail safe' fully-locked 'humped' option when driveshaft speed variations reach levels when any drive to any wheel is required.

The TDi's massive torque is delivered via a six-speed sequential Xtrac 'box, using some off-the-shelf Xtrac parts, but specifically designed for the car. It is clear that the VW designers have considered the dynamics of the vehicle carefully, and the car features measures to ensure as much weight as possible is kept as low as possible. An example is the alternator – sited low down on the side of the longitudinal gearbox, driven by a short belt.

Choosing diesel, as opposed to the more popular choice of petrol, means the flying Touareg could weigh in at just 1787.5kg



Rather than outright performance, VW engineers concentrated on vehicle dynamics, with careful placement of components

Mitsubishi Pajero Evolution MPR11

The machine to beat has been around for three years now. The Pajero Evolution's first event was the 2002 UAE Desert Challenge in Dubai, and the team contested a full rally raid series both the following year and in 2004, evolving the car consistently. Its evocative style was originally a Mitsubishi design concept and, over eight months, relevant rally raid components were engineered to suit that shape.

As a manufacturer Mitsubishi has the most extensive Dakar history, as, arguably, does its chief engineer, Thierry Viardot. He's worked at the Mitsubishi rally raid workshop in Pont de Vaux, France, for 20 years and 2005 was his 18th Dakar.

The combination of Viardot's experience and the amassed knowledge of Mitsubishi vehicles, together with a unique, strong, working relationship built up over the years with Japanese Mitsubishi engineers, has resulted in a record tally of 10 Dakar wins in 27 years. This year the 4.0-litre V6 engine is 11cm lower in the chassis and 5.0cm further back. This drives via a Ricardo gearbox with an integral viscous coupling-equipped centre diff to passive Xtrac mechanical diffs in each axle. Discussing the car with Viardot on this year's Dakar, his pragmatic experienced attitude shines through. The centre VC has an over-riding mechanical dog lock-up,

The demands of the harsh terrain encountered in the Dakar provide a unique set of problems for engineers to overcome

but the viscous unit itself has a particularly soft setting – sufficiently so for the unit to be in no danger of 'humping'. He also explained his view that 'tuning' the differentials is of very little importance in today's T1 cars, which have comparatively low engine outputs and cover immensely varied terrain. For a T1 to approach the sorts of top speeds available to the lighter buggies, Viardot admits that concentrating on aerodynamic efficiency is important.

It is clear Viardot abides by the 'make it clever, but keep it simple' philosophy common to most top motorsport engineers yet, compared to its rivals, the Pajero Evolution MPR11 encompasses two unique system innovations. For two years the Pajero has used a pull-type Sachs clutch on the output side of the longitudinal gearbox: 'For me the clutch is

➔

Regulation shuffle

Rally raid cars are categorised in the FIA's Group T, and in a move to bring the designations of the groups in the Cross Country regulations more in line with the 'Formula 1, Formula 2' hierarchy, for 2005 the FIA has simply swapped the group names over. T1 used to be for Standard Production (roughly equivalent to Group N), and T2 was Modified Cross Country Cars. For 2005 T1 is now the Modified Production Cars, and T2 is Standard Production. Which makes sense, but Dakar had published its technical rules for the 2005 event to the 2004 FIA regs well before the name switch, which was voted in last December, and therefore stuck to the old group designations. It is simply a name change, which will be valid for all other rally raids this year, and so for the purposes of this discussion we'll stick to the current ruling and refer to the 'works' Modified Production Cars as T1s.

The latest T1 cars can be one-offs but must comply with the International Convention on Road Traffic. Essentially, so long as they are made of non-transparent material, bodies are free. Parts with any aerodynamic influence must be fixed, and there are rules controlling how much of a buggy must be covered by its bodywork. Four-wheel drive T1s cannot be wider than 2000mm, two-wheel drives, 2200mm.

Minimum vehicle weights are pegged to a scale depending on engine cubic capacity. The normally aspirated 4.0-litre Nissan and Mitsubishi, for example, must weigh at least 1825kg. If they were two-wheel drive they must weight 1220kg. These weights are without crew or their kit, but include safety equipment and two spare wheels. If a car is designed with different diameter front and rear wheels (a buggy) and carries three spares during an event, all three may be included at the weight check. Visible ballast is allowed on the floor of the cockpit and is sealed by officials.

All engine charge air must flow through a restrictor: 34mm for two valves per cylinder petrol engines, 32mm for those with more than two valves per cylinder. If a diesel engine is supercharged (turbo diesel) it must have a 39mm restrictor. The equivalence formula for supercharged diesels is 1.5, while a supercharged petrol engine is subject to a ratio of 1.7, and the resulting calculated equivalent capacity (for petrol engines) must not exceed 2000cc.

Petrol engine compression ratios must not exceed 10.5:1, and they must have no more than 22 litres of inlet tract volume between the restrictor and cylinder head. This is set at 30 litres for supercharged diesels. Apart from the above, the rest of the engine rules contain a phrase to gladden the heart of any competition engineer; 'The engine and its preparation are free.'

Gearbox design is also free, providing it has a reverse gear and no more than six forward gears – if it has five forward ratios or less, then a crawler gear in a transfer box is allowed. Sequential changes must only be controlled mechanically, as must injection and ignition 'gear cuts'. Differentials and driveshafts are also free, although differential locking mechanisms have to be directly mechanical, or passive if operating dynamically.

A suspension rule works in concert with the engine intake regulations to bring a level playing field to performances. While suspension design is free, wheel travel is restricted (via steel FIA bump stops) to 300mm for dead axles and 250mm for all other types. The old works prototypes used to run, typically, some 400mm to 450mm suspension stroke and, considering the terrain these machines are designed to tackle, this later rule is very effective in promoting performance equality – it also concentrates the minds of suspension designers.

Systems to enable the inflation and deflation of tyres while on the move were allowed, but have been forbidden for this year. Often this is almost mandatory when trying to extricate a beached vehicle from a dune, but this year the operation can only take place while the vehicle is stopped.

really a critical component in rally raids,' Viardot explains. 'Most of the components, you can control their durability, their life, but the clutch. If you're stuck in dunes, you can burn out your clutch, and because of the clutch you lose the rally. So I said, "I want them to be able to replace a clutch by themselves in a short time."' Hence, crews carry spare clutches and are able to repair a failed unit within minutes.

The team required the latest advanced clutch spring and high temperature friction materials which are uniquely available in proprietary pull-type units. a Sachs pull-type clutch is also used on the Lancer WRC04, so the choice of this type for the Pajero was based simply on economics. Designated GMFZ 2/170X, the rally raid clutch is heavy, yet sits low in the vehicle and helps keep its centre of gravity low. The entire assembly, including housing, hydraulic release system, flywheel and clutch, can be changed in eight minutes, while changing the 9kg clutch module takes about 90 seconds. Temperature and dirt

> "RULES CONTAIN A PHRASE TO GLADDEN THE HEART OF ANY COMPETITION ENGINEER: 'THE ENGINE AND ITS PREPARATION ARE FREE'..."

intrusion is controlled by a pressurised active air ventilation system, and an infra-red sensor monitors temperatures and warns drivers of imminient overheating.

With comparatively unrestricted turbocharged engines, a weight of 1300kg and around 420mm of suspension stroke, the earlier prototypes were quicker than today's T1s, yet Viardot points to an area where advances have been made: 'The only thing with this car is that with such a small suspension stroke – the same as WRC – the performance is really good in rough sections. I would say the compromise on the setting is better than it was in the past, because we have to work. Before, with 400mm, maybe it's not the best [but this] works, it's controlled roll, you do not have too much bottoming.'

Which brings us to the second innovation in the machine to beat: its hydraulically-linked anti-roll bars. Licensed exclusively to Mitsubishi for rally raids (and to Citroën for the World Rally Championship, see Racecar V13 N6), Kinetic's RFS system distributes individual wheel bump forces

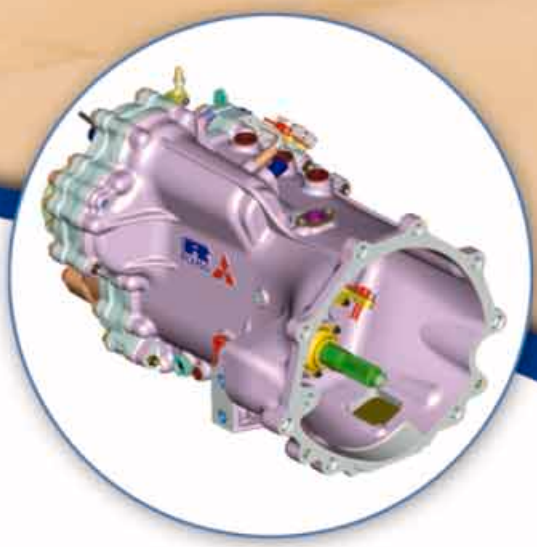
To improve dynamics, this year Mitsubishi mounted its 4.0-litre V6 engine 11cm lower and 5cm further back in the chassis

Suspension design is free, but wheel travel is now restricted to 300mm for dead axles and 250mm for all other types, and is governed by FIA-mandated steel bump stops – the idea being to level the playing field amongst competitors

evenly around all four wheels when a car is in roll. However, in rally raid conditions, traversing undulating dunes and so on, a car is often effectively subject to roll when it is not going round corners, and it would be advantageous for stability and control to disconnected the RFS. Which is exactly what happens in the Pajero – the drivers flick a switch, the hydraulic lines are opened and the system is rendered inactive.

Unlike rivals, the Mitsubishi does not have a mechanism to disengage rear drive when using the handbrake, as a driver aid to facilitate tight turns. Viardot: 'They never use it [the handbrake] in rally raids, except in the prologue in Europe, but you never win the Dakar in the prologue, and I think this is something some other teams do not understand! Even in Morocco you don't win the Dakar – we don't take care about seconds and minutes, I think the unit of measure in Mauritania is 15 to 20 minutes, and it's more interesting than to save 30 seconds in Morocco – we know this with our experience.' RE

Leading by design



Dakar Rally 2005

Ricardo are proud to be the transmission partner to Mitsubishi Motors Motor Sport and a part of the record-breaking fifth successive and 10th overall victory for Mitsubishi in the Dakar Rally.

Congratulations to all involved at MMSP on this amazing achievement in what is arguably the toughest motorsport event in the world. The Mitsubishi Pajero Evolution finished the 2005 event in first and second places, nearly 3 hours ahead of the opposition to clearly demonstrate a superb mixture of pace and reliability over the 8,956km of arduous terrain.

Transmission systems available from stock or designed to suit your requirements, please contact Iain Wight on +44 (0)1926 477152, motosport@ricardo.com

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Rapid improvem

During any design project there is a finite amount of time and funds in which to hone performance. Now a new weapon is accelerating aerodynamic optimisation

Words	Simon McBeath
Photos	Advantage CFD

Computational fluid dynamics (CFD) has revolutionised the speed with which alternative aerodynamic layouts on racecars can be evaluated. By alleviating the need for model (or full-scale vehicle or component) manufacture to test out every option that is conceived, time can be saved, and many more alternative ideas, concepts and directions can be explored in a given time. Scale model or full size wind tunnel validation is still required to verify the computationally derived solutions, but nevertheless CFD is now firmly established in this fertile field of development in professional motorsport.

Now, through the application of 'auto-optimisation' techniques, 'the decimal point in CFD productivity has moved,' according to Advantage CFD's principal Dr Rob Lewis. The key element in this new method is its ability to drastically cut the man hours involved in one of the most time consuming parts of CFD, a process known as 'meshing'.

There are in effect five steps in obtaining solutions from CFD: the CAD model must be generated; this model is then imported into a 'pre-processing' package; 'meshing' is then performed in the pre-processor (the 'mesh' being a three-dimensional grid of possibly millions of points at which the fluid dynamic calculations are carried out); the CFD calculations are then performed on the meshed model; and finally 'post-processing' generates results that enable visualisation and analysis.

Up until fairly recently, making and testing different designs, even where quite subtle changes had been made, involved altering the CAD model and, crucially, then re-meshing the modified model prior to doing another CFD run.

"WHILE CAD MODIFICATIONS MAY OR MAY NOT BE TIME CONSUMING, RE-MESHING CERTAINLY IS"

While CAD modifications may or may not be time consuming, re-meshing certainly is.

Another drawback of this manual method of making design changes and then re-meshing is that it doesn't actually guide the process towards an optimum. The aerodynamicist may have a specific target in mind for downforce, or drag, or lift to drag ratio, or may just be looking for improvement in one or more of those criteria. But only after the output has been analysed can a judgment be made on where to go next to seek further improvement.

This is where optimisation methods first came in. Racecar Engineering reported briefly on one such method in V13N2. Branded as CODAS, it was developed by the former UK government defence research and development agency now known as Qinetiq, and it was described as an 'iterative process combining an aerodynamic analysis (CFD) code, a numerical optimisation code and a parametric geometry generator'.

The methodology centred on making alterations to geometric parameters, for example wing chord, camber or angle of attack, running a CFD analysis, then using a mathematical method to determine whether the result was heading in the right direction relative to predetermined objectives like more downforce or less drag.

Figure 1

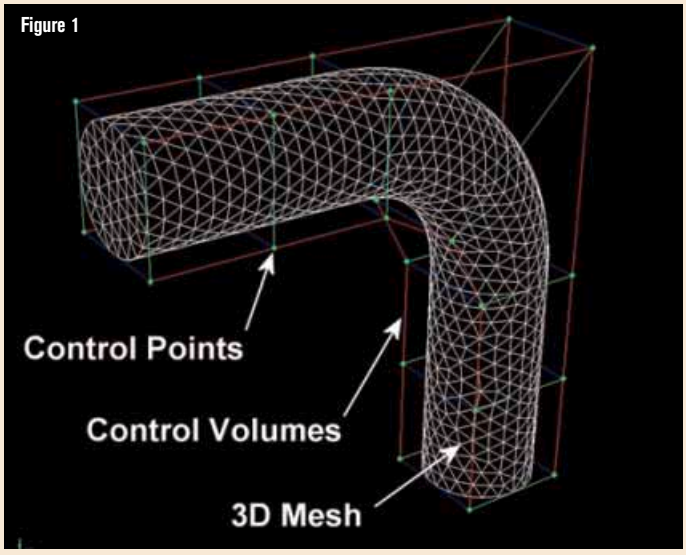
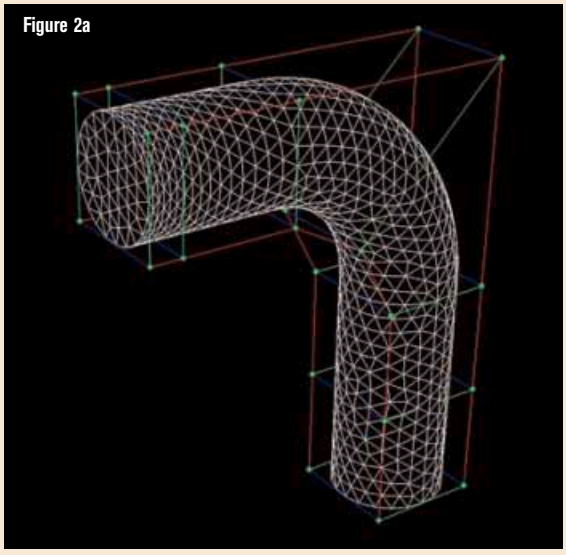


Figure 1 (left): model of a pipe elbow, showing the mesh, together with the control points and volumes that enable the geometry and mesh to be simultaneously deformed

Figures 2a, b and c (right): various types of deformation can be made to the model's geometry without needing re-meshing

Figure 2a



ents

The optimiser and parametric geometry generator combined to speed up the time involved in modifying a design and heading towards prescribed targets. However, after each geometry change had been made and transferred to the CFD module, the use of CODAS still required a new grid or mesh to be generated in the CFD module.

Bring on Sculptor, a new package from Idaho, USA-based company Optimal Solutions, for whom Advantage CFD is the sole European distributor. Sculptor is one of a new breed of 'mesh changing packages' that function not by making shape deformations on the geometry of the object under test, but instead by directly deforming the volume mesh along with the object shape. And this is why Advantage CFD is enthusing about productivity leaps. It has opened up the ability to make a large number of optimisation iterations in a much shorter timeframe than was previously possible because it eliminates the need to do time-consuming re-meshing at each geometry change. Needless to say Sculptor also includes a numerical optimisation code that guides the process towards improved solutions.

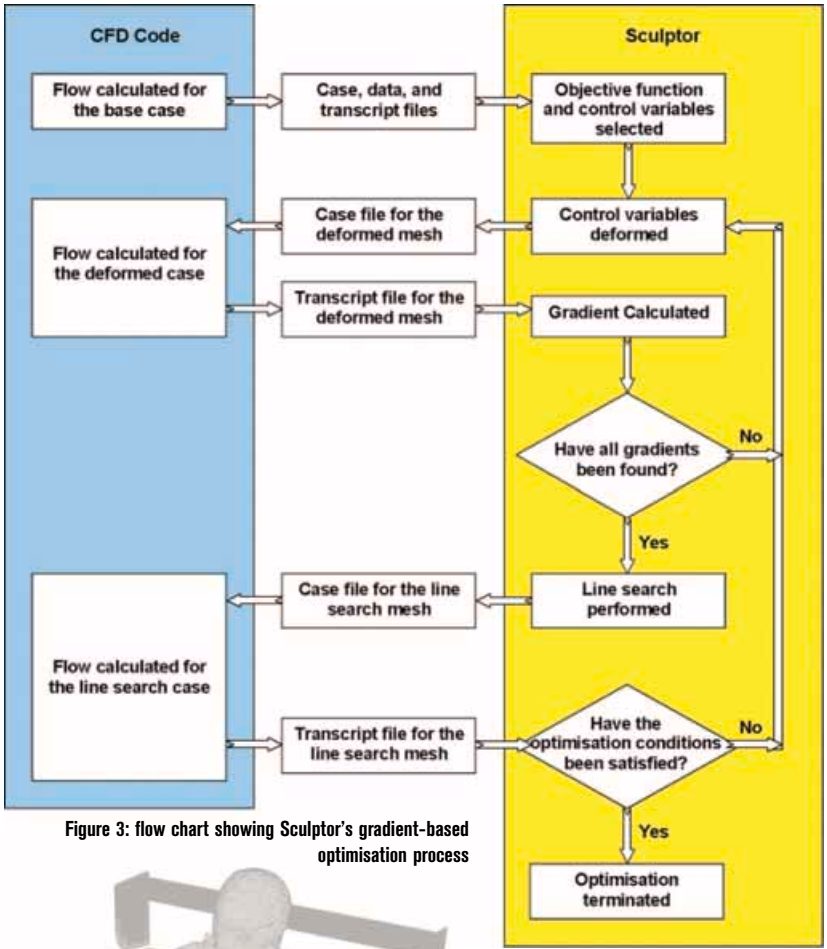


Figure 3: flow chart showing Sculptor's gradient-based optimisation process

Mesh deformation

The technique that enables mesh deformation involves defining what are called 'arbitrary shape deformation (ASD) volumes' around the mesh. The ASD volume can be simple or quite complex, depending on the type of deformation being performed. It is defined by connected control points, as shown in figure 1, which shows a model of a pipe elbow with a mesh defined on its surface. The green control points are joined by red lines to define the control volumes around the pipe elbow.

Once the ASD volume has been created it is 'frozen' – an operation that defines a →

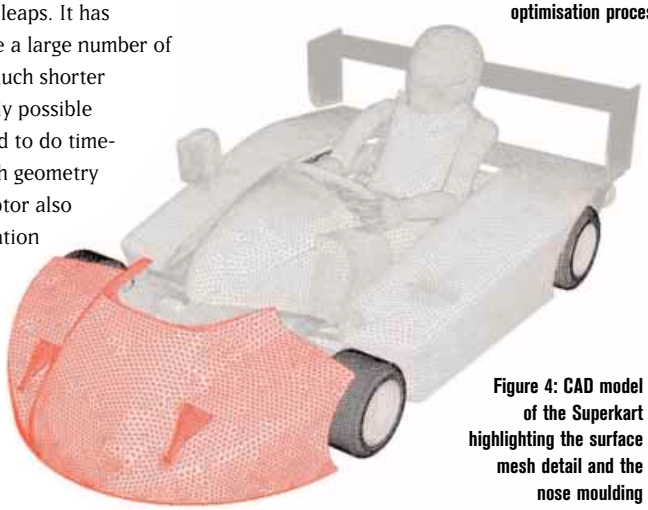
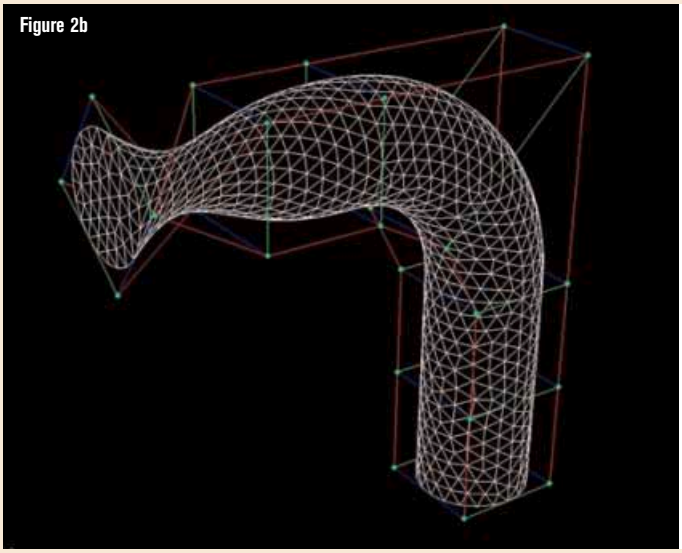
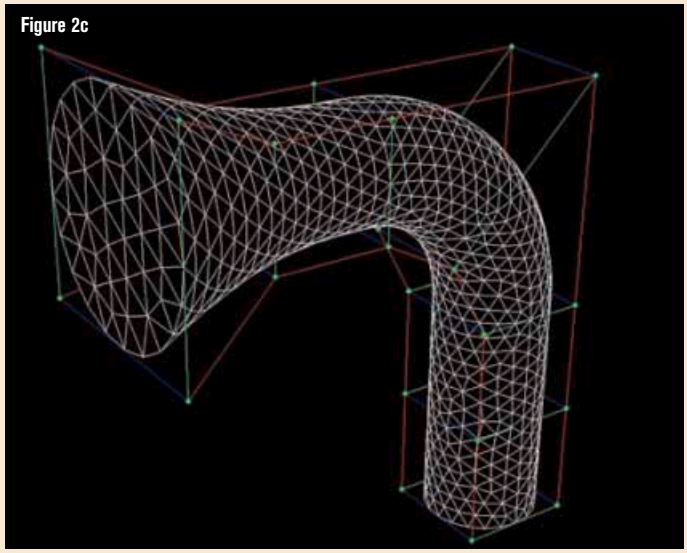


Figure 4: CAD model of the Superkart highlighting the surface mesh detail and the nose moulding





relationship between the mesh and the ASD volume, and moving the control points then deforms the object and the mesh. If you're familiar with CAD, the method is analogous to the way in which a Bezier curve is deformed by altering the position of its control points. While only the surface mesh on the pipe elbow is shown here and in figure 2, the idea is that the 3D mesh in the volume adjacent to the object is also deformed smoothly as the control points are moved. Figure 2 shows some types of deformations that can be made, and their effect on the object shape and surface mesh.

It will be apparent that if substantial deformations are made then the mesh could also deform substantially, and part of Advantage CFD's evaluation of Sculptor investigated how far this process could be allowed to go by studying 'cell skew', which refers to the deformation of the cells delineated by mesh points. The evaluation showed that Sculptor was able to smoothly distribute the mesh deformations and only in extreme cases were skewed cells created.

