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## Revolution!

### DeltaWing – the future for Sportscar racing?


### Lotus IndyCar

British company debuts 2.2-litre V6

### Formula 1 in court

Force India and Team Lotus head to head

### Mini WRC 01B

Update kit signed off for WRC contender

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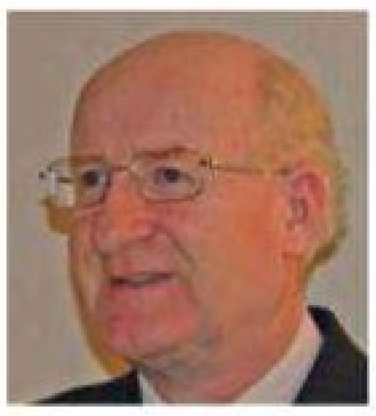


# Dressed to impress?

## Unravelling the code behind the WRC dress code

'Please do not embarrass yourself or your guests by failing to meet the club's agreed standard.' So says the dress code card produced by the British Racing Drivers' Club. The card is replete with a photograph of the flagship Silverstone clubhouse, resplendent in summer sun, white canvas awning and a selection of august members grazing sedately in their enclosure.

On the reverse side is the required litany of taste and discernment: No very short and / or frayed or scruffy shorts. No dirty and / or frayed jeans. No T or collarless shirts. No muddy or oily clothing. No scruffy trainers, absolutely no beach sandals or flips-flops 'worn by gentlemen' (surely redundant as no real gentleman would be seen in such footgear) and it should go without saying that no hats of any kind are to be worn inside. Race suits may be worn but never are they to be tied down at the waist – heaven portend!

Be warned that BRDC staff are empowered to eject any oiks that do not live up to the dress code. Mindful, however, of those poor apologies for human beings genuinely unsure if toupees count as hats or whether string vests can be construed as collarless shirts, there is always the generous option of inviting the Club Secretary to rule on the subtler points in order to prevent you being forcibly de-bagged and thrown out on your inappropriately-attired bottom.

One may chuckle, but were such codes to be applied to FIA championship sponsors then perhaps one could bar the sartorially challenged before they did any damage. How about a code which states that those who promise to sponsor a race series should stump up 100 per cent of the cash before being allowed to make boastful announcements to the press?

Late in 2011, North One Sport, cash-strapped offspring of Convers Sports Initiatives, failed to stump up the readies it had promised to the FIA and the result is a World Rally Championship forced to appear this year wearing the very latest in stark naked series sponsorship apparel.

The Convers Sports Initiatives website is still available for those with a penchant for the memorabilia of decaying businesses and, as an example of the Emperor's New Clothing syndrome, it leaves little, or rather everything, to the imagination. The entrapment sales puff for the company states, 'Convers Sport Initiative is a business specifically created to maximise an immediate and significant opportunity.' That text is posed surrealistically just below the legal announcement of closure from the administrators.

**"the very latest in stark naked series sponsorship apparel"**

Whenever a business claims to 'maximise an immediate and significant opportunity', most sensible people make polite excuses and depart swiftly, donning their hats only when outside the building, of course. Perhaps not so the FIA who seem sadly to have allowed a 'very short and / or frayed' business, quite clearly shod in 'flip-flops' to have persuaded it of sufficient pedigree to sponsor the series.

How often have we been here before? Just recently, we have suffered Donington Park F1 track, A1 GP, US-F1... I begin to lose count. Motorsport Emperors Without Clothes hiding their pink and shiny parts under glossy websites and 'oily clothing' seem to be breeding somewhere. When will the FIA and others learn to count the cash into their accounts before making press announcements and handing over the goodies? Repeat after me: Horse first, then cart. Horse first, then cart. Horse first...

**Dress code; very important**

We are informed that following the initial series sponsorship promises, the WRC may then have promised something to BMW such that BMW spent a clubhouse load of cash making the Mini into a WRC entrant. When BMW initially announced that they would a-rallying go, Ian Robertson of their board of management had high hopes: 'Mini customers have always shown great interest in motorsport. The World Rally Championship is the pinnacle of rallying, making it the ideal platform for demonstrating the competitive spirit of our brand.' But BMW eventually slimmed down their involvement amid growing concerns over poor European TV coverage, 'financial instability of key participants' and the never ending series of same old same old wins from Loeb. It has not turned out too well for BMW and they may now just be waiting for their Prodrive contract to end before taking control for themselves, or even walking away.

VW is presumed to be in next year's WRC but, if they just bought Citroën and changed the badges, it would save them a lot of effort. This season's WRC is well under way, yet despite the 2011 efforts to dry clean and re-make it into a more contemporary and fashionable garment, the same Citroën driver and team has already won the first six rounds. That does not seem so bad unless you know that the same Citroën team and driver has won the entire WRC for every one of the last eight years! The much-vaunted new 2011 engine regulations, brought in to lower costs and perhaps shake up the sport, seem to have had, er, no effect whatsoever on the results.

The WRC claims to be properly dressed as a world class competition, but it is not easy to see how it can justify that catwalk statement when one make and driver have dominated for nearly a decade. If eight years of same old wins had happened in NASCAR, many people would have been whacked and buried in unmarked graves in the boonies. Even in F1 the odd eyebrow would have been raised, and a long time ago Bernie would have whispered into a shell-like ear or 200.

The endless Loeb wins have helped make WRC rather a damper squib than everyone had hoped when the new regulations appeared for last season, and it is now time to go out and buy a new shirt, even if the current one does have a collar and club tie.

That is the trouble with enforcing dress codes – you still get the same people inside the new clothing – when what one really needs to guard against is not the schmutter, but them wot wears it.

# Evolutionary theory

## Nissan's V8 Supercars entry will test the category's progress

Nissan's leap into the V8 Supercars Championship next season represents a bold move from both the manufacturer and the category.

After 20 years of a Ford and Holden duopoly, the new-for-2013 Car of the Future (COTF) regulations have opened the class up to all makers of mid-to-large sized sedans in a bid to better reflect the now globalised state of the local car market.

Attracting investment from additional manufacturers has the potential to strengthen the teams affected by recent cuts to the Ford and Holden racing budgets, while simultaneously providing an opportunity to grow the championship's domestic fan base and increase its international relevance.

For Nissan, the commitment to providing existing Holden team, Kelly Racing, with monetary and technical support (through its NISMO factory in Japan) has been made as part of a push to become Australia's number one vehicle importer, and adds to a substantial portfolio of racing programmes worldwide.

While it's hard to fault the theory behind the decision, just how Nissan's entry will be accepted by the current crop of V8 Supercars' supporters remains to be seen.

The manufacturer's last spell in the category saw it dominate both the Australian Touring Car Championship and Bathurst 1000 with its Group A GT-R, before being mercilessly tossed aside amid a shift to the V8-only regulations that remain in place today. Nissan's last Bathurst appearance had, in fact, seen its drivers booed off the podium by a drunken mob well and truly living up to the race's 'bogan' supporter stereotype.

The championship has changed markedly in the intervening 20 years however, and is now a $300 million business that sits behind only the football and cricket codes on the local sporting landscape. The passion associated with the Ford vs Holden rivalry has undoubtedly played a major part in that growth, but a steady shift away from solely automotive industry sponsors and a noticeable increase in women and children attending events proves that the demographics have at least partially expanded.

**"not all of its fans have managed to evolve at quite the pace the local car industry has"**

What will undoubtedly help Nissan gain greater acceptance this time around is the fact that, while its steamroller GT-R programme possessed major budgetary and technical advantages over the opposition in the early 1990s, its new effort should take place on a much more level playing field.

Nissan's deal with Kelly Racing – believed to be worth between AU$3m and AU$5m per year – will bring the Melbourne-based squad up to the level of manufacturer funding currently enjoyed by Holden and Ford's flagship operations. Kelly Racing has taken three race wins since it was formed in 2009, but appeared unlikely to make the final step into the realm of championship contender without the backing of a manufacturer. And with the team's main rivals all being operated by satellites of British engineering firms (Triple Eight, Prodrive and Walkinshaw Performance), Nissan has effectively thrown its support behind an Australian 'underdog' that, conveniently, has a healthy supporter base of its own.

Most critical for V8 Supercars, of course, will be to ensure the performance of the new Nissan racecars – which will resemble the 2013 Altima body shape – is as closely matched as possible to the latest offerings from the incumbents. While engines and bodywork are the only areas of differentiation between manufacturers under the COTF rules, the fact that the entire 28-car field can be covered by as little as one second on any given lap leaves a very small window for a new marque to drop into.


**The last time Nissan was in V8 Supercars was 1992, with the mighty GT-R. You can be sure the new Altima-based entry will come out all guns blazing**

Nissan is understood to be developing a version of its VK56DE motor formerly used in FIA GT1 for its V8 Supercars assault. The engine's aluminium, quad-cam specification contrasts sharply with the cast iron, pushrod Ford (Boss 302) and Chevrolet (Aurora) units currently in the category, which have been gradually homogenised over the last decade to the point where they are now largely identical in their key dimensions and minimum weights.

As important as matching power and torque outputs will be, fuel consumption plays a key role in almost every modern day V8 Supercars race, and equalising the thirst of two-valve and four-valve engines may prove to be the biggest challenge.

The development of the Nissan's aerodynamic package will also be a sensitive process. Working in a country lacking an appropriate full-scale wind tunnel, V8 Supercars has conducted its previous parity testing in open-air environments, and says it has a 'highly confidential' plan for homologating the Nissan.

V8 Supercars' secretive approach to its involvement in the development of the Nissan racecar has undoubtedly fuelled some of the fears held among internet using and letter-writing supporters that Nissan's arrival will have a detrimental effect on what has been a highly successful category.

The fact that, within 24 hours of announcing Nissan's return, V8 Supercars deemed it necessary to remind its facebook followers that abusive language and racism would not be tolerated was an indication that not all of its fans have managed to evolve at quite the pace the local car industry has.

To the credit of the Car of the Future regulations, pandering to the lowest common denominator finally appears to be a thing of the past.

# Alpha, bravo, charlie... Delta

**The Nissan DeltaWing has started testing and will go to Le Mans 2012 carrying the number '0' as the Garage 56 entry**

**BY MARSHALL PRUETT**

Ben Bowlby's DeltaWing design was chronicled at the concept and design phase in *Racecar Engineering* and, with the prototype breaking cover on 1 March 2012 in California, its creator explained the challenges that were faced with bringing the car to reality.

'When the ACO were seriously considering us being Garage 56 they were concerned about safety, of course,' said Bowlby. 'And one of the things they said was, "Could you use a conventional LMP1 chassis? Does that fit with the concept?" I said, of course we can use a standard chassis. They said that would ease passing current FIA impact tests, so we looked at whether we could do a closed cockpit car and the drag advantage or whether to do an open cockpit car. And basically, George Howard-Chappell offered the AMR-One for sale.

'They were geared up, had spares and theirs is an open cockpit, which is very good as it doesn't get as much lift on the top surface when you spin the car around 90 degrees. We decided with the weight advantages and reduction in complexity, an open cockpit car would be a wise choice for us. And it was a way to shortcut the programme too, because we had to do the entire design and get a car on the ground, and we did that in exactly seven months. I don't think we would have finished the car in the time otherwise.'

With a primary and spare AMR-One chassis at Dan Gurney's All American Racers (AAR) southern California base, one of the unique solutions for the DeltaWing was finalised. The original plans had called for a bespoke chassis penned by Bowlby but, with the Aston Martin tub, there was a need to design and attach a new front suspension and steering sub-chassis to the AMR-One's forward bulkhead. Rather than just graft on the AAR-built composite piece, the team came up with a novel but simple attachment: 'There are four studs on quick release cams, two on each side, and a coupling that has a carbon composite piece mounted on the front, where a normal crash box would have been, except ours carries the whole front suspension. Beyond it is another new impact structure, a crash nose.'

With the featherweight front section in mind, Bowlby says torsional rigidity was never a concern. 'The three-point layout of the DeltaWing has 97 per cent of its business at the rear. Therefore, for cornering, the torsional impact of the influence of the chassis is virtually zero. There is no lateral load distribution transfer due to the chassis stiffness. And we were so exceptionally stiff, compared to what we needed, that we didn't even question it. That is the truth – the DeltaWing does not need enormous torsional stiffness to make it a viable deal for handling characteristics.'

Although the AMR-One chassis complied with crash test regulations, Bowlby's small, light front suspension module is required to undergo impact tests of its own.

'I met with the FIA and we worked out that the car's total weight, full of fuel and with the driver aboard, is 575kg. So we had to do the normal 14m/sec, full 575K crash test and maintain the 25g average.

'We've been working on those crash tests at a facility in Indy and they've been kind enough to lighten their crash rig so we can get down to minimum weight. In fact, we discovered there wasn't one [rig] in the world that was light enough for us to achieve the correct total mass because, by the time you strap the chassis on and the driver, fuel and all the rest of it, it always weighs more than 575kg.

One of the most noticeable changes from the display version of the DeltaWing is


**"an affordable solution for those who want LMP1 performance with the simplicity of a Formula Ford"**


**the** shortened wheelbase, a significant amount having been removed from the front of the chassis. 'The real car has a 120in wheelbase, but the reason for that is not the use of the AMR-One,' explained Bowlby. 'It's because the ACO requested that our car be no longer than 4.65m, simply because the pit box at Le Mans doesn't allow a car longer than that.'

**THE NISMO CONNECTION**

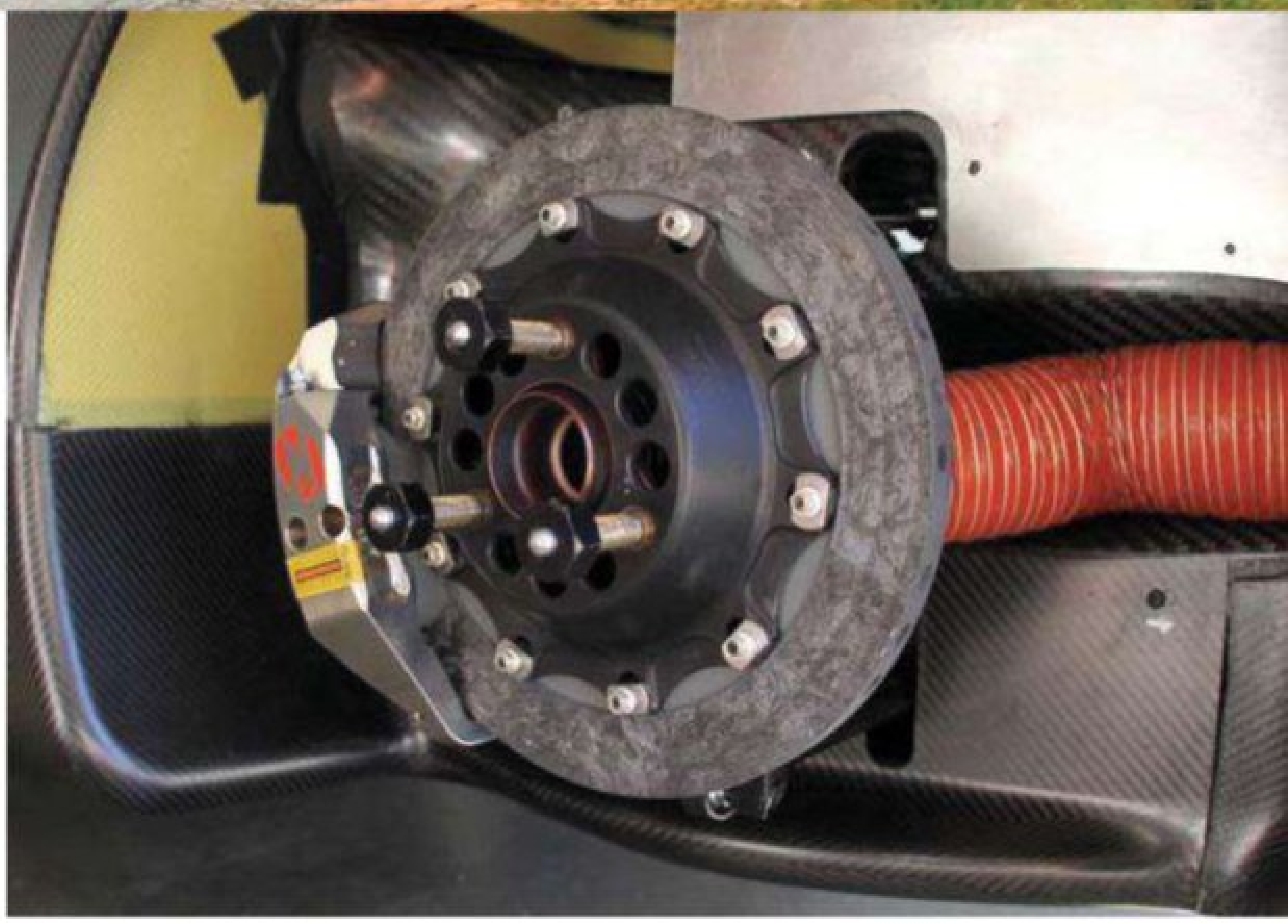
While Bowlby's team worked on the build and development of the DeltaWing in America, Ricardo Divila, technical advisor to NISMO (Nissan Motorsport International Ltd), was performing similar tasks on behalf of Nissan. 'My initial brief from Nissan was to look over the design concept and see what were the possibilities and if it was a valid project,' said the Brazilian. 'To do so meant looking at the initial CFD and 40 per cent wind tunnel data and some dynamic simulations. After liaising with Ben Bowlby, I started receiving the aero maps and car data, and from there did some simulations on my side, and prepared the KPIs (key performance indicators).'

With performance benchmarks established by Divila for NISMO, he began the validation process that would define the on-track and wind tunnel targets the DeltaWing needed to achieve to activate Nissan's official backing.

'The car then had to match these marks in different phases of the project, like the 40 per cent wind tunnel, full-scale matching CFD data, latG, top speed at a given circuit, braking and yaw rates at the same.'

Although the DeltaWing is obviously a very different animal to most racecars, Divila cites first-hand experience and understanding of some Bowlby open-wheel designs as the reason for the easy collaboration between the two men.

'We had overlapped already, as I had run his F3000 and ChampCars, plus he is someone who is very open. He did a very good job of creating and seeing through the concept and design of the DeltaWing, and it's nice to work with people with experience and knowledge. It provides an incredible amount of synergy. You don't have to explain anything, they know what you mean, and know



**With just two four-inch tyres sat close together for frontal grip, that has been the main point of contention from doubters of the DeltaWing concept, but early track tests suggest the unconventional design works. Unusual three-lug front hub arrangement was chosen to save weight**

**Weight saving and balance were major considerations throughout, with an extremely lightweight EMCO gearbox chosen to back the RML-prepared 1.6-litre, direct injection, turbocharged Nissan engine**

dynamics, aero and mechanics.'

After working with his own simulations and calculations, Divila says he was impressed with the detail work done by the team to maintain the car's original performance goals after switching to the AMR-One tub, amongst other things. 'After getting the project and seeing the data, I can only say there was a very good job done to claw back the L/D, as the use of an existing tub from an LMP1 car reduced the downforce by about 35 per cent through the loss of


the tunnel size. The only surprise to me was the exceptional straight-line stability. With a narrow front track, the car does not tramline over bumps in the way a conventional car would.'

In addition to Divila's technical input, the France-based designer's experience at La Sarthe should also benefit the team in June. 'I've been racing at Le Mans for decades and have a considerable amount of experience in the set up, preparation and running of a car there, so this is an area that could also be beneficial.'

After incorporating more detail changes related to using the AMR-One tub, Bowlby's DeltaWing design team, including Simon Marshall and Zack Eakin, along with AAR's Justin Gurney and John Ward, worked through the manufacturing list to complete the car. With Eakin's

Fortunately, the fuel, which is located right next to the engine now, doesn't change the weight distribution because it's working with the c of g.'

Once the DeltaWing heads to Le Mans, Bowlby anticipates having lighter bodywork on the car. 'For the bodywork, I think the budget was about 43kg. When we first put the car on the ground, it was 9kg (20lb) overweight. That was not because it was bad, it's just that the interim engine hadn't got the new crank, or new block. Also, our wind tunnel bodywork was heavy. It was the first lot out of the mould, and the car weighed 472kg (1040lb) dry. Now we have the proper bodywork which is lighter, although it's still not absolutely finished. We're down to, well, let's say we're below our target weight.'

**"the car does not tramline over bumps in the way a conventional car would"**

15kg (33lb) gearbox design being built at EMCO, and Ray Mallock Ltd preparing its 1.6-litre, direct-injected, turbocharged engine for the car, AAR began bringing the rest of the DeltaWing to life.

'Every single component of the car was new,' said Bowlby. 'Actually, there is a ChampCar shift lever and shift cable because we are manual shifting and want to do the testing on the electronic shift in a properly controlled condition. I don't think there is a single other component from another car.'

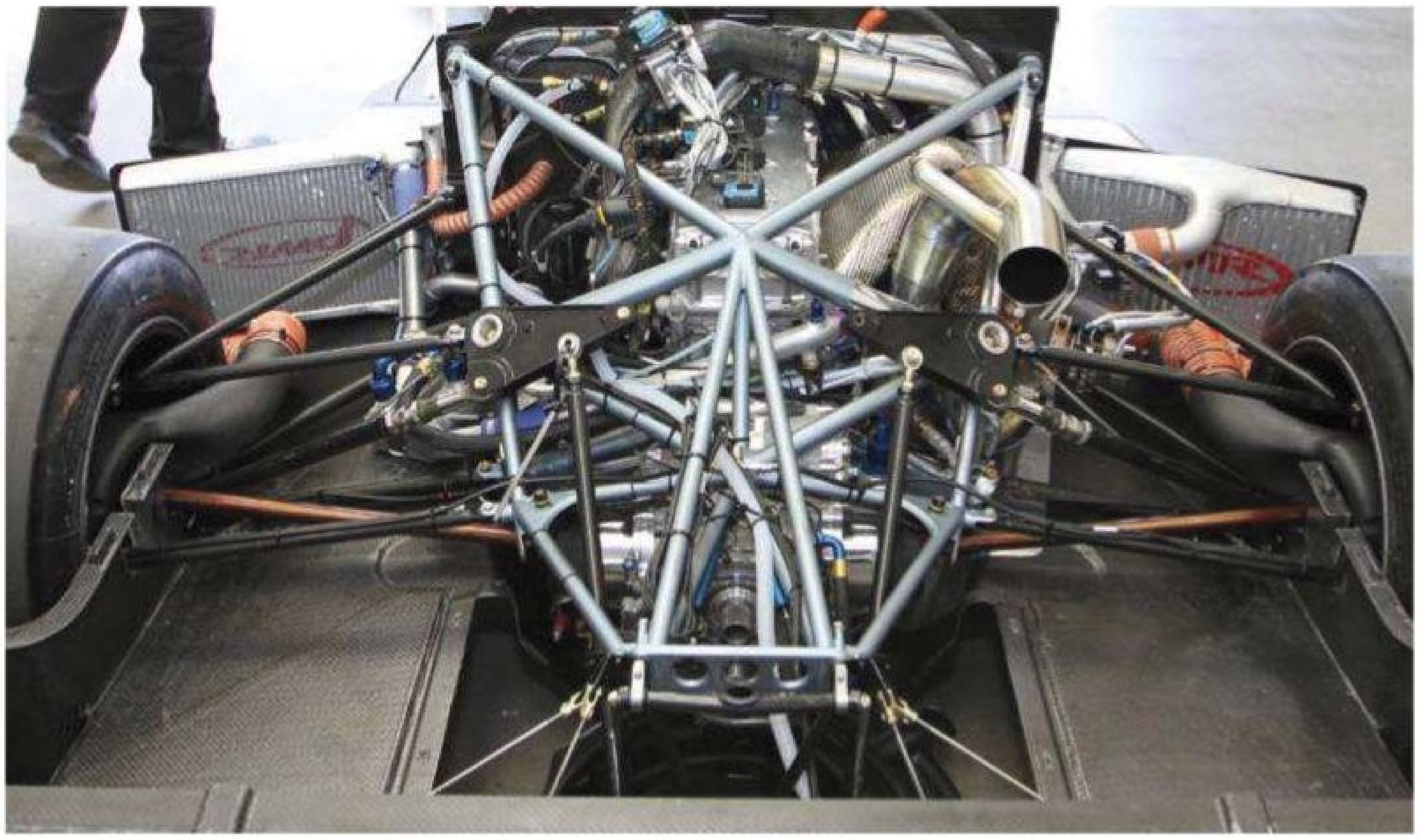
The team exploited the recess in the tub's rear bulkhead, moving the Nissan-badged RML engine inside the cavity as far as possible. 'In order to get the weight of the tub and the driver appropriately positioned so that we still gained 28 per cent front weight distribution, we had to sink the engine into the oil tank that was in the AMR-One chassis. We didn't make it any deeper than the existing divot, but we did make it wider. So that's an area where we did a lot of FEA work and we'll have to do some re-testing of the car in that area.

## REAR SUSPENSION

The DeltaWing's rear suspension is a visual feast. It doesn't have a name, but falls somewhere in the range of being a swing arm-push-pullrod system, for lack of a more precise term. 'It's very simple,' remarked Bowlby. 'The car has all of its roll damping from the rear axle. You can imagine the roll circumstances in a traditional car. It has both front and rear suspension and flexing and roll so all of our roll damping has to come from the rear. The mass of the vehicle has to be damped and rolled by the same amount and ratio as always. So what we did was to come up with a way to overdrive the shocks in roll but not in heave so we have optimum damping in heave. That translates to an increase in damping and roll so we get a decent amount of roll damping of the overall car, but it's all achieved at the rear without giving away grip.'

## FRONT SUSPENSION

Up front, the DeltaWing's suspension has an F1 look to it, with short links from the upright to the tub limiting camber gain



**Rear suspension is a combination of conventional pull and pushrod suspension thinking, with the dampers overdriven in roll but not in heave as the roll damping of the whole car is achieved solely at the rear**

and other functions normally expected from a cornering system. 'Other than positioning of the roll sensor, there is no camber gain or anything like that to speak of,' Bowlby confirmed. 'It's not designed that way. Basically, you run zero camber on the front suspension when there are steering angles applied.'

With such a compact front suspension, and the rear suspension responsible for most of the DeltaWing's handling performance, the design team continues to keep things as simple as possible.

'The front tyres, which are only four inches wide, have one millimeter toe out on each front wheel. Other than that, there's not much set up at the front. It was beautifully sort of juggled with by John Ward. And I think it's an extremely elegant layout. So far we haven't bolted an anti-roll bar in as the drivers tell us the car is so solid in the front and rear that it doesn't need any more support. The simulations tell us the car will be slightly better with a bit more anti-roll stiffness, but there still might be a penalty on things like that. I think we will just have to see what the tyres and the car needs.'

Contained within the front suspension module is a minute, non-traditional steering rack, which required the last-minute help of one of Bowlby's trusted friends to produce: 'The steering rack is a DeltaWing design. It's Zack Eakin and Simon Marshall's work,' he said. 'It's a very elegant bevelled gear, so we've got a pinion drive that's a bit like a Go Kart, where you end up having a pinion arm – for lack of a better word – assembly that allows the steering to activate.'

### BESPOKE TYRES

Finding the right tyre supplier to build the radical fronts and the more conventional rears came in a partnership between DeltaWing and Michelin, with Bowlby providing the renowned manufacturer his dimensional requirements. Silvia Mammone, Michelin global project leader for the DeltaWing, and Michelin technical liaison, Karl Koenigstein, used that data to produce the narrow front tyres at the same time as the company was manufacturing wide fronts for the likes of Audi and Peugeot.

Designing and manufacturing bespoke tyres for a car that did not exist and which had no real-life data to draw upon was daunting, at best, says Koenigstein: 'This was one of the concerns, not only from the standpoint of accuracy of the underlying assumptions, but also from the incertitude coming from the fact that the vehicle comes from an area beyond our experience base. Part of any feasibility study is an assessment of the resources required and whether we have the capacity to properly support a programme. Fortunately, we have been able to accommodate the DeltaWing development,' he said.

Anticipating the DeltaWing's performance through simulations of its own and striving to hit the target needed for the car in its virtual form was a crucial element of Michelin's pre-planning. With the time and resources alone that would be required to generate the 4.0/24.5 R15 fronts, Koenigstein and the rest of the team had a very small and precise window to hit.

**"They're sort of maxed-out FEA specials at the lightest possible weight"**

'Producing the narrow fronts required not only a dedicated mould, but also some modifications to the tyre building machines,' he explained. 'We tried to minimise the risks by conducting some sensitivity studies to see what happened if our simulations were not completely accurate.'

Based on wear rates during initial track testing, it's believed Michelin's front tyres would go as long at 8-10 stints at Le Mans, confirming the accuracy of the firm's initial projections.

To use the narrow Michelins, BBS produced bespoke three-lug front wheels, again to Bowlby's specification. 'The front wheel and tyre weigh 8.4kg (18.5lb),' he confirmed. 'The wheels are unique for the DeltaWing. We designed them hand in hand with Roman Miller and BBS. He loved the project and did this special design. They're sort of maxed-out FEA specials at the lightest possible weight. The Michelin tyre is 6kg (13.2lb)...'

Bowlby also explained the unexpected choice of wheel studs and lug nuts for the front of the car: 'The reason we've gone for three lugs is for about as many reasons as you could possibly imagine,' he said. 'First of all, in our analysis it was slightly lighter. In the front of the car it was particularly important to have light weight. Secondly, if you have multiple wheel lugs, you don't need a locking system. That's really important because it's weight saving. If you had a central locking system the whole wheel has to be so offset it's hanging out in the air stream and it's not really essential from a practical racing standpoint.'

At the back, the DeltaWing uses a more traditional single-lug design to carry the 9kg (19.8lb) 12.5/24.5 R15 Michelin tyre and 5kg (11lb) BBS wheel.

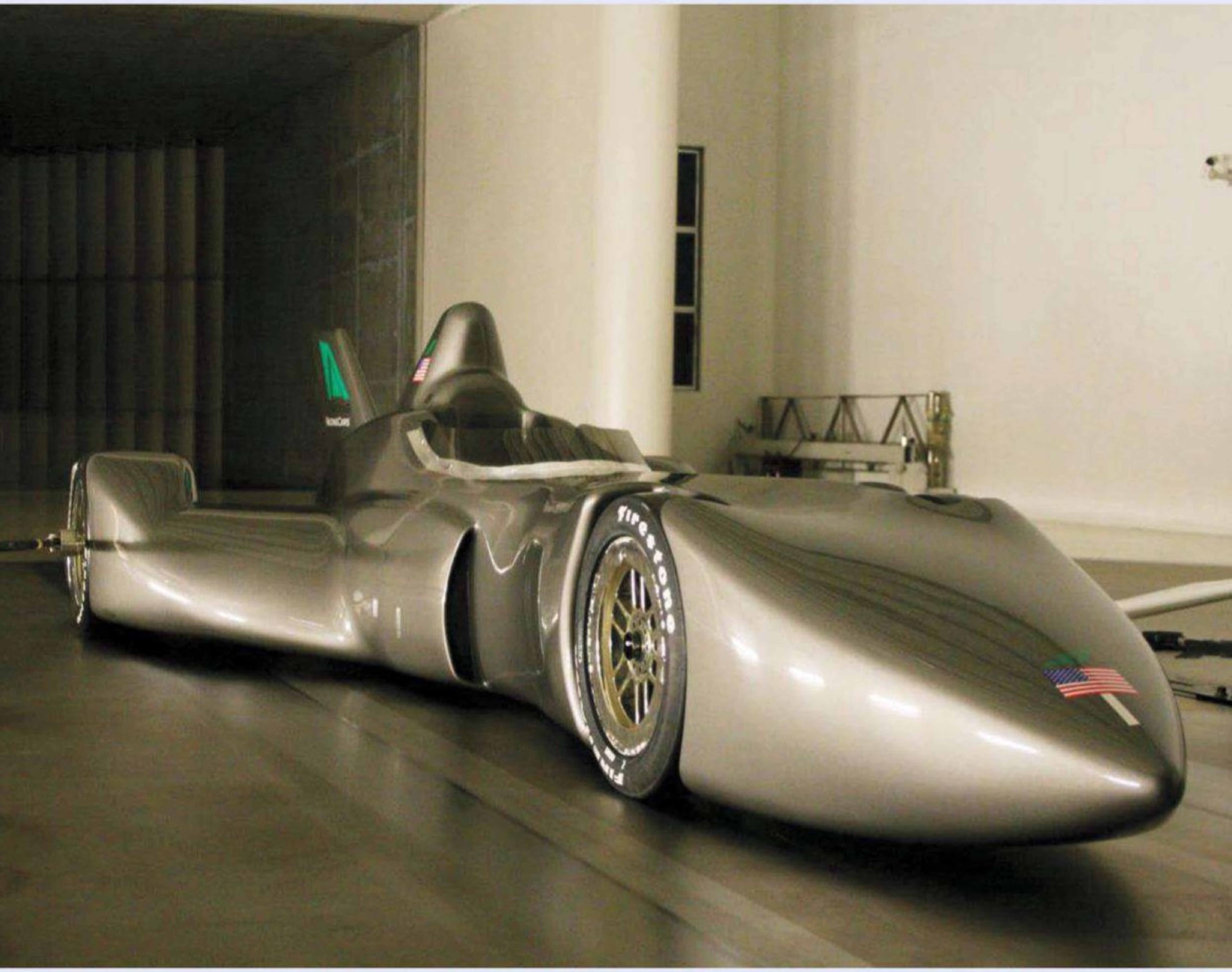
### AERO EXERCISE

With the DeltaWing being a largely aerodynamic exercise, Bowlby went into detail on the various traits and philosophies that went into the car.

'We've said all along that the DeltaWing is meant to be half of most values found in an LMP1 car. It's half the weight, has half the power and, in this instance, half the downforce and less than half the drag. The drag is, roughly, 550lb at 90m/sec at 201.34mph, with 2700lb of downforce.'

Like most of the car's dynamic performance capabilities, the majority of the aero balance is shifted rearwards.

'We're running around 25 per cent on the front,' said Bowlby. 'And we have an aero mass characteristic where, in fact, the balance stays remarkably consistent. The car makes much



more downforce at high ride height than it does when it's on the deck. And the whole structure attenuates when it gets close to the road, which is a very favourable characteristic we worked very hard to get. At Le Mans you have five straights separated by relatively slow corners. You have to have the car come up into a high downforce position if you can and be low drag on the straights.'

The DeltaWing concept vehicle was shown with its vertical fin extending past the rear bodywork, but this was trimmed for the Le Mans version.

'The ACO gave us a very open brief, but they wanted us to have no bodywork overhang on the back. I said, "okay, we'll chop everything off." We have so much stability in hand with the car that it was the safe thing to do. It all ended up working out pretty well, I think. The stabiliser is a yaw device but, more importantly, it creates high pressure on its leading edge, the leading side when the car is in yaw. That's a really big deal.'

Bowlby took a page out of Sprint Cup technology by aiding the DeltaWing's spin-yaw-lift reaction by designing the equivalent of roof flaps for the trailing edge of the car's under-wing tunnels which means the car could stay on the ground at 200mph and not lift-off.

One interesting aspect of the DeltaWing's aerodynamics involves a piece of technology from 1981 that caught Bowlby's eye at a time when he was planning for the car to be used in open-wheel racing. It comes from Dan Gurney's 30-year old Pepsi Challenge Indy car and its so-called Battery Layer Adhesion Theory (BLAT). 'After I had a basic package working, and once I'd run a full-scale Windshear to validate the CFD result, I sent a load of work to TotalSim, which included the BLAT design. On the first run they pulled more downforce on the high ride height than the previous sets… it obviously had a better characteristic because it didn't have as much downforce at low ride height… They're not actually skirts, they're way off the ground. They are vortex leading edges, if you like, delta plan form leading edges. So we developed and optimised that. It was so stable, the flow structure was so robust and it gave the car a characteristic where even in very nose-up angles – if it gets launched off the tarmac or something on the Mulsanne – the car was going to come straight back down. Very satisfying.'

**Front suspension has been kept remarkably simple and elegant, with no anti-roll bar, no camber and only 1mm of toe out on each wheel**

#### MOBILE EFFICIENCY

The drivetrain for the DeltaWing centred on compactness and lightness to fit the overall concept of mobile efficiency. 'Zack pretty much single-handedly did the entire gearbox,' reported Bowlby. 'He went through a number of iterations to find what we all considered the optimal layout. The design is one that was proposed by Jim Hamilton. It's a US patent held by Kenny Hill. It's a unique design and a very clever piece.'

### ROAD CAR RELEVANCE – DARREN COX, NISSAN EUROPE CHIEF MARKETING MANAGER, CROSSOVER AND SPORT

'With our range going forward, a number of the engine applications are becoming smaller in terms of petrol and either turbo or supercharged. Even the Micra will have a three-cylinder supercharged engine. If you look at the Nissan Juke, it has a 1.6 turbo, and everything we learn from this DeltaWing project will be put into that.

'We are looking at the Juke NISMO, which will be launched at the end of the year, and we will need to know more about making 1.6 turbo engines faster. You could imagine that, as we are in a group, maybe Renault Sport will have the same engines that we are using. We need to be on top of small capacity turbo engines and this is a rapid prototype of that. Yes, it is a race engine, but we are getting our production engineers involved.

'Don Panoz is not going to be happy just building one or two cars to do demonstrations. He is talking to us about using the road car engine with more horsepower as an LMPC engine, for example. Who is to say that the LMPC engine isn't the same as the Juke engine? Yes, this is a race engine built by RML, but it opens the door to do a lot more.

'Outside the marketing benefit, which is just stickers on the side of the car, one of the key things we are using in the company is confidence. We have fantastic products now in Europe. We are selling three times as much as we were four years ago and making more money because our cars are desired by the customers, but we are still not as confident as our market share and our products should be internally. Products like this allow us to bring people on board, not just engineers, but sales and marketing and see that we can be confident. We may only make it an hour into Le Mans, and get beaten up for it, but we have to show our teams that we can take risks, and do some crazy stuff.

'The product planners that put Qashqai together took a risk. We went head to head with Golf. Everyone said it was a niche marketplace, and we are now, in some markets, outselling the Golf. Sometimes you need to be extreme to prove the rule, and this is what this project does.

**"Sometimes you need to be extreme to prove the rule"**

'In terms of transferable technologies, what is road car development going to be about? Downsizing engines is a core part of it and, while we are not going to produce a road car like this, we need to learn about aerodynamics and weight reduction. We have got to get to Le Mans, make the DeltaWing reliable, and keep in line with the philosophy of the car, which is light weight. We can make it reliable by bulking everything up, make it 20 per cent heavier or whatever, but then you don't have the car how it was conceived. You have a balance. Downsizing engines, aerodynamics and weight loss are how we are going to have to go, and it is not going to look anything like this, but we will learn a lot of lessons.

'The original concept was that we were going to be engine suppliers. We put Ricardo Devila in the project, and he is very influential in NISMO, and knows Le Mans back to front. As he started to feed back to me, we put in more and more resource because we could see that it needed an OEM involved to take it to the next level, and there was advantage to us doing that. It wasn't the plan originally to be the Nissan DeltaWing… we just saw what a great project it was. If you look at the deal we have done, we are effectively helping them to get to Le Mans.'

In initial tests, Eakin's gearbox suffered from a number of gremlins related to communications and heat rejection, so a dedicated cooling system is in the works for Le Mans. 'None of the parts in the gearbox are going to be revised,' Bowlby confirmed. 'The shift strategy was just mangling everything. We were trying to make a Cosworth steering wheel talk to a MoTeC data logger and a Live Racing ECU. There were some language barriers.'

Intelligent torque vectoring, as Bowlby calls it, could also be fully enabled in time for the 24-hour race but, in testing, the team and its drivers were quite pleased with the open differential currently being used.

Even the DeltaWing's engine is an interesting solution, as it makes use of one of the very few Global Racing Engine designs that have been manufactured.

**FIRST CHOICE**

'The engine is supplied by Ray Mallock Ltd (RML) to Nissan,' explained Bowlby. 'RML and Nissan have been partners for a long time and RML has developed a four-cylinder, 1.6-litre engine. Best of all for us, they could make it weigh 70kg (154lb) and it would have all the performance and efficiency we were looking for. It's direct injection, petrol-fuelled and turbocharged. It's our first choice for what we wanted.'

Named the Nissan DIG-T, Bowlby is clearly enamoured with the performance and fitment: 'It makes 2bar boost, has 312Nm of torque in a straight, flat line and the power rises to 300bhp at 7500rpm. So far in testing it's achieved 225g/kw hour fuel consumption, which is bloody impressive – that's like a Prius! It runs on Shell E10 standard Le Mans pump fuel.

'It uses a two-plate Tilton carbon clutch, separate alternator, and sits in isolation on rubber mounts so it doesn't vibrate the rest of the car and gives us a nice, harmonious driving experience. It just does everything you could ask of it.'

**"The DeltaWing does not need enormous torsional stiffness to make it a viable deal for handling characteristics"**

With specific involvement from Jerry Hardcastle, VP vehicle design and development at Nissan Technical Center Europe, RML was able to tailor the DIG-T to the DeltaWing's unique weight and chassis balance requirements. 'RML have taken weight out of the engine wherever they can. It comes from modifying cylinder blocks, cylinder head castings, cam covers. Also, they're trying to drill out the crankshaft so it can be lightened as well. And, in the final modifications, the plenum layout has been changed because of the installation immediately behind the driver within the bulkhead.'

With the emphasis placed on lightness and reliability, Hardcastle says the DIG-T's proven direct injection system has remained untouched: 'In terms of fuel economy, we've taken that aspect of engine development out of the equation. It's a much lighter car, and we've already seen incredible fuel economy as a result. But going forward, that's an area we want to understand more, and now that we've actually got the car that is an area we can spend more time on.'

**Darrick Dong of DeltaWing brake supplier, Performance Friction**

**COMING OF AGE**

After two years of intense pressure to bring the DeltaWing to fruition, Bowlby says he took pride in seeing his creation turn, brake and accelerate with the best the factory LMP1 cars have to offer, and was also relieved to have his adventurous virtual concepts deliver as expected on track. 'It's been a pleasure, but a great surprise,' he said. 'It appears that in this day and age you can predict mathematically the performance of the car, the tyre, the aero and the vehicle handling characteristics. I just don't think you could've done that 10 years ago, maybe even five years ago.

'I think it's an incredible coming of age for the digital computer modelling world. Despite so many people saying it was impossible to achieve, you can still dream in this day and age. We've proven it.'

So will a production version of the vehicle be offered? Project partner, Don Panoz, has said he intends to use his Elan Technologies firm to manufacture the DeltaWing, but what will it cost buyers?

Bowlby: 'If I had to say a number, it would plus or minus a quarter of a million dollars,' he said with a laugh. 'Right now, though, it's a one off. We're paying a massive premium on the Aston Martin chassis, so the cost of the prototype isn't realistic, but it needn't be an expensive car – the part count is low, there's not actually a lot of material in them, there isn't a lot of tooling. In fact, it's a very simple car. With a tub of our own, I think the DeltaWing becomes an affordable solution for those who want LMP1 performance with the simplicity of a Formula Ford. That's our long-term wish.'

