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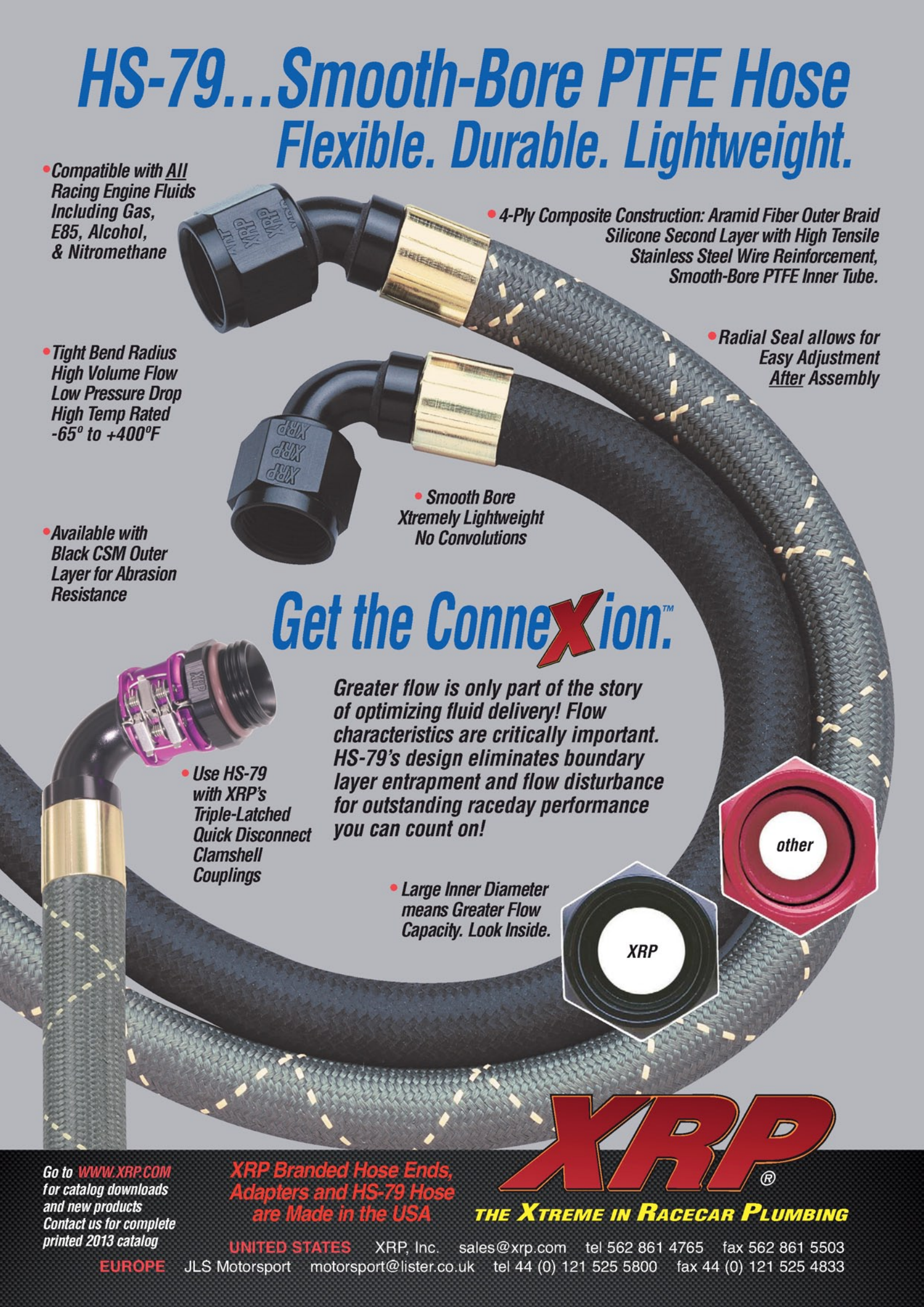

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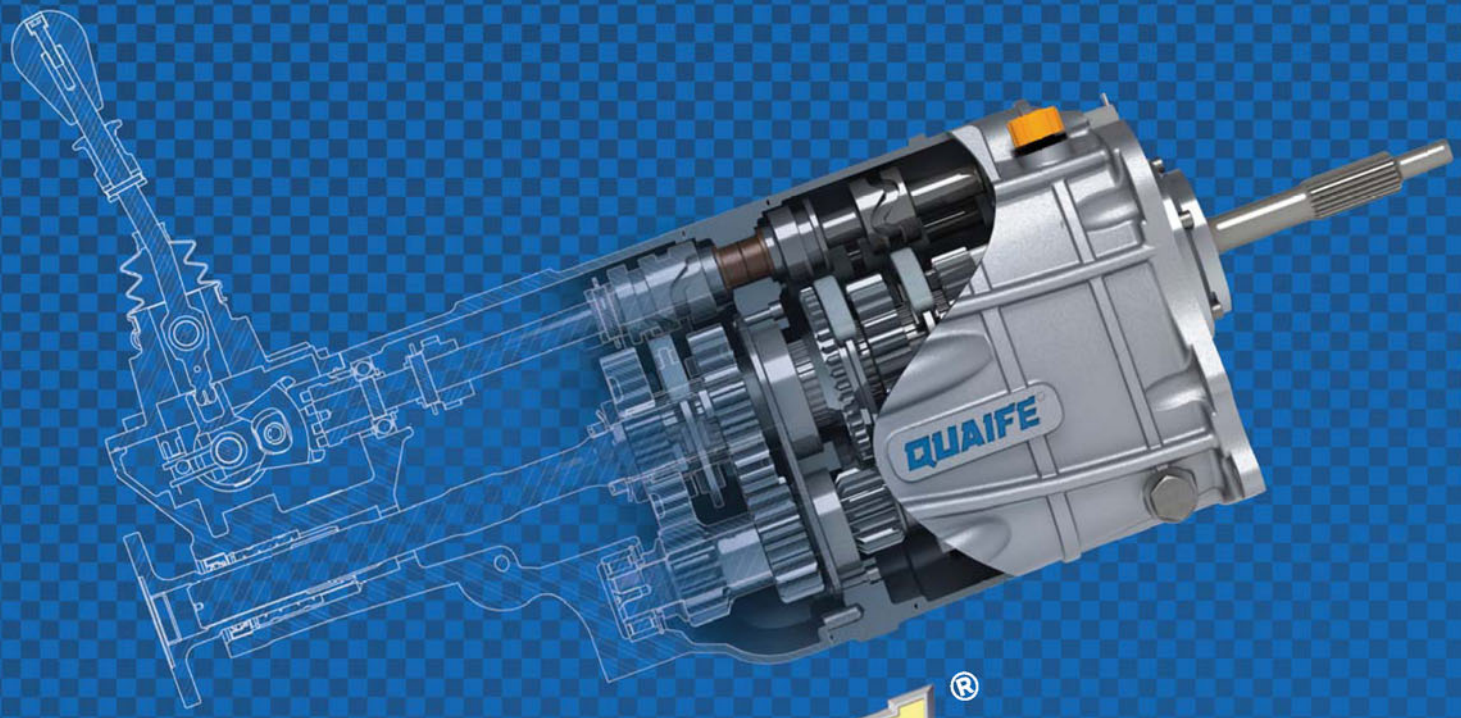

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Handling the driver

Dealing with the car itself is one thing, but then there's the person inside it...

As Shaw said: 'it is dangerous to be sincere, unless you are also stupid.' Wilde, meanwhile, called sincerity fatal.

So here we go fearlessly into the jungle, to discuss talking to drivers, causing widespread outrage in that tribe and I fully expect to brave the backlash.

If you, gentle reader, happen to belong to that afflicted genus, A Racing Driver, you can call the offices of *Racecar Engineering*, whose switchboard has the recorded message: 'After the tone, please leave your IQ or your blood pressure, whichever is higher,' in anticipation of this.

Please state your objection to any comments below by saying 'I beg to differ' and stating why, if you can be that articulate, although one thinks not.

On the other hand drivers usually do not read engineering magazines, being otherwise occupied using Twitter, whose concise 140 character format is still far too big in their limited world view to expand their thoughts, comparing their lap time at track X or discussing the feasibility or not of taking corner Y 'flat', so I may pass unscathed.

No man is a hero to his valet, so drivers tend to be dismissed by engineers as the troglodytes who malevolently and wilfully damage their steeds, and who will come out with another gem to encrust into that magnificent compendium, *The Racing Driver's Book of Excuses*, now up to volume XXVII.

The phrase 'we make them, they break them' is embossed on the escutcheon of every race engineer, on whose heraldic shield (quartered with azure slide rule rampant and tincture gules computer couchant) are found the well-worn phrases 'let me look at the data', 'you want it when?' and the central 'we need more time in the wind tunnel.' The engineer's view of the equivalent heraldic banner for drivers is 'we did dumb first. We do dumb best.'

In the early days of racing, engineers relied upon drivers to tell us what was happening beyond the confines of the pitlane. Their comments and the stopwatch, plus comments from the photographers about the shenanigans they had witnessed on the track, were the tools of the trade, which were scrutinised deeply, as boar's entrails in Roman times, to piece together a dimly lit view of the cars performance.

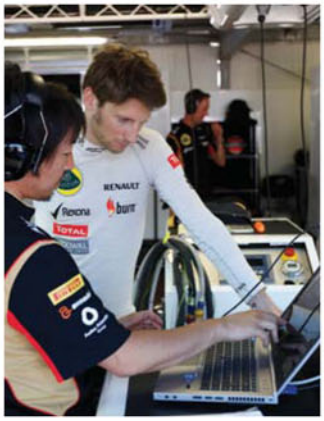
Before the days of data-logging veracity and good analysis by the driver, plus the TV replays, they were priceless nuggets. Some information on reality is useful. The rest was funny when it came out.

Pointing out grass in the rad intakes while driver swears he kept it between the white lines. Querying the driver about bent wishbones, hearing his protestations about taking care of the car until the weekly racing comic came out and had a photo of your car three feet in the air cutting across the kerbs at the chicane.

Even today it is hilarious to counter a driver's rant about the uselessness of 'that piece of shit car' with a calm word in the headphone 'you are on pole' and witness the backpedalling: 'well, it's not so bad. But I did drive my balls off.' And to be even more forbearing and not say 'that's your job, chap'.

It brings to mind the mattress sketch in Monty Python, where some drivers will state 'it's as different as chalk and cheese', when you know you have made a microscopic adjustment to the car, if only to do something, as you have three minutes to the end of the session, no more ideas and the car is still handling like a pregnant sow. Others will mention as an afterthought 'it oversteers a bit', while in the headphones the mechanics bring to your attention the fact that the rack stops are bent.

And they all have their particular bumblebee in the bonnet, or maybe bats in the belfry, which flutter out when they are not on pole. One world champion was an embarrassment to his mechanics, as the inevitable trip to the rig to check the dampers was so regular they eventually would take the dampers off, then lurk behind the Koni truck having a cigarette for the appropriate length of time, coming back to say all was well.



Data logging thankfully reduces the reliance on hiring truthful drivers

Knowing your driver can help unravel this Rosetta stone of meaning, understanding the nuances of words and looks that say 'I ran out of talent' rather than 'I ran out of road'. Mechanics all have their own tales of psy-war techniques, such as clattering spanners at the back of the car, while doing sweet FA, then having the driver go out and post his best time of the day, convinced that the car had improved.

It applies to testing also, where one has witnessed a driver saying, 'It is better' about a favoured mod, even if a tenth faster, while the red face, heavy breathing, popeyed dilated pupils and sweaty balaclava showed the truth in unmistaken body language.

Mechanics would clatter spanners, doing sweet FA, and then the driver would post their best time

To be fair, they can be right sometimes. After having struggled to setup a Lotus 69 F2 for all the sessions at Crystal Palace in the dim mists of the last century, with Emerson Fittipaldi's complaints in full 'jet turbine mode' (high pitch whine), I was astounded to see the green striped yellow projectile come up through the field to win.

As Emmo stopped the car below the podium, he took off his helmet and enthused 'this is the best car I have ever driven, let's do a meticulous set-down – this is how I need it for the next race.'

Strong praise indeed, seldom heard. Normally, driver's comment is more of the order of 'despite the [insert problem here] with the car, only my impressive driving talent, huge guts and unstinting perseverance got me the win.' Only in a less articulate fashion.

Upon standing up, the whole floor of the monocoque unzipped itself, having done most of the race with the dome head rivets ground off by the too low ride height, making the bracing function of said sheet diminish considerably, consequently softening the chassis torsionally, not a bad thing in that bumpy track. It had precariously stayed together as the driver's weight was evenly distributed all over the vestigial rivets.

But the humorous truth is when in the yearly kart race where those frustrated racing drivers, the engineers and mechanics, have it out with other teams, inevitably post-qualifying or race, one hears the time-worn excuses spouting from the erstwhile sneerer's lips: 'I was on the fast lap when I got held up by traffic' or 'he had a better engine/chassis/tyres, I would have creamed him.' Sound familiar?

Indeed all of us have the logical switch on the side of the head that gets flipped to 'off' when we put the helmet on, prior to red-mist mode on the track. But it's only once a year.

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More than just hot air

As tyre technology has evolved, so too has the business machine behind it

There has been a lot of coverage recently about racing tyres, specifically the controversy regarding Pirelli's offerings in F1. All I would comment is that artificial manipulation of any activity to add to its spectator attraction can easily backfire, and I don't believe either Michelin or Bridgestone would have allowed themselves to be pushed into this situation.

So maybe this is a good time to examine the racing tyre business overall in more depth. Not least, why do tyre-makers get involved with motorsport?

Tyres have played a hugely significant part from the very beginning of motor racing, not only due to the necessity for the cars to have something better than artillery wheels on which to run, but because in those pioneering years the resistance to punctures, durability and safety of road car tyres needed proving. What better way to achieve this than by winning motor races with their extremes of conditions and gruelling demands on performance?

Even up to the latter part of the last century, the reliability and long life of road tyres, together with wet road grip, were key points on the list of car owners' buying decisions. Therefore success in F1 and in major events such as Le Mans 24 hours, Indy 500 and Daytona 500 (plus rallies such as Monte Carlo of course) played a large part in advertising the quality and technology behind a tyre maker's regular products.

In the modern world, for the major tyre-manufacturing corporations, it is more about branding, image association and the other marketing-speak benefits. The practical attributes previously mentioned are mostly taken for granted, and something extra is needed to persuade the ordinary motorist away from purchases based mainly on price. Why else would Pirelli be in F1 (it's surely not to demonstrate the durability of its products) and Michelin looking like it wants to return? For the high-performance car market, where the biggest unit profits are to be made, motorsport bragging rights are particularly effective (along with tread styling, would you believe, showing again that perception rules as much as fact for the 21st-century consumer). Nonetheless, current F1 tyres aside, the technical feedback from the racetrack should not be underestimated, and is a legitimate rationale for a major tyre corporation to be in motor racing.

Sometimes a tyre maker will participate to support a car manufacturer that is a particularly important OEM customer, for instance Michelin working exclusively with Alpine (for which read Renault) in this year's ELMS, and Dunlop with Mercedes in the VLN. Worthwhile business synergies exist in these relationships.

Surely, however, the biggest change in racing tyre supply policy among big OEM and aftermarket players in recent years is having subsidiaries operating as a self-supporting business in their own right. There was a time when the dominant players in the tyre world would support their motorsport programmes solely out of the marketing budget, the return via publicity and product endorsement being deemed well worth the expense. However, things moved on and increasingly questions became asked at board level about the real return for the ever-increasing cost of going racing. Not only had the costs of making a much wider range of tyres (road and race) become greater, but the overheads concerning the whole design, development and especially the track support structure had ballooned enormously. A look around the support paddock at any major race event will reveal the commitment needed in manpower, massive trucks and trailers and sheer numbers of tyres on hand to service the teams.

LAT

Branding and image association are key for tyre manufacturers

Consequently, apart from the most prestigious levels typified by F1 and 'special relationships' already mentioned, race tyre departments have had to become commercial in their operation and outlook in order to survive, although retaining access to the invaluable technical resources is of the parent concern. As having tyres fit for purpose is essential, this is another significant addition to their running costs that racing teams have had to accept and work ever-harder to cover. The tyre bill can now sometimes exceed the engine supply charge on the budget spreadsheet. One can argue 'why not?' No part of the package has more effect on performance than those four black round things, so should this be a surprise?

To survive, race tyre departments have had to become commercial in their operation and outlook

The move to a business-based operation has been encouraged by the proliferation of single-make tyre championships at all levels, where competition to be the supplier can be very fierce. Promoters of a championship or series will expect a percentage of the nominated tyre company's 'take' to be paid back to them, and the tyre company can expect to have to pay bonuses and prize money on top. Winning the tender is certainly not a license to print money.

Nonetheless, the number of manufacturers involved indicates that a workable business exists in making and selling racing tyres. Despite formerly famous makes having disappeared from the racing scene altogether, Korean manufacturers Hankook and Kumho have been steadily raising their presence and profile and must eventually be represented at the highest levels of the sport.

Not at all to be overlooked are the 'pure' racing tyre companies which have existed and grown without any road tyre business. The biggest of these independents is surely Hoosier, based in Indianapolis in the USA, which has been going very successfully for many years and offers a huge range of bespoke rubber for all types of competition. In common with most of its race tyre company rivals, it also supplies big demand from off-road , hillclimb, vintage and rallying through to karting and motorbikes and truck racing.

So the business strategies, politics and entrepreneurial spirit as much as technology gains dictate the way in which racing tyres end up fitted to the world's racing cars. It is fortunate that this is so, because without tyres specially developed for them, these sophisticated cars would be going nowhere.

Make do and amend

The Dallara DW12 has been much-maligned, but a reliable engine formula and a string of performance enhancements have added interest – and now aero kits could finally be on the way

BY MARSHALL PRUETT

Chronicling the shortcoming of Dallara's DW12 IndyCar chassis has consumed many pages of *Racecar Engineering* since its testing debut in the summer of 2011, and with two years of hard-fought competition on its CV, an evaluation of its progress is in order.

The prototype Dallara IR12, as it was called before being renamed the DW12, broke cover at the Mid-Ohio road course and was quickly revealed to be an overweight, underwhelming and visually disappointing design-by-committee creation.

Its stated minimum weight of 1380 pounds was off by almost 200 pounds, it failed to meet the low-drag figures it needed to maintain 220mph lap speeds at Indianapolis, and it had a significant handling imbalance that was traced to an excessive rear weight bias.

If one could look beyond the DW12's girth, being slow on the most important oval in the world, and its struggles to react in a timely manner when the steering wheel was turned, the rest of the complaints that were levelled seemed trivial.

The reality of the DW12's limitations was eventually accepted by Dallara, and a host of performance-related improvements were put in motion. Halving the four per cent rearward weight bias was almost achieved by supplying new, swept A-arms. Drag was reduced with bolt-on bits and revised rear wheel guards, and with an increase in turbo boost for qualifying at Indianapolis, the tidal wave of pre-season dissatisfaction was reduced to a series of minor swells.

In Dallara's defence, the svelte car it originally proposed to IndyCar would have met its performance targets, but as continual input from teams and vendors swayed IndyCar's decisions on the final design, cost savings and convenience drove the weight up, and the DW12's potential down.

Despite the tepid response by the world of open-wheel racing, the DW12, with its 2.2-litre turbocharged V6 engine formula, was exceptionally reliable and - to the collective surprise of those who follow the series - produced good racing.

The 2012 season was notable for the hard-fought competition that far exceeded expectations. DNFs were rare, passing increased, and drivers were pushed to their physical limits on the road courses. A worrying start to the DW12's five-year tenure was put to rest by the end its first season and, by 2013, the car's painful birth and subsequent performance issues had largely been forgotten.

The DW12 could have been left untouched through to 2016, but with former team manager Derrick Walker accepting the post of IndyCar president of competition, the Scot enacted a plan that would avoid the stale, spec-minded approach that left the Dallara IR07 in place for nearly a decade.

'The global economy won't allow the kinds of short-term solutions we used to have in the CART days,' said Walker. 'So we just haven't bothered to try doing anything at all, which was the wrong approach, if I'm to be honest. You can't grow a series if you're trotting out the same old stuff year after year, so striking the right balance of keeping the basic DW12 chassis intact and adding elements of variety over time is what we set out to do.

'It's a lot easier to do a series of smaller changes than really big ones. We simply can't afford to have new chassis

IMAGES: LAT PHOTOGRAPHIC

"It's a lot easier to do a series of smaller changes than really big ones – we simply can't afford to have new chassis every year"

The DW12 has overcome its teething problems and is now producing some good racing

every year and rules that are always changing. So, starting in 2015, we'll do the first step by introducing aero kits.'

Custom bodywork has been announced and shelved on two prior occasions, but Walker believes the kits by Chevy (designed by Pratt & Miller) and Honda (done by Wirth Research and HPD) will now go forward without interruption.

The first announcement of introducing aero kits came in 2010 when the new-car concept was presented in Indianapolis, but IndyCar team owners shot it down, citing unnecessary expenditures when the base car would come with perfectly functional bodywork.

IndyCar took another pass at bringing aero kits to bear in 2012, but the same outcome was visited upon the series as the majority of the owners said they would not pay for the kits. Chevy and Honda reacted accordingly, shelving plans, although Chevy has been said to have tested a one-off high-downforce aero kit on its own.

New over-arching IndyCar boss Mark Miles tasked Walker with restoring the allure of record-breaking speeds to the month of May, and from that directive, a nine-year technical development plan was unveiled in June, including a third attempt to kickstart aero kit production.

IndyCar president of operations and competition, Derrick Walker

Significant engine homologation allowances for 2014 – including new heads, new turbo intake plenums, and the required use of larger twin turbos from BorgWarner – should help to push Indy's pole speed above the 230mph mark. Aero kits could make 235mph possible for 2015, and with a jump in power the following year, breaking Arie Luyendyk's 236.986 average from 1996 is conceivable for 2016.

The theme of speed and safety increases should continue from 2017-2018, but the most interesting developments could come in 2019.

Tony Kanaan passes Ryan Hunter-Reay for the lead at the Indy 500 2013

'We're looking at 2019 for opening things up and talking with our engine manufacturers beforehand on what kinds of technologies might be of interest to them,' added Walker. 'It's a long way away from where we stand today, but if we give it enough time, I think we can point things in a positive direction to enhance and embrace more technology.'

Asked if he'd be open to the allowance of hybrid energy systems – a growing trend on and off the racetrack – and the introduction of diesel-powered engines, Walker said he was open to anything to help the series.

'We don't pretend to know about every piece of technology that's coming down the pipeline, or what the world will see in its cars when we get to 2019, so we have to remain open-minded about what the automotive world could be using and what our manufacturers want to demonstrate in the IndyCar Series.

'Are we open to a KERS system? Yes, if the costs aren't too high, and that's the important bit. Would diesels be permitted? Yes, if it can be done in a way that doesn't advantage or disadvantage any one manufacturer. We've seen how hard it is, though, to find parity between the diesels at Le Mans and the non-diesels.

"People are frustrated with this spec car. We all understand why we went down this road, but I think maybe we went too far"

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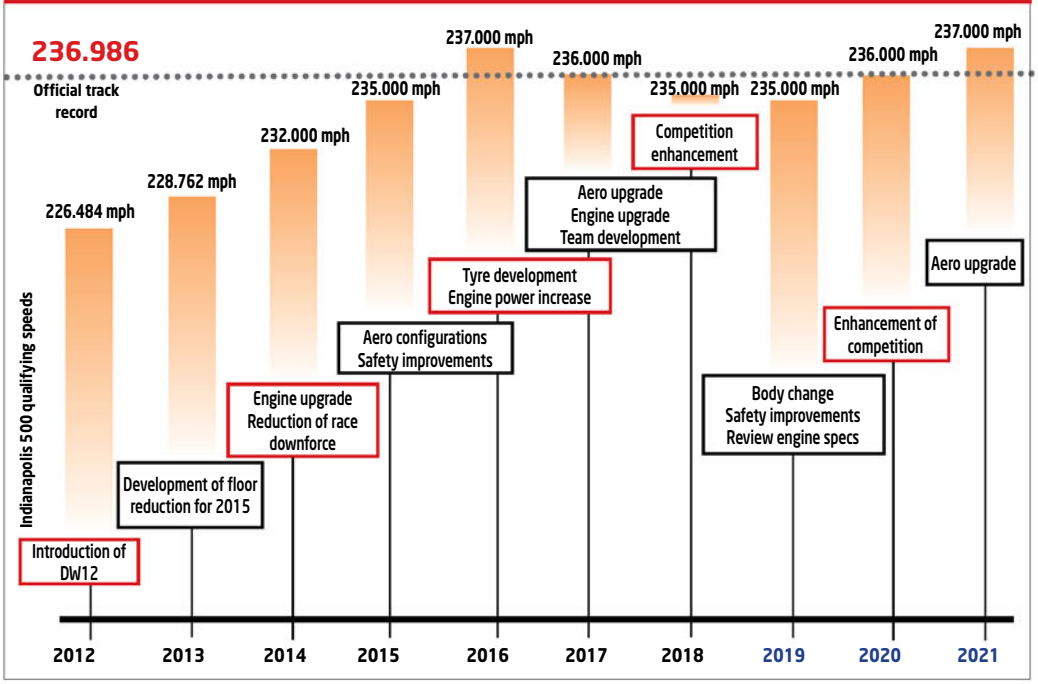

It wouldn't be easy, but we wouldn't avoid trying if asked.'

Walker's comment about the long wait to introduce new and relevant technology to the DW12 package is a concern, and could be revised if called for by its marques.

Asked if he could foresee moving the new-tech date forward, Walker admitted it would have to involve buy-in from multiple parties, including Dallara, before it would be possible.

'What I saw was a need to lay out some benchmark options for the future – some realistic things and some windows of opportunity. Every two years or so the engine manufacturers have a chance to do bigger upgrades than normal, but can we go beyond that and do more if they wanted to? These are options I've expressed to them. There are other aspects of changing the basic parameters – maybe displacement, or similar, and other opportunities on opening technology.

'We're talking with the manufacturers to see what they'd like to do – maybe in addition to what they're currently doing. Part of that line of dialogue is driven by the fact that we're charged with being caretakers of the formula, of giving a view of where we're headed and what might interest the fans. The long-term plan we unveiled was part of an efforts to open discussions there.

'And with the car, some of the same opportunities exist, but with the contracts in mind, we're set more in place with the chassis until it has run its course. We're talking with Dallara, naturally, to see how we could possibly expand some things if that's where our engine manufacturers want to go. Adding systems, for example, if it's a hybrid system, would involve our chassis partner and all the partners involved with the car to implement such a thing.

'Changes and modifications would be involved, so for whatever might happen there it would require all parties to sign off and agree to work together and possibly outside of the current contractual agreement.'

GM Racing director Mark Kent was encouraged by Walker's technology-boosting decree, but tempered his enthusiasm with a call to keep IndyCar's costs in mind as the plan unfolds.

'If you look back, less than 10 years ago we were racing V8s,' he said. 'Today we're racing twin-turbo V6s, direct-injection engines using E85, because it's relevant to the marketplace today. If you look at the timeline that Derrick laid out, I think he's talking about the next serious change out in 2019.

'At that time we'll look at where the industry's going. If we need to go to four-cylinder, we currently have quite a lineup of turbocharged four-cylinders in our production cars. So we've worked with IndyCar and other manufacturers to try to come up with a formula that is relevant for all of us.'

HPD technical director Roger Griffiths also expressed his support for Walker's outline.

'IndyCar has always been about innovation,' he said. 'So many people are frustrated with this spec car. We all understand

"It really helps to know what we're going to be working towards in 2014, 2015 and beyond. That's very refreshing"

Under the skin of the Dallara DW12, changes will ensure higher speed, but that needs to be linked to increased safety too, say teams

why we went down that road but I think maybe we went too far. Development doesn't always have to be expensive. Someone commented recently that I might not have the money to develop everything I want, but if one team does something one weekend I can always copy it the next weekend...

'At the end of the day this is the premier open-wheel racing series in North America, probably second only to Formula 1 in the world. We shouldn't be racing spec cars, we should be doing something innovative. We've got to be mindful of not letting the costs get out of control, but I think it's in an encouraging direction.'

Within the IndyCar paddock, a place known as a hotbed for scepticism, news of Walker's plan was met with a wait-and-see response in many circles, but the act itself – of formalising a path forward – was received in a positive manner.

Ganassi Racing managing director Mike Hull typified the tone in which Walker's message was intended.

'I liked that they have a written-out, organised plan,' he said. 'I support that, and

think the teams and the people that work on the cars should be satisfied with that kind of a segmented, progressive plan. It also helps for planning. It really helps us to know what we're working on in 2014, in 2015 and so forth. That's very refreshing.

'As for where we're going nine years from now, or however long, who knows. I don't know what the future will bring in terms of the formula, but what I like is the fact that we changed cars in 2012 and it meets the current safety standards. It's uprated for the driver and safety. If IndyCar can maintain the pace of safety as the formula goes forward, this speed increase plan is OK. I'd just like to know how they are going to maintain that.

'It's easy to say you're going to do something, but in this case – by moving the speeds closer to 240 at Indy – there will need to be a comprehensive plan for matching those increases with an equal effort to make the drivers safer. I don't know if anybody can say how that will be achieved, so if I had one reservation at this point, it's backing up the safety side of these plans with something concrete that might not be an off-the-shelf solution.'

As the series embarks on its bid to break Luyendyk's qualifying record, its manufacturers are aware they will be asked to make the biggest contribution to the effort. Aero and tyre developments will reduce the burden, but an increase in raw power will be required to find the 9mph leap in lap speed.

'I think we really would rather do it with turning up the boost as opposed to going to a capacity change,' explained Griffiths. 'That can be quite expensive. We know what happened in 2004 when we had to switch from 3.5 litres to 3.0. We know what that cost us – when you have to throw away 50 crankshafts and you've got to throw away other parts of the engine, it's going to get pretty expensive.

'So I think if they need more power then we need to look at doing it without changing major parts of the engine architecture. More power also comes at more expense, so we've got to address all sides of the equation. Doing it with more RPM is prohibitively expensive. Boost is the best starting point. Do they want 25 more HP or do they want 100 more HP? The challenges at 25 are a lot less than that of 100...'

On the topic of new technologies, Kent held true to his belief that financial relevance should govern any decision made by the series.

'General Motors is a leader on innovation so we don't shy away from it,' he explained. 'But we collectively need to be careful that by bringing it in you don't break the economic model or break the competition model. So I know in other venues where they bring it you've seen a tipping of the apple cart such that people without it left. That's the last thing we want to do.

'But if we can work with IndyCar and figure out how to bring some relevant technology in a way that meets everybody's objectives, very similar to the aero kit approach, we'd support that. Hybrids or diesels or whatever is may be, if IndyCar can show that it will help sell cars and increase the value for manufacturers competing in the series, we'd be open to sitting down and exploring whatever they have in mind.'

"More power will also come at more expense, so we've got to ensure that we address all sides of the equation"

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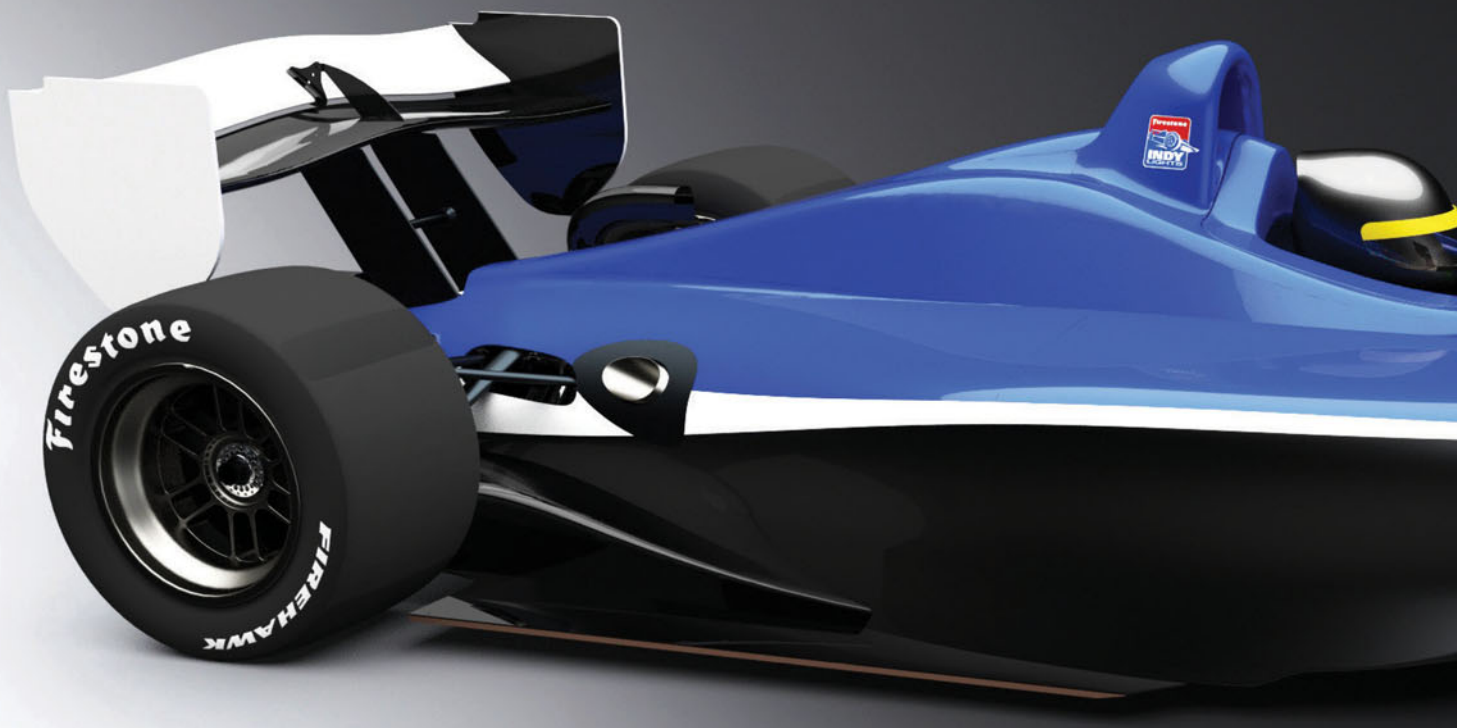
Flash Lights

Battling back following criticism of a long-in-the-tooth chassis and lacklustre grids, the top IndyCar feeder category looks set to welcome a smart new package

BY MARSHALL PRUETT



"Indy Lights needs to have its own identity - we aren't looking for an IndyCar clone"

Just as the IndyCar Series held on to its Dallara IR07 chassis for too long, replacing it at the end of the 2011 season, its Firestone Indy Lights Series has suffered the same fate.