Optimisation with Sculptor

It is possible to use Sculptor to perform deformations manually, but it does also provide in the code an 'embedded gradient-based optimisation algorithm' that examines the outputs from the CFD solver and guides Sculptor's deformation process towards what it calculates will be an optimum design. To do this it has to be told various things in advance.

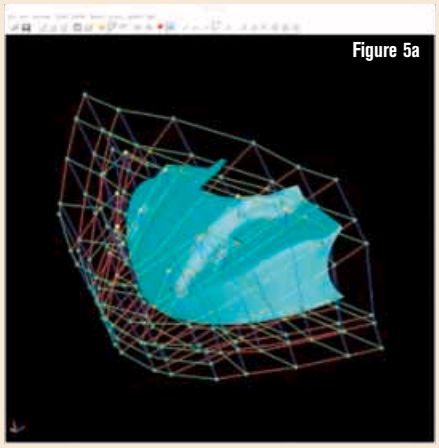
First, the control variables have to be selected. These are the control points, or groups of points, described above that define the ASD volume, and hence the manner in which deformations can be made. The optimiser can deal with any number of these variables so that it is possible to modify different parts of an object or design in a single analysis. Maximum and minimum limits for the control variables must also be set to determine the amount by which an object can be deformed.

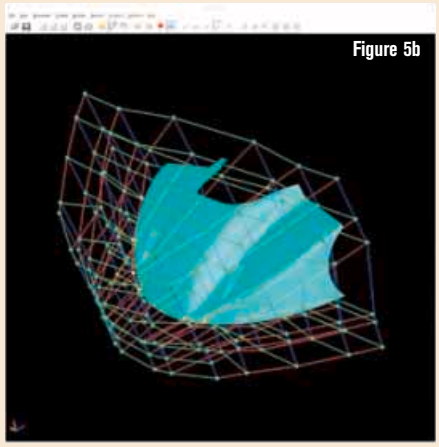
Next it is necessary to define which parameter to optimise. Known as the 'objective function.' This could, for example, be maximum downforce or minimum drag in racecar studies. The optimiser requires that a starting point in the form of a base case solution is imported from the CFD solver, and then the objective function is selected and a target value is specified.

Then the 'optimisation parameters' are set, and these control the speed and the accuracy of the optimisation process. Two of the most important of the optimisation parameters are the 'perturbation value' and the 'objective tolerance'. The perturbation value controls the magnitude of the deformation that Sculptor performs with each step in the procedure, and it needs to be small enough to carry out the optimisation accurately, but not so small that it is troubled by 'noise' in the solution from, for example, small variations in the objective function. It is also important that the perturbation value is not so large that optimal solutions are missed entirely.

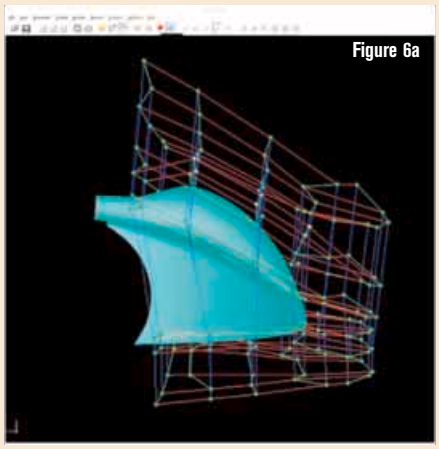
Rob Lewis used an elegant analogy to simply describe how this part of the 'gradient-based optimisation' proceeds: 'Think of it as if you were standing blindfold in a mountain range, and you need to get to the bottom. You need to make big enough steps to find the general downhill direction. If your steps are too small then you just sense the local 'roughness'. Too big and you could step over a valley [and miss your optimal solution]...'

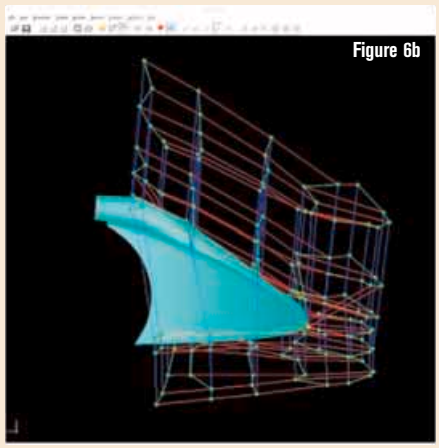
The objective tolerance controls when Sculptor thinks it has reached an optimal solution. If the change in the objective function following a deformation and CFD run is less than the value of the objective tolerance then the





Figures 5a and b: the deformation limits – the height of the outboard section is altered here





Figures 6a and b: the height of the inboard section is altered here

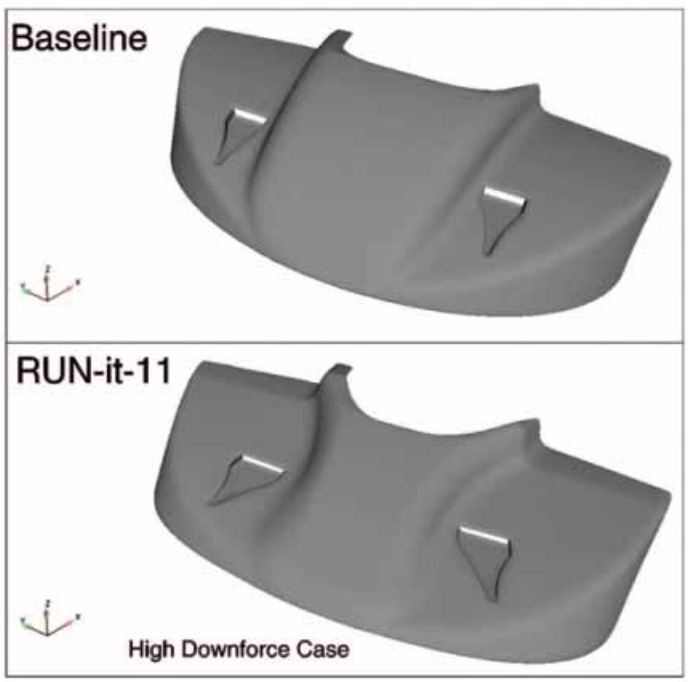
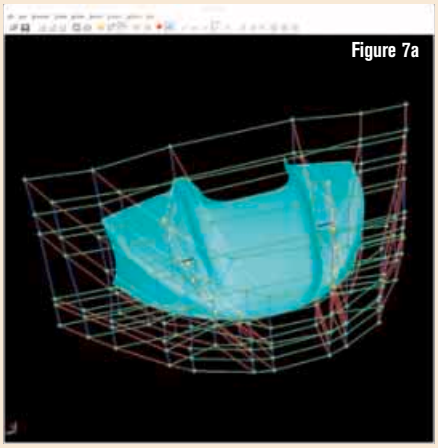
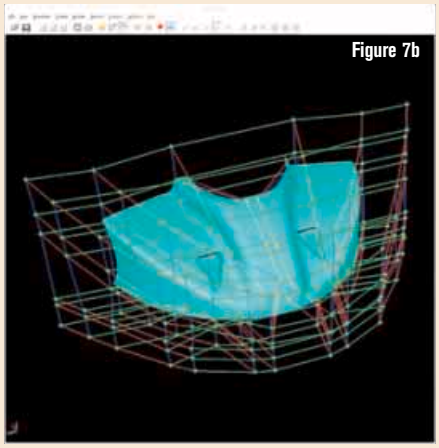
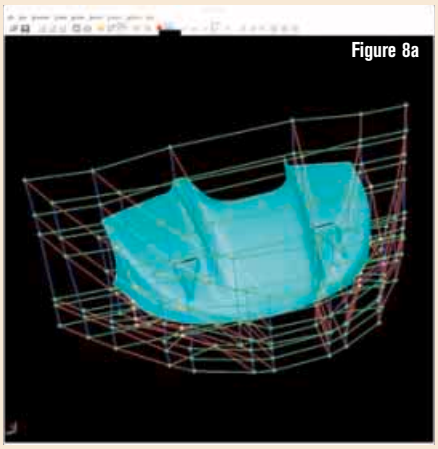


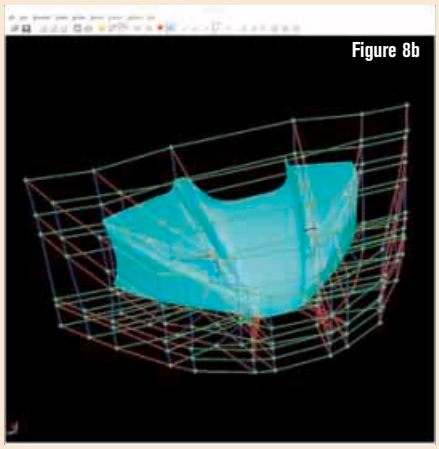
Figure 9: the high downforce Superkart nose compared to the baseline model





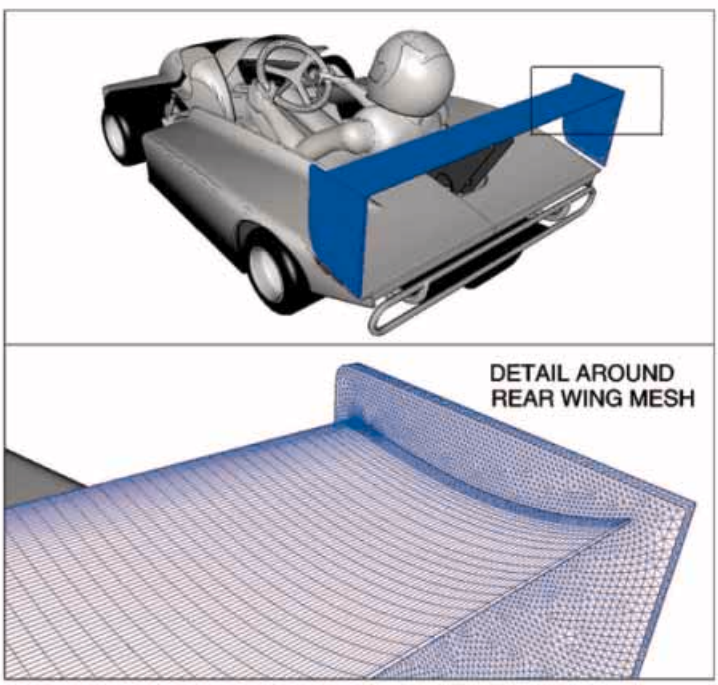
Figures 7a and b: the width of the inboard section is altered here





Figures 8a and b: the curvature of the leading edge is altered here

Figure 10: the kart's rear wing and mesh detail



optimiser decides it has converged on the optimum solution and terminates.

Having established all the requisite controls, the optimiser is launched, and Sculptor then performs all the deformations and CFD runs automatically until the optimiser determines that it has reached the optimum value for the objective function, or until the maximum permissible deformations have been performed. A flow chart describing the process Sculptor undertakes can be seen in figure 3.

In carrying out the optimisation process Sculptor first determines the most promising search direction by calculating the degree of the change to the objective function – be it downforce, drag or whatever – following perturbations to each of the control variables in turn, and making a CFD analysis after each perturbation. This is done by calculating the gradient for each variable in relation to the base case. Once the most promising gradient has been calculated the optimiser proceeds in making perturbations until the objective function reaches a maximum or minimum. Rob Lewis' analogy again: 'Back again, blindfold, in the mountain range and wanting to reach the valley, you make test steps in, say, two directions – forward and back, left and right. You assess each gradient and walk in the steepest direction that should reach the bottom quickest. This gradient test process would probably be repeated. But Sculptor's optimiser is not limited to two variables or dimensions like this, it can handle any number of variables.'

Nose job

To illustrate Sculptor applied to a real world example, Advantage CFD ran a project on the front fairing of a 250cc kart that competes in the CIK-FIA European Superkart Championship. Having already derived data for a baseline case, Sculptor was used to alter four variables in the front fairing geometry to search for the highest downforce and lowest drag cases. Figure 4 highlights the portion of the CAD model that was studied, and shows the surface mesh.

For CFD buffs, the entire model was evaluated using a 3.7 million cell hybrid mesh, with prismatic mesh around the rear wing and the diffuser, while the majority of the domain was meshed using in-house software to generate a hexahedral-dominant volume.

The four parameters on the front fairing that were altered were: the height of the outboard section; the height of the inboard section; the width of the inboard section; and the curvature of the fairing leading edge in the X-Y (plan view) plane. One of the valuable benefits of the way in which Sculptor carries out linked mesh and geometry deformations, according to Rob Lewis, is 'that it allows the type of complex deformations an aerodynamicist would want to make. Where you can only make parametric changes to the geometry using CAD it can be quite restrictive.' Figures 5a/b to 8a/b show the limits of the deformations that were applied to each variable on the fairing via the control points of the ASD volume.

A total of 38 runs were performed evaluating combinations of the four variables to search for various optimal solutions. According to ACFD the 'man time' involved in setting up these cases was a small proportion of the computational time taken to generate the solutions, and a fraction of the time that would have been taken had each case required re-meshing.

The solutions were interesting, too. The lowest drag case found a relatively modest 1.5 per cent reduction in overall drag. In this instance the fairing had a moderately narrower and lower inboard section, slightly higher outboard section, and less curvature on the leading edge. But the highest downforce →

case found 16 per cent extra front-end downforce for only a 1.1 per cent increase in drag, and this fairing had a much lowered nose with again a considerably narrower inboard section, as well as a 'broader' leading edge (see figure 9). The effect of these modifications was to increase the vertically acting surface pressure over most of the fairing's upper surface.

Winging it

In another project, the rear wing on the same Superkart was also subjected to an optimisation exercise using Sculptor. The aim was to change the rear wing geometry to achieve a reduction in overall drag without altering downforce. The project proceeded in two stages – the first stage optimised the span-wise twist and the scale of the aerofoil section size at several locations across the wing, the second stage then scaled the output from the first stage to match the original downforce level achieved by the original wing while generating less drag.

Similar CFD parameters were set up to those used in the nose optimisation project, and figure 10 shows some detail of the initial rear wing mesh. The kart was originally fitted with a two-element wing, but ACFD decided to change to a single element wing to help produce a more efficient way of generating the same level of downforce (see figure 11).

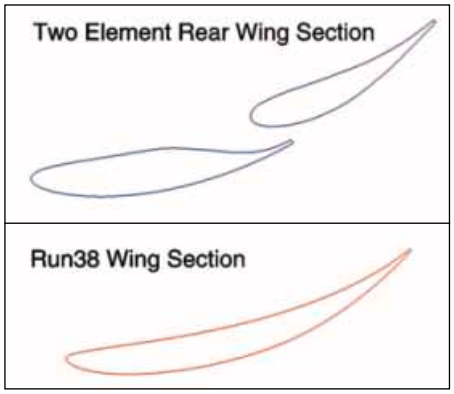


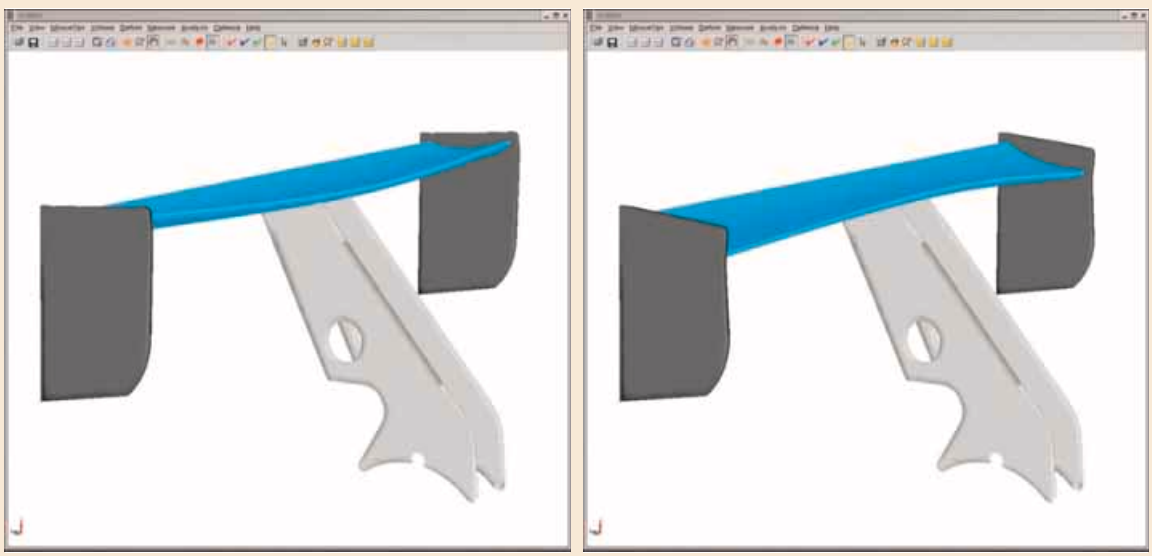
Figure 11: the original wing was two-element, ACFD switched to a single element to improve efficiency

The variable parameters for this project were: angle of attack of the outboard sections of the wing; angle of attack of the inboard section; section size of the outboard section; section size of the inboard section. These variables are illustrated in figures 12a/b to 15a/b. Once these parameters had been defined, Sculptor was set to work on the original case file again to achieve optimal solutions that met the project aim. Again, the time taken to set up and make the geometry changes with Sculptor was small in relation to the computational time involved, due to not having to re-mesh each change.

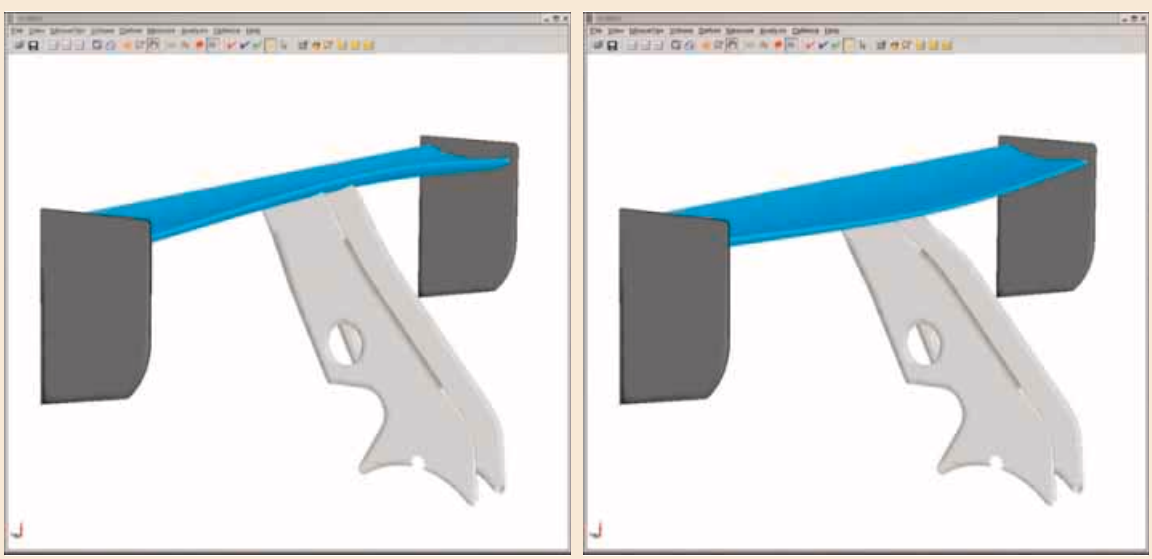
Initially stage one, comprising 36 runs, achieved an optimised wing profile. Stage two comprised further runs to scale up the profile found in stage one, to achieve the same level of downforce as the kart's original wing but with 1.8 per cent less drag. The last run went one step further to achieve 4 per cent more downforce for the same drag as the original wing.

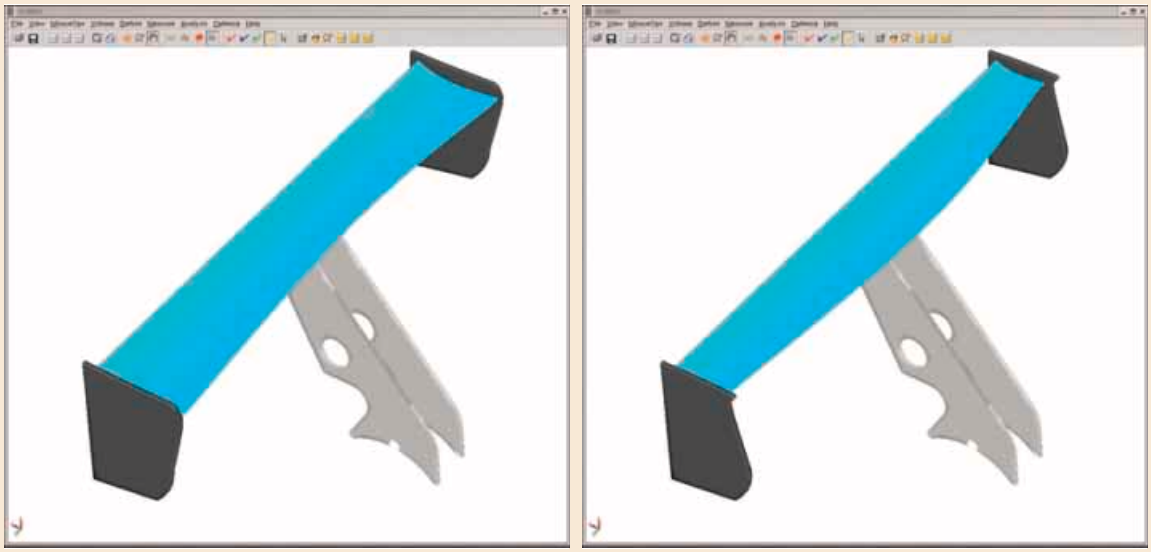
Figure 16 shows the geometry of the lower drag wing, and the variation in section along the span. It can be seen that the outboard sections have a longer chord, but also a reduced angle of attack compared to the inboard sections. Such a design, with a lower lift coefficient (shallower angle of attack) near its tips, reduces wing tip vortex formation, which is responsible for the reduction in drag seen here. ➔

Figures 12a and b: the deformation limits on the angle of attack of the outboard section of the Superkart rear wing

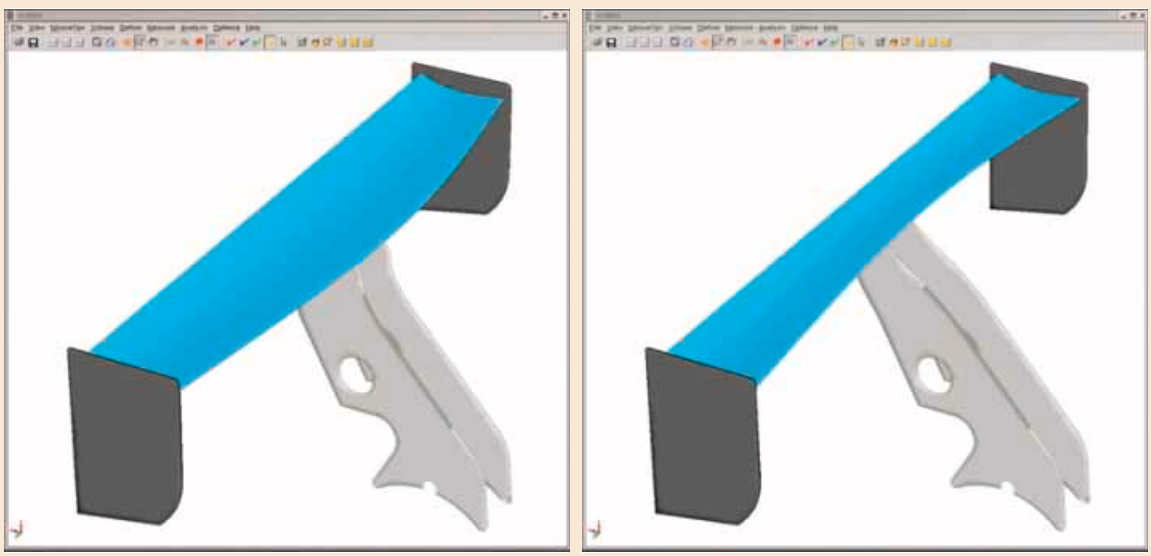


Figures 13a and b: the deformation limits on the angle of attack of the inboard section





Figures 14a and b: the deformation limits on the section size of the wing's outboard section



Figures 15a and b: the deformation limits on the section size of the wing's inboard section

Summary

Clearly, auto-optimisation based on mesh deformation is a very powerful tool to add to the aerodynamic research armoury, and it appears to have removed one of the principal constraining bottlenecks to the rapid evaluation of options. One result of this step forward is that attention seems to have re-focussed on the limitations of available computing power, and even though this continues to increase, probably, like brake horsepower, it will always feel inadequate.