## TECH SPEC

**Engine:**
Four cylinder, 1.6-litre Nissan DIG-T (Direct Injection Gasoline-Turbo)
**Maximum power:** 300bhp
**Maximum torque:** 312Nm

**Dampers:** coilover hydraulic

**Anti-roll bars:** torsion bar rear; no front anti-roll bar

**Transmission**
**Gearbox:** five-speed sequential
**Clutch:** 4.5in two-plate carbon
**Shift system:** electrically-actuated direct barrel rotation paddle shift
**Crown wheel and pinion:** planetary final driver potentially featuring efficient torque vectoring differential technology

**Driveshafts:** equal length, tripod-jointed halfshafts

**Brakes:** carbon / carbon
**Brake bias:** 40 per cent torque bias front
**Cooling:** ventilated uprights, air cooled

**Wheels**
**Type:** one-piece forged magnesium
**Size:** 15in front; 15in rear

**Tyres**
**Front:** 10/31 - 15 Michelin
**Rear:** 310/620 - 15 Michelin

**Chassis:**
**Target homologated weight:** 575kg
**Type:** FIA-homologated carbon fibre monocoque
**Jacking:** air jack

**Fuel and exhaust**
**Fuel system:** 40-litre, FIA-spec petrol fuel cell
**Exhaust system:** Inconel four-into-one; solenoid-controlled wastegate actuation

**Bodywork**
**Tub and body panels:** carbon composite

**Aerodynamics**
Twin vortex underbody downforce system, with BLAT (Boundary Layer Adhesion Technology)
**Centre of pressure:** 25% front
**Coefficient of drag:** 0.313


# Under pressure

**Judd's new Lotus IndyCar engine was produced in record time and, despite a daunting list of challenges and constraints, it looks set to be a contender by the end of the season**

**BY MARSHALL PRUETT**


**"550-700bhp across the mix of tracks with no changes to the specification"**

Factor in the impressively short nine-month gestation period for the new Lotus IndyCar powerplant created by Engine Developments Ltd (EDL) and the John Judd-designed unit has already earned an informal victory in its race from concept to reality. Whether the accolades for the new-for-2012, 2.2-litre, twin-turbo V6 can extend beyond its production timeline won't be known until the end of the season, but as EDL and Lotus prepare to take on Ilmor's twin-turbo Chevrolet V6 and Honda Performance Development's single turbo version, it faces a daunting challenge as a minnow in shark-infested waters.

Designated DC by Judd, the process of developing the Lotus engine was compressed from the outset. Despite announcing its intention to build an engine in November of 2010, Lotus then went in search of a partner to handle the project on its behalf, and had an agreement in place with EDL by mid-February 2011, with the opening of the 2012 season being just over a year later, on 25 March. Chevrolet, by comparison, announced its plans to build its own twin-turbo V6 IndyCar engine just days before Lotus, yet had already secured the services of Ilmor and had the project moving forward well before its press conference.

**"we're not at direct injection yet"**

That distinction would play a central role in every aspect of the Lotus project. Initially, all EDL had to rely upon was the rather fixed design and construction rules the manufacturers agreed to, with IndyCar mandating a maximum displacement of 2.4-litres, no more than six cylinders, four camshafts, one or two turbos, the use of E85 ethanol and the option of direct injection.

The series also asked for costs and weight to be kept to a minimum, with a fixed lease rate of $690,000 (£441,300) per car, which included the use of five engines, 2000 miles between rebuilds and 10,000 total miles of activity. Common, light materials were also called for – aluminium blocks and heads, in particular – to help IndyCar reach the 1380lb (626kg) minimum vehicle weight it envisioned. Identical chassis and bellhousing mounting points were also required to lessen the manufacturing burden on Dallara. And, with the variety of road courses and oval tracks visited by the series, IndyCar also asked its manufacturers to provide 550-700bhp across the mix of tracks with no changes to the specification.

Without the luxury of time to engage the Malaysian-owned marque on the finer aspects of its desired engine design, Judd says Lotus allowed the Rugby-based firm to arrive at the DC's final specifications on its own. 'They left us pretty much to do it,' said the veteran F1 and Sportscar engine designer. 'Their brief was to produce an engine to apply to the rules. We did the best we could based to a reasonable extent on stuff we've done previously because the time was fairly short. So we discussed various concepts with them and showed the layouts as we were going along, but they basically allowed us to use our initiative pretty well.'

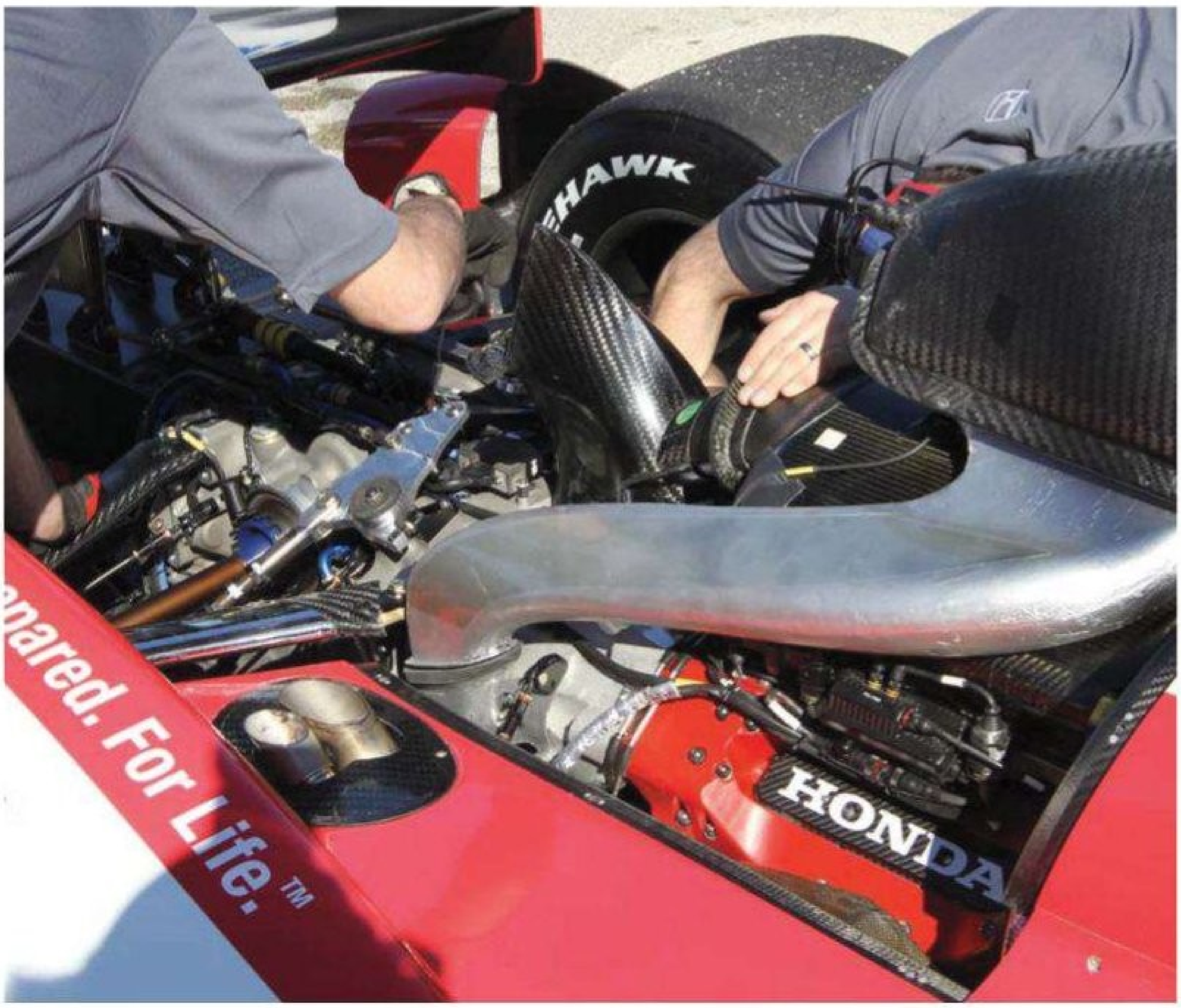
Judd's previous turbocharged Indy car experience came during the 1980s in CART with its 2.65-litre Brabham-Honda V8, and again in the 1990s when its V8 was quietly utilised by Toyota when fitment issues arose with the Japanese marque's first CART engine.

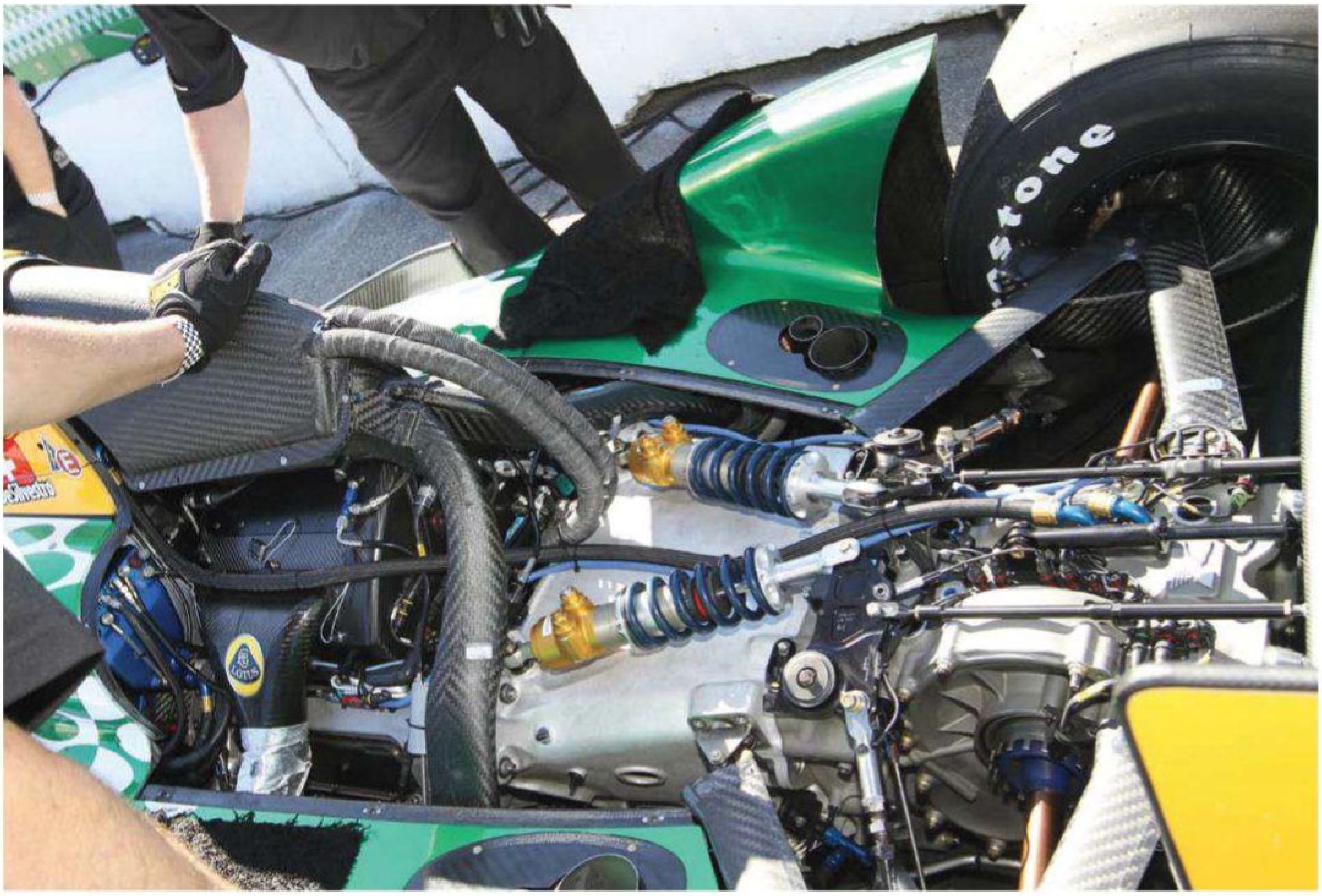
**SIGNIFICANT ADVANCES**

But there have been significant advances in engineering design made since then and, for the 2012 engine, Judd was keen to use them: 'We did the modelling and design with SolidWorks, and all the programmes that go with that,' he explained. 'We worked with Dallara on the modelling of the ducts to feed air to and from the turbos. That's a bit of an interface thing, really, the feed to the turbocharger, that duct is a Dallara part. And in turn, the turbocharger to the engine, that's a Lotus part. But we actually got Dallara to run a fairly basic closed simulation using the simple thing that comes pre-packaged from SolidWorks. And then we did it in more detail with Dallara throughout.'

If there was a benefit to Lotus' late start, it came in the form of the reduction in engine capacity from the original 2.4 litres to 2.2 litres in January, 2011. While Honda had already built a bespoke 2.4-litre unit by that point, EDL was able to start on a smaller capacity unit from the outset. And with many of the final engine regulations by then in place, including a 12,000rpm rev limit, Judd was able to assess the areas of interest to focus on: 'You need to maximise airflow

**Lotus' two rivals in the series are both big guns, with major manufacturer backing – Chevrolet's twin-turbo V6 (above) is built by Ilmor, while Honda Performance Development's version (below) is another single turbo unit**






**With pistons not homologated, these and the attendant compression ratio are crucial for the tuning potential of the engine. After that, it's down to the ECU**

and minimise friction, obviously. And to make some decisions about compression ratio, which, of course, will affect efficiency. This really takes on board stroke, the angle. You've got to think – it's a V6, it's balanced pretty well, so you need to sort out the firing process and what configuration crank you're going to use. The rev limit means probably if it was a 2.2-litre V6 for F1 that, say, revs at 18,000, you'd almost certainly have bought a shorter stroke and a bigger valve than you'd do for this application.'

#### CONVENTIONAL TUNING

Once built, EDL had a finite window to work within, as the series closed homologation 30 days prior to the opening round on March 25 2012, leaving Judd to stick to more conventional tuning areas.

'You do all the usual things like cam timing, lift, fuel injection, injector positions, fuel pressure, injector type, compression ratio, make sure the crank's not stirring up oil in the sump etc,' he explained. 'So you're basically working with this stuff all the time, in conjunction with trying to sort it out, to maintain and work on the durability and production manufacture issues as well. It's all inter-related. But in terms of power, it is breathing, cam timing, friction, compression ratio and mixture preparation.'

With the DC homologated, the number of performance items to exploit has been greatly reduced, but Judd still has a few items to play with. 'Homologation leaves the compression ratio pretty much free because the pistons are not homologated. The rules were drawn up in connection with engine people and I'd say there's nobody that wants to be tied down to a piston design right now because we don't know how durability is going to turn out. It's quite hard to know the usage profiles with different boost specs for small ovals and road courses. And the race will take place in different weather conditions – some hot, some cold – so to get a handle on durability in race conditions is something, I think, we won't know about until we're in the race. For us, I think the biggest single component affected by the usage profile is the piston. Most of the rest of the in-season tuning will come from the ECU.'

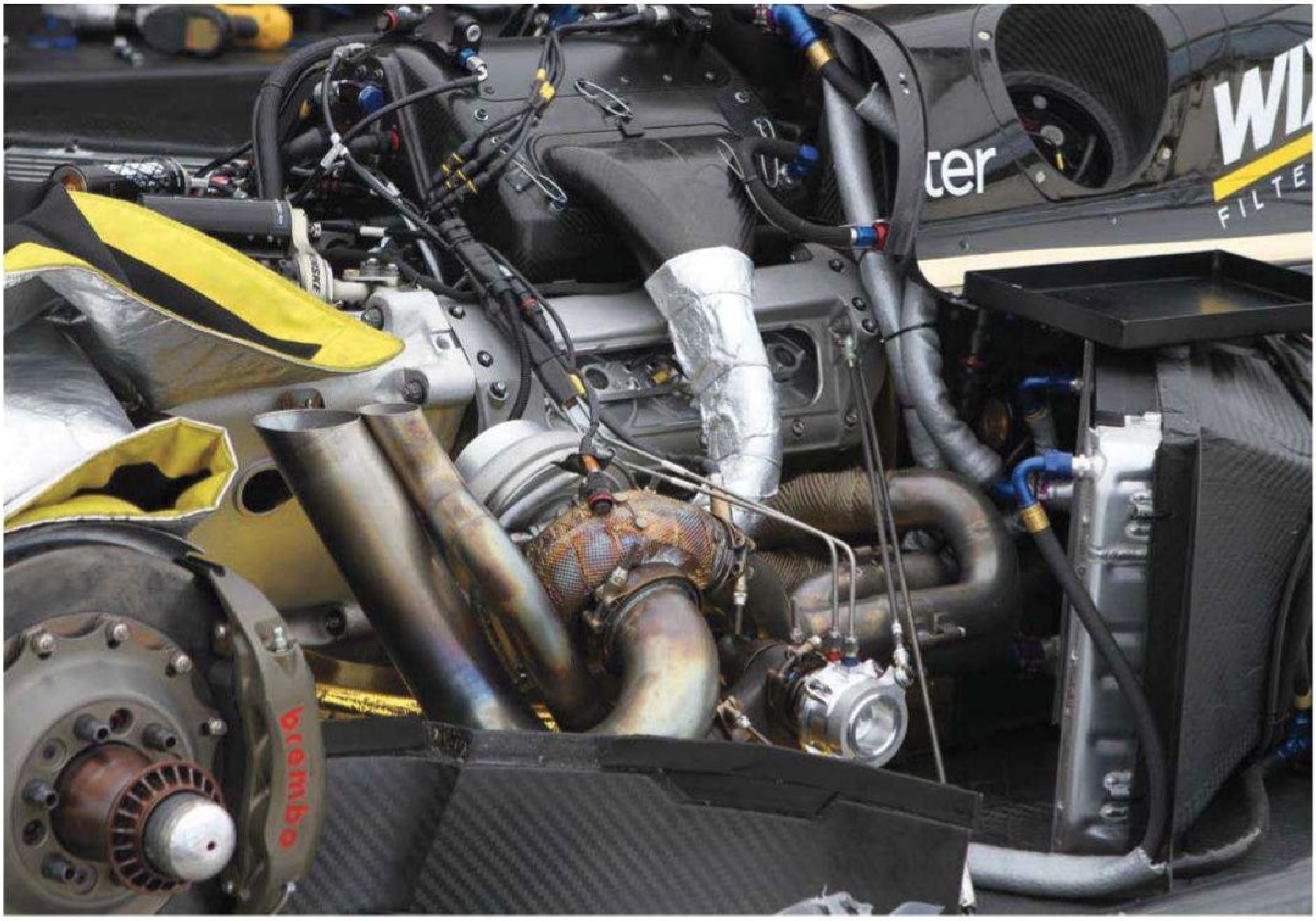
**"We did the modelling and design with SolidWorks, and all the programmes that go with that"**

#### ONE GOOD, TWO BETTER?

Judd opted for two turbos, rather than one, citing the difference in physical placement – either the traditional inside the bellhousing for single, or parallel to the exhaust ports for twin – as one of the considerations. But the series balanced the sizing of the Borg Warner turbine housings to provide equal airflow between single and twin turbos, and responsiveness characteristics and inertial differences also factored into the Lotus' final spec. 'It's a good old trade off,' he said. 'The HPD [Honda] has a nice, simple [single turbocharger] layout. I don't know if there's any weight difference or not. We thought at the end of the day the twin would be better and we were pretty concerned about the heat in the bellhousing in the single. We saw all that years ago with the CART stuff.'

IndyCar will permit the changing of housing sizes to optimise performance for different circuits, but once the single Borg Warner EFR9180 (with an A/R of 1.05 or 1.45) or twin turbo EFR6758 (with A/R of 0.64 or 0.85) layout has been chosen by a manufacturer, it cannot switch between single or twin turbos.

'The small turbine has the higher back pressure and there's a power penalty for that,' continued Judd. 'We don't have




**Judd opted for a twin turbo configuration, citing bellhousing heat, responsiveness characteristics and inertial differences as reasons for the choice**

enough miles on the track yet to know what difference that will make in the car. It's really a throttle response issue. The idea is a small turbo gives you better response. We just haven't done enough running on enough cars with enough gear ratios to be sure where we want to be on that. Certainly, I'm well aware that in the 2.65-litre CART days you ran the big turbo on the big ovals and the small turbos pretty much everywhere else.'

Although special attention was paid to make most components spec, the series left induction piping diameters, lengths and routing open. While its twin-turbo rivals at Chevy opted to take its air from the front of the airbox, Judd elected to feed its turbos from the back of the airbox.

The only major limitation Judd looked to meet with the piping was the maximum angle of inclination the turbo vendor listed for its units. 'The shaft can be no more than 20 degrees from horizontal,' Judd explained. 'We haven't seen it vibrate, or just a very small vibration if it did. If you start talking about greater angles there are other possibilities, but we decided we're probably better off to respect [the manufacturer's recommendation].'

Although the series required the use of the Borg Warner turbocharger, it left the choice of wastegate vendor open to each manufacturer, with Judd opting for units from Parallel Motion, suppliers to Audi's R18 LMP1 programme, amongst others.

### BOOST LEVELS

By the end of 2011, IndyCar had finalised its maximum boost levels, announcing 22.47psi for road courses, 20.29psi for short ovals and 18.84psi for speedways. McLaren was chosen as the spec ECU supplier, with its i400 unit allowing the series to have its own set of monitoring sensors and channels to police the engines, including assessing instant penalties when over-boost conditions are met.

With engine length set at a maximum of 460mm, a maximum bore diameter of 95mm, open stroke and a v-angle limit between 60 and 90 degrees, Judd took all the constraints in mind and opted to go as wide as the Dallara's engine cover would permit: 'We made it fairly wide, but not as far as 90 [degrees]. We want to make it as wide as possible for two reasons. One is the c of g. We've got space in the centre v as well. And two, to keep the firing angle as far apart as possible. If you have a three-pin crank and a 60-degree v, the firings would be, say, zero, 60, then it's 180. Zero, 60 and 240. You've got two very close together and two that are apart. You have to consider whether you think this will affect your durability in terms of engine parts and the transmission and clutch. The firing pulses overlap quite a bit. It's like a big three-cylinder engine. We went as wide as we could but we felt constrained a bit by the bodywork and getting in turbo ducts... It's all got to fit in there. It's pretty complicated.'

**"We made it fairly wide, but not as far as 90 [degrees]"**

Direct injection is an area of development Judd was forced to leave off the DC's initial design brief, due to the time required to develop the system, and its limited potential rewards. 'It's designed into the engine and the base end of the cylinder head castings have got bosses. We paid a lot of attention to the ability to use DI in the initial design but we're not at direct injection yet. Lots of road cars have direct injection and they use it for reasons that are totally different to a racing application. So you're looking at stratification at low part loads, fuel cuts and all sorts of things it's very good at, but aren't related to the full throttle, maximum power stuff that we care about for racing. At the moment, it certainly won't go

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**Despite the 18-22psi boost range, Judd has noticed engine wear in 700bhp road course configuration, and admitted there is more work to do**

on our engine at the start of this season, let's put it like that.'

In the interest of cost savings, IndyCar made an effort to keep exotic metals out of the engine, which Judd took no issue with. 'For cranks and pistons, as I tell people, if you go and dig a World War II fighter out of the ground, you could probably make them of the same material. Nothing has changed. Rolls Royce made all those things years ago. The basic crank material is what in the UK used to be called N40. It's all still pretty much the same thing. As far as I know, that is what's generally used. You can pay different prices for various degrees of purity and keep the inclusion sizes down, but it's basically a nitrided steel. Nitride for 80 hours and that's the business. Pistons are mostly aluminium 2618, which is just an international version of what used to be called RR58, Rolls Royce 58. I can't say everybody uses that, but it's pretty common.'

### LEADING LIGHT

Of the off-track races taking place between IndyCar's manufacturers, EDL emerged as the leader in lightness – a fitting category to win with its Lotus affiliation in mind – as the DC was rumoured to be as much as 20kg below the initial 100kg minimum the manufacturers agreed to. But when one of them came in well above the 100kg target, the series moved the minimum to 112.5kg, requiring heavy ballasting of the DC to meet the new limit.

## "It was actually our intention to design the main structural parts in a conservative manner"

'One has come in really heavy,' Judd said with a laugh. 'We did not particularly set out to make it light. We said, let's do what we normally do and make sure that the bits that need to be strong are stronger than usual. It was actually our intention to design the main structural parts in a conservative manner. We haven't got enough miles on any engine yet to know whether they really are conservative or not, but we'll find out pretty soon.'

In the first two months of track testing, EDL tried as many different exhaust configurations as made sense with the homologation deadline and the list of development priorities in mind. 'We've gone through a couple of iterations but, once you decide where the turbos are going, you pretty much decide on your headers. Again, it responds to length the same as a normally aspirated engine [but] that trade off between the closeness of the turbo exhaust port, the better the response, may not be the best thing for maximum power.'

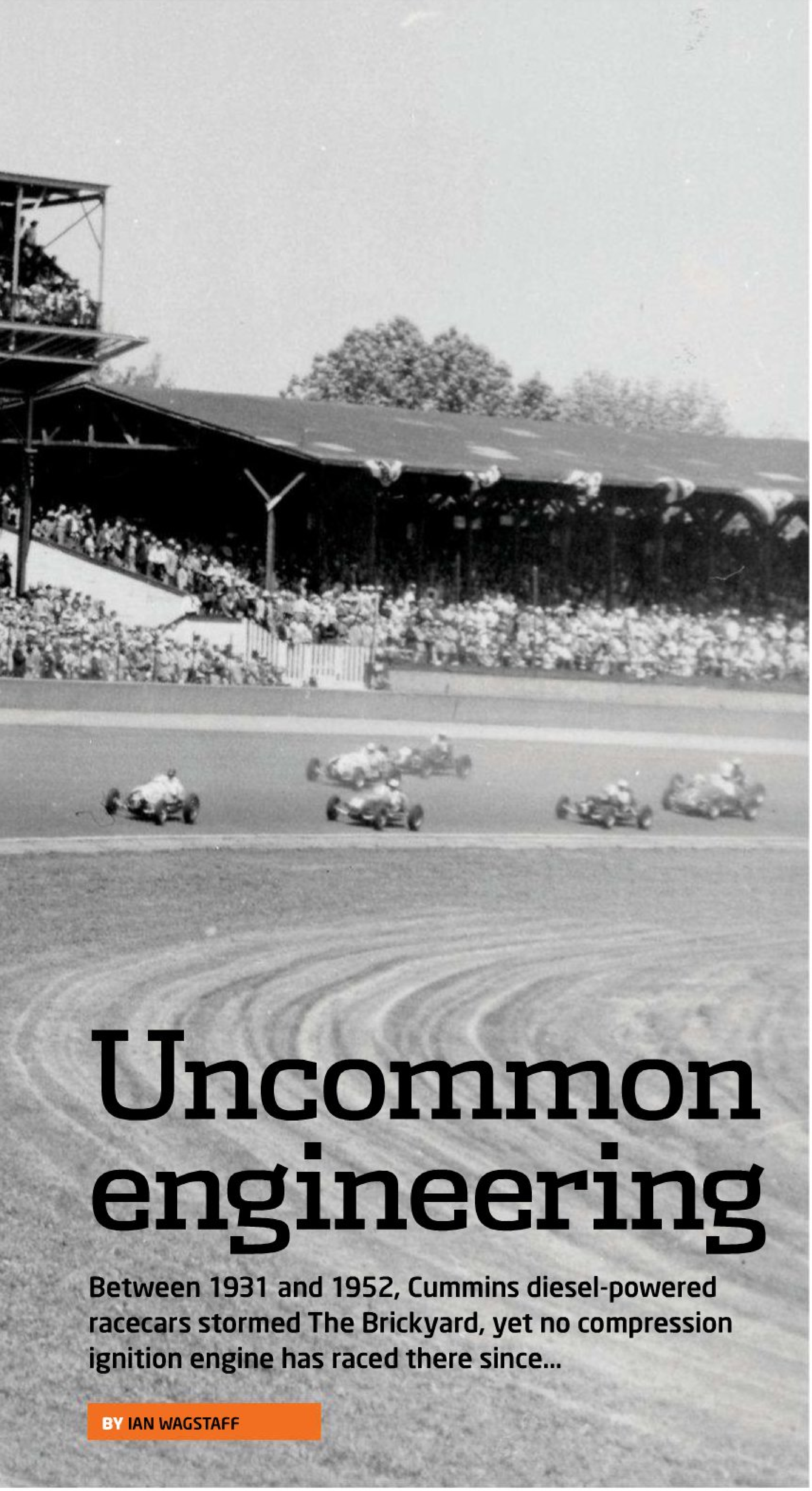
Lotus encountered issues when attempting to run its test engines on high boost in testing, but overcame the problem with its post-homologation powerplants. Despite the relatively low 18-22psi boost range, Judd says the DC's internals show signs of wear when the engine has been run in 700bhp road course configuration: 'We can sense the difference in engines between low and high boost. We can see the difference, and we have some work to do in regard to that. On the face of it, [22.4psi] is not huge pressure. In fact, it's lower than what we had on the old Champ Car engines years ago. [But] it's a different engine.'

The final change of note for Judd and the rest of the manufacturers came with a slight reduction in expected mileage for each engine. The 2000-mile minimum between rebuilds was reduced to 1850 shortly before the first round, which helped ease some of Judd's concerns slightly. 'It shouldn't be scary, and we are working towards it, but we're not there yet,' he conceded.

With its engines running just over one second off the fastest times set in pre-season testing at Sebring, the DC showed that Judd's approach to IndyCar's new formula is not only sound, but could eventually measure up to the giants at Chevrolet and Honda once the 2012 season hits the home stretch.


ARROW

A poor getaway at the start of the 1952 race left the diesel-powered Agabashian immediately way back in the pack



# Uncommon engineering

**Between 1931 and 1952, Cummins diesel-powered racecars stormed The Brickyard, yet no compression ignition engine has raced there since...**

**BY IAN WAGSTAFF**

Audi's motorsport engine guru, Ulrich Baretzky, admits that, when the then IndyCar League convened its round table on a future engine, he threw the thought of a diesel into the melting pot. After all, at that stage Audi was targeting the American market by running the diesel R10 in American Le Mans Series races. It was, perhaps understandably, never going to happen and Baretzky was more serious in suggesting an in-line four petrol engine. However, there was precedence.

On the first day of time trials for the 1952 Indianapolis 500, Freddie Agabashian drove his Cummins Diesel Special onto the 2.5-mile oval. After two quick warm-up circuits, he took the green flag that signified the start of his four-lap qualifying run. On his first lap he recorded an impressive 139mph that onlookers could hardly believe. The next three laps were not much slower and, with chunks of rubber tearing off a rear tyre, his final average was 138.010mph – a new track record. As a result, a diesel-engined car sat on pole position for the 1952 Indianapolis 500.

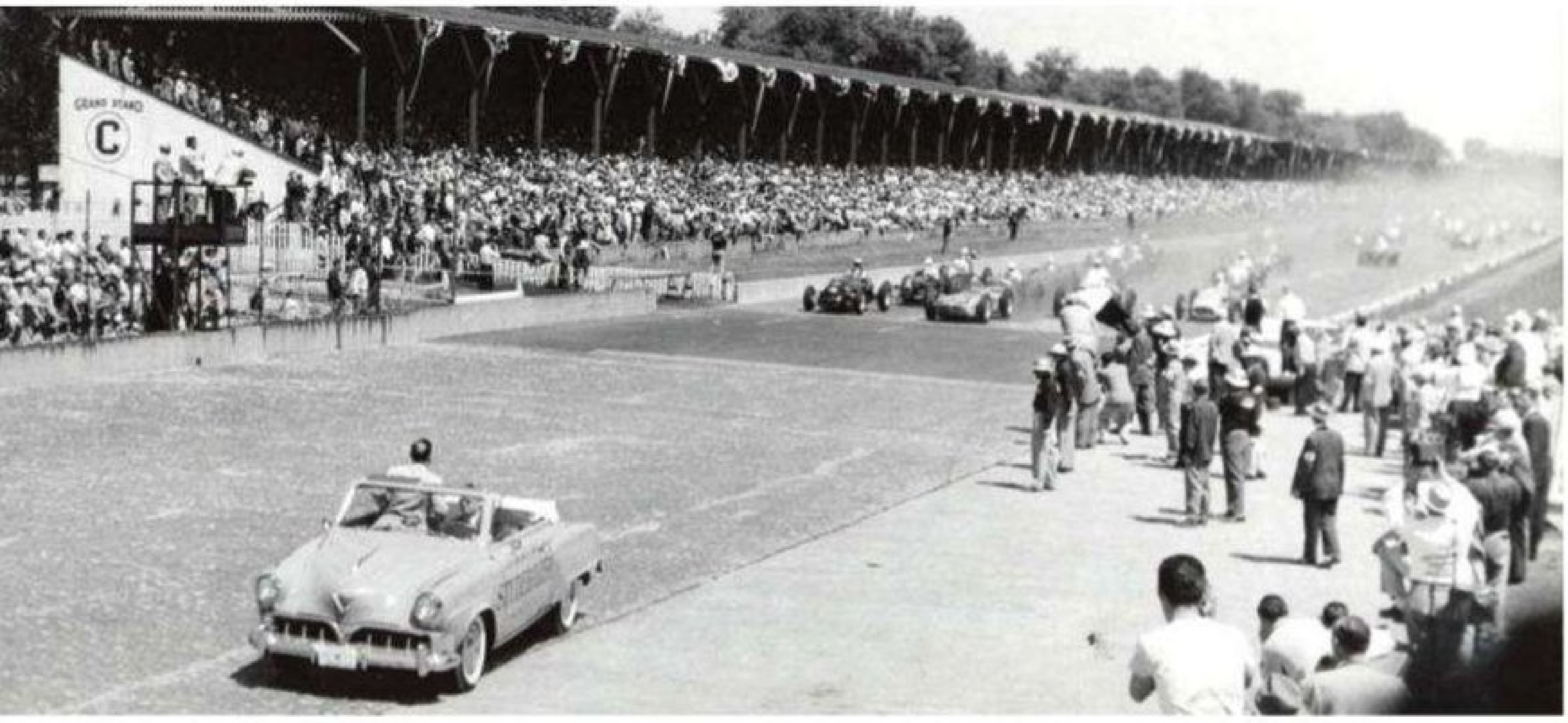
### CUMMINS A-COMING

The idea of entering a diesel car for the Indy 500 dates back to 1931. Stock engines were being encouraged to cut costs, and perhaps the most outstanding entry of all was the enormous Duesenberg entered by Columbus, Indiana-based Cummins. It was the first diesel to race at 'The Brickyard', having just set a 101mph record on Daytona Beach.

Cummins founder, Clessie Cummins, who had been on 1911 500 winner, Ray Harroun's, pit crew, had commissioned August Duesenberg to build the car from one of his Model A passenger car chassis. At 3389lb (1537kg) it was the second heaviest car on the grid that year.

Powering the car was an 85bhp, slow-speed, four-cylinder, four-valves-per-cylinder, 361.5ci marine engine, described as 'semi-stock', due to its cast iron pistons having been replaced by aluminium ones. (Four-valves-per-cylinder had been included in the regulations for the 1931 Indy 500 in an attempt to attract European entries but none took the bait.)

When Cummins first discussed the ides of a diesel entry with



Pole sitter, Freddie Agabashian, appears to be in the centre of the front row as the cars pull up for the start of the 1952 Indianapolis 500

the Speedway's owner, Eddie Rickenbacker, he had been happy that it would last the distance but concerned that it might not have the speed to qualify. The former fighter pilot said that if it could compete four laps at over 80mph it would be included on the grid regardless. In the event, driver Dave Evans achieved an average of 96.871mph.

During the race itself, Evans went the full distance on 31 gallons of fuel (costing a total of $2.55), without having to make a single pit stop. While his Cummins engine averaged 16mpg, the other stock blocks were averaging around 10mpg. Evans' riding mechanic, Thane Houser, did signal to the pits to enquire when they should come in as the water temperature was beginning to rise, but there was no answer so they kept plodding on. After the race, it was discovered that the crew member in charge of hand signalling had lost the piece of paper with the 'key' to those signals. The miscreant's name was Jimmy Doolittle, already by then a well-known figure in air racing and later to lead the famed Doolittle Raid on Japan.

### DURABILITY, NOT SPEED

Twelve cars finished ahead of the diesel that day, but that was not the point. The objective of the exercise had been to prove the diesel's durability, not its outright speed. The Duesenberg-Cummins was refurbished after the race and sent on a tour of Europe that included demonstration runs at Brooklands and Montlhéry.

Cummins used one of its own trucks to transport its racecar to Indianapolis. Truck sales soared after the car's blistering performance in qualifying

Three years later, Cummins entered two cars at Indy – one with an experimental two-cycle motor and supercharged, the other with a standard four-cycle engine. Debate was raging within the company about the relative merits of the two technologies and this seemed a good opportunity to put them head to head. 'Stubby' Stubberfield finished the race in 12th place with the two-cycle, which suffered vibration problems, while Evans went out with transmission troubles. Immediately after the race, the two-cycle engine contracted and then seized as it cooled and legend has it that Clessie Cummins promptly ditched it into the White River. The two-cycle engine disappeared forever, and no diesel of any kind would appear again until after the Second World War.

In an attempt to encourage variety for 1950, the race organisers allowed diesels a large displacement advantage. Cummins was attracted back, this time using a six-cylinder JBS-600 truck engine, increased in size to 401ci with an 1/8-inch overbore so that it could be used with the original rods and crankshaft (the limit for diesels had been set at 402ci, supercharged or not). Efforts were made to lighten the engine by fitting an aluminium head, block and pistons, plus a magnesium crankcase. Use was also made of a large, gear-driven, Roots-type supercharger, and on the dyno figures of 340bhp at 4000rpm on 15psi boost pressure were recorded.

**"Evans went the full distance on 31 gallons of fuel, without having to make a single pit stop"**

California-based Frank Kurtis was contracted to build a chassis, extended by four inches to accommodate the larger engine.

With Jimmy Jackson at the wheel, the green, rear-drive car qualified for the back row of the grid and dropped out of the race on the 52nd lap with supercharger drive failure. At this stage nobody was that impressed. But in September that year Jackson set six international records at Bonneville with the car, including the Flying Mile. The 'Green Hornet', as Jackson dubbed it, was converted into a dirt track Sprint Car before being restored and displayed at the Speedway's Hall of Fame museum. Meanwhile, the company vice president in charge of engineering, Clessie's brother, Don, went away to improve matters for 1952.

### INNOVATIVE DESIGN

The story of that year's car is not just of its diesel engine, but of its overall concept. Kurtis built the new car with an innovative, low-slung design – probably the lowest at the Speedway – based on weight control and a desire to lower the c of g. The engine was completely on its side and an offset driveshaft not only assisted in reducing height but also enhanced cornering. This configuration was eventually embraced by the rest of the Indianapolis fraternity, but it has been said that the slippery 1952 Cummins made a very early impact on the science of aerodynamics at the Speedway. Wind tunnel testing was carried out at the University of Kansas, supervised by Agabashian, and this is thought to have been a first for an Indy car.

Like its 1930s predecessors, the red and yellow 1952 Kurtis-Cummins 'roadster' was frugal and could probably have completed the race on just 50 gallons. However, weight and subsequent tyre wear was a problem. The car weighed almost 2500lb (1114kg) compared to the 1600lb (726kg) of the leading Offy-powered cars. This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**Dave Evans raced this four-cycle Cummins diesel-engined car in 1934, while team mate, H W Stubberfield, drove an experimental two-cycle engine**


**Freddie Agabashian competed in 11 Indy 500s. On five occasions he qualified in the top four, but 1952 was his only pole position**


**The 1950 Kurtis-Kraft diesel on display at the Indianapolis museum. Although green was considered unlucky in American racing, the colour was chosen in tribute to Arsenal Technical High School, Indianapolis where driver, Jimmy Jackson, had had been a standout at football**

**"The result was one of the biggest upsets in the history of the Speedway"**

was despite the fact that, thanks to magnesium components, the engine weighed around half that of a production version.

There was also the fact that a crude turbocharger had been installed. Although this was sometimes referred to as a supercharger it was in fact the first turbo to be used in the Indianapolis 500. Little was known then about the science of matching a turbocharger to a specific engine, and wastegates were not generally used. The turbocharger / compressor combination was selected to give peak boost pressure at peak engine rpm, with the pressure

**"The first turbo to be used in the Indianapolis 500"**

trailing off at lower speeds. A large turbo unit was used giving 20psi boost at 4000rpm engine speed, which resulted in an output of almost 400bhp. However, the boost was a mere 11psi when the throttle was opened out of the turns and it took between three and five seconds for the turbine to speed up to around 15-20psi down the straights. Unfortunately, because its air inlet was just inches from the track, the turbocharger also acted like a vacuum cleaner and sucked in dirt. It would be another 14 years before this technology returned to the Speedway.

### POWER PROTESTS

The respected Agabashian was concerned that the diesel's massive power could lead to protests being made so, in initial practice, he kept his speed down and there were those who wondered if he would even qualify. But with Don Cummins personally directing the operation, the main object of the exercise was to find the most effective method of weight distribution. In over 400 practice miles, Agabashian did not exceed 135mph. Then came pole day, and he let the car off the leash. The result was one of the biggest upsets in the history of the Speedway. His average speed was over a mile an hour faster than the four-lap qualifying record that Andy Linden had just set with his Offy-powered Kurtis. The jubilant crew members, having suffered weeks of toil, lifted Agabashian on to their shoulders. The Cummins' right rear tyre, though, was in shreds, which did not bode well.

### BORROWED TIME

In the race, Agabashian ran fourth for many laps before the turbocharger became blocked with lumps of rubber and detritus. Although it was for this reason that the car retired, it was discovered many years later that the crankcase had a crack running from the second crankshaft journal to the sixth, so even if the turbocharger intake had remained unblocked, the Cummins Diesel – which now resides at Cummins headquarters in Columbus – was running on borrowed time.

Don Cummins was aware that pressure from other competitors would probably result in a reduction of permitted engine capacity for diesels if his company was to return and a loss of any competitive advantage, so he called it a day after this momentous achievement, content in the knowledge that Cummins had demonstrated the potential of the diesel engine. As their business was not racing anyway, and its truck sales had increased dramatically, it was a case of job done. And job done well.

Three-time Indy 500 winner and the track's then general manager, Wilbur Shaw, remarked in his autobiography that he was 'itching' to drive the 1952 Cummins Diesel. A few days after the race he had his chance to test the car. 'Even though I didn't put as much pressure on the throttle as Fred had applied, it was a perfectly wonderful feeling to be back on the track and running at high speed,' he wrote. Despite Shaw's enthusiasm for the then unlikely technology, and the fact that they had proven to have both the speed and frugality to make them a sensible choice for racing, diesels were never to return to The Brickyard.