The 2002 Dallara Infiniti Pro Series model, now in its 12th year of service, has stifled interest in IndyCar's top feeder category, leading to single-digit grids this year.

An initiative to introduce a new chassis package for 2014 went as far as receiving proposals from notable suppliers including Dallara, Swift and Mygale, while new submissions from Multimatic (comprised of ex-Lola designers) and Radon (in partnership with Indy 500 winner Gil de Ferran), also came in.

Honda, Mazda and other engine manufacturers also expressed a desire to power the new Lights cars, but with budget cutbacks leaving the project on hold by late 2012, it took IndyCar's decision to hand over control of the series to Dan Andersen and his Andersen Promotions team in July to reignite the new-car project.

Andersen, who promotes and runs USF2000 and Pro Mazda, the first two rungs on the Mazda Road To Indy, completed the three-tier ladder by adding Indy Lights, and promptly hired Tony Cotman to oversee the series' equipment upgrade.

Cotman, for those who remember, was Champ Car's project leader for 2007's Panoz DP01, and again for IndyCar's Dallara DW12, and decided baby steps were in order for Indy Lights' first big move. 'Dan Andersen and I both agreed that you can't wait until 2015 for the new car to arrive and make things better,' he said. 'The impetus is to do all we can right now, for next year, using the current chassis, to get the ball rolling right away. So we asked ourselves what we could do, right off the bat, to make this car more attractive to drivers and hopefully new team owners.

'So we're going to open up the dampers, because that's an area where things have been needlessly locked down but can differentiate performance on the track and give drivers and teams a way to separate themselves. We'll go to a paddle-shift system, and are evaluating that at the moment. We could – and I stress could – make some aerodynamic changes. There'll be some changes to the visuals of the car, but that's less important than the dampers and paddle-shifting to me.'

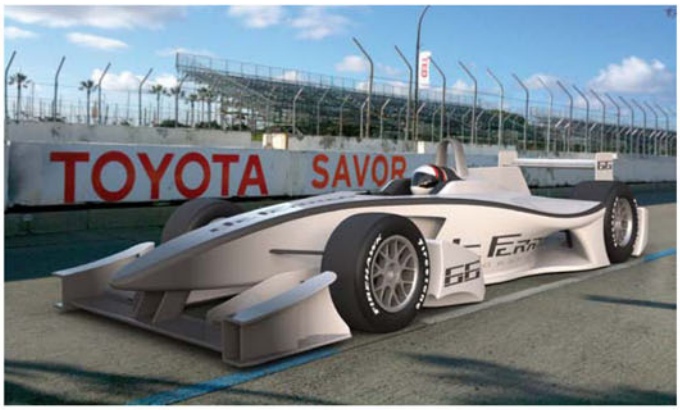
Indy Lights team owners have been adamant about keeping costs as low as possible, which made the 2014 changes a bitter pill to swallow for some.

'I know the current owners do not want to spend money on changes being made for the sake of change, or for a short-term gain with a new car coming,' Cotman added. 'That was a big point we took to heart when the upgrades were being thrown back and forth, and we came up with changes that could all be carried over to the 2015 car.

'The last thing any of us wants is to waste our owners' money, so while they might not all be excited about being out of

California-based firm Swift Engineering filed their Indy Lights design concept last summer

Mygale North America were formed by Bryan Herta Autosport's owners



The De Ferran proposal was created in partnership with Radon Sport

Rendering of the submission from the 2003 Indy 500 winner Gil de Ferran

Dallara's proposal bears more than a little resemblance to the firm's DW12

Reaction to the Dallara proposal was mixed at best, not helped by the chassis stasis in IndyCar and Lights

pocket, everything we're looking at doing is being done with the requirement that we can transfer them over to the new car. It might be a few different brackets or whatever, but we're after things that can be used for many years to come, not just next year.'

The transferable nature of the 2014 parts will likely result in the aforementioned aero updates being scrapped, but the introduction of a new Indy Lights tyre partner, as Continental takes over from Firestone, should add another interesting variable to the mix.

Cotman isn't ready to define what the new 2015 car will look like, or where it will come from, but did say that in addition to seeking clean-sheet designs, asking for a popular top-tier feeder series chassis to be modified for the rigours of oval racing is also a possibility.

That recognition – of the Indy Lights series needing to move away from a specialised chassis that holds minimal interest for drivers outside the USA – could help bring double-digit grids back in short order.

'At the end of the day, this still has to come back and Indy Lights needs to have its own identity in some way,' he said. 'I'm not saying that means you've got a go out and do everything different and build your own Indy Lights-specific chassis, but there are some things we need to consider if we're going to race ovals. We've got enough time.

'There can be adaptations made to a known chassis that drivers like in Europe or Japan or elsewhere, developed up front, and knowing what we've got to have it do down the road. It does limit the manufacturers who made such a car and can modify it where we need it, but it's been evaluated seriously. What we don't want to do is alienate young drivers. If they know they can use what they learn here in our car to also race elsewhere in the world, it's a win-win for everybody.

'And lastly, we aren't looking for a car that's an IndyCar clone. We want it to have its own identity visually. We want it to look amazing, which we know can be done. We are going for a car that's lighter and more nimble and really fast. Those are all the things a driver looking at GP2 or the Japanese Super Formula is wanting, and we've gone away from that over the years in Indy Lights. Dan is determined to fix that – and that's exactly what we'll do.'

"We don't want to alienate young drivers. If they know they can use what they learn here to race elsewhere, it's a win-win for everybody"

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M-Sport faces new challenge

Bentley Motors' choice of an unconventional route to develop its Continental GT3 racer has come up trumps, proving there is real potential in combining top rally engineering know-how with racing knowledge

BY MARTIN SHARP

"You can either do more of the same or you can do things differently. And I wanted to do things slightly differently"

It has been a decade since Team Bentley's Speed 8s came first and second in the Le Mans 24-hour race – and 73 years since Woolf Barnato's final victory at La Sarthe in the Bentley Speed Six.

Now, the British company has turned to rally speciliasts M-Sport to develop its new GT3 challenger, the Continental GT, for circuit racing. It is a strange choice on paper, but in reality it makes perfect sense.

Rally car engineering legend, Christian Loriaux, M-Sport's technical director, has concentrated his efforts on ensuring that Bentley's racing comeback enjoys similar success ten years on.

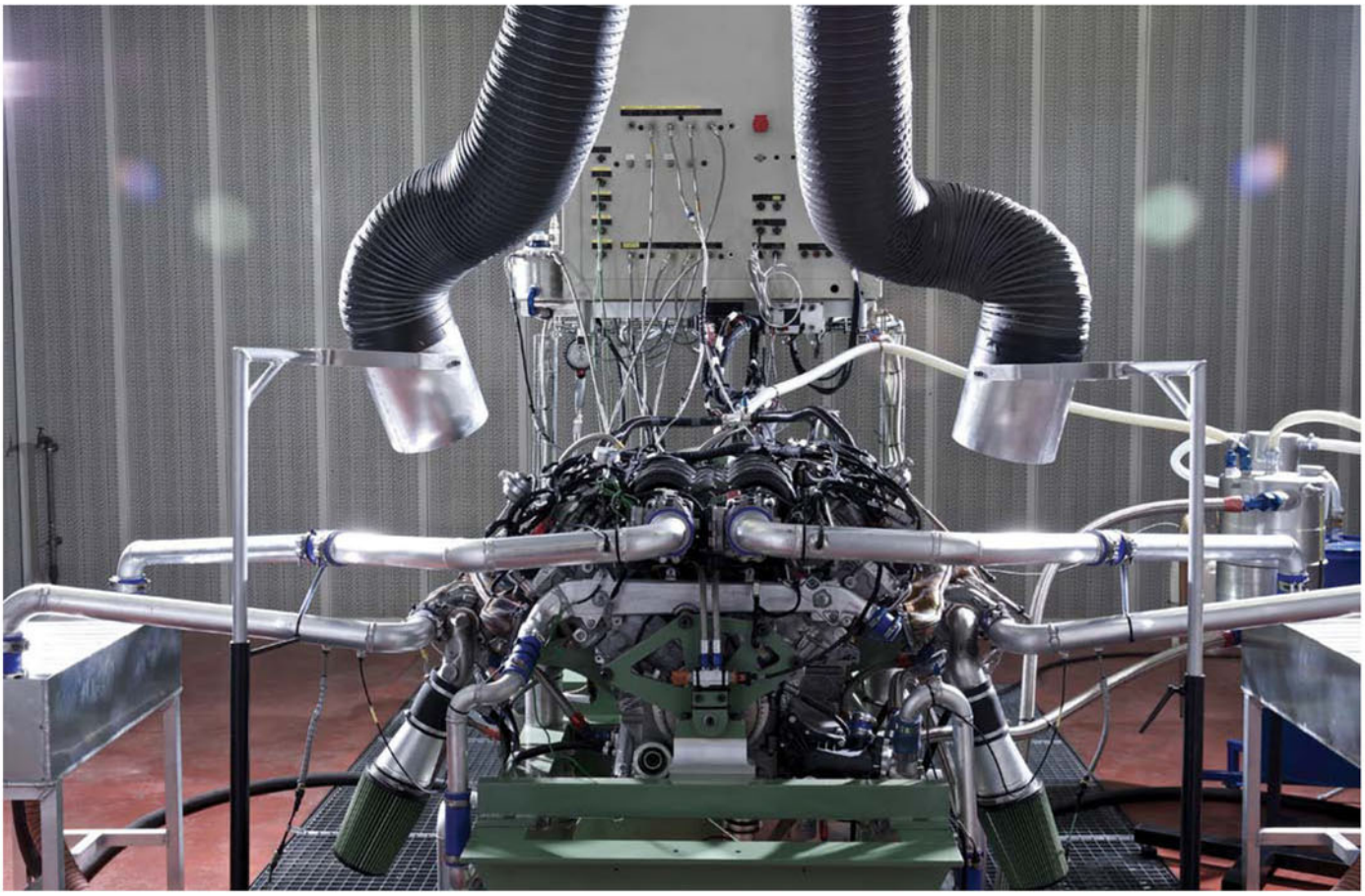
A very experienced specialised rally operation, M-Sport continues to spearhead Ford's rallying programme with a comprehensive 'ladder of opportunity' of Ford rally cars available for nearly all categories. The private company remains the first port of call for any team wishing to be competitive in the WRC with a Ford.

Bentley Motors' director of motorsport, Brian Gush, explains the reasoning in his choice of a professional rallying operation as technical partner for his GT3 racing programme: 'I wanted to do it slightly differently – a team that would be willing to collaborate with Bentley. You need to use the skills that exist within Bentley so that you don't make the same mistakes twice. There's a lot of information that exists at the company – production car knowledge – and I wanted a team that was going to take cognisance of that. And I wanted them to ask questions so that we could work together. Plenty of guys would say "just give me your money, just the cheque". They're probably very good and very successful, but this is motorsport and you want to do things efficiently. You want to do them in a Bentley way as well, with an eye for quality and an eye for detail, and I wanted to ensure that we had the best shot at involving the workforce here at our HQ in Crewe – they're all passionate about the sport.'

CHANGING METHODS

Gush had an already viable feasibility study of the Continental GT3 from investigations at his Crewe base and in consultation with the FIA. After considering a number of alternatives, Gush phoned M-Sport managing director Malcolm Wilson in September 2011. 'I said you can either do more of the same or you can do things differently. And I wanted to do things slightly differently,' he says.

'We kicked it around a bit as to how we'd like to work – or how Malcolm would like to work. He hadn't built a track car before and I saw that more of an advantage than a disadvantage because we're prepared to look at things not just to do things the way they've always been done, but to do them because they makes sense, and because we're making a quality bit of kit. M-Sport was



The Continental GT3 runs on a 4-litre twin turbo V8, capable of 600bhp. It's controlled by a Cosworth engine management system

a team that was prepared to do that with us. My designer Graham Humphrys was up there working together with Christian Loriaux.'

Humphrys developed the original Continental GT3 layout, which Loriaux describes as 'quite detailed, but in some ways a schematic'.

'Nothing was really designed or checked, so we had to change a fair few things,' he says. 'But basically how the engine was and so on, was done.'

M-Sport technical team's CAD/CAM machines were then set to work to crunch out developed and verified detail component designs for the required layout. Four engineers worked full-time with two others helping – effectively five full-time engineers on the job. 'It was big work,' Loriaux admits.

Bentley engineers Alistair McQueen, Humphrys and John Wickham are all also based at M-Sport's idyllic Dovenby Hall, Cumbria headquarters. They spend two days a week in Crewe and three days in Cumbria.

Gush explains that going to rally specialists M-Sport enabled Bentley to 'do things differently'. 'We wanted to build it as a Bentley, and not just a GT3 first, but it's a Bentley GT3 so it's got to be good and have attention to detail. And there is an enormous amount of learning out of the rally world that you can take on board, so the collaboration between Graham and Christian is great. For example, Graham is saying: "This is how we've done it in the past' and Christian's saying 'Well, why? Why do you do it like that?" In the rally world this is what we do, because you've got to get through the stage so you don't want the part to break – you want it to bend then at least you get to the end of the stage.

'And that applies in endurance racing as well. So there's a lot of synergy in the true sense of the word that can be gained between rally and race.'

Pragmatically, Loriaux adds: 'To be honest, the first thing is that the philosophy to make a car fast is the same for a touring car, a rally car or a Dakar car. They are always the same, to make the engine as efficient as possible, a good chassis, a low centre of gravity, good balance and so on. So the basics are the same anyway, that's for a start. After that, yes they are very different animals but in some ways not – they are still cars with four wheels.'

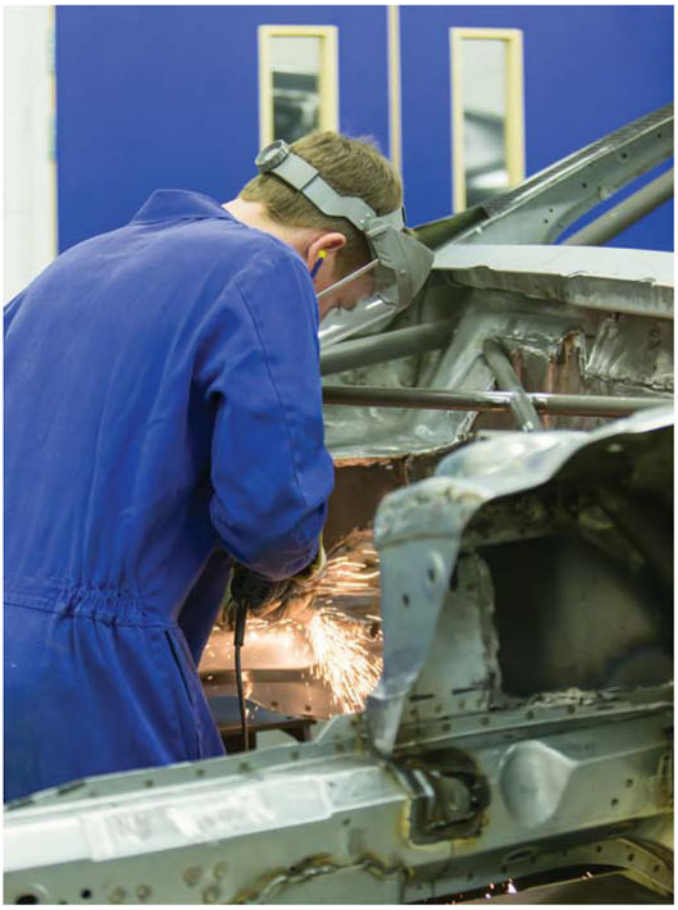
PACKAGING CHALLENGES

'In GT3, you're not on four-wheel drive and you don't have massive suspension travel,' adds Loriaux, 'so in terms of that the suspension kinematics and suspension design is very easy compared to a rally car.' Machined aluminium alloy hubs and fabricated wishbones with Öhlins dampers are used all-round on the Bentley. However, Loriaux does identify a – perhaps surprising – more difficult area with a GT3 car: 'After that the packaging is not easier – if anything the packaging of the car was very difficult because you've got a big engine into engine bays that are still reasonably small compared to the engine sizes.'

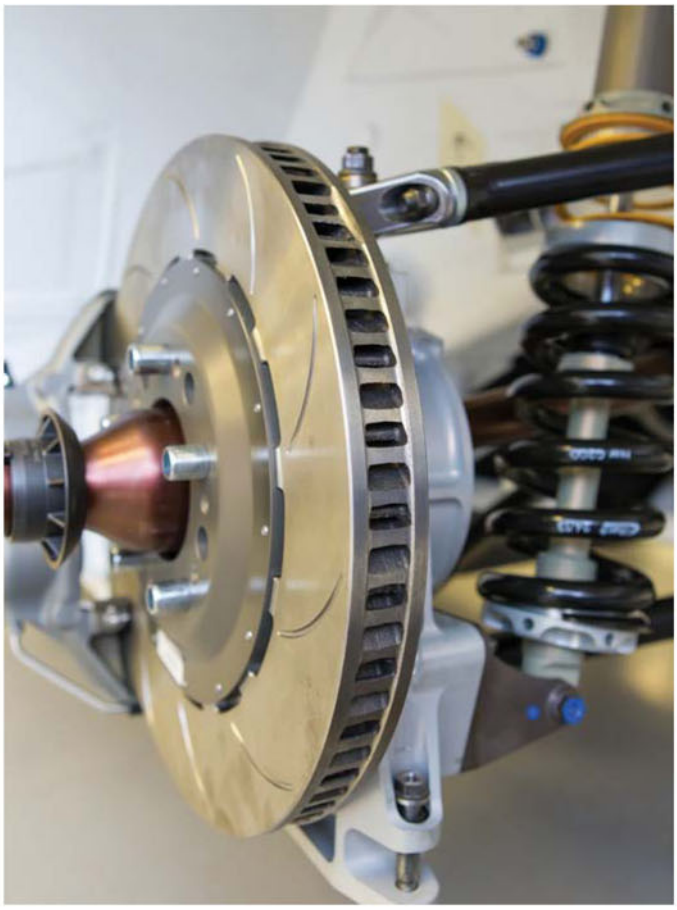
As a car, the Continental has a big frontal area, so aerodynamic efficiency is particularly important. The initial aerodynamic work has been theoretical, with dynamic testing to follow. Aero is of less importance to the efficiency of a rally car with its comparative lower speeds and restrictions on the frontal treatment dictating compromises on the aero balance of the entire car. 'We're learning about aerodynamics with the GT3 Bentley,' Loriaux admits.

From Gush's side, he is extremely satisfied with his choice of technical partner. 'When you see M-Sport in operation you realise that this is a brand that fits with Bentley. The location is great. We've kept the car as a Continental GT and the exterior styling has

"We used road car engineers, who know what the systems weighed, so we could accurately predict where the weight would land in a GT3"



Bentley's motorsport director Brian Gush is delighted with the seamless way his technical staff have linked up with rally specialists M-Sport



M-Sport manpower equivalent to five full-time engineers worked on the car – four working full-time alongside two on a part-time basis

remained really faithful. The styling and all that was done here in Crewe in the styling studio. And then the body-in-white guys went up to M-Sport while we were in that part of the programme.

'What's really efficient is to take a guy out of the road car engineering side and take him up there. And because the programme moves so fast you can just drag him in for a week and then you're past that phase and he goes back to his job. Whereas if you try and get a contractor, he takes a few weeks to come up to speed, then delivers for a few weeks and continues for a while before you realise you need to ship him back. But here it was absolutely instantaneous – an electronics guy who understands the CAN of the car, within two and half hours he's up there. And I've not had one person say "Sorry, I can't do it now" – they've all dropped what they've been doing and leapt up there. That's been really good – quick response, and always an enthusiastic one too.' It helps that one quarter of Crewe's 4000 Bentley workforce are engineering people.

Bentley kept the FIA informed of developments, from the feasibility study stage through to the car in physical development. 'They sort of gave the go-ahead at various junctures,' explains Gush. Homologation is planned toward the end of this year and is most likely to be achieved "locally" first through the UK's MSA then have that read across to FIA homologation. We're talking to them all the time.'

RELAXED RULES

Compared to the FIA's super-tight rallying technical regulations, GT3 rules are notably open. And for a good reason, as Loriaux explains: 'The GT3 regulations are made so that everybody can come with a car. As a result it was extremely important to have quite wide regulations – you have to go from a heavy Bentley with a massive steel bodyshell to a lightweight McLaren all in carbon and make them all competitive.

'So, for that – quite cleverly – the FIA left it reasonably open. The idea is that if you spend a lot of money you will be penalised on speed, so you have a performance balance test that's done by the FIA, and they keep an eye on what you're doing all the time to make sure you don't go too fast. So there's no point in spending a fortune to make the car go fast because then they slow you down. And, obviously, this is pretty much a commercial activity for the manufacturers so you make your car to the pace dictated by the FIA by spending the minimum money.'

The FIA Balance of Performance (BoP) test principle began in 2006. It looks into three specified performance criteria, covering aerodynamics, power output and weight. Once the cars are verified as conforming within the three specified windows, a track-based dynamic examination uses an FIA-specified driver to put in laps in each car type to verify that a team is not sandbagging and amass data, which is then used to adjust power output via an inlet restrictor, aerodynamics via wing angles and ride height, and weight via ballast. The Continental GT3 was due for its first BoP track examination just after *Racecar* went to press.

During the early Continental development period, the FIA expressed most interest in whether Bentley would be able to shed one full tonne of weight from the car to comply with GT3's 1300kg requirement. Gush had no qualms in this respect. 'We used road car engineers – who know what the systems weighed – to get the weight out. Then we could do a very good prediction as to where

"The GT3 regulations are quite wide so you can go from a heavy Bentley to a lightweight McLaren and still make everything competitive"

Bentley plans to contest two races with the Continental this year and has registered for the 2014 Blancpain series

the weight would land up in a GT3. And we've hit that target exactly, because our info on what components are in there is so exact. When we put the car on the scales it was bang on the weight.'

Gush points out that a Balance of Performance exists in all forms of motorsport. 'If you look at what GT3's established, they've got full grids of between 50 and 60 cars at every meeting and it's close racing. There's close to 14 or 15 manufacturers involved now – something's going right!'

Gush is also a strong advocate of the FIA's attitude to its BoP test: 'I think they are controlling it all quite well. It is clear what they're doing. They are looking at it all on the basis of data that they've gathered and as a result you've got some close racing. You see Mercedes-Benz winning one weekend, Audi winning one weekend, then you've got Ferrari, you've got Lamborghini – they're all in there with a chance.

'And the thing is, if you're in the race and in with a chance, you'll come back. If you've got no chance you won't come back. Ultimately, the proof of the pudding of the BoP is that all the manufacturers are there.'

He fully concedes that GT3 is a customer series and that cars must be cost-effective to enable privateers/gentleman racers to buy them. Equally, teams need a car with a quality build which is reliable and has the right performance. The Bentley aim is for the Continental GT3 to be a car which is desirable and performs. And the BoP principle naturally controls cost, as Gush explains. 'You wouldn't go to an ultra-lightweight shell because you'd just put ballast back in,' he says. 'The engine's free, so I could use forged pistons, I could use Carillo rods, I could put a flat [plane] crank in – all of that's free for me to do: but I'd just get a smaller restrictor.' Hence the hardware of the Continental GT3's 4-litre twin-turbo V8 being based on the road car's engine.

The V8 was chosen because it is 23kg lighter than the Bentley W12 and enjoys a 20mm lower centre of gravity. It is a proven unit, although M-Sport's engine expert Nigel Arnfield is scheduled to take a look at the unit and its Cosworth software shortly. Pre-BoP test,the team made an assumption about inlet restrictor diameter and has worked with that, although Brian Gush remains pragmatic about the final regulated dimension. 'I don't think they're going to give us any quarter. We're in the target weight so we weigh exactly what the others weigh; we've got aero which is exactly in the window and the other turbo cars shouldn't have any more power than us – and no less either.'

The car's pneumatically activated Xtrac twin-shaft six-speed sequential transaxle is mounted at the rear axle and contains the clutch, while an open propshaft delivers the power.

Bentley plans to contest two races with the Continental GT3 towards the end of this year and has registered the M-Sport/Bentley team for the five-round 2014 Blancpain series. Humphrys knows each of the five tracks well and has good data from them.

M-Sport/Bentley liaison has been problem-free, and Bentley's motorsport boss is proud of what has been achieved. 'The really good thing is that they don't come with any preconceived ideas, so they ask, we ask, and they ask. We communicate exceptionally well – I pick up the phone to Malcolm and within an hour we can be talking face-to-face when we meet halfway.

'It's great, and it's really all happened like that because they have no preconceived ideas as to the way it should work.

'They know how to make a quality product: they make cars that are highly technical and they've got a damn-fine facility, so they know what they're doing, and we know what we want and we know a lot about our own product. So you just put those together and and nobody's saying – to quote Kimi Raikkonen – "Leave me alone!

TECH SPEC

Continental GT3 Specifications

Engine: 4.0-litre twin-turbo V8, repositioned to the rear of the engine bay, Cosworth engine management system

Power: approx 600bhp derestricted

Oil System: dry sump, Mobil 1 synthetic motor oil

Transmission: rear wheel drive, Xtrac six-speed sequential transaxle gearbox, racing clutch, steering wheel mounted paddle-operated pneumatic gear shift

Drivetrain: carbon fibre propshaft, limited slip differential

Suspension: double wishbone suspension front and rear, four-way adjustable racing dampers

Steering: hydraulic, power-assisted

Brakes: ventilated iron disc brakes front and rear, Brembo six-piston front calipers, four-piston rear calipers, driver-adjustable brake bias

Safety: FIA-specification steel roll cage, Sparco six-point FIA safety harness, onboard fire extinguisher, onboard pneumatic jack system

Fuel system: FIA-specification racing fuel cell

Electronics: race-specification ABS and traction control. Lightweight race battery

Wheels: OZ Racing 18in x 13in rims

Tyres: 310 / 710 R18

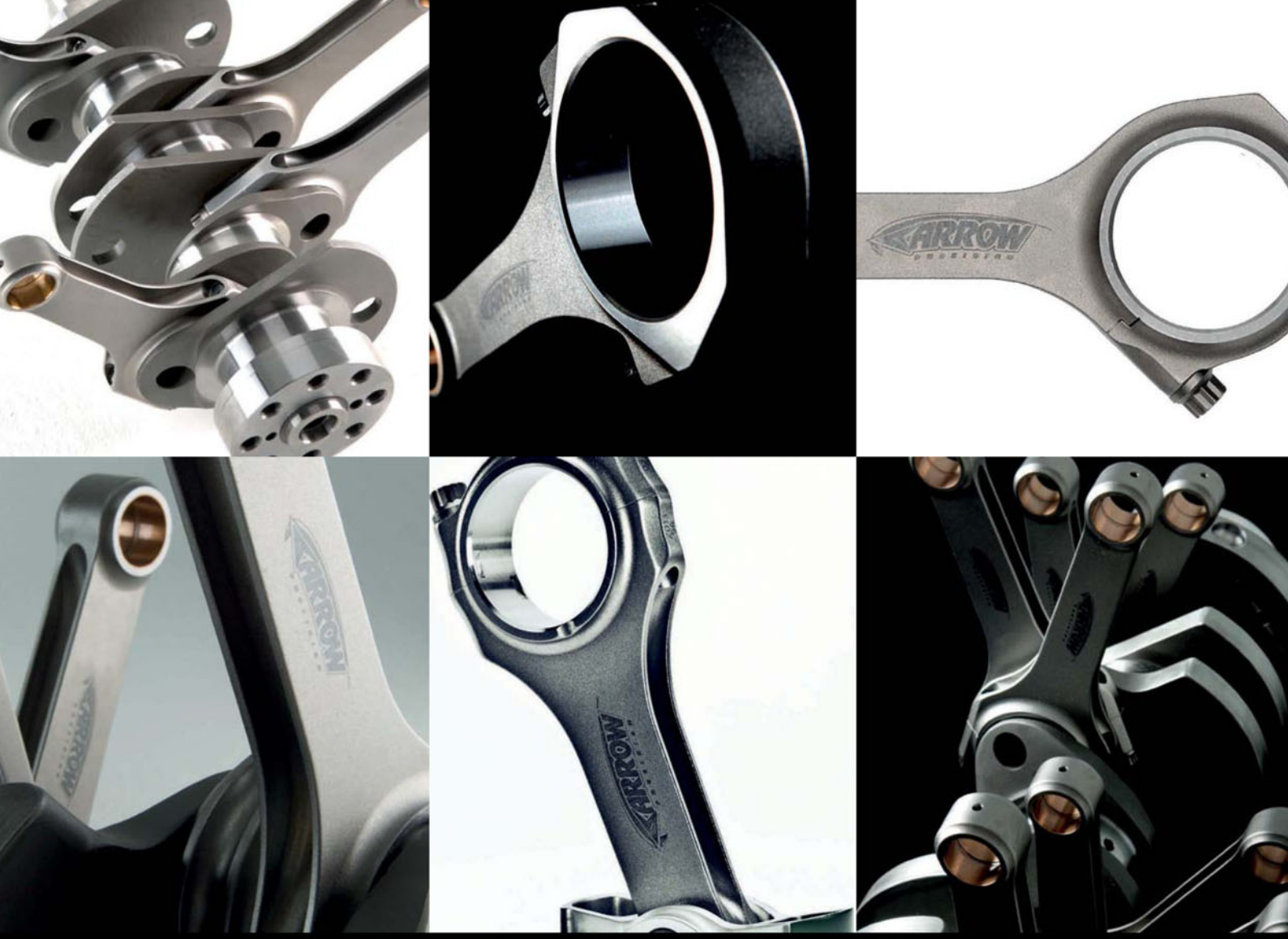
Aerodynamics: carbon fibre front splitter, rear wing and body panels. Lightweight, aerodynamically-optimised bumpers, bonnet, sills and fenders

Dimensions
Length: 4950mm
Width: 2030mm
Height: 1350mm

Weight: <1300 kg

Weight distribution: 52 : 48

"I think the FIA are controlling BoP quite well. They are doing it on the basis of data they have gathered, and it's made for some close racing"



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Design philosophy

From his apprenticeship at March to running his own team, the creator of the G92 recalls a career which has resulted in six Indy 500 victories, and dozens of IndyCar wins

BY IAN WAGSTAFF

"Robin Herd dragged us to his office – the stupid thing about it was that he let Adrian Newey go and kept me!"

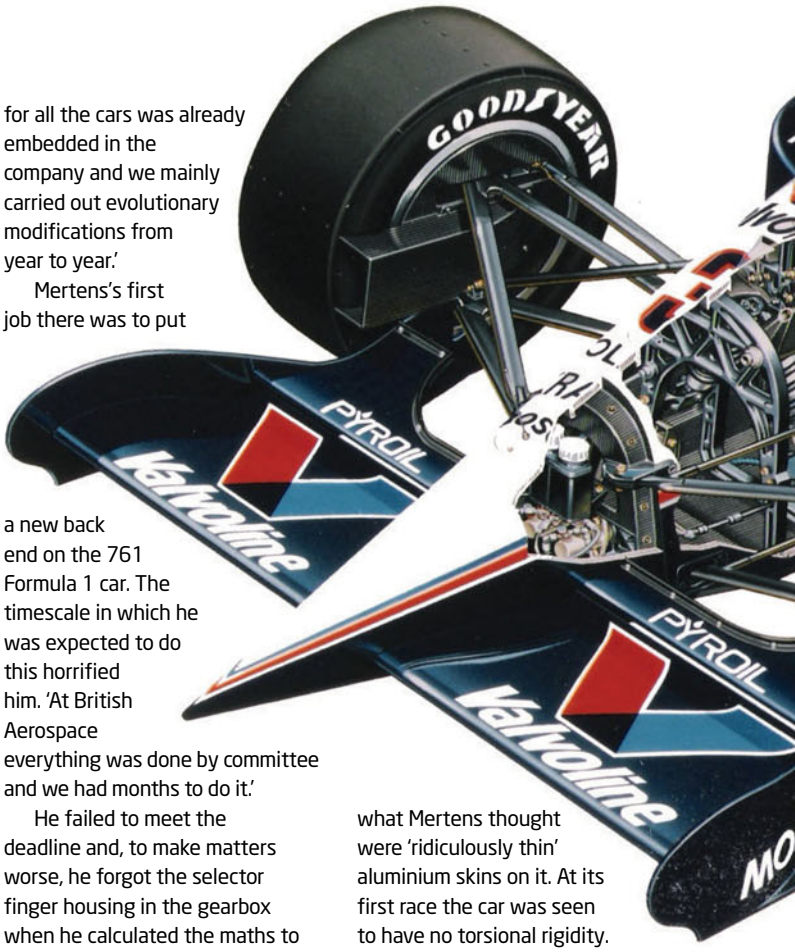
March boss Robin Herd was not amused. He had been informed that two of his design team were planning to set up their own operation. The duo was summoned to his office and one of them, a promising young man by the name of Adrian Newey, was dismissed. The other was allowed to remain.

It is something that still puzzles, and perhaps slightly amuses, Alan Mertens that he was that man. 'Robin dragged us to his office and sat us down but the stupid thing about it was that he let Adrian go and kept me!'

Mertens and Newey had become frustrated by the politics at March and had been plotting to form their own breakaway company to also build IndyCars. Discussions had already taken place with a couple of team owners, and it was one of these that Mertens believes tipped off Herd. Newey left to engineer Mario Andretti's Lola at Newman/Haas and the rest, as the cliché says, is history. Mertens remained for another two seasons, but in 1988 – still disillusioned with March – he quit to also become an IndyCar engineer, in his case with Rick Galles. He quickly gelled with driver Al Unser Jr who won four races with the Mertens-designed March 88C and finished second in the championship. It was a relationship that was to eventually lead to the Galmer G92 and victory in the 1992 Indianapolis 500.

Mertens had joined March in mid-1976 from the British Aerospace guided weapons division in Stevenage, England. 'The way I go about designing cars was very much influenced by the racecar engineering apprenticeship I did at March,' he says. 'In those days the foundation for all the cars was already embedded in the company and we mainly carried out evolutionary modifications from year to year.'

Mertens's first job there was to put a new back end on the 761 Formula 1 car. The timescale in which he was expected to do this horrified him. 'At British Aerospace everything was done by committee and we had months to do it.'