It is all too tempting to speculate on where this type of optimisation will lead us. One can't help making the leap of imagination to a situation where aerodynamicists arm themselves with the rule book that stipulates the dimensional constraints for a racecar category, draught an initial crude shape that fits the 'boxes' thus defined, and then feed the base case CFD file into a combined optimiser/mesher programme like Sculptor to produce the perfect solution in terms of downforce and drag. Thankfully there are probably at least as many optimum solutions as there are cars, tracks, drivers and racecar engineers.

In the meantime, this new optimisation tool should see a rapid expansion in the detail aerodynamic changes we see taking place where CFD is being used for aerodynamic development. But we're going to have to be ever more observant to spot them.

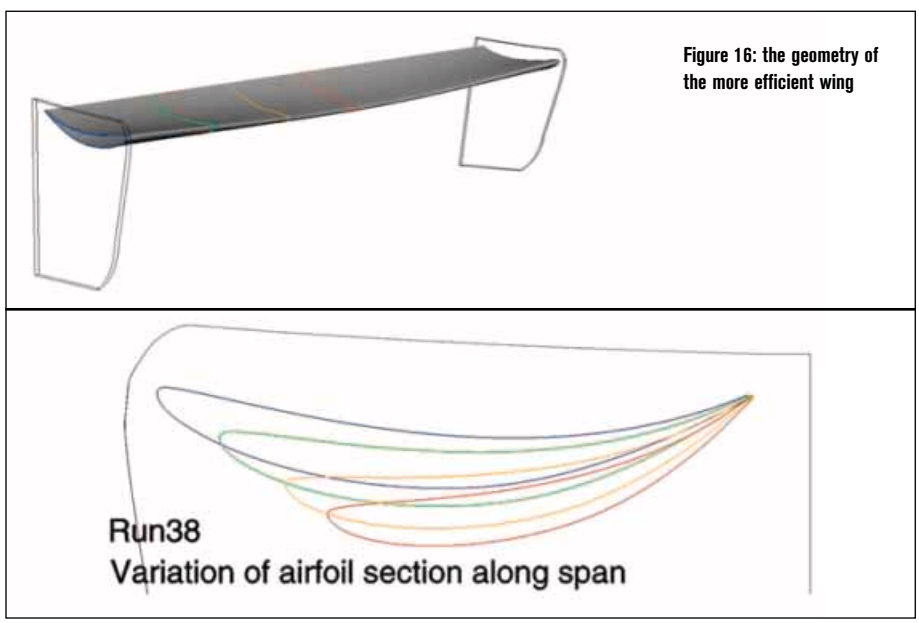


Figure 16: the geometry of the more efficient wing

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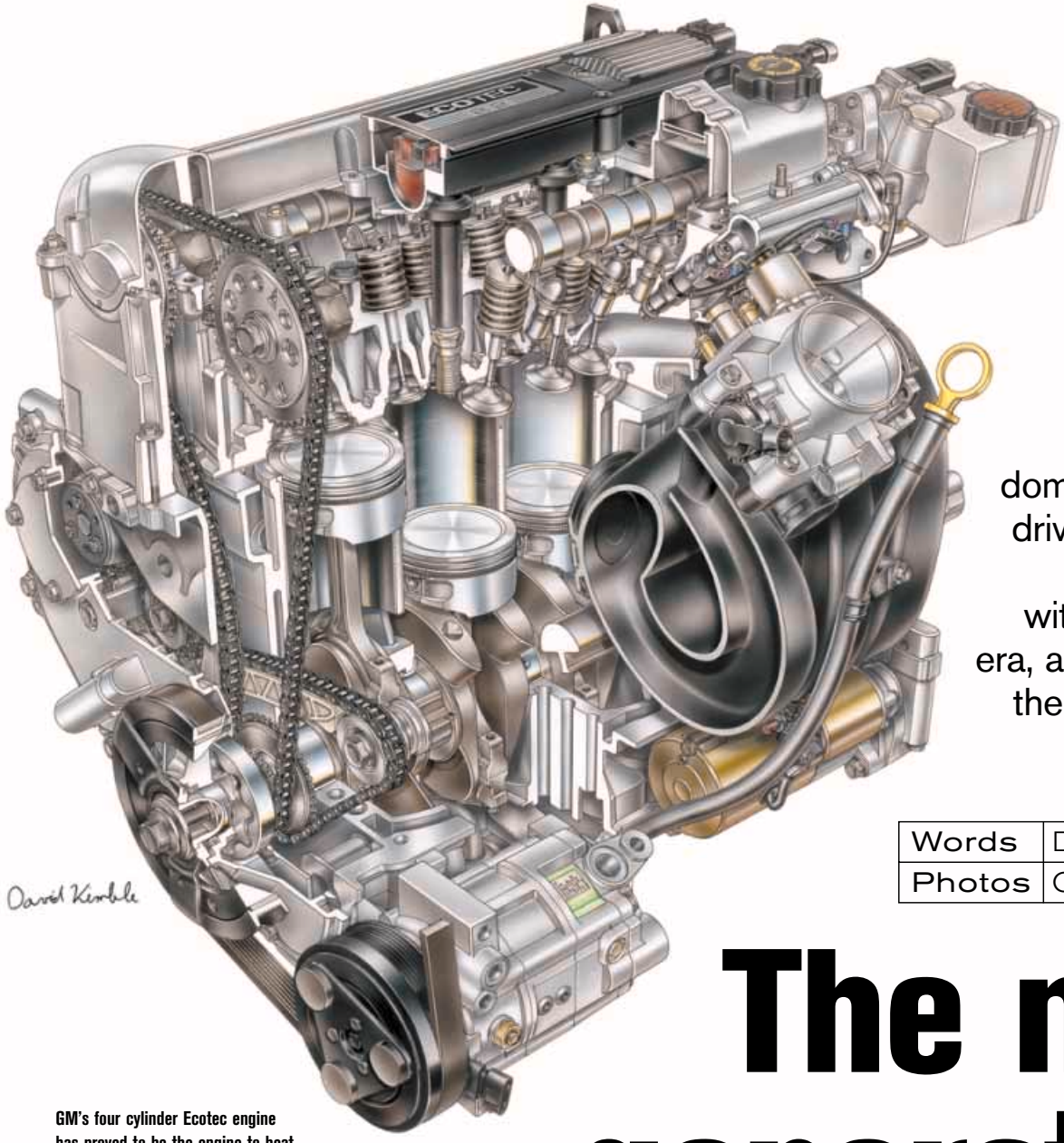


GM's four cylinder Ecotec engine has proved to be the engine to beat in the new sport compact class, powering more winning cars than any other powerplant

In a sport traditionally dominated by rear-drive V8 racecars, drag racing is witnessing a new era, and it's bringing the manufacturers out in force

Words	Dan Carney
Photos	Carney

The next generation

Popular social trends in the US are driving engineers and race tuners to face the challenge of developing vehicles, that are seemingly unsuitable for racing, into ferociously serious equipment. Probably no less ideal vehicles have served as the foundation for race vehicles since the arrival of heavy truck racing, but small, lightweight, front-drive cars designed for low cost and high fuel economy are now the hottest category in drag racing.

Drag racing has traditionally been the home of powerful V8, rear-drive cars, which possess encouraging building blocks for creating cars that accelerate rapidly over a short distance. But few such cars are available in new car showrooms, even in the US, and those that are available are typically beyond the budget of young enthusiasts.

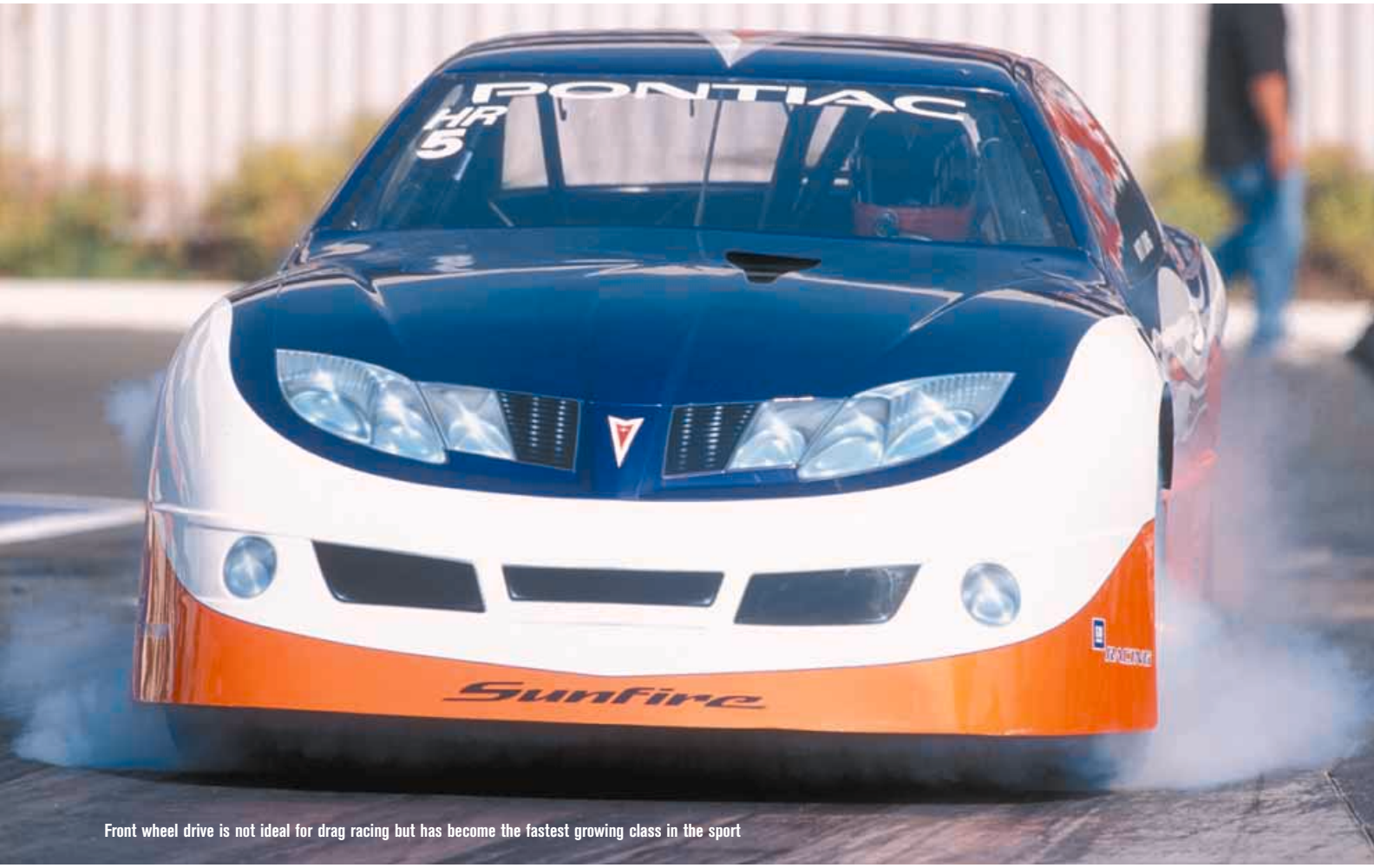
The result was that during the mid-'90s, increasing numbers of young Americans – especially Asian and Hispanic drivers in southern California – embraced economy cars as the starting point for building drag race cars.

"WHAT STARTED AS A GRASSROOTS FAD HAS BECOME A NATIONAL INDUSTRY"

Since then, what started as a grassroots fad has become a national industry.

The National Hot Rod Association (NHRA), the leading US sanctioning body for drag racing, embraced the cars, which have become known as 'sport compacts' and a new segment of the aftermarket performance industry has sprung up to provide racers with the hardware. Just as significantly for those parts suppliers, for each real racer there are dozens of imitators who want to give their daily driver the appearance, and maybe some of the performance, of a full blown racecar.

Different competitive categories permit different levels of modification, but NHRA's Hot Rod category attracts the most attention



Front wheel drive is not ideal for drag racing but has become the fastest growing class in the sport

because the cars retain significant portions of the production car, such as the unibody 'shell and production engine block and head castings. Tremendous freedom is permitted otherwise though, which is how mild 150bhp economy cars become 1000-plus horsepower racers able to slingshot down a quarter-mile drag strip in less than 8.5 seconds.

The stunning popularity of sport compact drag racing draws automakers to the sport in the hopes of winning the favour of young drivers at the beginning of their car-buying lives.

Manufacturer involvement

The question is how such power is achieved from such humble origins. The answers seem obvious: turbocharging and nitrous oxide. Turbo engines have become increasingly popular, both as original equipment and as factory-backed aftermarket equipment in recent years, as cars like the Subaru WRX, Mitsubishi Lancer Evolution and Dodge SRT-4 have come storming onto the market.

'Turbo development has come a long way,' observed Javier Ortega, head of NHRA's sport compact Hot Rod division. 'Gone are the days where guys take a turbo off the shelf and expect to make gobs of power.' Today's race engine builders carefully match the airflow potential of the engine's displacement, its head design and its camshaft characteristics. 'No more are they using these hair dryer-sized turbos that suddenly make power at 12,000rpm when they need it at 8000,' he said.

This development accelerated when manufacturers became interested in making sure their cars performed as well as possible. 'Because the manufacturers see the value of this type of racing, they have put development into the parts for these cars,' Ortega said. 'This is a golden era for turbochargers.'

> "THIS IS A GOLDEN ERA FOR TURBOCHARGERS"

Cars that don't come with factory turbos still use them for racing, and those that do, have the factory turbocharger replaced with something suitable for making more power. 'A turbocharger is not a cheap piece,' said Ortega. 'If you are trying to get a good turbo you are paying over $1000 (£550).'

The rise in popularity of turbocharging is attributable to the development of sophisticated, but affordable, electronic engine management systems that can keep turbo motors within their range of safe operation without blowing up. 'We totally owe it to the engine management computers,' Ortega said. 'That's the reason turbocharging wasn't successful years ago. A turbocharged engine is only going to live under these conditions with the right fuel mixture and ignition timing.' But it takes more than just bolting on a turbo or a nitrous bottle, or both, to make massive horsepower instead of just a massive explosion.

The Dodge, for example, produces over 1000 horsepower using a stock engine block, according to Greg Reeves, engineering manager Mopar racing parts at DaimlerChrysler Corporation. 'We really don't do a lot to it,' he said. 'other than fill in with block filler to support the cylinder walls.' The filler is a cement-like epoxy put in the block's water jacket, with only a little space left for coolant.

According to Gary Reed, vice president for special racing projects at Toyota Racing Developments, another solution is to weld in braces and gussets. 'In many cases the block is the limiting factor,' he said. 'The block starts flexing and eventually it causes a crack.' Toyota uses its four-cylinder truck engine as the foundation of its drag racing engines because they use iron blocks for greater durability. →

Although apparently unnecessary on a front-drive car, wheelie bars have become a necessity as teams struggle to get the power down on the track

It is even possible for manufacturers to improve the strength and stiffness of their production blocks, based on the experience of racing them. That was the case for the General Motors Ecotec engine. Although the engine is a very new design, engineers working on the racing programme found weaknesses in the aluminum block casting and pointed them out to the production engineers. 'Early on we failed some blocks, so we were able to make some recommendations,' said Russ O'Blenes, technical manager of sport compact drag racing for General Motors. 'We worked directly with the block design engineer.'

Limiting factors

While the racers struggled with failures, the production team was tasked with improving the engine's NVH characteristics for use in a new generation of cars aimed at a higher segment of the market. With the addition of some crucial gussets, some added wall thickness and some radiused corners, both purposes were served. 'It was nice we were able to make an impact on the reliability of the production stuff,' said O'Blenes. 'The feedback we were able to give the design engineers made them able to improve the production package.'

'We are pretty significantly over 1200bhp now,' said O'Blenes, of the Ecotec programme. 'We made over 85 dyno pulls, with over 70 of them on the same engine. They were all within a per cent or so of the original run.'

The Dodge race engines employ simple, sheetmetal head gaskets to withstand the substantial combustion pressure but at the bottom end, the production hardware hasn't proved up to the task, said Reeves. As is the norm, aftermarket pistons and rods are fitted, but even race-prepped production crankshafts couldn't handle all of the power. 'We've broken quite a few crankshafts,' Reeves said, 'and we haven't found any forged cranks that are close in size, so we are doing a billet crankshaft.

> "WE TOTALLY OWE IT TO THE ENGINE MANAGEMENT COMPUTERS"

'The aftermarket rods are aluminum, rather than titanium,' he added. 'We probably don't need titanium for this application.'

While parts, such as rods and pistons, are available off the shelf, others, like billet cranks, must be custom fabricated. 'When you make them one-off, they are too expensive to sell and make a profit on,' observed Reed. 'It might even be beyond the means of an independent racer to buy them. But if the demand is there, we can tool up and the cost comes down.'

Such custom work is especially tricky with regard to improving the flow of the production head casting. 'The problem you run into is that the head was originally designed for low emissions and maximum fuel economy, but in racing you aren't worried about that,' Reed said. 'You have to modify that to maximise horsepower so the engine can breathe. You have to redo all the porting and work on making the best possible combustion chamber area.'

All of this work is very time consuming, which again makes such parts costly. 'If you make one or two of them, you can make them by hand,' said Reed, 'but if you are going to make 16 to 20 of them, you write a CNC machine program.'

With such a prodigious increase in power output, naturally the transmissions need an upgrade, too. 'The limiting factor is the clutch and transmission,' said Reeves. 'We're trying a new transmission this year. It is a racing transmission, with a three disc-type of clutch. It is like a Formula 1 transmission turned around backwards in the car.'

Clutches, and the way the prodigious power is fed through them, is critical to all top drag teams. Sport compact racers, such as Mike Crawford in the Dodhe SRT-4, started out with sintered iron clutches but have progressed to carbon-kevlar which allows some slippage and prevents continual axle breakage

Despite their apparent non-suitability for drag racing, so-called sport compact cars have come a long way in a very short space of time, and manufacturers have been quick to capitalise on the burgeoning aftermarket possibilities

'The gearbox has proven in the past to be a weak link,' echoed Reed. 'Teams are still trying to find something that doesn't break,' he said. 'Most are using what started out as high performance dune buggy gearboxes.'

The final solution may prove to be this season's legalisation of sequential gearboxes.

"IT'S ALL ABOUT WEIGHT TRANSFER... DAMPER VALVING IS CRITICAL TO GETTING A FRONT-DRIVE CAR TO ACCELERATE"

'We just allowed sequential transmissions in the Hot Rod class,' Ortega said. 'A few competitors are working on it so we should see some more competitors with them soon.' Xtrac, Quaife and G-Force Transmissions are all supplying the sequential boxes.

The clutches are also critical. 'The way front-wheel-drive drag racing developed, at the beginning they wanted a really strong clutch with a sintered iron material,' said Ortega, →

'but that was very violent and you'd break transmissions and axles. Carbon Kevlar allows some slip, so it actually accelerates better.'

Automatic transmissions are also allowed, and are GM's preference. 'We really feel an automatic is a big advantage,' said O'Blenes. 'Every time you shift, it unloads the turbo. Plus you get the torque multiplication from the torque converter.' The company uses its standard 1465E automatic transmission for front-drive V6 cars. 'We run all stock gears, baskets and planetary parts,' he added.

As with the Ecotec engine, O'Blenes was able to influence the manufacturing production team to improve the standard product. 'On a daily basis we are in direct contact with the production engineer. We showed them some structural modifications that could be made to the transmission case that would help some high

"150BHP ECONOMY CARS BECOME 1000-PLUS HORSEPOWER RACERS"

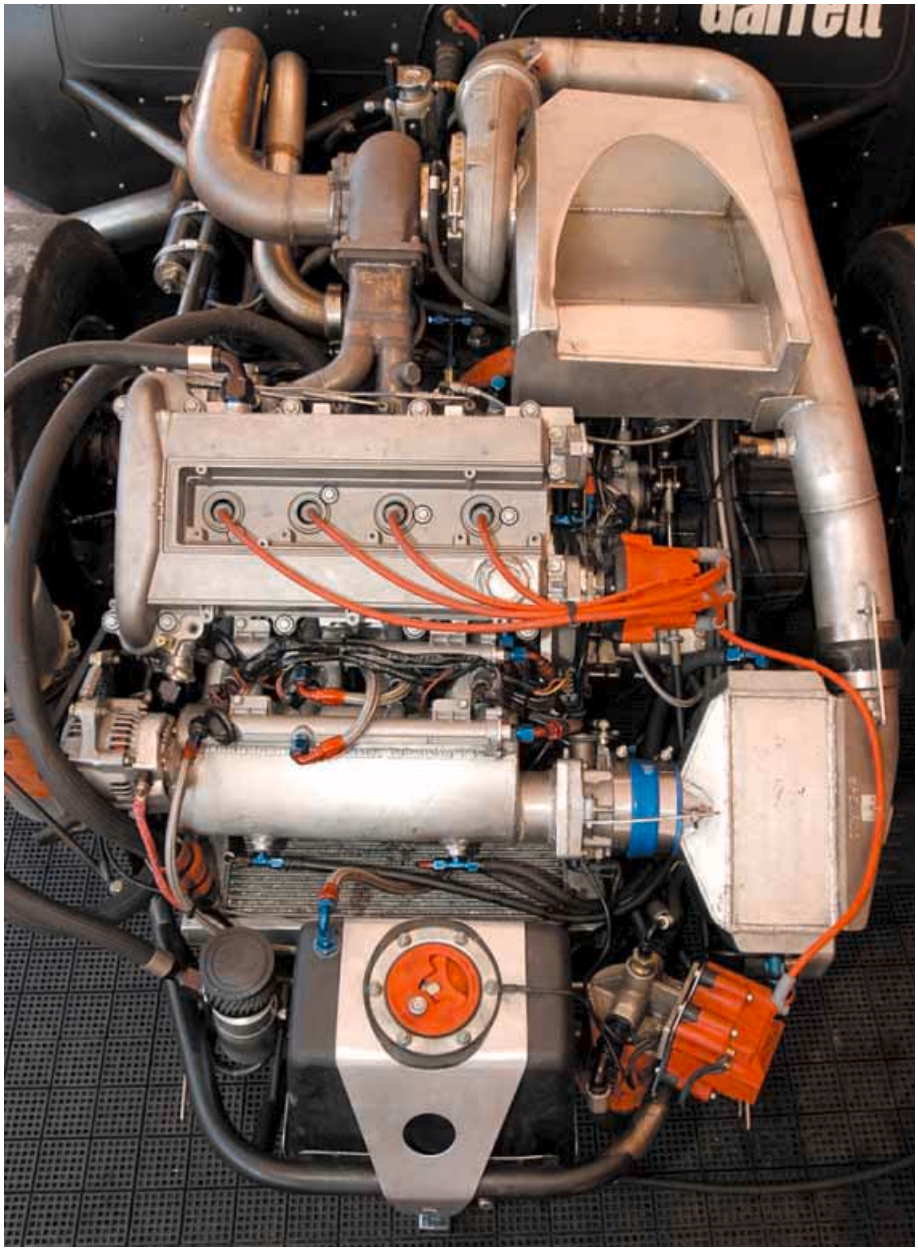
wear parts they see in warranty. There's a standard support sleeve, that for real high mileage cars they see as a wear issue.'