2 WRC

# Looks alike?

**Undisputed similarities between the Lotus T127 and the Force India VJM02 led the two teams to a High Court battle, which both claim to have won**

BY SAM COLLINS

It would be unfair and inaccurate to say that the Lotus T127 of 2010 was based on the Force India VJM02 of 2009, but it has now emerged that some elements of it were indeed direct copies, and the tale behind how it came about is a fascinating one.

A recent judgement made in the London High Court has revealed much of the background to the dispute, which has been rumbling on since late 2009.

The story begins before the team, which is today known as Caterham, was founded, and centres on the highly regarded Aerolab wind tunnel in Italy. Force India, then known as Midland, started to use the facility in late 2006, shortly after Mike Gascoyne joined the team as chief technical officer. Gascoyne knew the tunnel well, having used the sister Fondtech facility when he was at Renault, and Aerolab itself when he was at Toyota.

Although Midland had its own tunnel in Brackley, England, the largest model it could accommodate was 40 per cent scale. It was decided that to run a state-of-the-art Formula 1 programme, it would have to be upgraded to accept larger, 50-60 per cent models, which would involve taking the tunnel out of commission for several months. In the days before the resource restriction agreement, this was not an option.

Lola's proven wind tunnel in Huntingdon was the obvious choice, but when the experienced engineers ran Midland's 50 per cent model, they discovered the tunnel could not take its weight, which caused problems with the data sampling system. Another solution was required.

That solution was found in Aerolab in Sant'Agata Bolognese, Italy. Opened in 2003 as a joint venture between Fond Tech and Dallara, it was capable of operating with up to 60 per cent scale Formula 1 models at a nominal test speed of 50m/s (180 km/h). Gascoyne believed

**The car at the centre of the controversy is the 2010 Lotus T127, built in record time by a team headed by Mike Gascoyne. The car was the best of the new teams that season but, when pictures of the Aerolab-built wind tunnel model were released (right), it was fitted with parts of the Force India VJM02 wind tunnel model, including the tyres and crash helmet. Interestingly, the Force India tyres were in fact the wrong shape for a 2010 model**

that Midland, which at the time was ahead of Super Aguri in the world championship, could benefit from the expertise of Aerolab's staff, who could assess and develop the entire aerodynamic concept of the car, and essentially reinforce Midland's aerodynamic department. A development deal was signed, which would run from the end of 2006 until the end of 2009. The cost of the development was agreed at €246,833 (£206,200 / $328,700) per month in 2008 and €253,400 (£211,625 / $337,400) per month in 2009. The deal included stringent confidentiality clauses, as would be expected. For example, if work was being done for the team then no employee of any competitor would be allowed on site. There was also a further condition that Aerolab and its employees could not work for any other Formula 1 team in a development role (though other teams could still use the tunnel and its operational staff).

The 50 per cent model was modified to suit the Aerolab tunnel, a process that involved creating a new central spine. A secure FTP connection was also established between Midland (which by then was morphing into Spyker) at Silverstone and Aerolab so that both aerodynamic teams had freely flowing aerodynamic and CAD data.

Lola had resolved its tunnel's shortcomings shortly after the start of the 2007 grand prix season, so Spyker took advantage, instigating a parallel aerodynamic programme there using a second model, up until June of that year when its own tunnel came back on stream. At the end of the 2007 season, another change of ownership saw Spyker become Force India.

## AERODYNAMIC CHANGES

Part way through 2008, the FIA released the 2009 regulations, which saw substantial changes to the aerodynamic specification. In March 2008, Aerolab staff started work on what would become the Force India VJM02, with the diffuser and rear wing being the major areas of focus. At the end of the year, Gascoyne left Force India, and it seems this was the first step on the road to the High Court.

Not long after Gascoyne's departure, Force India decided that running two parallel aerodynamic development programmes, one in the UK and one in Italy, was too expensive and logistically challenging to be sustainable. It was therefore decided that Aerolab's contract would not be renewed in 2010.

Aerolab was by this point struggling to collect payment for its services on time from Force India and so, by January, instigated a payment plan to clear the outstanding balance.

**"The deal included stringent confidentiality clauses"**

But barely a month later, Force India defaulted, leaving Aerolab again out of pocket. So much so that, at one point in March, Aerolab stopped work due to non-payment, but re-started when the team needed some development work done on the diffuser and cleared two outstanding invoices in order to facilitate this.

Force India claimed it was short of funds due to a late shareholder payment, but it was becoming clear that Force India did not want to use Aerolab any more. Updates to the VJM02 model were few and far between and the Silverstone engineers stopped sending updated geometry from its own wind tunnel sessions to their

Italian counterparts.

By June 2009, Aerolab felt compelled to write formally to Force India to record its 'persistent (and serious) breach of your financial obligations' under the development contract, and inviting it to 'cure forthwith your breach by settling our outstanding credit.' The amount outstanding at that point was €764,260 (£638,625 / $1,018,180). Force India replied, proposing a payment plan, but then did not honour it. By the end of July 2009, Force India owed Aerolab €846,230 (£707,730 / $1,128,295), the equivalent of more than three month's work. Enough was enough and, after the FOTA-enforced summer break in August, Aerolab packed all of the parts of the Force India model into a box, and sealed it. The contents would be shipped to Silverstone once the outstanding bills had been paid.

When James Key, the then technical director of Force India, contacted Aerolab to find out the situation, he was informed that the facility was no longer working for the team and had been sub-contracted by its parent company, Fondtech, on behalf of another client.

### EIGHT-WEEK LEAD

That client was the Litespeed (that would go on to become Lotus Technologies Ltd) via Mike Gascoyne's technical consultancy, MGI. At the end of July, the team had a 50 per cent model built to develop its car for the 2010 season. Aerolab was confident it could prepare a new 50 per cent model in just eight weeks, as 18 months earlier it had built a similar model of a Formula 3 design for Volkswagen, and the same engineer who ran that project would be in charge of the Lotus programme.

Gascoyne told Tony Fernandes, who by now owned the team, in an email that 'The most significant aspect to guarantee car performance for 2010 is the aerodynamic programme. The intention was to use the Fondtech tunnel in Italy for 2009, switching to full time in the sister Aerolab tunnel when it became available in Jan 2010. However, having discussed the situation with Jean Claude Migeot of Aerolab, the Aerolab [tunnel] would be available immediately... I am proposing that we use both tunnels, starting immediately from August for the whole of 2009 and 2010... We are also starting from the current level of Force India due to the historical knowledge, not starting as a new team.'




**One area of contention was the rear wing, which utilised some of Force India's design data. But it was pointed out in court that it was not a copy of the VJM02 (top), which has a pillar-supported wing. Whilst the T127 initially had an end plate-supported wing (middle), later in the season the Lotus adopted a pillar wing developed independantly of the Force India data**

Once the deal was agreed, CAD models of what would become the T127's monocoque, side crash structures, rear crash structures, gearbox, suspension, wheels, nosebox and radiators / coolers were sent to Aerolab to start work on the new model.

But the short lead time appears to have led to some staff at Aerolab cutting corners in design work, a fact that was backed up by an email that was sent out, which read, 'invent as little as possible, unless time and costs dictate otherwise. Therefore use the previous F1 model as much as possible where design work is concerned.' That previous model was the VJM02. An open and shut case you might think. Not so. The High Court judge ruled that the VJM02's design was in the public domain by that time. It was also not very competitive and used a different powertrain to the T127. Crucially, though, the wheelbase had been changed by the ban on refuelling, meaning that 2010 cars would have to be a lot longer than the cars of 2009.

Yet there were some clear carry-over parts. The brake drums and ducts had been copied, or at least developed, from the VJM02, as had the wing mirrors, front wing end plate, driver's helmet, rear brake duct winglet and driveshaft.

Some of the front wing profiles were also similar, and indeed based on Force India data, albeit arranged somewhat differently. The differences were that all three aerofoils were shifted down by 9.35mm, the distance between the trailing edge of the main plane and the leading edge of the primary flap differed by 0.39mm and the area between the trailing edge of the primary flap and the leading edge of the secondary flap differed by 0.52mm. Finally, the angle of incidence of the Lotus flaps relative to the main plane was increased by 6.6 degrees.

The rear wing too was rather close in some areas to the VJM02 design. A Force India file was used to realise the specified rear wing geometry but, crucially, the wing assemblies themselves were quite different – the Force India rear wing was pillar-mounted, while the Lotus rear wing is end plate-mounted, which creates a major aerodynamic difference between them. In addition, the angle of incidence of the aerofoils relative to one another is different.

To develop the new model, Aerolab and FondTech's aerodynamicists spent 1,336.5 hours and the CAD draftsmen 2,530 hours, for which Lotus was charged a sum of €132,144

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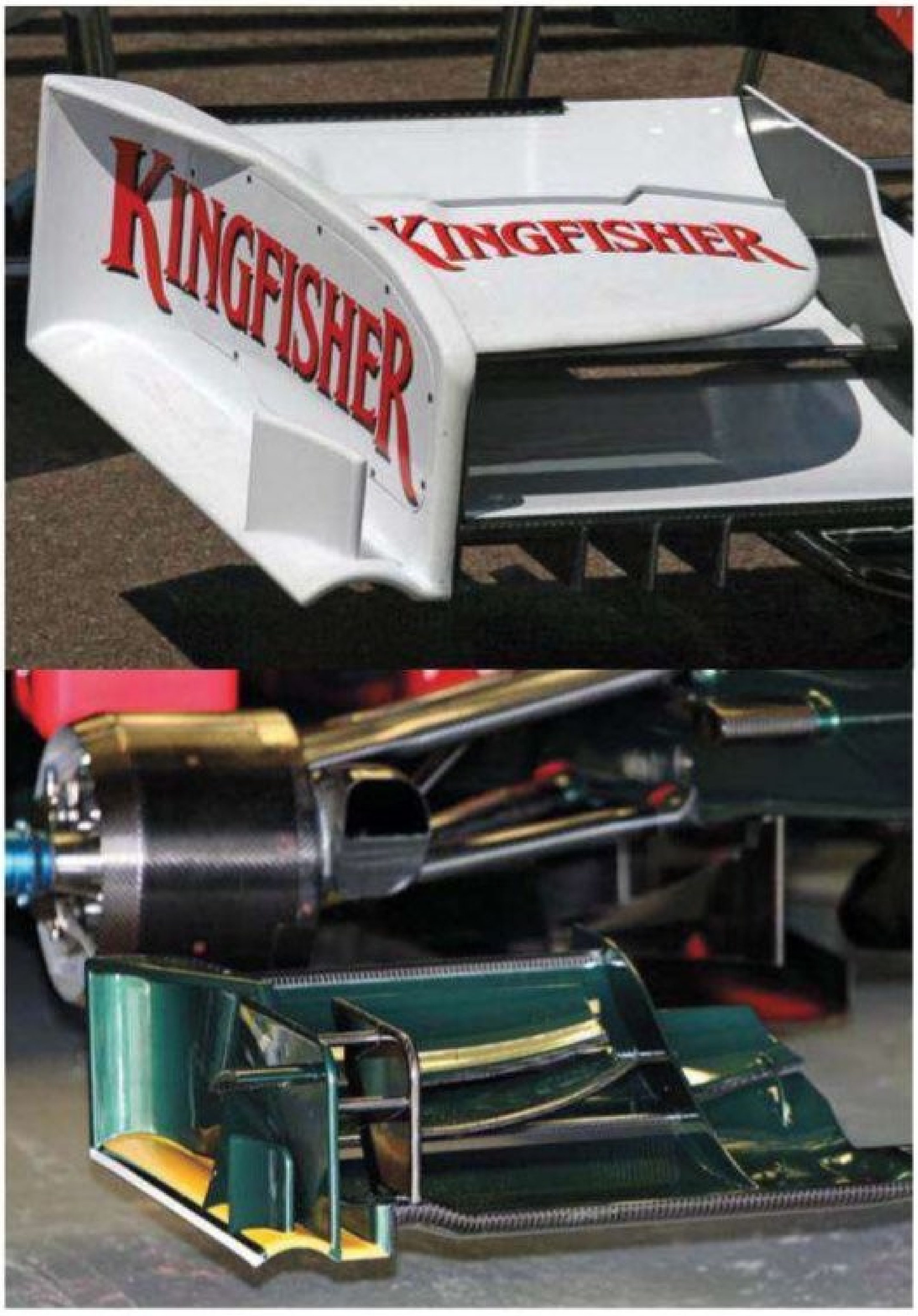
Once the model was built, a set of targets were established for its performance. These were detailed during a design meeting at Aerolab. 'At the moment the balance target is at 42 per cent. Obviously, the balance target will change in connection with the possible (although not yet confirmed) changes to front tyre size. The balance range that will be used is still unknown (±2 per cent, so 40-44 per cent seems to be a good range). It has been pointed out that the previous client (Force India) asked for a wider balance range (±4 per cent), which seems excessive.

'Given recent experience, and considering efficiency is close to 3.1 (all the coefficients are proportional to a surface of $1.47m^2$), the assessment of the downforce for the configuration R30 (start-up shall be Czt = 2.95 (correct value 2.75)).

'The load targets are as follows: start-up spec (Oct 2009): Cxt = 0.95 - Czt = 2.95 - A per cent = 42 per cent (correct value Cxt = 0.95 - Czt = 2.75). Launch spec (Jan 2010): Cxt = 0.95 - Czt = 3.10 - A per cent = 42 per cent (5 pt in load per month).'

In the first session between 12 and 21 October 2009, the front wing was almost completely re-designed, adding 8.1 points of downforce. In the second session, between 21 and 30 October 2009, the design of the diffuser was changed significantly, adding 9.4 points of downforce. By the end of 2009, the model was producing 263.3 points of downforce, a total gain of about 40 points (18 per cent). Aerolab and FondTech charged Lotus €1,669,800 (£1,397,150 / $2,225,250) for the wind tunnel testing carried out up to 31 December 2009.

But Aerolab was not happy with these gains, as an email sent internally shows: 'I would like to remind you all (without wishing to be critical and purely because we have to keep our feet back on the ground) that the model's performance is still well below the level expected to make the right impression. I am absolutely happy about all the improvements and consistency between the two tunnels but the truth is that we are still (as of yesterday) 7.5 per cent below the level we were expecting to start with a month ago. What's more, that level (which I gave as target) is just a point of reference using a 2009 car which, on average, has been the slowest (passing the Q1 with at least one car only five times out of 16 in dry qualifications). This is only to give you guys an idea of the mountain we still need to climb...'




**The front wing end plate of the initial T127 wind tunnel model was a copy of the Force India VJM02 design (top) but, by the time the Lotus ran for the first time on track, it had been extensively developed (bottom)**

## "Invent as little as possible, unless time and costs dictate otherwise"

The VJM02 was clearly a reference point for the team of aerodynamicists at Aerolab.

Gascoyne requested pictures of the initial model and, as Aerolab had not received the proper 2010-spec tyres from Bridgestone, it was decided for the photos the model would be fitted with Force India's wheels. Those wheels were then used for initial tunnel tests.

Some of the pictures sent to Gascoyne were also sent out with a press release published by *Racecar Engineering*, amongst others. Force India staff immediately recognised their tyres, which were marked, and started to look for other elements of the design. The media also picked up on the visual similarity between the model in the pictures and the VJM02, prompting Gascoyne to email Aerolab for clarification. He then passed on the information he received to Tony Fernandes in an email: 'At the start of the project I approached Jean Claude Migeot to enquire about the supply of wind tunnel services. Jean Claude owns two wind tunnels in Italy, one run by a company called FondTech, and the other by a company called Aerolab. Both companies have supplied wind tunnel services extensively in F1, notably FondTech to Tyrrell and Renault, and Aerolab to Toyota and, recently, Force India. We contracted FondTech to supply us with a wind tunnel model and wind tunnel testing time for 2009 as Aerolab had a contract with Force India to the end of 2009. However, in August Aerolab stopped working with Force India... We have subsequently engaged Aerolab on a three-year contract to supply wind tunnel services. The wind tunnel model was designed exclusively for us by FondTech.

'In the terms of our contract with them we have to supply them with chassis surfaces, suspension geometry, details of the Cosworth engine installation, radiator installation, Xtrac gearbox installation and also front, rear and side impact structures. All of this has been supplied by our design team and is unique to our own design and makes the model unique.

'FondTech have designed the first iteration bodywork, based on their experience and recent expertise. As most of the designers have recently been working on the Force India project, this expertise naturally is based on their development work. However, at no time have any design, drawings or other form of IP been used directly to the design of our car, only the design expertise of the designers. We have had the complete assurance from FondTech that this is the case, and any issue Force India have should be directed at FondTech, not Lotus. In this respect, it is no different from an employee moving from one team to another. That employee cannot take physical designs from one team to another, but is free to use the skill and experience he has gained for his new team. In this case, we have effectively employed around 40 wind tunnel staff at one go.

'In summary, I can confirm that Lotus have had absolutely no access to any information that could possibly infringe the IP rights of Force India, and I am happy for any relevant authority to fully audit the team to ensure this is the case. I have been informed by both FondTech

and Aerolab that they have not infringed the IP rights of Force India in the design of the bodywork for the wind tunnel model, and as there is now no further information flow between Aerolab and Force India, there is no way they could do so in subsequent developments of our aerodynamic design. Even the most simple of investigations on our model will rapidly identify it as unique to our design and different to any other car on the grid.'

Unsurprisingly, Force India saw things differently. There was already ill feeling between them and Aerolab, who had by then instigated legal action to recover the outstanding payments. The team therefore immediately instigated its own legal action claiming IP infringements and breach of copyright.

**FondTech, Aerolab's parent company released images of the proper T127 model in its wind tunnel when the partnership with Lotus was announced. This time the model had the correct wheels and driver helmet installed**

### THE SUM OF ITS PARTS

The VJM02 model consisted of around 370 parts, of which about 203 were aerodynamic parts, and the remainder mechanical. Force India alleged that Aerolab and Lotus copied 71 designs. Of these, 57 were designs or precursors of designs for wind tunnel model parts and 14 were assemblies or combinations of individual model part designs. Of the 57 individual model part designs, 36 were for aerodynamic components, the full-size equivalents of 25 of which were visible on the car during the 2009 season. The remaining 21 out of 57 were mechanical wind tunnel model parts which have no equivalent in a full-size car.

Of the 36 aerodynamic designs, nine are front wing parts, 12 are wheel barrel and brake duct parts, four are rear diffuser parts, two are rear wing parts and nine are miscellaneous development parts that never made it onto the Force India car.

Force India originally claimed compensation of £15,255,583 ($24,314,975) but, after various amendments, the final figure claimed was £13,771,419 ($21.945,530). This was said to represent the cost to Force India of the design and development of Force India's model from January 2008 to July 2009, less 50 per cent of the costs for April to July 2009 inclusive. The explanation for the deduction is that this represented an estimate of the costs of developing the front wing from the state in which it existed on the model at Aerolab.

There was clearly a legitimate case and Aerolab had clearly breached its confidentiality agreement with Force India, and had indeed copied some of the parts of the VJM02 for use on the T127, but these parts were not used to give the T127 pure performance and by no means could the T127 model be claimed to be a copy of the VJM05. The initial Lotus model produced 223.3 points of downforce with an aerodynamic efficiency of 2.512. By comparison, the Force India model to which Aerolab had access as at July 2009 (which did not represent Force India's most advanced geometry, for the reasons explained) produced about 272 points of downforce with an efficiency of 2.87.

The High Court found that Aerolab had breached Force India's confidence to an extent, but not to the extent it claims. Lotus Racing was found to have infringed copyright in only one area, as the judge pointed out in his summing up: 'In my judgment, the Aerolab / FondTech CAD files do reproduce a substantial part of the corresponding Force India CAD files for the following parts: the vortex generator, rear brake duct lower element and rear view mirror.' The team was found not guilty of any other wrong doing.

As a result, Force India was awarded damages against Aerolab (but not Lotus / Caterham) of €25,000 (£20,900 / $33,325) but, as Force India owed the Italian firm €846,230 (£707,730 / $1,127,960), the Court ruled that the damages should be set off against the outstanding balance. Predictably, both sides claim victory, with Aerolab issuing a press release titled 'Aerolab and 1Malaysia Racing Team cleared by High Court in London', whilst Force India issued its own release entitled 'Caterham (formerly Team Lotus) and Aerolab found liable for using Force India intellectual property'.

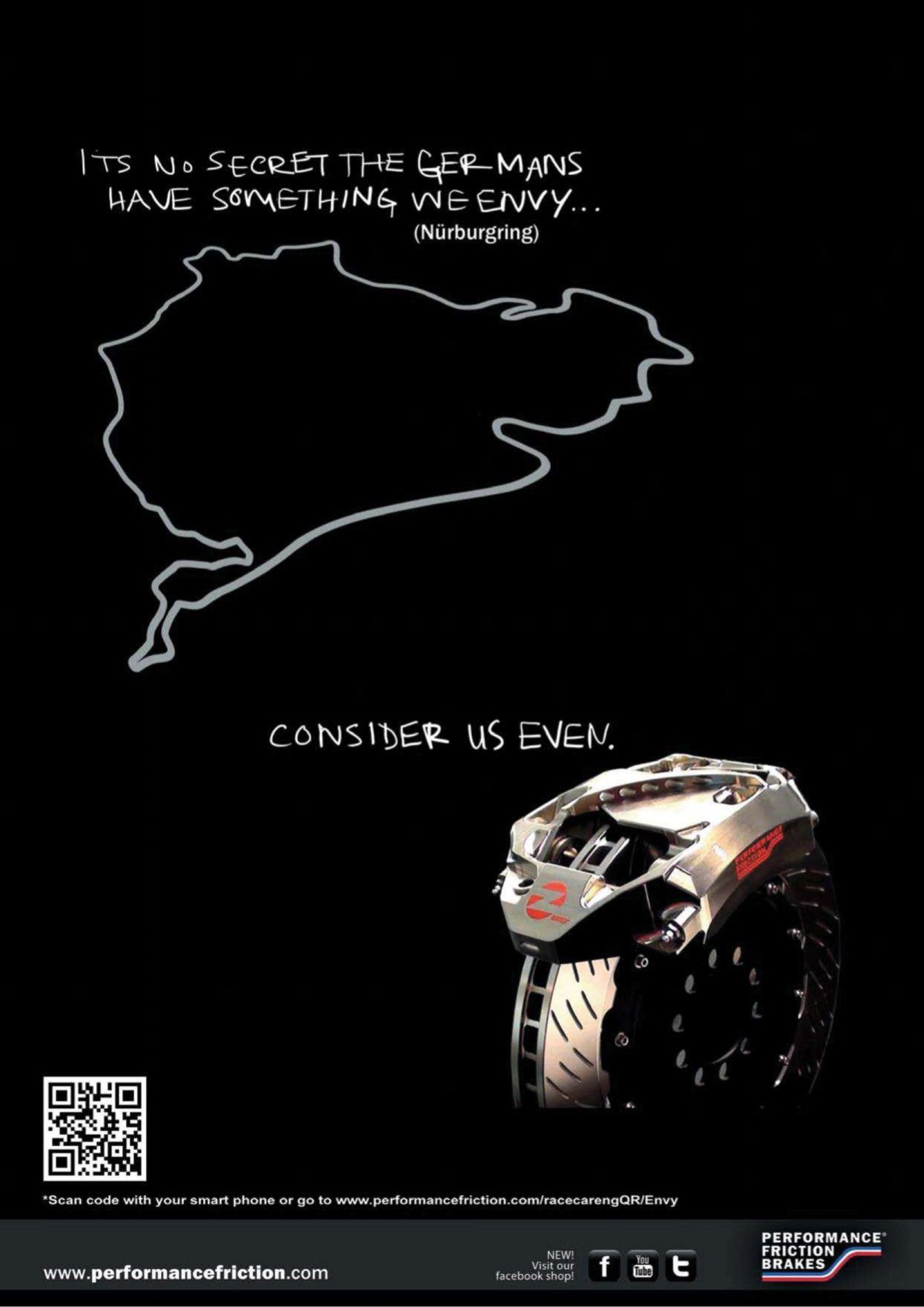
**"Predictably, both sides claim victory"**

### THE MARUSSIA CONNECTION

The final twist in the tale emerged shortly before *Racecar Engineering* closed for press is the involvement of the Marussia team. It has called for the FIA to 'look vigorously' into the case. It believes that the situation is a basic infringement of the FIA's International Sporting Code, article 151c, which refers to 'any fraudulent conduct or act prejudicial to the interests of any competition or to the interests of motorsport generally'.

This is the same regulation McLaren was found to have breached in 2007 when it was found to be in unauthorised possession of documents and confidential information belonging to Ferrari. In that instance, the team was fined $100million and lost its Constructors' Championship points. If the same penalty was applied to Lotus Racing (Caterham) it would lose its 2010 Constructors' Championship position of 10th, allowing both HRT and Marussia to move up, something which could be worth as much as £30m in prize money.

The FIA has yet to comment on the matter but, as it has no jurisdiction over Aerolab, if it decides to apply any penalty to Caterham it will have to find out whether it used any of Force India's IP that was *not* in the public domain, whether it knew it was doing so, or whether it trusted Aerolab to supply legal designs. Finally, did Gascoyne and his team push Aerolab to take short cuts? One thing that is certain is that the outcome of this case will be held up as an example for future intellectual property cases in motorsport.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# It's the small things...

**With more than 100 changes, the new 01B Mini WRC is an exercise in detail development**

BY MARTIN SHARP

The Mini WRC 01B is the latest version of the four-wheel drive competition car from the BMW-owned marque. It is not a complete new homologation, but it is an extensively updated one. 50 per cent of the updates are aimed at ensuring reliability and correcting mistakes, the rest at providing performance boosts.

A four-day, pre-approval gravel test in Spain drew positive comments about engine output improvements and rough stage dynamics from drivers, Kris Meeke and Dani Sordo, while post-test analysis and crack checking of all components with the correct sign-off mileage completed saw Prodrive release them for use.

#### WHEEL TRAVEL

On gravel stages, the Mini WRC appears to some to have less wheel travel than its WRC rivals, but this is a reflection of Prodrive's calculations, and design philosophy, which differs slightly to that of rival teams. Both Dave Wilcock and David Lapworth stress here the importance of *useable* wheel travel. A suspension travel increase can mean more unsprung mass, reduced levels of body control and, if the increased travel is to be used fully, softer suspension settings, which mean running the car higher, thereby raising the c of g.

Rough gravel road tests indicated to Prodrive that the full suspension travel lengths used by rival cars are not needed. While Prodrive could, with a re-design, engineer more travel into the Mini WRC's suspension, the Mini's maximum stroke has been decided through design criteria based on Prodrive's simulation models, statistical analysis and historical data from the company's days of developing Subaru rally cars.

#### SEQUENCE OF EVENTS

Part of this process involved breaking down stages into a sequence of events, from braking to launch to corner entry to mid-corner to exit, and weighting priorities to find the key events. By far the prime movers in reducing stage times were found to be mid-corner grip and corner exit, so these areas became the main focus. Wilcock points out that it is all about maximising the grip available, which is why recent cars have appeared with softer and softer suspension settings to target maximum grip, although ride height issues limit how soft one can go. While admitting the Minis run harder settings in bump than rivals, the Prodrive engineer points out that this is not the case with the rebound settings: 'When you've got use of a helper spring, you can have a variable spring rate, like anybody can. They all do. But the way we choose to run it, the heave is controlled separate to rebound.'

Prodrive also reasons that extended damper strokes require lengthy bump stops for end-of-travel protection, which also means lengthy compressed bump rubber heights. Wilcock: 'If you consider a full bump event with their [rival cars'] compressed bump rubber length and then what the stroke is to full rebound, it's not too dissimilar to what we've got. [But] we're able to use all of ours, right down to almost zero millimetres. Full stroke is full stroke.'

However, 2011 event experience highlighted areas for improvement on rough gravel rallies. The team tended to run the cars above design ride height to cope with large rocks. This trades bump travel at the sacrifice of rebound travel, so an 01B rough rally suspension package re-positions the nominal ride height through strut top mount specifications.

**"Everything upstream of the air restrictor throat is new"**

Shock absorber manufacturer, Öhlins', engineers were at the 01B's Spanish tests to help with the development process, and the team had a selection of dampers, all built up with different valving.

The 01B damper settings are revised for both customer cars (RRC, S2000) and World Rally Cars, and the Öhlins dampers remain compatible for front or rear applications, with different valve settings.

#### IMPROVED AIRFLOW

A number of 01B engine performance improvements aim for a four to five bhp increase through improved airflow, packaging, coolant flow and management. Everything upstream of the air restrictor throat is new.

The Mini's BMW WTCC-derived engines were originally built at BMW Motorsport, yet Prodrive has been doing new engine builds and rebuilds since September 2011. There are no upgraded 01B engine internals, although BMW Motorsport's experience of piston ring marks, indicating premature wear at high rpm, in World Touring Car Championship cars demanded a new ring pack, which is included in the papers submitted for Mini 01B, so all new rally car engine rebuilds will now adopt it.

Other unexpected issues that needed addressing included the car's propensity to throw alternator belts. The cause was found to be heavy frontal impacts, which caused a collision between a corner of the bumper and the alternator belt. Indeed, the 01A front bumper's vulnerability to cracking and breaking often resulted in it losing the lower portion through scraping on the ground, reducing overall downforce. This was temporarily solved by raising the ride height, but for the 01B the bumper has been manufactured using more flexible composite resins, which can move and return to original shape. It also has revised engine and cooling air intake positions and sizes (within the FIA 2500cm$^2$ limitation on frontal openings) and modified radiator ducting.

An electric water pump is also new for 01B, replacing the alternator belt-driven mechanical pump. This reduces belt length and vulnerability and aids serviceability, plus has the added benefit of removing the extra pressure drop seen at high rpm with the mechanical pump. Having full control of water flow with the electric pump also aids detonation control, plus fewer mechanical losses pick up some engine performance. The alternator is now re-located to the old mechanical water pump's position, and a Cosworth software upgrade controls the pump.

The alternator re-location also enables the turbocharger (previously fixed in a canted position) to be lined up with its air intake, both removing a potential fracture point in the piping and centralising the restrictor in the area where optimum air volume and a better flow path to the (revised) restrictor is available.

**ELECTRICAL UPGRADE**

Many of 01B's software revisions are 'tidying-up' – making fuel sensor calibration easier, for example, and these come together with completely new engine and chassis wiring looms. It is a big electrical upgrade, catering for the higher power requirement of the electric water pump and revisions of powers and grounds (earths) for correct sharing. A number of critical sensors shared grounds with non-critical sensors in 01A, introducing unwelcome signal-to-noise ratios due to distortion. Connectors on the engine loom are now of a higher quality for reliability, as it was found that the previous connectors tended to become unreliable after a high mileage had been covered.

Further electrical improvements include a lithium-ion battery which, in the event of alternator failure, improves the car's stage life to 20km, compared to its lead-acid equivalent's two kilometres. The new battery is also 12kg lighter, which contributes to a 14kg base weight reduction for the 01B, aiding ballast positions and overall car balance.

A kit of parts will be available to upgrade 01A cars to 01B around June or July this year and, once a joker is played for homologated parts, there is 12 months leeway from approval date before the fitment of those joker parts is mandatory.

All in all, more than 100 changes have been introduced for the 01B car, which the Prodrive WRC team debuted at Rally Portugal between 29 March and 1 April this year. The net result of all these updates will, the teams hope, be a faster, more reliable WRC contender.


**A great deal of the development work on the new Mini 01B has been on wheel travel, suspension settings and damper specification**

# New old stock racer

## Following in his father's footsteps, Danny Thompson has his heart set on 500mph

**BY SAM COLLINS**

Most people would feel uncomfortable exceeding 150mph in a car more than four decades old, and to contemplate challenging the outright wheel driven land speed record, 470 mph in a car of that age, seems incomprehensible. But that is exactly what Danny Thompson, son of the late Mickey Thompson, intends to do with Challenger 2.5.

'My father built this car 43 years ago. He ran it up to 400mph in testing at Bonneville and was all set to go for the record in 1968, but it was November and the weather was against us,' explains Thompson. 'They got everything down, dialled in and ready to go then went back to the hotel ready for the record runs in the morning. By the time they got back, the salt flats were flooded. The family Christmas card that year was a picture of my dad rowing a boat around the car, that's how flooded it was.'

Shortly after, Ford, the project's main financial backer, pulled its support and the car was put to one side and largely forgotten about. 'It just sat there for years until, in 1987, [my dad] came to me and said "I want to run this car again. Do you want to drive it?" Of course I said yes, so I was tasked with car development and preparation, while he would run the team and handle the sponsorship. Shortly after that, my dad was murdered, and I just let the car sit there until now.'

But at the PRI show in December 2011, Thompson revealed he was going to get the old car running again and finish what his father had started all those years ago.

The tubular steel chassis is fitted with a pair of 8.2-litre V8 engines, between which there is just enough room for Thompson jnr to recline. Both engines will be fuel injected, and will run on a mix of 40 per cent nitro methane and 60 per cent alcohol.

'We will run the engines like they do in drag racing without any coolant,' explains Thompson. 'Instead, the fuel acts as coolant, so we have to be careful that if I spin the wheels or something I do not back off too much to get traction back, as there will then be less fuel going into the engine and less coolant. So we have to be wide open the whole time.'

'In August, we are going to do some runs and make sure the car turns, that the engine combination works and the 'chute works. In September, we will go for the record at a private event. You can't do FIA record runs at the SCTI-BNI meeting as there are just too many cars to fit in a two-way run within the hour.'

**"My father built this car 43 years ago. He ran it up to 400mph"**

There are a confusing number of land speed records and classes, but Thompson is initially targeting the piston-engined, wheel-driven record, which currently stands at 417mph. After that, he will be going for the outright wheel-driven record of 470mph, currently held by Don Vesco's helicopter turbine-engined car. 'I think to secure the record, we will have to go 450mph but, to be honest, I don't care about what classes to go for, I just need to do 500mph. I want to be the world's fastest wheel-driven car. I want to be that badass guy. My dad is watching, just from somewhere else, and I think it's bitchin'!'


**With power from two nitro-fuelled, 500ci V8s making 1500bhp apiece, Challenger 2.5 has the potential to succeed**

### TECH SPEC

**Measurements**
Length - 29ft 7in
Height - 27in; 37 3/8in at canopy
Width - 34 7/8in
Weight - 5600lb

**Tyres**
The only thing that will come between the Bonneville salt and Challenger 2.5 will be custom-designed Mickey Thompson tyres with 1/32in rubber and four-ply sidewalls, tested to 590mph

**Brakes**
Ventilated disc brakes on all four wheels

**Extra braking systems**
2ft plot parachute, 7ft high-speed 'chute and 16ft final brake 'chute

**Chassis**
Spaceframe structure fabricated out of square and round 4130 chromoly tubular steel.

**Body**
42 aluminium alloy panels

**Engines**
Two mid-mounted 500ci V8s; fuel injected, running on 40 per cent nitro methane and 60 pe cent alcohol.
**Power:** approx 1500bhp each

**Transmissions**
Twin B&J transmissions with hand-built, triple disc Brooks / ATF clutches

**Communications / electronics**
On-board telemetry; data acquisition including wheel speed, engine functions, transmission temperatures and driver's vital signs


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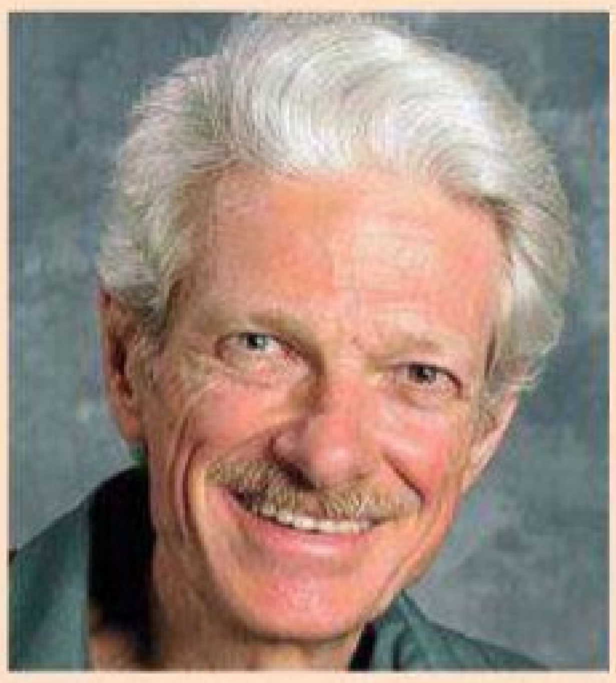

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# Arm in arm?

## Understanding the forces acting on A arms under load

**Q In a double A arm suspension are the forces opposite for the upper A arm vs the lower A arm? Example: in a left-hand turn is the force for the right front A arms inward on the lower and outward on the upper? I hope I made sense because I really want to know. I have watched *Minding Your Anti* [my video of a lecture I gave at UNC Charlotte in 2003, still available on DVD for US$50] a dozen times. It has helped me immensely. I just want to make sure I understand the forces correctly.**

For this discussion, we will assume that the suspension is of a type that has an upper control arm and a lower control arm, or can be approximated as such for modelling purposes. We will assume the lower control arm plane intersects the wheel plane below the wheel axis and the upper control arm plane intersects the wheel plane above the wheel axis. We will also assume there are no drop gears in the uprights.

If we are talking about the forces on the control arms induced by ground plane forces (longitudinal and lateral forces at the contact patch, the forces that create geometric anti-roll and anti-pitch effects), for the most part the answer is yes, the forces induced in the upper and lower control arms are opposite in direction. The main exception would be the case of longitudinal forces from braking or propulsion, where the torque is applied to the wheel through a jointed shaft and only the thrust acts through the suspension linkage – that is, propulsion with a sprung final drive (independent or DeDion suspension) or braking with inboard brakes.

**In terms of ground plane forces, generally speaking the forces induced in the upper and lower control arms are opposite in direction**


**Using inboard brakes, you remove the action of brake torque on the uprights and control arms, with only the retardation forces going through the uprights**

With regard to the lateral (y-axis) forces, it is necessary to remember that there are usually tension and compression loads on the upper and lower arms in static condition, just from holding the car up and holding the wheel in position. Ordinarily, in a front suspension the balljoints are inboard of the wheel plane, and the ride spring acts on the lower control arm. That means there is a bending load and a tension load on the lower control arm and a compression load on the upper control arm, when the car is not doing anything but resisting gravity. The loads from cornering or braking are additive to (or subtractive from) the static loads.

On the outside wheel, when cornering, the y-axis ground plane forces will reduce the tension load on the lower arm and the compression load on the upper control arm. There will also be some increase in the normal, or z-axis, force, which will have an opposite effect. As long as the vector sum of the z and y forces has a line of action that is outboard of the upper balljoint, the lower control arm sees tension and the upper control arm is in compression. When the vector sum line of action is inboard of the upper balljoint but outboard of the lower balljoint, both control arms are in compression. If the vector sum line of action passes inboard of the lower balljoint, the lower control arm is in compression and the upper is in tension.

When the vector sum line of action passes through the upper balljoint, the lower arm sees neither tension nor compression, and the upper arm sees compression. That is, there is no moment about the upper balljoint to generate a force at the lower balljoint, but there is a moment about the lower balljoint that can generate a force at the upper one. When the vector sum line of action passes through the lower balljoint, there is no compression or tension load on the upper arm, and there is a compression load on the lower arm.

**"the loads from cornering or braking are additive to the static loads"**

#### JACKING COEFFICIENTS

But when we are considering jacking coefficients for x and y-axis forces, for purposes of determining geometric anti-roll and anti-pitch effects, we are concerned with the changes from static conditions. For y-axis forces, for an outside wheel the changes due to ground plane force are always in the compression direction for the lower control arm and in the tension direction for the upper control arm. For an inside wheel, the changes are always in the tension direction on the lower arm and in compression on the upper.

For braking, if the brake is outboard there will be a rearward force at the lower side view projected control arm and a forward force on the upper side view projected control arm. The rearward force on the lower will be greater than the ground plane force, and the sum of the forces on the upper and lower (which will be subtractive from each other) will equal the ground plane force.

But if the brake is inboard, there will be rearward forces at both the upper and lower side view projected control arms. The torque of the brake will not act on the upright and the control arms. It will react directly through the caliper and rotor (disc) mounts on the sprung structure. Only the retardation force will act through the upright, and it can be thought of as acting on the upright at hub height.

The upper and lower forces will each be less than the ground plane force (and additive to each other). Their sum will still equal the ground plane force.