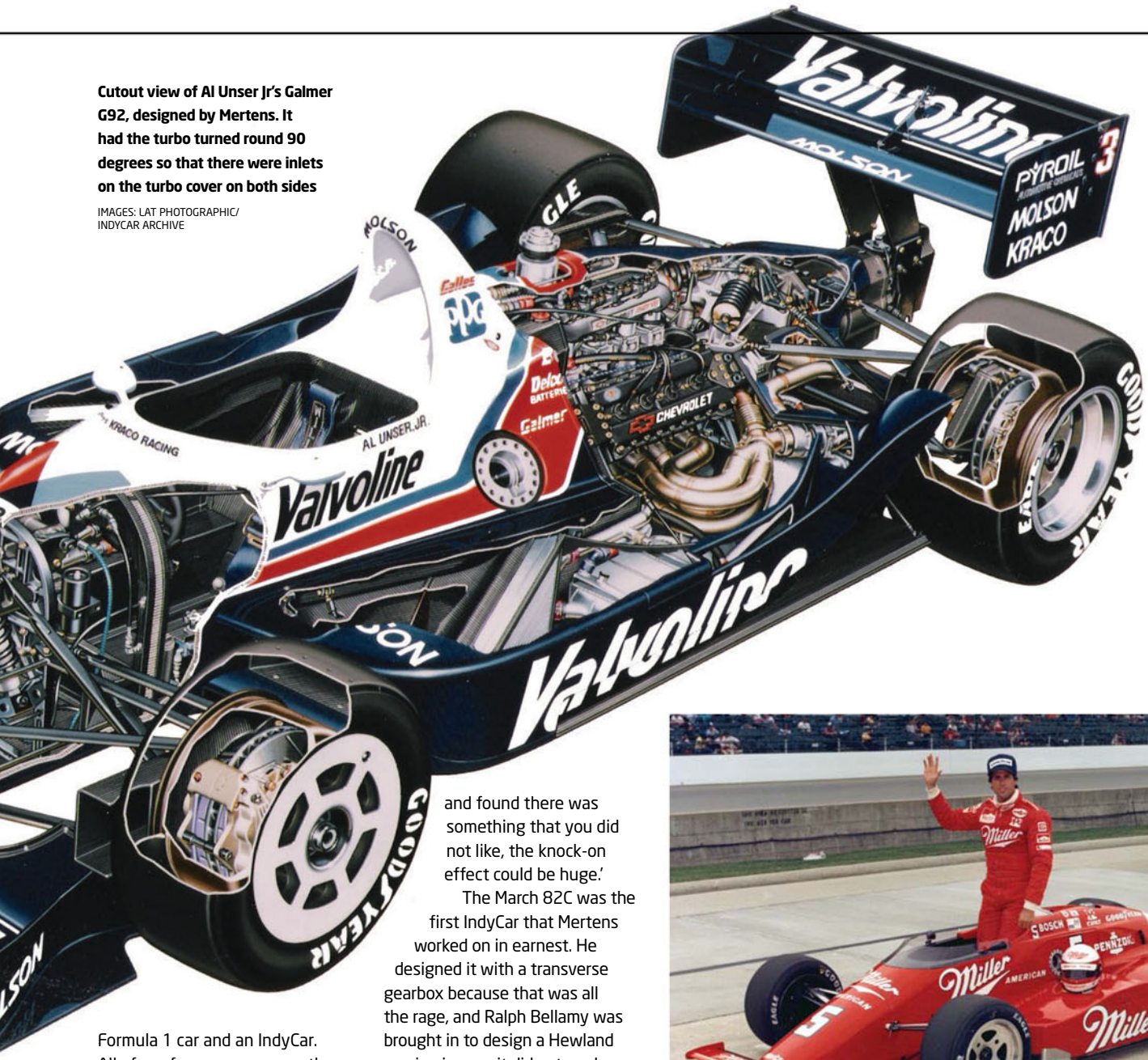


He failed to meet the deadline and, to make matters worse, he forgot the selector finger housing in the gearbox when he calculated the maths to do the rear wing overhang. The car failed scrutineering at Monza and the team had to jury rig the wing at the track. Mertens got away with his misdemeanour largely because Ronnie Peterson won with the car that weekend. He was, however, about to embark on a steep learning curve as he was then tasked with the design of the Formula 3/Atlantic/Super Vee cars.

Once he had finished work on the 793, Herd took him to March Engines in Cowley, England, where John Gentry had been responsible for the BMW-powered IMSA car. The idea was to create an F1 car for John Macdonald and Mick Ralph, which became the RAM. Paul Brown created the chassis while Mertens worked on the running gear. Brown was convinced that an aluminium honeycomb structure was so strong that he could put what Mertens thought were 'ridiculously thin' aluminium skins on it. At its first race the car was seen to have no torsional rigidity. A new set of skins had to be manufactured from 16-gauge aluminium, flown out to the race and riveted and glued on to the outside of the chassis.

'I had no race engineering experience, so at races I was dragged around by Robin and Gordon Coppuck who did the engineering,' says Mertens. 'My task seemed to be to drive the rental car but, essentially, I was there to learn.' After a couple of years, Mertens became dissatisfied with this and asked to return to March Engineering. He was put in charge of the drawing office and the IndyCar programme.

Here, he was reunited with Coppuck who had been brought on-board to convert the March 811 into a Speedway car. 'He showed us the way and what the difference was between a



Cutout view of Al Unser Jr's Galmer G92, designed by Mertens. It had the turbo turned round 90 degrees so that there were inlets on the turbo cover on both sides

IMAGES: LAT PHOTOGRAPHIC/ INDYCAR ARCHIVE

Formula 1 car and an IndyCar. All of our focus was now on the Indianapolis 500 – we didn't care about anything else.'

'My first lesson from Gordon was that when you start to design a racecar in a new arena, you first try to find people with experience in it and you need to do your market research. You need to understand who and what you are competing with and what primary assets your competition has. We did this in stages over the next few years as we designed successive IndyCars. We learned by trial and error on our own, through feedback from race teams and watching the competition.

'When I start a project, I typically work from the driver outwards. You place the driver, the fuel tank and the engine and work your way out from there. Logically, if you started from the outside and worked your way in and then got to the middle and found there was something that you did not like, the knock-on effect could be huge.'

The March 82C was the first IndyCar that Mertens worked on in earnest. He designed it with a transverse gearbox because that was all the rage, and Ralph Bellamy was brought in to design a Hewland version in case it did not work. Those early years competing at Indianapolis were relatively easy with little competition and, in 1984, 29 of the Indy 500 starters drove Marches. 'We were only competing against ourselves,' says Mertens. 'However, we were under pressure to make each IndyCar more successful than the last and just as it was getting difficult, along came Adrian Newey, who was a genius. We got him in from Southampton University where we were trying to do wind tunnel testing. Our approach had been pretty agricultural.'

The first IndyCar they did together was the March 85C. 'In his typical uncompromising manner, Adrian went for broke with the aerodynamics. When he showed me what I had to package the car in, I told him "you must be joking". Working with him were the best days of my time at March.'

(Top) Danny Sullivan in the Penske-March 85C, a car co-designed by Alan Mertens and Adrian Newey; (above) Alain Prost in a March 793 trails in third behind the 783 of Brett Riley in a Formula 3 race at Donington Park in 1979

Al Unser Sr in the Penske-March at the 1987 Indianapolis 500. A late addition to Penske's driving lineup that year after injury to Danny Ongais, Unser ran the back-up car – a March 86C – and went on to win the race for a fourth time

In 1988, Mertens left March to join Rick Galles's operation and engineer an 88C for Galles's manager, Ed Nathman. On hearing that Mertens had quit March, Nathman suggested he work for the team. 'His logic was: "who better to have as the team's resident engineer than the designer of the car that it was running?", says Mertens.

Mertens had regularly attended the Indy 500 as a designer, 'partly to soak up the flak from the customers, and partly to collate their feedback.' During this time he did not actually engineer any of the cars – he says – 'although I may have looked over the occasional shoulder and made a grunt or remark.' So, 1988 was his debut as a race engineer.

He admits that it made him nervous. However, he and Unser Jr, who respected the fact that Mertens had once raced himself (in Formula Ford) quickly gelled. The result was an excellent season for the Galles team, which was the only one that seemed to be able to make the 88C work effectively, winning four races and finishing second in the championship. Unser Jr's method of testing was very patient. 'He did it by numbers and he worked methodically through a process that he had learnt from his dad.'

Mertens remembers getting 'a lot of grief' from March's customers. At Long Beach they had a meeting into which he was called to say that they felt Galles now had an unfair advantage in using the designer of the car. Mertens pointed out that his loyalty had to be to the team that was now paying his wages.

The 88C proved to be loose coming out of turn two at Phoenix. Mertens decided that it needed a stiffer rear anti-roll bar. 'It's very difficult when you have a loose car to convince a driver that you need one of these,' he says. 'I reasoned that we had a "push induced loose". The car was coming off turn two pushing with too much lock on. As Junior unwound the lock coming off the corner, the front would bite and send it loose. To cure this we cut the handle off a hydraulic jack, slit it down the middle and welded it around the rear anti-roll bar. Now the car came alive, I had earned my stripes and overnight had, apparently, become a race engineer. My confidence grew with Junior's help and the feedback that I got from him was tremendous.'

At Indianapolis, Galles and Unser Jr asked what Mertens's ambitions were and what it would cost to keep him. 'I said I wanted to start my own company, to design and build my own racecars. They looked at each other, Galles asked Junior what he thought and he said, "Yeah, go for it!"' The result was Galmer Engineering, which initially worked as an operational research and development facility for the Galles team, and which was based in former March premises in Bicester, England.

A serious illness in his family meant that Mertens was understandably troubled prior to the 1989 500. However, thanks partially to Unser, 'I shook myself out of it' and during the week after qualifying their Lola was turned into what the driver described as one of the best racecars that he ever had at Indianapolis. With less than two laps to go, Unser Jr and Emerson Fittipaldi were fighting for the lead, six laps ahead of the rest, the Galles car just in front. Into turn three, Fittipaldi drifted up the apron and his Penske brushed the Lola's left rear wheel. Unser Jr spun, hit the wall and slid down into the infield. Fittipaldi maintained control and went on to win. 'Knowing what we had gone through, that destroyed it for us,' recalls Mertens. 'Then we went through the most miserable season.'

"I typically work from the driver outwards. You place the driver, the fuel tank and the engine and work your way out from there"

However, a win at the very end of the season set them up for 1990 when the CART championship fell to the team. That year the decision was made for Galmer to manufacture its own car, the Chevrolet-powered G92.

'We had a good database from the 1991 Lola and we integrated some of its mechanical parts into the design,' he says. 'However, we wanted to break the conventional IndyCar mould, so we had a more futuristic shape.' There were, however, some basic things wrong with the initial design. Work had been done in the quarter scale wind tunnel at MIRA, but when the team commenced testing it found that the car was performing unpredictably. Former March and Brabham engineer, Andy Brown, was brought in as aerodynamicist. 'The car was not working well and there were problems with the front wing stalling on road courses,' recalled Brown.

'Andy was brilliant,' says Mertens. 'He helped to solve a lot of the aero problems, but there were some that we could not do anything about as they were inherent in the build of the car.'

It was found that the bell housing was not stiff enough, which meant that some of the car's structural integrity was lost. That did not hurt it on road and street courses, but it certainly did on high-speed ovals. The exhaust and twin waste gate systems were used to blow the air as it came out of the back of the tunnel, which meant that when the driver was on and off the accelerator it was changing the centre of pressure of the car. Again, this worked for it on street and road courses but not the ovals.

Two Galmers were built for 1992 with Danny Sullivan winning third time out at Long Beach (the fifth consecutive win there for Mertens). The 500 narrowly fell to Unser Jr, giving Mertens a sixth victory at the Brickyard to add to those he had won with March. 'Cosworth gave us an XB engine, which I still have,' he says. 'We did a wind tunnel model for it, but Rick Galles – being a Chevrolet dealer

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(Above) Rick Mears in the Penske-March 84C, which won the 1984 Indy 500; (below) Al Unser Jr at the 1992 500 in the G92, an event that Galmer won despite the team hearing they were to be closed on the morning of the race

– did not want to go down a Ford route so we didn't use it. Michael Andretti dominated the race in 1992, but it was the failure of his XB engine that gave us the win!'

Despite Unser Jr's 0.043-second victory, the G92 did not receive good press. Recalled Brown, 'I think a lot of that was due to the fact that the pre-season testing did not go well.' However, the problems were pinpointed before the season started using the Leyton House wind tunnel at Brackley and calling in favours from F1 contacts.

'We did a number of things on the G92 which were innovative,' recalls Mertens. 'For the first time we turned the turbo round through 90 degrees so that there were inlets on the turbo cover on both sides. In theory that was supposed to pull the air down and keep the laminar flow over the rear wing. Because of this we blew both the undertrays with the primary and wastegate exhaust. Because the underwing of the car had to stop at the centre line of the rear wheels, we designed the outer case of the gearbox with a smooth finish with the ribs on the inside, where typically most gearboxes had them on the outside.'

There were some who thought the G92 to be too stiff, so a less torsionally stiff chassis – the G93 – was manufactured and tested in the weeks leading up to the last race of the season. It was something of a gamble, and Unser Jr finished in a lower position than normal, falling from first to third in the championship.

Mertens and his team were looking good for 1993 with some excellent numbers being noticed in the wind tunnel. Brown reckons he did not see better until the 1996 Reynard. However, the money was not available to develop the car any further, despite interest in a customer version, and in the November the operation was reduced to a skeleton crew. 'We had even got as far as ordering the material for the buck for the tub when the order came down for us to stop work.'

Mertens sold much of the information from the Galmer – with the exception of Brown's aero package – to Reynard, helping it to kickstart an Indy dynasty of its own. He also became a partner in the PacWest team for several years. With the advent of the IRL, Mertens spoke to Tony George about becoming one of the chassis suppliers but that did not happen. Reunited at Galles with Unser Jr for 2000, he was persuaded to move full-time to the USA.

In 2009 Mertens got wind of the fact that the next IndyCar was about to be put out to tender. With Bruce Ashmore (who had designed the 1990 Indy 500-winning Lola) and the late Tim Wardrop (one of the most experienced engineers around the Speedway) he decided to 'have a run at it'. It was a well-balanced trio, with Mertens being known for his mechanical design ability, and Ashmore for his aero work. A company was created, known as BAT after their first names. A business model was created with a plan to conduct open source manufacture. After a series of meetings, the trio found itself in front of IndyCar's ICONIC board. Its members included a number of former colleagues from Mertens's March and Galles days, so he was fairly optimistic. However, the then IndyCar CEO, Randy Bernard, asked if they would be prepared to share the project with another company. This did not make financial sense, so their meetings came to nothing.

"The way I go about designing cars was very much influenced by my apprenticeship at March"

Mertens is a designer who has moved from one era to another. Perhaps significantly, the first time he used CAD was on the Galmer G92. 'In the past you would do a scheme and then pass it down the line for the other designers to do the detail work. Much of the scheme would be implied, as opposed to being explicit, so there could be misinterpretation over dimensions and tolerances.'

AutoCAD was used on the G92. 'I don't think I've ever known a car, let alone a completely new design, go together so relatively seamlessly and I attribute that to the CAD system.'

Subsequent sponsorship from Autodesk took some of the pain out of the costs, and Mertens has stayed with Autodesk ever since. For the last eight years, he has done everything with its Inventor programme – 'a superb piece of software,' he says.

'I try to stay contemporary with all of this,' he says, 'but my mind is almost as if I am still doing it on the drawing board. I still think in the old-fashioned way.'

In recent years Mertens has worked in the commercial nuclear industry but has also taught at the University of New Mexico where there is a Formula SAE programme. 'I still teach the basics the way that I learnt them at March. I then encourage them to adapt this to the modern day tools.'

Over the last nine years he has hired people for the nuclear industry with Formula SAE experience, even though the work is different. 'They think through and develop the concept, design and manufacture their own product. They are way more rounded engineers than those that purely do the theory.'

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The return of Galmer

Alan Mertens's latest creation is an open wheel single-seater for F1000, which offers a whole host of interchangeable components to help customers keep costs down

Galmer, best known for its 1992 Indy 500 victory, is still a car constructor. After an abortive composite chassis supercar project, it turned its attention to SCCA D-Sports racing, but its latest project – seen here for the first time – is an open wheel single-seat racecar with a tube frame chassis to suit the SCCA F1000 or FB series. It has independent inboard suspension front and rear, actuated by pushrods with overhead mounted spring damper units.

The chassis itself is constructed out of 4130 Chromoly tube which is TIG welded throughout. The rear of the chassis is of modular design, making it adaptable to various formulae and, in the case of the F1000, there are a number of different engine installation kits to suit different engine makes and manufacturers. It is quite narrow, and based on a two pedal configuration requiring a hand actuated clutch and paddle shifts for gear changes.

The frame is optimised for the Suzuki GSXR 1000 engine package, generally the engine of choice in F1000 which allows for any 1000cc motorcycle engine. The engine is not a stressed member and is installed and removed via a removable spaceframe above the engine bay.

'Considerable attention has been paid to this area of the chassis, as with the whole chassis, so as not to compromise torsional and beam stiffness and safety in and around the rear roll hoop area,' explains designer Alan Mertens. 'The cockpit sides also have carbon anti-intrusion panels for crash protection.

'In the rear roll hoop area, additional protection is afforded to the driver via a cockpit mounted deformable headrest structure around the driver's head. It also has a quick release steering wheel mechanism for easy entry and exit of the cockpit.'

Mertens has designed most of the car's suspension components to be interchangeable, reducing cost for customers. This includes: billet machined aluminum uprights, wheel bearings, wheel hubs, top wishbones, wishbone clevises, rod ends and spherical bearings, rockers, shock absorbers, brake rotors and calipers.

'The pushrod front and rear suspension has a rocker arrangement which gives a velocity ratio of 1.25:1, making small incremental changes to wheel rates easier,' adds Mertens. 'The front rocker has a slight rising rate characteristic for stability under heavy braking and entry into corners. The rear rocker has a slightly falling rate to optimise traction coming out of corners. The anti-rollbar control front and rear is via a T-bar system with an adjustable blade, giving five positions of stiffness.

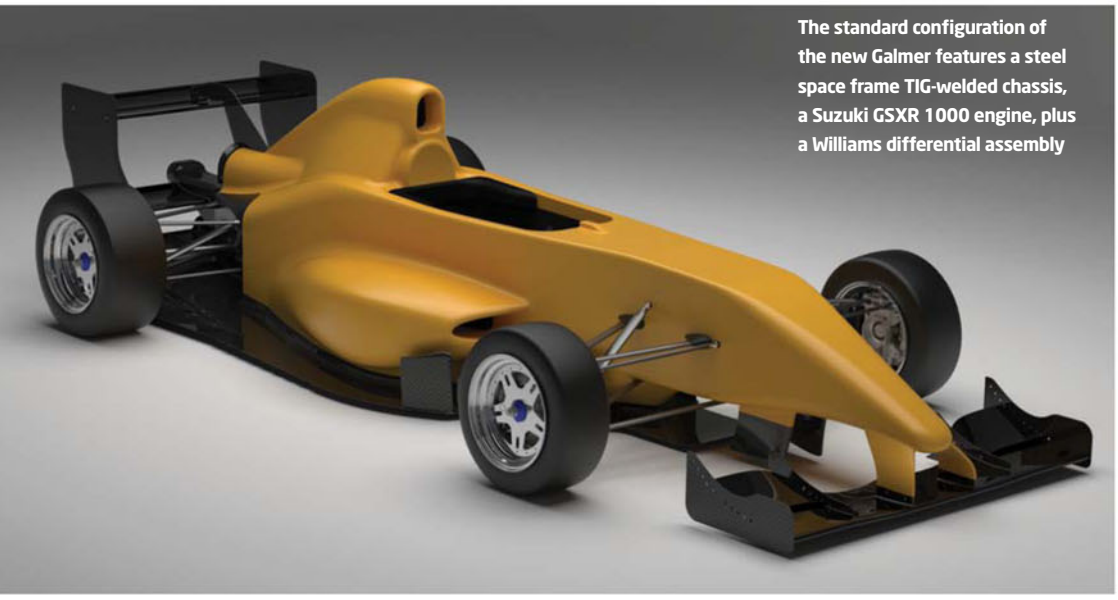
There is a dual braking system, with individual master cylinders for the front and rear with a driver adjustable brake balance bar, 10-inch ventilated rotors and billet machined aluminium calipers.

The differential unit has independent mounting side plates, which allow for quick and easy chain removal and tensioning. The fuel tank is centrally mounted underneath the driver's seat, isolated from the driver and the engine compartment by a firewall.

Cooling is via side mounted water and oil coolers ducted in through the side of the car that exit through a tight Coke bottle rear end and the engine compartment at the rear. The engine air inlet duct is centrally located and situated above the driver's head, while air is also bled off this duct to feed cooling flow through the engine compartment.

The car has a rear diffuser and front and rear wings for overall downforce, with the front and rear wings being adjustable for balance changes. It also has front and rear crash attenuators, the front being in the form of a carbon nose box and the rear a carbon structure attached to the rear subframe.

It is expected to be ready for the start of the 2014 US F1000 series, and could also race in the UK, Asia and the Middle East.



The standard configuration of the new Galmer features a steel space frame TIG-welded chassis, a Suzuki GSXR 1000 engine, plus a Williams differential assembly

TECH SPEC

Galmer F1000

Chassis: 4130 steel space frame, TIG welded

Body: hand-laid lightweight epoxy glass fibre with reinforcement as required

Engine: Suzuki GSXR 1000. Alternate engines packages to special order

Drivetrain: Williams differential assembly and half shafts by Taylor Race Engineering. Tripod joints by GKN

Brakes: front and rear billet machined Aluminum 4 pot calipers, custom 10in diameter x 0.75in thick-vented cross drilled discs with aluminum hats

Suspension: aero A-arms with inboard push rod suspension from 4130 aircraft quality steel TIG welded

Springs: Hyperco

Rod Ends: Aurora

Steering rack: backlash adjustable rack and pinion

Wheels: aluminium three-piece

Wings: front wing, mainplane with twin adjustable flaps. Rear wing, two element adjustable

Tyres: Goodyear, Hoosier, Dunlop, Avon

Dimensions
Front track: 64in; rear track: 62in; wheelbase: 98in; overall width: 67in; length: 168in; height: 38.7in
front wheel: 13in x 7.75in;
rear wheel: 13in x 9in

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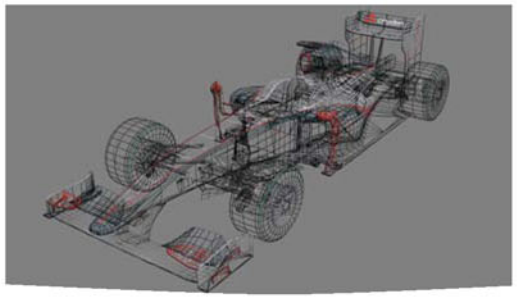

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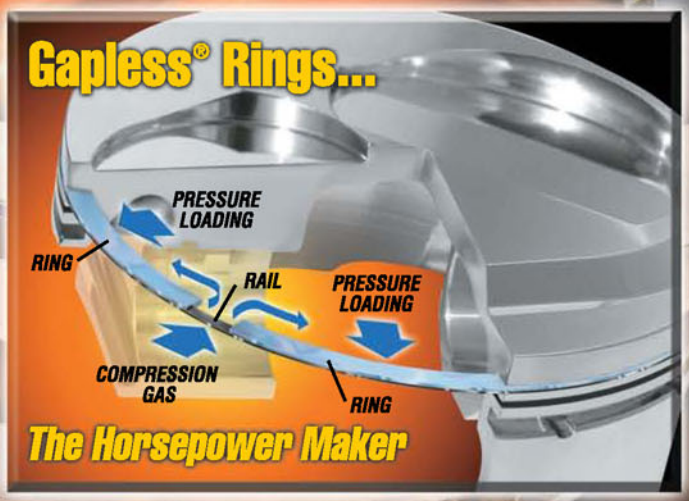

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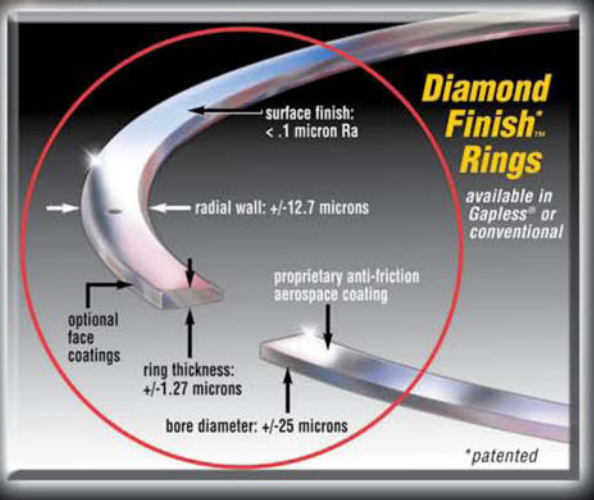

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Off-road suspension

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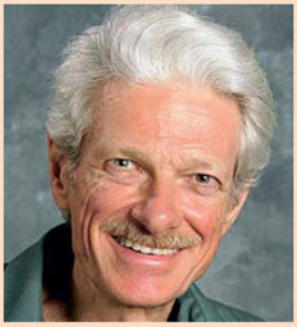

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QUESTION

I am currently designing a new off-road racecar. My current racecar uses trailing arm suspension both front and rear.

For the new car I plan to increase the suspension travel, and want to change the front suspension to parallel equal wishbones, and retain semi-trailing rear suspension.

I have been told that the combination of these two suspension types will cause the car to pitch (bounce), and become unstable. By changing the front suspension, I am trying to eliminate the issue of camber change during cornering. This can cause the wheels to 'tuck under', and roll the car in short course racing, where wheel ruts have developed.

I have also noticed with VW Beetle-based racecars that bounce seems to only occur at certain speeds.

Is there a way of calculating trailing arm length/angle to control the pitch of the car, and would reducing the size of the rear tyres also reduce the bounce?

There is no suspension that can keep a car from rolling if it hooks a rut really hard. Best hope is that it doesn't make a bad situation worse

THE CONSULTANT SAYS

I'm not as conversant with off-road cars as with oval track and road race ones, but I think I can help a bit.

There is no suspension that can keep the car from bicycling or rolling over if it hooks a rut really hard. The best we can hope for from the suspension is that it doesn't make a bad situation worse. And even that is a bit tricky. If the roll centre is low – ie if there is little geometric anti-roll – the cg will translate more toward the wheel(s) hooking the rut as the car rolls on the suspension, and that may make the car more prone to rollover. If the roll centre is high, the tendency will be for the car to jack when it hooks the rut. This will raise the cg and make the car more prone to rollover that way.

The suspension on VW Beetles that really has a tuck-under problem is the swing axle rear suspension, not the trailing arm front. That's why VW went to a semi-trailing arm design for late Beetles, and most off-road cars nowadays likewise use either pure trailing arms or semi-trailing. I doubt that VW-style trailing arm front suspension makes the car more prone to rollover upon hooking a rut. It does have zero camber recovery in roll: the wheels lean with the sprung structure.

However, parallel control arms also have zero camber recovery in roll. As seen in off-road vehicles, they usually slope upward toward the frame, and create more anti-roll than pure trailing arms, but not more camber recovery in roll. If anything, the increased anti-roll makes the car more inclined to jack up when it hooks a rut.

The anti-roll and the jacking are inescapably related. The geometric roll resistance comes from the jacking forces. The outside wheel's suspension tries to jack up when the tyres make lateral force, and the inside wheel's suspension tries to jack down, and that fights the roll. In hard cornering, the outside tyre makes more ground plane force than the inside one, so the car jacks up overall.

It is possible to arrange A-arms or trailing arms to produce some camber recovery in roll. This involves making the A-arms non-parallel, or making the pivot axes of the upper and lower trailing arms non-parallel in front view. I generally recommend doing that. As ballpark recommendations, for independent suspension, I suggest front view swing arm lengths between 65 and 100 inches (two to three metres or a bit less), or camber gain as measured on the shop floor around 0.6 to 0.9 degrees per inch. This strikes a reasonable compromise between camber change in ride and camber change in roll, for a wide range of vehicles. The wheels then lean about three quarters to a bit more than half as much as the sprung structure in cornering, plus a bit more due to various compliances. Longer front view swing arm lengths may be desirable where camber control in ride is a priority.

Off-road tyres tend to be camber-insensitive, due to tall sidewalls, compliant carcass design, and low inflation pressures. Some are also made with rounded tread profiles to make them even more camber-insensitive. Even so, it is better to have good camber properties in the suspension than not. However, minimised camber change in roll should not be counted on to keep the car from overturning when it hooks a rut. It is doubtful that it provides any benefit at all in that regard.

Suspension geometry does influence pitch due to ground plane forces – forward, rearward, and lateral forces at the contact patches. However, suspension geometry has little influence on oscillatory behaviour in response to bumps. That's mainly a matter of springing and damping. I would not shy away from using A-arms in front to avoid problematic oscillations due to bumps.

I would, however, study the science of oscillatory behaviour in suspension systems. This is a

subject for at least a chapter in a vehicle dynamics text, but I will try to address it a little.

First of all, there isn't one single way that things in the system can oscillate. There are multiple masses and compliances, and different ways that things can move. I think the questioner is describing an oscillation of the sprung mass, especially at the rear, in response to either a single sequential disturbance at the front axle and then the rear one, or a series of these.

All oscillations in suspension systems are sensitive to excitation frequency. The system has natural frequencies for its various modes of oscillation, and when the system is excited at a frequency close to any of those, resonant reinforcement will occur. Excitation frequency on bumps depends on the frequency of bumps with respect to distance, and the distance the car travels with respect to time, which is its speed.

Pitch and bounce have specific meanings in vehicle dynamics, and they are not the same. Pitch can have at least three meanings, although all of them are somewhat related. It can mean angular movement of the sprung mass about the transverse (conventionally the y) axis. It can mean equal and opposite displacements of the front and rear suspensions. It has a third meaning in ride engineering, which is the one that concerns us here.

In ride engineering, pitch is the movement of the sprung structure in response to the application of a pitch moment, with no vertical or other forces. In all cases, one end of the car will go up and the other will go down, but usually not equal amounts. There will then be some point along the wheelbase where vertical displacement is zero. This is called the pitch centre. Its location depends on the wheel rates in ride at the two ends of the car. It does not depend on the location of the sprung mass cg, nor on the suspension geometry. Note that this is not pure pitch in the sense that we would use the term in describing modal suspension displacements. It normally involves some heave in addition to pitch. So, a somewhat different use of the word.

Here, bounce is the movement of the sprung structure in response to a vertical force applied at the sprung mass cg, with no rotational or other force. This causes same-direction displacements at the front and rear, but not in equal amounts. Unequal front and rear displacement implies a centre of rotation either ahead of the car or behind it. This is the bounce centre. Its location depends on the wheel rates at the two ends of the car, and the location of the sprung mass cg, but not on the suspension geometry.

For cars with no front/rear interconnective springing, the best ride is obtained when the pitch centre is near the middle of the wheelbase or slightly aft, and the bounce centre is a considerable distance behind the car – say three to five times the wheelbase. To get this, the front static deflection (sprung weight divided by wheel rate) has to be greater than the rear, yet front and rear wheel rates need to be similar. This is only possible when the car is at least somewhat nose-heavy.

In a very tail-heavy car, we cannot have both at once. If the pitch centre is near the middle of the wheelbase, the bounce centre will be ahead of the car. If the bounce centre is behind the car, the pitch centre will be well to the rear of the wheelbase midpoint.

A pitch centre near the rear axle will result in the front of the car rising a lot under power and dropping a lot in braking. This is a problem if we have a splitter, valance or front wing that needs to be kept a controlled distance from the ground. On an off-road car, it may be OK, but the front suspension has to have lots of travel. Unless the rear tyres are much larger than the fronts, a large front anti-roll bar and/or a high front roll centre will be needed to curb oversteer. On rear-engined buggies, the rear tyres are often much larger than the fronts.

By far the more common approach with a tail-heavy car is to have the front static deflection a good deal smaller than the rear; the front end is stiffer than the rear, relative to the weight it carries. The bounce centre is then ahead of the car. This works decently, provided the bounce centre isn't too far ahead of the car. As a rule of thumb, we want it one to two wheelbase lengths ahead of the front axle line. That is, we want the front static deflection around half to two-thirds of the rear. In other words, we need a front static deflection that is either moderately greater than the rear or considerably smaller. If the front static deflection is similar to the rear or just slightly smaller, we get a lot of rear suspension movement on the second oscillation following a large, short disturbance such as a speed bump or raised railroad crossing.

If the suspension is fairly heavily damped with respect to its springing – ie if it has a fairly high damping ratio – there won't be much of a second oscillation, and all this won't matter very much.

The questioner mentions the role of tyres. Certainly when the tyres are very compliant, they become a significant part of the overall springing. In off-road vehicles, this is the case, although the rest of the suspension is soft too. The tyres need to be big and compliant to provide ample traction and flotation. Unfortunately, it's hard to damp a tyre. The shock can't act on the tyre sidewalls. They have some damping internally, but not enough. The only way to damp oscillation on the tyres is by inertia damping. That's why inertia damping was hot in F1 for a while, until it was banned. (I understand some teams are still incorporating inertial elements in the suspension, but that's not really equivalent.) The tyres are a large part of the springing on those cars, not because the tyres are highly compliant but because the rest of the system is very stiff.

Front suspension needs lots of travel in the American Rock Sports Challenge

When the tyres are very compliant, they become a significant part of the overall springing

INERTIA DAMPING

Lightly sprung and damped passenger cars quite often use inertia damping. The engine/transmission assembly has soft rubber mounts, and these and the front suspension are deliberately tuned to have natural frequencies that create interference rather than reinforcement. It would be quite possible to apply the same principle at the rear of a buggy.

This would involve knowing the spring rate of the tyres, and a representative rate for the rubber motor mounts, which are quite non-linear. A given set of mounts would only be right for a particular range of wheel rate and tyre spring rate combinations. Still, if done right, this could offer some advantage.

Returning to the original question, I would not shy away from using A-arm front suspension. But I would be careful, when taking advantage of the longer arms to use more travel and softer front springing, to not get the front static deflection or natural frequency in the range that creates an unfavourable relationship with the rear.

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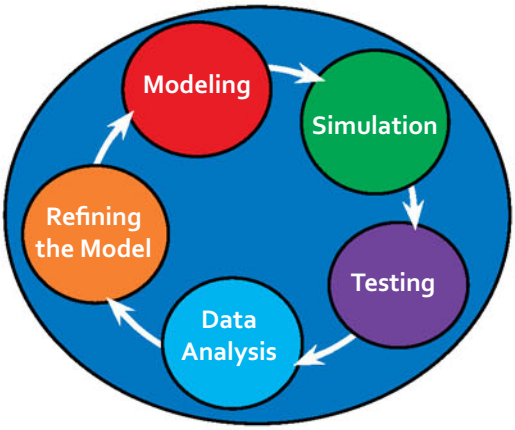

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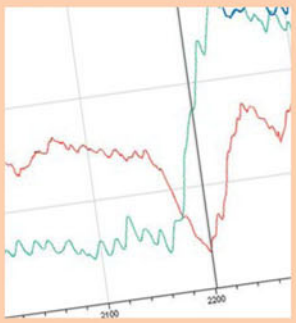


Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

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

How to estimate drag coefficients

A quickfire briefing on the way to arm yourself with vital aero information without the need to conduct coast down tests

With aerodynamics dominating the world of motorsport, engineers are more interested than ever in the aerodynamic performance of the vehicle. It is widely appreciated that the optimal aerodynamic setup for a car is a trade-off between lift and drag. This article will look at estimating the drag coefficient for a vehicle without the need for coast down tests. Not only is the drag coefficient useful in aerodynamic performance analysis, it is also required in order to calculate the power produced by the vehicle. By calculating the forces due to drag and rolling resistance, the resultant force can be attributed to the engine and therefore the engine power can be calculated.