Standard, front-drive driveshafts are also woefully inadequate to the task of putting more than 1000bhp to the wheels. 'One of the first hurdles was the axle shaft,' recalled Ortega. 'On a typical front-wheel drive car, the axle shaft wasn't designed to handle 1000bhp. Teams broke them all the time, so some of them used to carry 10 or 20 axles.'

Using purpose-built racing axles has mostly solved the problem. 'Now they might carry one spare,' he said. The leading axle suppliers are Mark Williams and The Driveshaft Shop, he said. 'They are both great products, but each individual has a budget. With Mark Williams, money is no object. The Driveshaft Shop caters for teams with a budget.'

Driveline durability has also benefited from the use of brakes to hold cars on the line before launch. 'They now use a hydraulic handbrake to hold the car,' said Ortega. 'They apply the brake and actually pretend they are going to launch, and then let the clutch out a little bit. Now you are loaded and ready to go. When you launch, the shock to the driveline is reduced.'

The launch procedure using the hand brake sounds complicated at first, but ultimately is successful. 'They release with the hand brake, which is the lever next to the shifter,' Ortega said. 'In order to launch, the car just has to be in first gear. They push the brake lever forward to release, so when they let go they are able to reach forward and grab second gear.'



The ancillaries may be a far cry from the production engines but the internals of GMs race Ecotecs are surprisingly similar

Pre-loading the driveline also serves to get the car's wheelie bars in position to help with the launch. Wheelie bars were invented to help prevent rear-drive drag racers from lifting the front too high under acceleration, so they were seemingly unneeded for front drivers.

But front drive cars need to minimise rear weight transfer, and the wheelie bars can give the cars a longer effective wheelbase. 'The first innovation for better traction was the introduction of wheelie bars to the front-wheel drive car,' said Ortega. 'The rules mandate that the wheels on the wheelie bars must be free rolling at the starting line, but the moment the lights go off, the wheelie bars are okay to touch the ground,' said Ortega. 'The minute they let go of the clutch [to pre-load the driveline], the car will squat on the back, thereby applying weight to the wheelie bars.'

According to O'Blenes: 'You try to get the wheelbase as long as the rules will allow because it changes your lever point.' The NHRA (National Hot Rod Association) says the wheelie bars may extend no more than 65in from the back of the rear bumper to the centreline of the axle on the wheelie bars' wheels.

Damper valving is also critical to getting a front-drive car to accelerate and, if you look at the Hot Rod class, you only see one brand of shocks – Penske. 'It's all about weight transfer. They don't want the car to come up as fast as it does. When the weight wants to transfer to the back, they have a little more resistance.' So abundant rear compression damping discourages rear squat. Meanwhile, soft front rebound damping lets the tyres stay on the road when the front rises. 'You have to keep the power planted on the ground,' he said. →

Having a stiff body structure is also helpful to good traction. Although the production unit body structure is retained, the roll cage contributes significantly to the stiffness of the cars. 'It is a full race cage,' said Ortega, 'from the b-pillar back, you cut off the trunk, but it needs to keep the rear shock tower assembly. We don't allow the whole front to be tubes, but we do allow tubing from the front shock towers forward. The firewall and the shock towers however must be stock.'

According to O'Blenes, the biggest concern was getting the structure right. 'We were able to take everything we learned in designing the car [for manufacturing] and optimise it with the minimal number of tubes.'

All this production-based technology has contributed to the Hot Rod class becoming the most popular and competitive class in this new era of front-drive drag racing. O'Blenes: 'What is nice is that it is closely production based. Our cars are pretty advanced but, with proper modifications, you can come straight out and be pretty competitive.'

"WE WERE ABLE TO MAKE AN IMPACT ON THE RELIABILITY OF THE PRODUCTION STUFF"

But being competitive is getting harder all the time. While current cars run the quarter in less than 8.5 seconds, this has come up pretty quick. The teams see the next barrier falling soon. 'We've been testing a lot,' said O'Blenes. 'Our goal is to be the first Hot Rod in the sevens...' RE

NHRA Sports Compact rules

Hot Rod class
Four-cylinder, front-wheel-drive cars only
Tube chassis prohibited

Engine:
Maximum displacement 2.5-litres
Engine swap permitted, but must be from same manufacturer as body
OEM block and head mandatory
Maximum two power adders (turbocharger, nitrous oxide etc.) permitted.
Dry sump permitted.
All engine block and head castings must be available in a production car or truck from a recognised OEM production assembly line, with a minimum production run of 5000 units

Fuel:
Only methanol, NHRA-accepted ethanol, or NHRA-accepted gasoline (petrol) permitted

Nitrous Oxide:
Commercially available nitrous oxide permitted, including supercharged and turbocharged engine

Supercharger:
Permitted (though screw-type supercharger prohibited)
Liquid intercoolers limited to water and/or ice only

Turbocharger:
Maximum turbo size: 78 mm, single configuration only
Injection of any liquid, gas or any other substance into the inlet or exhaust housing prohibited
Turbocharger compressor wheel must be constructed of cast or billet aluminum (exotic material wheels prohibited)

Transmission, Automatic:
Non-original, OEM automatic transmission permitted, but will be assessed a weight penalty
Transmission brake permitted

Transmission, Manual:
Aftermarket or non-original OEM transmission permitted
Automated, timer-type, pneumatic, electric, electronic, hydraulic, etc. shifting mechanism prohibited
Each individual shift must be a function of the driver and controlled manually
NHRA-accepted aftermarket clutchless transmission permitted with 150lb weight penalty
Aftermarket transmission must be accepted by NHRA prior to use

Suspension, front:
Upper mounting point for strut assemblies must be in a factory location
Adjustable camber/castor mounts are permitted
Lower control arm may be strengthened provided factory mounting points to chassis are maintained
Aftermarket or fabricated lower control arms must use original mounting points
Lower mounting point for strut assembly may be modified for improved castor or camber
Strut tower braces, lower tie bars, sway bars and limit straps permitted
Traction bars/devices permitted – must be bolt-on only
All front suspensions must utilise one, and only one, working shock absorber/strut per wheel
Shock/strut must attach to original OEM upper mount and maintain minimum 1in wheel travel

Suspension, Rear:
Factory independent suspension may be replaced with straight axle suspension, but must retain original upper mounting points
Strut tower braces, lower tie bars, sway bars and limit straps permitted
Rear suspension must maintain minimum shock travel of 1in
All rear suspensions must use at least one working shock absorber per wheel
Strut must attach to original OEM upper mount

Wheelie Bars:
Permitted (maximum length 65in from rear bumper)
May be adjustable, but must be fixed during run
Pneumatics, hydraulics, electronics etc prohibited
Wheelie-bar wheels must spin free at the starting line – any preload prohibited

Frame:
Centre driver position prohibited
OEM chassis, with complete OEM firewall mandatory
Wheel tubs, tube chassis etc prohibited
Non-OEM tubing in front of firewall prohibited, except to tie shock towers to rollcage
Must retain original wheelbase for body used, plus or minus 2in
Maximum wheelbase variation left to right is one inch

Tyres:
Drive tyres maximum width of 10.5in
Non-drive tyres must be for automotive use, with a minimum width of 3in

Body:
OEM 'shell must be retained, with original rear wheelwell opening, and must be readily accessible for inspection
Other body panels may be replaced with lightweight replacement panels
One-piece, lift-off front ends permitted
Front spoiler/lip permitted, maximum 1in
(NHRA is evaluating the use of non-OEM aerodynamic devices such as lips or wickers on wheel openings, or wickers on rocker panels, side skirts, underbody diffusers etc and may prohibit such items for 2005)

Data Recorder:
Permitted
Wheel speed sensors of any type on any wheel, including wheelie-bar wheels, prohibited

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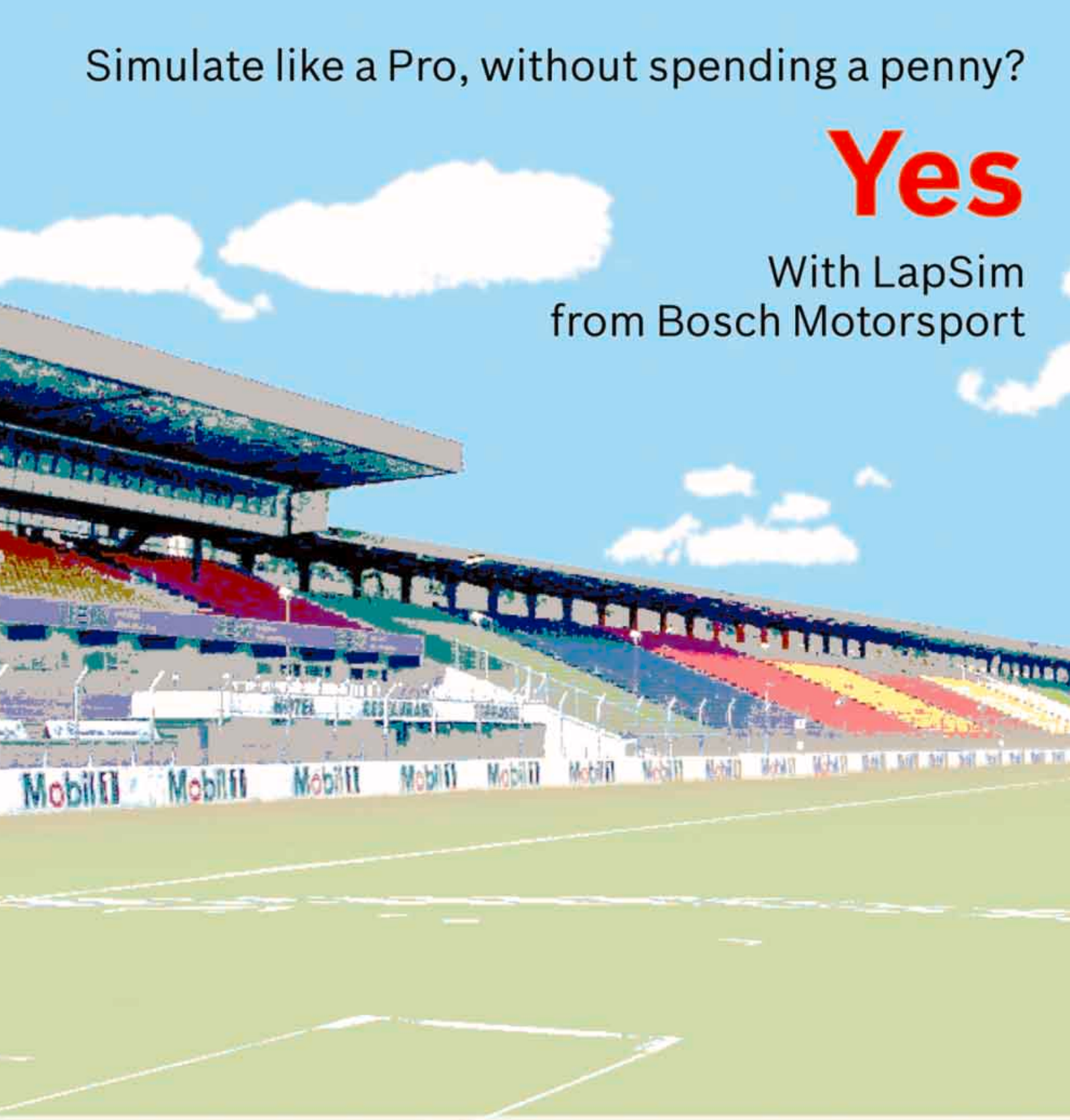

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Raceshop

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

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

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via: racecar@ipcmedia.com

Race simulation software

Words | Ian Wagstaff

Modern simulation software can save both time and money in development and on-track testing

The design, construction and development of a racecar is an expensive and time consuming process involving continual iterative changes in design and set-up to refine the vehicle and enable a driver to lap as quickly as physically possible. The performance of the car will depend on the ability of an engineer to continually enhance his understanding of the effect that design and set-up parameters have on ultimate track performance.

Traditionally, if a designer wanted to explore the effect of a design feature, or a race engineer investigate the effects of changing a set up parameter, it was necessary to build a car, take it to a race circuit and perform detailed testing to understand the effect of each variable on lap time through analysis of on-board data recorded during testing.

However, companies such as Pi Research, DATAS and Bosch Motorsport have produced race simulation software that mean the designer or engineer doesn't have to stray from his computer, or even touch a real car. 'What if' virtual tests can be run without the car even having to take to the track. By entering a range of information, the engineer defines the physical characteristics of the car and constructs a complex mathematical model. With this he can modify the design or set-up of the vehicle and simulate the outcome with his mouse. As DATAS co-founder Chris Murphy states, this means 'no hardware costs are involved, and there is nobody to upset.' However, Pi's Damian Carter points out that, despite the capabilities of simulation software, it is important to emphasise that simulation is not a magic solution. It cannot design a racecar, or automatically define the optimum set-up, and in no way replaces the designer or engineer. Motorsport will always encompass variables that cannot be fully simulated – not least of all the drivers themselves. →

> **"'WHAT IF' VIRTUAL TESTS CAN BE RUN WITHOUT THE CAR EVEN HAVING TO TAKE TO THE TRACK"**

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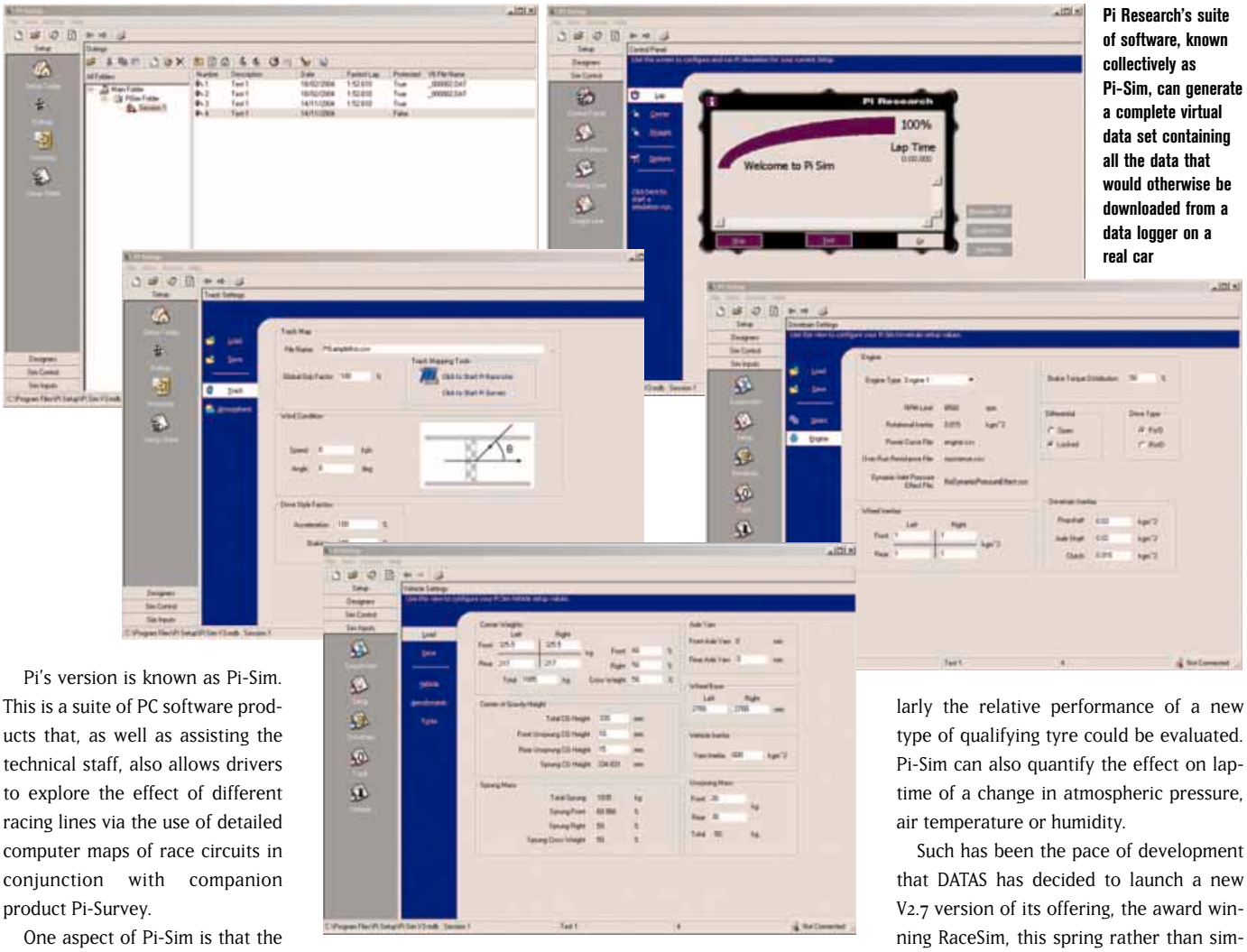


Pi Research's suite of software, known collectively as Pi-Sim, can generate a complete virtual data set containing all the data that would otherwise be downloaded from a data logger on a real car

Pi's version is known as Pi-Sim. This is a suite of PC software products that, as well as assisting the technical staff, also allows drivers to explore the effect of different racing lines via the use of detailed computer maps of race circuits in conjunction with companion product Pi-Survey.

One aspect of Pi-Sim is that the simulation generates not only a predicted lap-time, but also a complete virtual data set containing all the data that would be downloaded from a logger on a real car, and more. This can be viewed and analysed in the same way that data from track testing would be using Pi's Toolbox software.

It may be that a team wishes to run a new car at a certain circuit, or is visiting a new track for which it has no baseline set-up. With Pi-Sim, basic set-up parameters such as gear ratios or wing settings can be established in advance of visiting the track. Performing a 'parameter sweep' may even automatically optimise some settings. This is a process that uses the power of batch run simulation to generate predictive data for a pre-defined combination of settings in order to select the optimal combination. An example is the selection of optimal front/rear wing positions in order to optimise the downforce/drag relationship, and thus minimise lap time. The engineer can also experiment with the effect of various wing settings on the car's balance or compare the benefits of running different aerodynamic configurations for qualifying and race. In this way the available track time is put to best use to refine a set-up having already rejected concepts that do not enhance the ultimate performance of the car.

Pi-Sim is not confined to use off-track though. It was also designed as a trackside tool that is quick enough to use during a test or qualifying session when an immediate decision is required. An example is if the weather conditions change between sessions at a circuit. The engineer can determine the effects on top speed of a change in wind speed or direction on maximum speed and decide if it would be advantageous to modify the top gear ratio. Similarly the relative performance of a new type of qualifying tyre could be evaluated. Pi-Sim can also quantify the effect on lap-time of a change in atmospheric pressure, air temperature or humidity.

Such has been the pace of development that DATAS has decided to launch a new V2.7 version of its offering, the award winning RaceSim, this spring rather than simply update the existing V2.6. Included will be installation heights, Goodyear black box tyre models for NASCAR users, lap sim target balances, developed 4-7 post rig simulation and other new modules. RaceSim already has over 1600 input parameters, more than 480 dynamic calculated output variables and a 15-degree of freedom dynamic model.

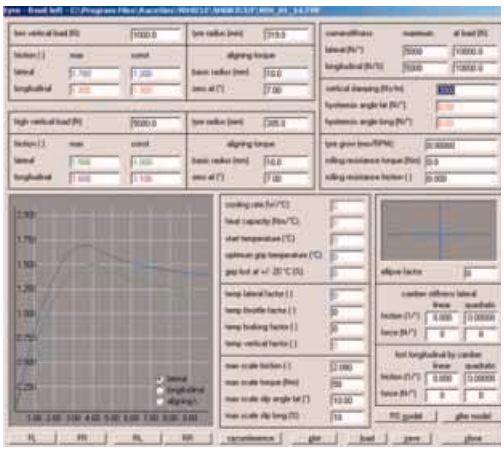
'It was essential,' says Chris Murphy, 'that RaceSim was introduced as a tool that any race engineer could use.' As such, it has a very high level of detail and features a help file, as well as validation – in other words it will prove if a customer's mathematics are correct.

The company was established in 1999 by Formula 1 designer Chris Murphy and vehicle dynamicist Steffen Kosuch. Murphy states that it is unique in that it is not only a developer, but also an end user of its own products. He points to the fact that this season he will act as consultant race engineer to the Barcelona Competition team in GP2. 'It enables us to generate our own development and to be able to do our own de-bugging.' Customer feedback is not likely to be as reliable.

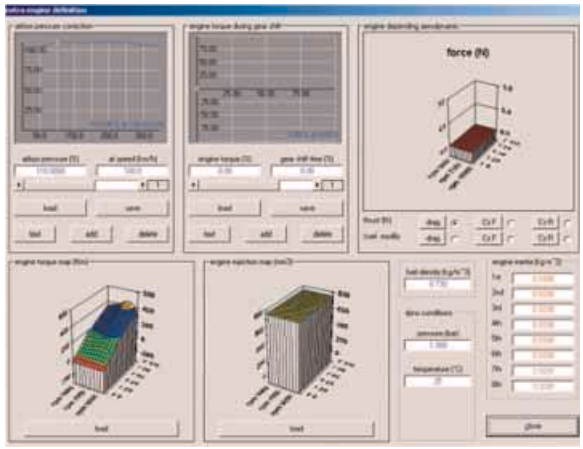
RaceSim, which Murphy describes simply as 'a race simulation tool used for predicting the performance of a racecar around a lap of any given track [or rally stage]' comes in three levels, including one dedicated to the Dallara Formula 3 car (including the 2005 version), developed in conjunction with the Italian racecar constructor. A standard version is available for other formulae such as touring cars or F3, while a more advanced expert version, which includes transient event simulation and some other modules, is targeted at F1, Champ Car, IRL and NASCAR.