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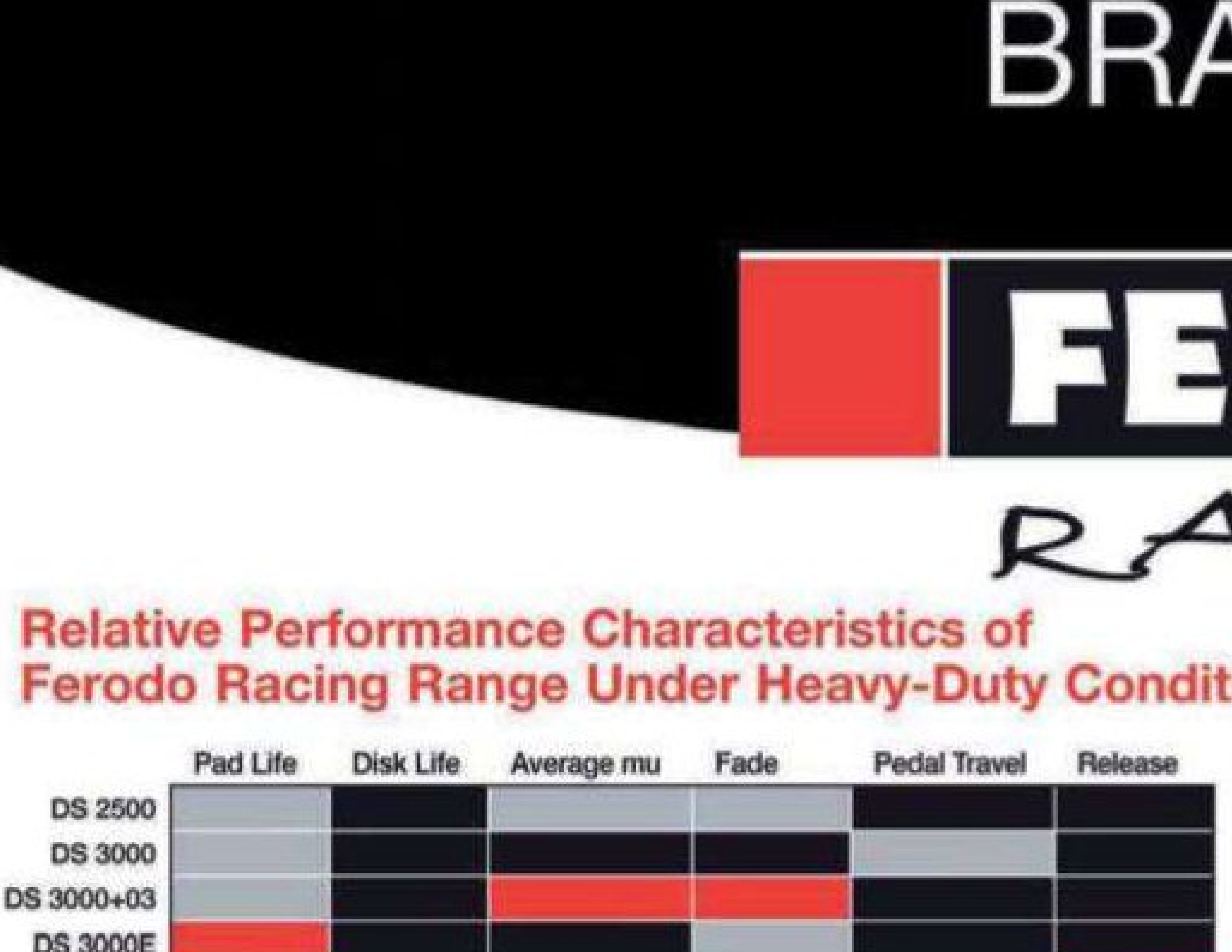


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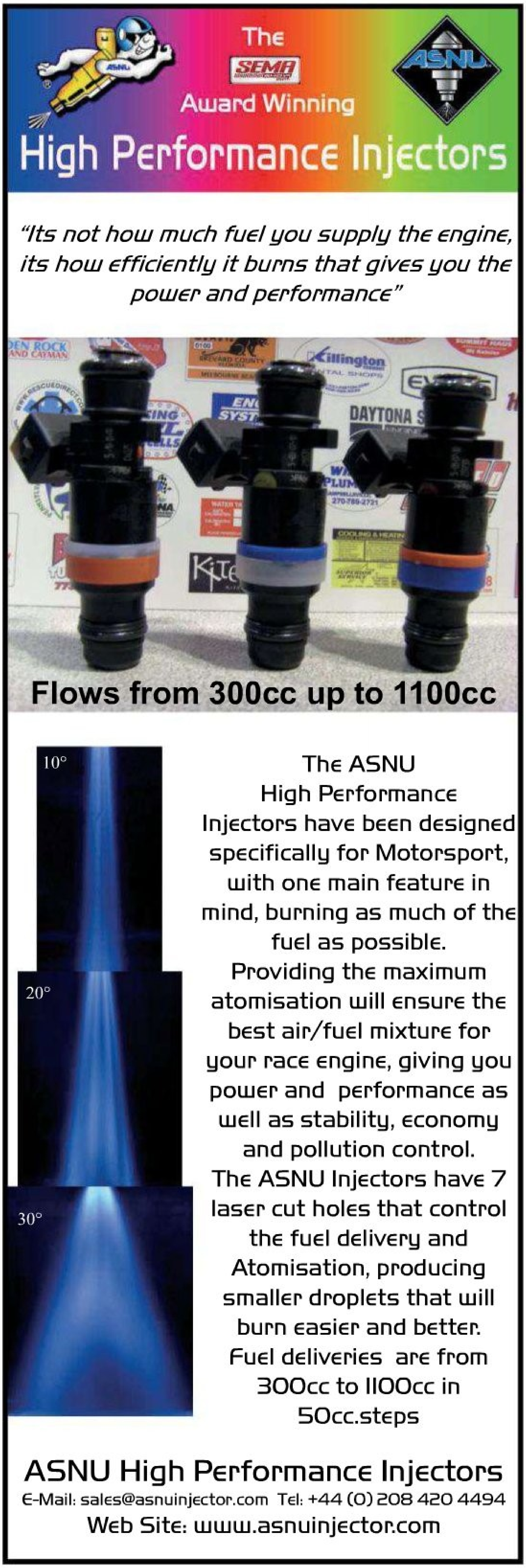
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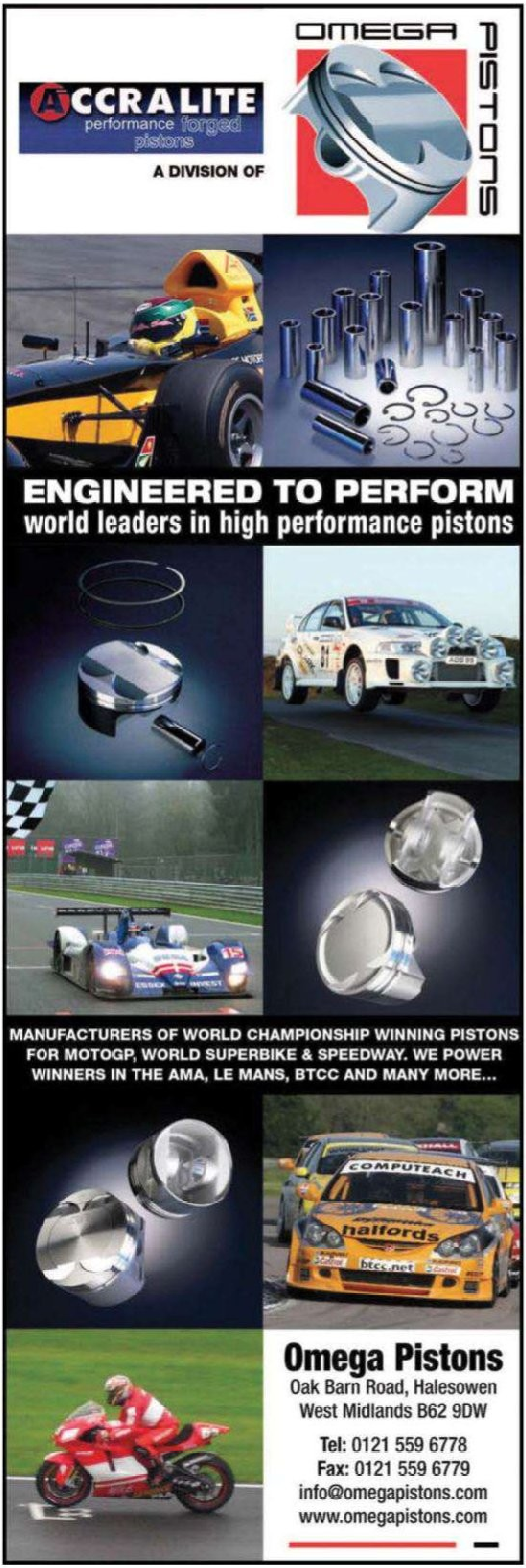
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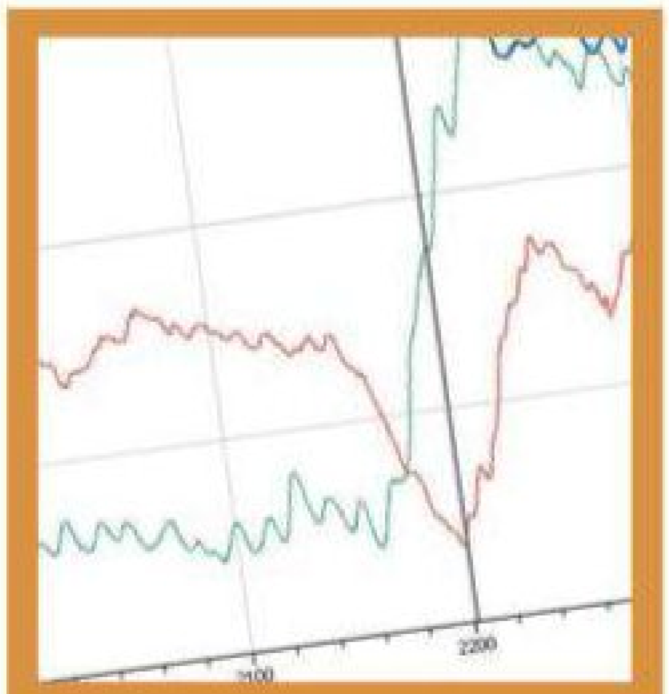

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**To allow you to view the images at a larger size they can now be found at www.racecar-engineering.com/databytes**

# Less is more

## Getting the most out of commonly logged data channels

Data engineers often fall into the trap of thinking bigger (i.e. more sensors) is better, but this is not always the case. A surprising amount of information can be gleaned from a small selection of channels and some good analysis techniques. This article will explain a few tips and tricks to getting the most out of commonly logged channels. For the purpose of this piece, we will use data collected from a Go-Kart data system.

### TIME AND DISTANCE

In order for any data analysis to take place, we must first choose a domain for comparison. The two domains commonly used are time and distance. It is therefore imperative that both of these are available to us.

The sole purpose of data analysis in competitive motorsport engineering is to identify where improvements can be made. Obviously, in a racing environment, being able to see where the car / driver can go faster is extremely useful to engineers – some would say imperative. A quick way of identifying this is by using a compare time function. This

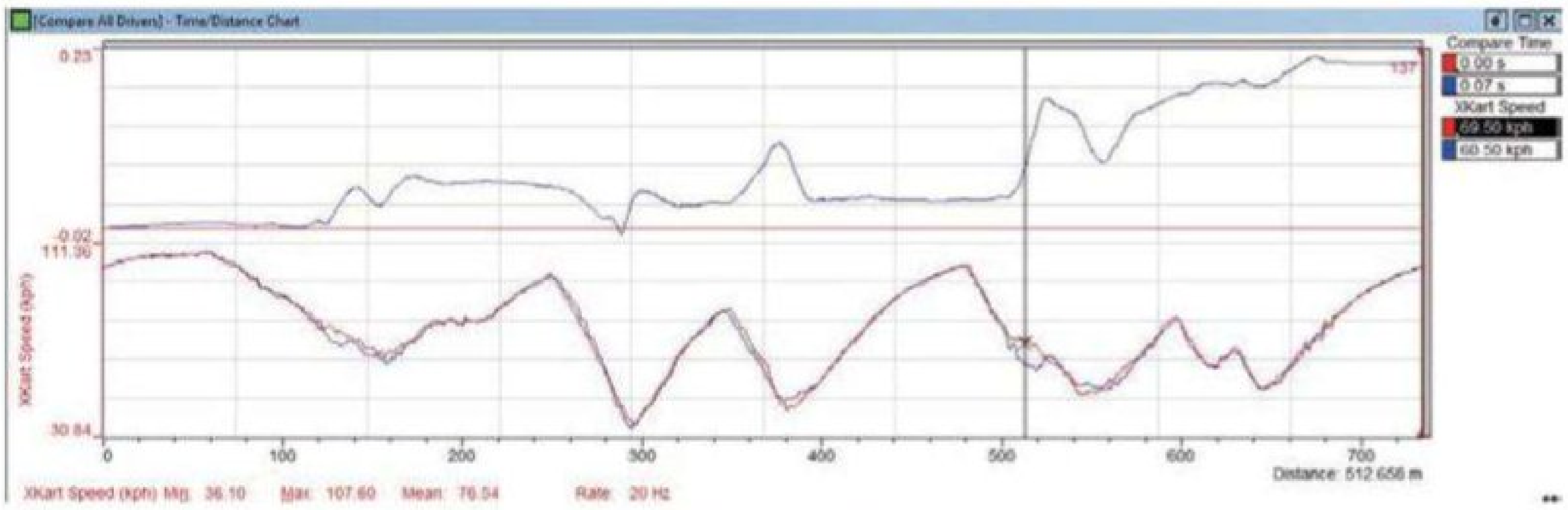


Figure 1: compare time trace plotted on a time distance plot

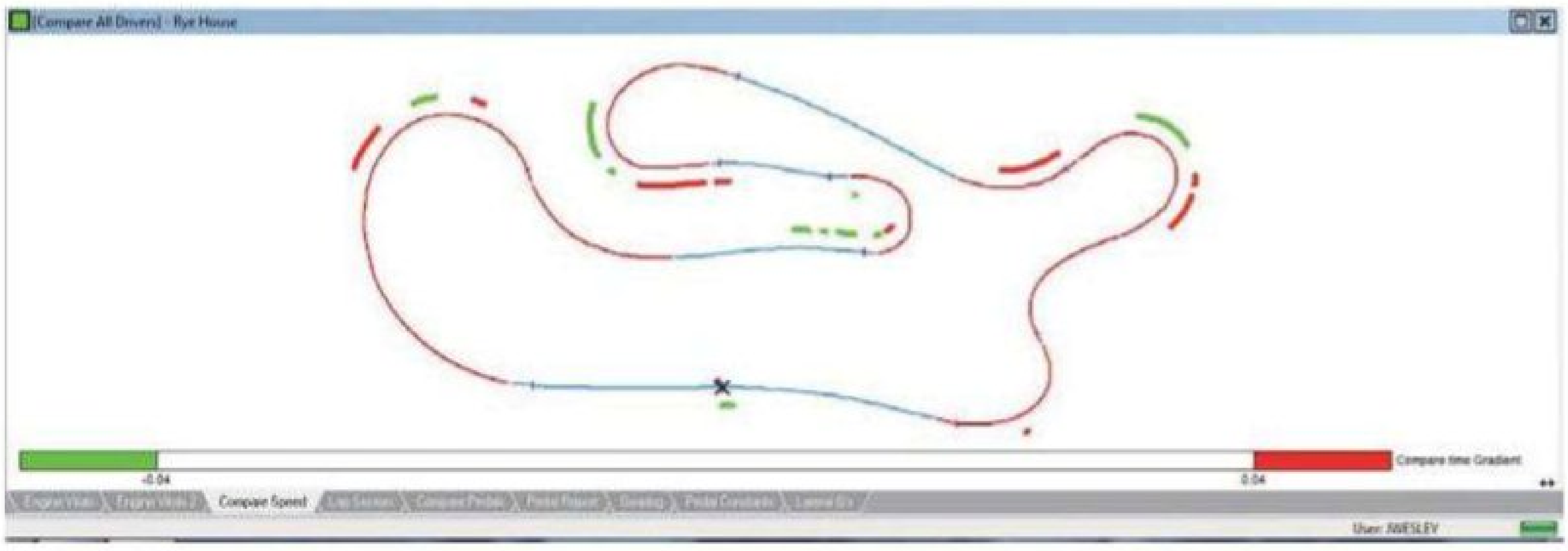


Figure 2: compare time gradient plotted on a track map to highlight main areas for improvement

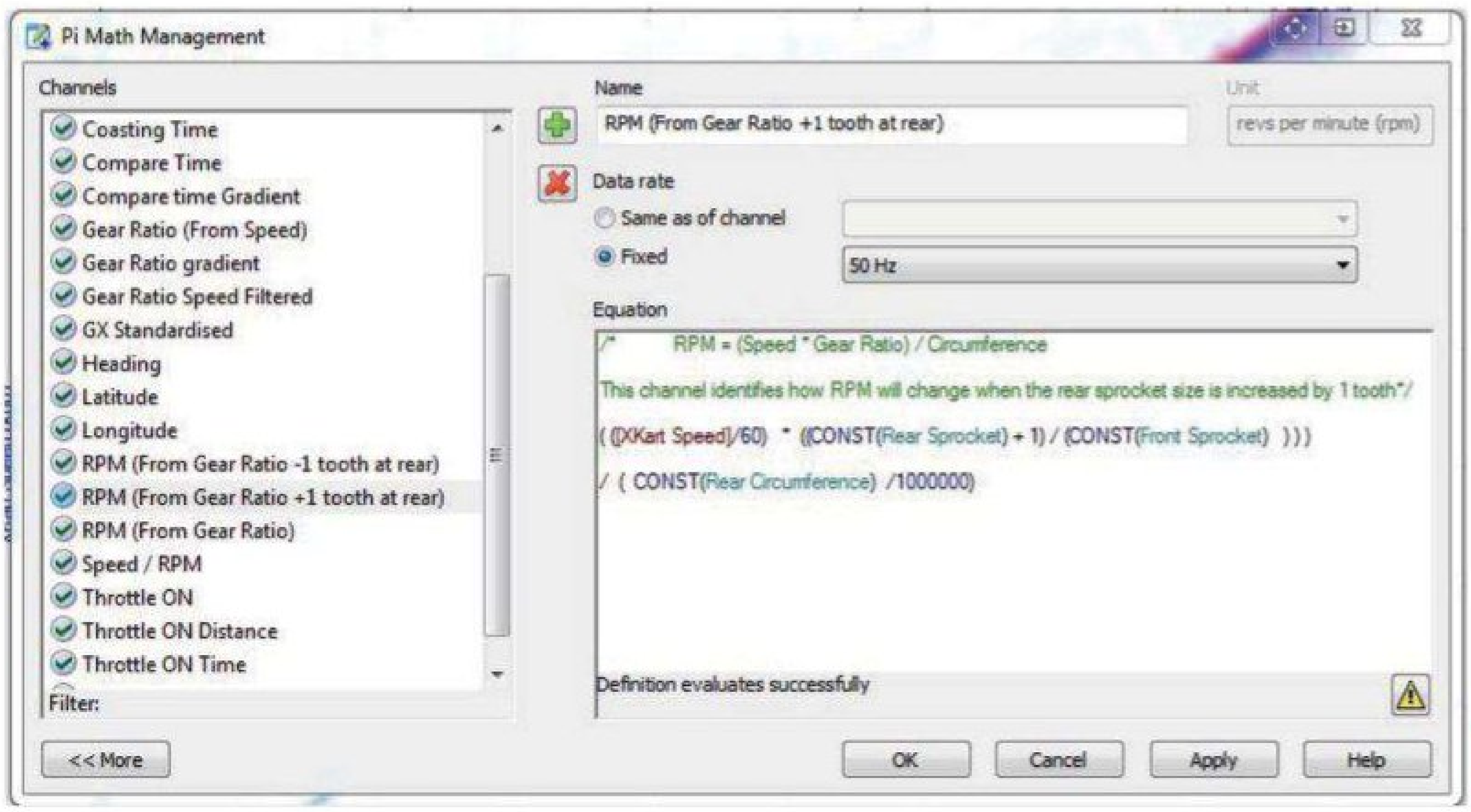



Figure 3: calculation for predicting rpm based on a one tooth change in the rear sprocket of a Kart

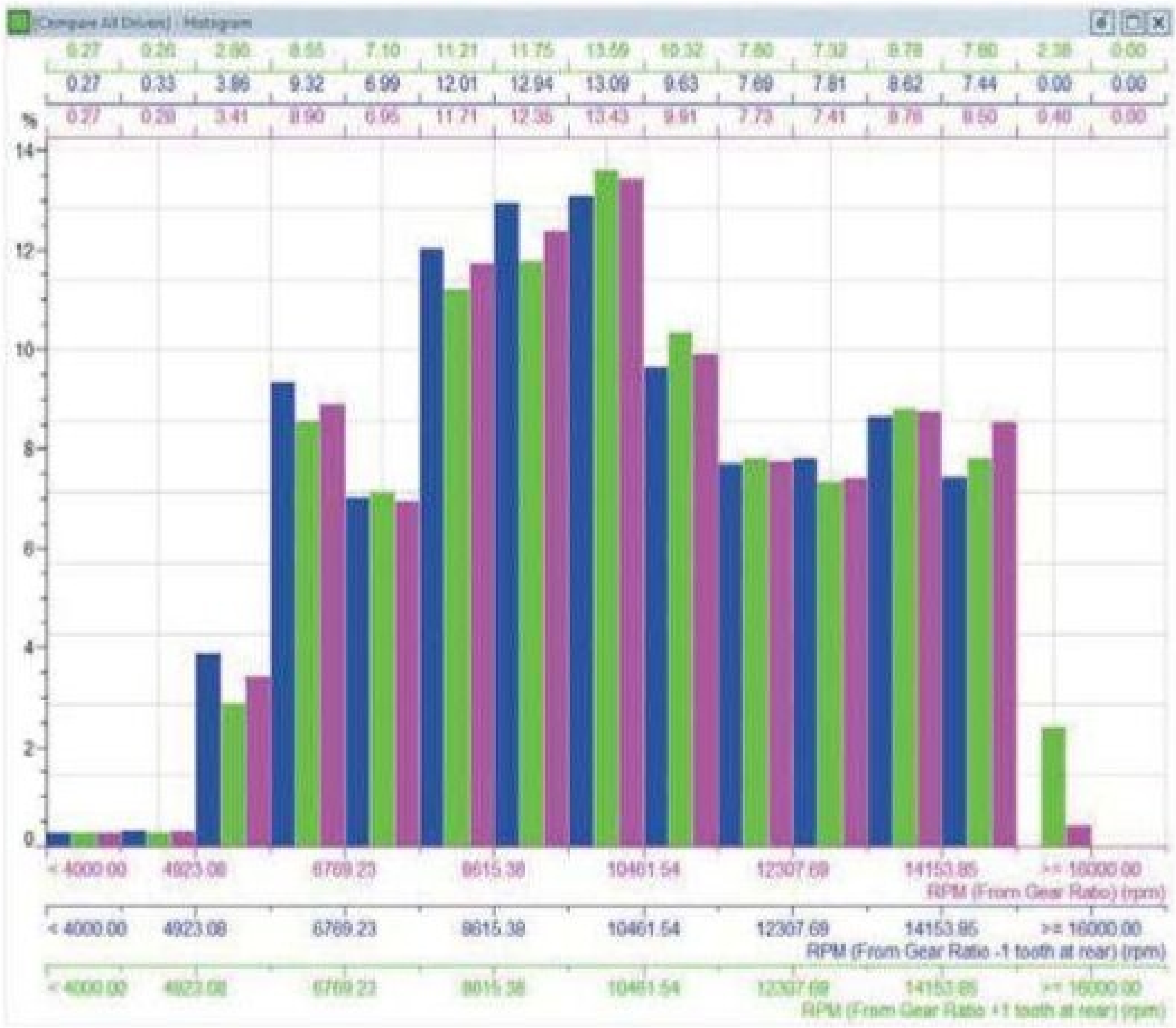


**Figure 4: histogram of the real rpm spread with the calculated ones alongside. This can give vital clues about gearing**

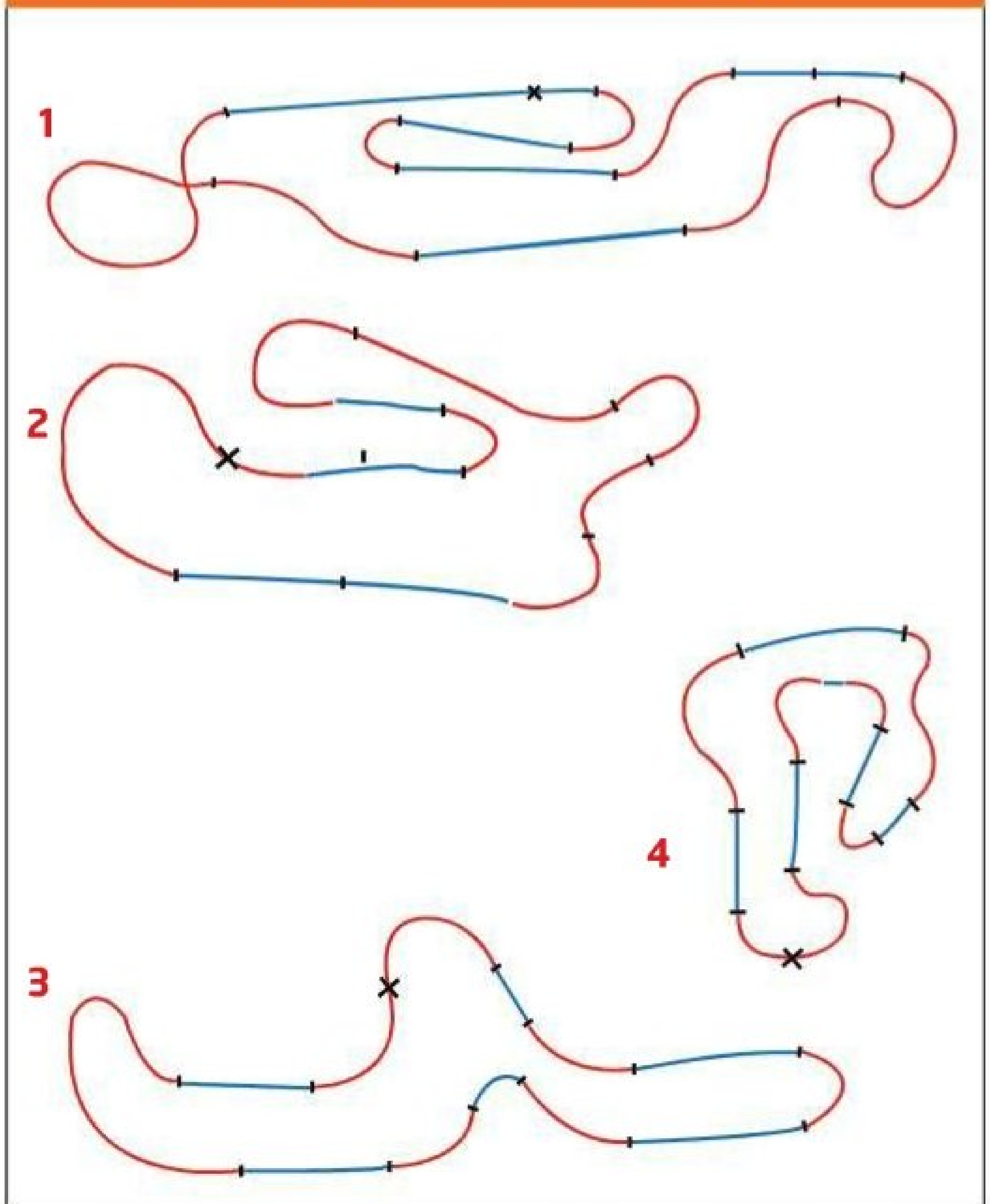
channel calculates the difference in time at a set distance. For example, if datum data set A takes one second to travel 10m, and data set B takes 1.5 seconds, the compare time channel will give a delta time of -0.5 seconds at 10m. This compare time trace can then be differentiated and plotted on a track map to highlight where time is being lost or gained at a high rate.

After the areas that need improving have been identified, vehicle performance needs to be analysed, and a very useful channel to analyse engine performance is rpm.

### SPEED AND RPM

Traditionally, the rpm trace is simply plotted on a time / distance plot to identify maximum and minimum rpm on straights and corners and where the rev limiter is active. This

### CHALLENGE – identify these Kart circuits




```
/* Throttle ON
 Constant Throttle full is the threshold set which determines what
throttle percentage is deemed as "ON" */
choose ( [Throttle Percentage] > CONST (Throttlefull) , 1 , 0)
/* Time ON Throttle */
integral ( [Throttle ON] , Hold )
/* Distance ON Throttle */
integral([Throttle ON] * ([XKart Speed]/3.6), Hold)
```

[Compare All Drivers] - Red Pedal Report

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lap number | | 287 | 288 | 289 | 290 | 291 | 292 |
| Lap time (sec) | | 63.710 | 63.798 | 63.312 | 63.798 | 63.371 | 63.056 |
| Throttle ON Time (s) | diff | 41.92 | 41.30 | 42.78 | 39.76 | 39.90 | 40.50 |
| Brake ON Time (s) | diff | 14.26 | 13.72 | 13.58 | 14.52 | 13.60 | 13.96 |
| Coasting Time.time (s) | diff | 7.52 | 8.76 | 6.92 | 9.50 | 9.86 | 8.58 |
| Throttle ON Distance ... | diff | 904.55 | 904.65 | 935.20 | 863.36 | 860.70 | 900.73 |
| Brake ON Distance.le... | diff | 313.94 | 302.48 | 300.10 | 319.87 | 302.98 | 308.86 |

**Figure 5: it is interesting to look at how the driver's use of the pedals directly impacts the lap time, especially the time spent using neither pedal, described as the coasting time**

information is very useful, but when speed and rpm are combined, more advanced information can be found.

On a Kart, using speed, rpm, front and rear sprocket values and rear tyre circumference, a prediction can be made as to how the rpm range will change when a sprocket change is made. This information is track specific and uses the speed trace with a known gear ratio from an outing to calculate how the rpm trace will change when gearing is changed. This can then be plotted on a histogram for easy analysis.

If the power output along the rpm range is known, a look-up table can be used in conjunction with this to plot the engine torque produced for the different gear ratios. This makes selecting the optimal gear ratios for a circuit even simpler.

### PEDAL TRACES

As well as looking at vehicle characteristics, analysing driver inputs can yield significant performance advantages, too.

If throttle and brake traces are logged, a useful technique is to use maths channels to calculate the time and the distance spent using each pedal per lap. This allows a quick overview of how the driver is using the pedal inputs throughout a session. The distance on the brakes channel can then be used in further, more detailed analysis, such as to calculate braking efficiency at a particular circuit. Using a tabular outing report, pedal information can be analysed in a concise and simple way, which gives a perspective not otherwise attained from looking at the raw traces on a time distance plot.

Using the three maths channels below, the throttle on distance and throttle on time can be calculated. By using the same principals for the brake pedal and combining brake and throttle channels, coasting information can also be determined.

### OVERVIEW

By using the techniques outlined in this article, engineers can make sure they make the most use of the data they are collecting. It also shows that, with just a few inputs and the right analysis tools, an engineer can gain far more insight from seemingly basic vehicle data than most assume. This additional information, once analysed and understood, can be translated into set-up changes and focussed driver coaching, which ultimately will make the racecar go faster.

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**Simon McBeath** offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk. In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

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# The hole truth

## A first look at the effects of mandatory wheelarch apertures

Observers of Le Mans Prototypes will be aware of wheelarch louvres, which facilitate the release of pressure within wheelarches and also kill off some lift over the top of wheelarches, both to the betterment of downforce. These had been regulated for some time in terms of the area required, so it was something of a surprise when the ACO announced that from 2012 there would be mandatory apertures rather than louvres in the tops of front and rear wheelarches, with minimum and maximum areas stipulated and limits on location.

The data in figure 1 compares with and without wheelarch apertures, with the mandatory-for-2012 engine cover fin fitted in each case. Whereas the engine cover fin seemed to make negligible difference to drag, even at the maximum yaw tested (six degrees), the wheelarch apertures *did* make a difference, increasing drag by around 2.6 per cent at zero yaw, and making a similar difference across the yaw range tested here. This is reasonably significant in terms of straight-line performance, but it must be said that this first attempt at creating the apertures simply involved cutting holes to the prescribed maximum size in the existing wheelarches, with no attempts at shaping to mitigate the effects.

The effect on total downforce

The first iteration of front wheelarch aperture tested

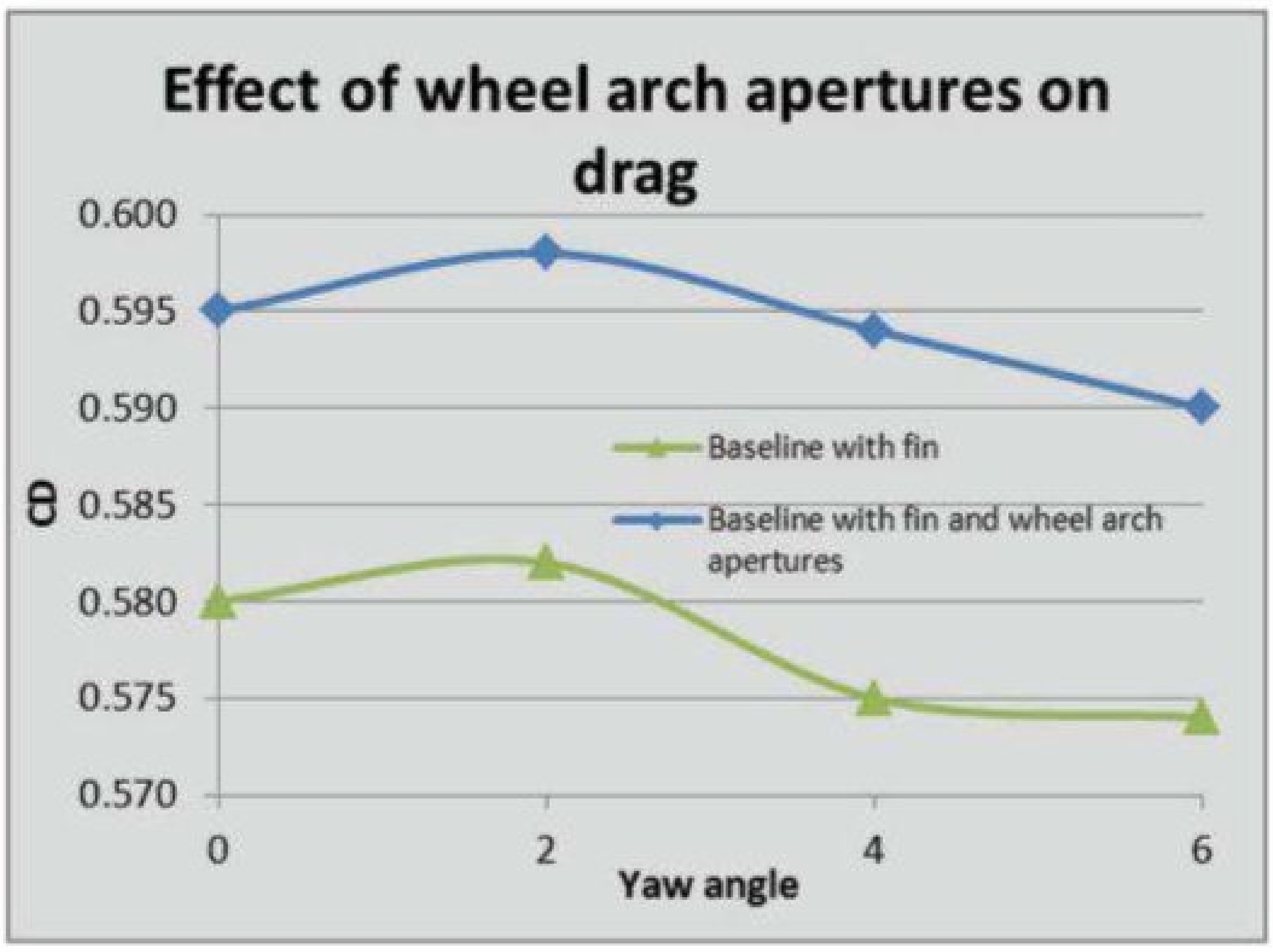



**Figure 1: wheelarch apertures altered drag**

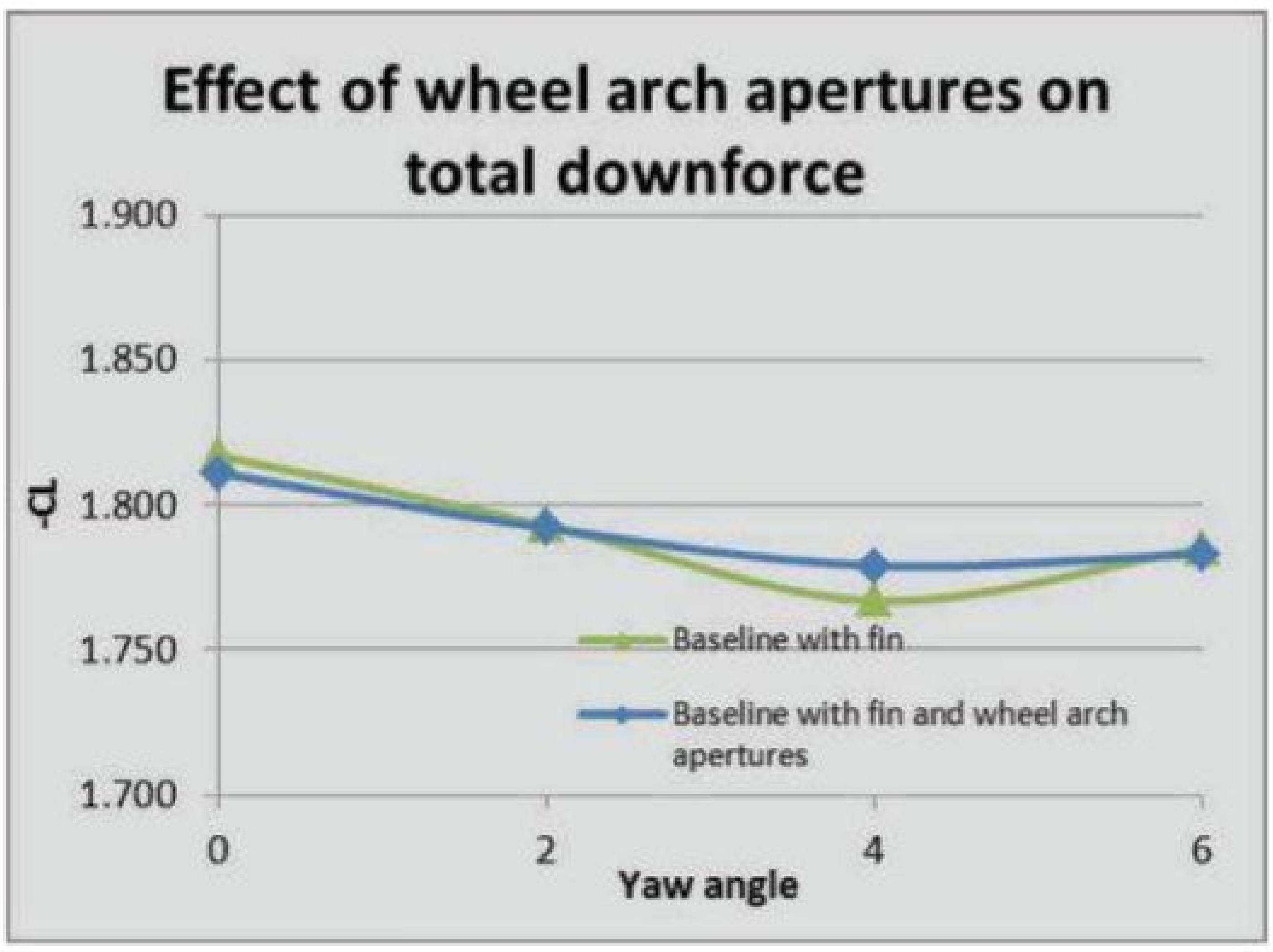



**Figure 2: the first iteration wheelarch apertures made only small differences to total downforce**

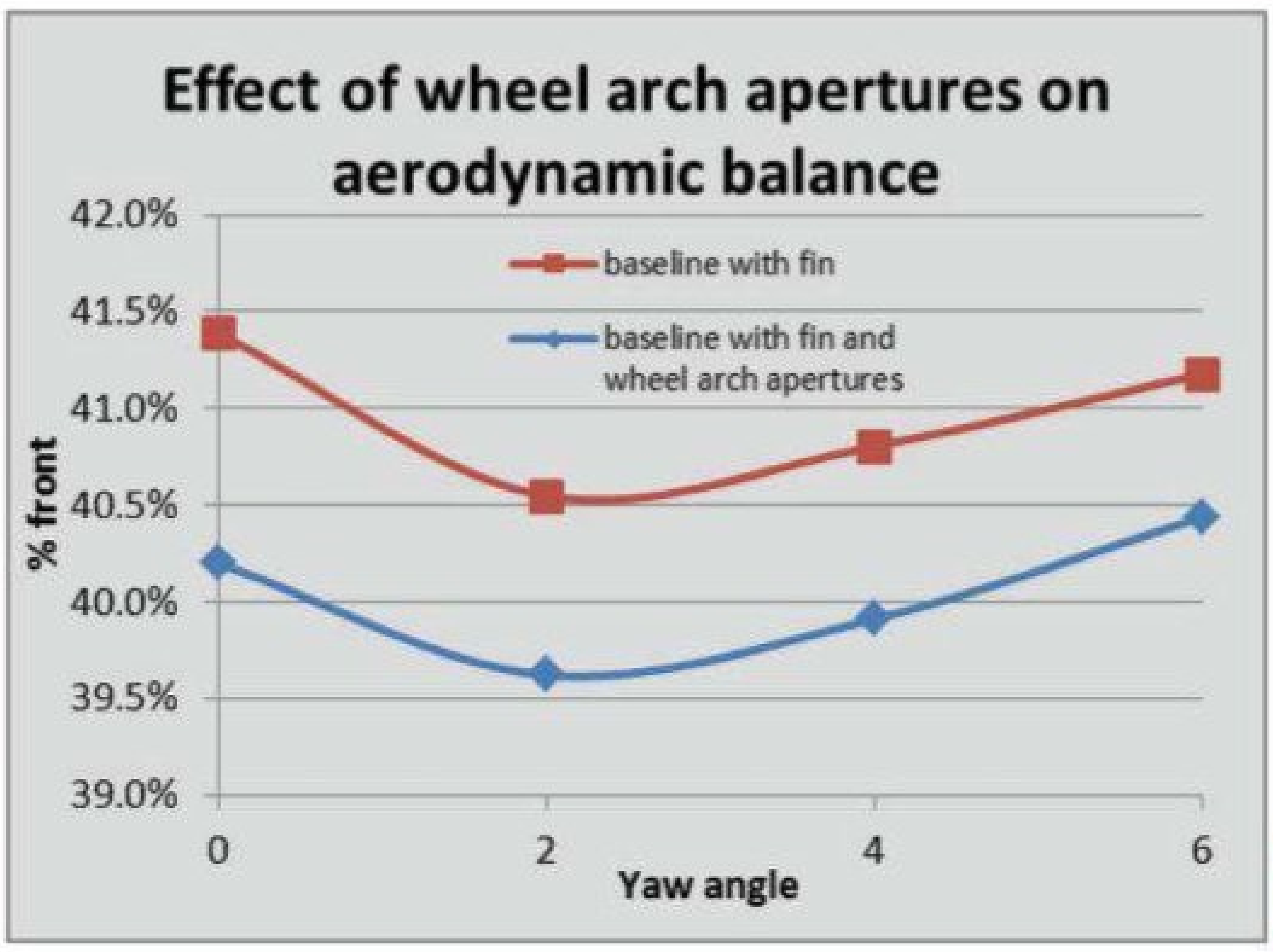
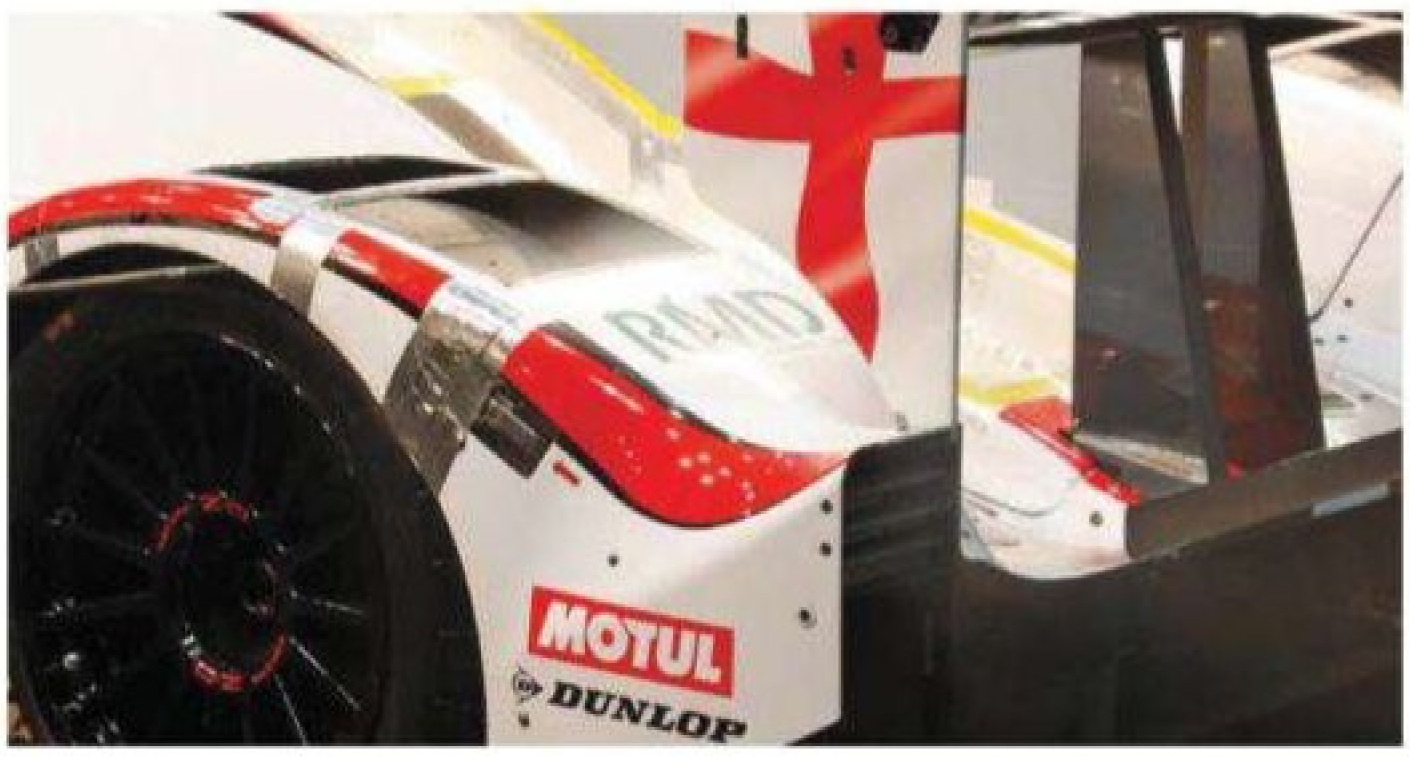



**Figure 3: the wheelarch apertures also altered aerodynamic balance**


The smoke plume showed little smoke actually emerging from the front wheelarch aperture


The first iteration of rear wheelarch aperture tested




Smoke can be seen emerging through the slotted rear panel, as well as spilling out of the rear wheelarch aperture

was more surprising, as figure 2 demonstrates. Here it can be seen that the pattern of total downforce reduction with increasing yaw was very similar with the wheelarch apertures opened up, compared to the baseline case with the engine cover fin, although the worst effect of yaw at four degrees was mitigated somewhat with the open apertures. The general impression here is that total downforce actually changed remarkably little by opening up the wheelarch apertures, but that paints a benign picture that belies reality.