In this example, the drag is calculated by comparing the vehicle acceleration at two different speeds, the first being at low speed, where drag is low, and the second being at high speed, where drag is high. They are compared at full throttle, over the same engine rev range so it can be assumed that the engine power produced in both cases is equal. Rolling resistance is assumed to be equal in both cases and the gear ratio is accounted for. The resulting difference in acceleration can be attributed to a difference in drag force, from which the coefficient of drag can be calculated. See **Equations** below.

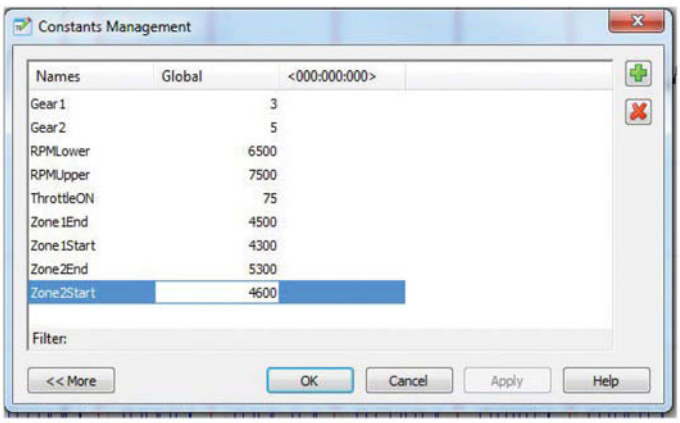
The first step is to define various qualifiers to define the two zones and eliminate as many sources of error possible. The following qualifiers are used:

Equations

$$Drag\ Force = \frac{1}{2} * \rho * C_D * A * V^2$$

Where ρ= air density, A = vehicle frontal area, V = vehicle velocity and C_D = coefficient of drag
Rearranging to make C_D the subject gives

$$C_D = \frac{2 * Drag\ Force}{\rho * A * V^2}$$



This example has two zones defined at the start and the end of a straight

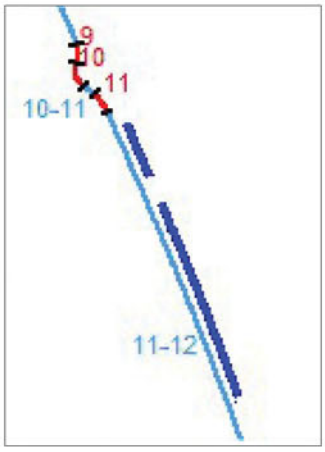
QUALIFIERS

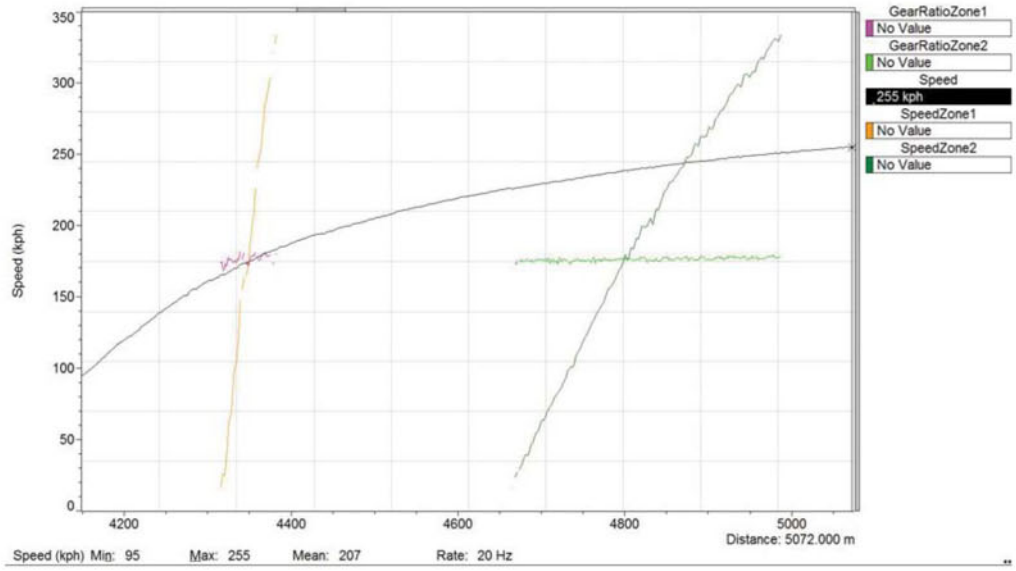
Qualifyer Zone 1
choose([RPM in range]+[Throttle in range]+[Zone1]+[GearZone1] == 4, 1, 0)

Qualifyer Zone 2
choose([RPM in range]+[Throttle in range]+[Zone2]+[GearZone2] ==4, 1, 0)
Each of the channels reference constants so that they can be edited easily. This allows the following parameters to be set:

Zone Distance Start
Zone Distance End
Lower RPM Limit
Upper RPM Limit
Throttle On threshold
Gear

Not only is the drag coefficient useful in aero performance analysis, it is also required in order to calculate the power produced by the vehicle





Using a gating Function, the speed in each zone can displayed

SpeedZone1
gate([Qualifyer Zone 1], [Speed])
By taking the speed at the start of the zone and the speed at the end, the average acceleration for the zone can be approximated by calculating the change in speed divided by the time taken.
Gear ratio is also calculated by dividing Speed by RPM for each zone. So long as the vehicle is in the same gear, this value should be more or less constant.

GearRatioZone1
gate([Qualifyer Zone 1],([Speed]/[Team RPM]))

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Average Gear Raio	Average Speed difference (m/s)	Average Acceleration (m/s^-2)	Average Speed (m/s)
0.025542	4.97	3.62	48.42

Lap Number	Time start (s)	Time end (s)	Time difference (s)	Gear	Gear Ratio (avg)	Speed start (kph)	Speed end (kph)	Speed difference (kph)	Acceleration (kph/s)	Average Speed (kph)
1	89.80	91.88	2.08	3	0.025649	165.40	192.78	27.38	13.16	179.09
2	88.75	90.97	2.22	3	0.025584	165.90	192.86	26.96	12.14	179.38
3	92.04	92.04		3		165.24	165.24			165.24
4	92.04	93.54	1.50	3	0.025524	165.24	185.12	19.88	13.25	175.18
5	86.65	88.03	1.38	3	0.025506	164.90	183.04	18.14	13.14	173.97
6	88.42	88.74	0.32	3	0.025577	166.10	170.24	4.14	12.94	168.17
7	88.56	88.72	0.16	3	0.025523	166.72	167.84	1.12	7.00	167.28
8	85.32	85.32				163.32	163.32			163.32
9	85.32	87.28	1.96		0.025432	163.32	190.96	27.64	14.10	177.14

Heading	Value	Unit
Gear 1 Gear	3	-
Gear 1 Ratio	0.025542	-
Gear 2 Gear	5	-
Gear 2 Ratio	0.034842	-
Acceleration Ratio	0.733092	-
Acceleration Gear 1	3.617	m/s^2
Normalised Acceleration	3.617	m/s^2
Acceleration Gear 2	1.397	m/s^2
Normalised Acceleration	1.905	m/s^2
Drag Acceleration	1.712	m/s^2
Drag Force	2139.503	N
Velocity	66.846	m/s
Vehicle Mass	1250	kg
Frontal Area	2.100	m^2
Air Density	1.200	kg/m^3

Coefficient of Drag	0.38001

The drag acceleration is estimated by calculating the difference in the 'normalised' accelerations between the two zones. The normalised accelerations take into account the gear ratio cancelling out the expected change in acceleration due to the gearing. This leaves a difference in acceleration due to the change in drag only, from which the drag force is calculated using F=ma. This force represents the drag force in the high speed zone only, as the drag in the low speed zone is assumed to be zero. By using the velocity in the high speed zone, the coefficient of drag can be calculated from the initial derivation, with the user only being required to provide three values – vehicle mass, the frontal area and the air density.

Between the data analysis package and Microsoft Excel, values are calculated quickly and easily giving a drag coefficient representative of real life. The accuracy of this value can be improved by averaging over more runs and gaining accurate values for the vehicle mass, frontal area and air density. These techniques can then be used in situations such as information gathering about the competition, or if a series organiser wants to make that sure the playing field is even.

COSWORTH

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A surprise package

Continuing our aerodynamic studies of a 1970s Lola sports racer, where the quest for gains is providing some puzzles

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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Sports racing car design may have evolved in the 35 years since this two-litre Lola T390 BDG originally raced, but the air flowing over racecars hasn't changed, at least not in the way it creates aerodynamic forces! So the chance to put such a car in the wind tunnel, something that probably didn't happen in its original era, was not to be passed up. This particular car had recently been restored by Gerry Wainwright Motorsport, who kindly prepared it for our session.

Back in the day, it seems that the T390 suffered from a shortage of front downforce, and photos taken 'in period' show some fairly radical splitter and end fence arrangements. The car's restoration provided a relatively modest but practical splitter, and pre-wind tunnel session track testing had revealed inherent aero understeer. And this was backed up by the wind tunnel, the initial baseline run showing a fairly meagre 10 per cent of total downforce on the front wheels, as reported in last month's column. However, with some rear ride height adjustments and judicious taping up of part of the front radiator inlet aperture, this was fairly easily converted into a satisfactory 37.7 per cent of total downforce on the front, given the car's static weight split of 42 per cent front, 58 per cent rear.

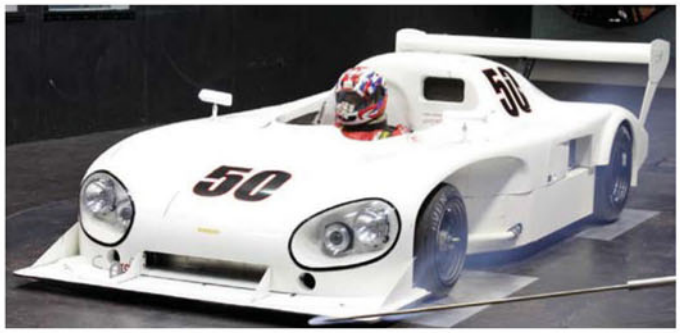
DOWNFORCE DELVINGS

But with the admittedly quite large chord rear wing at a very modest angle, total downforce was relatively modest, so once it was clear that a satisfactory balance could be obtained, efforts shifted towards improving overall downforce and efficiency. The final configuration change reported last month saw us tape over the large rectangular aperture next to the driver's head that was allowing air into the engine compartment and, as hoped, this improved drag and rear downforce, but left the balance at just 35 per cent front. Given that there was endless scope to increase rear downforce with a rear wing angle increase, attention moved to the front end again.

With the need to keep the Lola's appearance 'in period', and without the option of changing to a longer splitter during the session for practical reasons, the simplest option was to try out some of the variations of splitter end fence that appeared in original photos. Indeed the car was delivered to the wind tunnel with modest triangular end fences plus a couple of smaller triangular fences inboard, either side of the radiator inlet aperture. The first change was to extend the outboard fences into rectangular ones of the same height. The results in terms of data and the changes to the data (in 'counts' where 1 count = a coefficient change of 0.001) are shown in **Table 1**.

So this simple modification shifted an extra 6.3 per cent of the downforce on to the front end, also increasing total downforce by over 4 per cent. Although drag increased by over 3 per cent, there was nevertheless a very small increase in overall efficiency. Rather like some configurations of dive planes then, this first end fence extension was a potent if not very efficient balance shifter, whereas a slightly longer splitter would probably have yielded the same front downforce gain with little, if any, drag change.

Earlier in the session the rear ride height had been increased in two 10mm increments to help shift the aerodynamic balance forwards. The response was beneficial and essentially linear, but given that a 20mm increase



End fences on the splitter could be seen to modify the airflow around the front corners of the Lola T390 BDG

End fence iteration 1 produced a significant effect

Removal of the inboard splitter fences had a modest effect

seemed somewhat excessive from a mechanical dynamics viewpoint, and that it seemed possible to gain front percentage by other means, the rear ride height was lowered by 10mm again to give a more equable compromise. The aerodynamic data arising are given in **Table 2**.

This, then, showed quite a step backwards in total and front downforce, and also in balance and efficiency, but the rear ride height was one that could be lived with. So efforts to obtain front end gains were resumed, and next up came the removal of the inboard triangular fences each side of the radiator inlet aperture. This yielded the results in **Table 3**.

This produced a little more front downforce for no penalties, and although a minor benefit, it was a step in the right direction.

There then followed three further iterations of splitter end fence, which for brevity will be tabulated and described together to allow a few questions to be asked! Splitter end fence iteration 2 was a larger, taller triangular shape; iteration 3 was an even bigger triangular shape; while iteration 4 was a rectangular shape of the same height as iteration 1 but extended forwards to the full length of the splitter. See **Table 4** for the results relative to those in the previous configuration in **Table 3**.

This then was a mixed bag. Iteration 2 sprang a surprise by being a backward step (in downforce and balance terms) for reasons that are still not clear despite much post-session pondering. The only positives were a slight drag reduction and a slight rear downforce increase, both unexpected and neither of which was being sought at this point! Iteration 3 produced the biggest forwards balance shift (just). And iteration 4, the extended rectangular fence, was clearly the best of the group in terms of total downforce, balance shift and efficiency. The general conclusion appears to be that there needed to be some height to the forwardmost part of the fence, but that extra height at the rear of the fence was either no advantage or a disadvantage.

Taking the best of these splitter end fence configurations then, the %front figure was now 45.7 per cent, some way in excess of the target value of 37-38 per cent. This paved the way for adding some more rear downforce to achieve a balanced, higher total downforce setup that would hopefully engender safe and predictable mild understeer at aero speeds.

Next month: we'll round off this particular study with some final balancing acts, another idea that didn't work (together with accompanying excuses), and the application of some more race tape.

Racecar's thanks to Gerry Wainwright Motorsport

Table 1: the effect of extending the splitter end fences, iteration 1, changes relative to the previous configuration

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Iteration 1	0.522	0.580	0.243	0.337	41.4%	1.111
Change, counts	+17	+23	+47	-25	+6.3%	+0.008

Table 2: the effects of dropping rear ride height by 10mm again

	CD	-CL	-CLfront	-CLrear	%front	-L/D
RRH -10mm	0.513	0.488	0.150	0.338	30.7%	0.951
Change, counts	-9	-92	-93	+1	-10.7%	-0.160

Table 3: the effects of removing the inboard splitter fences

	CD	-CL	-CLfront	-CLrear	%front	-L/D
- inboard fences	0.513	0.492	0.155	0.337	31.5%	0.959
Change, counts	0	+4	+5	-1	+0.8%	+0.008

Table 4: the effects of various end fences relative to the configuration in Table 3

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Iteration 2	-7	-29	-37	+8	+6.0%	-0.044
Iteration 3	+30	+11	+76	-65	+14.4%	-0.033
Iteration 4	+18	+46	+91	-45	+14.2%	+0.054

End fence iteration 2 produced a major surprise...

End fence iteration 3 was fairly potent...

...But end fence iteration 4 was the pick of the crop

Opening up the rulebook

In 2014, Balance of Performance at Le Mans will provide headaches – but there looks set to be a lot of freedom for manufacturers

BY PETER WRIGHT

There are many definitions of competition, but the one that applies best to motorsport is: 'a test of skill and ability'. The radical changes to the nature of competition in both F1 and WEC for 2014, from pure performance to a performance/unit of energy, will really test the skills and ability of those taking part, including drivers, engineers, manufacturers and teams.

But there is another aspect of competition that is going to affect all those who participate in F1 and WEC: competition is what drives evolution. In Darwinian terms, when the environment changes, species have to compete under new conditions – the fittest survive and thrive. To adapt, they mutate, and natural selection determines the successful variations. Both F1 and WEC are going to change, in that the successful drivers, cars, manufacturers and teams will not necessarily be the same as currently.

In the WEC and for Le Mans in particular, the ACO has brought its experience with hybrid LMP1 cars together with the FIA's experience of KERS in F1, to draw up an ambitious set of regulations for 2014. The ACO has never shied away from offering competitors a range of potential solutions

The ACO has never shied away from offering competitors a range of potential solutions

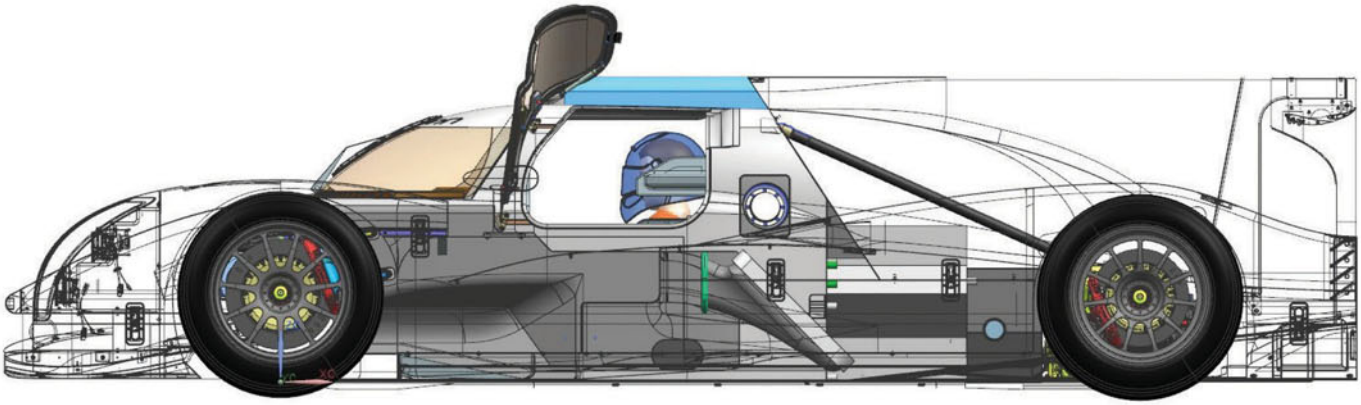
to a competition task, and have managed to balance the performance of the offered technologies so that no one technology dominates and drives all others to extinction. In endurance racing there has always been an element of efficiency in determining performance over the 6-24 hours that make up the majority of races. Once diesel engines were permitted and understood, their outright performance had to be balanced with gasoline engines using intake orifice diameter, and their efficiency balanced by the maximum fuel tank size. For 2014 it is an order more complex.

The 2014 WEC regulations have allowances for a broad set of configurations to be chosen by the constructor, balancing:

Fuel type v fuel energy/lap v maximum fuel flow rate v tank size (total refueling time) v recovered energy used/lap.

A technology factor balances gasoline v diesel v energy, being made up of the product of a fuel technology factor and a K technology factor, which sets out to balance the weight differences of different powertrain and energy recovery systems.

This is the factor that is then used to determine the energy/lap balance.



Major body panel rules are essentially unchanged, while at the rear the maximum wing height is 950mm - there is no minimum

Audi ran an experimental car at the Le Mans test to help Michelin prepare tyres for 2014 using live track data

What is remarkable for motorsport regs in this day and age, is how much is free, taking in:

- **Number of cylinders**
- **NA or turbo**
- **Gasoline or diesel**
- **RPM**
- **Boost (up to 4 bar)**
- **Engine capacity**
- **Compression ratio**
- **Injection pressure**
- **Powertrain weight**
- **Source of energy recovery - two systems allowed**
- **Power of energy recovery system (ie rate of energy recovery and return)**
- **One or two axles used for energy recovery and delivery**
- **Choice of energy returned/lap v fuel used/lap**
- **Energy storage system**

If a manufacturer has not decided whether it wishes to promote gasoline or diesel, it must take the table balancing numbers for each of the performance factors, assemble its best technology for IC engines and ERS, including power, efficiency, weight, storage capacity etc, and start simulating.

The core processors at Audi, Porsche, and Toyota must have cooked themselves during this concept phase as combination after combination has been simulated. Of course the results must be combined with aerodynamic data, tyre data and will be highly circuit dependent. How each circuit is weighted (WEC championship v Le Mans) is up to each competitor, but he must also take into account the differing requirements of qualifying, race, actual race pace, race length, weather conditions, yellow flags, safety cars and traffic. In this respect, there are few substitutes for recent endurance racing experience, although statistical analysis of preceding seasons will be carried out.

The balancing values published by the FIA/ACO are based on discussions with manufacturers, powertrain dynamometer tests, plus simulation. Of course the only people who actually know what is possible technically and what may be so in the future are the manufacturers... and they are the competitors.

Toyota have raced a gasoline, port-injection, NA V8 for the last two years, and word has it that they will continue with it in 2014

If we assume that the FIA/ACO have got their numbers right - and at this stage there is no reason not to - how will the three manufacturers resolve them into LMP1 configurations? Party to the regulation writing and balancing calculations, they must think they know where the possibilities lie to gain an advantage, so it is interesting that they have come up with such different solutions.

Toyota have raced a gasoline, port-injection, NA V8 for the last two years, and rumour has it that senior management back in Tokyo have decreed that they must continue into 2014 with the same engine. A strange decision, until one looks at their hybrid road car powertrains and sees that they are all gasoline NA powered. Instead, Toyota are going for the maximum ERS, though they will deny themselves any waste energy recovery from the exhaust - they will use the two axles as their permitted two ERS. Planning to fit a motor/generator to each axle for maximum kinetic energy recovery and subsequent acceleration, it is believed they will use 2013 systems to give a total 600cv electric power from their Nisshinbo capacitor storage system. 1150cv total and 4WD should catch their drivers' attentions and be invaluable when dealing with the traffic. As Sébastien Loeb said about the Pikes Peak Peugeot: 'That is one

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(Top) LMP1 concept for 2014 from Yorkshire, UK-based manufacturer Perrinn; (above) Dome's S103 LMP1 model is put through its paces in the wind tunnel

horsepower for each kilogram – think about it!'. The Toyota drivers will have more than that on full tanks. The issue will be how long a tank of fuel lasts.

Toyota believes that its gasoline NA engine technology is the way forward for road cars, in contradiction to Europe's belief in the downsized, turbo GDI. It is not known whether they will put direct injection on their LMP1 engine – Porsche has shown that it is possible on a high-revving engine, but it is a big programme. Not to do so would be surprising, as the economy benefits are well proven.

With around a minute's braking in a 3 1/2 minute lap of Le Mans, and around 11MJ of energy to be harvested with a 600cv (450kW) system, Toyota should be able to fully exploit the 8MJ allowance – just under 18 seconds of full electric power to both axles. With the ACO's stated desire that the hybrid part of LMP1s should be used to improve economy not performance, it makes sense to use this performance boost mainly for dealing with slower traffic (LMP2s and GTEs), so minimising loss of performance.

It is alleged that, when Porsche let it be known that it would be developing an LMP1 car for entry in 2014, the management of Audi – and Audi Sport in particular – was somewhat shocked. One must presume that someone high up in the VW-Audi Group, which owns Porsche, approved this in-house competition, and perhaps decided to hedge their corporate bet by allowing both diesel and gasoline approaches to interpreting the Le Mans regulations. The one and just about only thing that is certain about the Porsche is that it is a gasoline-powered car. Both Audi and Porsche are endurance racers and both know how to win Le Mans, so expect no technological stone to be left unturned. Not much else is known about the Porsche powertrain, but it is bound to be GDI. For efficiency it no doubt will be turbocharged and Porsche has plenty of turbo experience. Capacity and the number of cylinders have not yet been stated, but power is effectively limited by the fuel flow of 95-87.3kg/hour, depending on the selected energy returned by the ERS system. Rumours include four cylinders in line, V6, flat-6, and V8, covering most eventualities! The capacity will be traded against RPM, max boost being set at 4 bar, and the number of cylinders will be as few as possible compatible with the optimum cylinder capacity of 300-350cc. So the engine is likely to be 1.5-2 litres, and either four or six cylinders.

A comparison with the 2014 F1 engine rules is interesting:

- **1.6 litres, V-6**
- **15,000rpm maximum**
- **No boost limit**
- **100kg/hour max fuel flow**
- **500 bar maximum fuel pressure**

While F1 fuel is tightly controlled by the regulations with suppliers free to formulate within them, WEC fuel is from a single supplier

Six cylinders are too many for an optimum 1.6 litres, and no one will go as high as 15,000rpm due to the friction and pumping losses effect on efficiency. It is all like this for the theoretical benefits of the noise produced. As a result, the Porsche engine is likely to be more efficient than an F1 engine, though the latter can use a higher boost pressure, subject to fuel, and will undoubtedly be subject to a great deal more research and development expenditure. It may well all come down to the fuel specification difference between the two formulae.

Taking as a given that both fuels have very similar energy contents, though, it should be noted that this is not specified in the F1 regulations. These rely on the tight specification of the permitted hydrocarbons, and there may well be significant differences in the gasoline characteristics sought after by the manufacturers who are racing a turbo engine, striving for optimum power/unit of energy flow rate, ie efficiency.

For thermodynamic reasons the WEC gasoline engine engineers will want to run the highest possible pressure ratio – the combination of first stage compression in the turbo compressor and second stage compression in the cylinder, ie the compression ratio. Then they will always try to run as lean an air-fuel ratio as possible, limited by detonation. The fuel specification can help in two ways: charge cooling and octane rating. With GDI, there is little opportunity to use the evaporation of the fuel to cool the charge, so delaying detonation must be the prime consideration.

While the composition of F1 fuel is tightly controlled in the regulations, with suppliers free to formulate within those restrictions, WEC fuel is from a single supplier. It would have been fascinating – and probably pretty baffling to anyone other than a fuel chemist – to have sat in on the WEC Fuel Working Group sessions, as Porsche, Toyota, and anyone else with an interest (Nissan, and even

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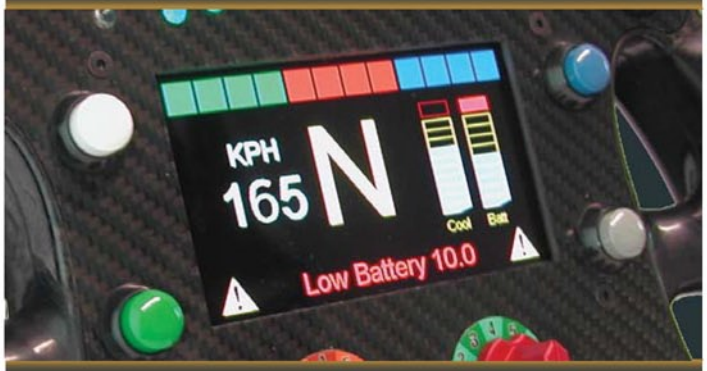

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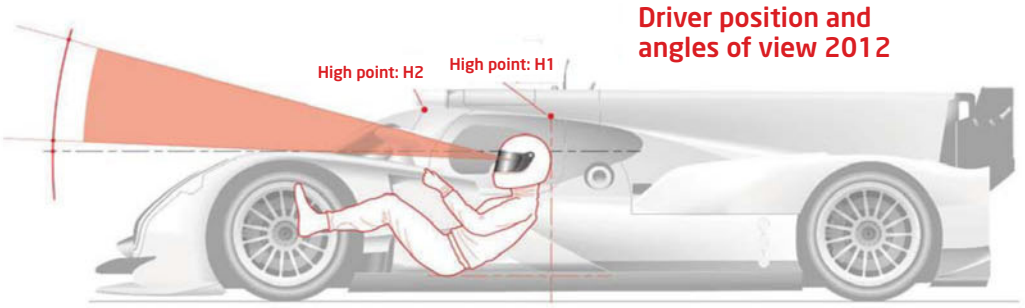
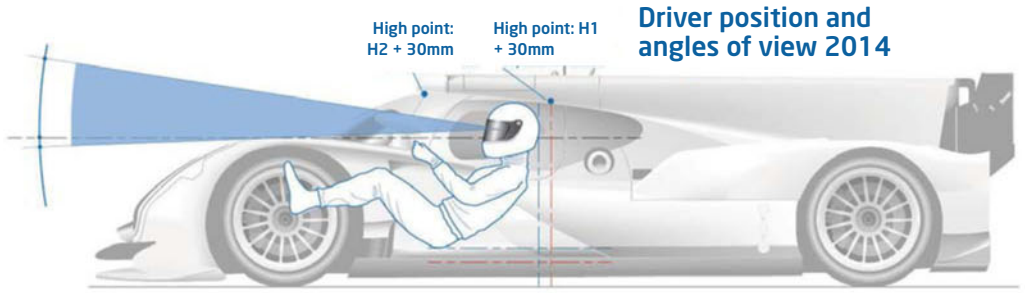




VALUES OF ENERGIES AND POWER FOR LE MANS CIRCUIT

		No ERS	ERS OPTIONS			
Released energy	MJ/Lap	0	< 2	< 4	<6	< 8
Released power	kW	0	Not limited	Not limited	Not limited	Not limited
Car mass	kg	850	870	870	870	870
Petrol energy	MJ/Lap	150.8	146.3	141.7	137.2	134.9
Max petrol flow	kg/h	95.6	93	90.5	87.9	87.3
Petrol capacity carried on-board	l	66.9	66.9	66.9	66.9	66.9
Fuel technology factor	-	1.061	1.061	1.061	1.061	1.061
K technology factor	-	1	0.983	0.983	0.983	1
Diesel energy	MJ/Lap	142.1	140.2	135.9	131.6	127.1
Max diesel flow	kg/h	83.4	83.3	81	78.3	76.2
Diesel capacity carried on-board	l	54.8	54.8	54.8	54.8	54.8

perhaps Audi) thrashed out the gasoline specifications. Porsche would have lobbied hard for those components that would help a turbo, namely those that influence the octane rating. F1 fuel must include 5.75 per cent of 'bio-components' which are defined tightly in the regulations. The WEC undertakes that the gasoline will be 20 per cent 'bio basis' and diesel 10 per cent. It is well known that most of the biofuels, such as ethanol, methanol and isobutanol, raise the octane rating.

With its single-source policy, precise definitions are not required. My guess, and it is only a guess, is that Porsche were highly influential in the specification discussions, and that the 'bio' part was worked hard. Audi meanwhile, with a wealth of data on their V-6 turbo-diesel, are likely to have to abandon their maximum power option and concentrate on economy. What this will mean in terms of the trade-off between capacity, rpm and boost, we will have to wait and see. The key to diesel economy relating to fuel is to ensure complete burning of the droplets, and the lack of a limit on fuel pressure will assist them in reducing droplet size.

Both of the turbo-engined protagonists, Porsche and Audi, will use energy recovery from the engine exhaust as one of their two permitted ERS, and therefore will be confined to kinetic energy recovered from and returned to just one axle: the front one. Simulation shows that there is a negative performance and economy return from adding weight to the car to increase the capacity of the energy store, and so all competitors will be limited in their energy recovery specification by the weight limit. Toyota, with a gasoline NA engine, will be able to fit the largest (heaviest) storage, Porsche next, and Audi – with its heavier diesel – the least. Toyota will stick with capacitors, Audi with the WHP flywheel, and if Porsche marketing has anything to do with it, they will use batteries. The variety of solutions suggest that there is no clear 'best' way forward, and if that turns out to be so, then the FIA and the ACO will have done their work well.

Both Porsche and Audi will use energy recovered from the engine exhaust as one of their two permitted ERS

Provided we are allowed to see how Porsche and Audi have each set out to optimise the use of the two different fuels, the Germanic technical fight will be surely the most fascinating in motorsport for many years, watched by fans and road car manufacturers alike. It is likely that one or other will take the spoils at Le Mans, but don't discount the Toyotas. They are building a very powerful car that could make for a very effective racing machine in the crowded WEC environment. Given some breaks with weather and safety cars, as in 2013 they could surprise.

As for mutations in the future, the regulations contain an interesting article:

Non-conventional specifications: cars with specifications which are considered today as unusual in motor racing may be eligible...

- **On the basis of special regulations so as to maintain the Balance of Performance between the cars as well as the safety requirements**
- **Provided the rules established by the administration and by the ASN of the country where the event is organised are respected**

This provides a way forward for Nissan's promise to look at a future LMP1 car based on what it learns from its Garage 56 ZEOD concept. 2014 and beyond holds plenty of promise.

Movements in LMP1 aero

The draft 2014 regulations point to some interesting new directions, including a smaller overall width and a clampdown on blown diffusers

BY SIMON MCBEATH

While never an easily digestible read, the relevant set of technical regulations is always the first port of call of the racecar engineer to determine the restrictions they impose and the freedoms they permit. With a raft of significant and complicated changes relating to the new 'energy allocation formula' for 2014 (see p40), the rule changes relating to bodywork and aerodynamics seem relatively minor in comparison. However, it will be vital for any team aiming to be competitive to design the best overall package, and that they hit the ground running aerodynamically, so to speak. We have examined Article 3: Bodywork and dimensions of Version 06 of the FIA's draft 2014 LMP1 technical regulations to pick out the changes from this year and to highlight the potential ramifications.

In addition to the phased-in 'closed cars only' regulations for LMP1, the key changes for 2014 in draft version 06 are:

- **reduced overall width**
- **adjustable front wing element permitted**
- **rear wing span increased**
- **blown diffusers prohibited**
- **options for locations of wheel arch cutouts**
- **increased maximum height**

So let's look at these in more detail and consider the potential impact.

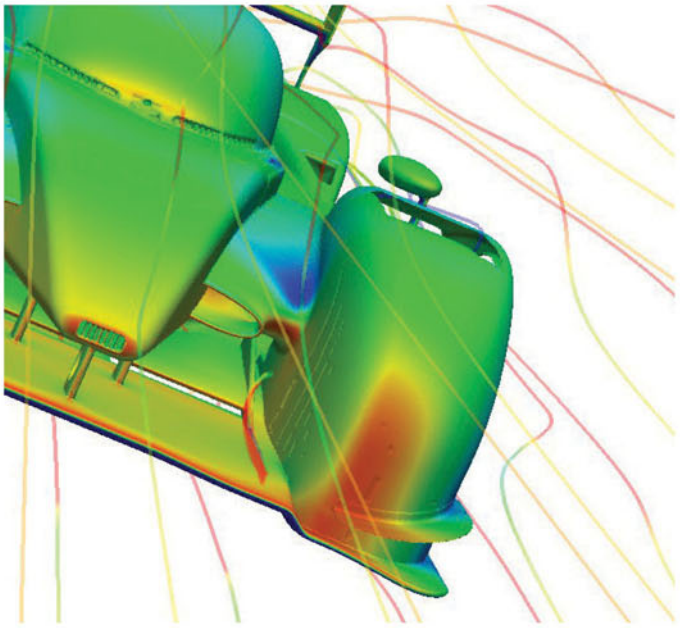
SIZE MATTERS

Draft version 06 states overall width as '1900mm maximum and 1800mm minimum' compared to a maximum of 2000mm up to and including 2013. It seems improbable that anybody will build a car less than the stated maximum width, so LMP1 cars will probably all be 1900mm wide from 2014 until further notice. A 5 per cent reduction in width obviously yields a 5 per cent reduction in frontal area, with attendant 5 per cent reduction in drag if all other things were equal, although they rarely are.