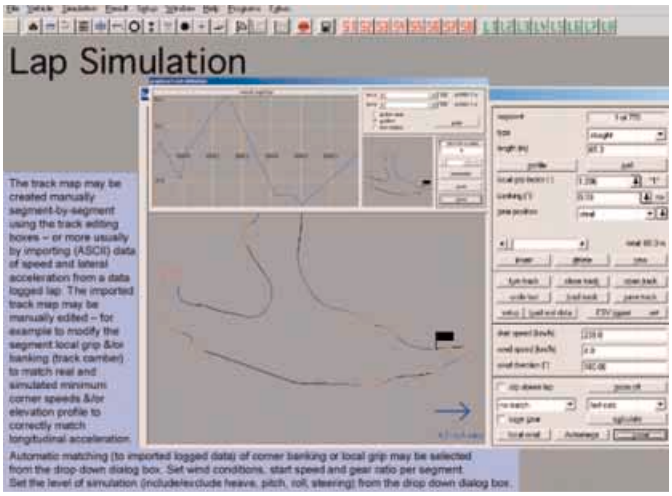
RaceSim standard can be →

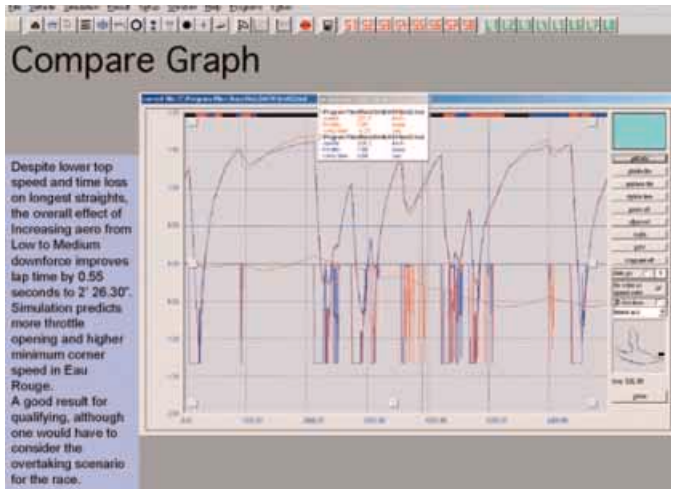
"SIMULATION IS NOT A MAGIC SOLUTION. IT CANNOT DESIGN A RACECAR, OR AUTOMATICALLY DEFINE THE OPTIMUM SET-UP"



DATAS has recently launched a new version of its award-winning RaceSim simulation programme. With incredibly detailed levels of input, including tyre models for NASCAR users, 4-7 post rig simulation and validation, its V2.7 version is an incredible tool. It is available in three levels and can be upgraded modularly to specifically suit the end user



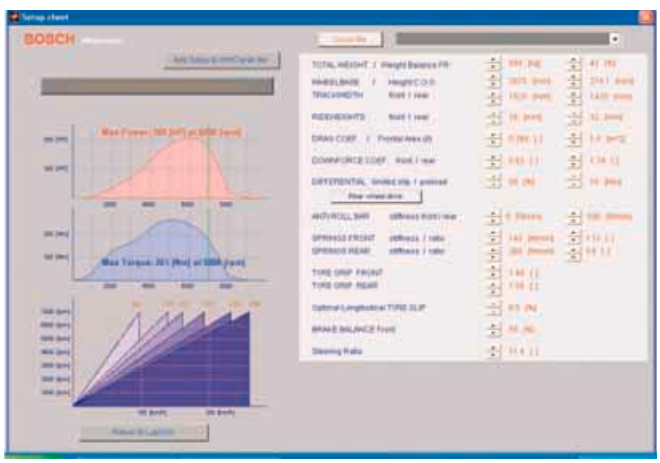




upgraded modularly, or as a step change to full expert level. The transient event simulation of the expert version can be used to understand in much greater detail the complete dynamic behaviour of the vehicle when it turns into a corner, hits a bump or when the brakes or throttle are applied. A transient event can be used like a data system but in a virtual environment. The engineer must still decide whether an output is better or worse.

The standard version of Bosch Motorsport's LapSim is a free download from the company's Internet site: www.bosch-motorsport.com. In this way the company aims to introduce the use and functionality of simulation models and, of course, the approach used by LapSim in particular. Bosch's Chris Van Rutten explains that it is not a demonstrator and can be used to determine the main parameters of the vehicle. A 'demo' would have called for an extra investment in time and been more difficult to promote.

The software of the standard version is equal to the expert version. The main difference between the two is that within the standard version the vehicle is specified by 15 parameters covering a range of vehicles from a hot hatch to a Formula 1. Other parameters, as used in the expert model, are estimated or set at zero. Van Rutten admits that most of those who download the standard model will probably never buy the expert version 'but it promotes the name Bosch'. There is also the fact that those who do buy the expert version will already understand what they are getting.



Despite being a free download from Bosch, LapSim is much more than just a demo model

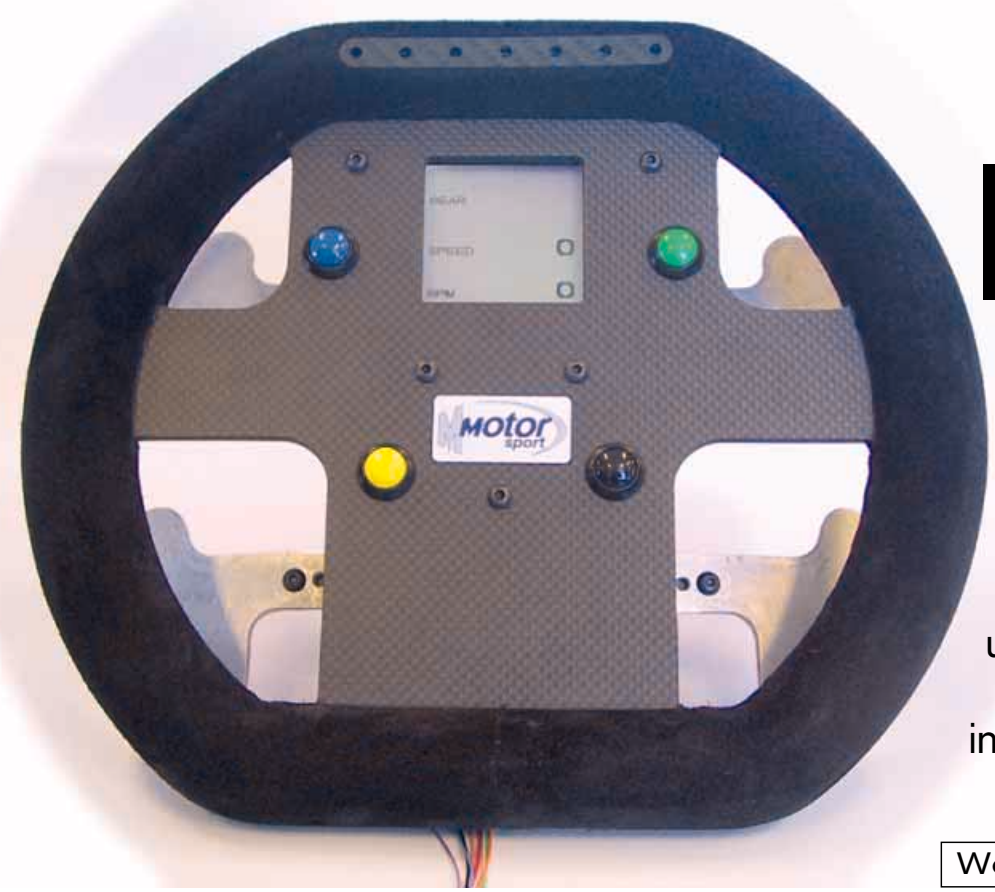
Van Rutten points out that what many forget is the definition of a model: 'It means a simplification of a complex reality supplying the ability to analyse the influence of certain variables on the behaviour of the reality.'

It is important to set certain boundaries regarding what extent the model takes influences into account. If the influence of a certain parameter cannot accurately be accounted for by the model, Van Rutten reckons it is better to leave it out. There is little reason for over-complicating a model – while this may impress a potential buyer, if the details cannot be taken into account accurately, they are merely 'window dressing,' he says.

He points out that this is not a route that he followed with LapSim, which he describes as user-friendly. He has programmed LapSim in such a way that it is easy to compare the model with on-car recorded data. This includes not only speed, but also such as slip angles, longitudinal slip, spring travel, accelerations and differential speed etc.

By combining on-car recorded data with simulation results, LapSim is claimed to offer the possibility of identifying parameters which are often overlooked or unknown to the smaller teams, such as tyre characteristics and aerodynamics.

The correlation between the simulation model and the real car is said to be easy. The team can work on the model to see in which area the car could be improved, but due to the consistency of the model, it can also use the software to check whether the car functions as it should. This way the team can quickly determine whether there is a problem in that car or not. RE



In your hands

Finally a company has come up with an answer to drivers' prayers – a modular, fully integrated steering wheel that costs less than a family car

Words | Dave Hancock

Now racers can have a steering wheel, designed, laid out and configured to suit their own preferences without spending a fortune

In a modern, cramped cockpit the steering wheel is the ideal platform on which to mount the majority of controls and instruments, yet in the past bespoke steering wheels have been prohibitively expensive.

Now UK-based EM Motorsport Limited has launched an innovative new advanced display steering wheel that offers a wide variety of solutions to cockpit packaging. Destined initially for the new GP2 series, the modular design means that it can be used in a wide variety of racecars.

A 5mm thick flat carbon panel is the main structural component of the steering wheel. It can be formed in the shape (within limitations) and size required by the customer and is supplied with a foam rim. Inset along the top of the rim are seven LEDs in a line – these can be used to indicate recommended gearshift points or can be driven separately.

> "THE MODULAR DESIGN MEANS THAT IT CAN BE USED IN A WIDE VARIETY OF RACECARS"

Mounted to the carbon panel behind an anti-glare screen is a 128x128 pixel LCD display with a viewing area of about 46mm (high) by 50mm. This display is driven via a 1Mbit/s CAN connection by a data logger or controller as a satellite module. Seven pages of data are available and are scrolled sequentially by pressing the green button to the right of the display. Any data available via the CAN network can be displayed – usually each page would have a title and numeric information. However, graphic representations of data can also be displayed as can, for instance, a map of the circuit. A page or pages can be configured to act as alarms and to display automatically – the blue button to the left would be used to acknowledge the information.

Two further buttons are fitted in the lower portion of the wheel. The black one may be wired through to the ECU to operate, say, a pit lane speed limiter, while the yellow button could operate the driver-to-pits radio link.

A housing behind the steering wheel protects the display and contains a small printed circuit board to which the connectors are mounted.

Also behind the steering wheel are two paddle switches for semi-automatic gearshift actuation or full throttle gearshifting. Mounted in CNC-machined aluminium alloy enclosures, each switch has a lever with adjustable end stops, an adjustable return spring, an optional detent mechanism for positive 'clicks' and a single pole change over 6amp electrical switch and wiring. Paddles can be supplied by EM Motorsport or manufactured by the customer to suit its driver(s). Usually, the paddles would be configured so that one provides upshifts, the other downshifts. Operating both simultaneously would put the transmission into neutral, but only if it was previously in first or reverse gear.

Two clutch actuation paddles are also fitted behind the steering wheel. These affect a non-contact (Hall effect) rotary sensor and are interlocked so that either lever can be used to operate the clutch. Again, EM Motorsport can supply the paddles or leave this to the customer.

The advanced display steering wheel fits a standard SPA Design quick release mechanism and there is provision for a through-column connector linked to a curly cord.

FIA homologated and crash tested in the GP2 cars, the new steering wheel is said to be cost effective compared to purchasing a conventional steering wheel with paddles and a dashboard display. EM Motorsport anticipates most interest from F3 and sportscar teams. This new product raises the possibility of drivers having a personalised steering wheel – not only of physical dimensions to suit them but configured to display data in the exact manner they prefer. RE

EM Motorsport Ltd
John Eccles House, Oxford Science Park
Oxford OX4 4GP, UK
Tel: +44 (0) 1865 338336
Email: ian.stone@emmotorsport.com

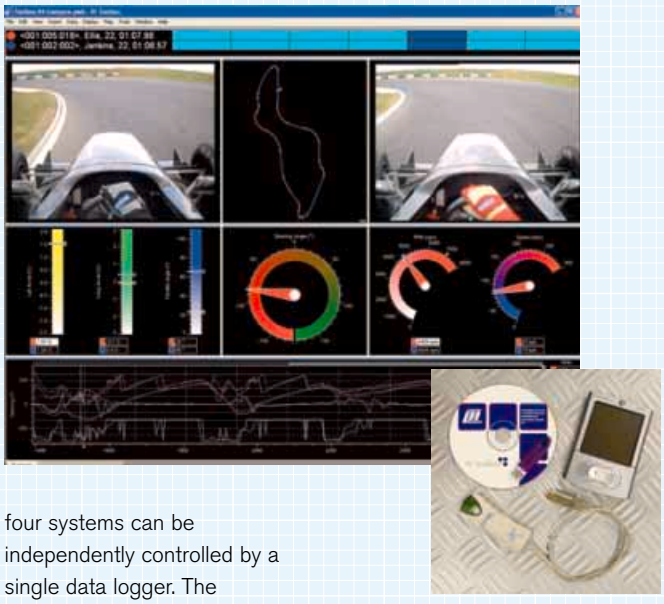
Burning issue

Nimbus Motorsport has manufactured a range of race underwear which it guarantees is fire resistant, and is specifically designed for those relying on protective clothing at trackside or behind the wheel.

The new Carbon X underwear, in addition to being comfortable and lightweight, will not burn when exposed to intense heat or flame. The fibres that make up the material carbonise and expand, when heated eliminating any oxygen content within the fabric. The material is not coated with a fire resistant coating, which can deteriorate over time with washing and general wear. Instead, it is the material itself which is high on the LOI (limiting oxygen index). The fibre is said to retain its shape and keep the wearer cool at the same time.

For more information call **+44 (0)1377 236170**, email **info@nimbusmotorsport.com**, **www.nimbusmotorsport.com**

Faster, lighter, more flexible Toolbox



Pi Research, producers of advanced electronics and software products, has introduced the Pi Toolbox Version 4.

The Toolbox has dial and bar displays and four simultaneously recording cameras from its Video Indexing Data System (Vids II), as well as an integrated third party HTML information source, with web browser and the ability to synchronise data against GPS time. Vids II will replay using Pi's frame rate algorithm, providing distance synchronised playback as well as an auto-synchronised 100 base T-ethernet off-load, which will ease installation, as well as improving off-load time. The four systems can be independently controlled by a single data logger. The lightweight logger and junction boxes reduce the general weight and operation, and have faster processing and additional CAN ports for greater flexibility.

For more information call **+44 (0) 1954 253600**, email **enquiries@piresearch.com**, **or visit www.piresearch.com**

Nine way for the highway

Deutsch, UK-based specialist in connectors, has launched its new nine-way connector. The Autosport Double Density connector follows on from the Deutsch Ultra^{lite} five-way connector but has the same aluminium alloy size six shell as the Autosport Micro^{lite}.

The connector is suitable for blind mating, has a choice of in-line and two-hole mounting styles, as well as a PCB option, and is ideal for sensor applications.

The nine high-conductivity, crimp-type, size 24 solid contacts were developed specifically for racing teams using smaller wire sizes (such as 30AWG). The connector incorporates new technology in contact retention and moulding to allow for more contacts in the same area. Other features included are six keyway orientations, with a visual indicator, an integral environmental wire seal to IP67 and a boot termination feature with no requirement for backshells.

For more information call **+44 (0) 1424 852722**, email **p.webb@deutsch**, or visit **www.deutsch.co.uk**

Flexible, far reaching friend

UK-based Agriemach Ltd has launched a tool specifically designed for servicing difficult-to-reach radiator and heater hose clamps.

The heavy-duty flexible shaft enables access to awkward locations allowing for simple, straightforward and quick operation.

The shaft has a reach of 620mm and gives a clamping range of 64mm. The locking arm keeps the clamps locked in the open position and also offers a quick release.

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

Measure for measure

UK-base Lee Products is offering free of charge a slide rule device which can be used for calculating lohm rates. The Lohmolator specifies hydraulic valves.

For applications or calculations where temperature affects the fluid viscosity, the software for lohm's law can also be supplied free by Lee Products on floppy disc.

For more information call **+44 (0) 1753 86664**, email **sales@leeproducts.co.uk**, or visit **www.leeproducts.co.uk**

Pocket welding wire guide

A new 24-page guide has been launched by UK-based welding specialists ESAB. The pocket guide carries ESAB's range of solid filler wires for TIG-welding applications.

Variants applicable to ferritic, low alloy and stainless/heat resisting steels are covered, as are the variants for welding of aluminium and nickel based alloys. Information on each wire is presented in a standardised format that includes information on suitable welding positions, international standard classifications, mechanical properties and rod sizes. The guide includes a section containing basic health and

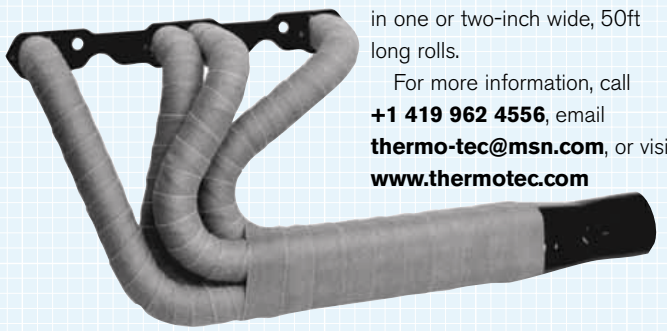
safety information and refers users to additional relevant information, including a table of chemical compositions for Tigrod wires.

For more information call **+44 (0) 800 3893152**, email **info@esab.co.uk**, or visit **www.esab.co.uk**

It's a wrap

USA-based Thermo-Tec has introduced its new Generation II copper exhaust insulating wrap, which is claimed to improve heat performance up to 40 per cent more than current technology by utilising a new proprietary coating developed by Thermo-Tec that they are calling improved Thermal-Conduction-Technology (T-C-T).

By more successfully controlling heat, Generation II copper wrap is claimed to free more horsepower, reduce under-hood temperatures and increase exhaust scavenging. Copper wrap contains no asbestos and is capable of withstanding continuous heat up to 2000deg F.



Generation II wrap is available in one or two-inch wide, 50ft long rolls.

For more information, call **+1 419 962 4556**, email **thermo-tec@msn.com**, or visit **www.thermotec.com**

Hydraulic spring perches

USA-based Hyperco has announced a new range of its hydraulic load cantering spring perches. The thread-on body perches are manufactured to fit the Penske 7500 series shocks (2.25 and 2.5in springs), and Penske 8100 series shocks. The units thread onto the shock body and replace the OE perch.

The company claims the Hyperco/ICP spring perch virtually eliminates side forces in the shock/spring assembly, reduce friction and enhance mechanical grip at the tyre.

For more information call **+1 574 753 6622**, fax **+1 574 753 8161** or visit **www.hypercoils.com**

Do you have any new products or services to tell us about?

We want to hear from you if your company is launching any new products suitable for the motorsport market at all levels.

Tell us and our readers about your new devices, from connectors and pumps to engines and gearboxes. Just send in a press release with an accompanying image (if sending by email, please ensure the image is high resolution) and it could be featured within this Racegear section.

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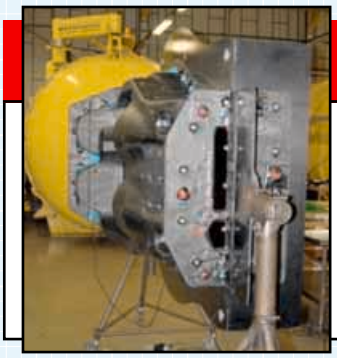
Three-valve Chevy cylinder heads

USA-based company Barry Grant Incorporated has produced a new, retro-fit, aluminium, three-valve cylinder head for use on conventional small block Chevrolet engines, Vortec-headed small blocks and pre-'86 LT1 engines.

Designed with two inlet valves of 1.4in diameter and a conventionally sized exhaust valve, the new three-valve arrangement is said to produce, at 0.500in of lift, a curtain area almost 40 per cent greater than a 2.02in two-valve head. Smaller inlet valves also means smaller, lighter valve springs and spring pressures, enabling engines to rev higher and more reliably. Excellent cylinder filling characteristics mean the new heads are said to work well in both mild tuned and high performance racing and street applications.

For more information call **+1 706 8648544**, email **tech-sales@barrygrant.com**, or visit **www.barrygrant.com**



Next month in Racecar Engineering

Lola LMP2

A close look at the B05/40, the new customer prototype from Lola

PLUS...

- New composite bond tech
- What is balanced?
- Sporting trials technology
- Engine dynamometers

In the May issue of
Racecar engineering

WHO WORKS IN MOTORSPORTS

The Undisputed Guide for the 2005 Season

The only ever published directory covering all major Motor Racing Series worldwide with all practical information on over 170 teams, 370 drivers, 250 cars, 350 sponsors & suppliers, 800 journalists, 300 PR & press officers, 80 circuits & 100 officials & series organisers

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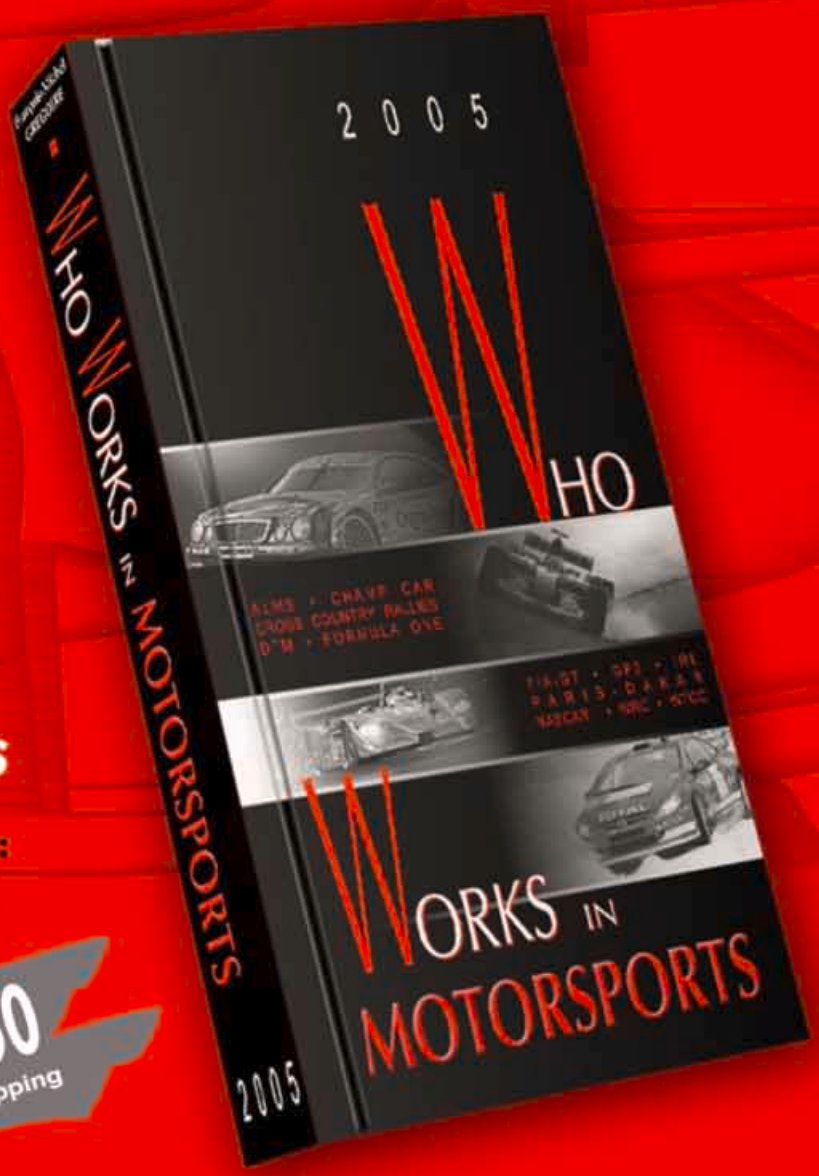

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RACECAR ENGINEERIG

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

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1.1
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A-MAC USA (1) 408 727 9288
Fax (1) 408 988 8998
A-Mac Fabrication, 1745 Grant Street, Suite 2, Santa Clara, CA 95050, USA

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Clyse Farm, Stathe, Nr Bridgwater TA7 0JN England

GRAN TOURING CLASSICS 001 562 596 9242

GOULD Tel 01635 44466
Fax 01635 30056
Gould Engineering Services, Unit 7, Arnhem Road, Newbury, Berks, RG14 5RU

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

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

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

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

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

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

LOLA Tel 01480 451301
Fax 01480 456722
Lola Cars International, Glebe Road, St Peters Hill, Huntingdon, Cambridgeshire PE18 7DS, England

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Lola Cars Inc, Suite B, 2801 Fortune Circle East, Indianapolis, IN 46241, USA