A clearer picture is revealed by looking at the effect of the wheelarch apertures on aerodynamic balance, as given by the '%front' figure, indicating the proportion of total downforce felt on the front axle. What actually happened is that front downforce decreased slightly, while rear downforce increased slightly, resulting in a more rearward aerodynamic balance to the downforce (less '% front') across the yaw range tested, although the pattern of balance shift with yaw remains similar.

We might speculate on the mechanisms involved here. Unlike louvres, which prevent air from directly entering from the front, the apertures evaluated here probably do allow air to enter from the front. So it would also seem probable that the front wheelarch apertures might have been allowing some air (or more air than previously) to enter the arches and generate an increment of front lift that reduced front downforce. But with open rear panels there is egress available from the rear arches so, if any air were to want to enter the rear arches, then it would find an easy escape route. In practice here, rear downforce increased slightly, which one might suppose could simply have been a mechanical leverage response to the front lift reduction, or it could have been that the rear wheelarch apertures actually allowed more air to escape from the rear arches than did the original louvres.

## INDIVIDUAL EVALUATIONS

Fortunately, the front and rear wheelarch apertures were also evaluated separately, so we are able to divine a little more information. The individual aperture tests were carried out at a different ride height combination though, so we will report their effects here as 'Δ' or 'delta values'. That is, the differences relative to the previous configuration. The rear wheelarch apertures were opened up first and the fronts second. The Δ values are given in counts, where 10 counts equal a coefficient value of 0.010.

So things were not as simple as the previous conjecture supposed. In fact, opening up the rear wheelarches alone was responsible for the additional drag we saw above. And perhaps surprisingly, additional downforce was created at the front as well as the rear, with the balancing actually shifting slightly more to the front at maximum yaw as the front downforce deltas increased with yaw and the rear downforce delta for the final yaw adjustment decreased.

Going on to open up the front wheelarch apertures produced the delta values in table 2. In this case, drag reduced slightly at low yaw but changed very little at higher yaw. Total downforce also reduced somewhat at low yaw but reduced less at higher yaw, while front downforce decreased across the yaw range, with maximum effect at four degrees. Rear downforce increased slightly across the range.

So the effect of opening up the front arch apertures fitted better with the mechanisms conjectured here than did the effect of opening the rear arch apertures, which seemed to have a more 'global' influence. Remember, though, that these tests were performed in a fixed floor, non-rotating wheel tunnel.

As stated, this was only a first iteration exercise to determine the extent of the effect of opening up the apertures. Subsequent development will undoubtedly mitigate some of the drag, downforce and balance changes.

Racecar Engineering*'s thanks to Greaves Motorsport.*

**Table 1: the effects of opening up the rear wheelarch apertures alone, expressed relative to the previous configuration**

| Yaw, degrees | CD | -CL | -CLfront | -CLrear |
|---|---|---|---|---|
| 0 | +20 | +34 | +13 | +21 |
| 2 | +22 | +42 | +17 | +25 |
| 4 | +22 | +46 | +19 | +27 |
| 6 | +17 | +34 | +19 | +16 |

**Table 2: the effects of opening up the front wheelarch apertures, expressed relative to the configuration in table 1 above**

| Yaw, degrees | CD | -CL | -CLfront | -CLrear |
|---|---|---|---|---|
| 0 | -4 | -14 | -22 | +9 |
| 2 | -6 | -18 | -24 | +7 |
| 4 | -2 | -5 | -26 | +11 |
| 6 | +1 | -4 | -17 | +12 |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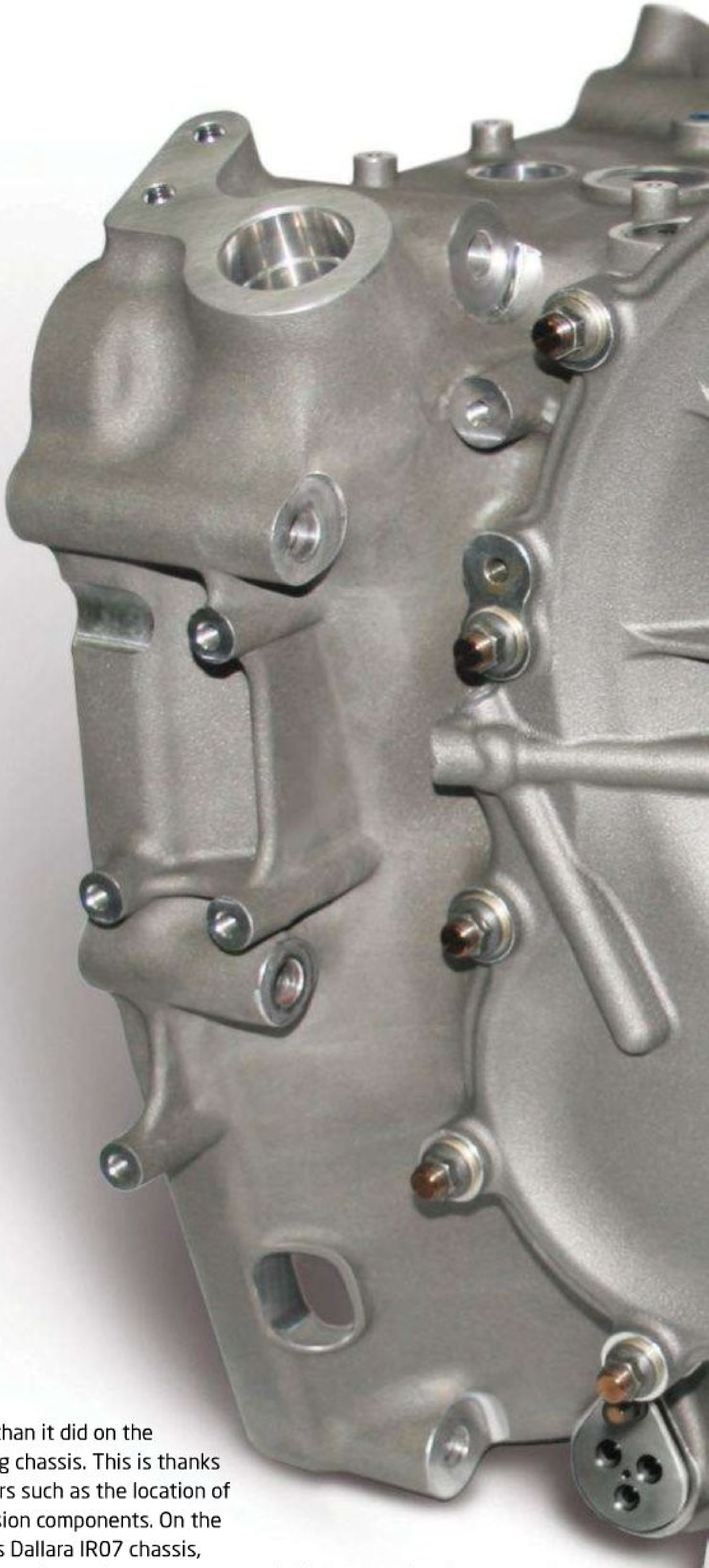
# Indy gear



**Better, cheaper, longer lasting and approved by everyone. That was the brief, this is the result**

BY LAWRENCE BUTCHER

2012 sees the debut of the Dallara DW12, the all-new IndyCar racer, designed to replace the outgoing IR07 chassis, with the intention of reducing costs to teams, increasing safety and provide exciting racing for the fans. Incorporated in the DW12 package is a new, six-speed, sequential transmission that will be produced by UK-based manufacturer, Xtrac. The company was the logical choice as it previously supplied a transmission to the series, in the form of the Xtrac 295, which provided reliable service for the best part of a decade.

The new gearbox is the product of a coordinated effort between everybody involved, which made for an unusual development programme, as Richard Billyeald, principal engineer at Xtrac, explains: 'It was a very interesting project because it was not just us and Dallara. It involved the teams and IndyCar as well. So the teams obviously have their own wish list and some things we could do and others we couldn't. You ask 12 teams what they want and you will usually get 12 different answers back. IndyCar were obviously setting the spec with Dallara too, so there was a good relationship with them, too. However, the budget for the transmission was considerably tighter, thanks to IndyCar's cost-saving intentions, so incorporating all of the improvements [we wanted] was challenging.'

The new transmission, designated the 1011, has minimal carry-over parts from the old unit, though it is not an entirely new design. 'We had a number things we wanted to change from the original 295 'box, and some features we wanted to retain,' highlights Billyeald. 'It was a well regarded 'box and the guys working on it liked it and liked working on it. We wanted to maintain serviceability, with the gear cluster coming out of the back [so] you can change it mid-race, which has been done! But there were some improvements, such as changing the overall ratio without breaking the 'box off the car, that we also wanted to incorporate.'

### CLOSE COMMUNICATION

The working relationship with chassis manufacturer, Dallara, was a close one by necessity, with modern communications making occasions such as daily conferences a simple matter. This close working partnership was vital as the transmission forms an integral part of the chassis, to an even greater extent than it did on the outgoing chassis. This is thanks to factors such as the location of suspension components. On the previous Dallara IR07 chassis, the suspension rockers were mounted on the bellhousing, whereas on the DW12 they are integral to the gearbox casing. The result is a gearbox that has grown in length and a bellhousing that has shrunk. Considerable collaboration was also required in relation to the design of the rear crash structure and the attendant tests. 'The side push off and rear crash tests were very important. The rear crash structure was initially tested on its own and then attached to the gearbox and re-tested as a whole,' explains Billyeald. Xtrac's F1 knowledge and experience gained with series such as A1GP meant that accommodating the impact requirements was a relatively straightforward task.

The close sharing of CAD and simulation data with Dallara, combined with the company's own extensive FEA abilities, also

## "You ask 12 teams what they want and you will usually get 12 different answers back"

**With the suspension rockers now integral to the gearbox casing, the 1011 gearbox is slightly longer than its predecessor. Key amongst the design improvements is serviceability, with the gear cluster and diff / spool all accessible without having to remove the gearbox from the car**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**In house gimbal test rig allowed Xtrac to do physical simulations of the *g* forces the gearbox will undergo on track**

helped the design of the two structures to be fully integrated.

The transmission's lubrication system has benefitted from the latest advances in gearbox design and simulation, not least the fact that Xtrac now has an in house gimbal test rig. The rig allows physical simulation of g forces under braking and cornering, providing validation for results of computational fluid dynamics simulations. Interestingly, the forces produced by racing on a banked oval are easy enough to accommodate when designing the system, the challenge was ensuring sufficient oil pick-up on road courses.

**Xtrac took a huge risk signing up to the IndyCar project, agreeing to build 75 gearboxes and undertake all the development work themselves**

### AUTOMATIC GEAR SHIFT

One other area on which the design team concentrated was the integration of the Megaline Automatic Gear Shift (AGS) system. The previous 295 series 'box had started life as a manual unit and had the AGS grafted on later in its development, whereas the 1011 was always intended to use the system. Although the earlier integration had been successful, there were certain areas the design team wanted to 'tidy up'. One of these was the provision of a reverse gear. In the 295, a reverse gear was a later addition, only required when road course events were introduced into the series. The 1011, on the other hand, was designed with it from the outset.

While the system components are sourced from Megaline, all of the calibration and software set up is done by Xtrac, with shift maps and timing critical to both the efficiency and longevity of the gearbox.

As has already been highlighted, IndyCar is keen for the DW12 to provide significant cost savings to teams. Though the new transmission is very competitive on cost, the key savings will be in relation to service and maintenance man hours, as Billyeald explains: 'In the past, when you wanted to change from a road course to an oval set up, it would involve taking the bevel gears out and removing the 'box from the car to access the drop gears. With the new one you can simply take the side cover off and change the final drive without disturbing the bevels. Swap the spool out for a diff and you are done. All while only having to remove one corner of the car.' While the top teams will probably still take off the 'box and have two separate 'boxes to suit different tracks, to teams that don't have the budget for such extravagances these savings will be most welcome. Further time-saving benefits come from features such as the externally adjustable differential, which will allow rapid set up changes trackside.

### FINANCIAL COMMITMENT

Beyond the basic engineering challenge, the scale of production required by IndyCar presented large scale logistical and financial challenges to Xtrac. Simply taking on the project was a considerable undertaking, as technical director, Adrian Moore, underlines. 'I think the biggest thing for us from a commercial side is the fact that we had to commit to this project early in the process. We get our income from selling gearboxes. No one paid us to develop the 1011, so it is a very long term project for us. We have to make 75 'boxes, 30 plus by the end of January. So that scale of financial commitment is enormous and the technical risk of doing it is large. I am not convinced that any other racing manufacturer currently has either the financial resources or technical competence to take that risk.' This volume of production could be accommodated by the company's existing manufacturing set up, but it still required very careful planning of the production process to avoid bottlenecks during development.

While there is no doubt that Xtrac can produce a far more advanced gearbox than the 1011 – as evidenced by the company's F1 involvement – the new transmission is an excellent example of cooperative engineering. In a market increasingly dominated by one-make series, the ability to produce high specification transmissions to a tight budget, yet tailored to a dedicated set of requirements, is bound to be advantageous.

**"We wanted to maintain serviceability, with the gear cluster coming out of the back"**

# Light years ahead

**The new Renaultsport 3.5 may not be as 'new' as the series is claiming, but there is genuine innovation in its Cosworth electronics system**

BY SAM COLLINS

In motorsport, the word 'new' is a funny thing, and is often used rather subjectively. When is something new and when is something merely dressed up as new? Renaultsport Technologies' 'new' 3.5-litre Formula car is a perfect example of this.

The car is designed as the 'new' spec for Renault's flagship racing series, which sits in that confusing mess of spec series just below Formula 1, banded with IndyCar, GP2, Formula 2, AutoGP and Formula Nippon. With such competition for a finite number of wealthy, or at least financially-supported drivers, all of these series are constanly trying to out do each other with 'new' cars and equally 'new' concepts.

The 2012 Formula Renault 3.5 is certainly visually different to its predecessor, with new front and rear wings and a different cockpit. But beneath that, the base chassis of the car and a third of the components it comprises have been carried over in an attempt to control costs. Admittedly, Dallara has made some small modifications to the tub to accommodate a higher neck restraint and incorporate anti-intrusion panels to improve side-impact safety. Other tweaks have been applied to pass tougher FIA crash tests, but is it really 'new'?

Externally, Dallara has extensively re-worked the aerodynamics to compete with rival series such as GP2, including making this the first spec series to incorporate a Formula 1-style drag reduction system (DRS). Based on the same idea, the Renault version is a little less extreme than the systems employed on grand prix cars, with a much smaller moveable element. The driver activates DRS by pressing a button on his multi-function steering wheel, which causes a blade to disrupt the airflow through the two parts of the rear wing and reduce drag. Beyond DRS, the new wing package offers a 34 per cent increase in downforce.

## 'NEW' ENGINE

Power has also increased with a 'new' engine. Built by Zytek Engineering, the 3.4-litre V8, known as ZRS03, delivers 530bhp, which is 50bhp more than its predecessor. It offers a wider operating range, with the rev limit set at 9500rpm (running on 102 octane fuel).

But the 'new' engine is like the 'new' car, in that it is based on the proven Zytek ZG348,

which has previously been run in Le Mans Prototypes, only with the cylinder head cover and intake manifold modified to allow perfect positioning. Like its predecessor, the engine runs 4500km between rebuilds.

Mated to this is a Ricardo six-speed sequential gearbox, fitted with a pneumatic rather than hydraulic control. This new set up, developed with Shiftec, improves useability and saves weight. The self-locking limited slip differential offers four engine / transmission combinations.

The magnesium casing supports the rear suspension anchor points and has been re-designed to fit with the new engine, which has a different crankshaft height. However, its internal structure remains the same, which has enabled teams to retain their gear ratios, offering a significant cost saving over an all-'new' transmission. The triple-plate carbon clutch also remains unchanged from the previous version of the car.

Other mechanical changes have been made to improve the performance of the car. The suspension is very conventional, as you would expect for this type of car, using double wishbones and pushrod-actuated, two-way adjustable spring / damper units (identical front and rear). The front uses a monoshock layout familiar to anyone who has seen the version employed on the Dallara Formula 3 solution, while twin dampers are fitted at the rear, as one might expect. However, the two-way adjustable Sachs dampers themselves *are* new (at least to Formula Renault) and, in total, offer a weight saving of 4kg over the whole car. Unsprung weight has also been reduced through the use of new aluminium uprights that are 65 per cent more rigid than the old units and 3kg lighter each.

### WEIGHT WATCHERS

Weight loss was clearly something of a theme for Dallara's engineers and, despite the beefed-up, and consequently heavier, safety structures, the 2012 car has come in 15kg lighter in total compared to the 2011 model. Much of that weight reduction is due to an innovative electronics system, which includes neither a starter motor or a battery.

A capacitor-based electronic control box from XAP enables temporary energy storage, smoothing the current from the alternator and keeping the on-board electronics energised for three minutes after the engine has stopped, negating the need for a battery.

The loss of a starter motor has been enabled by using Formula 1-style anti-stall software loaded into the new ECU from Cosworth. Sealed and interchangeable, the ECUs can be checked quickly and easily by Renaultsport engineers to ensure equality, crucial in any spec series.

That factor was key in Cosworth winning the contract to supply the series. The English firm had impressed with its ECU supply to Renault's smaller capacity (2.0-litre) spec open-wheel series when that series received its new car in 2010.

### STEP CHANGE

'The sheer number of cars involved meant it was something of a step change for us,' explains Pio Szyjanowicz of Cosworth

## TECH SPEC

**Dallara T12**

**Class:** Formula Renault 3.5

**Chassis:** carbon fibre monocoque with anti-intrusion panels

**Engine:** Zytek ZRS03 naturally aspirated V8, 3396cc
Max power: 530bhp at 9250rpm
Max torque: 445Nm at 7250rpm
Max revs: 9500rpm

**Transmission:** Ricardo six-speed sequential with Shiftec pneumatic control, self-locking LSD

**Clutch:** 140mm triple plate

**Suspension:** double wishbone with pushrod-actuated Sachs dampers

**Brakes:** Brembo six-piston calipers, 270 x 28mm Carbone Industrie discs

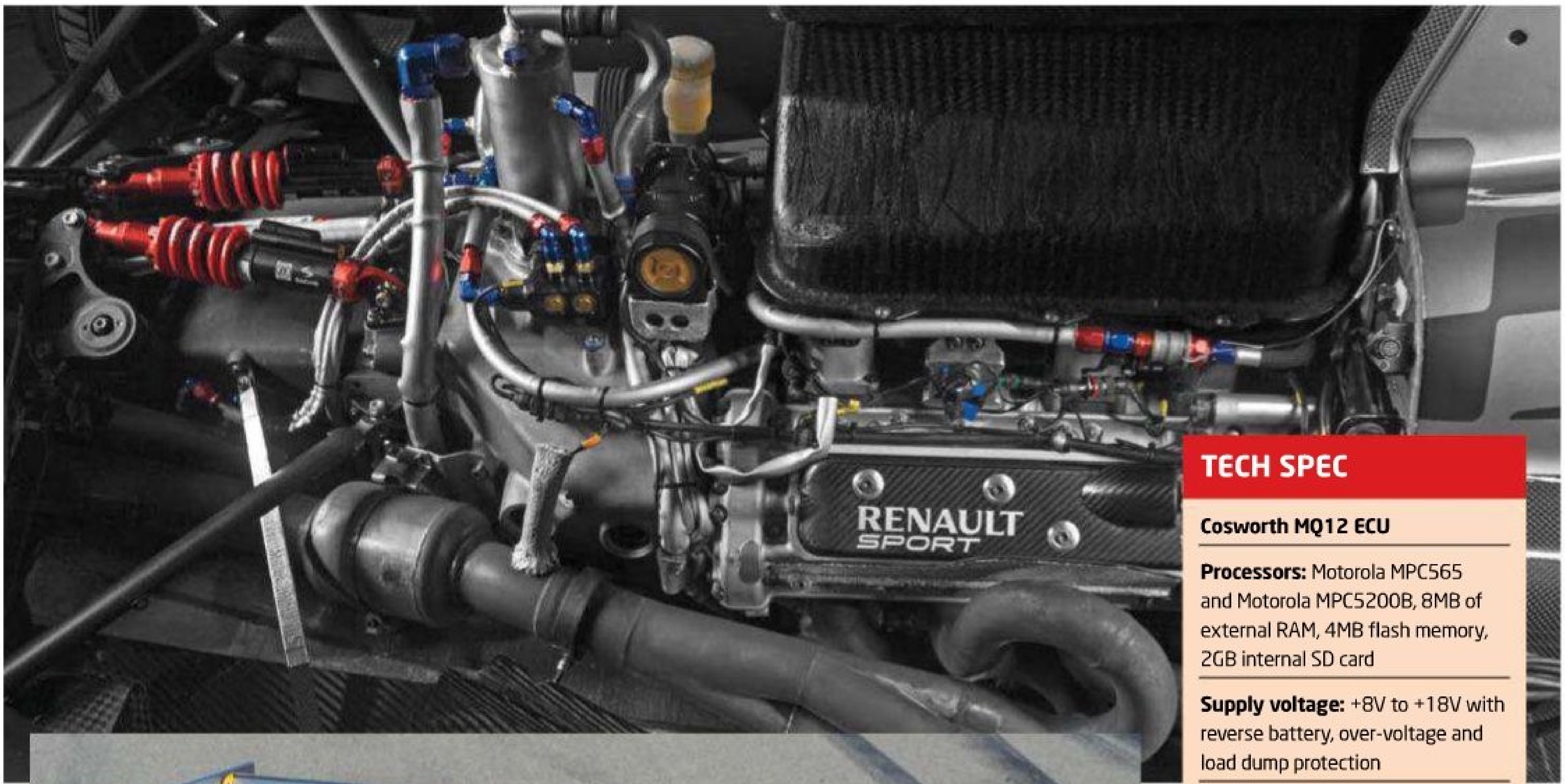
**Wheels:** OZ Racing magnesium monobloc
Front: 12 x 13in
Rear: 13.7 x 13in

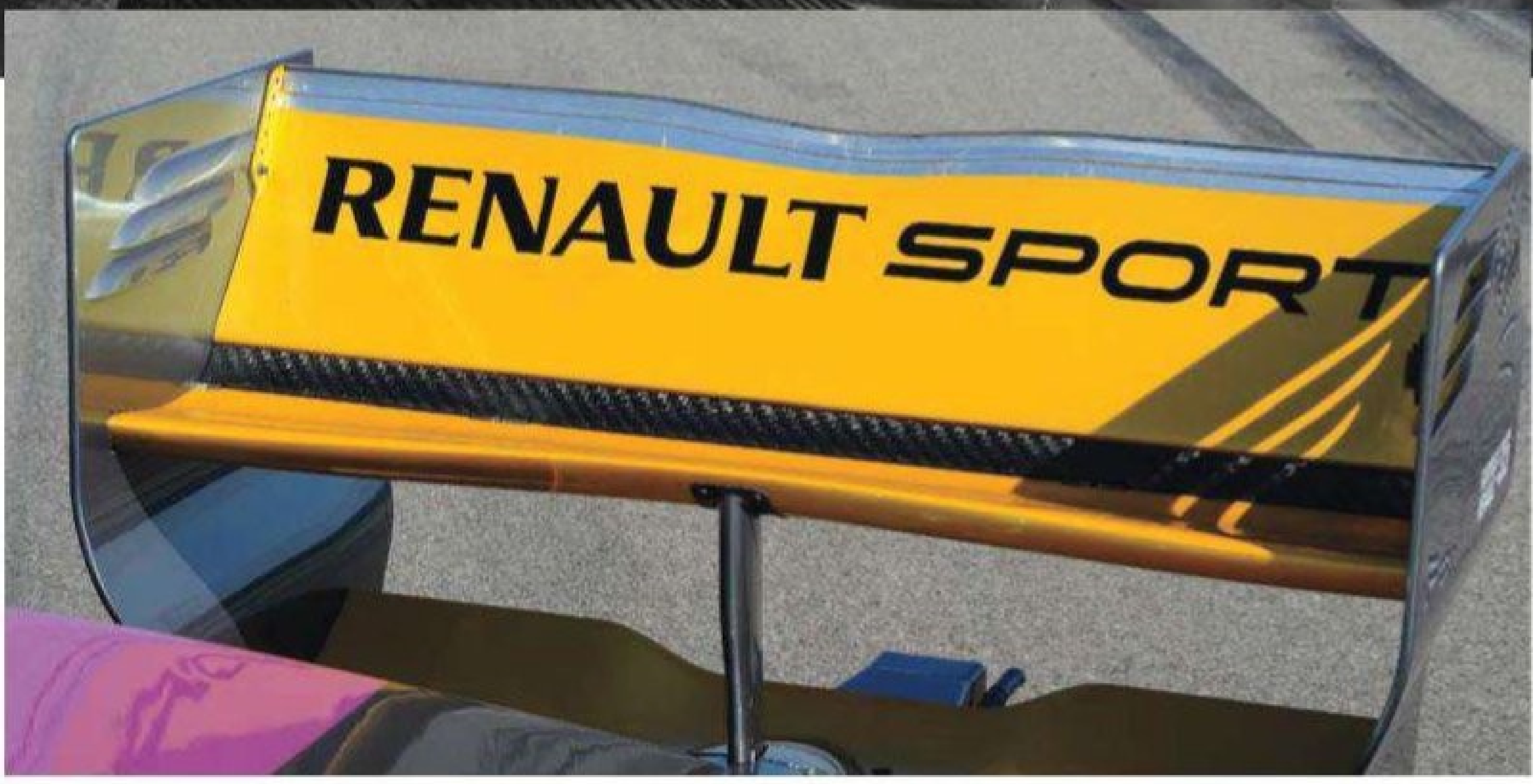
**Tyres:** Michelin
Front: 26 x 26 x13
Rear: 32 x 66 x 12

**Fuel tank:** 110 litres

**Dimensions:**
Length: 5070mm
Width: 1930mm
Height: 1048mm
Wheelbase: 3125mm
Track: 1630mm (F) / 1529mm (R)


**"an innovative electronics system, which includes neither a starter motor or a battery"**




**The inclusion of a Formula 1-style, driver-operated drag reduction system (DRS) makes the aero package on the Renault 3.5 unique amongst spec series**

Electronics. 'I think that they have sold over 250 cars. To do something like Superleague or Formula Nippon is one thing – supporting 24 cars and 12 teams or whatever. But it is a very different prospect looking at up to 300 cars around the world. You simply cannot have support engineers at every single event. So you have to develop a system that is fundamentally easy to use, and we achieved that. Essentially, we took on the burden of running the series in terms of the electronics. That really lead us to getting the contract for the new 3.5 car.'

The ECU chosen by Cosworth is its Pectel MQ12, which features two Motorola processors, 20 configurable injector / PWM drivers combined with 12 IGBT ignition outputs and 16 logic level coil driving outputs, making this ECU capable of fully sequential fuelling on normally aspirated, turbocharged and supercharged engines of up to 12 cylinders. Fly-by-wire capability is also included, along with provision for stepper and DC motors, which are employed on the Renault 3.5. The MQ12 crank and camshaft pattern recognition system allows the ECU to be used with virtually any OEM timing wheel. This sophisticated pattern recognition algorithm also facilitates synchronisation during slow and uneven cranking conditions.

After some work on the Zytek engine on the firm's dyno to get the fly-by-wire working with the new engine and ECU combination, it was taken to Renaultsport's facility in France and fitted to the first test car. 'It fired up first time and that was quite a momentous occasion,' recalls Cosworth's lead engineer. 'Then it shifted first time too, as the ECU also controls that. Indeed, one of the things the test drivers like Andy Soucek commented on was how well it shifts, and how it works in different conditions.'

The new Formula Renault 3.5 is available exclusively to teams chosen to participate in the Formula Renault 3.5 series, for a price of €220,000 (£183,600 / $292,000) (excluding VAT) for a complete car. An upgrade kit for the previous generation chassis is also available for €125,000+VAT (£104,300 / $166,000).

## TECH SPEC

**Cosworth MQ12 ECU**

**Processors:** Motorola MPC565 and Motorola MPC5200B, 8MB of external RAM, 4MB flash memory, 2GB internal SD card

**Supply voltage:** +8V to +18V with reverse battery, over-voltage and load dump protection

**Engine configuration:** 1-12 cylinders, 2 stroke, 4 stroke or rotary, natural or forced induction

**Digital outputs:** 20x PWM alternate function (5A), 16x logic level driven

**Digital inputs:** 16x dedicated, can also be configured as analogue inputs

**Logging throughput:** 2000 samples per second

**Crank and cam sensor:** dual crank input, single dedicated cam input, Hall effect or inductive

**Injector / PWM drivers:** 20x peak and hold (5A peak, 2.5A hold)

**Thermocouple inputs:** 3x k-type (12 bit)

**Analogue inputs:** 37x dedicated (12 bit), 2x wide band lambda (12 bit), 8x knock sensor (12 bit) with configurable gain stage, 16x digital configured as analogue

**Auxiliary outputs:** 1x full bridge (10A) peak, 2x full bridge (5A) peak, 1x stepper motor alternate function

**Ignition drivers:** 12x IGBT internal clamp (+400V, 20A), 16x logic level driven

**Internal sensors:** 4x ECU internal temperature, 1x battery voltage

**Comms ports:** 1x RS232 (RXD/TXD port) 2x CAN 2.0B, 1x CAN/RS232, 1x Ethernet (100baseT)

**Case operating temp:** -25degC to +70degC

**Weight:** 622g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# Race tyre development

## Where physics and chemistry meet Black Art

Most people tend to regard tyres as just black doughnuts that separate their car from the road and involve an irritating running cost to be minimised every couple of years. Racers, on the other hand, are very picky about their rubber and are willing to go to extreme lengths to test and effectively calibrate their racecar to the rubber and the circuit, so that they can arrive at each new circuit with the optimum set up for the first day's practice.

BY CHARLES CLARKE

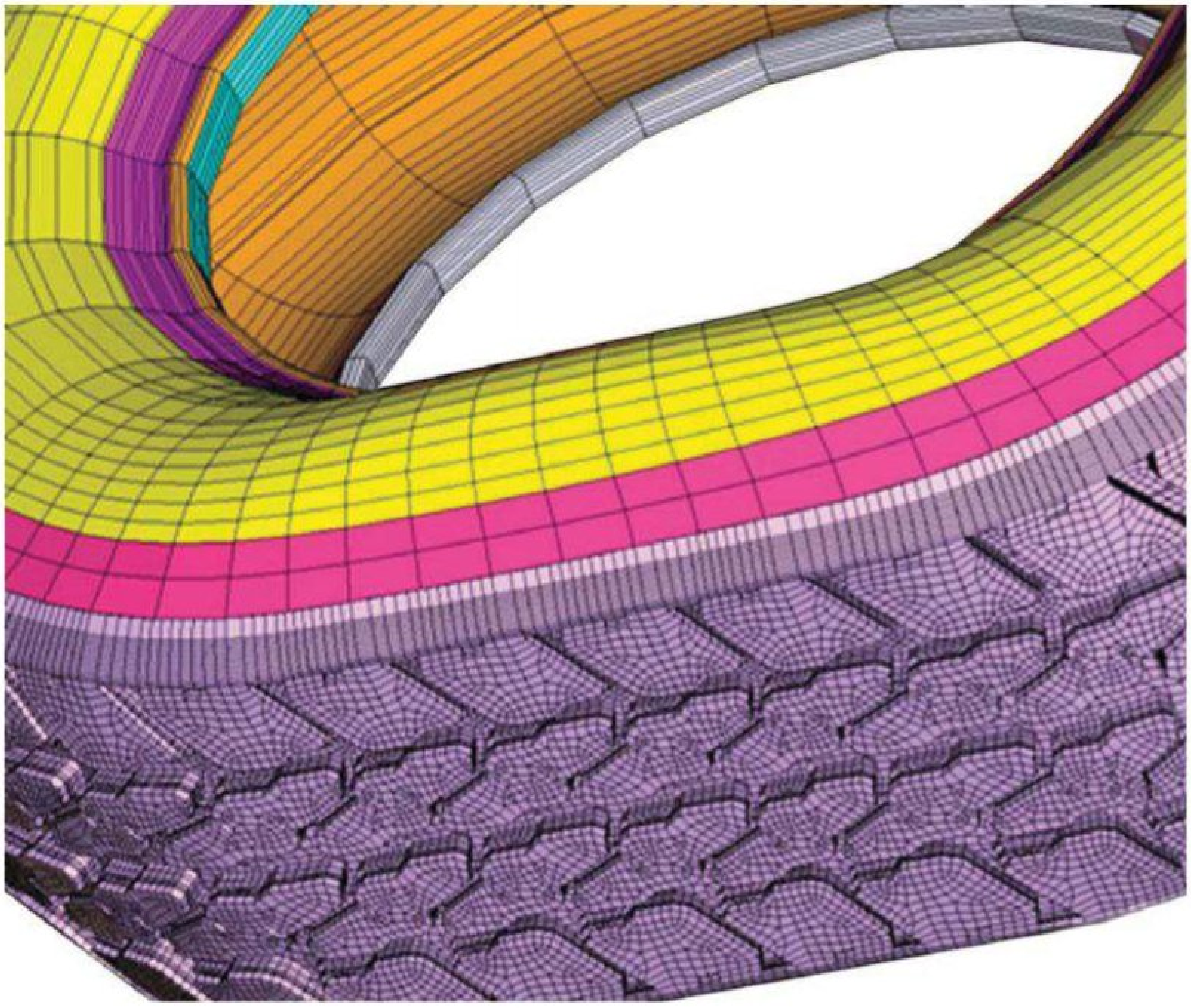
It's not until you take a detailed look at tyre design and manufacturing processes, however, that you begin to understand the complexity of this critical part of any racecar.

There are a great many 'normal' design and manufacturing considerations in the tyre design process, but at the margins there is considerable informed guesswork and approximations that produce the goods that racers depend on.

In many ways tyre design is similar to aero design – you check your basic scheme with CFD, you make a wind tunnel model, you test it and then you test the full-size car on the track. With tyres you do the same basic geometric CAD that you would do with any component. What's different is the analysis. Rubber (it's not actually rubber; almost all compounds are synthetic these days) is hideously non-linear – the stress is not directly proportional to strain – and each compound behaves differently.

**"Rubber is hideously non-linear – the stress is not directly proportional to strain"**

You have to use a specialist non-linear analysis code to stand any chance of simulating the behaviour of the tyre, and here's



Abaqus and Simulia from Dassault Systèmes -- comprehensive modelling of rubber behavior including viscoelasticity and automatic creation of 3D treaded tyre models from 2-D cross-sections

Optimum construction where tread compounds are laid up at the right angles for precise performance

where Abaqus and Simulia from Dassault Systèmes comes in. A huge amount of intellectual endeavour by hundreds of software developers over several decades has made Abaqus probably the best non-linear analysis code available.

As important as the developers are, it's the technical partnerships with tyre companies that make the software what it is today. Companies like Dunlop Motorsport, who are continually pushing the technology to its limits to provide the best service for their racing partners, are essential in the development of the simulation software.

With the high profile of Bridgestone, Pirelli, Michelin and other premium tyre brands, it's easy to overlook the major contribution Dunlop has made to motorsport. But Dunlop is a major player, particularly as a technical partner to BMW in GT Racing, in the American Le Mans Series (ALMS), Nürburgring 24 Hours and the World Endurance Championship (WEC).

But it's not until you look around a tyre plant that you realise how manually intensive

Laying up the carcass layer by layer by hand on the tyre building machine

tyre production is. Preconceptions of automated processes with tyres rolling off conveyor belts in their thousands are way off the mark. At Dunlop Motorsport, each tyre is virtually hand made, albeit with the aid of huge machines and sophisticated background compound chemistry processes.

The factory in Birmingham resembles the dark Satanic Mills of old, due to the carbon black in the air and that unmistakable 'rubber' smell that takes you straight back to your first visit to a bicycle shop. Many other preconceptions are false too, notably that tyres are made

**"It's easy to overlook the major contribution Dunlop has made to motorsport "**

entirely of natural rubber.

'In my department, we tend to concentrate on GT and Sportscars in GT2, GT3, LMP1, LMP2,' says David Meenan, a design engineer with Dunlop Motorsport at Fort Dunlop in Birmingham, UK. 'We have some development partners that have commercial deals but, because there is such a demand for our product, it walks out of the factory on its own. We don't have to embark on huge marketing campaigns, it sells itself.'

### HIGHLY TUNED

In developing a race tyre, Dunlop starts with slick tyres. It might look easy because there is no tread involved, but it's not. A lot depends on the construction of the tyre and a range of compounds used. 'Sometimes we take seven or eight different compounds to an event,' says Meenan. 'Some cars are highly tuned to certain conditions that require certain types of tyres, and then there are the more general products for the less highly tuned cars, which just have a soft, medium or hard compound combination. In between all that, for our development partners we would have smaller gaps in the performance of each compound.'

The word 'compound' is confusing here as, when talking about finished tyres, it is used to differentiate between actual tyres. As a constituent in the manufacturing process it refers


The alchemy of performance tyres; the mixing desk where ingredients turn into world beating compound

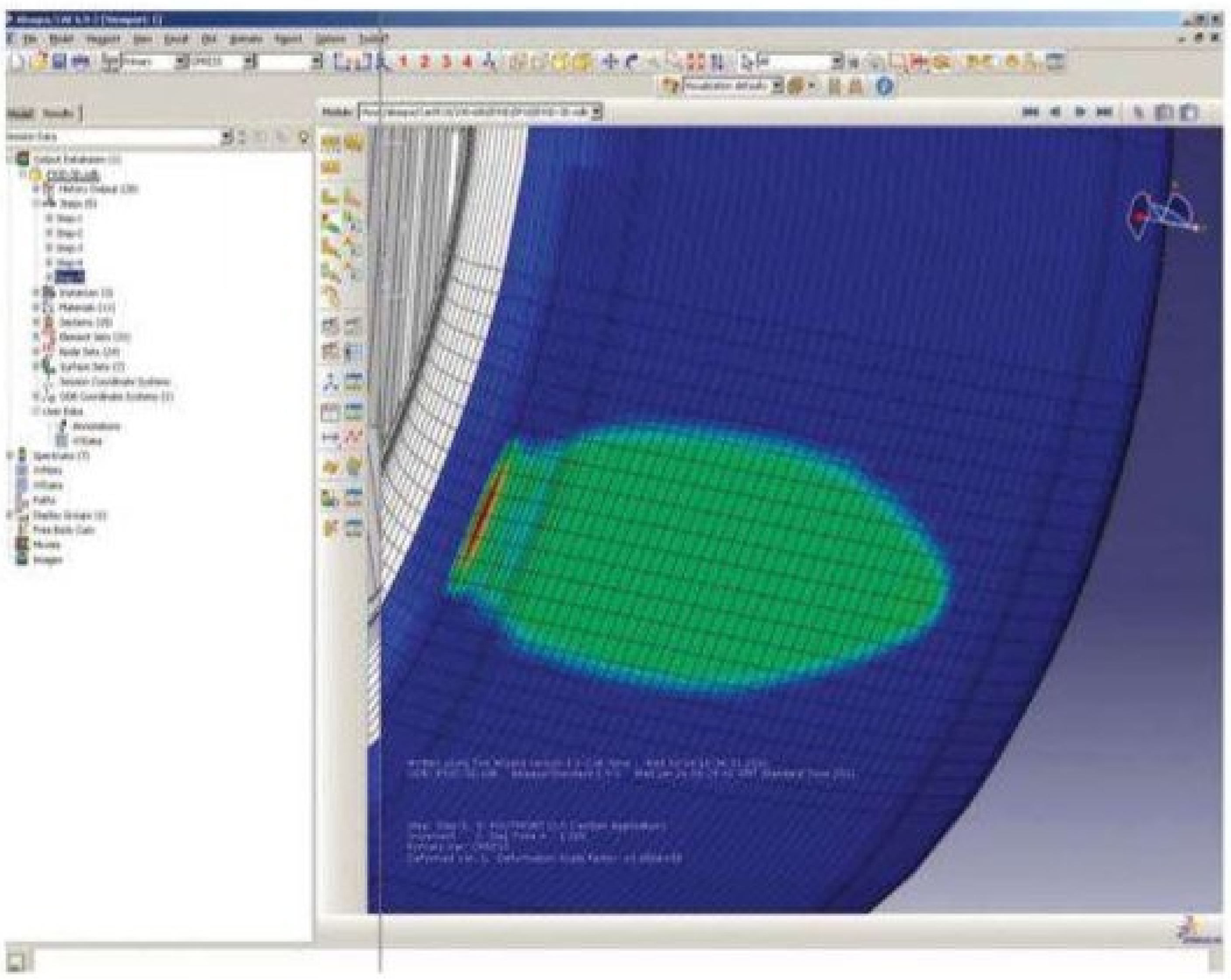
to the particular mix, or recipe, of the rubber.