Cars will probably be able to achieve pretty similar and possibly slightly better levels of downforce and efficiency in 2014

Maximum height increases from 1030mm to 1050mm, or slightly less than 2 per cent, this probably to facilitate an increase in the height of the seated driver (to improve the driver's visibility). It will also mean that the top edge of the rear engine cover fin is 20mm higher than previously too. If this height increase is solely to provide more cockpit height, this will add incremental frontal area, but less than the 2 per cent if just the cockpit 'bubble' is 20mm higher. So, with the reduction in tyre width from 15-inch to 14-inch, frontal area is likely to be about 4 per cent less than previously.

The width reduction would also yield a 5 per cent reduction in plan area, the maximum length of 4650mm remaining unchanged, which in turn would lead to a reduction in underbody-generated downforce of similar proportions and perhaps more, given that the disrupted flows around the wheels will have a greater effect on the central areas of the underbody that do most of the work. With this narrower 'working section' in mind, it seems likely that attention will be paid to front diffuser design as well as the deployment of more prominent devices to help in this area, such as the fences seen on the Toyota TS030 at its roll-out test at Paul Ricard in early 2012. With a narrower working span it might also be the case that a more aggressive front diffuser angle could be implemented before stall problems occur, but any such changes will be hard to observe.



On the proposed Perrinn LMP1 car, a pair of front flaps of defined size can be used, which could enable easier tuning of total downforce and aero balance

FRONT FLAP

One additional factor that ought to allow the front diffuser to be worked harder, if needed, is the new front flap element that is explicitly permitted in the 2014 regulations. In full, its definition in version 06 is:

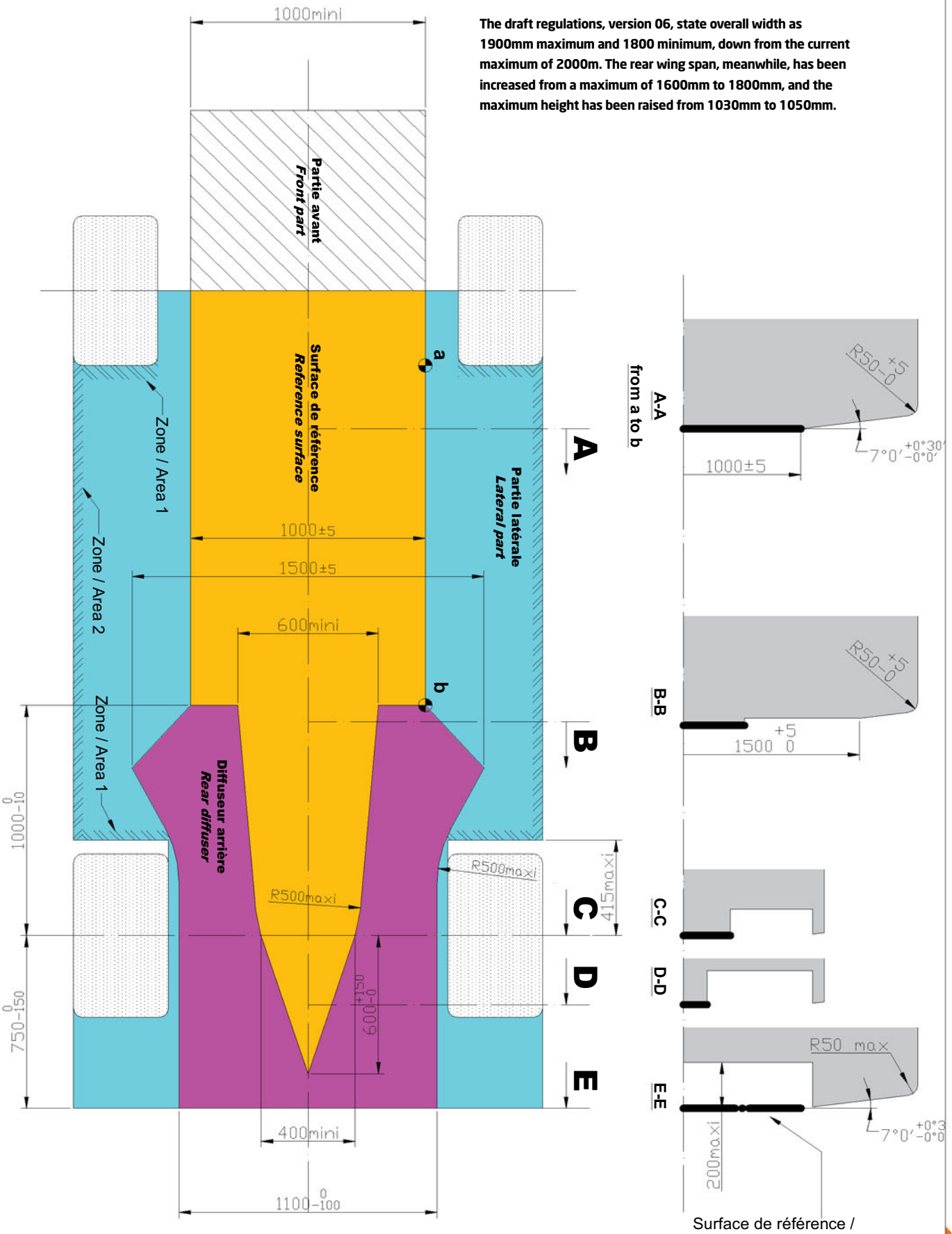
It is permitted to add one wing profile adjustable by means of tools (front flap).

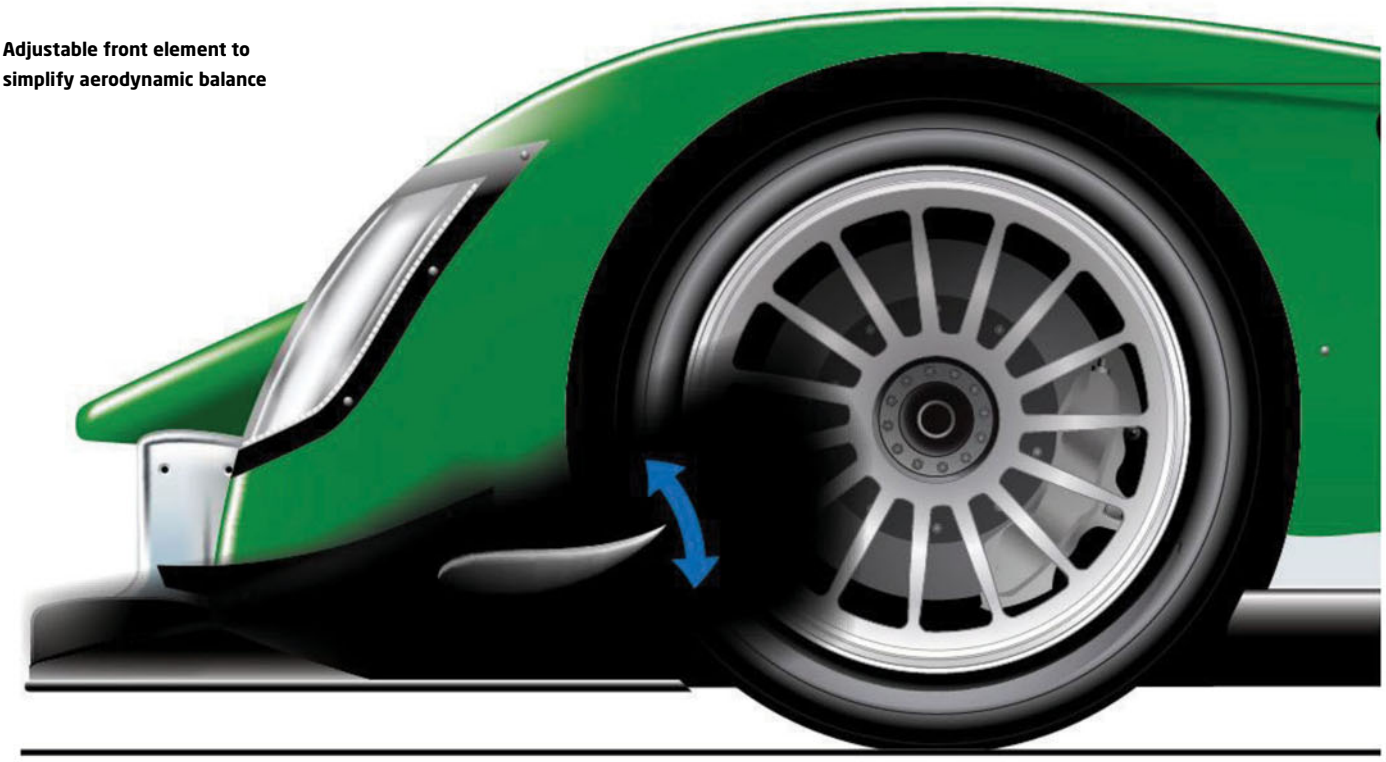
It may be split in two parts symmetrical about the car's centreline. It must be situated:

- **Behind the rear edge (trailing edges) of the elements that form ... [the forward part of the splitter] ... with a longitudinal overlap**

A WHOLE NEW DIMENSION

The draft regulations, version 06, state overall width as 1900mm maximum and 1800 minimum, down from the current maximum of 2000m. The rear wing span, meanwhile, has been increased from a maximum of 1600mm to 1800mm, and the maximum height has been raised from 1030mm to 1050mm.





Adjustable front element to simplify aerodynamic balance

of 30mm maximum and a maximum height of 300mm from the reference surface
- **Between the two volumes around the front wheels... [the wheel arch regions]**
- **In front of the front wheel axle**

In other words, as shown on the Perrinn LMP1 CAD renderings, a pair of front flaps of defined size can be used. These will not only help to augment the performance of the central splitter, which could now be even more akin to the main element of a dual element wing than previously, but they will also enable much easier fine tuning of total downforce and of aerodynamic balance. With front (and rear) overhangs beyond the axle lines unaltered from 2013, the contribution of the principal front end downforce-inducing device may potentially be greater in 2014. With the reduced overall width, however, these gains could be mitigated as even with narrower tyres there will also be slightly less room between the chassis and the wheels for under-splitter airflow to be extracted ahead of the sidepods. This may in part be behind the adoption of the front flap, by way of compensation.

WHEEL ARCH CUTOUTS

Moving further aft on the car, in Version 06 of the regulations there are two options for the front and rear wheel arch cutouts. These were introduced in 2012 as another means of reducing the likelihood of flip overs by reducing lift and overturning moments when cars get sideways. We saw in Aerobytes (*May 2012, V22N5*) with the Greaves Motorsport Zytek LMP2 car in the MIRA full-scale wind tunnel that when running within a 'normal' yaw angle range, the effects of the 2012 wheel cutouts on drag downforce and balance were relatively minor.

The draft rules include some key phrases that are obviously aimed at prohibiting the use of blown diffusers

The 2014 definitions have been altered in some detail respects and made simpler, but also include an option to create the openings in the inner face of the wheel arches rather than the upper surface, apparently to reduce the amount of spray projected upwards in wet weather. It is unclear whether these are options for discussion that are yet to be finalised in the definitive regulations, or options for designers to select from. However it would seem probable that the cut-outs in the inner faces of the wheel arches would be effective at preventing lift from pressure build-up within the arch when a car got sideways and also less disruptive to the aerodynamics of the upper surfaces during normal running.

TAIL FIN

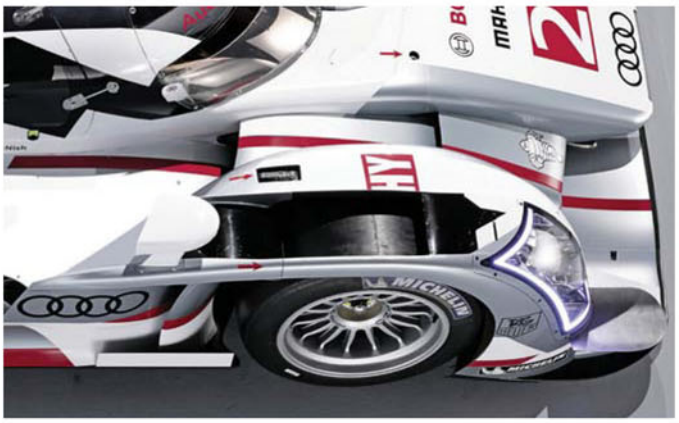
These fins were brought in as yet another device aimed at reducing the chances of flip overs when cars get sideways, the intention presumably being to generate increased pressure on the car's upper surfaces when at very high yaw angles. No doubt there would also be a significant yaw returning moment or rudder effect at high yaw angles too that would help to straighten a car when well out of line. Having said that, when testing the Greaves Motorsport Zytek LMP2 car in Aerobytes last year, we saw very small restorative yaw moments across the 'normal' yaw range of 0 to 6 degrees. Incidentally, for practical reasons we were unable to run the car to high yaw angles, the fin being very much a prototype.

The 2014 definition of the tail fin remains unchanged from the 2013 closed car regulations except for the increase in maximum height by 20mm to 'between 1040mm and 1050mm'. Presumably this change was made to reflect the same increase in maximum permitted height, but if the height of the rear body surfaces were to be unaltered, this would expose an increase in the side view projected area of the fin, which would potentially make the device more potent in its operation, should the situation arise.

REAR WING

The rear wing regulations have been changed in two significant respects: the span has been increased from the 1600mm maximum imposed in 2009 to 1800mm, and complex shaping has been banned by a clause requiring 'a constant section throughout the length of the rear wing'. In other respects the wing regulations remain the same, with the wing excluding end plates comprising of a maximum of two elements and having to fit an imaginary box 250mm horizontally x

It seems unlikely given the regulations that the rear wheel extensions, effectively full-width rear wings, will continue in 2014. The option exists for wheel arch cutouts to go in the inner face of wheel arches front and rear



The cut-outs in the inner faces of the wheel arch would be effective when the car gets sideways and less disruptive to the aerodynamics of the upper surfaces

150mm vertically by 1800mm transversely. Within that definition then there is infinite scope for designers to come up with different profile designs that meet their aerodynamic targets. And with the 12.5 per cent increase in permitted span and hence aspect ratio (span divided by chord) should come greater downforce for similar drag or less drag for similar downforce for a given profile. Also, up to the maximum wing height of 950mm, the height of the wing is infinitely adjustable across a fairly wide range, offering another degree of freedom in attaining aerodynamic targets.

That the span has not been increased to the maximum overall width limit of 1900mm is perhaps because rear ends tend to taper in plan view anyway. But with just a theoretical 50mm to play with on either side of the wing, it seems unlikely that 'wheel arch winglets' such as those that first sprouted on the Toyotas at Silverstone in August 2012 and later adopted by Audi will be worth implementing. Indeed, a change to a clause that deals with the area behind the rear wheels sees a relevant addition:

Vertical surfaces below the horizontal plane situated at Z=690mm are allowed as long as their entire top edge is visible from above.

The addition would appear to counter Toyota's engineering supremo Pascal Vasselon's assertion in August 2012 that 'Nothing prevents you from adding a second endplate', by prohibiting vertical surfaces behind the rear wheels higher than 690mm above the reference plane (unless otherwise expressly permitted, like the normal rear wing end plates). So winglets on the outside of the regular end plates could not have outboard end plates, and at only 50mm maximum span the winglets would scarcely be worthwhile. Had the maximum wing span been the same as the maximum body width, the topic would have been consigned firmly into history.

Meanwhile, 2013 seemingly saw the exploitation of exhaust gases for aerodynamic benefit, but the 2014 draft rules version 06 include some key phrases that obviously aim to prohibit any such practices. They are:

- **'Blown diffuser is forbidden'**
- **'Exhaust pipe outlets must not be inside the diffuser'**
- **'No point of these outlets must be situated less than 300mm from the trailing edge of the rear diffuser'**
- **'Any point of these outlets must be visible when seen from above or the side'**

So that's that, then. Or is it? Blowing into the rear wheel wells as Audi were thought to be doing will be difficult with the exhaust outlets within 300mm of the trailing edge of the diffuser. But there may still be scope for the exhaust outlets to be located and aligned to provide some benefit that falls outside the phrase 'blown diffuser', whatever that actually means.

And just in case anyone was thinking about 'fluidic switches' or other devices that alter aerodynamic configurations while on track, two more key phrases have been included that clearly prohibit any movable bodywork parts or elements when the car is in motion, and any system operated either automatically and/or by the driver that modifies the airflow.

SUMMING UP

One other interesting clause in the 2014 draft is the addition to the 'permitted openings' phrase to allow 'two additional air intakes ... the sole authorised function of which is to cool a mechanical element or a heat exchanger'. This inclusion probably relates to concerns over greater cooling demands of the new-for-2014 energy recovery systems and associated hardware, which makes one wonder about the effect of such additional cooling on total drag and how significant that might be.

Taking an overall view on the gains and losses to be achieved relative to the 2013 regulations, a finger in the air assessment is that the cars will probably be able to achieve pretty similar and possibly slightly better levels of downforce and efficiency in 2014, depending on specific track demands. There may however be some disparity if ERS systems entail different cooling demands that incur slightly greater drag. Time alone will tell.

Within the wing regulations there is seemingly infinite scope for designers to come up with different profile designs

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Global forming

Toyota's new 1.6 litre, four cylinder engine could be key to the Japanese firm's return to the World Rally Championship

BY SAM COLLINS

Almost as soon as Toyota quit Formula 1 at the end of the 2009 season, rumours linked the Japanese marque to a return to the World Rally Championship. These rumours intensified when it was revealed that Toyota's European motorsport engineering consultancy, TMG based in Cologne, Germany had started work on an all-new engine suitable for the series.

The turbocharged 1.6-litre inline four was built to the so called FIA Appendix, or Global Race Engine, rulebook making it suitable for a number of applications including the the WRC and WTCC, but until now TMG has never admitted that it is working on a WRC programme.

'It is a rally engine,' says Rob Leupen, TMG's director of business operations. 'We are developing it for the WRC but we would like to see it used in other series like WTCC but I don't think that will happen soon. It is a TMG project to investigate a return to the WRC, but we are not sure which car we will use. Right now we are building a WRC prototype which we will use to test the engine next year. After that we will discuss with Toyota the possibility of a return to the WRC. We know that there are some new models coming and we are looking to 2016 or 2017. But what we are doing now will not be homologated.'

Work started on the new engine in 2010 and it ran for the first time in early 2012. A team of engineers headed by Norio Aoki, Global Racing's engine general manager, had to decide on the engine's source. The rules allow manufacturers to use a production block as a basis, or to create a bespoke design, and there are subtle differences in the regulations for each.

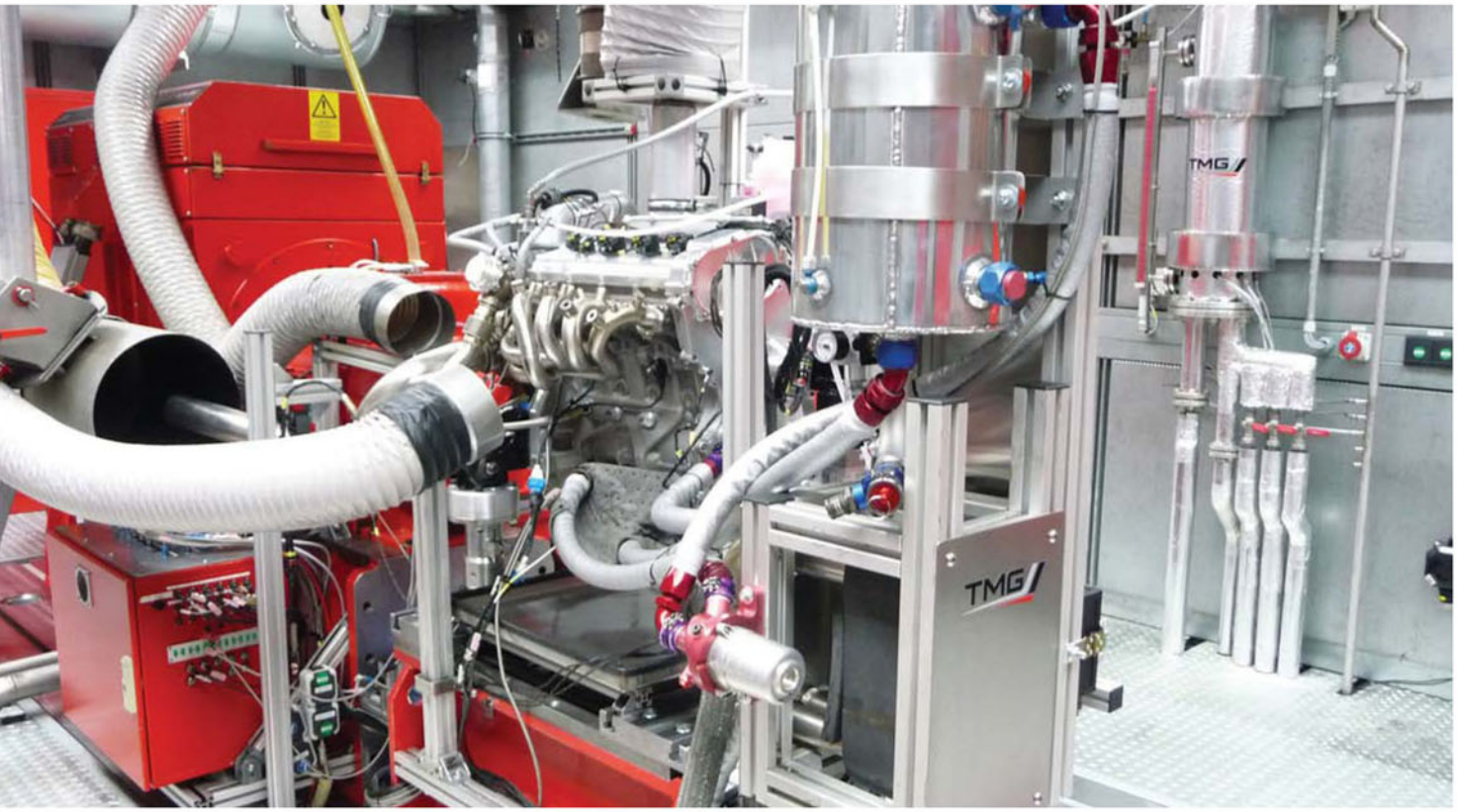
Those using production-based engines have a different main bearing size, which on paper allows for more power and less friction, for example. But most manufacturers, including TMG, have opted to develop the bespoke engine instead, as overall it lets them design things to be exactly as they want them.

'We looked at several engines in the Toyota lineup but decided to develop it from scratch,' says Aoki. 'It's nice to be able to develop a completely new engine, but it took some time to build up the team as we needed some new skills. Going to a four cylinder was a new world for us, as was direct injection.'

Because of the Appendix engine's roots in the GRE concept, many of the dimensions are not particularly written for a rally engine. Initially the GRE rules were intended to be used in 600bhp Formula 1 trim, which means that there are some odd details in the regulations, such as the 12kg crankshaft weight which is not ideal for a 300bhp WRC unit.

Despite the lack of references in-house, the TMG engineers

TMG opted against developing a mono cylinder version of the engine for testing, citing time and practicality as reasons for the four-cylinder route



The new engine, running on an AVL dyno. The turbocharged, direct injection 1.6-litre inline four was developed from scratch by TMG

decided against developing a mono cylinder version of the engine due to both time and budgetary contraints. 'We just went straight for the four cylinder,' Aoki says. 'With a normally aspirated engine, we would have gone to the mono cylinder to understand the combustion, but with a turbo engine we would need to simulate some of the back pressure, and this itself is a developmental step.'

TMG has a comprehensive engine development facility with a multitude of dyno cells and test rigs. In 2009 almost all of these were setup to run the big high revving normally 2.4-litre V8s and 3-litre V10s found in F1, but when the Japanese marque left that category TMG decided to increase its capabilities and now has a range of dynos suitable for smaller, forced induction engines such as the GRE and the forthcoming GT500/Super Formula NRE engines.

One major area of the still ongoing development of the engine is the injector shape and location. 'With this we do a lot of simulation and optimisation on the nozzle shape and spray pattern, but we work with a supplier who also suggested things,' says Aoki. 'There are two ways to use the injectors, either from the top or the side, and that was something to measure. We use what we have here in the best way and also collaborated with a university for the research, and the injector supplier also fed back to us.

'We have not decided on the nozzle shape, it's possible that we will use an off-the-shelf part – that's the cheapest route but it may not be the best. With more budget you would test limitless shapes and patterns but we have to make this engine commercially.'

The Yaris-R concept car, which could form the basis of the next generation Toyota World Rally Car, will make its public debut at the Frankfurt motorshow

One choice that TMG was not troubled by in the engine's development was the selection of a turbocharger. All cars in the WRC have to use an off-the-shelf unit that they cannot adapt or touch. Despite the limitation, TMG is still developing the engine as it does not have to homologate it before it goes into competition.

'With road car engines you get to a certain point and they are done, but you never really finish racing engines,' continues Aoki. 'As long as you have the opportunity to change things, even with F1 engines which were homologated, people were tweaking things due to reliability problems. With this engine we have lots of freedom as we are not racing yet.

'If we run without a restrictor, different turbo, camshaft and timing then there is more power, but there is more potential. I think there is a big spread between the GRE engines, and we fully expect to be at the top of that spread.'

The first official engine installation of the TMG GRE is in fact not a competition car at all. It will make its public debut at the 2013 Frankfurt motorshow in the front of the new Toyota Yaris-R concept car, which according to Toyota is 'a highly focused machine, designed to deliver the maximum driving pleasure.' It is believed that it may form the basis of the next generation Toyota World Rally Car.

"I think there is a big spread between the different GRE engines – and we fully expect to be at the top of that spread"

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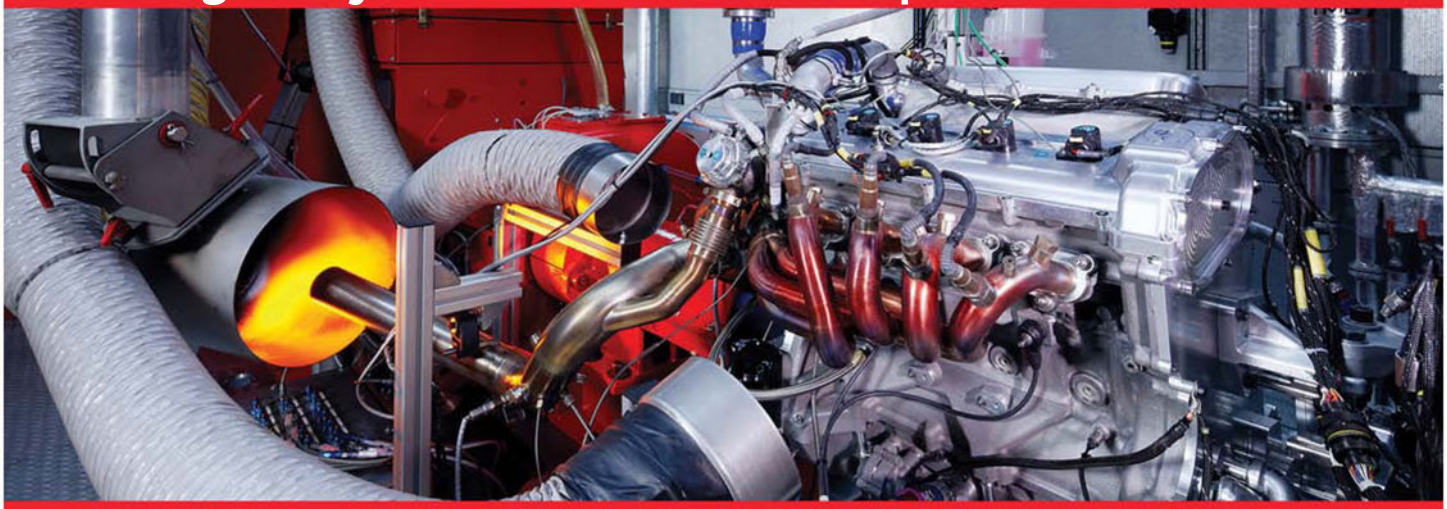

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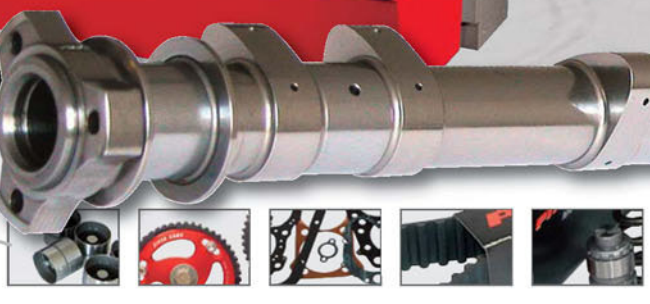

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VW's fast starter

Upon entering the World Rally Championship, Volkswagen needed a brand new engine – and came up with a very small, capable and neat turbocharged unit

BY SAM COLLINS

When Volkswagen decided to quit cross country rallying in favour of the World Rally Championship, it was simply because the marketing value of the Dakar rally did not last all year.

For its 2013 World Rally project, Volkswagen's motorsport department created the all-new Polo R WRC – a four-wheel drive two seat hatchback designed for everything from the fast asphalt of the Mosel vineyards to the frozen tracks of Sweden via the mud and gravel of Wales.

A rule change introduced for the start of the 2011 season saw the mandatory adoption of 1.6-litre turbo engines with direct injection, in line with the trend to downsizing – a discipline in which Volkswagen and Audi have been something of a pioneer. Indeed it was from within the Volkswagen group that the idea of the Global Race Engine (GRE) was born, the concept being a small capacity efficient four cylinder turbocharged engine which could be used across motorsport including in Formula 1, World Touring Cars, Formula 3 and of course the WRC.

All of the engines would be inline four cylinder, turbocharged units with direct injection and built to a very strict set of technical regulations.

Despite instigating the new rules Volkswagen, did not initially develop an engine, but once the firm made the decision to enter the WRC then it was clear that new engine would be required. Dr Donatus Wichelhaus is Volkswagen Motorsport's head of engine development and his team was tasked with creating the new power unit.

'We did not have very long to do it,' he says. 'We started just after winning the 2011 Dakar Rally, and the first engine was running on the dyno 10 months later.' Development of the engine was not as straightforward as that timescale suggests however, Wichelhaus had to make a crucial decision about the engine's design direction. The WRC allows for not only the GRE-based engine known officially as an appendix engine, but it also allows for a production block-based engine.

'We started with a totally clean sheet of paper and had to choose between the appendix engine and the production engine rules,' explains Wichelhaus. 'Both have to fulfil most of the same dimensions and the weights, but there are some differences, meaning each has its own advantages and disadvantages. The main differences between the production engine and the appendix engine are the main bearing diameter and the cylinder spacing, otherwise all of the other major dimensions are the same. It is very restrictive – the weight of the piston, flywheel, the diameter of the valve stem, loads of things like that are mandated. Everything that is friction- or power-related is defined by the regulations.'

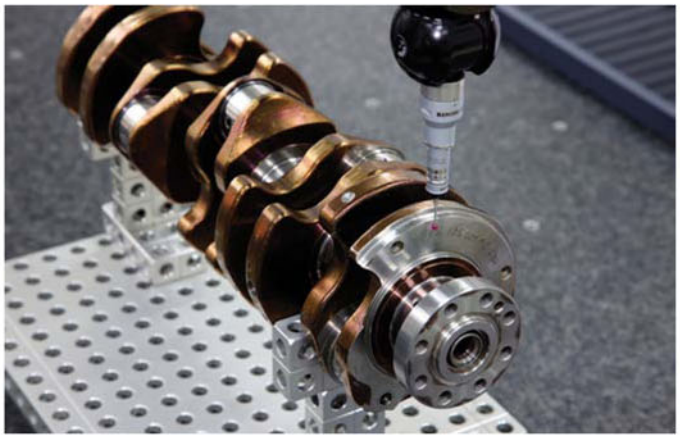
Volkswagen and Audi have been some of the key driving forces behind the Global Race Engine concept, and this meant that it was clear from the start of the WRC project that the group would develop a bespoke unit rather than a production-based engine. 'From near the beginning it was clear that we would like to go for the appendix engine, says Wichelhaus. 'This is because we have seen a better future for that engine in other categories of motorsport, we hope that the FIA uses the same engine regulations in several categories, like Formula 3. That's why we went that way. I think it's the same for all manufacturers, when you start such a project you have to consider all options.'

Once Wichelhaus and his team had decided on which direction to go the design process was relatively straightforward, though it would be totally alien to the designers of VW's last four wheel drive World Rally Championship car the Golf G60 of 1989 and 1990.

'In the past you had to rely on the experience of engine builders who just knew how to make it work, but now we have the computers to do all of that. You have to calculate everything and maybe then test it all on the dyno. So much of the design is computer-driven, issues like heat transfer, cooling system design and mechanical thermal stress are purely done in the computer. So

"In the past you had to rely on the experience of engine builders, but now we have the computers"

The VW Group was one of the instigators of the Global Race Engine concept



we went for the best option that the computer told us and then we went on the dyno with the prototypes, we had some options with the cylinder head, geometry for the intake things like that but it was mostly done in the computer.

'But while there are some good calculation and simulation packages on the market, they are not 100 per cent precise, so at the end of the day you need the engine on the dyno. We did a single cylinder prototype, it was a good way of improving the combustion chamber design.'

"It will be a problem for the sport when spectators realise this is all old technology in front of them"

One choice that Wichelhaus was not troubled by in the engine's development was the selection of a turbocharger. All cars in the WRC have to use an off-the-shelf unit that they cannot adapt or touch. 'We have to use a FIA specified turbocharger, so variable geometry as used in our road cars is not allowed, it is a sealed box. Like an old engine, in production you have variable valve timing, variable turbos and camshaft variations. I think at some point this will be a problem for the sport when the spectators realise that this is all old technology in front of them. I think Le Mans has the right approach with its regs by just giving the energy per lap. This is really good for technical innovation and those who are interested in it.'