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

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

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

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

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

MATT WATERMAN MOTORSPORT DESIGN Tel 0408 216357

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

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

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

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

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Fax 0039 0861 86246/805651
Email: picchio@picchio.com or picchiospa@email.it
Website: www.picchio.com
Zona Industriale Ancarano 64010 - Ancarano (Teramo) Italy

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

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

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Protoform Race Engineering, 51 Ponderosa Drive, Horseheads, NY 14845, USA

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

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Fax 01865 883789
Ralt Engineering, Sutton Farm House, Sutton, Witney, Oxfordshire OX29 5RD, England

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

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

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

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

SCARAB Tel 01636 822033R
RS Racing & Specialised Services, High House,Kirton Road, Egmanton, Newark, Nottinghamshire NG22 0HF, England

SEZIO FLORIDA RACING
Tel: 001 776 878145

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

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

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Minerva Developments, Grafton Lodge, Binton, Stratford-on-Avon, Warwickshire CV37 9TX, England

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

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

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

TPG 0039 682 32225

VAN DIEMEN Tel 01953 888195
Fax 01953 888178
Van Diemen International Racing Services, Chalk Road, Snetterton, Norfolk NR16 2JZ, England
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3608 Morris Street, St Petersburg, FL 33407, USA

Database 2
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AERODINE USA (1) 317 271 1207
ANDREAM LTD
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Unit 12 Norwich Road Industrial Estate, Watton, Norfolk IP25 6DR
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Fax 01480 456722
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US Importer
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Lola Cars Inc, Suite B, 2801 Fortune Circle East, Indianapolis, IN 46241, USA
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SARDOU France (33) 1 60 01 03 67
THE WING SHOP **Tel: 01258 860716**
Fax: 01258 860716
E-mail: info@wingshop.co.uk
Web: www.wingshop.co.uk
SPA AEROFOILS LTD 01827 260026
UNI OF MARYLAND USA (1)301 405 6861
QINETIQ 02700 100942
ZEUS MOTORSPORT 01604 878101

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Shepperton, Middlesex TW17 8AA
ALL WAYS FORWARD 01242228111
ARP USA (1) 805 525 5152
ARROW SUPPLY 01234 840404
CLARENDON **01455 841200**
COAST FABRICATION USA (1) 714 842 2603
DATUM ENGINEERING 02476 383032
DZUS FASTENERS EUROPE 01252 714422
FASTENER FACTORY 01327 311018
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Fax (1) 217 324 3717
PROTEX FASTENERS LTD **01527 63231**
SPECIALITY FASTENERS 01803 866371
STAUBLI France (33) 4 50 65 60 60
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FAX 01327 858096
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LINREAD NORTHBRIDGE MOTORSPORT 01162 572924
RALLY DESIGN 01795 531871
SAFETY DEVICES **01353 724202**
SPA DESIGN **01827 288328**
SPA TECHNIQUE **USA (1) 317 271 7941**
ATL **USA (1) 201 825 1400 Fax (1) 201 825 1962**
Aero Tec Laboratories Inc, Spear Road Industrial Park, Ramsey, NJ 07446-1221, USA

FUEL CELLS
ATL **UK 01908 351700 Fax 01908 351750**
Aero Tec Laboratories Ltd (Europe), 1 Patriot Drive, Rooksley, Milton Keynes MK13 8PU
FUEL SAFE SYSTEMS USA (1) 714 842 2211
GOMM METAL DEVELOPMENTS 01483 764876
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PRONALS France (33) 320 99 75 10
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GARTRAC 01428 682263
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Fax 01606 737683

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BRISE AUTO ELECTRICS **01322 277622**
MM COMPETITION **08707 444666**
McCLAREN ELECTRONICS 01483 261400

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

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DEUTSCH 01424 852721
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MAGNETI MARELLI **Italy (39) 02 972 27570**
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SAKATA MOTORSPORT ELEC. INC. (714) 446 9473
SERVO & ELECTRONIC SALES LTD 01797 322500
SPECIALITY FASTENERS 01803 868677
RAYCHEM 01793 572217

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Germany (49) 711 8111 USA (1) 312 865 5200
SBD MOTORSPORT 0208 391 0121
EFI TECH USA (1) 310 793 2505
HELLA UK 01295 272233
LUMENITION 020 7403 4334
MAGNETI MARELLI Italy (39) 02 972 27570
MM COMPETITION **08707 444666**
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
MSD IGNITION USA (1) 915 857 5200
PI RESEARCH 01954 253600
PIAA (UK) 01934 814812
STACK 01869 240404
McCLAREN ELECTRONICS 01483 261400
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HELLA 01295 272233
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NOVATECH MEASUREMENTS **01424 852 744**

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CHAMPION AUTO 0151 522 3000
KS MOTORSPORTS Germany (49) 2271 44905
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NGK Japan (81) 52 872 5937 UK 0208 202 2151

SPARKPLUG LEADS
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MM COMPETITION UK **08707 444666**

WIRING HARNESSES
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COMPETITION DATA SYS USA (1) 716 631 2880
DC ELECTRONICS 01621 856451
SBD MOTORSPORT 0208 391 0121
EFI TECH USA (1) 310 793 2505
BERU F1 SYSTEMS 01374 646200
MAGNETI MARELLI **Italy (39) 02 972 27570**
MM COMPETITION **08707 444666**
MOTEC Australia (61) 3 9761 5050
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THE STRAIN GAUGING CO **01256 320666**
TONY JAMES **01379 854485**

2.3 Controls

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SBD MOTORSPORT 0208 391 0121
HEWLAND ENG 01628 827600
JACK KNIGHT 01483 764326
PRODRIVE 01295 273355
QUAIFE ENGINEERING 01732 741144
RICARDO MIDLANDS TECHNICAL CENTRE 01926 319399
RINGSPANN (UK) 01234 342511
THE STRAIN GAUGING CO **01256 320666**
STONE FOUNDRIES 020 8853 4648

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

INSTRUMENTATION
ACTIVE SENSORS 01202 480620
CRANFIELD IMPACT CENTRE 01234 750944
LMI STACK USA 001 714 637 1155
LUMENITION 020 7403 4334
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MM COMPETITION **08707 444666**
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
PENNY & GILES 01202 409409
PI RESEARCH 01954 253600
QINETIQ 08700 100942
SPA DESIGN 01827 288328
STACK 01869 240404
McCLAREN ELECTRONICS 01483 261400
THE STRAIN GAUGING CO **01256 320666**
VARIOHM 01327 351004

MIRRORS
GRAND PRIX RACEWEAR 0208 987 5500
SPA DESIGN 01827 288328

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CHEVRON RACING 01565 777395
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Fax 01480 456722
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2.4 Suspension Systems

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PROFLEX UK **01200 442345**
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2.5 Suspension Components

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COMPTECH USA USA (1) 916 933 1080
DEREK BENNETT ENG **01565 777395**
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AURORA BEARING USA (1) 630 859 2030
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GETECNO Italy (39) 010 835 6016
QINETIQ **08700 100942**

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

COILSPRINGS
COIL SPRINGS 01142 758 573
COMPTECH USA USA (1) 916 933 1080
EIBACH 01455 285850
EIBACH Germany (49) 2721 511220
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PERFORMANCE SPRINGS **01253 716900**
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PROFLEX UK 01200 442345
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GOLDLINE BEARINGS 01952 292401
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DEMON TWEEKS 01978 664466
EIBACH Germany (39) 2721 5110
UK 0455 285850
USA (1) 714 727 3700
FASTENER FACTORY 01327 311018
OHLINS RACING UK 0208 974 1615

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

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Fax 01525 385898
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Web: www.circuitsupplies.com
BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
DELPHI BRAKE SYSTEMS 01926 472472
EBC BRAKES 01604 583344
ENDLESS BRAKES Japan (81) 267 68 0071

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USA (1) 310 533 1924 USA (1) 317 244 1000 USA (1) 704 662 9095
MOSA FREIN Belgium (32) 81 73 32 73

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EUROPE +44 (0) 1280 843 390

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

2.7 Brake Components
CALIPERS
ALCON COMPONENTS 01827 312500
AP RACING 02476 639595
BREMBO Italy (39) 035 605111
UK 02476 679168
BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
GKN SQUEEZEFORM 01952 244321
PERFORMANCE FRICTION USA (1) 803 222 2141
01280 843390
EUROPE +44 (0) 1280 843 390
PROFESSIONAL M/SPORTS 01626 332289
QINETIQ 08700 100942
RACE BRAKES New Zealand (64) 9377 2000
TAR.OX Italy (39) 039 587814
WILWOOD USA (1) 805 388 1188

DISCS
ALCON COMPS 01827 312500
AP RACING 02476 639595
ATE 020 8654 8836
BREMBO Italy (39) 2 240 9631
UK 01280 700664
BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
CARBONE INDUSTRIE France (33) 0472 355700

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GRANDPRIX RACEWEAR
Tel: 01908 220777
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PERFORMANCE FRICTION USA (1) 803 222 2141
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MARDI GRAS M/SPORTS 01327 858 006
RAYBESTOS USA (1) 815 363 9000
TAR.OX Italy (39) 039 587814
TILTON USA (1) 805 688 2353
WILWOOD USA (1) 805 388 1188

FLUIDS
ALCON COMS 01827 312500
AP RACING 02476 639595
BENDIX France (33) 1 4 972 2305
UK 01942 723828
CASTROL 01793 512712
CASTROL Malaysia (603) 245 2642
CASTROL USA (1) 305 270 9433
CASTROL USA (1) 973 305 3912
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01280 843390
TILTON USA (1) 805 688 2353
WILWOOD USA (1) 805 388 1188

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BT BRAKE TECHNOLOGY Germany (49) 6003 829119
USA (1) 239 772 4261
CARBONE INDUSTRIE France (33) 1 4 972 2305

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EUROPE +44 (0) 1280 843 390
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ENDLESS BRAKES Japan (81) 267 68 0071
FERODO 01298 812520
FGR 01885 400639
MINTEX 01274 854000
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RAYBESTOS USA (1) 815 363 9000
TAR.OX Italy (39) 039 587814
TILTON USA (1) 805 688 2353
WILWOOD USA (1) 805 388 1188

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TILTON USA (1) 805 688 2353
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HILLGARD Sweden (46) 300 60590
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TOYO 01933 411144
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BP 01442 232323
BURMAH 01793 511521
PETROCHEM CARLESS 01372 380532
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CENTURY 01782 202521
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ELF France (33) 1 4744 4546
UK 0208 902 8820
ESSO UK 01372 222000
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QINETIQ 08700 100942
RED LINE OILS 01476 861195
REPSOL Spain (34) 91 456 53 00
UK 0207 581 1933
SLICK 50 UK 0116 2881522
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STP USA (1) 305 771 1010
UK 01488 682655
TECH-LINE USA (1) 919 480 0905
TEXACO UK 0207 719 3000
VALVOLINE USA (1) 606 264 7222

Database 3
ENGINE & TRANSMISSION COMPONENTS

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

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

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AUTOSPRINT 01675 464857
CAT-CAMS Belgium (32) 3 320 2560
COMPETITION CAMS USA (1) 901 795 2400
CONNAUGHT 01795 843802
CROWER USA (1) 619 422 1191
DAVID NEWMAN 01689 857109
SBD MOTORSPORT 0208 391 0121
DUNNELL ENGINES 01449 677726
FGR 01885 400639
HARROP Australia (61) 3 9499 7433
KATECH USA (1) 313 791 4120
KENT CAMS Tel 01303 248666
KENT CAMS BY JT FRANCE (33) 3207 46480
LUNATI USA (1) 901 365 0950
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Fax 01233 500300
www.pipercams.co.uk
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QUAIFE ENGINEERING 01732 353747
SWINDON RACING ENGINES 01793 531321
TWR ENGINES 01993 871000
ULTRADYNE USA (1) 601 349 4447

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

CONRODS
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ARROW PRECISION 01455 234200
ATECH MOTORSPORTS USA (1) 330 630 0888
CLARENDON ENG 01455 841200

ARROW

ARROW PRECISION ENGINEERING LTD
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Email: enquiries@arrowprecision.co.uk
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CONNAUGHT 01795 843802
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SBD MOTORSPORT 0208 391 0121
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Fax: +33(0)320746489
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SCHRICK Germany (49) 21 91 9500
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Fax +44 (0) 1455 233545
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Email: enquiries@arrowprecision.co.uk
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BLANC AERO France (33) 296 68 33 39
CARRILLO INDUSTRIES USA (1) 949 498 1800
COAST FABRICATION USA (1) 714 842 2603)
COSWORTH 01604 752444
USA (1) 310 534 1390
CROWER USA (1) 213 543 1390
SBD MOTORSPORT 0208 391 0121
LINREAD NORTHBRIDGE MOTORSPORT
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ATECH MOTORSPORTS USA (1) 330 630 0888

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EAGLE USA (1) 901 345 5886
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GRAINGER & WORRALL 01902 324460
LAYSTALL ENGINEERING 01902 451789

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Viking Road, Wigston, Leicester, LE18 2BL
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CRANKSHAFTS
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Fax: 01902 422133
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ARROW PRECISION ENGINEERING LTD
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COMPTECH USA USA 001 916 933 1080
FARNDON ENG 02476 366910
HARROP Australia (61) 39 499 7433
KAITEN PRODUCTS USA (1) 714 220 2227
QUARTERMASTER USA (1) 847 540 8999
SWINDON RACING ENGINES 01793 531321

GASKETS
COMETIC BY JT FRANCE (33) 03207 46480
GOETZE Germany (49) 221 21 74690
GORE-TEX USA (1) 410 392 3200

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

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

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SBD MOTORSPORT 0208 391 0121
DUNNELL ENGINES 01449 677726
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GKN SQUEEZEFORM 01952 244321
LAYSTALL ENG 01902 451789
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3.2 Engine Ancillaries

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WEBCON 01932 287100

FUEL INJECTION

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ASNU Tel 0208 420 4494
BGC MOTORSPORT 0208 880 4205
BOSCH 01895 834466
Germany (49) 711 8111
USA (1) 312 865 5200
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Fax: USA (1) 248 362 1032
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MARREN USA (1) 203 732 4565
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MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
NIPPON DENSO Japan (81) 56 625 5511
UK 0208 591 7700
PECTEL CONTROL SYSTEMS +44 (0)1954 253610
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TWM INDUCTION USA (1) 805 967 9478

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AN MOTORSPORT DESIGN 01628 776320

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Fax (1) 201 825 1962
Aero Tec Laboratories Inc, Spear Road Industrial Park, Ramsey, NJ 07446-1221, USA
ATL UK 01908 351700
Fax 01908 351750
Aero Tec Laboratories Ltd (Europe), 1 Patriot Drive, Rooksley, Milton Keynes, MK13 8PU
BROWN AND MILLER UK 01753 553610
USA 704 793 4319
CONNAUGHT 01795 84380
EXACT ENGINEERING 01803 866464
FAE MACHINE USA 317 243 3092
FLEXOLITE 01684 891898
FUEL SAFE UK 01799 541955
USA (1) 714 842 2211
GOODRIDGE CA USA (1) 310 533 1924
GOODRIDGE INDY USA (1) 317 244 1000
GOODRIDGE EAST USA (1) 704 662 9095

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

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

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FAX USA (1) 562 861 5503
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ATL USA (1) 201 825 1400
UK 01908 351700
EXACT ENG 01803 866464
KINSLER USA (1) 248 362 1145
PRONALS France 33 3 20 997510
SPECIALTY FASTNERS 01803 866371

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

BROWN AND MILLER UK Tel: 01753 553610
Fax: 01753 577477
Unit 7-7A, Langley House, Middle Green Trading Estate, Langley, SL3 6DF USA Tel: 704 793 4319
Fax: 704 793 4321
4005 Dearborn Place NW, Concord, NC 28027
DELPHI BRAKES SYSTEMS 01926 472472
EARL'S USA (1) 310 609 1602
EXACT ENG 01803 866464
FASTENER FACTORY 01327 311018
FHS MOTOR RACING 01753 570863
FLUID CONTROL PRODUCTS INC USA (1) 217 324 3737
Fax (1) 217 324 3717
GOODRIDGE UK 01392 369090
GOODRIDGE CA USA (1) 310 533 1924
GOODRIDGE INDY USA (1) 317 244 1000
GOODRIDGE EAST USA (1) 704 662 9095
HCL FASTENERS 01282 411992
HENRY'S ENG USA (1) 410 435 3142
JLS MOTORSPORT 0121 525 7733
KINSLER USA (1) 248 362 1145
SAMCO SPORT 01443 238464

SFS PERFORMANCE Tel: 01582 488040
Fax: 01582 412277
Website: www.sfsperformance.co.uk
Unit E Kingsway Industrial Estate, Kingsway Luton LU1 1LP
SPECIALTY FASTNERS 01803 866371
SPEED FLOW 0208 530 6664
THINK AUTOMOTIVE 0208 568 1172
UNICLIP AUTOMOTIVE 01932 355277
XRP INC USA (1) 562 861 4765

INTERCOOLERS

AH FABRICATIONS 01432 354704
FLUID CONTROL PRODUCTS INC USA (1) 217 324 3737
Fax (1) 217 324 3717
PACE PRODUCTS 01440 760960
SERCK MARSTON 0208 965 2151
SFS PERFORMANCE 01582 412 697

OIL COOLERS

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

OIL FILTERS

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

OIL PUMPS

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

OIL SEALS

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

OIL SUMPS

AH FABRICATIONS 01432 354704

A.R.E DRY SUMP SYSTEMS
USA: (1) 916 987 7629
www.drysump.com
CONNAUGHT 01795 843802
JENVEY DYNAMICS 01746 768810
MILODON USA (1) 818 407 1211
PACE PRODUCTS 01440 760960
STONE FOUNDRIES 0208 853 4648
SWINDON RACING ENGINES 01793 531321
TITAN MOTORSPORT 01480 474402
TREVOR MORRIS ENG 01547 530289

OIL TANKS

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

RUBBER & ELASTOMERIC COMPONENTS

BUTSER RUBBER LTD Tel: 01730 894034

STARTER MOTORS

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

THROTTLE BODIES

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

THROTTLE VALVES

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

TURBOCHARGERS

GARRETT AUTOMOTIVE 01695 22391
HOLSET ENG 01484 422244
INTERPRO ENGINEERING 01454 412777
QINETIQ 08700 100942
TURBO TECHNICS 01604 764005

WATER COOLERS

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

WATER INJECTION

ERL 01273 581007

WATER PUMPS

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

3.3 Engine Electronics

COMPUTER SUPPLIERS

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

DATA-ACQUISITION

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

INTERCOMP USA Tel (1) 763 476 2531
Fax (1) 763 476 2613
14465 23rd Avenue N, Minneapolis, MN 55447, USA
ISAAC INSTRUMENTS INC. Tel: (450) 658 7520
Fax: (450) 658 3322
Email: isaac@isaac.ca
Website www.isaac.ca
25 Robert, Chamby, Quebec, Canada J3L IS2
LONGACRE USA (1) 425 485 0620
McCLAREN ELECTRONICS 01483 261400
MM COMPETITION SYSTEMS 08707 444666
MOTEC Australia (61) 3 9761 5050
MOTEC (EUROPE) UK 08700 119100
MOTEC JAPAN Japan (81) 489 46 1734
MOTEC SYSTEMS USA USA (1) 714 897 6804
MOTECH USA (1) 804 973 1399
MOTOR SPORT ELEC Australia (61) 7 3290 1309
MOTORSPORTS INTERFACE 01327 311011
MTS Powertrain Tech Tel 01932 351516
Fax 01932 351517
7 Glen Court,Canada Road, Byfleet, Surrey KT14 7JL
NIPPON DENSO Japan (81) 56 625 6951
PECTEL CONTROL SYSTEMS +44 (0)1954 253610
PENNY & GILES 01202 409409
PERFORMANCE TRENDS USA (1) 248 473 9230
PI RESEARCH 01954 253600
POLY LOGIC 01462 621066
QINETIQ 08700 100942
QUANTUM SUSPENSION 01243 865058
RACE DATA ENGINEERING USA (1) 714 449 1445
SAKATA MOTORSPORT ELEC. INC. (714) 446 9473
STACK Tel 01869 240404
Fax 01869 245500
email: sales@stackltd.com
Wedgewood Road, Bicester Oxfordshire, OX26 4UL
STEVE BUNKHALL 01223 303025
VARIOHM 01327 351004

ENGINE MANAGEMENT SYSTEMS

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

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

ENGINE SENSORS

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

KULITE SENSORS Tel 01256 461646
Kulite House, Stroudley Road, Basingstoke, RG24 8UG, England
MAGCANICA INC USA 858 454 8950
McCLAREN ELECTRONICS 01483 261400
THE STRAIN GAUGING CO 01256 320666
VARIOHM 01327 351004

REV-LIMITERS

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

3.4 Transmission Components

CLUTCHES

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

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

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

COMPLETE TRANSMISSIONS

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

CWP'S

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

DIFFERENTIALS

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

DRIVESHAFTS

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

GKN MOTOR SPORT Tel 0121 313 1661
Fax 0121 313 2074
Unit 5, Kingsbury Business Park,
Kingsbury Road, Minworth, Sutton Coldfield,
Birmingham B76 9DL, England
METALORE USA (1) 310 643 0360
PANKL 0043 3862 33999
TEX RACING USA (1) 910 428 9522
TRAN-X GEARS LTD 02476 659061

GEARS

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

UNIVERSAL JOINTS

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

Database 4

FACTORY EQUIPMENT

4.1 Factory Hardware

AIR LINES & FITTINGS

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

AIR TOOLS

DESOUTTER AUTOMOTIVE 0208 205 4884

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

CNC MACHINING CENTRES

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

CRACK DETECTION

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

CRYOGENIC TEMPERING

FROZEN SOLID 01449 674914

DUST EXTRACTION EQUIP

DENCER 01789 470198

DYNAMOMETERS: CHASSIS

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

DYNAMOMETERS: DAMPER

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

DYNAMOMETERS: ENGINE

AVL Germany (49) 61 34 71 790
DSP TECHNOLOGY 01932 351516
DYNAMIC TEST SYSTEMS 01842 755744
ENGINE & DYNAMOMETER 01708 857108
FROUDE CONSINE 01905 856800
JKM AUTOMOTIVE USA (1) 508 966 2531
LAND & SEA USA (1) 603 329 5645
LOTUS ENGINEERING 01953 608000
MOTORSPORTS INTERFACE 07788 890412
TAT Germany (49) 7252 84258

DYNAMOMETER INSTRUMENTATION

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

ENGINE BALANCING EQUIP

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

ENGINE HOISTS

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

ENGINE STANDS

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

FLOW BENCHES

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

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

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

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

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

TOOL CABINETS
DURA 01295 712800

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

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

4.2 Factory Software

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

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

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

Database 5
CIRCUIT EQUIPMENT

5.1 Pits Equipment

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

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

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

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

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

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

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

CORNER SCALES
A.R.T. USA (1) 914 889 4499
DEMON TWEEKS 01978 664466
LONGACRE RACING USA (1) 206 885 3823
NOVATECH 01424 852744
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
REDLINE MOTORSPORT Tel 01606 737500
ROLLCENTRE 01480 464052

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

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

ELECTRIC STARTERS
POWER TRANS SOLUTIONS 01722 332126

ENGINE HOISTS
DUNLOP AUTOMOTIVE 0121 384 4444
FACOM UK 01932 566099

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

FIRE EXTINGUISHERS
CHUBB 01932 785588
ESSEX RACING USA (1) 404 889 4096

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

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

FUME EXTRACTORS
DENCER 01789 470198
INGERSOLL RAND 01204 690690

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

HAND TRUCKS
OMS RACING 01132 575956
SILVERSTONE RACE SERVICES 01327 858441

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

INSPECTION LAMPS
ESSEX RACING USA (1) 404 889 4096

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

NOISE METERS
CIRRUS RESEARCH 01723 891655

PIT BARRIERS
KAISER & KRAFT 01923 233312
SLINGSBY 01274 721591

PIT BOARDS
ACTIVE ENGINEERING USA 001 714 637 1155
DEMON TWEEKS 01978 664466
ESSEX RACING USA (1) 404 889 4096
GRAND PRIX RACEWEAR 0208 987 5500
KS MOTORSPORT Germany (49) 2271 44905
REDLINE MOTORSPORT Tel 01606 737500
TRIDENT 01327 857822