'We have quite a range of compounds and we can choose from this range for particular circuits and weather conditions,' continues Meenan. 'If it's wet we have what we call a cut slick option, which is a soft slick tyre with 'tractor-style' cuts in the surface [angled cuts from around the middle of the tyre outwards]. For race tyres, these are all hand cut at the factory.'

The cut slicks are used in situations where there is light rain, but not enough to go to intermediates. This is particularly useful for circuits like the Nürburgring where it can be very dry at the start of the lap and damp or even wet at the back of the circuit.

## HAND-CUT GROOVES

The grooves are only 3-4mm deep and are cut with a variety of blades in a hand-cutting tool that heats up to the temperature of a cool soldering iron. Dunlop looked at the possibility of automating this tread cutting process, but it's not as quick as cutting by hand. The tread cutters are a little bit like sheep shearers - they are deft in what they do and can cut tread very quickly, setting their blades so they don't go anywhere near the bandage (the fabric part of the carcass). If the process was automated, in situations where the bandage is closer to the surface an automated machine could cut into it.



The contact patch modelled in CATIA showing areas of high stress

'Because this is part of the development process, having the tread cut by hand means we can change the pattern instantly without having to re-programme any machine tools or produce more tyres,' says Meenan. 'It can't be moulded in because we're changing the product so regularly - that wouldn't be cost effective.

'The tread pattern generally comes from us and is based on feedback from tests. We would try a range of different patterns and converge on what we think is a good compromise for all conditions. A lot of theory goes into tread design and we have a number of our own programmes to help us choose the optimum tread pattern for particular conditions - things like a water clearance analysis for sections of tread produce the required volume of rubber and you work out the appropriate clearances at any position across the section to give you the pattern at a particular point.

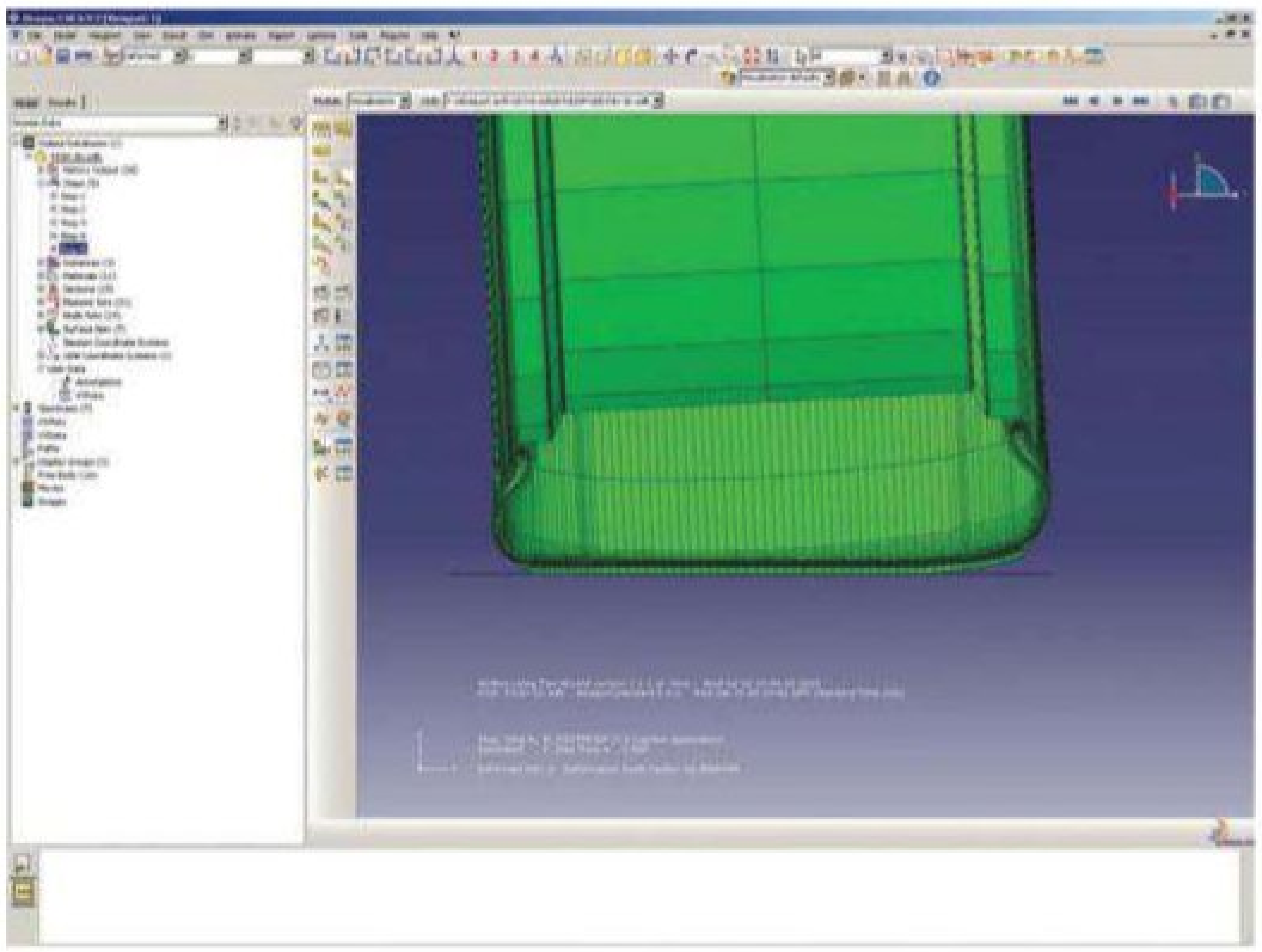
> **"The tread pattern is based on feedback from tests"**

The hand-cut grooves give you enough water clearance to make a slick tyre work in variable light rainy conditions, and on longer laps like Nürburgring where it could be dry for three quarters of the lap. 'It's very difficult to tweak a compound [swap tyres for better grip] in these conditions as it's either going from dry to wet or wet to dry, so the best you can do is provide the possibility for water clearance when it's encountered,' explains Meenan.

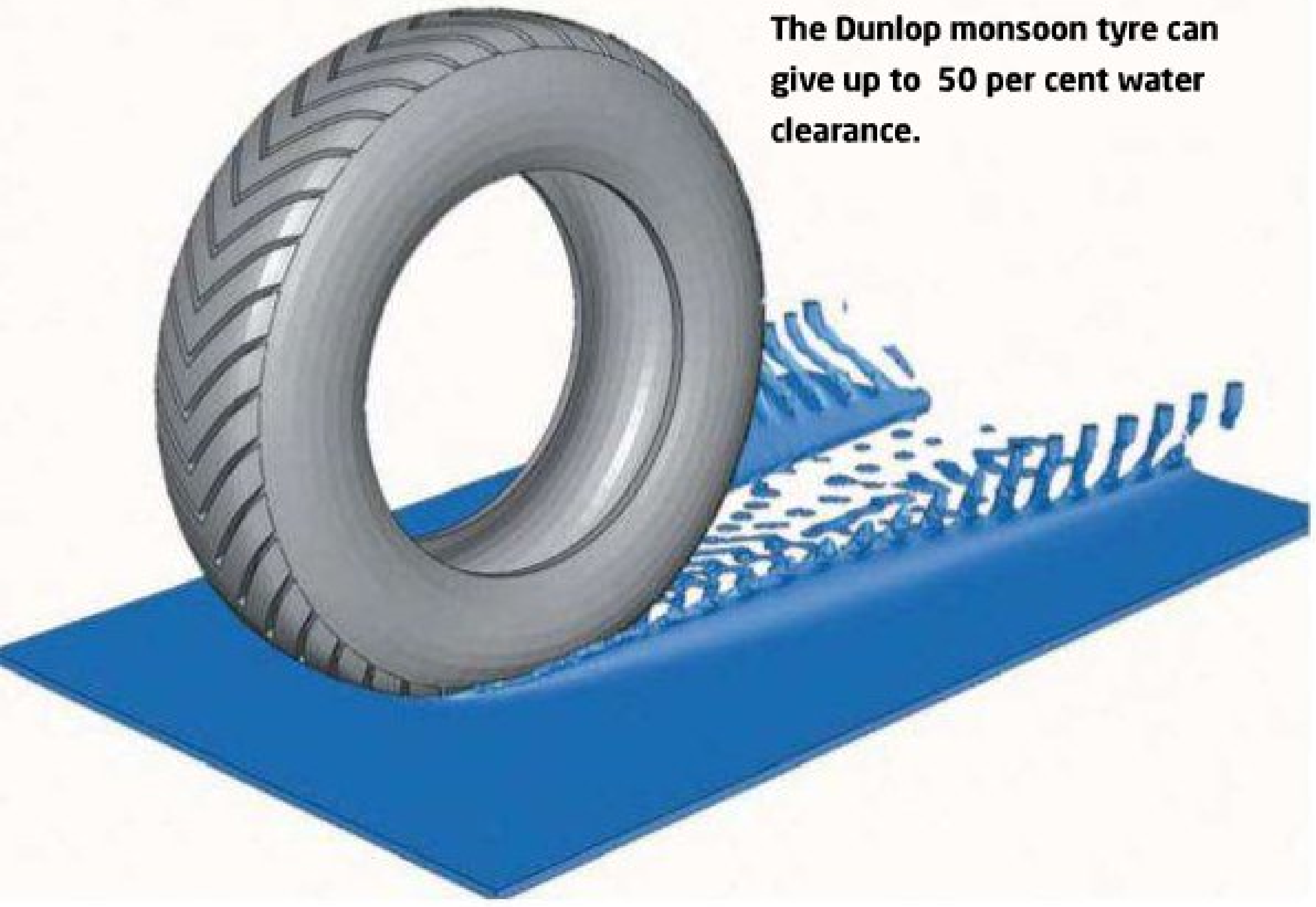
The Dunlop intermediate gives about 30 per cent water clearance, the wet about 40 per cent and what they call the monsoon tyre gives about 50 per cent clearance. In comparison, the cut slick gives about 15-20 per cent water clearance, depending on the number of cuts made and their depth.

Dunlop does slick testing at several locations and wet testing where it can. 'At the end of this year, we went back to Sebring in Florida. We have lots of experience from Sebring, especially with BMW. We did a few 12-hour tests there before


Rapid prototyping allows Dunlop to change the profile of the build machine segments in hours rather than days



CATIA - SIMULIA Model showing a loaded cambered cross section



The Dunlop monsoon tyre can give up to 50 per cent water clearance.

last year's season,' says Meenan. 'We did other tests with the cars that went on to win Sebring. We had one of the best performing cars at that race in the GT class.'

### A BIT OF EVERYTHING

Dunlop went back there this year because the old airfield that is Sebring is one of the tracks where they see both the smoothest and the bumpiest surfaces, as well as fast and slow corners and some high-speed sections. It's hard on cars – Audi goes there for weeks, just to do endurance testing on the chassis – and on tyres, too. Also the weather can be unpredictable there, so it has a bit of everything. 'We think Sebring is the best all-round circuit for testing,' says Meenan. 'In Europe, you have to go southern Spain or Portugal to get anything close. Estoril, Jerez or Portimao at testing time (in the off season) can be wet or foggy, whereas Florida is bound to give you dry days. We went to Sebring with all our development partners to prepare for ELMS (European Le Mans Series) and WEC (World Endurance Series, the new name for the ILMC).'

'We use some element of CAD to design the tyres,' says Meenan. 'We would start off with a construction we may already have, make some modifications and put it through Abaqus. We compare different designs this way. And from that we can get the delta stiffness – the difference between the tyres. Because our process is so well honed, the percentage difference we see with the FEA simulation we also see on the track.'

It's difficult to get absolute correlation with track testing because there are so many variables that you can't control absolutely. 'Things like the actual construction and lay up, the way the tyres shape in the mould, the way the tyre fits on the rim are more predictable than how it performs with the car,' explains Meenan. 'Our biggest challenge is trying to optimise performance for a specific car. From previous tests we would decide on the area that we would like to explore from a car performance point of view, improve the front or balance the rear etc. We would have a weight distribution or stiffness balance that we would want to target, so we would take a few options [different tyres] in that area to test. Baseline is another variable term. When describing a test, baseline is a term that describes a tyre that is a known quantity. This is one that has a given construction and compound that the team and driver know well and know how it reacts with the car. In a given test, the tyre variants will be compared and contrasted to the baseline tyre. In the test shown here, the baseline would generally be in the middle, with two softer and two harder compounds either side. After a test, the baseline is usually the optimum compound combination for the car and the circuit, and this is the combination that goes into the race set up process where dampers, aero and suspension geometry are adjusted.

**"the percentage difference we see with the FEA simulation we also see on the track"**

'We have a lot of on-board data logging, with a number of accelerometers and slip angle sensors. We work very closely with the race engineers and the drivers to get an understanding of how the tyres are performing,' says Meenan. 'We have a long relationship with a number of drivers so we can trust their feedback.

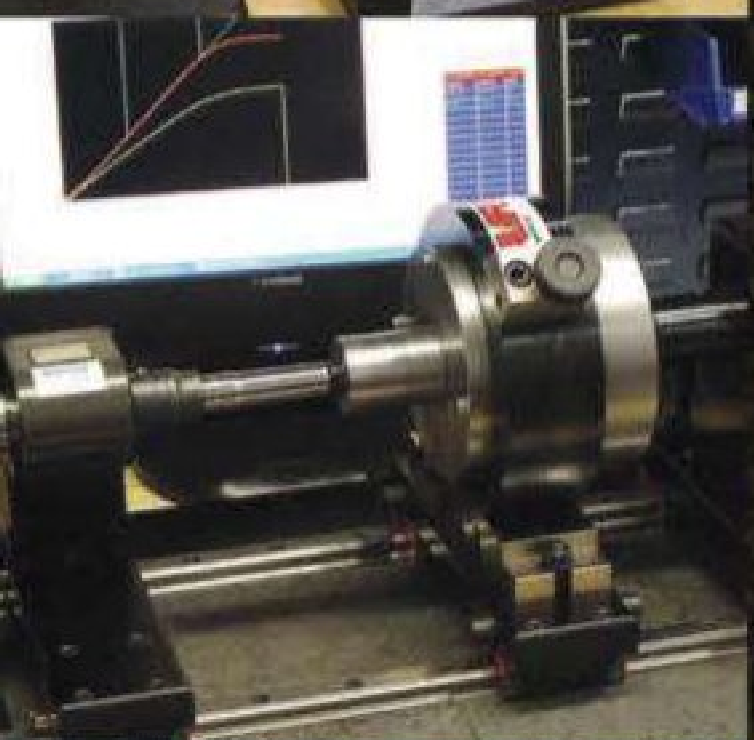
'The driver would go out with a baseline tyre and we generally tell him it's a baseline (a tyre that he knows well). We give him as long as he wants to understand how the car is reacting on the baseline set and then we go into a test programme where we have five test tyres,' continues Meenan. 'The baseline could be in the middle or at the start of the sequence. We sometimes







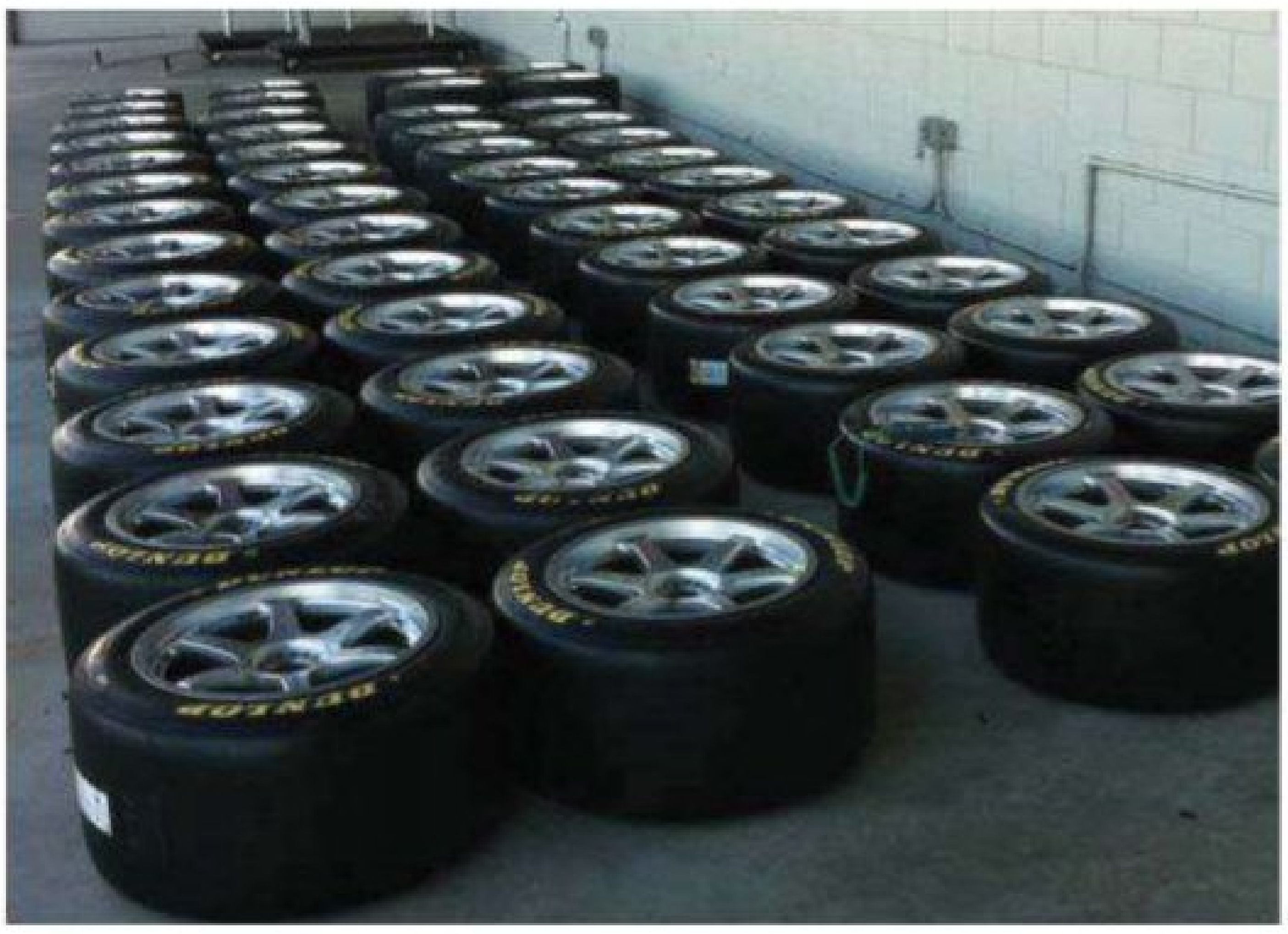



put them in illogical places so the driver doesn't know which is the baseline tyre. If he's good, he can usually figure it out.'

'We then give rating sheets after each run and he rates the tyres on warm up, consistency and balance front to rear. Then we have a section that relates to low and high-speed cornering performance. He rates each section individually, describing whether the car is neutral or has understeer or oversteer. You would be surprised how consistent this procedure is.

'If we have a baseline and we want to go stiffer, we go where we think we need to be in two steps and then go one step further just to see where the edge is and how much is too much. Once we've found a baseline front we will use it and try some rear options to find a better balance, and then we would tend to home in on a best front with the best rear. It's A, B, A testing, but it works. We go through this procedure pre-season with development partners and it puts us in a good place to go to the first race. We might try some compound options as well in this test programme.'



**Just another test session -- up to eight different compounds are tested back to back**

'Once we have found a promising tyre combination on lap time performance and driver feedback, we do an afternoon's worth of set-up work to help the teams optimise the set up. Teams will work with dampers, aero and kinematics to get the optimum from the tyre combination. The driver would also work on his driving style for a specific set. Once we decided on a [conclusive] baseline option, we test that on a vehicle kinematics rig and get some force and moment data back and put that into the car's FEA simulation.

'We use an external company that does a lot of work for us and other developers in these race series,' continues Meenan. 'They have a rolling road that generates force and moment data for a variety of slip angles, inclinations and loading. In this way, we get more data about the performance of the car tyre and driver combination, so that we can 'calibrate' our simulation and predict more accurately how it will perform at different tracks and in different conditions.

'We generate slip ratio curves, which allows teams to set the differentials and traction control settings and to understand the maximum slip that the tyre will stand before traction control needs to operate. The kind of testing we do is much more rigorous than people generally believe is necessary for a tyre manufacturer, but our objective is to understand and gather as much data as we can, to feedback into our computer systems in order to produce more accurate simulations next time around.'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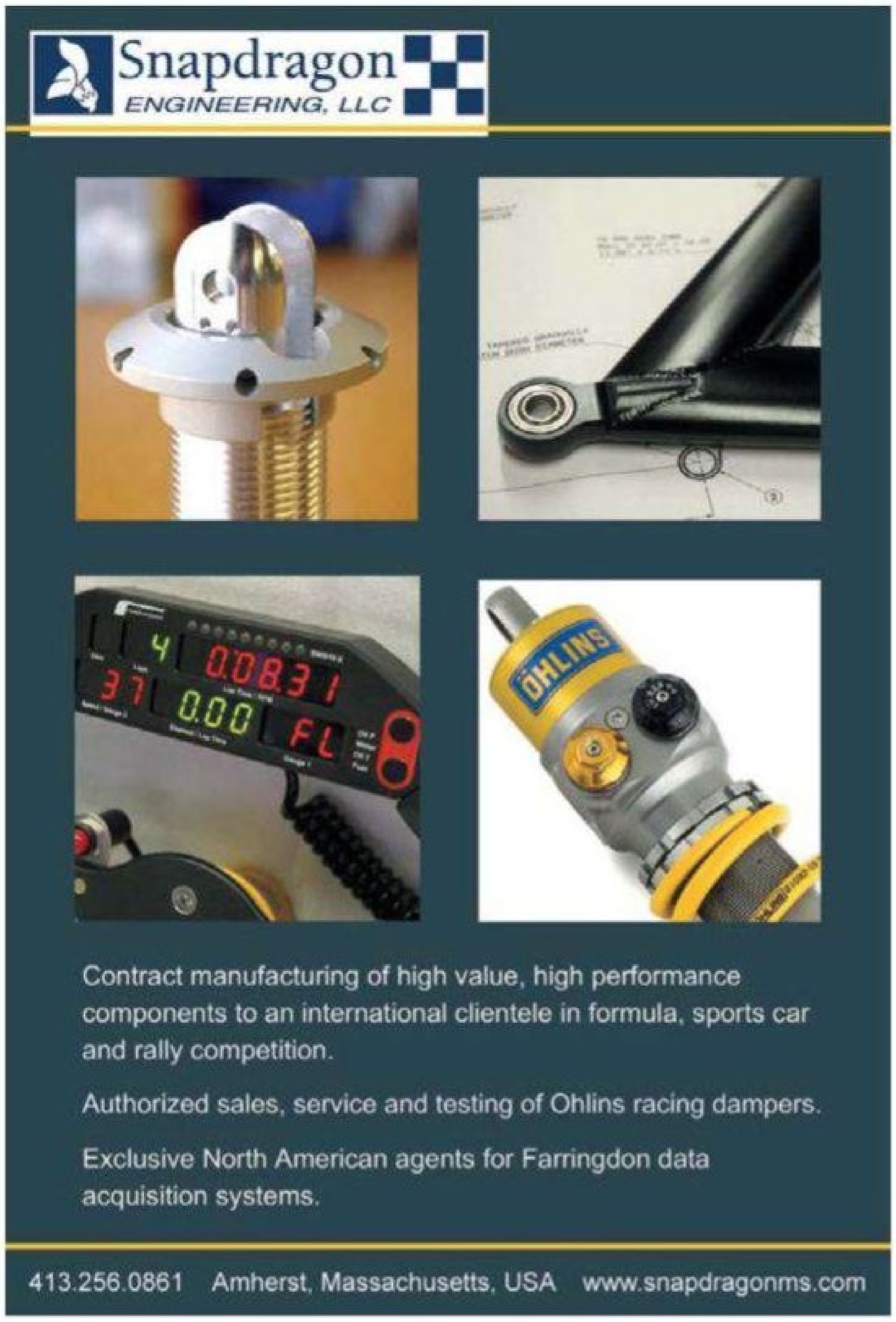
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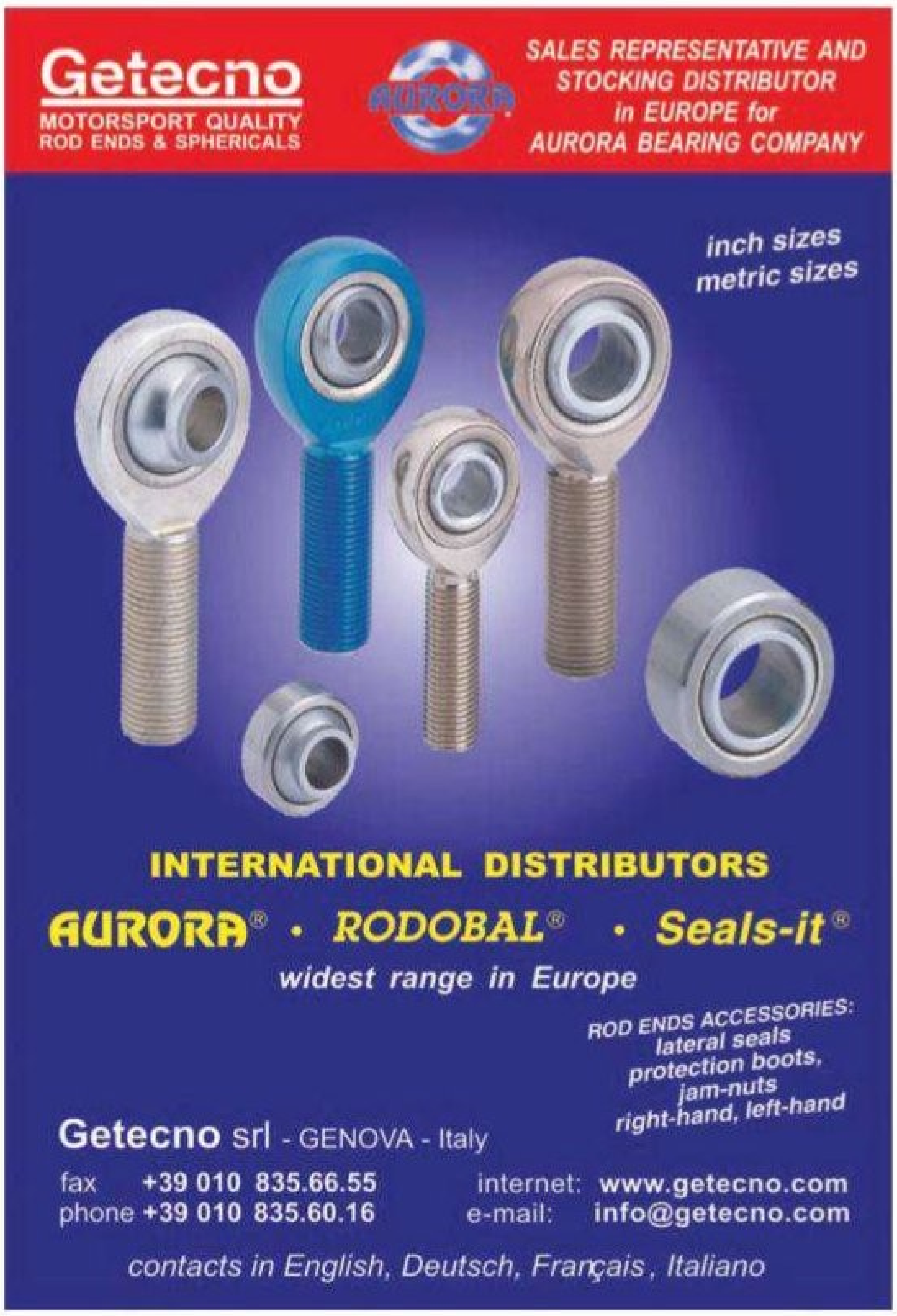
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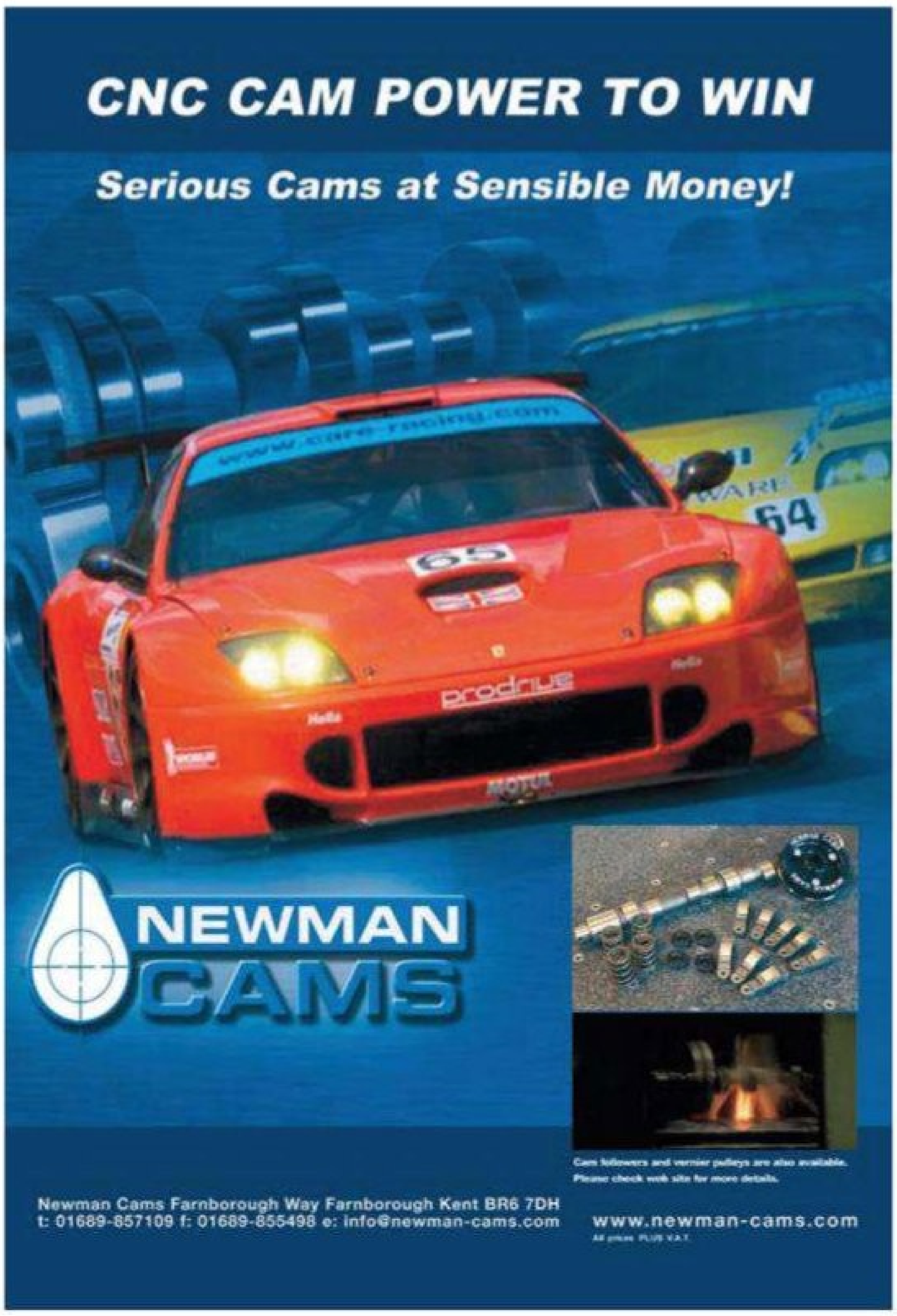
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# Filling in the blanks

## Calculating an engine curve from nothing

**BY** DANNY NOWLAN

From time to time you will be placed in a situation where you are going to have to calculate an engine curve from little or no information. While this might discourage some people from using analytical tools to calculate gear ratios, it is not as hard as you might think. All you need is an idea of maximum power, a rough idea of aero drag characteristics and minimum and maximum rpm. You can then fill in a significant number of the blanks, and this is what I am going to explain how to do in this article.

Before I begin, though, let me just say that I feel it is a very sad state of affairs that there is actually a need for this kind of article at all, but this has been motivated by a number of my customers needing to construct engine curves because their engine suppliers are either unwilling, or are trying to lock them into their bespoke tools. Some of this is due to said suppliers being paranoid about their engine dyno curves becoming public.

However, having extensive experience in the field of engine management / tuning, let me tell you that engine dyno curves are, at best, comparative tools and should be treated as such. The real trick is having the skills to produce that curve, which is why good engine builders / tuners are worth their weight in gold.

In chassis terms, it's like knowing car 'a' took the corner at 146km/h and car 'b' took the car at 148km/h. Just because we know the speed, it doesn't necessarily mean we know what the race engineers did to get them there.

The first step toward the engine curve is to ascertain the drag of the car. If you have been to a good, reliable wind tunnel you can skip this bit. If not, read on. Most race series will give a reliable ballpark figure for maximum horsepower. While it

**"Engine dyno curves are, at best, comparative tools"**

**Table 1: F3 parameters for drag calculation**

| Item | Quantity |
|---|---|
| Power | 150kW |
| rpm | 6500 |
| Rolling tyre radius | 0.28m |
| $a_x$ | 0g |
| Vx | 220km/h |
| Gear ratio value | 3 |
| $m_t$ | 500kg |

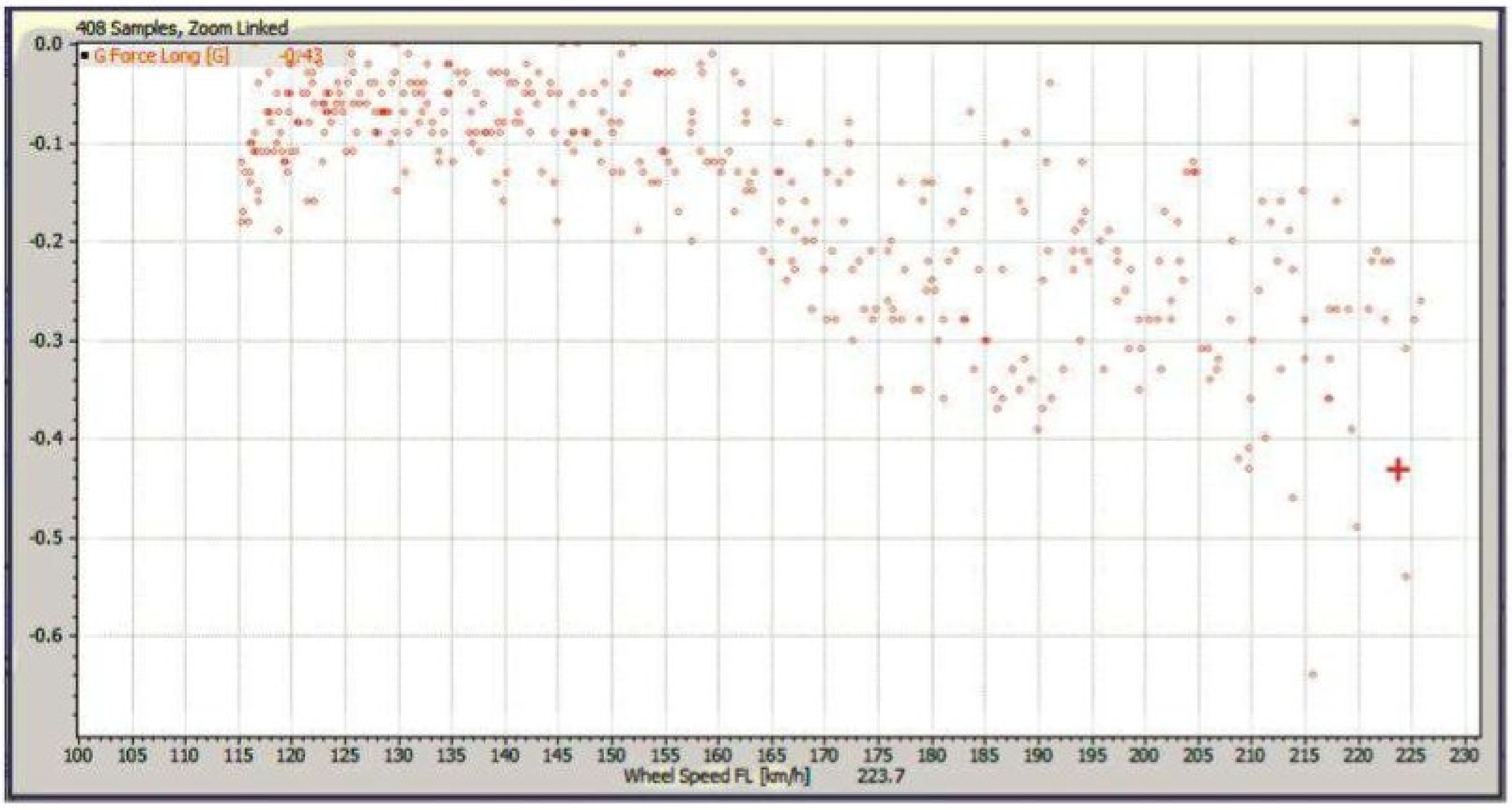



**Figure 1: coastdown result plotting acceleration vs vehicle speed**

will not be accurate to within a tenth of a kW, this, together with race data, is good enough to obtain a solid idea of the car's drag. To illustrate this, let's walk through an example calculation with an F3 car. The F3 parameters we will be using are shown in table 1, above.

Our ace in the hole here is that engine power is torque x the angular velocity of the crankshaft. Working on the maths, this is seen in equation 1.

From table 1, the torque for our engine is 220Nm so, assuming a driveline efficiency of 90 per cent, the coefficient of drag is given by equation 2.

### STRAIGHT TO THE POINT

The best point to take for this calculation is at the end of the longest straight at maximum speed. At this point, most racecars are nearly balanced, so it's a good starting point.

The beauty about this quick hand calculation is that it gives you a reference point. This is important for two reasons: 1) It gives a baseline to form the engine power around; 2) It is a valuable sanity check for manufacturer-supplied aeromaps. I have lost count of the number of times I've had to use this for the latter... As an aside, what do you do if the manufacturer-supplied aeromaps are radically different to the ones you have calculated? Well, until you have better information, scale it to the drag values you have calculated. It's not perfect, but will get you by.

**"Another approach to take is to conduct a coastdown test to determine drag"**

Another approach to take is to conduct a coastdown test to determine drag. What you are plotting here is vehicle speed vs longitudinal acceleration. You should then have something that looks like figure 1, above.

In this case, all you need to do is convert acceleration to m/s$^2$ and speed to m/s, then export them to, say, Excel and Matlab and you are well on your way to determining the drag coefficient. I will leave it to the interested reader to figure out the details (hint to engineering students / junior data engineers, look at equation 1).

### THE MAIN EVENT

Now that we have drag, it is time to get on to the main event, which is determining the engine curve. The information we'll need from our data to do this is illustrated in figure 2.

The principal channels you'll need are longitudinal acceleration ($a_x$), vehicle speed, rpm and gear selected. If you don't have gear selected, don't worry because determining the gear ratio is very straightforward. All you have to do is calculate engine speed / wheel speed and that will get you right in the ballpark. The trick, though, is to concentrate on the straights, hence why I've thrown in the lateral acceleration and steer angles so these can be readily identified. The other item we'll need is the engine speed to wheel speed ratio of all the gears from the set up sheet.

Using these factors, you will be able to determine the engine curve, as follows:

- **The first step is to export all the channels listed in figure 2 to a csv (comma-separated values) file. Concentrate on straight data only.**
- **Open this in Excel.**
- **Once you have the file open, identify where the gear position is and insert a column.**
- **In this blank column, next to the gear position, put in the appropriate engine speed / wheel speed ratio (there are a multitude of tricks you can use to automate this process, which can be readily found).**

Once this is complete, we are ready to estimate the engine curve. The equation we are going to be using to do this is shown in equation 2.