But unlike the 2014 F1 and Le Mans engine regulations which use an energy restriction via a fuel flow meter, the WRC engine uses more traditional air restrictor something that Wichelhaus is not a great fan of.

'You do not have such a thing in production engines – it put the whole engine development in a strange direction,' he says. 'Air restrictors mean the physics of the engines are different from production engines. You can see that in the valve timing – there is no overlapping of valves because otherwise you would get exhaust in the combustion if you did. It's very strange.

'A fuel restrictor is a better approach. When you have technology from production engines, you can learn how you can stretch the efficiency of engines which you can then take into mass production models. You can't do that with air restricted engines. But to adapt this engine to fuel flow would be quite difficult. With an air restrictor you limit the air mass that goes through the engine. As soon as you reach that limit, the flow through the engine gets lower and lower, so the turbocharger can over-rev because of the under pressure on one side. And because the air restricted engine results are so different you can't use that data for anything.'

A set of targets for the car – specifically the engine – were agreed and set by the VW motorsport engineers in Hannover, Germany. 'In rallying the car has to be as light as possible, be at the right level of performance, and be reliable. Then it is up to the driver to go fast and not crash, adds Wichelhaus. 'The car also has to be easy to work on in the service park. Because of the regs, the engine is over-dimensioned, so the reliability should not be a problem. For example the pistons weigh 350g – in F1 they weigh 290g and they are much bigger. The centre of gravity of the whole engine is specified. The intention of the rules is that if you have a bigger budget you have no chance to go faster.'

After all of the work done by Wichelhaus and his team, the resulting engine is a small and neat unit producing in excess of 300bhp and 420Nm of torque. It has already been tested on rally stages in the new Polo R WRC chassis and has shown great reliability. 'It has been good from the beginning we have had no mechanical failures at all,' says Wichelhaus. 'I think this is due to all of the optimisation that we did before, all the computer simulations.' It certainly worked – the Polo R was on the podium on its debut and won its second ever event, after which it dominated the championship.

SODEMO RALLYCROSS

Global Race Engines are not restricted to just the air restricted versions found in the WRC and WTCC – they also appear in their most extreme form in Rallycross. French engine specialist Sodemo has developed its own for use in the Supercar class of the local championship. 'It's based on the new family of Renault-Nissan alliance engines, specifically the M5MT aluminium block,' says company boss Guillaume Maillard. 'It was developed by Nissan and you can find it in the Juke and the Clio.' The Frenchman has found the open rules of rallycross refreshing compared to other championships. 'I am passionate about it, I like the sport and I want to see it become more professional. I think that 1.6 turbo engines like this will become more common. There is great interest in the sport at the moment – along with WRC it is probably the last area where you can really develop your own engines. We do all the Group R rally classes, but there is no real freedom any more – everything is controlled and blocked. But in rallycross you can really express your knowledge.'

Like all GRE engines, the Sodemo-Renault is a turbocharged 1.6-litre inline four with direct injection, but unlike the bespoke engines of Toyota and Volkswagen, the French unit retains many standard parts. 'This engine is smaller than some older rallycross engines and lighter too, weighing 125kg with all of the ancillaries, but we still kept the standard block, head and gaskets to reduce the cost,' says Maillard. 'We concentrated on the crankshaft, rods, pistons and valve train as well as the dry sump system. The crankshaft is bespoke and machined from billet, the pistons and rods are also bespoke and designed in house with manufacturing being outsourced.'

The engine, which does not run with a restrictor, features both direct and indirect injection, with two injectors per cylinder. 'We do it like this to improve the combustion throughout the rev range and it makes much better torque at low rpm. We are still working on the management strategies to optimise both direct and indirect injection,' says Maillard. Sodemo has developed its own electronics to run on the engine including a bespoke ECU, dash and wiring loom.

Unlike the WRC and WTCC engines, there is no spec turbocharger in rallycross and Sodemo has taken full advantage of this. 'We have developed a special turbocharger with Garrett,' says Maillard. 'We had some particular requirements, but we do not want to disclose too much about this. The turbo is bespoke for this engine.'

The engine produces over 500bhp and has strong torque 550Nm torque. Max power is at 8500rpm. The engine including ECU and loom retails for around €70,000.

Get into gear

Smooth and reliable transmission is essential in all forms of motorsport – and a wide variety of suppliers are constantly working to ensure that each change is as smooth as the last

BY GEMMA HATTON

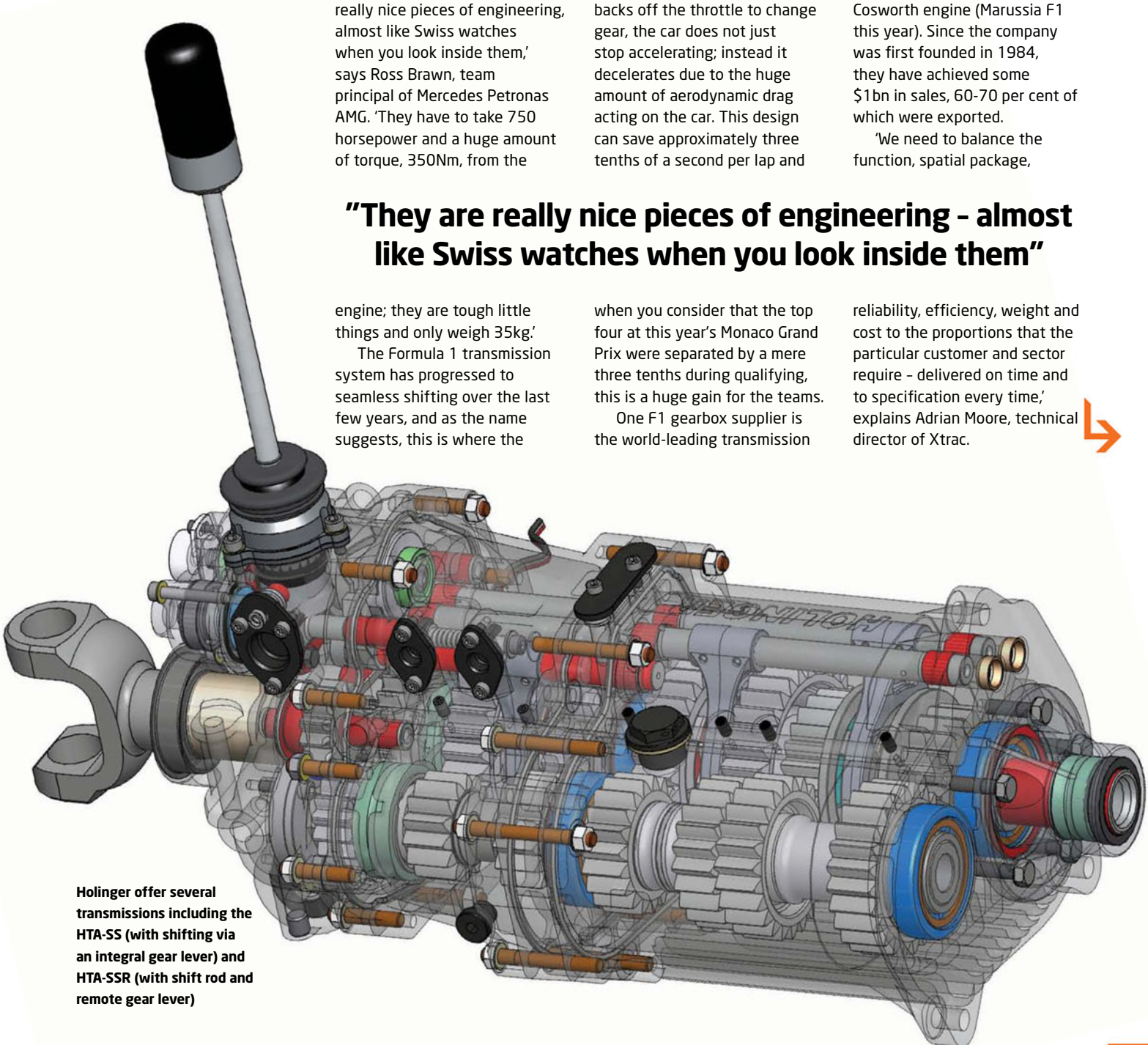
0.05 seconds is the average gear shift time in Formula 1, which occurs approximately 3100 times per race. 'They are really nice pieces of engineering, almost like Swiss watches when you look inside them,' says Ross Brawn, team principal of Mercedes Petronas AMG. 'They have to take 750 horsepower and a huge amount of torque, 350Nm, from the engine; they are tough little things and only weigh 35kg.'

The Formula 1 transmission system has progressed to seamless shifting over the last few years, and as the name suggests, this is where the next gear is selected before the current gear is disengaged, and is regarded as the 'ultimate' transmission design. At such high speeds, when the driver backs off the throttle to change gear, the car does not just stop accelerating; instead it decelerates due to the huge amount of aerodynamic drag acting on the car. This design can save approximately three tenths of a second per lap and when you consider that the top four at this year's Monaco Grand Prix were separated by a mere three tenths during qualifying, this is a huge gain for the teams.

One F1 gearbox supplier is the world-leading transmission specialists Xtrac, who supply their products to the top motorsport teams, as well as high technology industries, including F1 teams running the Cosworth engine (Marussia F1 this year). Since the company was first founded in 1984, they have achieved some $1bn in sales, 60-70 per cent of which were exported.

'We need to balance the function, spatial package, reliability, efficiency, weight and cost to the proportions that the particular customer and sector require – delivered on time and to specification every time,' explains Adrian Moore, technical director of Xtrac.

"They are really nice pieces of engineering – almost like Swiss watches when you look inside them"



Holinger offer several transmissions including the HTA-SS (with shifting via an integral gear lever) and HTA-SSR (with shift rod and remote gear lever)

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'Our most successful projects have been the previous generation of IndyCar gearboxes (the P295) which we manufactured 400 of. They were extremely reliable for many years. The current generation (the P1011) which was launched with the DW12 car last year also features this reliability, with over 80 supplied to date. Our incredible track record at the major endurance events includes supplying the Dakar winner 19 times in the last 21 years and 35 cars – including eight out of the top 10 – at Le Mans this year.'

2014 will see major changes across all types of motorsport, making it a busy year for Xtrac. 'We are very involved in the 2014 F1 and LMP1 gearboxes which have had significant rule changes,' says Moore. 'In terms of the automotive sector, we are working on various transmission projects for EV and hybrid vehicles. In the last year we have launched our new R5 rally gearbox, the P1113, and our new Rally Raid gearbox the P1173, as well as several bespoke designs of transmissions for particular applications. In addition, we continue to support our existing touring car, Sportscar, rally, Moto GP and F1 customers and products.'

ALBINS OPTIONS

Another major player in the transmissions industry is Albins, who are the largest high performance transmission manufacturer in the southern hemisphere, targeting not just motorsport applications, but also upgrading OEM transmissions. Their success began with the Volkswagen transaxle, which through design optimisation of the shafts and gears helped them gain a technical advantage that put Albins well and truly on the map.

Their most popular product is currently the ST6 transaxle which is now the control transmission for the V8 Supercars Car of the Future category. The 1100Nm-rated gearset is manufactured by gear profile grinding, shot peening and isotropic polishing, which all offer a high precision finish, and demonstrate the level of detail involved when manufacturing gears. Profile grinding is achieved with the use of CNC

Example of the ST6 from Victoria, Australia-based supplier Albins. It's currently the control transmission for V8 Supercars of the Future

XTRAC ACHIEVES TOP GEAR

The world leader in high performance transmissions was featured in the 'Best of British' episode of this year's series of Top Gear. Xtrac sat alongside companies such as Red Bull Racing, Bloodhound and Williams F1 in a parade down the Mall in London, demonstrating to the 350 million worldwide viewers examples of the past and present engineering accomplishments found in Britain's Motorsport Valley.

The programme highlighted Xtrac's successes due to their involvement in developing the transmission systems for IndyCar racers, every Dakar winner since 2009, 63 per cent of this year's Le Mans starters – including the winner – as well as the Marussia Formula 1 car.

'It was great to be included in the show as the company is totally owned by all the employees,' explains Peter Digby, managing director of Xtrac, 'so it just feels that bit better because the efforts have been recognised by something as important as Top Gear. 'I thought the show was brilliant. I'm a big fan anyway, but it was great that they were able to pay tribute to the British automotive industry and bang the drum about how important it is.'

A batch of Xtrac 1011 gearboxes in progress at the British firm's factory

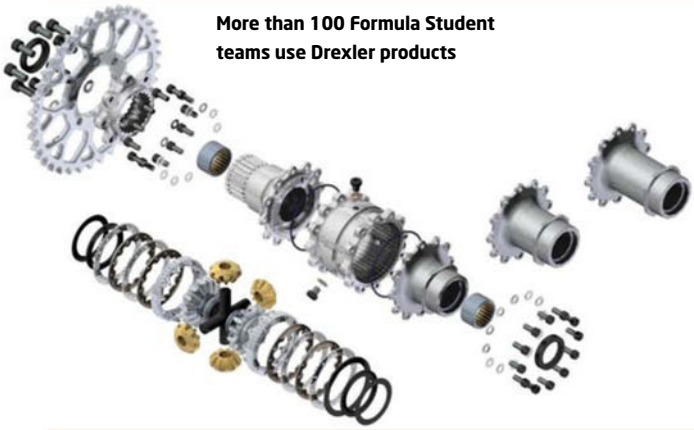
"Xtrac's most successful projects have been the previous generation of P295 IndyCar gearboxes – they were extremely reliable for many years"

FS TEAMS CHOOSE DREXLER DIFFS

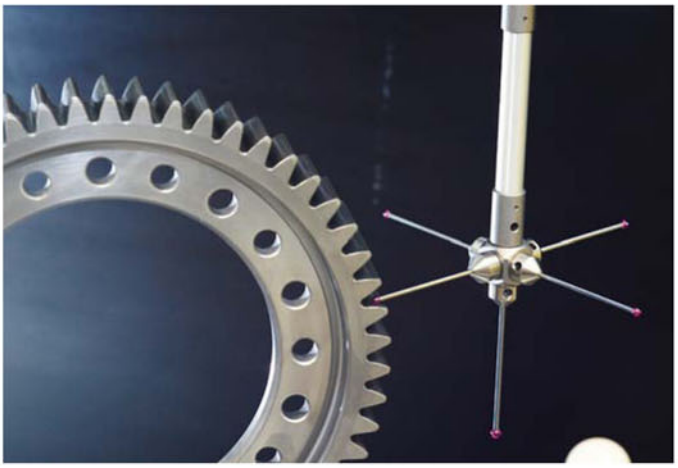
Drexler is a common name in the world of Formula Student. Looking through all the teams, it's pretty rare that a team runs any other type of LSD differential.

'For Drexler, the Formula Student competition is an opportunity to spread the brand awareness of Drexler among prospective engineers, to support the development in automotive engineering and to gain new experiences and thought-provoking impulses for our products,' explains Carola Roll, purchasing manager at the firm.

'Currently, there are more than 100 Formula Student teams using Drexler products, so we will of course continue to produce these differentials and improve them.' The future for the Formula Student-designed Drexler will be an adjustable version that will be coming to market next year.



More than 100 Formula Student teams use Drexler products



A Kaiser WZB transmission component being checked for accuracy

Quaife's ATB helical LSD differential, designed for VAG 02Q (4WD)

machines. Whereas, shot peening is a cold working process which bombards a metal surface with multiple small spherical metallic, glass or ceramic 'shots' to gradually dent the surface. This results in an increase in compressive stress beneath the surface layers as they resist the deformation, which is highly beneficial when compared to tensile stress created by other manufacturing processes, as it can lead to fatigue and cracking. Isotropic polishing does not actually polish the part, it uses a one micron thick film which chemically reacts with the surface of the metal in a vibratory tub.

The film physically removes the microscopic surface discontinuities and, once complete, a mild alkaline mixture is added to remove all traces of the film, known as burnishing. All this precision manufacturing contributes to achieve 14 millisecond gear changes, with zero mechanical misalignments during a 5000km endurance test.

'The greatest evolution we have seen in transmission technology has been durability and durability while delivering a lightweight product that has a high torque rating – it's the challenge in motorsport,' explains Tim Possingham from Albins. 'Then there are secondary considerations such as shift event speeds, design considerations such as increased ease of maintenance and – finally – manufacture efficiency. This, in effect, means that we aim to design something that outperforms other products but at the same time is manufactured and delivered to the market at a competitive price.'

'Our ST6 range of products is a sequential six-speed package that we have released with transaxle and inline gearbox variations. The transaxle is also available to suit front and mid-mounted engines. It is lightweight, has a drop gear option and has innovative inspection ports that reduce maintenance costs by facilitating gear inspection without pull-down.' Drop gears allow an overall ratio change, so in some respects it is similar to changing the "final drive" of the car. It is a more effective way of changing the overall gear rations to suit different tracks.'

The success of the ST6 is securing a bright future for Albins. 'We are currently working on a smaller variation of the ST6 to suit lower power applications, as the ST6 is mainly aimed at very high powered applications and hence has a physical size that is prohibitive to a large section of the market. We are also constantly experimenting with seamless shift technology.'

THE FULL MILLING

The precision manufacturing of the gears presents major challenges. 'We are working on the milling of splines and gears to make otherwise impossible geometries a reality,' explains Ragnar Bregler, from Kaiser WZB, 'we mill the splines to the quality level of grinding with the smallest run-out, which makes it possible to machine gears and splines right next to bearings and shoulders. The future for our company is designing the

"We are working to make otherwise impossible geometries a reality"

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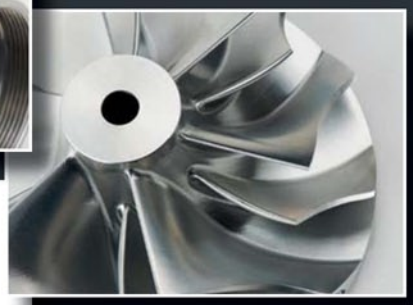

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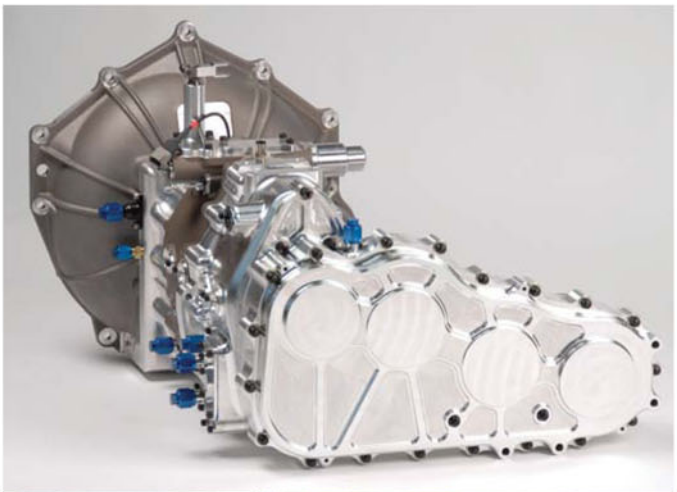
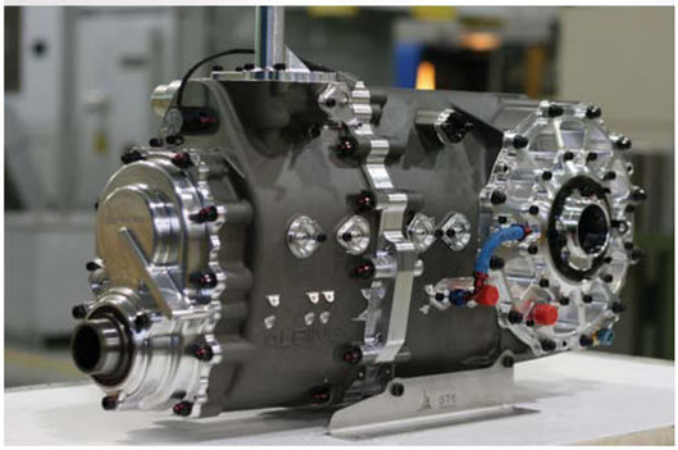
The Quaife six-speed heavy duty in-line RWD sequential gearbox has been designed as a replacement for the Nissan 350Z gearbox

3J Driveline limited slip differentials are claimed by the manufacturer to be the 'strongest, most progressive and versatile LSDs on the market'





The Albins ST6 is a sequential six-speed package. The firm is currently working on a smaller version to suit lower power applications

"Designing a part that can withstand abuse, be it load or heat, while keeping weight down, is the biggest challenge for transmissions"

K-M-P'S PORSCHE PADDLESHIFT

K-M-P have developed a pneumatic 'plug and play' Porsche Paddleshift kit, system designed for sequential gearboxes. The design is optimised to fit straight into a 996/997 Porsche racecar, making it extremely easy to implement. The unit contains the control unit, three valves, a pressure sensor. The actuator is only pressurised during the actual shift, therefore manual shifts are possible. The unit comes with pre-programmed Porsche settings.

lightest components while utilising a mix of the most suitable materials and coatings in the smallest available space.'

HOLINGER DESIGNS

Another manufacturer that thrives on versatility is Victoria, Australia-based Holinger, who supply everything from GT through to drifting and the Dakar Rally. 'Designing a part that can withstand abuse, be it load or heat, while keeping the weight down to a minimum is the biggest challenge for transmissions,' a spokesperson said.

'Materials and manufacturing processes have come a long way, enabling more detailed and complicated designs to come to life, but weight v performance is always the challenge. In these modern times, with more "longevity" required in motorsport components, it has also become important to make products that cover more and more distance.'

Holinger's most successful product has been the RD6 gearbox which has found its way into many front-engine rear or four-wheel-drive race cars over the years. As it can withstand huge amounts of horsepower and torque from turbo 4s and 6s all the way to massive V8s and V10s, while being lightweight.

'Traditionally Holinger have always been only a gearbox manufacturer. In-line transaxles have never featured on our product list, but we are currently developing a range of transaxles for both GT and off-road racing. These will feature a specialised ring and pinion tooth geometry, fully designed and developed in-house, which should greatly increase the gears load carrying capacity for a given weight.

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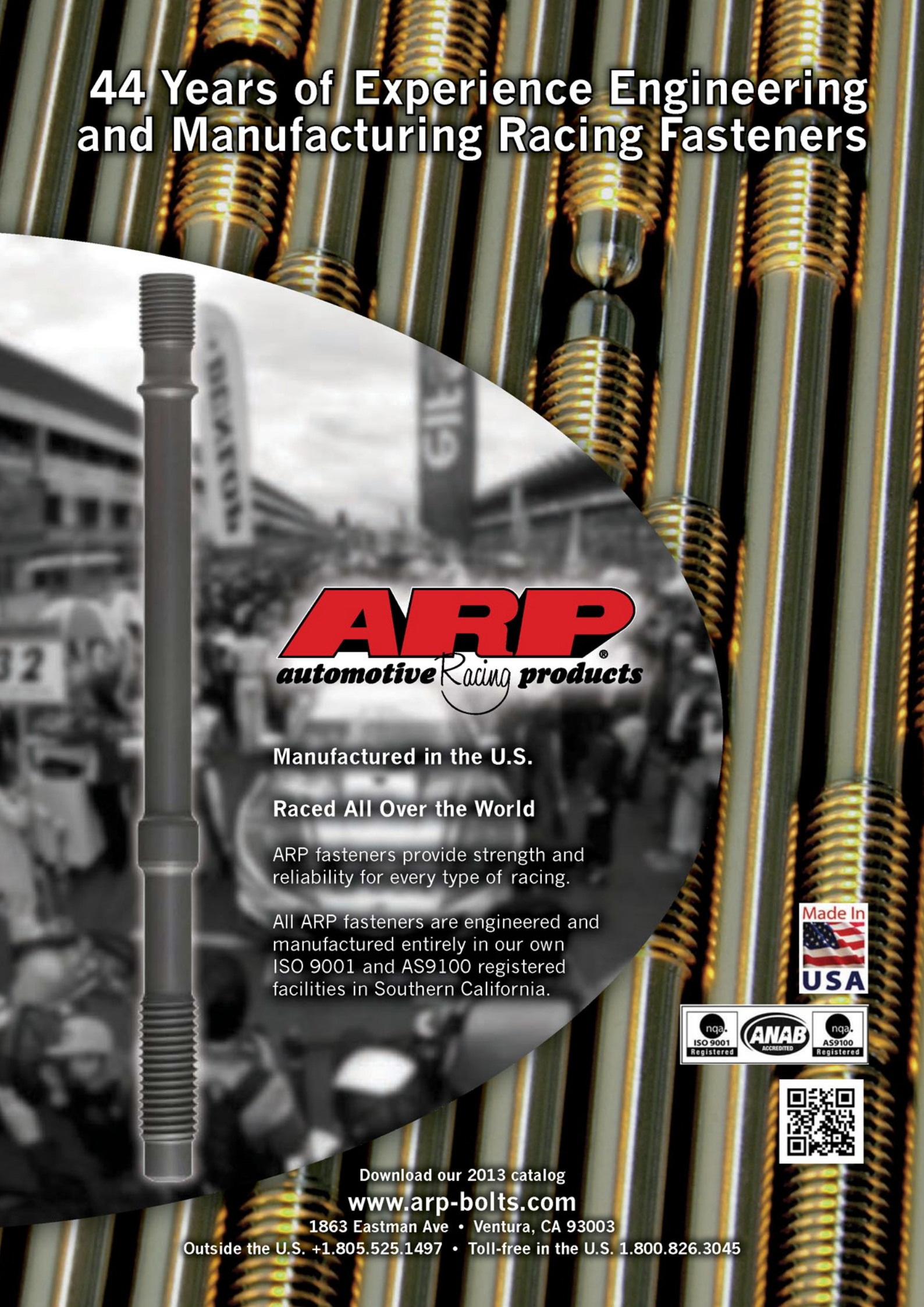

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The case for using simulation packages

If you're serious about racing, this is a tool you need on your side. Here's why...

BY DANNY NOWLAN

One of the things that continually blows me away about the racecar engineering community is that, as a general rule, they simply don't understand simulation. I've been working in this industry for nearly 20 years, and not just as a simulation principal. I've worked in the trenches as a data and race engineer in fields as diverse as F3, F3000, A1GP, V8 Supercars, Sportscars and GT cars to name a few. I've seen first hand just how effective simulation can be and I've lost count of the number of times when using simulation has given me that critical edge.

Let me state this up front: if you're a race and data engineer and you're not using simulation as far as I am concerned you're crazy. I would go as far to say that you're stark raving mad. I don't say this because I have a vested financial interest in it, simply because I've seen time and time again how simulation has changed the way people approach their race engineering and how it has allowed them to do a lot more with very scarce resources.

The case for simulation is so open and shut that part of me actually regrets having to write this article. The first thing that it brings to the party is that it forces you to understand your car in ways you never thought possible. I have lost count of the number of times I've had customers say: 'We never realised that about the car.' As well as this, it is simply a fantastic tool to quantify both the tyres and aero of the racecar. Both of these are critical elements of the car's setup and time and again ChassisSim has been a vital element in quantifying both of these components. Lastly, nothing prepares you for a race weekend like making small, sensible adjustments, using a racecar simulator. All of these elements on their own are very compelling. However, the combinations of all these components make the simulation case a complete no-brainer.

If you're a race and data engineer and you're not using simulation, frankly you're stark raving mad

But before I get into these reasons in more detail, it would perhaps be wise to explore where simulation tyre models come from. One of the biggest criticisms I see levelled against simulations is that the tyre models have no foundation in reality and they are based on various misunderstandings of vehicle dynamics. Well I can't speak for other simulation providers, but I can tell you that, as far as ChassisSim is concerned, that couldn't be further from the truth. Also, as many of you reading my articles would know,

while I'm not the biggest fan of the Pacejka tyre model, what it does do very well is represent what the tyre is doing at a particular temperature condition. It can't do a half bad job at it because it forms the cornerstone of what road car manufacturers use to fine tune their ABS and vehicle dynamics features. To claim that this is not the case is just complete and utter unadulterated nonsense.

One of the cornerstones of ChassisSim is its ability to reverse engineer tyre models from data. The core of how it achieves this is by comparing actual to simulated data and changing the tyre model to minimise the error. This process is illustrated graphically in **Figure 1.**

This is an example of a comparison between actual data and a tyre model derived from changing the tyre model to minimise the error between actual lateral acceleration and simulated lateral acceleration. Mathematically we are minimising the following function shown in this equation:

$$cf = \left| a_{y\_act} - a_{y\_sim} \right|$$

where...

cf	= the cost function
A_{y_act}	= actual lateral acceleration
A_{y_sim}	= simulated lateral acceleration

Effectively what we are doing here is doing a lot of track replays, recording the simulated lateral acceleration, and we change the tyre model to minimise the difference between simulated lateral acceleration and actual acceleration. It's that simple.

The other thing that I need to address is that any simulators worth their salt are based on multi-body vehicle models. I've spoken at length about where multi-body vehicle dynamic models come from and while I can't speak for other simulation packages, the multi-body vehicle dynamic model is one of the core features of ChassisSim. I'm not alone on this. The simulation software of every road car manufacturer has a multi-body vehicle dynamic model as its basis.

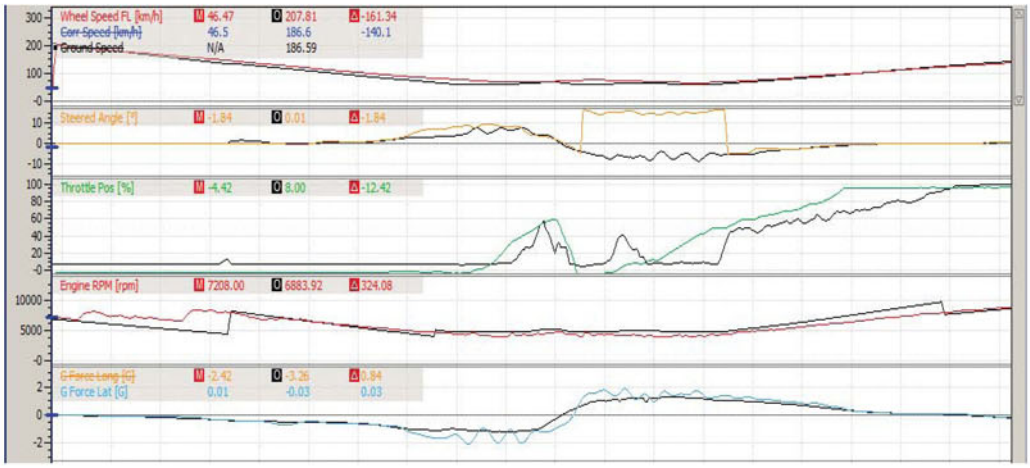


Figure 1: a comparison of actual to simulated data

For me the first compelling reason to use simulation is that it will force you to understand your car in ways you never thought possible. The more accurate a simulator, the more it will punish you when you make mistakes when you are modelling the car. This is a very good thing because it will force you to understand the car in ways you never thought possible. It forces you to understand your motion ratios, suspension geometry and it will shed light on your tyres and aero in ways you never thought possible. This knowledge is invaluable.

Let's illustrate how it can help with some case studies.

First, an instance where it was important to get the motion ratios right. A couple of years ago I did a bit of work for a Star Mazda team in the US. The team I was working with presented me with the first simulations and nothing added up. It was a mess. Anyway, circumstances got me in front of the car and I measured up the motion ratios. Once I put in the correct motion ratios in, it was a night and day difference. All of a sudden the simulations added up and we did some great work with the car. It's so important to correctly measure the car up.

The next case study I'd like to talk about is using race data to construct a tyre model. See **Figure 2** for an example of what you can produce.

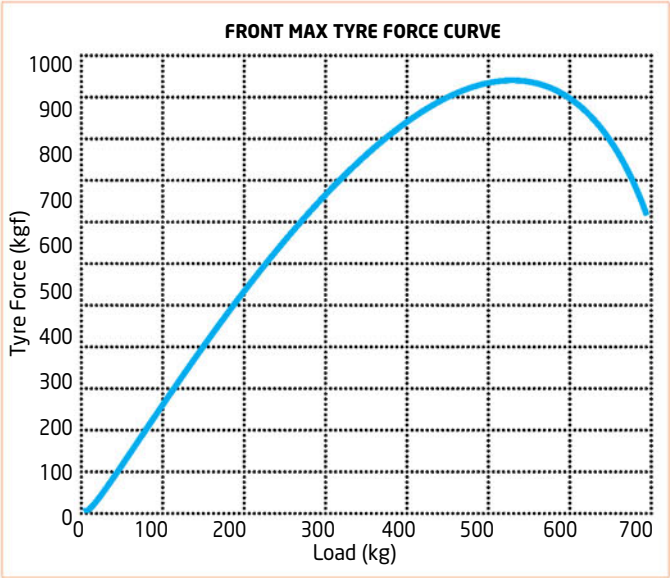


Figure 2: traction circle radius vs load

This was taken from the first generation A1GP car. This is still a case study very close to my heart, because it signalled the point where ChassisSim went from 'this was a good idea' to 'my lord, this genuinely works'. The ability to use race data to construct tyre models is invaluable. What it tells you is where you need to be in the tyre performance envelope to get the most out of the tyre performance. This knowledge has the ability to transform the performance of the racecar.

The last case study in terms of car modelling I'd like to talk about is when the aero correlation doesn't work out as expected. To illustrate this, consider this plot of simulated pitch vs actual pitch, **Figure 3**.