PIT CANOPIES
PIT BITS 01727 858297

PIT LANE MARKERS
KAISER & KRAFT 01923 233312
SLINGSBY 01274 721591

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

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

RADAR GUNS
ESSEX RACING USA (1) 404 889 4096

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

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

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

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

REFUELLING RIGS
DEMON TWEEKS 01978 664466
ESSEX RACING USA (1) 404 889 4096
GTC COMPETITION 01483 272 151
PREMIER FUEL SYSTEMS 01332 850515
REDLINE MOTORSPORT Tel 01606 737500
SPA DESIGN 01827 288328
THE STRAIN GAUGING CO 01256 320666

SCISSOR PLATFORMS
SLINGSBY 01274 721591

SETUP FLOORS
ACTIVE ENGINEERING USA 001 714 637 1155
4-PATCH 01376 348246
KS MOTORSPORT Germany (49) 2271 44905
ME MOTORSPORT 01884 253070
RML 01933 402440
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
THE STRAIN GAUGING CO 01256 320666
SPA AEROFOILS LTD 01827 260026
UNIVERSITY OF HERTFORDSHIRE 01707 284270

SETUP GAUGES
A.R.T. USA (1) 914 889 4499
CYBER DYNAMICS 01869 347812
DEMON TWEEKS 01978 664466
ILONGACRE RACING USA (1) 206 885 3823
ME MOTORSPORT 01884 253070
REDLINE MOTORSPORT Tel 01606 737500
THE STRAIN GAUGING CO 01256 320666

SPACE HEATERS
FASTENER FACTORY 01327 311018

STOPWATCHES
CASIO 0208 450 9131
DEMON TWEEKS 01978 664466
ESSEX RACING USA (1) 404 889 4096
GRAND PRIX RACEWEAR 020 8987 5500
KS MOTORSPORT Germany (49) 2271 44905
RACING RADIOS USA (1) 404 366 3796
REDLINE MOTORSPORT Tel 01606 737500
TRIDENT 01327 857822

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

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

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

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

TORQUE WRENCHES
ESSEX RACING USA (1) 404 889 4096
FACOM UK 01932 566099
NORBAR TORQUE TOOLS 01295 270333
RALLY DESIGN 01795 531871

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

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

TYRE TEMPERATURE GAUGES
ESSEX RACING USA (1) 404 889 4096
THE STRAIN GAUGING CO 01256 320666
TRIDENT 01327 857822

TYRE TROLLEYS
OMS RACING 01132 575956

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

5.2 Paddock Equipment

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

MOTORHOME HIRE
ATLANTIC COAST 01297 552222
DAVID WILSON'S TRAILERS 01825 740696
DUDLEYS 01993 703774

MIDLAND INTERNATIONAL 02476 336411
SPIRES OF OXFORD 01865 875539
WESTCROFT AMERICAN 01902 731324

Database 6
COMPETITION CAR CHASSIS COMPONENTS

6.1 Driver's Equipment

ANTI MIST FLUIDS

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

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

BOOTS & GLOVES

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

COOL CAPS & SUITS

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

DRIVING SUITS & ACCESSORIES

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

HELMETS & ACCESSORIES

QINETIQ Tel 44 (0) 8700 100942
www.QinetiQ.com
Cody Technology Park,
Ively Road , Farnborough, Hampshire, GU14 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 (66) 729 5628
APPLIED FIBREGLASS 01842 765339
ASQUITH BROTHERS 01924 402001
C&B Consultants Aerodynamics 01202 617 707
CML GROUP 0151 647 5531
COMPOSITE DESIGN USA (1) 727 539 0605
CRANFIELD UNIVERSITY 01234 754152
CROPREDY BRIDGE GARAGE 01295 758444
DEREK PALMER ENGINEERING 01555 893315
DON FOSTER France (33) 470 580308
EARS MOTORSPORT 01625 433773
FIBRESPORTS 01268 527331
GRAHAM HATHAWAY RACING 01621 856956
GTC COMPETITION 01483 272151
GTI ENGINEERING 01280 700800
HAMLYN MOTOR SERVICES 01582 841284
HEDDINGTON COACHWORKS 01380 850198
INTAPORSCH 01273 834241
LOTUS ENGINEERING 01953 608000
LYNX MOTORS 01424 851277
MERLIN BODYCRAFT 01280 705156
MITCHELL NZ (64) 78236188
PODIUM DESIGN 07000 763486
SPA COMPOSITES 01543 432904

COMPOSITES SPECIALISTS

Active engineering USA 001 714 637 1155
ACTIVA TECHNOLOGY 020 8974 1615
ÆOLUS TECHNOLOGY USA (1) 970 472 1288
APPLIED FIBREGLASS 01842 765339
ASTEC 01332 875451

ATLAS COMPOSITES LTD Tel 0115 930 4058
Fax 0115 930 4558
Email enquirys@atlascomps.co.uk
Website www.atlascomps.co.uk
Unit 1, Belfield Street,
Ilkeston, Derbyshire DE7 8DU

B&K RESINS 0208 464 7734
C&B CONSULTANT AERODYNAMICS 01202 661707
CARBON FIBRE TECHNOLOGY 01508 488257
CARBONE INDUSTRIE France (33) 14 972 2305
COMPOSITE AUTOMOTIVE TECH 01249 443438
COMPOSITE DESIGN USA (1) 727 539 0605
COMPOSITE WINGS 01953 885478

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

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

KOMPREX Tel 0191 416 8200 Fax 0191 415 5962
Website www.komprex.com
Email sales@komprex.com
58-59 Hutton Close, Crowther Ind Est,
Tyne & Wear NE38 0AH

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

DESIGN AND ANALYSIS

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

RICARDO MIDLANDS TECHNICAL CENTRE
Tel 01926 477208 Fax 01926 477222
Email: pmarkwick@mtc.ricardo.com
Website: www.ricardo.com
Southam Rd, Radford Semele, Leamington Spa CV31 1FQ

FABRICATION

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

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

ASTEC 01332 875451
AZTEK 01509 261299
BBW 01483 722 713
BOB SPARSHOTT ENGINEERING 01908 618080
BRADY FABRICATIONS 01869 252750
BRISE ALLOY FABRICATIONS 01322 222343
BSS PARTS 01772 601602
CHEVRON RACING 01565 777395
CHIP GANASSI RACING 01243 544192
CML GROUP 0151 647 5531
COLMET PRECISION 01296 681658
COMPOSITE DESIGN USA (1) 727 539 0605
COMPETITION FABRICATIONS 01953 454573
CRANFIELD UNIVERSITY 01234 754152
CTG RACING 01202 871102
DEREK BENNETT 01565 777395
DJ RACECARS 01663 734518
DOCKING ENGINEERING 01327 857164
EUROTECH MOTORSPORT 0121 3314944
FOXCRAFT ENGINEERING 01264 810110
B Y G.FORCE PRECISION ENG 01243 544192
GOMM METAL DEVELOPMENTS 01483 764876
GRAHAM HATHAWAY RACING 01621 856956
GTC COMPETITION 01483 272151
HAMLYN MOTOR SERVICES 01582 600745
HAUS OF PERFORMANCE USA (1) 714 545 2755
JAGO DEVELOPMENTS 01243 789366
KRONTEC MASCHINENBAU (49) 9401 700352
LOTUS ENGINEERING 01953 608000
LYNX MOTORS 01424 851277
MACDONALD RACE ENG 0208 889 1633
MATRIX ENGINEERING USA (1) 888 249 0013
MASON ENGINEERING USA (1) 805 527 6624
MICRO CRAFT USA (1) 909 947 1843
MIKE TAYLOR DEVELOPMENTS 01609 780123
MIRKO RACING USA (1) 408 776 0073
POLSON 01440 820371
PREMIER AEROSPACE 01332 850515
QinetiQ 08700 100942
RACEPREP 3001 01903 734499
RBS 01788 543094
RETRO TRACK & AIR UK 01453 545360
RICARDO MIDLANDS TECHNICAL CENTRE
Tel: 01926 477152
Fax: 01926 319352
Email: iain.wight@ricardo.com
RILEY & SCOTT USA (1) 317 248 9470
Ray Mallock LTD (RML) Tel 01933 402440
Fax 01933 676519
www.rmlmallock.co.uk
6-10 Whittle Close, Park Farm Industrial Estate,
Wellingborough, Northants NN8 6TY England
SNAPDRAGON MOTORSPORTS USA (1) 413 2560861
SPA AEROFOILS LTD 01827 260026
SOUTH CERNEY ENGINEERING 01285 860295
UNICLIP AUTOMOTIVE 01932 355277
VAN DYNE ENGINEERING USA (1) 714 847 4417
VIN MALKIE RACING 01565 777395

MOULDING

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

SPACEFRAME DESIGN

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

Database 8
DRIVETRAIN & SUSPENSION ENGINEERING SERVICES

8.1 Engine Services

RACE PREPARATION

ALDON 01384 572553
ANDY ROUSE ENGINEERING 02476 635182
AUTOKRAFT 0121 777 2083
AZTEK 01509 261299
BJ MOTOR ENGINEERS 0161 748 8663
BR MOTORSPORT 01926 451545
DAVE CROSS MOTOR SERVICES 01246 477566
SBD MOTORSPORT 0208 391 0121
CLEM COMPETITION USA (1) 214 503 8044
CONCEPT MOTORSPORT 0208 568 0293
CONTINENTAL M/SPORT USA (1) 513 459 8888
DBR MotorSport Tel 0161 627 4189 Fax 0161 627 4189
Unit 4 Forge Ind Estate, Green Acres Road,
Oldham Lancashire, OL4 7LE

DJ RACECARS 01663 734518
DTM POWER 01865 407726
DUNNELL ENGINES 01449 677726
EARS MOTORSPORT 01625 433773
EDS 01708 857108
ELABORAZIONE COLASUNO 0207 738 8331
ENGINE DATA ANALYSIS 01977 516622
ENGINE SHOP 01280 812199
FISCHER ENGINEERING USA (1) 818 767 8840
FORWARD ENGINEERING 01676 523526
GEMINI ENGINEERING 01474 534779
GEOFF RICHARDSON ENGINEERING 01480 861599
GF BECK MOTORSPORT PREPARATION 01646 621184
GOLDFLOW 01491 875554
GOODMAN RACING ENGINES 01327 300422
GRAHAM HATHAWAY RACING 01621 856956
GRIFFIN MOTORSPORT 01793 771802
HARPERS PERFORMANCE 01642 818188
HARTWELL 01202 556566
HAUS OF PERFORMANCE USA (1) 714 545 2755
HT RACING 01474 872888
IRMSCHER 01543 414466
IVAN DUTTON 01923 816277
JANSPEED MOTORSPORT 01722 321833
J MATTIS ENGINETECH Greece 003 019 512 761
JOHN WILCOX COMPETITION ENG 01455 230576
JONDEL 01933 411993
KENT AUTO DEVELOPMENTS 01303 874082
KREMER RACING Germany (49) 221 171025
LE SPORT France (33) 14 582 4400
LIGHTNING PERFORMANCE USA (1) 904 439 5283
LINGENFELTER USA (1) 219 724 2552
MARDI GRAS MOTORSPORTS 01327 858 006
MATHWALL ENGINEERING 01252 703191
MATRIX ENGINEERING USA (1) 888 249 0013
MAXSYM ENGINE TECH 01608 685155
MERLIN DEVELOPMENTS 01283 511184
MILLINGTON 01746 789268
MINERVA MOTORSPORT 01509 233970
MINISTER RACING ENGINES 01634 682577
MIRKO RACING USA (1) 408 776 0073
MIS M/SPORTTECHNIK GERMANY (49)263680394
MOUNTUNE RACE ENGINES 01621 854029
NEIL BROWN ENGINEERING 01775 723052
PHIL JONES ENGINE DEV 01454 310936
PHIL MARKS ENGINE DEV 01564 824869
PRICE MOTORSPORT USA (1) 812 546 4220
PRIMA RACING 0115 9491903
PRODRIVE 01295 273355
QUICKSILVER RACE USA (1) 3016980 9009
QUORN ENGINE DEVELOPMENTS 01509 412317
RACE ENGINE DEVELOPMENT USA (1) 760 630 0450
RACESPEC 01925 636959
RACE TECHNIQUES 01242 245640
RACING BENT USA (1) 714 779 8677
RANDLINGER Germany (49) 761 16373
ROAD & STAGE MOTORSPORT 01524 844066
ROADSPEED PERFORMANCE 01453 750864
RPM FRANCE (33) 3 86 66 00 08
SCARBOROUGH Canada (1) 416 759 9309
SEARLE 0208 305 2250
STEVE CARBONE RACING USA (1) 918 835 6596
SWAYMAR 01932 868377
SWINDON RACING ENGINES 01793 531321
TECNO 01268 764047
TERRY SHEPHERD TUNING 01695 574454
THINK AUTOMOTIVE Tel 0208 568 1172
Fax 0208 847 5338
Email matt@thinkauto.co.uk
292 Worton Road, Isleworth, Middlesex, TW7 6EI
THUNDERBIRD RACING INT LTD 01623 622848
VAN DYNE ENGINEERING USA (1) 714 847 4417
WARRIOR 01825 764833
ZYTEK ENGINEERING 01332 48974
ZEUS MOTORSPORT ENGINEERING LIMITED
Tel 01604 878101 Fax 01604 878111
The Racing Stables, Blisworth Hill Farm,
Stoke Road, Blisworth, Northants NN7 3DB

8.2 Engine Services

REBUILDS

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

HEWLAND ENGINEERING Tel 01628 827600
Fax 01628 829706
Waltham Road, Maidenhead, Berks, SL6 3LR

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

8.3 Suspension Services

SETUP SPECIALISTS

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

SHOCKBOX DAMPER SERVICES **Tel: 07919 340550**
Website: www.shockbox.co.uk
Email: ghbj@compuserve.com
67 Blackthorn Road, Attleborough, Norfolk, NR17 1YJ UK

THE STRAIN GAUGING CO	**01256 320666**
UNIVERSITY OF HERTFORDSHIRE	01707 284270

ENGINEERING SERVICES

RACING INDUSTRY TECHNICAL SERVICES	
	USA (1) 248 645 1724

8.4 Metal Services

BEAD & SAND BLASTING

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

COATINGS

CAMCOAT PERFORMANCE COATINGS	**01925 445003**

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

LURO COTE	USA (1) 909 885 3223
KENT MOTORSPORT CASTINGS	01795 662288
POETON	01452 300500
POLYMER DYNAMICS	USA (1) 713 694 3296
QINETIQ	**0 8700 100942**
SWAIN TECH	USA (1) 716 889 2786
WALLWARK HEAT TREATMENT	0161 7979111

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

FINISHING

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

FOUNDRIES

AEROMET	01795 415000
BA HARRISON	0116 2769351
GM DESIGN	0117 985 9964
FINECAST	01903 765821
H GRIFFITHS ENGINEERING	01582 600629
JENVEY DYNAMICS	01746 768810
KENT AEROSPACE CASTINGS	01795 476333
KENT MOTORSPORT CASTINGS	01795 662288
QUALCAST	0132 760260
UK RACING CASTINGS	01227 750877

HEAT TREATMENT

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

MACHINING

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

KRONTEC GMBH **Tel Germany (49) 9401 5253-0**
Fax Germany (49) 9401 5253-10
Pommernstrabe 33, 93073 Neutraubling, Germany

LANGSTONE ENGINEERING LTD	02392 452430
LINGENFELTER	USA (1) 219 724 2552
LOTUS ENGINEERING	01953 608000
MACDONALD RACE ENG	**0208 889 1633**
MASON ENGINEERING	USA (1) 805 527 6624
METAL SPINNERS	0191 267 1011
MILSPEC PRODUCTS	**USA (1) 407 814 8997**
QINETIQ	**0 8700 100942**
PANKL AUSTRIA	**(43) 3862512500**
PERFORMANCE MACHINE	USA (1) 303 828 4546
PREMIER AEROSPACE	01332 850515
PREMIER FUEL SYSTEMS	01332 850515
QUAIFE ENGINEERING	01732 741144
RICARDO INC	USA (1) 734 397 6666
RICHARD BARRETT MOULDS	USA 353 282 9842
TITAN MOTORSPORTS	01480 474402
TREVOR MORRIS ENGINES	015474 289
TRICK MACHINING	01493 751666
VIN MALKIE	01565 777395

METAL MATRIX COMPOSITES

BP METAL COMPOSITES	01252 37

CRANFIELD UNIVERSITY **Tel 01234 754902**
Fax 01234 751671
Email motorsport@cranfield.ac.uk
www.motorsport.cranfield.ac.uk
Motorsport Group, Cranfield University, Cranfield, Bedfordshire, MK43 0AL

GM DESIGN	0117 985 9964
MMCC	USA (1) 617 893 4449
PANKL	Austria (43) 3 8625 12500

METAL SUPPLIERS

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

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

TITANIUM SPECIALISTS

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

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

TUBE FORMING

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

8.5 Race Preparation

CHASSIS

ACTIVE ENGINEERING	USA (1) 714 637 1155
AMS	01831 501363
AMT MOTORSPORT	01444 483477
ANEX SYSTEMS	01869 345038
AUTOMECH	0161 775 1851
AVONBAR	01932 840058
BARWELL MOTORSPORT	0208 397 4411
BR MOTORSPORT	01926 451545
BRR MOTORSPORT	01327 858055
CHRIS LEWIS MOTORSPORT	01677 422623
DEREK BENNET ENG	**01565 777395**
PRO MOTORSPORT	01555 893315
DOME CARS LTD	Japan (81) 75 744 3131
DON FOSTER	France (33) 470 580308
FOXCRAFT ENGINEERING	01264 810110
FRP RACING	01494 771609
GRAHAM WISEMAN	01278 685349
HAUS OF PERFORMANCE	USA (1) 714 545 2755
HAWKINS RACING	0208 579 1438
INTERPRO ENGINEERING	01454 412777IVAN
JACK CRONE RACING	USA (1) 909 371 6090
JOHN VILLAGE AUTOMOTIVE	01246 450580
K2 RACE ENGINEERING	01825 766728
MACDONALD RACE ENG	**020 8889 1633**
MARDI GRAS MOTORSPORT	01327 857246
MARK BAILEY RACING	01380 850130
MARK DUNHAM RACE ENG	01353 648208
MATRIX ENGINEERING	USA (1) 888 249 0013
MELTUNE PX MOTORSPORT	01923 242536
MIRKO RACING	**Tel USA (1) 408 776 0073**
	Fax USA(1) 408 779 9319
	16890 Church Street, Building no.14, Morgan Hill, CA 95037, USA
PLANET MOTORSPORT	01403 891553
PODIUM DESIGNS	07000 763486
QINETIQ	**0 8700 100942**
RACECRAFT INTERNATIONAL	01789 297000
RACE TEC DESIGN & ENGINEERING	01386 871292
RILEY & SCOTT	USA (1) 317 248 9470
Ray Mallock LTD (RML)	**Tel 01933 402440**
	Fax 01933 676519
	www.rmlmallock.co.uk
	6-10 Whittle Close, Park Farm Industrial Estate, Wellingborough, Northants NN8 6TY England
ROY KENNEDY RACING	01327 858055
SCHNITZER	Germany (49) 8654 2034
SHENPAR PRODUCTS	01332 862901
STARTLINE UK LTD	01933 665752
STORM MOTORSPORT	01474 85 4367
TECH-CRAFT MOTORSPORT	01926 496075
TOLLBAR RACING	01433 631698
TT AUTOMOTIVE RACING	0147 485 3456
VIN MALKIE	01565 777395
ZAKSPEED	Germany (49) 2636 87923

Database 9

TESTING SERVICES

9.1 Chassis Testing

CALIBRATION SERVICES

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

CRASH TESTING

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

MEASUREMENT EQUIPMENT

AUTOSPRINT	01675 464857
BEAUFORT RESTORATION	01795 83288
BERU F1 SYSTEMS	01374 646200
CCA DATA SYSTEMS	01525 378938
CRANFIELD INSTITUTE	01908 694134
GENESIS ELECTRONIC SYSTEMS	01923 893 999
INSTRON SCHENK	01494 456789
INTERCOMP	USA +763 476 2531
KISTLER INSTRUMENTS LTD	01420 544477
LONGACRE	**USA (1) 425 485 0620**
LOTUS ENGINEERING	01953 608000
MICROLEASE	0208 427 8822
MIRA LTD	0247 635 5000
MOTORSPORTS INTERFACE	01788 890412
QINETIQ	0 8700 100942
ROEHRIG ENGINEERING	**Tel USA (1) 336 431 1827**
ROTO TEST AB	**Sweden (46) 85 325 5890**
THE STRAIN GAUGING CO	**01256 320666**

ROLLING ROADS

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

STRESS ANALYSIS

COSINE TECHNOLOGY	01706 378851
LOLA	**Tel 01480 451301**
	Fax 01480 456722

WELD TESTING

C & B CONSULTANTS AERODYNAMICS LTD
Tel 01202 661707 Fax 01202 685588
Email candbaero.uk@candbconsultants.com
www.candbconsultants.com
Unit2B, 8 Cowley Road, Nuffield Ind Est, Poole, Dorset, BH17 0UJ

C & B INTERNATIONAL INCORPORATED
Tel 317 291 0978 Fax 317 536 0656
email candbaero_indy@email.msn.com
6210 La Pas Trail, Indianapolis, IN 46268, USA

KISTLER INSTRUMENTS LTD	01420 544477
WIND TUNNELS ACTIVA TECH	0208 974 1615
AIOLOS ENG	Canada (1) 416 674 3017
CRANFIELD INSTITUTE	01908 694134
CRANFIELD UNIVERSITY	01234 754152
DOME CARS LTD	Japan (81) 75 744 3131
IMPERIAL COLLEGE LONDON	0207 589 5111
LANGLEY FULL-SCALE	USA (1) 757 766 2266
MARCH	01280 704160
MICRO CRAFT	**USA (1) 909 947 1843**
MIRA LTD	0247 635 5000
OHIO STATE UNIVERSITY	USA (1) 614 292 5491
RMCS (CRANFIELD)	01793 785359
QINETIQ	0 8700 100942
SARDOU SA	France (33) 16 00 10 367
UNIVERSITY OF MARYLAND	USA(1) 301 405 6861
WESTLAND HELICOPTERS	01935 702190

WIND TUNNEL MODELS

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

9.2 Engine Testing

COMBUSTION ANALYSIS

AM TEST SYSTEMS	01253 780780
AUTOSPRINT	0121 236 5133

AVL DEUTSCHLAND Gmbh GERMANY (49) 6134 7179-0

CRANFIELD INSTITUTE	01908 694134
CRANFIELD UNIVERSITY	01234 754152
INTEGRAL POWERTRAIN	01908 278600
KISTLER Instruments Ltd	01420 544477
LOTUS ENGINEERING	01953 608000
MACHTECH	01923 269788