## EQUATIONS

**Equation 1**

$$T = \frac{60 \cdot P}{2 \cdot \pi \cdot RPM}$$

where,
P = power in Watts
RPM = engine speed

**Equation 2**

$$C_D A = \frac{gr * T / r_t - m_t \cdot g \cdot a_x}{0.5 * 1.225 * (220/3.6)^2}$$

$$= \frac{3 * 200/0.28 - 550 \cdot 9.8 \cdot 0}{0.5 * 1.225 * (220/3.6)^2}$$

$$= 0.937$$

**Equation 3**

$$T = r_t \frac{(0.5 \cdot \rho \cdot V^2 \cdot C_D A + m_t \cdot a_x)}{gr}$$

where,
T = engine torque (Nm)
$C_D A$ = drag
V = forward vehicle speed (m/s)
mt = total car mass (kg)
$a_x$ = longitudinal acceleration (m/s$^2$)
gr = engine speed / wheel speed for the required gear
$r_t$ = rolling tyre radius (m)

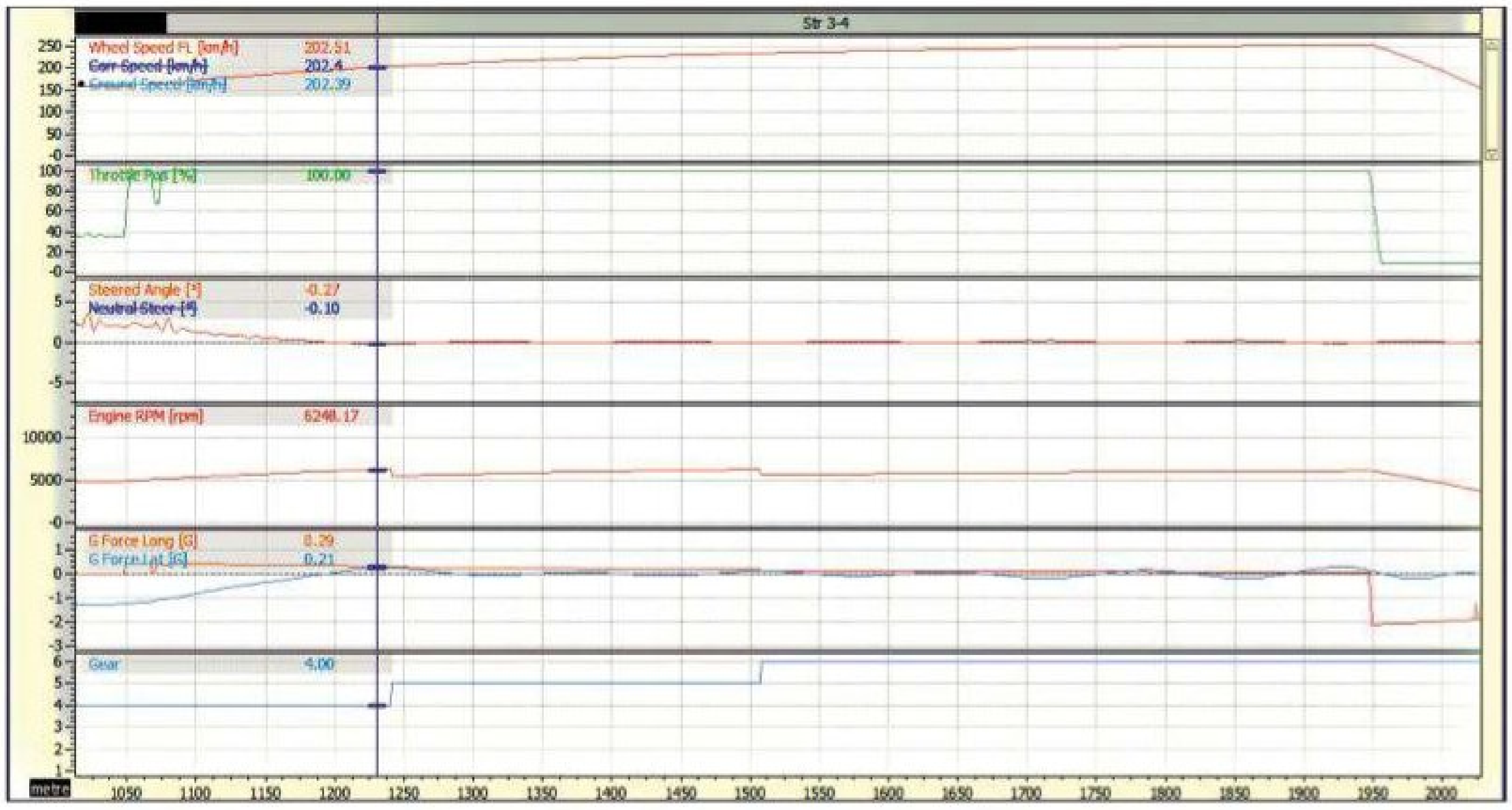


**Figure 2: required channels for engine curve calculation**

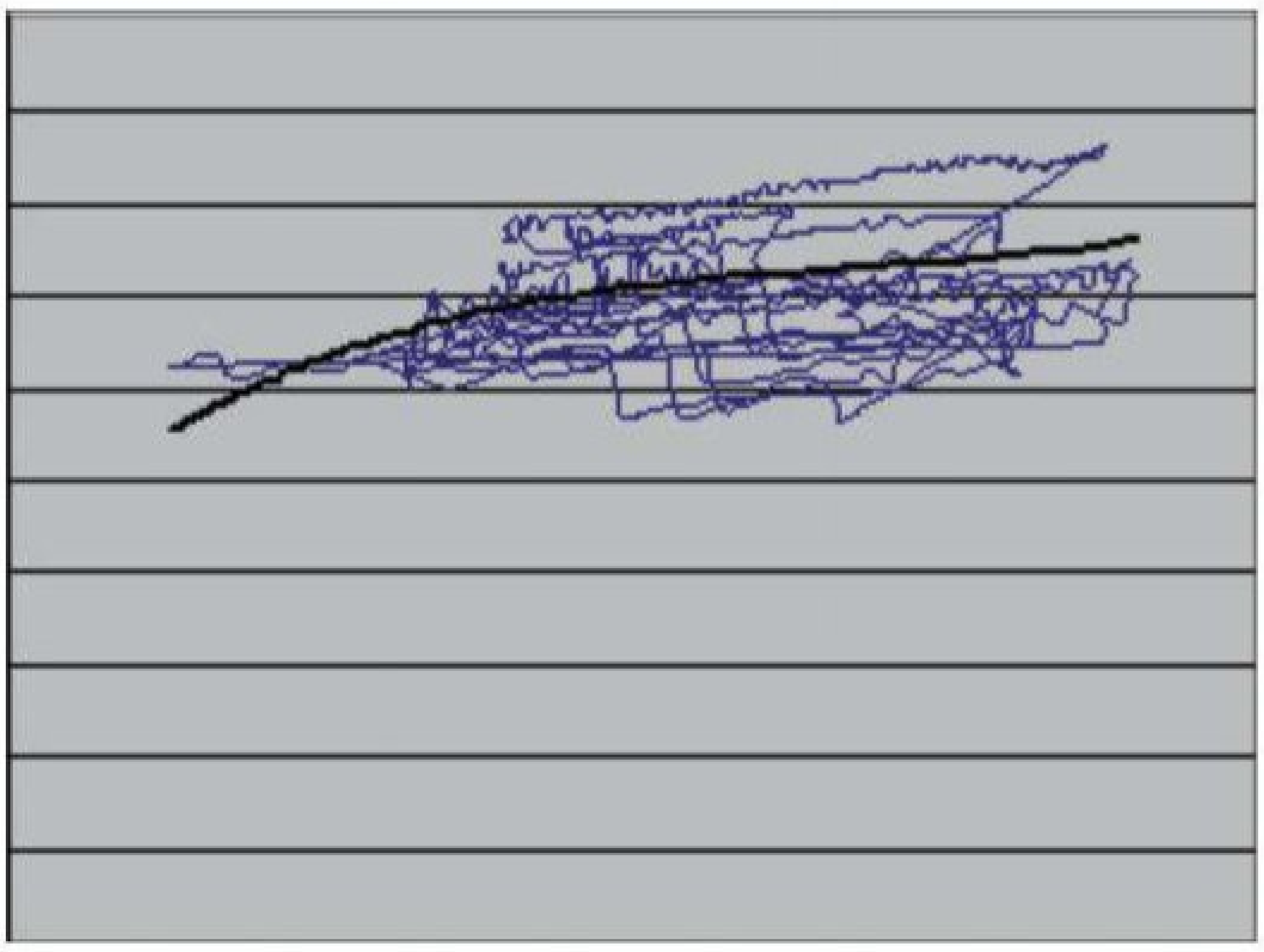


**Figure 3: engine power curve from race data**

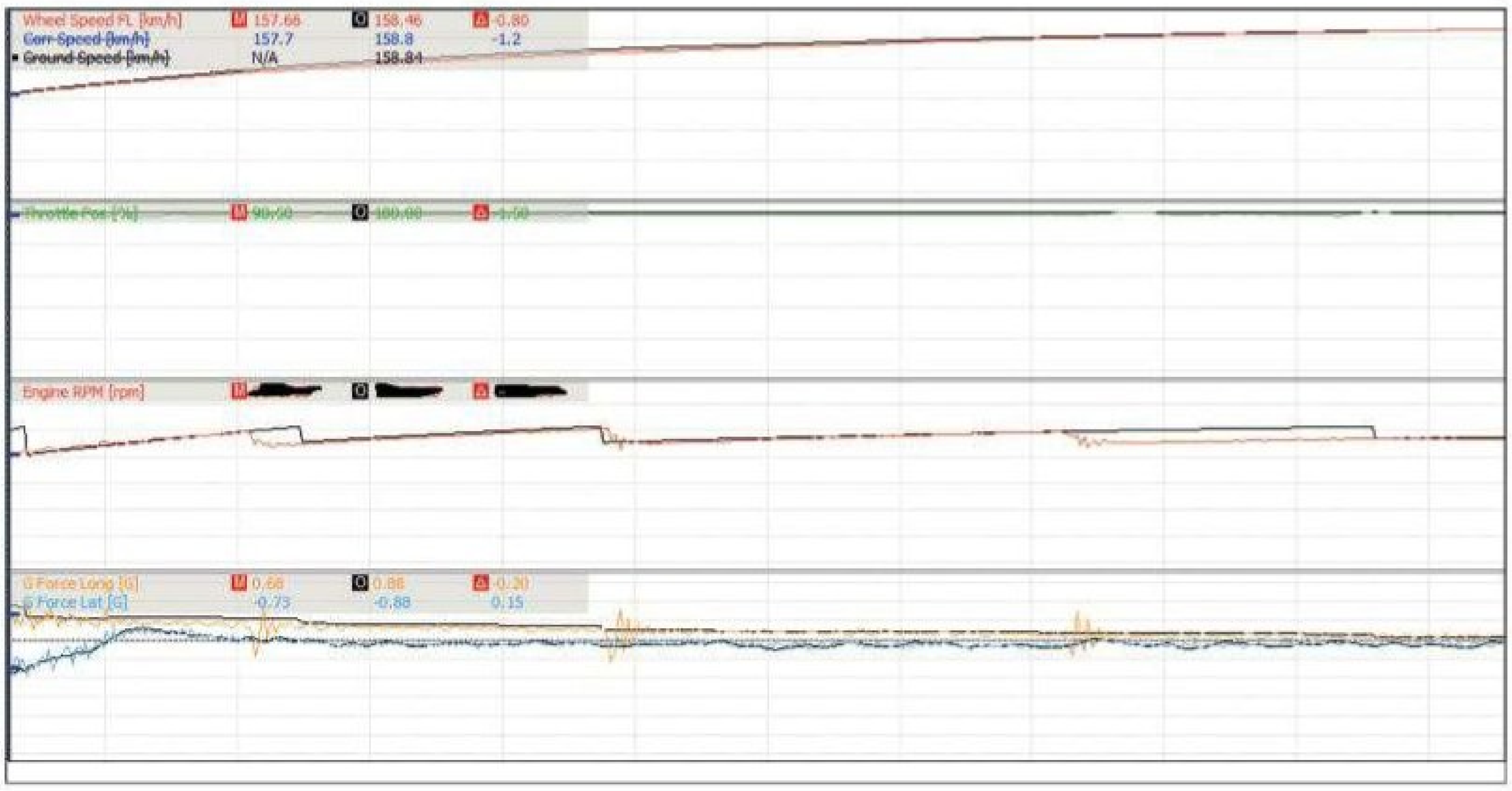


**Figure 4: example of simulated vs actual data using a race data-generated power curve**

So all we need to do now is convert each individual bit of data (speed and acceleration) into SI units, for which you can easily create a column. Then you need to create a new column with this formula and you are done. If you are feeling brave, you can put a column next to it and convert this into either kW or bhp.

Before I discuss results, let me briefly cover what we have discussed here. You'll notice I haven't included rolling resistance drag in equation 2. I have done this for two reasons. Firstly, as a rough rule of thumb, aero drag usually dominates everything. I've only dealt with a couple of racecars where rolling drag has had a significant effect. The second reason is for simplicity. Yes, you can add rolling drag into equation 2, the only drawback being you need pushrod loads to determine the rolling drag. The important thing is I want you to do this, which is why I'm keeping it simple.

When you have done this, you plot rpm vs torque and engine power and do a curve fit. It will look something like figure 3.

First things first, my apologies for blanking out the data, but unfortunately, the specifics are confidential. However, what it does illustrate is that you can get some very clear and discernable trends from race data.

One point I haven't touched on is how we deal with a ride height sensitive aero map. Believe it or not, it's actually not all that difficult. You need to export dampers and wheel loads. If you have them, you need to know the look-up table of drag for front and rear ride height. The only challenge is you'll need to do this with either a Visual basic, Matlab or Maple script. This is now well beyond what you can do with a maths channel.

### THEORY INTO PRACTICE

But how does this stack up in real life? To see, a sample ChassisSim simulation is shown with the power curve generated in figure 3. While this isn't perfect, the acceleration is very close and the speeds are within a km/h. Again, because this is live data I've had to remove all the scales. What is abundantly clear, though, is that you have something you can start using to think about gear ratios and use for sensible vehicle performance analysis. I think you can also see we have obtained quite a bit of data on what the car is doing. We can also see that this is a very effective work around when we don't have engine data.

> **"Something you can start using to think about gear ratios"**

In closing then, calculating an engine curve from nothing isn't hard. All we need is some rough idea of maximum power, some good data and the appropriate channels and we are well on our way. While this is not perfect – and I don't claim that it is – this technique will get you a significant way down the road so you have a usable engine curve you can use to engineer the car. Also, the beauty of what we have discussed is that you can make it as simple or as complicated as you like. It also provides a valuable tool that you can put in your analytical tool set.

# From small acorns...

## HRT and Marussia missed the final F1 pre-season test, but now look to be competent performers in 2012


The April edition of *Racecar Engineering* featured the new-for-2012 grand prix cars, with the exception of two that, as the issue closed for press, had yet to appear. HRT and Marussia both failed to prepare their new types in time for final winter tests at Barcelona and, as a result, were limited to just 100km of running on hard 'demo' tyres before arriving at Albert Park for the Australian Grand Prix.

Marussia had hoped to make it to Barcelona but, shortly before the team was due to leave for Spain, the MR01 failed one of its crash tests. Under a new regulation introduced at the start of the season, all cars must be fully homologated before doing any official running, and that failure left the Russian-badged car unable to take part.

### MCLAREN PARTNERSHIP

After some modifications, the car passed its tests and managed a low key roll out at Silverstone. Immediately noticeable was the fact that the MR01 does not feature the nose hump found on every other 2012 F1 car, apart from the McLaren. Perhaps this is no surprise, though, as part way through last season the team signed a technology partnership with McLaren. This has resulted not only in a low nose but also the use of the McLaren transmission, which features a composite front case and a titanium rear. Using this casing limits the team to using the McLaren inboard rear suspension pick-up points and means the car has pullrod-actuated dampers, whereas the 2011 car, which utilised the Xtrac 1044 transmission, had a pushrod rear

**BY SAM COLLINS**

suspension layout.

The Marussia continues to use the Cosworth CA 2.4-litre V8, which is thought to produce approximately 733bhp. It does not, however, feature an energy recovery system, putting it at a disadvantage compared to its rival, Caterham.

Beyond the nose of the car, it is fairly conventional, with one of the few notable elements of the design being the upper side impact structures sat slightly forward of the sidepod ducts. These are similar in concept to those of the Lotus E20.

This generally conventional approach has rewarded the team with a very reliable car straight out of the box and, as *Racecar Engineering* closed for press, that meant the lucrative 10th place in the Constructors' Championship.

However, once Caterham iron out all of the gremlins in its more advanced CT-01, it is likely to out perform Marussia on track.


**"a very reliable car straight out of the box"**


**Neither the Marussia MR01 (above) or the HRT F112 (left) are ground-breaking racecars, but with both chassis using proven components from the likes of Cosworth, McLaren and Williams F1 they should be able to put in respectable showings this year. The lack of KERS on either car is an indication of budgetry constraints, but there's no doubt the season ahead will prove an interesting one for both teams**

The other team that failed to make its debut in the last official pre-season test was HRT, but that has become customary for the team, which has never undertaken any testing ahead of the first race of the season. In reality, the F112 had a short shakedown run at Barcelona after the official testing had concluded, but the team's second chassis arrived in Australia incomplete. This meant the scrutineers had to wait until Friday to put the car through technical inspection. In the end it was academic as, between the two F112s, just 54 laps were completed, all of which were outside the 107 per cent qualifiying time, so neither made it into the race. All that was to change a week later in Malaysia, though, with both cars starting the race and one of them running as high as 10th at one point.

Like the MR01, the F112 is a fairly conventional car. The chassis is a development of the F111, itself a lightly updated Dallara F110. With some of the update work carried out by Oxford, England-based Dash CAE, the car retains the Cosworth CA engine used in the F111 but now mated to the tiny Williams F1 transmission in place of the Xtrac unit used in 2010 and 2011. As with Marussia, this has allowed the team to switch from a pushrod to a pullrod rear suspension. The Spanish team also lacks KERS.

At Melbourne, the car featured a number of upgrades from its Barcelona shakedown run. Immediately noticeable was the updated front wing (the initial wing appeared to be a 2011 item, but with some elements removed).

To see the team undertaking development work is encouraging, but remember in its debut season the only components changed were the fuel tank (because it leaked) and the wing mirrors (because they were illegal after a rule change).

Over the winter, the team has moved into a new headquarters in Spain and many of the team personnel are new. Hopefully, this could see a new lease of life for the tiny organisation.

# Machine age

## McLaren's exclusive deal with tool manufacturer, Mazak, has led to a wealth of detail improvements on the 2012 car


**Below the unusual (for 2012) low nose, the McLaren has a radical new wing, constructed from billet aluminium, skinned with carbon, with ballast pockets**


**Roll hoop is also machined from billet, and passed the crash test with flying colours, so will be pared down even further for the 2013 car**

**Wheel gun jaws are made in titanium to save on weight - not to make the job of the pit crew easier, but to save money on travel. With the wheel guns being shipped several thousand miles around the world over the course of a season, the saving on shipping outweighs the cost of manufacture**

McLaren's MP4-27 has attracted great interest since its launch in early 2012. Winning the first grand prix of the year and securing pole position at the second, it is clearly a strong design, and is the only car on the grid, aside from the back-marking Marussia, to feature a low nose chassis.

Beyond the nose, which is merely a continuation of the design concept of all recent McLarens, visually the car is fairly unremarkable but, as is so often the case, the details hold much of interest.

Recently, the team revealed that it had renewed its exclusive CNC supply deal with machine tool manufacturer, Mazak, which has supplied a number of machines that change the way some components are made.

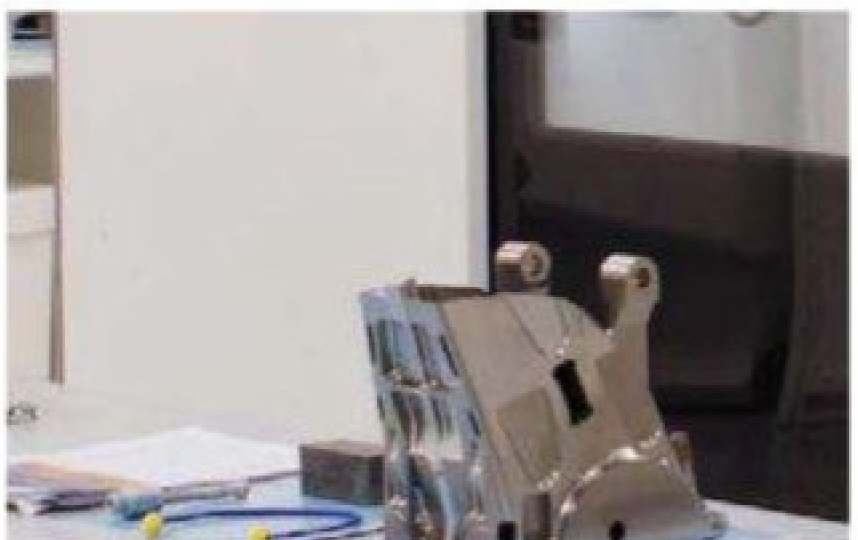
Amongst these is the front wing, which is built rather like a modern aircraft wing, with a highly flexible aluminium central spar, so flexible in fact that it can be twisted with just one hand. The spar is then skinned with carbon fibre to give it stiffness. The spars are machined from a solid 160kg aluminium alloy billet down to the final part which weighs around 2-3kg. Ballast is carried in a pocket between the two front wing supports. This

**BY SAM COLLINS**

is not the first time McLaren has used an aluminium wing. In 2009, the team manufactured a wing entirely from aluminium as it did not have time to skin it with carbon ahead of the Hungarian Grand Prix. It was then filled with tungsten to ensure it was the correct weight!

Also cut from solid billet is the roll structure of the car, which McLaren thought was marginal when it came to passing the pre-season crash tests. However, it passed easily, so the MP4-28 version for 2013 will have even more material removed (a saving of five per cent is targeted), reducing weight at the highest point of the car.

McLaren supplies both Force India and Marussia with gearboxes and, as a result, the manufacture of these is not covered by the Resource Restriction Agreement, but the team can still make savings in this area. Consequently, the advanced machine tools the team uses are used to make some parts more efficiently. The innermost part of the rear crash structure is a good example, as it is made from two halves of machined titanium, as is the rear case of the gearbox (the front is carbon fibre). In the past, the rear case and crash structure used to be mated to each other, so when the car suffered a rear impact the gearbox was written off. Now that is not the case. So for 2012 McLaren will make 24 gearboxes and just 12 crash structures, representing a significant saving. And whilst the RRA may not be in Formula 1 for much longer, a budget cap looks unavoidable, so for every £100,000 saved in the machine shop by working more efficiently, another machinist can be employed.



**Huge savings have been made by halving the number of machined titanium crash structures made**

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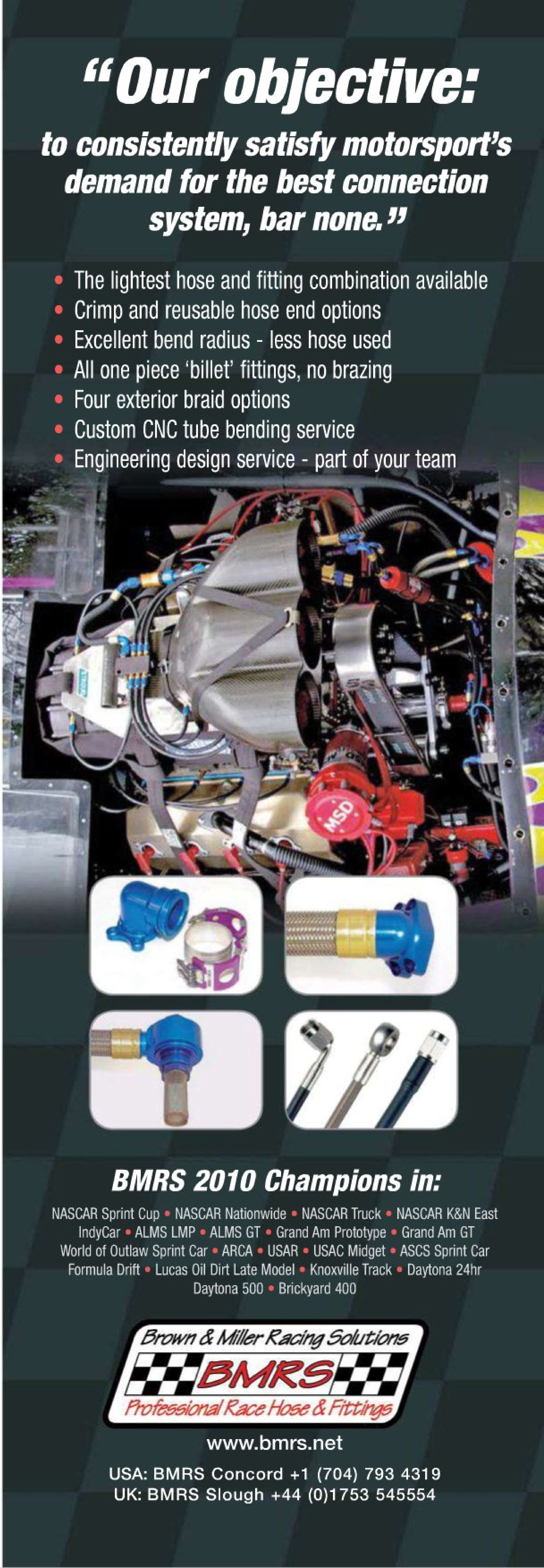

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# Tata signs up as F1 starts to float

Formula One Management (FOM) has moved to ensure it has more control over the future broadcasting of Formula 1 by signing a deal with Indian telecom giant, Tata Communications.

With the world's largest network of under-sea cables, Tata Communications is to install fixed-line connectivity at every Formula 1 venue. Once the technology is in place, this will give FOM the ability to do rights deals through live streaming without any technical restrictions. It will also save FOM a fortune in not having to transport its large broadcast centre around the globe.

Speaking at the London announcement of the deal, Bernie Ecclestone said: 'We've been a little bit asleep with this type of communication, so we decided we ought to wake up. We looked into the market to see who could provide the services we needed, and that's why we've chosen Tata Communications.'

It has emerged that TV figures were down in 2011, amidst talk that the Red Bull dominance of the World Championship was a turn-off for some fans.

FOM, which runs F1 on behalf of rights owner, CVC, has not yet released TV figures for 2011, and would not respond to questions regarding the numbers over the previous year, though a source has told *Racecar Engineering* that they are down by at least 10 million viewers.

While 10m is a relatively small number in terms of the 527m total quoted for 2010, it is significant that FOM is not publicising the numbers, which have previously been released when the figures have increased and announced with much fanfare on the official Formula 1 website.

Yet Bernie Ecclestone has himself suggested that the figures are down, saying, when asked about Sebastian Vettel's 2011 dominance at the announcement of the new deal with Tata: 'It wasn't good. The only person that would say no to that would be Sebastian, but I think everybody else would agree with it.' When asked about the TV ratings, he added, 'I'm surprised we survived with [the TV ratings] we got right at the end.'

The Tata deal is sure to add value to Formula 1, meaning it takes on a further significance in light of the news that Formula 1 may be set to float. The possibility of a flotation on the Singapore stock exchange came to light at the start of the season, and Ecclestone has since admitted he is trying to persuade CVC to go ahead with it.

**"It is understood that CVC provisionally values Formula One at approximately $10 billion"**

Since late 2005, the majority owner of London-based Formula One has been CVC Capital Holdings, a UK-controlled offshore investment fund, but a substantial stake is held by Lehman Brothers, the American bank that has just emerged from Chapter 11 bankruptcy and will make its first payment to creditors next month. The Formula One shares are among a number of assets that will be sold by the administrators as part of this process. It is the Lehman shareholding that is expected to be the subject of an IPO (initial public offering) in Singapore, although CVC might also include some of its 63.4 per cent stake.

After the CVC Capital Partners investment firm, the Lehman estate is the second biggest shareholder in Delta Topco, the Jersey-based holding company of the Formula One group. Its stake of 15.3 per cent, estimated to be worth $1.5 billion, will hardly dent its massive $450bn debt.

Ahead of the IPO, CVC has appointed Goldman Sachs to advise on placing some shares with a new investor. Temasek Holdings, one of the foremost sovereign wealth funds in Singapore, has already been approached, according to unconfirmed reports. Such a deal would help to establish a benchmark valuation of Formula One ahead of the IPO and, later, a full flotation. It is understood that CVC provisionally values Formula One at approximately $10 billion, more than 30 times its net profit.

This year, the group's after-tax profits are expected to exceed $300 million for the first time. This implies a net profit margin of more than 15 per cent, despite the fact that, under the current arrangements, the teams share between them 50 per cent of the underlying profit. Teams also receive 'prize money' from Formula One which, in the year ending 31 December 2010, totalled $658m.

An IPO would create options for the teams to buy into Formula One, but none has so far expressed interest in doing so.

CVC's moves towards an IPO come as it negotiates a new Concorde Agreement with the teams and the FIA, which will set out the commercial arrangements between 2013 and 2020. The buzz in the grand prix paddocks is that, to secure their signatures on the new deal, Ferrari and Red Bull might have been offered shares in Formula One and seats on its board of directors.

**Sebastian Vettel's dominance of the Formula 1 World Championship may have hurt television figures**

# Top brass take pay cuts and overall profits rocket at Williams

**Williams Grand Prix Holdings'** board of directors has seen its overall pay cut by close to £2m as the company has struggled to come to grips with difficult environments on and off the track over the past two years.

The decreases in pay have come to light in the company's recently released financial results for 2011, and it also seems that these cuts have gone some way to increasing the company's profit margin last year. Williams made a headline profit of £7.8m in 2011.

Under the heading of 'Directors' emoluments and compensation', a total salary of £1,175,510 was listed for 2011, which contrasts starkly with £3,004,407 for the year before. The big losers seem to be Frank Williams himself - down from £1,002,581 in 2010 to £229,795 in 2011 - and Patrick Head - down from £503,713 in 2010 to £111,447 in 2011. Both Williams and Head have stepped down from the board over the past year, and it's interesting to note that they also waived their salary entitlements between April and December 2011.

The overall group results show a turnover increase of 14.8 per cent from £91m in 2010 to £104.5m in 2011. The EBIT (earnings before interest and taxes) was £7.6m, up from £6.3m in 2010 (20.6 per cent) while net profit was up 30 per cent, from £6m to £7.8m. However, much of this increase is accounted for in the decrease in the salaries of the board members.

The core business results - its F1-related activities - showed an increase in turnover of 12.7 per cent - from £91m in 2010 to £104.5m in 2011 - and EBIT up by 19.5 per cent from £8.2m to £9.8m. Net profit was £9.6m, up 24.7 per cent on 2010's £7.7m

Just before he left the company, Williams' chairman, Adam Parr, said: 'The Group has enjoyed a strong performance over the last 12 months, in spite of continuing difficulties in the global economy. Our 2011 Annual Report shows strong results and our current cash position is excellent. At 29 February 2012, the Group held net cash of £29.2 million. We can therefore look ahead with confidence.'

Other figures worthy of a second look in the report include an increased turnover for Williams Hybrid Power (WHP), up from £200,000 in 2010 to £2.1m in 2011, although WHP did make an expected loss of £1.9m (loss of £1.1m in 2010) 'due to significant ongoing research and development investments'.

# Historic site to become hub for historics

**The area around** the site of one of one of the most notable events in British history now looks set to become a centre for the historic motorsport community in the country.

Marley Lane Business Park, close to Battle in East Sussex (named for the famous 1066 arrow-fest) is being marketed as a centre of excellence for historic motorsport companies, and the people behind it hope to create a cluster of top-flight businesses in the sector at the site.

**Jaguar specialist, CKL Developments, is behind the initiative to attract more companies involved in historic motorsport to the south east coast of England**

Melvin Floyd, managing director of CKL Developments, the historic racing company behind the initiative, told *Racecar Engineering*, 'We want to develop the site into a historic motorsport techno-park, and try and encourage people directly related to this business on to the site. It's not really about the companies working together, it's more about creating a mini Coventry [the centre of the UK car industry].'

Jaguar specialist, CKL, already trades from one of the buildings, and there is a paint and body shop and vehicle storage - an integral part of the historic scene - already in operation, plus two vacant units and space for six more. The units will be competitively priced, says Floyd: 'It's the going rate for this sort of size of unit, and the actual quality of the units is going to be of a very, very good standard.'

Floyd says that while the concept is new in historic motorsport, the area has always been a hotbed for racing business and, latterly, historic motorsport activity: 'Down in the south east there are probably four or five specialist companies that are all at the top of their game that we work with and we know very well. But when you look back on the history of this area, it's always had this hive of motorsport industry. Maybe it's because we're close to Dover and it's easier to get to Europe.'

## BRIEFLY

### Korea move

The usually reliable *Korea Herald* has reported that the Korean Grand Prix will save more than $20.5m in costs this year, after it reached a deal with FOM. The South Jeolla province government negotiated a deal in which it will no longer pay the annual TV licence fee to FOM - estimated to cost $15.6m - until the end of its contract, while the race commission fee will be cut by 10 per cent. The debt-ridden provincial government has been negotiating with FOM for a year, and is contracted to host the loss-making race until 2016. Last year, the race generated around $23m, but spent around $79m, and the organisers fully expect to lose more than $26m this year.

### PURE power

PURE, the engine maker set up by former BAR boss, Craig Pollock, to supply powerplants to F1 when the new V6 turbo engine formula comes in in 2014, is to move into the Toyota Motorsport facility in Cologne, the base from which the Japanese company's F1 team operated. Pollock says he was attracted by the facilities, and particularly the quality of the test benches. He's also insisted that the PURE engine's development is already so far advanced that it could start competing next year, if the need arose.

### Peru power

Next year's Dakar Rally - the 35th in total, the fifth in South America - will begin in Peru for the first time. The event will start on 5 January in Lima and finish in Santiago, Chile, on 20 January, after a rest day in San Miguel de Tucuman, Argentina. The well known Rally Raid was switched from its traditional Paris - Dakar route in 2009, due to security concerns.

# Rallycross to see mainstream event exposure in USA

**The company behind** US Rallycross, and one of the country's top circuit operators, have teamed up to help build up the popularity of this exciting sport in America.

Global Rallycross Championship (GRC) and Speedway Motorsports Inc (SMI) - which owns and runs eight of the US's top circuits - have announced they are to run Rallycross events at selected NASCAR Sprint Cup and IndyCar race weekends.

The events will take place throughout 2012 at SMI tracks Charlotte Motor Speedway, Texas Motor Speedway, New Hampshire Motor Speedway and Las Vegas Motor Speedway, and the companies hope the inclusion of well-known names such as Ken Block, Tanner Foust and Travis Pastrana will help sell the initiative to the public.

The Global Rallycross Championship enters its second year in 2012 and boasts strong manufacturer support, with Hyundai, Ford and Subaru all committed to the series and fielding factory-supported teams. Top line sponsors such as Puma, Discount Tire, GoPro and Motegi Racing are also involved.


'A high-impact show with a jaw-dropping wow factor.' So says Marcus Smith of SMI

Marcus Smith, president and chief operating operator of SMI, said: 'Speedway Motorsports has always been committed to providing the very best in motorsports entertainment, and the Global Rallycross Championship will be a tremendous complement to several of our NASCAR and IndyCar weekends. It's the ultimate combination of action sports and motorsports where 'big air' meets high speed. These drivers combine racing, drifting and stunt jumps into a high-impact show with a jaw-dropping wow factor.'

Ford Racing director, Jamie Allison, supported the move: 'For Ford, Global Rallycross is an important fan outreach that allows us to connect with new generations of fans by showcasing our exciting new vehicles like Fiesta and Focus in action sports.' He added: 'We applaud Speedway Motorsports and GRC officials for taking this step to move Rallycross to the next level.'

This year's Global Rallycross Championship preliminary schedule is as follows: 26 May (Charlotte Motor Speedway), 9 June (Texas Motor Speedway), 30 June - 1 July (X Games, Los Angeles), 14 July (New Hampshire Motor Speedway), 1 September (venue TBA) and 29 September (Las Vegas Motor Speedway).

# Numbers look good for Audi Formula 1 entry

**The momentum behind** Audi's expected entry into Formula 1 within the next three years continues to build, with exceptionally good sales reported by the company in 2011.

The German prestige car manufacturer's annual results showed that Audi had the largest volume increase in its history last year, with more than 1.3 million cars sold, which increased its revenue to €44.1 billion. That translated into a healthy profit of some €5.3 billion.

The figures make 2011 the most successful year in the company's history and, with experts expecting the car market to grow by four per cent in 2012, the company is looking to build upon its success.

Rupert Stadler, chairman of the board of management at Audi, said: 'Never before have we had such a large increase in deliveries in a single year… We want to continue on this path in 2012 and grow more strongly than the market as a whole.'

Auto Union last competed in Grand Prix racing pre-war

The results come soon after Wolfgang Dürheimer, the CEO of Bugatti and Bentley and Volkswagen Group's motorsport representative, made it clear to the German press that one of the group brands would be racing in Formula 1. While it has not been said that this brand will be Audi, there are a number of indications that this might be the case.

Firstly, of the 10 brands Volkswagen Group owns, the only one with a product range that could take on the four brands currently on the F1 grid in various forms (Renault - as engine supplier - Ferrari, McLaren and Mercedes) is Audi. It also has a range of vehicles that is wide enough to cover all the bases should another manufacturer enter the fray.

Also, Porsche is to return to Le Mans and the World Endurance Championship in 2014 and, while there has been some talk that the two companies could go head to head for a year, during the 2010 Paris Motor Show Porsche chairman, Matthias Müller, made it clear that either Porsche or Audi would compete at Le Mans, while the other would go to Formula 1.

It is thought that Audi will enter the open-wheel series as an engine supplier to begin with, probably in 2014 at the very earliest, before buying out an existing team for 2018. With Red Bull's existing sponsorship links to VWG (with Audi in DTM and SEAT in WTCC, plus a rumoured switch from Citroën to VW in WRC next year) it is thought that Toro Rosso - which is widely believed to be up for sale and is already in partnership with VW as its road car supplier - is a likely candidate.

# Office Depot scoops sponsor award

**Office Depot has** been awarded the 2011 NASCAR Driving Business Award, an accolade that is presented annually to the official NASCAR partner that demonstrates extraordinary leadership and results through its participation in the NASCAR Fuel for Business (NFFB) Council.


**It's more than just having the name seen by fans, sponsorship offers lucrative business opportunties, too**

The award was bestowed upon NASCAR's official office supply partner at a ceremony in Las Vegas. The NFFB Council is a programme that brings together an exclusive group of more than 50 official NASCAR partners to get more out of their sponsorship, namely by bringing them together four times a year to buy and sell products and services. This environment is said to offer the unique opportunity for companies to save time and construct customised deals to help address specific business needs.

Since the NFFB Council's inception in 2004, it has facilitated hundreds of millions of dollars in annual revenue and savings to its participating members. For example, Ford, which was last year's recipient of the Driving Business Award, has sold more than 20,000 vehicles through the Council.

Office Depot, which is also a sponsor of reigning NASCAR Sprint Cup Series champion, Tony Stewart, and the no 14 Office Depot / Mobil 1 Chevrolet, was given the award in recognition of its successful performance on the NFFB Council in 2011.

But the company has a long history of driving business through its NASCAR partnership and has been an official partner since 2005. Through the NFFB Council, Office Depot has secured new business accounts with Chevrolet, Ford, the National Corn Growers' Association, Getty Images and NASCAR RV Resorts.

'Office Depot is honoured to be this year's recipient of NASCAR's Driving Business Award,' said Kevin Peters, president of North America for Office Depot. 'Our sponsorship in NASCAR and active involvement with the NFFB Council provides Office Depot with strong B2B opportunities because sponsors within the sport want to do business with each other. And we've also been able to deepen relationships with many of our customers by bringing them to NASCAR races. The sponsorship has proven to be a great business-building tool for Office Depot over the years.'

## BRIEFLY

### Aero centre

Hidden amongst the 'granny tax' and 5p on a pint in the recent UK Budget statement was the rather more welcome news that the government is to invest in a £60m UK centre for aerodynamic design. 'The centre will support innovation in aerospace technology, commercialise new ideas and spin-off technologies and wider applications in other sectors.'

### Spanish flyers

The Formula 1 event promoters in the Spanish cities of Barcelona and Valencia have agreed in principle to alternate their grands prix, starting in 2013, according to Bernie Ecclestone. Both have admitted they are struggling to pay the annual fees charged by Formula 1 at a time when the world economic situation is hitting their nation hard.

## MINI INTERVIEW - Wolfgang Dürheimer

**In 2014, you will have Porsche and Audi against each other at Le Mans. What are the rules?**

In the group? There are basically no rules. It is fair play as usual when you are playing your colleague, and the better will win.

**Is it a rule that they come with different drive solutions, so Audi will stay with diesel and Porsche with petrol?**

This is an opportunity, because both technologies will be explored to the limit, and both are extremely important for the group. On one side the petrol, the other side the diesel, and to push both to the limit is good, and it is also good for potential competitors. No matter what they choose for their racing propulsion, they will have a strong competitor from our group.

**Is there a time limit on the two brands competing against each other?**

No. There are no limits, but there are a lot of series around the world, in different continents, that give opportunities for other racing activities other than in Le Mans. It will be interesting to see both companies racing against each other in Le Mans, but I personally don't think it will be a long time that they are doing it. It is not decided who will be the one to leave.

**Are you worried budgets will run out of control?**

They will not run out of control if the manufacturers that prepare the cars walk through the work with open eyes, and find the right connections. It is affordable.

**What about the budgets for a major manufacturer programme in 2014?**

To compete in Le Mans you can do it with 50 million [Euro], and a World Championship would double that. I think that the guys in the ACO will at the right time interfere and get it under control as Formula 1 does it.

In comparison to three years ago, there are remarkable changes [in Formula 1]. It doesn't happen in five or six months, but in the long-term view you can see the budgets of Formula 1 dramatically coming down. By forcing the engines and gearboxes to run for a couple of races releases a tremendous amount of very good engine guys who are on the market all of a sudden.

**Would the lower cost put Formula 1 back into Volkswagen Group's thinking?**

I personally like the idea for the VW Group, with its many brands, to have one in Formula 1. In Europe and Asia, it is still the most important racing series and there is no balance of performance. It is open for everyone, and you can give it your best shot and see how good you are. This is what I like from a motorsport point of view, and I am working on this idea.

**So are you encouraging one brand to take up Formula 1?**

Yes.

**Will you reveal which one?**

No.

## PEELING BACK THE STICKERS No1: MICROSOFT DYNAMICS

**Lotus certainly** made the Formula 1 and business world sit up and take notice at the start of the F1 season with the announcement that it had landed a sponsorship deal with Microsoft. The deal, which is for three years, sees the computer software giant's logo – or more specifically that of its Microsoft Dynamics arm – grace the upper bodywork of the E20 racecar.

Neither Lotus nor Microsoft would be drawn on whether this is just a supply deal, a Lotus spokesperson telling *Racecar Engineering* that it will not release financial details of its sponsorship arrangements. But it is significant that the original release states: 'As *part* of the partnership, Microsoft Dynamics solutions, which are designed to enable organisations to be more agile and globally competitive in today's business environment, will be implemented at [the] Lotus F1 Team base to facilitate the team's business transformation. For the duration of the agreement, Microsoft personnel will work directly with Lotus F1 Team to transform and optimise operations towards a world class facility.'

The word to note here is 'part', suggesting that there's more to this than just a swap of expertise and services for exposure on the car, driver overalls and team uniforms. That said, it is certainly offers a chance to highlight the capabilities of the company within the ever-changing environment of F1 that is exciting Microsoft Dynamics. Christian Pedersen, general manager, Microsoft Dynamics ERP product marketing, said: 'This is a sport where every single thousandth of a second counts. Even the smallest parts of a car go through constant enhancements in design, aerodynamic optimisation and structural strengthening. Thousands of evolutionary designs are created during the racing season based on terabytes of logged data, wind tunnel tests, and computerised simulations running on cutting-edge super computers. Bringing out innovations faster and better than competitors creates an intense sense of urgency in the organisation, where a process from design conceptualisation, procurement, manufacturing, testing and deployment to the car is often counted in days and is critical to the success of the team on the track.

'Managing a time sensitive operation like Lotus F1 requires that the people in the organisation are equipped with the right set of tools – tools that are powerful, agile and give people the information they need to do their jobs effectively anywhere and on any device.'


While it's not known how much Microsoft is spending, it is worth noting that Hewlett Packard's similar 2010 sponsorship of the same team – then known as Renault – cost around $1.5m.