The actual car is coloured, and the simulated car is black. I want to draw your attention to the 3rd and 4th traces, which is front and rear pitch (averaged damper movement front and rear). As we can see the front isn't too bad. There's a little tweaking we need to do, but nothing major. However, there is a 10mm discrepancy at the rear where the simulated car has produced too much downforce. Most people at this point would think the simulator is rubbish. No, it isn't rubbish – it has just shown you that there is a hole in the aeromap. The great thing a simulator provides is the ability to go in and quantify what went wrong. I can tell you from

The more accurate the simulation is, the more it will punish you when you make mistakes with the modelling of your car

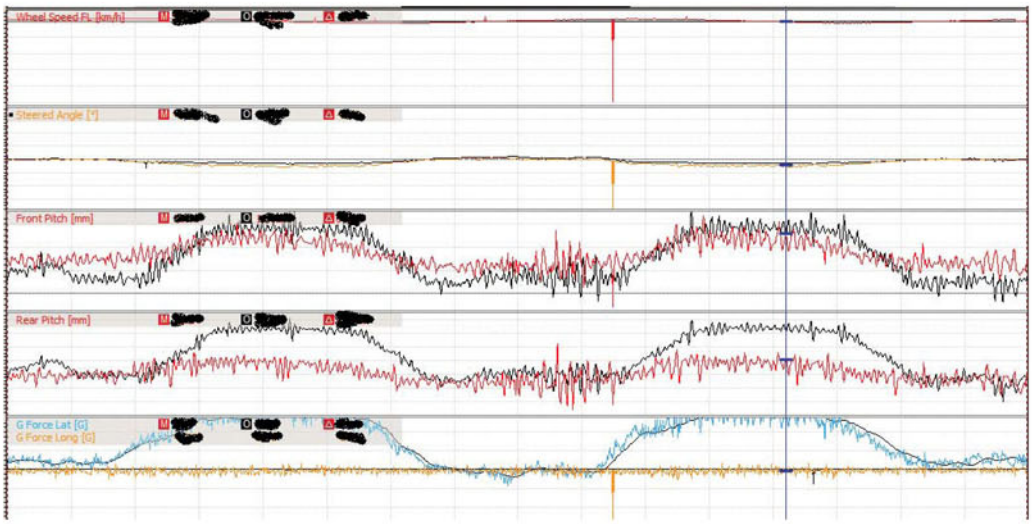


Figure 3: simulated pitch vs actual pitch

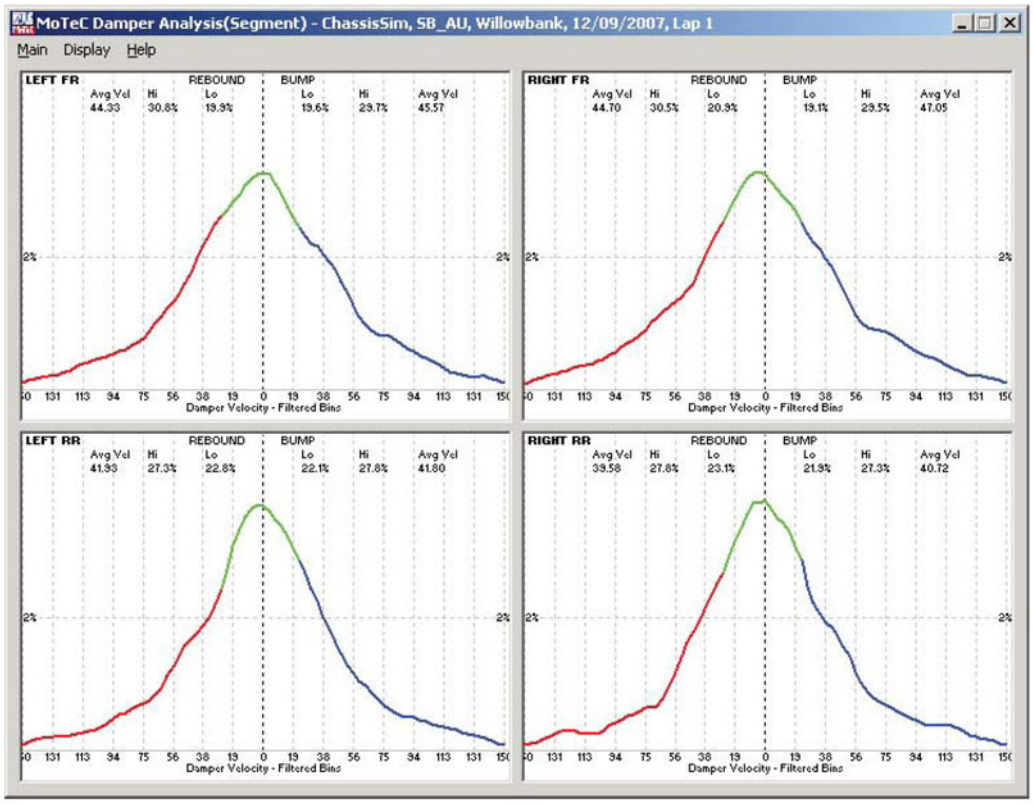


Figure 4: damper histogram

experience that this helps to provide you with the knowledge that can help win races.

The other thing where simulation excels is in evaluating small sensible changes to your setup to get you ready for the race weekend. As a simulation principal, one of the biggest impacts I've seen with teams using simulation is when they work through small, sensible changes to a setup they are ready to go for the race weekend. It doesn't necessarily deliver the magic setup – that's not a simulator's job. What it does, however, is show the options they need to work on so it makes the best use of track time. I've been direct witness when ChassisSim has effectively dictated what goes on in the free practice!

One thing I should add , however, is that you must use a simulator as a scalpel and not as an axe. Simulators work best when you're working in the setup range you usually run. Don't expect it to work if you're – say – running a 800lbf/in rear spring and expect it to magically work when you run 100lbf/in rear spring. Ditto if you're running something like a 20mm front roll centre and jack it up to 200mm. In this instance, you will have taken the tyre load regime into an area that you haven't modelled. Consequently, all you're doing at this point is guessing. Having undertaken tyre modelling on both of these extremes, I can tell you that what you get is radically different. Consequently, when you're using a simulator you'll get the most out of it when you use small sensible changes.

In terms of setup variables, there are a couple of areas where simulation excels. One of these comes when you're evaluating damping. To illustrate this, consider the damper histogram shown in **Figure 4**.This is a typical histogram you'll get from any set of data with properly calibrated dampers.

You can run this analysis all day long and you never need to turn a wheel. I have customers who just use simulation primarily for this purpose, and they don't pay attention to lap times. Also, just remember for transient simulation packages such as ChassisSim, every simulation run you do is the equivalent of running the car through a seven-post shaker rig. It doesn't replace the rig, but it arms you with data that makes the time you spend on it all the more valuable. This has been proven by the increasing traction we've been finding with the shaker rig toolbox.

Another area where simulation truly comes into its own is in tuning the ride height bump rubber package for a particular circuit. One of my customers really begged me to log bump rubber displacements in ChassisSim. I'm really glad he did because it allows you to look at plots such as **Figure 5** overleaf.

In a single plot we can see what is going with the damper displacements, the ride heights and what we need to do with the bump rubbers. This is truly invaluable information, because it gives you vital data in relation to when to engage the bump rubber and more importantly when not to engage it.

I should also add that if you have a good aero model and you have modelled the bump energy properly, the estimates for ride heights will be conservative. That will give you confidence to know that it won't slam into the deck at the first session.

The great thing a simulator provides is the ability to go in and quantify what went wrong. This provides knowledge that can help you win races

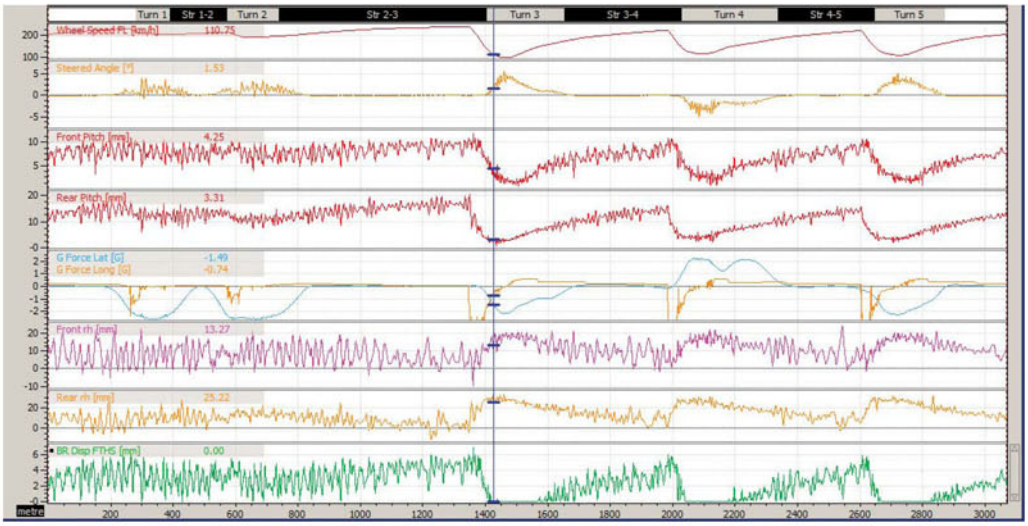


Figure 5: plot of speed damper displacements, ride heights and bump rubber displacements

I should also add that we have touched the surface of what you can do with simulation. Some of the things I've seen ChassisSim used for are:

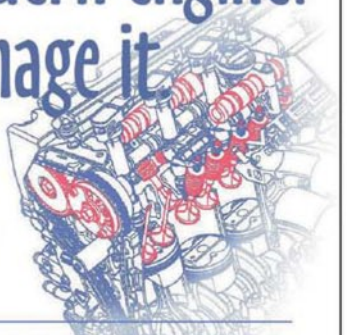
- **Playing with the ride height envelope to exploit the sweet spot of aeromaps**
- **Investigating damper setup to maximise mechanical grip**
- **Playing with cambers and suspension geometry**

This list just touches the surface of what you can do with a simulator. One thing I will say is you will get the most out of simulation if you treat it like a calculator. We in the simulation community are not in the business of producing magic wands. If you're looking for the one of those, then you'll be disappointed. The true role of a simulator is to give you a very complete picture of what is going on with the car. What you do with that information is then entirely up to you.

In closing, let me reiterate how important it is to make simulation an integral part of your engineering setup. I would go so far as to say that it's one of the first things you should be doing when you acquire your racecars. The reasons for this are many, varied, and utterly compelling. Simulation will demand that you know your car inside out, a reality I've seen time and time again across the ChassisSim community, and there's absolutely no question that this is a good thing. It also gives you a window to what the tyres and aero are doing in race conditions, and exploiting this is vital for unlocking the speed of the car.

Lastly, a simulator is an ideal tool to prepare for a race weekend and to explore your usual setup range of variables. All of which hopefully makes the case for simulation pretty clear.

You will get the most out of simulation if you treat it as a calculator – it can give you a very complete picture of what is going on with the car



Save Formula Student

Teams are turning up with great tech, fine paint jobs and a well-drilled crew. But with one key rule routinely broken, is anybody actually learning anything?

I participated in Formula Student competitions between 2006 and 2012, and was design leader for a student team that designed and built their own complete racing engine from scratch (and CNC machined everything that was possible by ourselves, see *Race Engine Technology* magazine #54). In my time I also TIG-welded entire spaceframes, wishbones, uprights and CNC programmed and machined our aluminium suspension uprights. My own experience was that five years of Formula Student were probably the best years of my life, and will probably never be equalled in terms of capacity for innovation, real teamwork, real camaraderie, and a pace of learning of such frantic magnitude that would put most of F1 to shame.

However, the face of Formula Student has changed a great deal since 2006, and I saw the transition occurring with my own eyes. I would also state that this transition is not for the better. Formula Student has (for many teams, universities and apparently judges), increasingly become a showcase for turning up with the most technology, the best paint job, and the most professionally turned out and drilled team. All of which on the face of it seem very laudable qualities indeed. In fact, it is clear that unfortunately not one of these qualities necessarily contributes to the personal, intellectual, moral or technical development of the students themselves (of course there are exceptions to this in a small number of exceptional teams). It is a fact that the vast majority of FS cars at every event are in direct and clear contravention of Rule A6.1 (page 12, FSAE regulations 2013):

A6.1 – Student Developed Vehicle

'Vehicles entered into Formula SAE competitions must be conceived, designed, fabricated and maintained by the student team members without direct involvement from professional engineers, automotive engineers, racers, machinists or related professionals.'

If this rule were enforced at the next competition, the number of eligible runners at an event like FSG might be counted on one hand. There is an argument that some teams cannot build their own cars because of safety fears at their establishment, or that they don't have any equipment. But I think this is a cop-out, preventing teams really learning what running a racing business is all about, which is to need something, and then getting together to make a plan in order to achieve it.

Not to complain that it's 'difficult', and so allow a sympathy loophole though which anyone can now leap with anything up to an entire chassis being constructed almost 100 per cent by renowned motorsport firms, stickers being applied and this being declared a 'Formula Student car'. When, in fact, it is nothing of the sort.

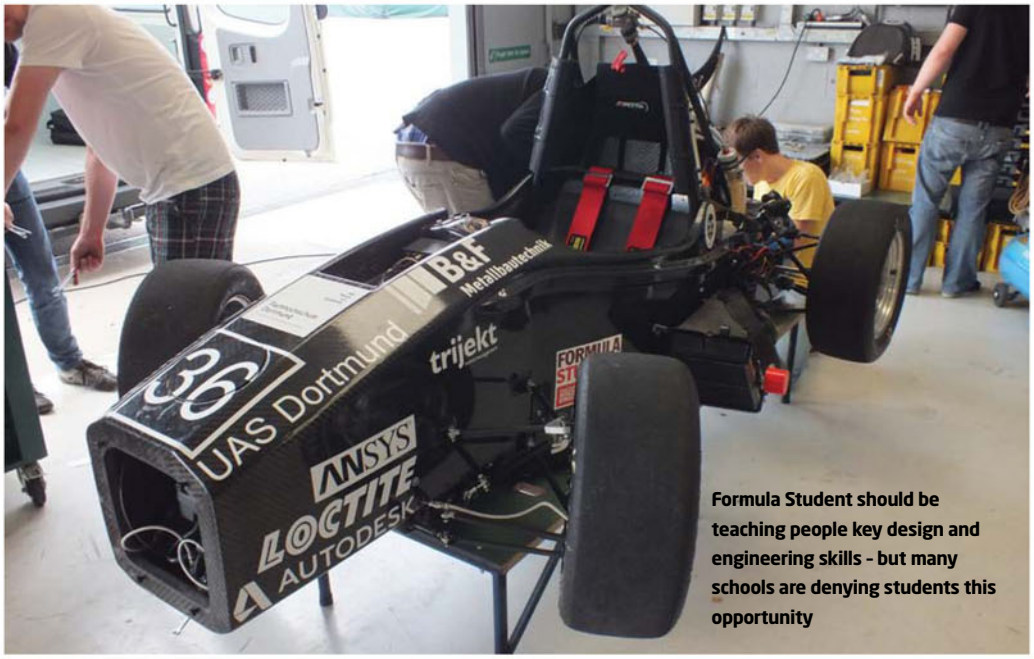
For a really dedicated and intelligent group of students, building a vehicle to the letter of the rules in section A6.1, would be NO barrier to innovation nor to the technical level achievable. For example, UWA constructed their own moulds for their CFRP tub, and cured it by constructing a 'hot box', around the finished mould which was heated by hot air guns applied to well located vents. Not an autoclave in sight. Allowing teams to blatantly contravene rule A6.1 also allows universities to carry on denying students access to manufacturing facilities, because 'everyone else is doing it' – as in everyone else is farming out machining, curing, testing, welding, moulding etc to external companies.

If rule A6.1 was enforced, students really would build it all themselves

If this rule were properly enforced, it would empower students to really have their own racing team, really build it all themselves and to really gain the sort of self-confidence that can only ever come from having done it all yourself. It would also force universities to get behind learning, and to not merely listen to their litigation department's risk reports. If there are teams who claim that they 'cannot' build their own cars, because it's 'difficult', or because they're not imaginative enough to beg/borrow/buy/rent appropriate facilities and equipment – I would question their eligibility to consider themselves worthy of competing to go home with their heads held high as young racing enthusiastic engineers of the future.

The regulatory bodies responsible for running Formula Student are responsible for far more than just helping to setup and run the events, by their actions they shape the way students learn and function at their universities. Rule A6.1 should be either enforced to the letter, or it should be deleted with immediate effect from the rules and regulations. If it is to be deleted, all concerned must be comfortable with the fact that the competition would – in principle, practise and letter of law – cease to be a primarily learning exercise.

Calum Douglas



Formula Student should be teaching people key design and engineering skills – but many schools are denying students this opportunity

Honda, Toyota and Nissan unveil 'DTM compatible' GT500 cars

Three new 'DTM compatible' GT500 cars have been unveiled by Honda, Toyota and Nissan.

In 2012, a deal was struck which saw Super GT and the DTM share a common chassis and technical rulebook. The new GT500 cars use a number of components from the DTM design including the chassis (although built in Japan by Toray Carbon Magic) front splitter, floor, rear diffuser and rear wing.

The deal was long discussed behind closed doors. Initially the Germans – led by Hans-Werner Aufrecht – had wanted the Japanese to fully embrace the new DTM regulations, even using the same German-built chassis. This was a major sticking point for the Japanese, as was the fact that some teams had found that it was impossible for the DTM cars to be built and run for the costs claimed by ITR.

Eventually the Japanese contingent agreed in principle to utilise the DTM concept, but they wanted the chassis to be made domestically with a number of changes to accommodate endurance racing and driver changes.

The GT500 cars are all powered by all new 2-litre turbocharged inline fours built to the Japanese NRE (Next Racing Engine) regulations. Dallara's new SF14 Super Formula chassis will share the same units. DTM, however, will continue to use its 4-litre V8s until it develops its own downsized engine formula of 2016 or 2017.

Despite the fact that the cars all share the same chassis, designed to be front engined, the Honda is mid-engined, and is also fitted with a Zytek hybrid system. Hideo Sasaki, the head of motorsports department at

Toyota unveiled their new Lexus GT500 model at Suzuka in August

Honda's NSX is the only one of the three to feature a mid-engine layout

LAT

Formula E TV deal targets burgeoning US EV market

Formula E has scooped a TV rights deal which will secure its exposure in the US, the biggest market for producers of electric cars in the world.

The multi-year deal with Fox Sports, one of the largest global sports networks, will also see the championship aired in more than 80 other territories.

Alejandro Agag, CEO of championship promoter Formula E Holdings, said that securing coverage of the series in the US was good news for Formula E (FE). 'America is a key market for electric cars and to show our races live in the US will be central to promoting this type of mobility,' he said.

The United States has seen a whopping 522 per cent increase in EV sales over the past year, while the US is also the home to the highest number of plug-in electric vehicles in the world. Since 2008 more than 116,000 road-going electric cars have been sold in the United States, and the country can claim a 46 per cent share in global sales of EVs.

But Agag also welcomed the network's commitment to broadcasting the championship in markets outside the US: 'We are very proud to announce this major agreement between Fox and the FIA Formula E Championship, and to be partnering a truly global organisation that fully believes in the future of racing. This global broadcasting deal will bring our Championship to nearly 90 countries and a potential 180 million households worldwide.'

Carlos Martinez, president Latin America for Fox International Channels, who helped broker the deal with FE, said: 'This series makes racing very relevant well into the future. With a global approach to acquiring knowledge and fast-tracking technology through the world of international racing competition, the FIA Formula E Championship is much more than just another weekend at the track... it makes racing an integral part of solving one of the world's most daunting challenges and we are thrilled to be a part of that process.'

Fox Sports has exclusive and non-exclusive rights in more than 80 territories including Canada, Latin America/Caribbean, Netherlands, Italy, Hong Kong, Malaysia, Indonesia, Singapore, Taiwan, South Korea, Australia, key Asian territories and other areas of Asia, India and Africa.

The FIA Formula E Championship for electric racecars is scheduled to kick off in September 2014, and race in 10 major cities, two of the rounds being held in the USA, around the streets of Los Angeles and Miami.

the firm discussed the new car at the launch: 'We will be competing with a GT500 car built based on the concept model of the new NSX, which is planned to be launched in the market in 2015. To preserve the image of NSX, we could not compromise the mid-engine and hybrid. I would like to express my appreciation to the JAF, GTA, Toyota and Nissan for their understanding on this subject. It was very difficult and disadvantageous to go with a mid-engine since a standardised monocoque designed for a front-engine car had to be used, but – on the other hand – it was a good challenge for our development team. For the hybrid, the system used in the CR-Z GT of GT300 class will be evolved and adopted.'

A new wave of GT300 cars based around a different 'mother chassis' will also appear in 2014. The first of these, a Toyota GT86, will make its race debut later this year in Thailand.

LAT

Nissan's GT-R Nismo GT500 is set to race in Japan next year

SEEN: CITROËN C-ELYSÉE WTCC

This is said to be Citroën's first ever circuit racecar, and it is due to hit the tracks in the WTCC next year. The C-Elysée WTCC uses the same 1.6-litre 380bhp engine that powers Citroën's DS3 WRC machine and the car is the first to be produced to the updated World Touring Car regulations, which are to come into force next year.

Citroën Racing technical director Xavier Mestelan-Pinon said: 'From a strictly technical perspective, the choice of a three-box saloon body was ideal in terms of aerodynamics. Apart from this aspect, we were able to install the various components fairly easily. As this is our first track racing car, we constantly had to ask ourselves questions about the relevance of our choices, but that's what makes this a particularly exciting challenge.'

The C-Elysée is a C-segment saloon aimed principally at high-growth international markets such as those in Latin America, China and Russia. Citroën says the C-Elysée road car is already 30 per cent ahead of its initial sales target, with 30,000 orders placed. The racecar will make its first public appearance at the Frankfurt Motor Show.

It's believed that current WTCC runners Honda and Lada are developing their own cars to the new regulations, while there is also a chance that Seat's 'Leon Cup Racer' concept might be modified to fit the new tech rules, too.

WHEEL-DRIVEN RECORD BROKEN

George Poteet and Ron Main's Speed Demon has established a new land speed record for a piston-engined, wheel-driven car. During Bonneville Speed Week, the car hit 451.933mph with Poteet at the wheel, setting a new combined record of 437.183mph.

During Speed Week, a car that beats the old record on a single run qualifies for a record attempt. It then makes a second run. The two times are averaged and if that number beats the previous record, a new one has been set. This does not meet the FIA criteria for records which require a two-way pass within one hour.

Speed Demon is powered by a 5-litre 2200 horsepower V8 engine and has now won the prestigious Hot Rod Trophy at Bonneville for five straight years.

The team is not resting on its laurels, however, and has stated that it intends to be the first wheel-driven car to break the 500mph barrier and exceed the current outright wheel driven record currently held by Don Vesco's Turbinator.

Sauber hits back at 'false' reports and rumours

Sauber has come out fighting in response to reports in the German media that its financial rescue deal with a group of Russian organisations is on the verge of collapse.

The Swiss team is angered by what is calls 'false reports and rumours' that have claimed its financial tie-up with a group of Russian concerns (see *REV23, N9*) was unravelling, and that the involvement of the National Institute for Aviation and Technology (NIAT) was looking doubtful.

But in a statement Sauber has strongly denied these claims while making it clear that the tie-up with NIAT was always intended to be a technical partnership rather than a sponsorship deal or financial bailout. The statement said: 'A financial involvement on the part of NIAT was never mooted. The plan envisaged a purely technical partnership.'

Sauber has also said that initial payments from its other new Russian backers have now been received – these are the Investment Corporation International Fund, and the State Fund of Development of Northwest Russian Federation.

As part of the deal the team agreed to sign up Russian driver Sergey Sirotkin, the son of Oleg Sirotkin, the head of NIAT, which Sauber says it has now done, and there is a chance he will take a race seat next year.

Sauber's statement reads: 'The collaboration with Russian partners, as announced by us, is progressing well. The contract with driver Sergey Sirotkin is in place. Preparations for his involvement in the team, as likewise announced, will start next week [late August] following the end of the customary holiday period in the sector.

'Beyond this, initial payments to the team have already been made, as per contract.'

The statement closed with a parting shot at the media: 'We are astounded at the heedlessness with which some media are prepared to spread false reports and rumours.'

Worry for constructors as FFord considers F4 future

Formula Ford manufacturers have said they are disappointed by the news that Ford is in talks with the FIA about switching to its new Formula 4, which is to become the FIA-backed entry level category in the UK.

If the talks come to fruition then Formula Ford will be known as Formula 4, dropping the name that's been synonymous with this level of racing since 1967, but still running the current Formula Ford EcoBoost engine.

While ostensibly an open formula, a new Ford-backed FIA Formula 4 will initially run a Mygale carbon-tubbed chassis, the French manufacturer having shown a concept F4 car earlier this year.

The news has not been received well by other chassis producers who have committed to the EcoBoost formula and have invested in new spaceframe cars. Sinter boss Lindsay Allen told *Racecar*: 'I do feel let down. I've invested a lot of money in this. We were given five years stability, then they changed the regulations and put wings on it, and then we were promised another stretch of stability.'

A new Ford-backed FIA F4 will initially run a Mygale chassis

LAT

Gavin Ray, boss of Ray Racecars, who has already spent £70,000 on developing a new car, said: 'We've designed a car to the tubular chassis regulations, and we've got a chassis sitting here... I'm really upset by the way we've been treated.'

'I don't really see that there is a marketplace for [FIA F4] in the UK anyway.'

However, head of Ford Racing at Ford Europe, Gerard Quinn, has told *Racecar* that this is far from a done deal and the views of all involved in the formula will be taken into consideration: 'The FIA have spoken to a number of manufacturers, Ford being one of them. Nothing has been planned or confirmed – it's very much work in progress, and our discussions continue, but at the heart of all this is the stakeholders in the championship.'

Quinn says that a decision should be made by the end of September, but he does not see Ford switching to F4 before 2015. 'From a personal standpoint my recommendation would be that it's not something that you would rush into. If it is the case that it's Ford that's going to move this forward, then a properly planned period of transition is something that I would recommend.' This might involve running spaceframe cars in a 'class B,' it's believed.

NASCAR secures long-term TV future with lucrative NBC deal

NASCAR has secured a $4.4bn TV rights deal with NBC Sport Network, while also extending its agreement with Fox Sports for a further two years, a brace of deals which will secure its TV coverage for the long term.

The NBC tie-up, which is to be over 10 years, will give the broadcaster exclusive rights for 20 Sprint Cup Series races, representing the slice of the action that is now shown by ESPN and Turner Sports.

However, both ESPN and Turner will see out their contact – 17 races and three races respectively – through next year, with NBC taking over in 2015. It's understood that they were both unwilling to stretch to the $4bn-plus asking price, and so did not take up their options on continuingto cover the premier US motorsport series.

The news means NBC Sport Network and Fox Sports will now be the two NASCAR broadcasters from 2015, and the latter has added a further two years to the agreement it signed with the US stockcar governing body last October, with the 'multi-platform, multi-series media rights' arrangement now continuing until the end of 2024.

On top of this, Fox Sports has added exclusive rights to three additional NASCAR Sprint Cup Series events and the first 14 NASCAR Nationwide Series events of each season. Fox Sports secured exclusive rights to the entire NASCAR Camping World Truck Series season through 2022 last autumn, and that part of the agreement has also been extended through 2024. NASCAR refused to comment on the financial terms of the agreement.

NBC have rights to 20 Sprint Cup races

LAT

NASCAR says its media rights package for 2015 and beyond is now complete, with Fox Sports holding rights to the first 16 Sprint Cup Series races, first 14 Nationwide Series races and the entire Camping World Truck Series season. NBC, which last broadcast NASCAR events in 2006, will televise the final 20 Sprint Cup Series races, final 19 Nationwide Series races and the K&N Pro Series and Whelen Modified Tour events, beginning in 2015.

NASCAR vice president of broadcasting and productions, Steve Herbst, commented: 'NASCAR on Fox has been very popular with fans everywhere and we believe its expanded schedule will strengthen its relationship with the fans and provide the sport with many opportunities to cross-promote and grow our combined audiences.'

Meanwhile, Fox has also signed a five-year deal with IMSA to cover the United SportsCar Racing series, a deal that will run through until the end of 2018.

BRIEFLY

Pirelli back in WRC

The FIA has confirmed that Pirelli will return to the World Rally Championship next year, joining Michelin, DMACK and Hankook as a WRC tyre supplier. The Italian manufacturer had produced control tyres for the WRC for three years before it pulled out in 2010. FIA rally director Jarmo Mahonen said: 'Having Pirelli return to the series is very positive, and together these four brands will provide a great platform for open competition as well as choice and variety for our competitors.'

Indy twins

IndyCar has confirmed it's to make twin-turbo systems mandatory as it attempts to ensure parity between the engine makers involved in the series, Chevrolet and Honda. The change was announced during the first two-year manufacturer homologation update cycle since the series was reopened to engine competition. Honda will benefit most from the rule change, as it currently races its 2.2-litre V6 in a single-turbo configuration.

Tiga to burn bright at Le Mans once more

Racecar manufacturer Tiga could be heading back to Le Mans, as its new owner looks to repeat the glory days of the 1980s with the famous sports prototype marque.

Gentleman racer Mike Newton recently took control of the company and it will now continue to provide parts and support for historic Tiga chassis dating from 1974-1989, as well as developing its current CN2 sportscar, but it is also evaluating a return to Le Mans with an LMP2 Tiga.

A statement from the company said: 'Part of the ex WFR CN car package [which Tiga has acquired] also included the LMP2 project, and a detailed design review is being undertaken to determine whether this can be updated into a competitive cost capped LMP2 project.'

But Newton said the Le Mans project is still in its early stages: 'We have been working together over the last couple of years as a platform for the new CN Series cars. We now have a number of exciting opportunities in the pipeline, and look forward to continuing this iconic brand. While the LMP2 option is very exciting, we are at the very early stages with this project.'

In the shorter term Tiga will continue to develop its CN12a, while there is also a future evolution of a further CN2 design which is an update on the 2011 WFR chassis, planned to be launched later in the year.

The company also plans to build a dedicated 3100sq ft building adjacent to the Orex Competition base in Northwich, Cheshire, UK, which will house the cars and design resources.

Tiga, which was originally founded by Howden Ganley and Tim Schenken, has had success on the world stage in sportscars previously, when a Spice-Tiga GC85 Ford won the Group C2 Teams title in 1985. In the company's first incarnation it built nearly 400 chassis, from Formula Ford to Group C, before it folded in 1989. Mike Taylor acquired the rights to Tiga in 2007, and it was he who sold the resurrected company on to Newton.

LAT

Tiga will provide support for historic chassis, and also plan a new LMP2 car

'Fast Track' casting company invests in innovative rapid 3D technology

Well-known motorsport castings company Grainger & Worrall has invested half a million pounds into new rapid prototyping machinery.

The all-new S-Print HHS sand printer is said to be the first commercially available installation of its type in Europe. The equipment, which has been housed in a purpose-built production facility at Grainger & Worrall's Bridgnorth, UK site, makes use of a high heat strength (HSS) binder paired with a low-expansion sand mix to create highly intricate core structures, directly from CAD data.

Grainger & Worrall tells us the tool-less casting technology provides greater design freedom by enabling the construction of previously unfeasible internal geometry, when compared with directly-milled sand moulds.

Edward Grainger, director of the family-run company, said: 'Our commitment to delivering market-leading programmes for our client-base means we are seeking, constantly, to improve our infrastructure and capabilities. Our latest investment will further enhance our ability to offer customers across the automotive, motorsport and aerospace sectors greater benefits in terms of time, cost and performance.'

The new purchase comes in the wake of the company recently being included in the prestigious Sunday Times Fast Track International 200 survey, which ranks Britain's private companies with the fastest-growing international sales.

Matthew Grainger, director at Grainger & Worrall and brother of Edward, said: 'It's great to be included in this influential listing. It is recognition of the hard work the whole company has undertaken over the past few years to drive the business forward internally. This fantastic achievement has only been made possible through the hard work and dedication of our talented and innovative workforce.'

Grainger & Worrall was founded in 1946 by pattern makers and brothers-in-law Vernon Grainger and Charles Worrall in Upper Gornal, West Midlands, UK. The family company remains privately-owned, and is now run by co-founder Vernon Grainger's three grandsons: James, Matthew and Edward.

£10m prize for low emission technology

The UK Government has offered a new £10m prize as an incentive to help develop the next generation of ultra-low emission cars.

Chief secretary to the treasury, Danny Alexander, announced the prize during a visit to McLaren, and explained that its aim was to encourage commercial and investment opportunities in Britain's car industry through the next generation of technology.

The prize will be given for the technological improvements which enable ultra-low emissions vehicles to run as long as, and as far as, conventionally fuelled cars, without needing to stop or burn fossil fuel. Critically, the prize will only be targeted at technology for everyday cars that are comparable in price to conventionally fuelled cars, in order to ensure that the next generation of low-emission cars are affordable for all.

The competition will start by the end of the year and will be open to all, including businesses, universities and engineering experts – including those involved in motorsport. A panel of expert judges will assess the applications against a set of criteria to determine when the prize has been won.

The new prize comes on top of investment the Government is already making in ultra-low emissions vehicles, where it claims some £400m has been committed in this parliament (from 2010) to help increase take-up of this type of transport, through subsidised unit prices. There will also be £500m of investment in the next parliament, the Government says.

Speaking at the McLaren Technology Centre, Alexander said: 'The McLaren P1 is a great British technological success story. But we want more companies to invest in this research so that Britain is the global leader in ultra-low emission vehicles, and that is why we have announced a prize for innovations which will enable the next generation of low emissions vehicles to run as long as and as far as conventionally fuelled cars.'

INTERVIEW: MICHAEL ZELE

Austrian Michael Zele started his motorsport career as a mechanic at Helmut Marko's RSM Marko team in the late-90s, before moving on to Walter Lechner Racing, where he became chief mechanic for the Formula Ford operation. He then set up Zele Racing in 2002. The team raced in the World Series by Nissan, before Zele stopped competing as a team in order to concentrate on developing the car for the stillborn Superfund Formula. At the start of last season the team re-entered racing in Auto GP. Zele has also engineered racecars on a freelance basis in Formula 3, sportscars and other formulae.

What's the attraction of Auto GP to you?
Well to be honest, from my point of view, it makes more sense than any other formula at the moment. Although the car is not really the latest spec, if you compare it with World Series or a GP2 car, at the end of the day it is very good value for the money. It's a bullet-proof car and it's easy to maintain and to handle for the teams. It was designed by Lola to run in A1GP, which was obviously low maintenance back then because the cars were pretty much travelling from racetrack to racetrack all the time, and it makes it quite a lot easier for the teams to run the car, and more economical, too. It's always produced very good racing. That's purely because it's not so much depending on aero grip.

Auto GP cars are running with a heavily revised aero kit this year. How is it working out?
I think the new kit has obviously gained a little bit of performance. We're definitely faster in a straight line than last year, so it's got less drag... In general I would say it gained between one to one-and-half seconds over last year's car.

What's your opinion of the news that Auto GP might re-join the WTCC package for next year?
The biggest problem we had last year is that we had five races in the beginning of the season, until the beginning of June, and then just two races for the rest of the season, which made it difficult for us. The calendar they propose for next year looks more evenly spread, and if you have four instead of two overseas races, then it makes sense to send all your equipment overseas [outside Europe]. If there are only a couple of races and you send all your stuff away for six months, then it doesn't make sense at all. I think we are welcome at the WTCC, we are not the fifth wheel on the wagon, and at most of the tracks we have a very good crowd. The calendar is very good – we go to Argentina, Japan and China, which is basically opening the door to new markets. Staying in Europe there is just too much competition [for driver and sponsor budgets] from other championships.

Will a move to a worldwide series drive budgets up?
For 2013 we have calculated around €500,000 to €550,000. It is very good value, and you get a lot of car for the money. And for next year we're probably looking at a slight increase, but I wouldn't expect it to be a massive increase with the overseas rounds. From my point of view it's not going to be more than €600,000 because you do not need personnel for the whole season, or a big amount of personnel for the season, because you just need them for four weekends over five months. What you spend on flight tickets you will probably save on truck transport.