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

DYNAMOMETER SUPPLIERS

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

DYNAMOMETER SERVICES

ACCURATE ENGINEERING USA (1) 216 232 1156
CELTIC PERFORMANCE ENG 01362 696729
AIRFLOW RESEARCH USA (1) 818 890 0616
ALDON AUTOMOTIVE 01384 78508
AMG MOTORENBAU Germany (49) 7144 3020
ANDY ROUSE ENGINEERING 02476 635182
ARIAS 01403 784022
ATKINSONS MOTORSPORT 01539 732500
AUTOKRAFT 0121 777 2083
AUTOMECH 0161 7751851
AUTO SPECIALISTS USA (1) 704 786 0187
AVONBAR 01932 840058
EVOLUTION ENGINEERING 0207 703 2225
BERTILS ENGINES USA (1) 708 395 4244
BJ MOTOR ENGINEERS 0161 748 8663
BOB WIRTH RACING USA (1) 510 487 3279
BRAYTON ENGINEERING USA (1) 517 279 8458
BR MOTORSPORT 01926 451545
BRODIE BRITTAIN (BBR) 01280 702389
CAMBRIDGESHIRE SPORTS 01954 210248
CARBONE RACING USA (1) 918 835 6596
CENTRAL AUTO TECH 0121 4558392
COMPETITION ENGINE 01296 435389
CONCEPT MOTORSPORT 0208 568 0293
CONNAUGHT 01795 843802
DAVE CROFTS 01246 477566
DAWSON AUTO DEVELOPMENT 01327 857729
DESIGN & DEVELOPMENT 01695 574454
DRAGON PROJECT RACING TEL 0118 974 4175
DUNNELL ENGINES 01449 677726
DYNOMITE USA (1) 603 329 5645
EAGLE ENGINE CO USA (1) 805 373 6806
ELABORAZIONE COLASUNO 0207 738 8331
ELLIOTT & SON 01306 711275
EDS 01708 857108
ENGINE DATA ANALYSIS 01977 516622
FAST CAR CLINIC 01274 579564
FISCHER ENGINEERING USA (1) 818 504 0300
FONTANA AUTOMOTIVE USA (1) 310 538 2505
FROUDE CONSINE 01905 856800
GAERTE ENGINES USA (1) 219 223 3016
GEMINI ENGINEERING 01474 534779
GEOFF RICHARDSON ENG 01480 861599
GMH ENGINEERING USA (1) 801 225 8970
GOODMAN RACING ENGINES 01327 300422
GRAHAM HATHAWAY RACING 01621 856956
HARPERS PERFORMANCE 01642 818188
GEORGE HARTWELL 01202 556566
HASSELGREN ENGINES USA (1) 510 524 2485
HAUS OF PERFORMANCE USA (1) 714 545 2755
HIGHGATE ENGINEERING 0208 951 4923
HODSON ENGINEERINBG 01732 463658
HOLBAY RACE ENGINES 01473 623000
HOLMAN AUTOMOTIVE USA (1) 704 394 2151
HUDDART 01270 665405
INTEGRAL POWERTRAIN 01908 278600
INTERPRO ENGINEERING 01454 412777
INTER-TUNING Belgium (32) 473 865032
IVAN DUTTON 01923 816277
JANSPEED ENGINEERING 01722 321833
JENNETTS ENGINES 01993 891776
JF ENGINES 01491 680719
JOHN BROWN ENGINEERING 01903 773022
KREMER RACING Germany (49) 221 17 1025
LANGFORD & PECK 01933 441661
LINGENFELTER USA (1) 219 724 2552
LISTER CARS 01372 377474
LOTUS ENGINEERING 01953 608000
LYNX MOTORS 01424 851277
MRE 0208 889 1633
MAXSYM ENGINE TECHNOLOGY 01608 685155
MACHTECH 01923 269788
MATHWALL ENGINEERING 01252 703191
MERLIN DEVELOPMENTS 01283 511184
MICKEY MAROLLO USA (1) 607 734 2148
MINERVA MOTORSPORT 01509 233970
MINISTER RACING ENGINES 01634 682577
MOUNTUNE 01621 854029
NEIL BROWN ENGINEERING 01775 723052
NELSON ENGINE SERVICES 01249 815929
OSELLI ENGINEERING 01865 248100
PAUL PFAFF RACE USA (1) 714 894 7573
PHIL JONES ENGINE DEVELOPMENTS 01454 310 936
01564 824869
PIPER FM 01233 7327377
PRICE MOTORSPORT USA (1) 812 546 4220
PRIMA RACING 0115 9491903
PRO/CAM USA (1) 616 847 5000
PRODRIVE 01295 273355
QUAIFE ENGINEERING 01732 741144
QUICKSILVER USA (1) 301 698 9009
QUORN ENGINE DEVELOPMENTS 01509 412317
RACING BENT USA (1) 714 779 8677
RICARDO INC USA (1) 734 397 6666
RICARDO 01273 794144
ROAD & STAGE MOTORSPORT 01524 844066
ROTO TEST Sweden (46) 8 532 55890
SCARBOROUGH Canada (1) 416 759 9309
SEARLE 0208 305 2250
SCHENCK PEGASUS USA (1) 248 689 9000
SOUTH CERNEY ENGINEERING 01285 860295
SPECIALISED ENGINES 01375 378606
STERLING ENGINES USA (1)209 267 5081
SWIFT MOTORSPORT 0191 5867311
SWINDON RACING ENGINES 01793 531321
TREVOR MORRIS ENGINES 0154 74289
VAN DYNE ENGINEERING USA (1) 714 847 4417
WARRIOR 01825 764833
WESLAKE DEVELOPMENTS 01797 224000

ENGINE BALANCING

AUTOMOTIVE BALANCING USA (1) 562 861 5344

FLOWBENCH ANALYSIS

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

FUEL ANALYSIS

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

INJECTION ANALYSIS

ASNU 0208 420 4494

OIL ANALYSIS

AM TEST SYSTEMS 01253 780780
BOB WIRTH RACING USA (1) 510 487 3279
CRANFIELD INSTITUTE 01908 694134
LOTUS ENGINEERING 01953 608000
QINETIQ 0 8700 100942
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RICARDO 01926 319399
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MIRA LTD 0247 635 5000
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CRANFIELD UNIVERSITY 01234 754152
GM DESIGN 0117 985 9964
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AEROBYTES

with Simon McBeath

Wing end plates

How big should wing end plates be? It's a frequently asked question, and this month we provide some pointers

The regulations in many categories provide at least some limitations on the size of wing end plates that can be utilised at the front or rear of a racecar. Maximum height above the ground or a reference plane is usually restricted and, if the rules don't limit minimum height too, then other practical constraints such as the ground or other parts of the racecar will. There is also the dictum of minimum weight – of some importance with parts that are generally well beyond the wheelbase and, at the rear, high up as well.

The question still remains though – how big, aerodynamically speaking, is good? To attempt to answer that, first let's examine what end plates do. The usual textbooks tell us what we intuitively appreciate – that end plates help to maintain the pressure difference between the upper (pressure) and lower (suction) surfaces of a racecar wing by preventing the 'spillage' of air from the former to the latter around the wing tips. The important variable is said to be the height of the end plate, h, relative to the span, b, of the wing (see figure 1).

Bigger end plates have the effect of increasing the effective 'aspect ratio' (AR) of the wing by reducing this spillage, and this benefits both the downforce and induced drag (the portion of drag directly resulting from downforce generation, and the dominant source of drag from most racecar wings) generated by the wing. Indeed the aeronautical textbooks indicate that an increase in lift coefficient and a decrease in induced drag coefficient should be expected with an increase in AR.

Relating this to end plates, Milliken and Milliken tell us that the effective aspect ratio is proportional to h/b up to values of h/b 0.6, when the gains begin to tail off. In other words, bigger is better, up to a point. But we need to get a bit more practical. For one thing, end plates rarely protrude the same distance above a racecar rear wing as below it, usually because of maximum height restrictions, but also the general desire to run the wing as close to maximum height as possible to try to find some 'clean' air above and behind the racecar.

So Advantage CFD looked at the effects on a two-element wing in 'free stream air' of some more realistic-looking end plate variations compared to the no end plate case – as shown in figure 2. The force results are shown in the table (right), and do indeed show a trend toward more downforce and lower drag.

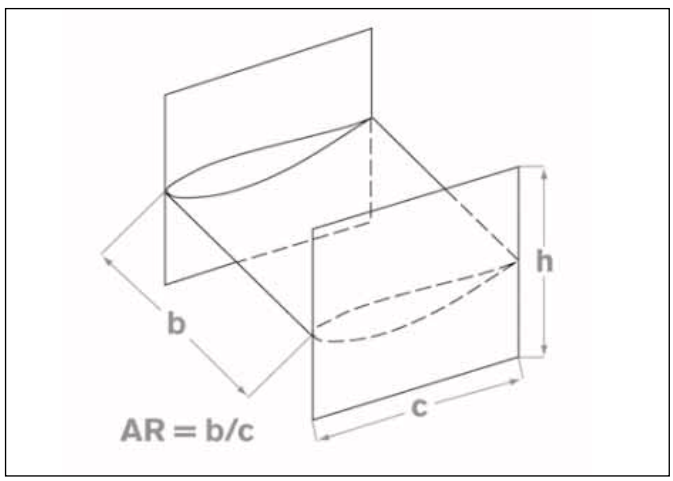


Figure 1: end plate and wing terminology, where h = height and b = span and c = length

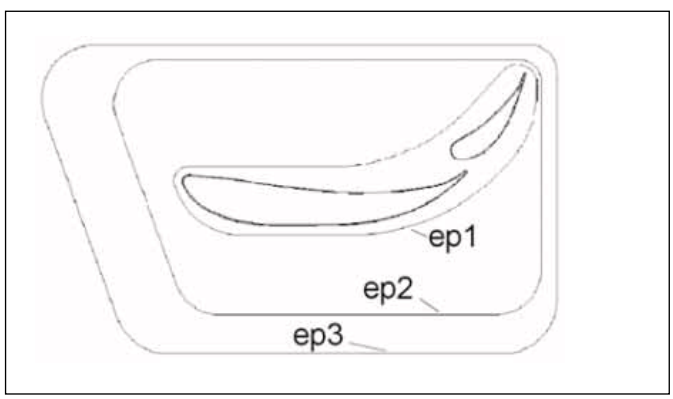


Figure 2: end plate variations tested, in the case of a two-element wing in free stream air

Force results

Case	Downforce (N)	Drag (N)
ep0	769.2	194.8
ep1	786.7	188.3
ep2	873.4	183.8
ep3	900.1	178.1

The graph in figure 3 is a plot of the lift coefficients across the wingspan, from the wing centreline on the left of the graph to the wing tip on the right. The downforce generated near the tips declines far more drastically with no end plate, or just the small end plate, compared with the medium and large end plates where the reduction is much less marked. →

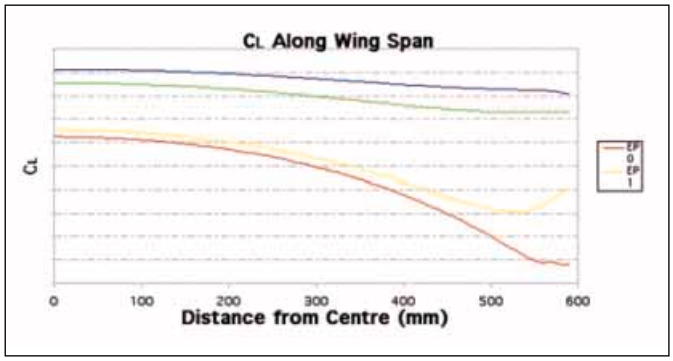


Figure 3: lift coefficients along the wingspan from the centreline to the wing tip

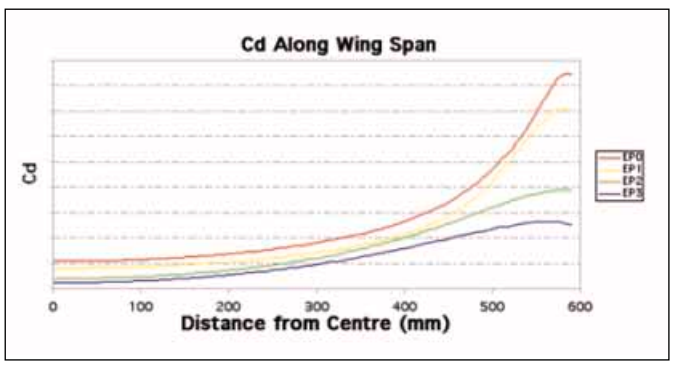


Figure 4: drag coefficients across the wingspan from the centreline (left) to the wing tip

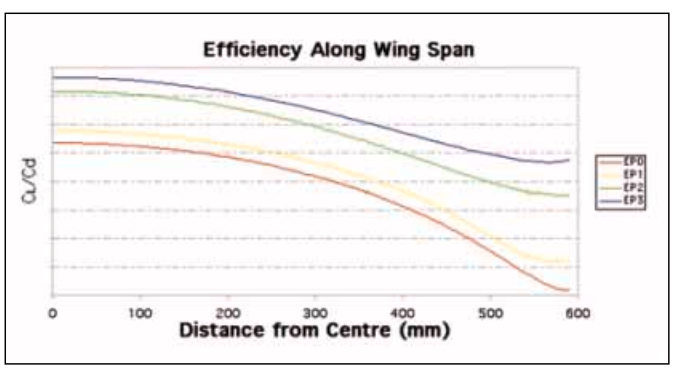


Figure 5: efficiency along the wingspan from the centreline (left) to the wing tip (right)

Thus, with decent sized end plates fitted, the lift coefficients near the wing tip are more akin to the values they would be at a similar distance from the centreline of a much wider wing without end plates. This confirms the notion that end plates effectively increase the aspect ratio which, for a given chord dimension, is the same as saying that end plates have effectively increased the wingspan.

Figure 4 plots the drag coefficients across the wingspan in a similar way, and again it is evident that drag increases near the wing tips far more with no end plate or the small end plate than it does with the medium and large end plates. Figure 5 plots lift divided by drag in the same way to indicate how the wing's efficiency changes across the span.

As always, CFD can help to visualise what's going on. Figure 6 shows the wing tip vortices in the no end plate case. The flow from the upper (pressure) surface to the lower (suction) surface, initiating these powerful vortices, is evident.

Figure 7 shows the large end plates installed. The vortices are now produced at the tips of the end plates, moving their influence away from the wing itself. Furthermore, there are pairs of vortices formed, at the top and bottom of each end plate, and these merge downstream into a single vortex. Thus, taller end plates move the vortices further from the wing where they have less detrimental effect on its performance, reinforcing the idea that increased efficiency is related to end plate size.

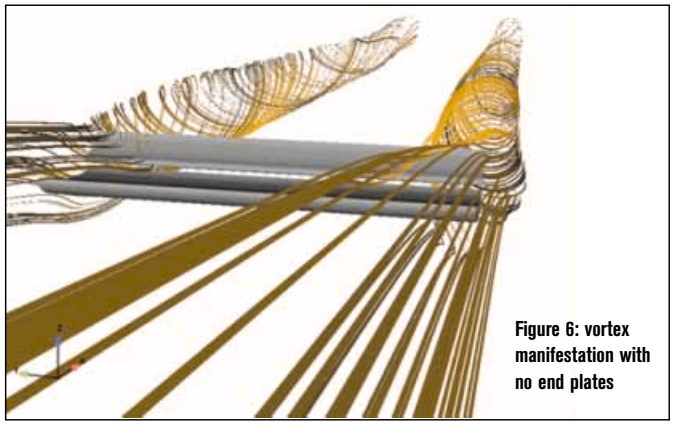


Figure 6: vortex manifestation with no end plates

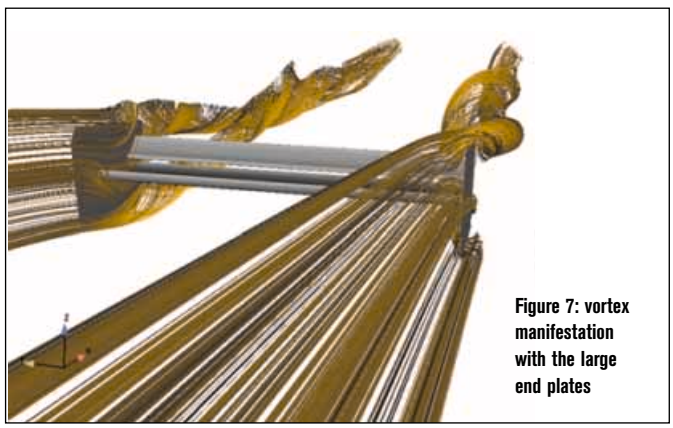


Figure 7: vortex manifestation with the large end plates

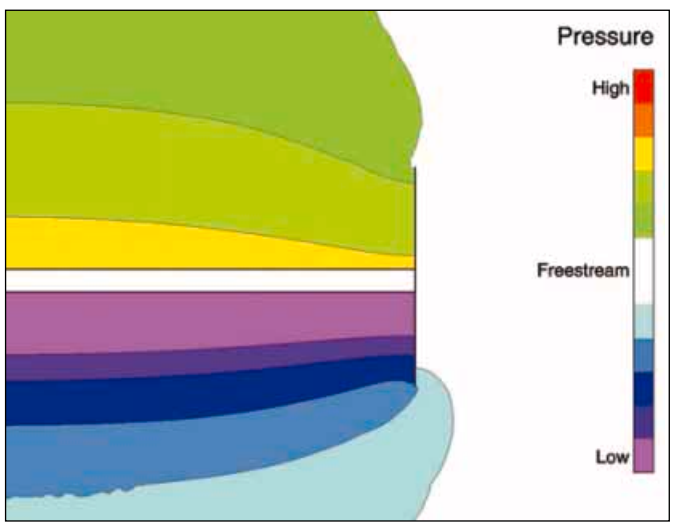


Figure 8: pressure contours near the end plate itself, as viewed from ahead of the wing

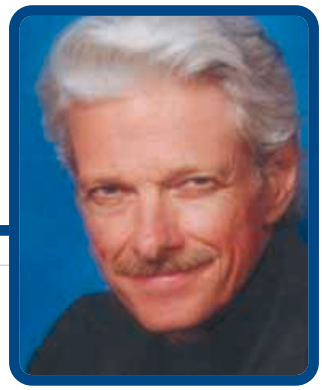
However, there are reasons for thinking that we should have more end plate below the wing than above it. First, as already mentioned, it is probable that the rules and the high mounting of a wing will make this inevitable. Second, the pressure distributions above and below the wing also suggest this is a good idea. Figure 8 illustrates the pressure contours near the end plate above and below the wing, just downstream from the leading edge (before the flow gets complicated by vortex formation).

The pressure increase above the wing is much smaller than the pressure decrease below it. Thus, the influence of the wing extends further below it than above it. Put simply, this means we need more end plate below the wing if vortex formation is to be reduced to the same extent as above it.

Extending this notion, the ideal size of end plate will also depend on the downforce level of the wing. Lower downforce wings create smaller pressure changes, and hence the wing's influence on the pressures in the air around it extends less far, meaning smaller end plates can be used.

Mark Ortiz is

THE CONSULTANT



More on tyre width and effect

All photos: www.sutton-images.com

A classic example of the 'bigger is better' tyre theory – the hugely successful Lotus 72

Q **Last month we looked at the complex issue of why more rubber on the road doesn't necessarily equate to more traction. This month we continue the discussion by looking at some real-world effects that have a bearing on the situation.**

A First of all, the degree to which tyres follow the **A** = F_n/P rule varies considerably. A very flexible tyre, at moderate load, may have a contact patch as large as 97 per cent of theoretical, whereas a fairly stiff tyre may be well below 80 per cent.

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

We are all aware of run-flat tyres currently being sold, which will hold up a car with no inflation pressure at all. As **P** approaches zero, F_n/P approaches infinity. If **A** does not approach infinity, and the tyre does not go flat, the contact patch area as a percentage of theoretically predicted area approaches zero.

One might suppose that the effect of carcass stiffness would be significant mainly in street tyres, with run-flats being an unrepresentative extreme. Yet I have seen dramatic differences in carcass rigidity in different makes of racing tyres intended for the same application. The Formula SAE car run by the University of North Carolina Charlotte uses 10in wheels. Hoosier and Goodyear both make 6in nominal-width tyres for the application. The stiffnesses of these tyres differ dramatically, with the Hoosiers being much more flexible than the Goodyears. The Goodyears are so stiff that they will support the front of the car (without the weight of the driver) with little visible deflection, even when completely →

In theory, a wide tyre with a similar tread compound should last longer than a narrow one, allowing teams to use a softer compound. However, driving style can affect this drastically…

deflated – run-flat racing tyres! So how closely do these tyres approximate $\mathbf{A = F_n/P}$ in this load range? Not very closely at all.

My point here is that tyre stiffness – vertically, laterally, and otherwise, is not purely a function of inflation pressure, so it is a bit risky to try to infer contact patch size from pressure and load. Therefore, we don't necessarily know that two tyres differing only in width will have the same contact patch area at the same inflation pressure and load, or even that tyres of the same size do.

Anyway, if it is approximately true that $\mathbf{A = F_n/P}$, it follows that a wide tyre will have greater vertical stiffness, or tyre spring rate, than a narrow one, at any given inflation pressure. It will also have a smaller static deflection at a given load, which is why the contact patch is shorter. The flip side of this is that for a given static deflection, or tyre spring rate, a wide tyre needs a lower inflation pressure. Consequently, if we compare wide and narrow tyres at similar static deflection, or tyre spring rate, rather than similar pressure, they will have similar length contact patches and the wider one really will have more rubber on the road, just as we would intuitively suppose from looking at them.

As we make a tyre wider, not only does vertical stiffness increase for a given inflation pressure, so does the tension in the carcass due to inflation pressure. A tyre is a form of pressure vessel. We may think of it as a roughly cylindrical tank, bent into a circle to form a donut or torus. Borrowing from the terminology of pressure vessel design, we may speak of 'hoop stress' in the walls: the tensile stress analogous to the load on a barrel hoop. For a given inflation pressure, the hoop stress is directly proportional to the cross-sectional circumference, or mean cross-sectional diameter. When the carcass is under a higher pre-load, the tyre acts stiffer laterally. This effect can easily be seen in bicycle tyres. A fat bicycle tyre will feel harder to the thumb than a skinny one, at any given pressure. If we try to inflate a mountain bike tyre to the pressure we'd use in a narrow road racing tyre, the tyre will expand its bead off the rim and blow out. So when we compare narrow and wide tyres at equal inflation pressures, the wider one will be stiffer laterally as well as vertically, and it will achieve this at no penalty in contact patch size.

Finally, there is the question of tread wear. As we have noted, if the contact patch is longer, it has a larger slipping zone near the limit of adhesion, and it also spends a greater portion of each revolution in contact with the road. Not only do these factors influence how hot the tyre runs, but also how fast it wears. Therefore, assuming good camber control, a wide tyre should last longer than a narrow one, with similar tread compound. The astute reader will see where I'm headed. If we need to run a given number of laps or miles on a set of tyres, then with wider tyres we can trade some of the inherent longevity advantage, and run a softer compound.

> **"TYRE STIFFNESS – VERTICALLY, LATERALLY, AND OTHERWISE, IS NOT PURELY A FUNCTION OF INFLATION PRESSURE"**

Okay, summing up, what does a wider tyre get us?

- It runs cooler, and/or
- it makes more efficient use of its contact patch by having a greater percentage adhering, and/or
- it can run at lower inflation pressure and therefore actually have a larger contact patch, and/or
- it can have greater lateral stiffness at a given pressure and therefore keep its tread planted better, and/or
- it can use a softer, stickier, faster-wearing compound without penalty in longevity

Note that most of these effects in turn play off against each other. We can only blend and balance them, and get a tyre that is somewhat cooler running, has a somewhat lower operating pressure and somewhat larger contact patch, has somewhat greater lateral stiffness, and survives long enough with a somewhat stickier compound, all at the same time. That would explain an improvement in grip, wouldn't it? RE

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