Of course, an amount such as that would be a drop in the ocean for a company like Microsoft, which has an income to make even an F1 budget look like small change. It recently announced a staggering revenue of $20.89 billion for the quarter ending December 2011. Microsoft Dynamics is a part of Microsoft's Business Division.

# Dallara's US aero programme takes flight

**Dallara is involved** in a project to make pilotless aircraft decoys for the US military, while it has also revealed it will be building an alternative IndyCar aero kit for a single organisation in 2013.

The Italian company is making parts for the US Miniature Air-Launched Decoy (MALD) project, which is an aircraft that duplicates the combat flight patterns and electronic signatures of American war planes.

Dallara, which is working with Raytheon on the project, will bring its racecar design expertise to the table by developing a quick change system for the nose, which will allow users of the MALD greater flexibility in selecting the electronic warfare package they need, and the ability to react quickly to changing situations. The concept is said to be based on the way racecar nose assemblies are designed to be quickly replaced at pitstops.

Meanwhile, Dallara has confirmed it will be making a new alternative aero kit for IndyCar in 2013, but only for one client. For 2012, all the new Dallara DW12-spec cars will be using its own bodywork but, for next year, any engine manufacturer (or other organisation) is allowed to produce their own aero / body kits for the series. Diversity among the cars was one of the original aims for the new formula and this was seen as a way to provide an element of open competition in the series.

Andrea Toso of Dallara has said the company would concentrate on building new cars and providing spares packages for the current aero configuration in 2013, rather than going into competition with other manufacturers with a kit bearing its own name. But he also said that it would be willing to build kits for another company under contract: 'The development of a brand new aero kit is a large investment and Dallara would not be profitable if doing [this] on its own. You have to be humble enough to provide the platform and let them play, though Dallara is interested to provide its engineering resources to develop the aero kit for a third party company that might be looking at this opportunity to promote and activate its own business.'

This has now come to pass, and, while the identity of Dallara's partner has not been revealed, it's thought to be a well-known company not currently involved in the automotive industry.

## CAUGHT

**Chad Knaus,** the crew chief on the no 48 Chevrolet in the NASCAR Sprint Cup, has been fined after the Hendrick Motorsports' car was found to be running with c-posts that did not conform to the regulations. The infractions, which were discovered at the Daytona 500, originally also cost the team 25 points in both the drivers' and owners' championships, but both penalties, plus a six-race suspension for Knaus and car chief, Ron Malec, were overturned after a successful appeal. However, Knaus and Malec have been placed on probation until May.

**FINE: $100,000 (£62,850)**
**PENALTY: probation – May**

# INTERVIEW – SVEN SCHNABL

Team principal and technical director, Sven Schnabl, has been running Porsches for close to 10 years. He has engineered 911s in the Porsche Carrera Cup Germany, Porsche Carrera Cup Asia and Porsche Mobil1 Super Cup. Before that, Schnabl worked on Alfa and Ford Super 2000 Touring Cars, as well as providing technical assistance to the Vitaphone Maserati squad. Schnabl has considerable expertise at the Nürburgring Nordschleife too, with campaigns with an M3 and a 996 RSR, as well as V8STAR and Ford Mondeos under his belt.
In more recent times he has run an Aston Martin, before taking charge of Falken's 997 GT3R in both the VLN and N24 race.

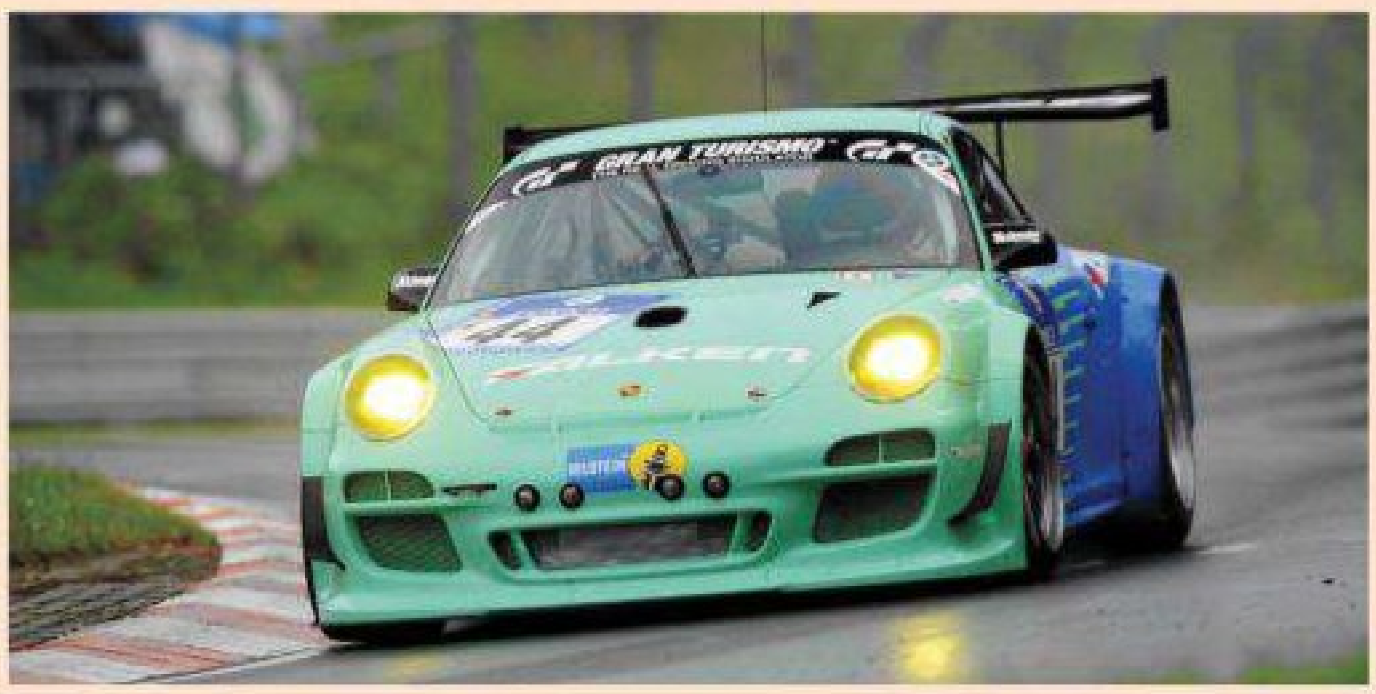
**Q. What changes have you made to the car over the winter?**
First we go over the whole car and service the consumables. This winter, we've changed the fuel pumps and filters, for instance, and serviced the uprights and driveshafts. We have fully rebuilt the engine with some minor upgrades [and] also done the gearbox, upgrading to paddle shift. Chassis-wise, we have a new front anti-roll bar, but that is about it.

**Q. Are these changes part of an upgrade kit from Porsche or are they your own ideas?**
We are not allowed to upgrade anything on the car except the brake pads, dampers and, of course, the tyres. All the other upgrades are courtesy of Porsche. We are going to run different brake pads and most likely dampers at one of the early VLN races as a test. We also will have a number of different tyre constructions and compounds from Falken to work through ahead of the N24 [Nürburgring 24 Hours].

**Q. What will these changes mean to the performance of the car?**
The engine upgrades offer more power and better overall driveability. I think the paddle shift will be a big improvement and will help the drivers avoid mis-shifts. We'll get better control of the front axle thanks to the new anti-roll bar, too. The anti-roll bar has the same outside diameter but a larger inner diameter, so the material is a little thinner and therefore the roll bar is softer.

**Q. Have you made any set up changes for the new Falken tyres in 2012?**
No, not yet, we are still waiting for the tyres. Once we have these we'll be able to refine the set up. We were very surprised how well the tyres worked with the Porsche right from the off. Maybe it was experience from Falken's ALMS campaign with the GT2, but the tyres worked really well from our very first test.

**Q. What do you do to the Porsche for the N24 compared to other races?**
We make very few changes. The car is designed for long distance races so we don't even have to lower the rev limit. The car runs the same spec as it has in all the other races before. We simply install additional lights, as well as the illuminated number panels, and try to ensure we have fresh parts for those that are lifed.



**Rare breed – the Porsche 997 GT3R, a racecar with no known weaknesses**

**Q. How many hours before the engine needs a rebuild?**
30 hours.

**Q. What chassis set up is needed for the Nordschleife? And how does it differ from other tracks?**
We tend to go softer to cope with all the bumps and jumps. We also have increased suspension travel compared to when we run on grand prix circuits.

**Q. Can a Porsche win the N24 this year?**
It's a good question. We don't know about the competition and it is such a long race. Personally, I think there is a chance for a podium, maybe more. If, and I mean *if*, everything goes well.

**Q. What are the strong points of the Porsche compared to its N24 competitors? And are there any weaknesses?**
The Porsche car is so reliable. We know the track and we know the car so experience is one of the biggest advantages. With a good balance of performance package and a good tyre from Falken, we are in a strong position. As for weaknesses, there are none that I know of.

**Q. What is required to win the Nürburgring 24 Hours?**
Well, it's obvious; first you have to finish! Then you need good drivers, a good team, good tyres, good strategy, a good car – and lots of luck!

# OBITUARY – TED CUTTING

**Former Aston Martin** designer, Ted Cutting, has died at the age of 85. Cutting, who will be best remembered for designing the Le Mans 24 Hour-winning Aston Martin DBR1, began his career in racing at Sydney Allard's team in the late '40s, after a spell in the Fleet Air Arm, before leaving to join Aston in 1949.

Once he had worked his way up through the ranks and into the design team, he initially worked alongside former Auto Union designer, Robert Eberan-Eberhorst, before becoming chief designer in 1955.

His first design for the company was the legendary DBR1, Aston's first tubular spaceframe chassis, for which he was responsible for just about every part, including chassis and the famously beautiful body.

Cutting also designed the 1957 DBR2, the 1959/'60 DBR4 and DBR5 grand prix cars, plus the Project 212, 214 and 215 coupés. But when Aston dropped its race programme in 1963, he left to join Ford, where he worked until the end of his career. In retirement, he lectured in motor engineering and kept a close interest in both Aston Martin and Ford.

**Ted Cutting 1926-2012**

**Cutting's glorious DBR1 was the company's first tubular spaceframe racecar**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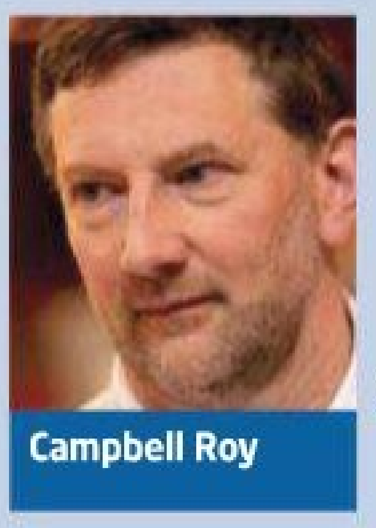
## RACE MOVES

**Jost Capito** has moved from the Ford Motor Company to head up Volkswagen Motorsport, effective 1 May 2012. He takes over from **Kris Nissen,** who will support his successor during the transition phase, and subsequently assist the Group in an advisory capacity. Capito began his career in 1984 as a development engineer for BMW's high-performance engines. He joined Porsche in 1989, first heading the Porsche Carrera Cup Organisation and later all Porsche brand racing championship campaigns. He held executive posts at Sauber Petronas Engineering and was chief operating officer of the Sauber Red Bull Formula 1 team from 1998. He moved to Ford at the end of 2001 where he latterly held responsibility for Ford's global performance vehicle business and for motorsports strategy.


Campbell Roy

LAT

Williams chairman, **Adam Parr**, has left the company. Parr joined Williams as chief executive officer in 2006 and **Frank Williams** recently said he was his natural successor to head the organisation. He has been replaced by former Diageo CFO and Williams non-executive director, **Nick Rose**. Frank Williams will continue to oversee the company.

**Steve White,** the managing director of safety fuel tank company ATL's European arm, will be retiring from the company at the end of May. White, who has been at ATL for 35 years, will be replaced by **Gilles Dawson,** currently ATL's chief designer.


Pedro de la Rosa

LAT

**Jean Marchioni** is now managing director at Lola Cars International. Marchioni is well known within the international motor racing community, having worked as a team manager in a number of formulae including LMP, ChampCar, Grand-Am, Formula Atlantic and Trans-Am.

Lola has confirmed that **John Gobbi**, who has been acting as interim managing director of Lola Composites since the start of the year, has now accepted the position on a permanent basis. Gobbi, a chartered engineer, has previously worked at a number of top technology providers, including Nortel, Partnertech and Bookham Technology.

**Paul Brooks,** senior vice president of NASCAR and president of NASCAR Media Group, is to leave the company in early May to concentrate on a number of outside personal and business interests. However, Brooks – who has been with NASCAR for the past 19 years – will continue as a senior advisor to the company in key areas, including broadcasting, media strategy and innovation.

**Ben Michell** is now principal engineer – race engineering, at Dunlop Motorsport. He moves from his previous post managing the GT tyre development at the company and he will work alongside vehicle dynamics consultancy, OptimumG.

**Claire Williams,** the daughter of Williams F1 team owner, Frank, has joined the board at Williams Grand Prix Holdings as director of marketing and communications. The position became available following the decision of **Dominic Reilly** to leave the company at the end of March.

Respected Swedish rally driving school boss and former driver, **Anders Kullang**, – the man who taught Sebastien Loeb how to left-foot brake – has died at the age of 68. Kullang won the 1980 Swedish Rally and three Swedish national titles in a successful career that stretched from 1970 until 1988.

**Campbell Roy** is no longer with the Mini World Rally Team, which is now called the Prodrive WRC Team. His place as team manager has been filled by **Paul Howarth,** the former Subaru World Rally Team (also a Prodive-run outfit) operations director.

**Pedro de la Rosa** is the new chairman of the Grand Prix Drivers' Association (GPDA), taking the place of **Rubens Barrichello**, who is racing in IndyCar this year after losing his seat at Williams.

Specialist motorsport insurer, Ellis Clowes and Company, has appointed two new members of staff, **Chris Scoble** and **Chris Budd**, who join the firm from Paul Napier Ltd and will work in Ellis Clowes' Professional Indemnity and Directors and Officers Liability division.

# Bernie's 'successor' quits Allsport post

**David Campbell,** the man tipped by many to be Bernie Ecclestone's successor as Formula 1 ringmaster, has quit his post as managing director at Allsport Management.

Campbell took the job at Allsport, the company that deals with Formula 1's sponsorship and corporate hospitality business, in March 2011, replacing long-time Allsport boss and company founder, Paddy McNally. He then joined the Allsport board in July last year.

A former boss of London's O2 Arena, Campbell was chief executive of AEG Europe – a division of worldwide sports and entertainment company, Anshutz Entertainment Group – before his move to F1 was announced in December 2010.

Geneva-based Allsport is controlled by CVC Partners, the private equity firm that has a controlling stake in Formula 1, and it is primarily involved in the sale of trackside advertising. Indeed, Allsport sells the advertising to every grand prix except Monaco. The company also runs the Formula 1 Paddock Club. It was bought by CVC in 2006.


**Allsport is controlled by CVC, who also run the Formula One Paddock Club**

## OBITUARY – ROBERT FEARNALL

**Well known circuit manager** and former motorsport scribe, Robert Fearnall, has died at the age of 59. A lifelong motorsport fan, he was brought up near Oulton Park, although it is with Donington Park that he will forever be associated.

Fearnall first worked in motorsport as a journalist on *Autosport*, where he went on to become its deputy editor before a move to the Silverstone press office – and even a stint as co-driver to James Hunt on the 1973 Tour of Britain, the pair winning the part-rallying, part-racing event in a Camaro.

When Donington was re-opened in 1977 (it had been closed since WW II) Fearnall was installed as its managing director and promoted a range of events at the track through his Two-Four Sports concern.

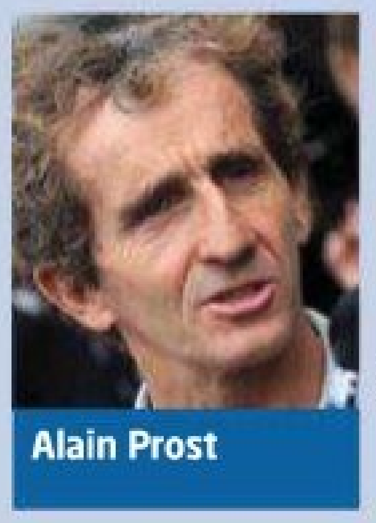
After the failed Simon Gillet attempt to get F1 back to Donington, many of the staff, including Fearnall, lost their jobs, but Kevin Wheatcroft – son of founder, Tom, and current boss – said: 'When I got the keys back on Christmas Eve '09, there was nobody. Everybody had been made redundant. But Robert Fearnall, whose name has been linked with Donington for years, and has been a loyal family friend, was literally sat on the doorstep waiting for me to come back with the keys!'

Fearnall oversaw some notable firsts for the venue, including the DTM's first visit to the UK, and was also in charge at the circuit when Wheatcroft senior's dream came true in 1993 and a Formula 1 grand prix was held at the track. That race will live long in the memories of UK motorsport people, as will Robert Fearnall.

**Robert Fearnall 1952-2012**

## RACE MOVES

**Gemma Mole** is the new championship co-ordinator for the Volkswagen Racing Cup, one of the UK's top one-marque saloon car championships.
Mole started working in motorsport at Brands Hatch in 1999, becoming Motor Sport Vision Racing's competition secretary and administrator in 2007, and later joint co-ordinator of the successful Club MSV Trackday Trophy race series.


Alain Prost

LAT

Four-time F1 world champion, **Alain Prost**, has become a 'brand ambassador' for Renault. It is said he will provide technical input to the company, as well as representing the French motor manufacturer at events. Prost recently won the Trophée Andros ice racing championship at the wheel of a Dacia Lodgy Glace.

**Ken Wolfe**, a crew member in the NASCAR Camping World Truck Series, has been indefinitely suspended from all the US Stock Car governing body's events after violating NASCAR's substance abuse policy.

**Josh Williams** won an Australian talent search to find an apprentice mechanic to finish their apprenticeship with the Tradingpost Racing V8 Supercars squad.

**John Dunlop** has filled the newly created role of director, commercial and marketing, at V8 Supercars Australia. He will lead the organisation's sales, sponsorship and marketing teams and will report to V8 Supercars chief executive officer, **David Malone.** He was previously head of his own sports management agency and has also worked for PGA of Australia.

**David Hewitt,** the operations director at Group Lotus, has joined the Make It In Britain campaign, which has been launched to promote UK manufacturing. The idea of the campaign is to challenge the misconception that 'Britain doesn't build anything anymore', which it says is an outdated view that restricts investment, finance and recruitment into the manufacturing sector.

**Alex Wurz** has returned to the Williams Formula 1 team to become a driver mentor. Wurz will travel to grands prix this year, and will give the relatively inexperienced Williams' drivers, **Pastor Maldonado** and **Bruno Senna**, the benefit of his long Formula 1 experience.

**Moving to a great new job in motorsport and want the world to know about it? Or has your motorsport company recently taken on an exciting new prospect? Then send an email with all the relevant information to Mike Breslin at bresmedia@hotmail.com**

## OBITUARY – SELWYN HAYWARD

**The founder of Colchester** Racing Developments, Selwyn Hayward, has died aged 78. Famous for its Merlyn racecars, the company was a stalwart of the UK motor racing scene throughout the '60s and '70s.

While Hayward initially built front-engined Formula Juniors, the Merlyn name really came to the fore with the arrival of Formula Ford in 1967, and its FF1600 was the chassis of choice for future Formula 1 world champions such as Emerson Fittipaldi and Jody Scheckter.

The Mk11 and 11a Formula Ford, and its Mk20 successor, continue to race to this day, and are competitive propositions in the Historic FF1600 arena.


**Tim Schenken at the wheel of a Merlyn FF1600 in 1968**

**Selwyn Hayward 1933-2012**

## OBITUARY – ALAN MANN


**Whatever Mann touched turned to gold, and red**

**The man behind** those iconic red and gold Ford Touring, Sports and GT cars of the 1960s, Alan Mann, has died at the age of 75 after a long illness.

Alan Mann Racing was one of the top teams of the 1960s, winning world Sportscar manufacturers' titles and European and British Saloon Car titles for the Blue Oval, and running the likes of Jackie Stewart, Graham Hill and Jacky Ickx in its cars.

A quick driver himself, Mann found himself in the role of team manager after starting a racing programme for the Ford dealership he was working at, Andrews of Southwick. Success soon followed and Alan Mann Racing was set up as a Ford team in 1964, the outfit almost winning the Monte Carlo Rally at the very first attempt the same year.

But it was on the circuits where the team really made its name, with Sir John Whitmore and Frank Gardner driving Mann's Escorts and Falcons to victory after victory, while Sportscars were also a happy hunting ground with wins for GT40s and Shelby Cobra Daytona Coupés.

One project for which Mann will always be remembered was the Ford F3L of 1968. This radical machine was powered by the then new Ford-Cosworth DFL Formula 1 engine and, while it proved fast enough to take pole positions, set fastest laps and lead major races, poor reliability prevented it from finishing a single race.

Mann retired from racing when the Ford contract ended in 1969, going on to work in the specialised aviation industry and buying Fairoaks aerodrome in Surrey. He went on to develop the airfield and also create a number of profitable businesses there.

**Alan Mann 1936-2012**

## BRIEFLY

### Formula Renault axed for 2012

The first casualty of the crisis hitting the professional single-seater championships in Europe (see V22N4) has been British Formula Renault, which has announced that it will not be running in 2012 after an extremely disappointing entry of just six drivers, and is now diverting all its efforts into returning the championship to full strength in 2013. The championship has been in slow decline since the introduction of the Barazi-Epsilon chassis in 2010, with an average of just 13 cars on the grid last year.

On a brighter note, the Formula Renault BARC Championship – which makes use of the older Tatuus chassis – has reported it is expecting a bumper grid of close to 20 cars in 2012.

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ELECTRONICS

# MoTeC PDMs

**MoTeC has unveiled** new additions to its range of Power Distribution Modules (PDMs). These provide electronically-switched power to the various systems in the vehicle and offer an alternative to conventional relays, fuses and circuit breakers.

There are several models available with different outputs and connector options. All are compact, robust and lightweight, and all share the same PDM Manager software, which allows a high level of user configurability. The PDM allows circuits to be enabled either by direct input to the PDM, a CAN-generated input or a user-defined condition. Up to 200 logic operations and functions are possible and can be used to selectively turn off systems. Unnecessary fans, lights and wipers during engine cranking. It is also possible to automate a shut-down sequence of ancillaries if battery voltage drops. The units simplify wiring and switch requirements and reduce weight, but one of the most significant benefits is the diagnostics ability.

A range of PDM diagnostic information is available via CAN, including over-current errors, current power draw of connected devices, input pin status, voltage at input / output pins, internal PDM temperature and voltages. An impending failure of a motor or an electronic device is usually preceded by a current draw that is higher or lower than normal, so the monitoring of these channels can be very effective for early detection of a circuit problem before it becomes a major issue.

**See www.motec.com.au for more information**


HARDWARE

# OBP bias valve

**OBP Motorsport** has recently released a new brake bias valve for use on competition vehicles to regulate the front-to-rear brake pressure.

By placing the valve in line to the rear brakes, more pressure is applied to the front to alter the brake balance. The highest pressure reduction available is 60 per cent, allowing for a wide range of adjustment to be made to a racecar's balance. The unit features a lightweight aluminium body with anti-corrosion internals and also includes a pre-set and lock option for rapid adjustment.

**See www.obpltd.com for more information**

HARDWARE

# Viper fittings and filters

**UK-based Viper Performance** has unveiled several new products in its motorsport range of plumbing solutions. First up is a new selection of push-on fittings to enable NBR-lined braided hoses and 200-series hoses to be fitted to conventional hoses. These are said to be ideal for low pressure oil / air / fuel lines and are available in an anodised red / blue finish or a svelte piano black polished finish for a more discreet look. They come in 120, 45, and 90-degree angles, plus a straight connector and are available in all popular AN sizes from -6 to -12.

The second new addition is a range of reusable oil filter units, designed specifically for competition use. The filters are completely re-usable, with a washable stainless steel filter element that can be cleaned and re-used up to ten times. The unique feature with this filter element is that it has a 4000gauss magnet providing 50kg of pull that can attract ferrous swarf under 30 microns and remove them from the re-circulating oil. This is also useful for inspection of swarf, which could have potentially catastrophic consequences for an engine. The oil filter housing is made of solid billet aluminium, satin anodised, with a knurled grip for easy handling, making for quick and easy filter removal without the need of tools.

**See www.viperperformance.co.uk for more information**

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MEASUREMENT

# Mitutoyo micrometer


**Metrology specialist, Mitutoyo,** has announced the release of what it claims to be the world's first micrometer to offer 0.1µm resolution measurement. The unit utilises the company's patent pending absolute rotary sensor, manufactured utilising their own high precision screw machining technology. This sensor reduces instrument error to ±0.5µm to deliver accuracy with no trade off in operability. The system also eliminates the need to re-set the origin each time power is turned on, enabling measurements to be taken immediately upon start up.

In addition, the measurement origin can be pre-set to any value within the display range to reduce set-up time and improve repeatability. The display can be zeroed at any position, making comparison measurement easier.

Display resolution can be switched to 0.5µm if 0.1µm measurement is not required. Additionally, the micrometer supports output to measurement data applications such as MeasurLink, Mitutoyo's proprietary statistical processing and process control programme, which performs statistical analysis and provides real-time display of measurement results for SPC applications.

**See www.mitutoyo.co.uk for more information**

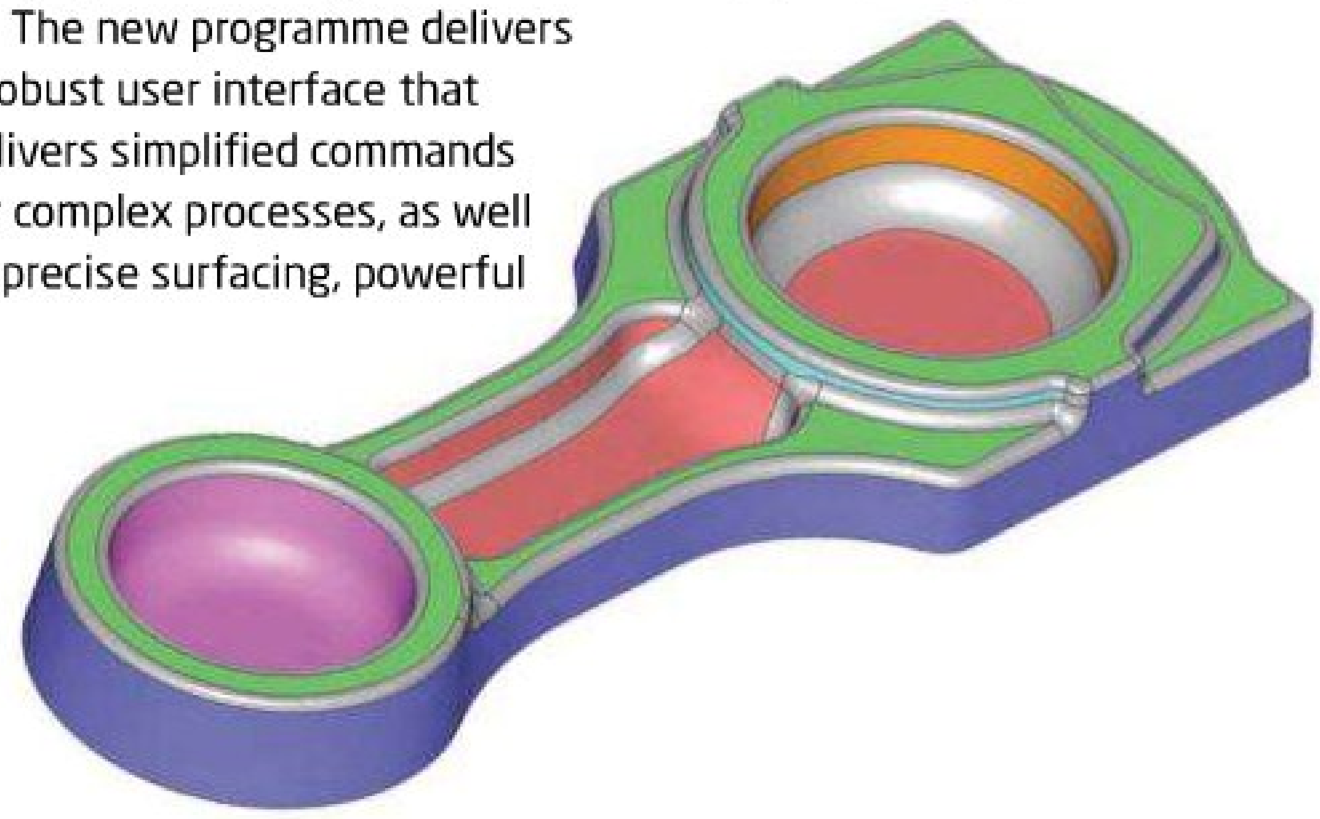
SOFTWARE

# Geomagic reverse engineering solutions

**Geomagic, a developer** of 3D software for creating and inspecting digital models of physical objects, has launched a new version of its Geomagic Studio software system. Geomagic Studio 2012 can transform scans of physical objects into precise 3D models and deliver this data into polygon, surface and CAD models for use directly in reverse engineering, product design, art, rapid prototyping and analysis. The data can also be transferred directly from Geomagic Studio as history-based parametric models into popular MCAD systems.

The new programme delivers a robust user interface that delivers simplified commands for complex processes, as well as precise surfacing, powerful automated point cloud data clean-up and rapid surface repair of models. It has been enhanced to deliver better sketching and patching tools, a new scripting environment for automation of functions at the command level and improved handling and viewing of mid to large-range data. Geomagic Studio supports direct output of 3D parametric data into major MCAD platforms, including Autodesk Inventor, SolidWorks, CATIA and Creo Elements/Pro (formerly Pro/Engineer).

**See www.geomagic.com for more information**



MACHINE TOOLS

# DMG 85FD machining centre

**Machine tool manufacturer,** DMG, has released its new DMU85FD, a compact universal machining centre that is capable of both turning and complex milling operations in a single set up. Maximum table load capacity is 1000kg and maximum workpiece dimensions are 850mm diameter by 590mm. Maximum table rotational speed is up 800rpm, while stability and dynamics in the tandem drive version allow an additional 40rpm in the swivel axis.

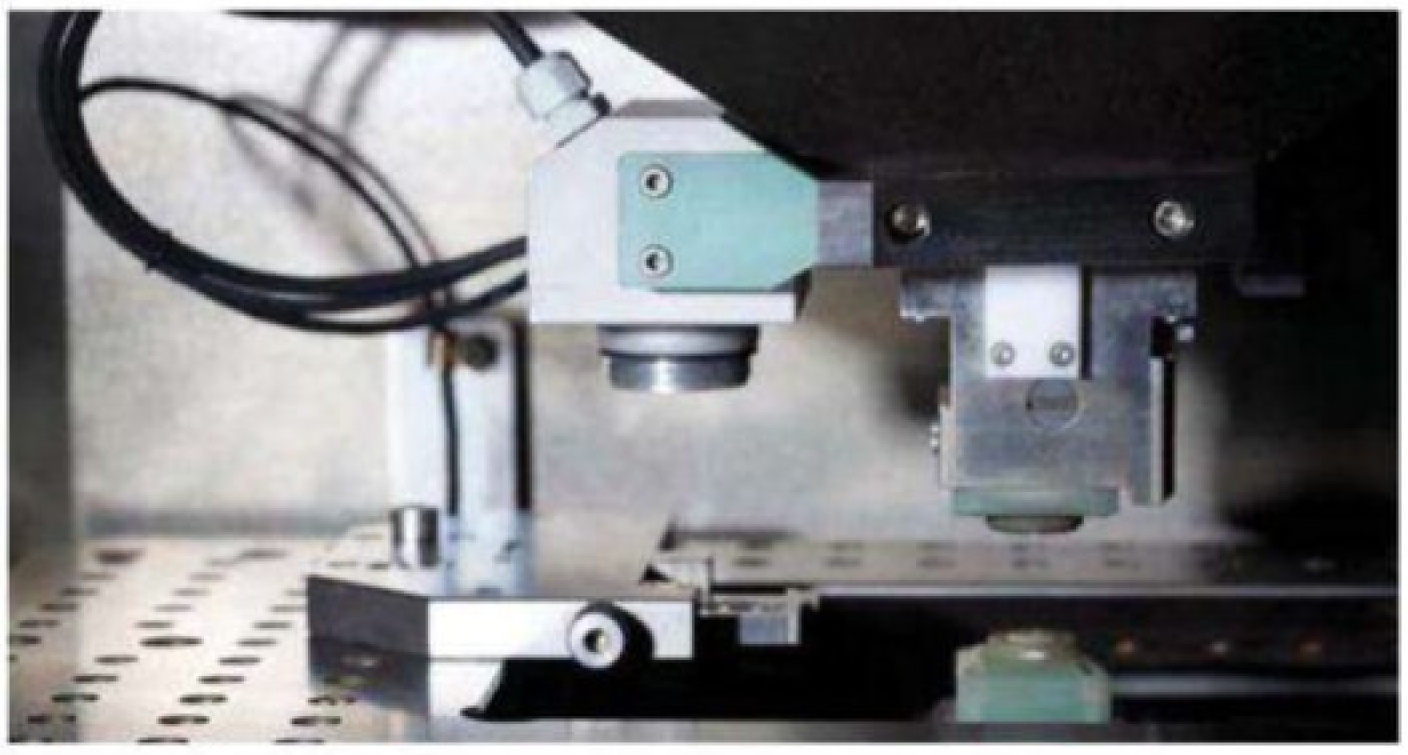
The DMU 85FD has an 18,000rpm, 35kW spindle and an HSK-A63 tool interface. An HSK-H100 spindle option delivers 44kW / 288Nm torque.

The FD also incorporates special mill-turning cycles to facilitate single set up operation. These include automatic checking and correction of imbalances, automatically varied rotational speeds to avoid component vibration and swivelling of long tools into the workpiece. Mill-turning cycles such as piercing, undercutting or multi-blade tool usage are available by default to assist maximum productivity.

**See http://us.dmg.com for more information**

MEASUREMENT

# AgieCharmilles Integrated Vision Unit



**EDM (electronic discharge** machining) machinery specialist, AgieCharmilles, has recently introduced its new Integrated Vision Unit (IVU) to provide optical measurement of EDM-machined details that a 3D probe cannot deliver. With this technology, the company says it is possible to visualise and measure components directly on the machine tool and correct machining errors. EDM is often used for the manufacture of intricate parts with very close tolerances, which the IVU system allows careful measurement of.

The IVU allows for accurate manufacture of highly detailed parts, and tooling for the production of electronic components, to very fine tolerances. The company recommends the IVU to complement its CUT 1000 EDM machine, with the unit allowing for faster and more accurate set up for machining operations, with high accuracy measuring cycles available for edges, part alignment and centring – all to micron accuracy.

The IVU's charge-coupled device (CCD) camera produces clear images, even in less than ideal lighting conditions. Fixed on the machine's upper head and with a backlight installed on the lower head, the camera's autofocus provides images that are analysed by dedicated software to deliver the metrology information required, while also allowing for visual inspection.

**See www.gfac.com for more information**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# Round and around the table

The director of Lotus Motorsport, Claudio Berro, is no stranger to committee meetings. In a recent interview, he told me, 'Every time you have an idea, it goes around the table and, when it comes back to you, it has cost you another million Euros and is completely different to what you originally proposed!'

This, I assume, is what happened to the Global Race Engine – a brilliant idea that was to cater for IndyCar, Formula 3, the WTCC, WRC and even Formula 1 and Le Mans. The engine proposed was a four cylinder, turbocharged unit that could be between 1.6 and 2.0 litres. It fitted with the way manufacturers were thinking – downsizing while maintaining the same power output, or even being faster. The 1.6-litre turbo was the new 2.0-litre hot hatch, and was to be sold as a premium product. It was an idea championed by Audi's chief of motorsport engines, Ulrich Baretzky. His idea went around the table, supported by the VAG and PSA groups, and arrived back as a 1.6-litre V6 for Formula 1, a 2.0-litre six cylinder at Le Mans, a 2.0-litre turbocharged engine for the BTCC and a 2.2-litre V6 for IndyCar. This wasn't cost saving, and it narrowed the market for manufacturers looking for cost-effective racing solutions.

**"it narrowed the market for manufacturers looking for cost-effective racing solutions"**

With these decisions taken, a new plan was hatched for Le Mans. The idea to balance energy carried by a car was simple, and brilliant. It had widespread support among the engineering community, manufacturers and marketing folk, too. Anyone who wanted to run their car on petrol, diesel, rocket fuel or milk would start on a level playing field. There would be no more balance of performance arguments. Diesel would carry the same energy as petrol, bio-ethanol, hybrid or hydrogen. The only regulations would concern safety.

On the back of this, Nissan seriously considered an LMP1 programme, and others were expected to join in. Audi wanted to build a lightweight car, and hoped for a limit of 650kg without a hybrid system. It would have used a smaller engine, used the energy efficiently, and delivered a thermal energy recovery system on which Baretzky and his team have been working for years.

In short, it was the Delta Wing idea, rolled out to any manufacturer who wanted to join in.

While the regulations are yet to be released, at Sebring, the opening round of the World Endurance Championship and the American Le Mans Series, details of the bullet points issued by the ACO started to emerge. The rule makers appear to have bottled their ambition, and instead are heading back down the route of balancing performance, thereby reducing endurance racing to another sustained period of arguments, politicking and, frankly, boredom from the general public.

Engine capacity is to be limited to 5.0 litres, with a minimum weight of 850kg. What? That is not an innovation, that is an invitation to disaster. Such a heavy car would demolish any gains in going to a small capacity engine and, bizarrely, the most efficient way forward would be a large capacity engine.

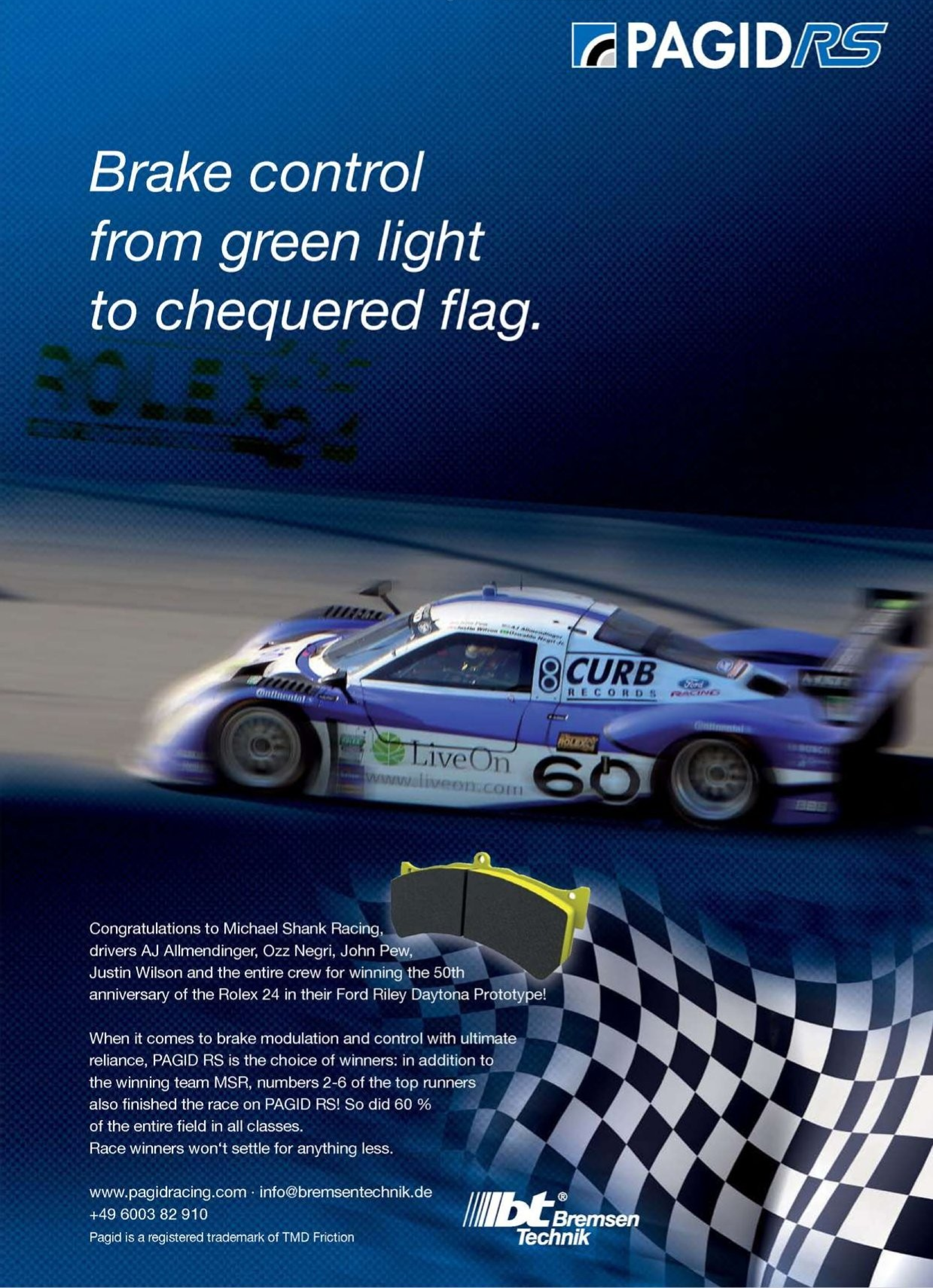
Coupés would be *de rigueur*, although, sensibly, the Germans recommended the field of vision be regulated to ensure drivers can see where they are going. Tyre sizes will be reduced to 14in, but Dunlop and Michelin both had to fight against a plan for a narrow tyre wall. With the downforce generated by the LMP1 cars, they needed a bigger tyre to cope, and the ACO appears to have accepted this plan.

A fuel flow meter will help restrict performance, and new regulations will reduce the amount of energy used over two laps by around 40 per cent. Hybrids will still have an advantage, and I understand there will be three classes – one at 8MJ in which the manufacturers will have to compete, one at 4MJ and one at no megajoules at all, for privateers.

The plan for a GTE Hybrid category appears to have been opposed by major manufacturers, as does a plan to have GT3 cars in place of GT2. That, apparently, sent Corvette into orbit, and its threat to withdraw from the category seems to have been taken seriously.

Meetings were held at Sebring and manufacturers are busy trying to drag the rule writers back to the energy-based formula. The commission, led by Sir Lindsay Owen-Jones, has said publicly that they hope to announce the regulations by Le Mans. A series of meetings are now planned ahead of Le Mans to iron out the problems, and the credibility of Sportscar racing rests in the hands of these committees. Berro may hold his head in his hands.

EDITOR
Andrew Cotton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