You have had two former Formula 1 drivers in your car this year – Narain Karthikeyan (who left the team in May) and Christian Klien. How have they found the Auto GP racecar?
They both think it's a good car to drive. It's a big single-seater, it's

Todt could face challenge for FIA top job

Jean Todt's second term as president of the FIA may not go unchallenged, with a former confederate of the Frenchman's predecessor in the post saying he is considering putting himself forward.

David Ward, who was one of Max Mosley's key aides and who has been head of the FIA Foundation road safety division for the past two years, has let it be known that he is thinking about standing for the presidency.

Ward says the reason for him considering going for the FIA top job is to spark a debate and to offer a choice of candidates. 'This is not what I intended nor what I wanted, but I am certainly thinking about standing because it is important to have a debate,' he told *The Times*.

LAT

David Ward is considering running

'You can only have a debate if there is a choice of candidates, and there is no debate if there is no choice,' Ward added.

Ward has a background in politics and in the early-90s he was an adviser to the then-leader of the Labour Party, John Smith. He was also involved in the scandal involving Bernie Ecclestone and the Labour Government in 1997, when the Government was accused of taking a £1m bung from F1 in the hope of fending off a ban on tobacco advertising.

Ward first joined the FIA as director general of its European Bureau, which is based in Brussels. He has often worked with the British Government and European Parliament on behalf of the FIA.

Before he could become a candidate, Ward would need to gain support from a number of the national FIA-affiliated organisations.

CAUGHT

Ferrari has been fined €15,000 but escaped a penalty after it was found to be running with an illegal DRS setup during the Hungarian Grand Prix. FIA technical officials reported the team to the stewards as data downloaded following the race revealed that its driver, Fernando Alonso, used DRS on three occasions when he was not within one second of the car in front – the system should only be able to be triggered when a car is following within a second of another as they pass an activation point.

The FIA said that a setting error by Ferrari caused the problem, but as any advantage gained had been negligible –

powerful, and it's fun to drive; because you can actually drive it on the throttle, on power. It's obviously lacking a lot of aero in comparison to Formula 1, but it's still a quick car.

How good a prospect was the Superfund Formula car that you developed?
It had at least GP2 potential. The initial testing we did was pretty much GP2 pace, what they're doing now. It was a 4-litre Judd V10 engine, and with the ethanol we were running we had around 800bhp. We had traction control and paddle-shift, carbon brakes – Formula 1 brakes actually. So it was a pretty sophisticated car. But it was probably a bit too heavy, because in the mid-noughties Airbus Industries bought so much carbon material for the A380 that there was a shortage and the price went through the roof. So they decided to go down another route, to make it with slightly cheaper carbon materials, but then it turned out heavier than they really wanted it. But the car itself, it had potential for sure.

reckoned to be less than one second advantage over the entire race – it did not think a time or points penalty was called for.
FINE: $15,000

Butch Hylton, the crew chief on the No 17 Red Horse Racing run Toyota in the NASCAR Camping World Truck Series, has been fined $5000 after the roof of the truck failed to meet the minimum height restriction at post-race inspection following the Pocono Raceway round of the championship. The truck's driver, Timothy Peters, and its owner, Tom DeLoach, were each docked points in the driver and owner championships.
FINE: $5000
PENALTY: 6 points

BRIEFLY

The full Conti
IMSA and Continental Tire have signed a tyre deal for the new-for-2014 United SportsCar Racing championship, the series which is the result of the amalgamation of the ALMS and Grand-Am. Starting with next January's Rolex 24 at Daytona, the Continental deal will extend to the new series' Prototype (P), Prototype Challenge (PC) and GT Daytona (GTD) classes. The GT Le Mans (GTLM) category will be open to multiple tyre manufacturers. Continental will also return as title sponsor and exclusive tyre supplier to the IMSA Continental Tire Sports Car Challenge (CTSCC).

New site for Bosch
Bosch has chosen a site in Coventry, England as the base for its UK motorsport operation. The company has taken a 5600sq ft unit at the University of Warwick Science Park. The new Bosch Warwick Technology Centre is to provide engineering support and services for its UK customers and around 30 engineers are to be based at the facility. In 2012, the German company generated sales of €52.5bn worldwide. Bosch also has a base at the MIRA Technology Park in Nuneaton, UK.

Printing money
Stratasys has reported record financial results for the second quarter of 2013. The American 3D printing company has posted revenues of $106.7m for the second quarter, representing a 20 per cent increase over the $88.7m recorded for the same period last year. The company also invested a net amount of $10.3m in R&D during the second quarter. Last year Stratasys acquired Israel-based Objet, which was also a major player at the high end of the 3D printing sector, while in June of this year it bought MakerBot, a builder of desktop versions of 3D printers.

RACE MOVES

Steve Hallam is to leave his position as managing director at crack V8 Supercars outfit Walkinshaw Racing at the start of next year. He will be succeeded by **Adrian Burgess**, who is currently on gardening leave after parting with Red Bull Racing Australia, where he was team principal. **Roland Dane** will take over Burgess's role at Red Bull, a position he has filled in the past.

There's been an engineering reshuffle within the Rahal Letterman Lanigan IndyCar oufit, with **Gerry Hughes** being named as head of development, while **Neil Fife** has taken over Hughes's former post as race engineer for Graham Rahal. **Mitch Evans,** who was most recently team manager at Ganassi's second team, has also joined RLL, taking on the post of crew chief for both Rahal and his team mate James Jakes.

Mathew 'Techo' Nilsson is to leave V8 Supercars team Ford Performance Racing at the end of the season. Nilsson, who is engineering manager at the works Ford outfit, is believed to be heading back to a team fielding Holdens, Ford's fierce rival in the Australian touring car series. He worked at Holden works team HRT before joining FPR in 2010.

Doug Duchardt is now executive vice president and general manager at top NASCAR outfit Hendrick Motorsports. The former General Motors executive, who has been at Hendrick Motorsports since 2005, will now oversee all of the organisation's racing activities. He started out at Hendrick in the post of vice president of development.

As part of a technical partnership between V8 Supercar squads Ford Performance Racing (FPR) and Dick Johnson Racing (DJR), FPR senior engineer **Campbell Little** is to work regularly with the fellow Ford outfit between events, while continuing to engineer Alex Davison's FPR car at the races.

The former lead motorsport design engineer at Gill Sensors, **Neville Meech**, has founded a new UK-based design and engineering consultancy to service the motorsport and automotive industries. Meech has more than 12 years of experience working closely with engineers within F1, sportscars and IndyCar.

Richard Childress Racing crew chief **Luke Lambert** was unable to take his post in the pits for the Indianapolis Motor Speedway NASCAR Sprint Cup counter, due to an eye complaint. The team engineer on the No 31 **Jeff Burton**-driven car, **Matt McCall**, took his place for the duration of the race.

LAT

Former IndyCar ace **Gil de Ferran** (pictured) has joined the FIA Formula E Championship as an official ambassador. The Indianapolis 500 winner and former Honda F1 team sporting director will act as an adviser to the new Championship, while he will also be an official spokesman for Formula E, particularly in North America.

Frank Tiedeman, the founder of the Monoposto Register, which evolved into the Monoposto Racing Club, has died at the age of 92. Tiedeman was a successful club racer, and he was also the first Monoposto champion, at the wheel of a Cooper 500-based special called a Mille-cent.

NASCAR has named former crew chief **Chris Wright** as its new NASCAR K&N Pro Series East director. Wright has previously been a crew chief, shop foreman and consultant for teams in the NASCAR Nationwide Series, NASCAR K&N Pro Series and NASCAR Canadian Tire Series.

Renowned aerodynamicist, F1 designer and current chief technical officer at Red Bull, **Adrian Newey**, has been awarded an Honorary Doctor of Engineering degree by Oxford Brookes University. Newey commented: 'My university education has proved to be invaluable throughout my career and I have worked with a number of highly skilled graduates from Oxford Brookes. The university offers some excellent engineering courses which are taken up by students from around the world.'

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James Allison confirmed in new Ferrari role

Former Lotus tech chief James Allison is now working at rival F1 team Ferrari as its chassis technical director, having taking up the post at the beginning of September.

As a result of Allison's arrival, former technical director Pat Fry has taken on the role of director of engineering. Both Allison and Fry, who previously worked together at Benetton in the early-90s, will report to team principal Stefano Domenicali.

Allison was previously at Ferrari between 2000 and 2005, when the Scuderia won five championships in a row with Michael Schumacher. He moved on to Renault, as Lotus was previously known, in 2005, and was made technical director there in 2009.

In May of this year, just after Allison left Lotus, Ferrari president Luca di Montezemolo said talk of him moving to Ferrari was just rumour. 'I know nothing,' he said, 'so I cannot deny anything. As far as I know, these are just rumours.'

Ferrari lead driver Fernando Alonso, a man who has been vocal about the team's dip in form as this season has progressed, will welcome the signing of Allison, having said earlier this year that he would like to work with him again, and that he considers him to be one of the top technical men in Formula 1, 'I worked very closely with him and was world champion with him two times,' Alonso said. 'Then I came back to Renault in 2008-2009 – in 2009 he was already technical director and we were not so successful with that car, but we saw the Lotus car in the last two years and it is no secret that he's one of the top men in F1.'

LAT

OBITUARY – JOHN COOMBS

Former race team owner John Coombs has died at the age of 92. Coombs, who for many years owned the Surrey Jaguar dealership Coombs of Guildford, first became involved in racing as a driver in the 1950s, competing in Formula 2 and sportscars before deciding to build up his own team.

Coombs' team excelled in saloon car racing, particularly with Mk2 Jaguars, and also had success in GTs and Formula 2. He also played a big part in the early career of Jackie Stewart and is largely credited with persuading Jaguar to develop its lightweight E-Type racecar.

When Ken Tyrrell first took his team to Formula 1 in 1968, Coombs took over his Formula 2 operation, running luminaries such as Stewart, François Cevert and Piers Courage. He also persuaded Tyrrell to give Patrick Depailler a seat in F1.

During the 1980s Coombs scaled back his racing operations, while he also switched his dealership's allegiance from Jaguar to BMW. Eventually Coombs became disenchanted with BMW and he sold the dealership, retiring to Monaco. He kept a workshop in Guildford, though, and was involved in historic racing, particularly active in preparing cars for the Goodwood Revival meeting.

John Coombs 1922-2013

RACE MOVES

NASCAR has appointed **Kip Childress** as its K&N Pro Series West director. **Les Westerfield**, who has served as the interim K&N Pro Series West director during the first half of the season, will resume his role as NASCAR Touring Series technical coordinator and NASCAR K&N Pro Series East race director.

Veteran team manager and crew chief **Tony Glover** has been appointed as the NASCAR Touring Series technical director. As a crew chief, Glover has 24 NASCAR Sprint Cup Series wins to his name, including Daytona 500 victories working with **Sterling Marlin** (twice) and **Ernie Irvan**. He also accumulated 45 Coors Light Pole Awards with 11 different drivers and guided two drivers to NASCAR Sprint Cup Series rookie of the year honours.

Matt Brannock, the director of operations at NASCAR venue Martinsville Speedway, scooped the Security Professional of the Year Award at the US's National Sports Safety and Security Conference. The track itself also won the Facility of Merit Award at the Orlando-based event.

Tony Gaze has died at the age of 93. Gaze was the first Australian to start a Formula 1 grand prix and was also instrumental in persuading the Earl of March to convert RAF Westhampnett into a race circuit, later called Goodwood. During the second world war Gaze was a fighter pilot, flying Spitfires, and was awarded the Distinguished Flying Cross. He also setup Australia's first international racing team, called the Kangaroo Stable.

Well-known motorsport photographer **Max Le Grand** has died at the age of 73 after losing his battle with cancer. During his life he also authored racing history books including The RAC Rally and Brands To Bexhill.

Paul Newsome has been promoted to the post of chief technical officer at Williams Advanced Engineering – the division of the group that adapts F1-based technologies for a range of commercial applications. Newsome joined the company in January 2011 as Head of High Performance Vehicles, where he was responsible for the team that designed and built the C-X75 hybrid supercar in conjunction with Jaguar Land Rover.

LAT

Zytek founder **Bill Gibson** (above) has been awarded an honorary degree of Doctor of Engineering by the University of Sheffield. Gibson joined Lucas as an electronics engineer on graduating from Sheffield University in 1971. A decade later he established Zytek, first supplying engine management systems but going on to become a major force in motorsport as both a chassis and an engine builder.

Red Bull's pit crew was the fastest in Formula 1 for the first half of the season, according to figures supplied by German publication *Auto Motor und Sport*. The reported average pit stop time for **Sebastian Vettel** and **Mark Webber**, up until Spa, was just 2.83 seconds.

Vincent Gillet has been appointed vice president, marketing, at Red Bull title sponsor Infiniti. Gillet, who has 20 years of marketing experience with leading premium brands across the retail, wine and spirits, and hospitality industries, will be based at the company's global headquarters in Hong Kong.

Global fluid systems company **Pirtek** has secured the naming rights to the V8 Supercars Enduro Cup, which is an all-new championship that will run within Australia's premier motor racing championship, V8 Supercars. Points for the Enduro Cup will be scored at the three long distance V8 races: the Sandown 500, Bathurst 1000 and Gold Coast 600.

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

BUSINESS TALK: CHRIS AYLETT

The right time for growth

With renewed focus and good planning, new customers could be yours

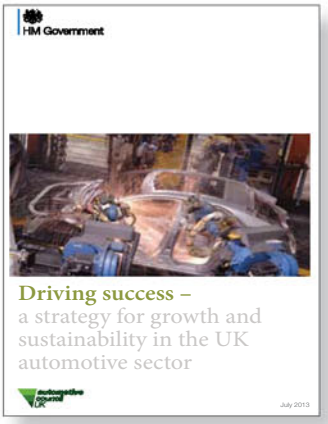
UK and European economies are emerging, blinking in the pale sunlight of economic upturn, but with caution and limited confidence. At the MIA, I am constantly drawn into great discussions on business strategies and how to select the best to grow business. Since 2008, survival has been the target and motorsport has done a pretty good job of it. Hunkering down, minimising staff costs, finding efficiencies and winkling out new business.

But now plans must focus on maximising the upturn – and that means chasing and securing significant new business.

Historically, suppliers have focused on motorsport demands. Never take your eye off the ball or your customer slips down the league. Following reductions in sponsorship, many now feel it's better to 'spread their bets' and supply outside motorsport. Caterham, Williams and McLaren have grown their non-motorsport, with increasing success. All gain from wider media recognition and increasing reputation for innovation bringing new customers and investors, while still delivering results on track.

Many in the supply chain have chosen to more fully exploit their engineering expertise in new sectors, with the bonus of bringing new ideas back into motorsport. I favour using every bit of capability to the full – whether stock, material or people. This is no time to ignore any business opportunity. Management has to meet demands from all customers – whether winning races or in automotive, defence or marine, for example.

I receive substantial new business enquiries every week from these new sectors, which I relay to MIA members. The figures are surprising – a major powertrain customer recently told me of their plans to find new suppliers from motorsport. To develop a new powertrain takes seven years and significant investment – £2m to proof of concept, £30m to demonstrate how to scale up ready for manufacture; and a further £50m to fully setup the concept to manufacturing readiness – over £80m for each powertrain development. They want motorsport suppliers to meet part of these to deliver results more efficiently, effectively, in a shorter timescale.



To help grow your firm, read this

For more on this, read the joint UK automotive industry and Government strategy announced recently – *Driving Success* – which plans future growth and sustainability in UK automotive. You can find it using the search function on www.the-mia.com. This is the most exciting business news for UK motorsport in 50 years or more, clearly committing to enhance links between the £50bn UK automotive sector with the energy efficient expertise of motorsport companies. Major companies on the Automotive Council plan to commercialise more motorsport ideas within mainstream automotive and share new technologies and innovation.

The UK is Europe's fourth largest vehicle producer, and the Government is determined to get ahead of the game in R&D and low emission vehicles, in part by using the strengths of UK motorsport companies. The UK automotive supply chain has some weaknesses, which they identify motorsport as being capable of improving – not in high-volume production, but in essential R&D prototype, pre-production work.

UK automotive is growing fast – sales up 17 per cent between 2010 and 2011, 2.5 million engines made in 2012, over £6bn investment in vehicle and engine manufacturing in the past two years. Cars produced will grow from 1.6 million to 2 million in the next three years – in 2009 it was less than half that. These strong, well-financed new customers now want motorsport to become new suppliers to help meet low emission challenges.

Jointly with Government, they will invest £100m a year for the next 10 years to develop new supply chains through a new Advanced Propulsion Centre (APC) hub programme. This will fund a wide range of small, early stage, technology proof of concept R&D programmes, ideal for motorsport companies. The APC plans to make the UK the go-to location and R&D hub for new powertrain development and manufacture.

Motorsport must take its share as these new customers build momentum. Success in business relies on luck, but you can make your own luck, and this is what motorsport has done. Delivering world-class and high performance solutions for many years has secured them an exceptional reputation for delivery, quality and excellence. This made their luck, as the automotive world now needs more capability to deliver energy-efficient solutions, which have long been central to success in motorsport.

Now, one of the largest automotive group of customers in Europe, admitting it needs help and doesn't have the number of suppliers to meet new challenges, plans to invest £100m a year to grow a new supply chain, and openly invites motorsport companies to engage with them.

To help meet their low emission challenges, they want to migrate from motorsport more lightweight vehicle innovations, manufacturing and joining technology, next generation CAD for weight reduction, innovative energy storage technologies and to improve the efficiency and technology of internal combustion engines – incorporating fuel injection, downsizing, hybrid, waste heat recovery and low carbon fuels. There are many businesses in motorsport who can help meet these challenges.

If I have learnt anything in the last two decades, it is to never totally rely on next year's sponsorship, no matter how successful you have been. It will be some time before sponsors return to previous levels, and when they do they will be more savvy than ever – demanding more for less – and this will put pressure on motorsport suppliers to keep prices low. So while continuing to use your expertise to gain from motorsport as best you can, also spread the risk by finding customers in other sectors. Here you have a golden new customer – Automotive UK – saying 'we want to deal with motorsport companies' and we have billions of pounds to spend over the next decade.

Grab this with both hands! Download the Driving Success report, check what this gift horse is saying, and plan to take your share. I am proud that the MIA has been central in developing this programme, so do contact us for advice. Let's work together to make motorsport more commercially secure for the future, so we can enjoy our racing business for many years to come.

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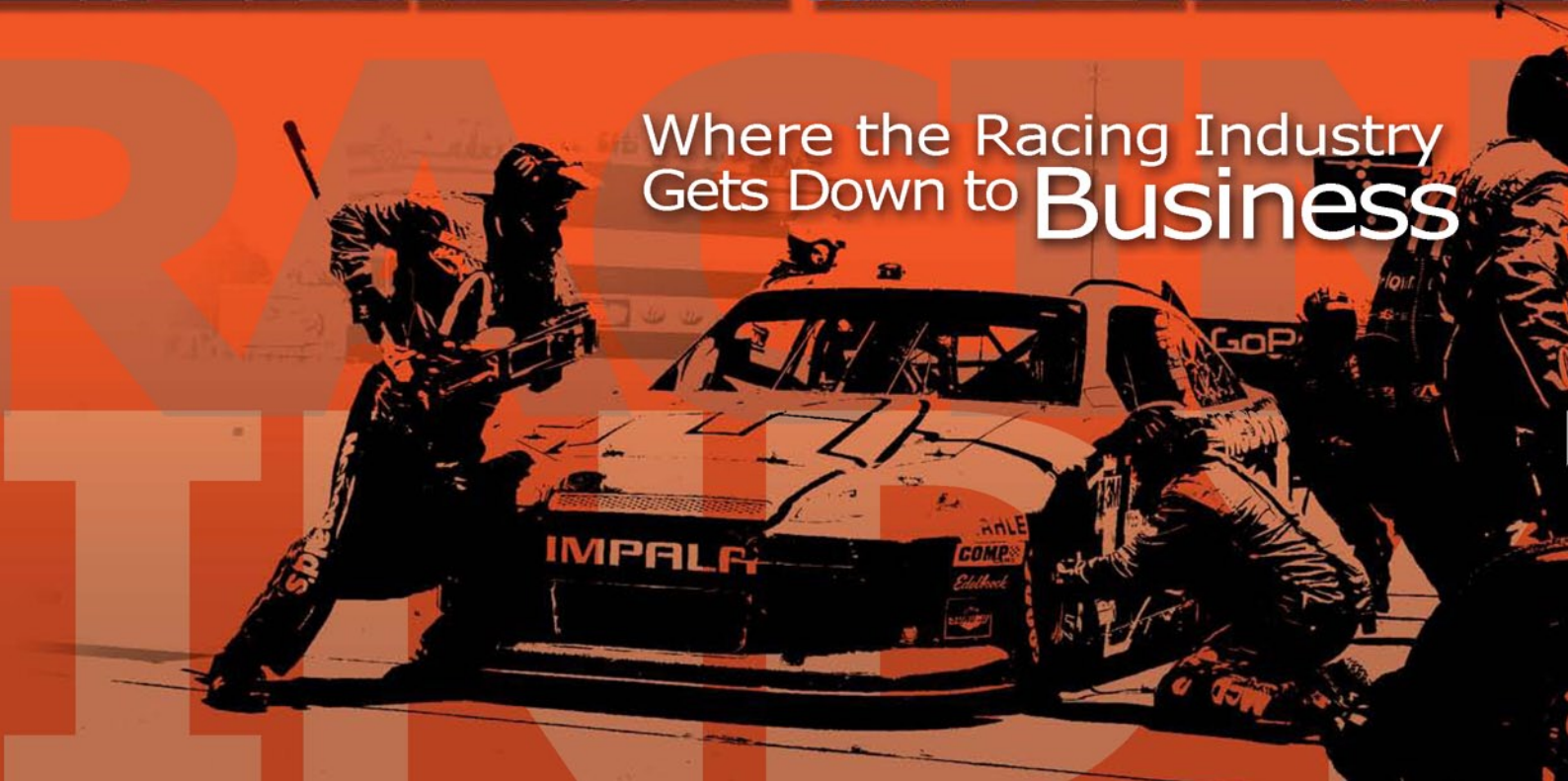

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MOUNTINGS

New Earl's oil cooler clamps

Fluid control specialist Earl's has released a trio of stylish oil cooler clamps to allow easy mounting of modular type oil coolers. The anodised aluminium mounting system is made with E-coated steel hardware and rubber isolators to rigidly mount coolers in a variety of locations and orientations. The rubber isolators keep vibration from reaching the cooler for longer life and helps allow for less than perfect installation situations while maintaining a firm grip.
www.holley.com

MACHINING

Kern Micro

Kern Precision has released the Kern Micro, a new compact five-axis vertical machining centre. The Kern Micro is aimed at manufacturers that have ultra-precision requirements and a wide range of production needs from nanoscale to large sized parts. The machine tool can accommodate large work pieces up to 350mm in diameter and 220mm in height, yet takes up little space.

The Micro is designed to offer machining accuracy down to ±0.5 microns, with achievable part accuracy down to ±2 microns. Besides a small footprint, the Micro features a tool cabinet with quick-change pallet for more than 200 tools. The system also includes a workpiece palletisation system using a System 3R Macro Magnum or Erowa Power automatic chuck as a pallet receiver. Other key features include an automatic laser tool measuring system, a workpiece probing system, and an advanced temperature control system for maintaining and ensuring the highest possible accuracy.
www.kern-microtechnic.com

DISPLAYS

MoTeC C125

Data logging and ECU specialist MoTeC has recently released a new dash display, the C125. The 125mm LCD display is high resolution, ultra bright and anti-reflective for easy reading in direct sunlight. Users can select from numerous supplied layouts, within which the channels, labels and measurement units are all configurable to cater for individual driver preferences. The new display also features an integrated array of high intensity LEDS for use as shift lights, warnings or other driver alerts. The function, colour and brightness of each light are fully programmable, allowing users to create customised sequences for their application. The C125 can be supplied as a powerful standalone unit, or in a complete, race-ready kit. The kits include a 10Hz GPS sensor, pre-wired buttons, a plug-in loom with power adaptor and an Ethernet cable. In all instances, the C125 can be ordered with or without logging. Non-logging displays can be upgraded at any time in the field by purchasing a 120MB logging upgrade. Convenient plug-in adaptor looms are available for connecting the C125 to many factory or aftermarket ECUs to display and log vital engine data. For later model cars it can be as easy as plugging into the vehicle's OBD port. For those wanting additional functionality, an I/O upgrade is also available to enable numerous inbuilt inputs and outputs.
www.Motec.com

TRANSMITTERS

Kistler 4080A

The new Kistler Type 4080A is a piezoresistive absolute pressure transmitter for racing and harsh environment applications. The compact and lightweight sensor is supplied with an M6 mounting thread and is ideal for measurements in hydraulic systems. Kistler envisages the sensor being used in applications including pressure and temperature measurements in gearboxes, steering systems, braking systems, water and oil circuits and hydraulic systems. The transmitter offers a constant temperature output and is available for pressure ranges of 5, 10, 20, 130 and 250 bar and will operate in temperatures from -40 to 120degC.
www.kistler.com

TOOLS

Proform valve spring compressor

Proform claims that its new Pneumatic Valve Spring Compressor can cut cylinder head disassembly times by half. Pulling the tool's trigger supplies up to 350 pounds of force using 125-psi air-compressor pressure (it will operate with as little as 100psi if required), compressing even the most heavy duty valve springs. With the valve spring compressed, its keepers and retainer can be easily removed, helping to speed up engine assembly and disassembly times.

www.proformtools.com

MACHINING

Nakamura NTJ-100

The new Nakamura Tome NTJ-100 is a fast, B-axis, twin-turret, twin-spindle milling and turning centre. It's aimed at the production of smaller components featuring multiple facets, particularly where angular positioning of the work piece is required. The upper, B-axis turret can swing through 182 degrees for the in-cycle milling and drilling of angled features, while one-hit machining is further enhanced by Y axes on both turrets that offer an 80mm stroke on the upper turret and 65mm on the lower turret. The angular positioning capability of the B-axis turret configuration typically gives much shorter cycle times on components than an ATC (Automatic Tool Changer) type machine, due to its shorter chip-to-chip times. It is claimed that the small dodecahedral, servo-driven turrets give a chip-to-chip time of around 1.5 secs, compared to 8 secs for an ATC machine. An innovative feature of the NTJ-100 is the ability to mount up to six turning tools on the face of the upper turret, which can be tilted to machine the work piece using the B-axis.

www.nakamura-tome.co.jp

SECURITY

Facom traceable tools

Facom has launched a new RFID range of tools. These are tools fitted with transducer chips that are monitored via a terminal mounted on the tool cabinet (or anywhere else convenient). Each time a tool is taken away or returned, it is logged. Users either punch in a code or wear a tag that lets the system know who is using the tool. The new range consists of over 700 products to cover every application, with particular focus on the tools which are at the highest risk of being lost. RFID technology is wireless and allows storage and retrieval of information remotely. It enables the identification of a tool thanks to an electronic chip which is encapsulated inside the tool running on energy supplied by the short distance radio signal from the transmitter. Enclosed within a shock-resistant shell, the chips are durably protected, even against chemical agents, without modifying the basic features of the tool or its ergonomics.

www.facom.com

THROTTLE BODIES

Jenvey downdraft bodies

Jenvey Dynamics has released its TFP range of throttle bodies, which have been designed to replace downdraft carburettors to facilitate a conversion to EFi. The bodies are primarily intended for use on V and boxer engines. The TFP range have a bore spacing of 90mm making them compatible with the regular Weber IDF-type manifolds and are available in a range of bores from 40mm through to 50mm.

www.jenvey.co.uk

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Top tips for attracting and engaging visitors at your exhibition stand

Tony Tobias has many decades of experience in creating an exhibition experience that help strengthen relationships and improve communication. Here's his primer on how to go about drumming up interest at your stand

Exhibitions have the potential to offer a good return on investment, ROI – but only if you know how to grab the interest of the passing footfall.

Making the most of your exhibition stand involves focusing on two key things – attracting visitors to your stand and then communicating with them once they are there. If you get it right you can build new relationships, and plenty of new business leads.

However, every stand at the exhibition will be trying to do the same. So, how can you be sure to stand out?

ATTRACTING VISITORS TO YOUR STAND

Successful engagement has to start with getting visitors to your stand in the first place. Here are four tried-and-tested attention-grabbers:

1. **Unique stand design – a stand with spectacular design features can be more attractive than any gimmick. Many stand builders focus solely on conveying product or service information – they don't think about attracting attention. Bold colours and innovative lighting can help to draw people to you.**
2. **Technology – a neat gadget or two can be like a shiny object to a magpie. One of the most popular pieces of tech I observed at a show was a gearbox with the option to actually shift gears, which had visitors queuing across rows of stands. Everyone passing by wanted to try it, so it gained the stand even more attention!**
3. **Entertain your visitors – you could run a competition, offer refreshments, soft drinks, good quality biscuits or a well-known industry personality on the stand. Entertainment is a sure-fire way of gaining initial attention.**

ENGAGING VISITORS AT YOUR STAND

OK, so you've made the important first impression and successfully attracted visitors to your stand. Now, then, you need to engage them. There is no single way to achieve this, but it's best to combine a few techniques.

Here are six ideas that we have used successfully on exhibition stands:

1. **Engaging staff: well-presented and friendly staff with the knowledge of the company, who will ask for business cards, and hand out literature.**
2. **Videos – a high-quality video on a TV monitor or iPad is eye-catching, stimulating and informative. Be sure to include a call-to-action such as 'take one of our leaflets' or 'scan this QR-code to send us an email' to increase follow-up contacts.**
3. **Live tweets – display a live Twitter feed and invite questions to your offsite social media sales team – helping to engage and inform your visitors even when all your on-site staff are busy.**
4. **Get your iPad out – cool gadgets not only help attract visitors to your stand, they can also be a great way of gathering contact details, completing surveys and demonstrating your products.**
5. **Coffee – it may sound obvious, but it does work. Good quality hot drinks can be hard to come by at events, so you may find you're offering something that a lot of visitors are looking for! It also gives you time to engage the visitor in conversation while they wait for it to cool.**

FOLLOWING UP

By far the most important advice is to follow up on the visitors as soon as you return to your office after the show closes.

However you decide to attract and engage visitors, it is always vital to follow up with your new leads within a few days of the exhibition. If you have the resources – make the contact personal. A personalised message is so much more memorable and will do wonders for the perception of you and your brand.

Exhibitions are a big investment – but done right they can deliver huge rewards. So be sure to think carefully about how you are going to attract visitors, engage them and follow-up with them afterwards. By considering these areas at the planning stage you can expect to considerably increase your return on investment.

For more information on how to exhibit at Autosport International, contact the head of business development Tony Tobias: **tony.tobias@haymarket.com**

Piper step up technical ability with high quality cam grinding equipment

Piper can trace its roots back almost 50 years, longer than most other cam companies, but it takes more than history and heritage to keep a company at the top of its field. It takes constant improvement. Piper Cams have just taken delivery of a Berco Lynx 2000 specialist CNC cam grinding machine.

Unless you are a camshaft expert that probably won't mean much to you, but this very special piece of equipment is the same as those used by several current Formula 1 engine builders, including Ferrari to produce their highly sophisticated race cams. For the technically minded, this machine can produce a negative radius profile down to 15mm - to our knowledge no other machine in UK can achieve this.

Furthermore you won't need to be a Formula 1 team to benefit (or afford) this level of technical excellence, as Piper will be using this equipment on the performance cams it produces for your race, performance or classic car.

Piper's unique production techniques enable them to produce 'Formula 1 quality' camshafts at a highly competitive price, and also offer prototype and small batch camshafts to fulfil race and out-of-production classic requirements.

Piper will be exhibiting at the Autosport International Show, in Hall 8, stand 8605.

To view the full range of Piper Cams visit visit their website: **www.pipercams.co.uk**

Tilton clutches commits to ASI

Tilton Racing were the first to bring the carbon/carbon clutch to the Formula 1 world, winning it's first race in 1987, in Ayrton Senna's Lotus-Honda, and Tilton's technology can still be seen in most clutches today. Tilton's driveline components have been winning Championships for years, including 17 out of the last 21 NASCAR Cup competitions.

Tilton will be exhibiting at next year's Autosport International Show, which is highly beneficial for the company as a Tilton spokesman explains. 'We get to display our products to the European market, stay in touch with existing customers and meet new customers. We are able to support our distributor in the UK and competition suppliers, and displaying within the Engineering section of the ASI show has worked very well.

'We have exhibited since "Engineering" days were first established. The show is nearly on par with the Performance Racing Industry show and better than the SEMA show.'

Tilton will be displaying their recent Generation 3 range of hydraulic release bearings (HRB), which are available in four different mounting styles. 'These hydraulic release bearings (concentric slave cylinders) offer a wide range of height options to fit virtually any application. We will be introducing our newly redesigned 600-Series Overhung and Firewall-mount pedal assemblies too.'

Visit Tilton at Autosport Engineering, Stand E548.

INTERNATIONAL MOTORSPORT
6 - 12 JANUARY 2014, UK
BUSINESS WEEK

The IMBW schedule is as follows:

6-7 January
Race Tech World Motorsport Symposium

8 January
MIA 'Low Carbon' Racing Conference

9 January
MIA Business Awards Dinner

9-10 January
Autosport Engineering in association with Racecar Engineering

9-10 January
MIA Workshops

9-10 January
UKTI International Business Exchange

10 January
Motorsport Safety Fund 'Watkins Lecture'

9-12 January
Autosport International

International Motorsport Business Week (IMBW) will again bring the industry's key figures together in Birmingham on 6-12 January 2014. Now in its fourth year, IMBW will host a range of focused events to provide a week of extended networking and business opportunities, leading into Autosport International.
www.autosport international.com/trade

Trade registration
Registration is now open for Europe's largest dedicated motorsport trade show, Autosport International 2014. Being held at Birmingham's NEC on 9-12 January, the event will again include two days dedicated to industry guests, Autosport Engineering in association with Racecar Engineering, on 9-10 January. Adult tickets are £26, with discounts available for group bookings. Register now at:
www.autosport international.com/trade

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www.racecar-engineering.com

Much of the European soccer season is under way, which means that the lunchtime conversation once again revolves around the transfer market, players on or off form, teams laughably being thrashed by lowly minnows. Then the conversation switches to what's on the television tonight, and away we go again the next day.

In Europe, football is like a religion, a ritual of life that must be observed. It is central to the weekend activities for many families, who are prepared to invest thousands of pounds on their season ticket, plus the cost of getting there. That, and the cost of the team kit, home and away, for parents and children...

It's the same all over – in the US it is baseball and American football, a sport that has support from college football right up to Super Bowl, a game that I usually manage to catch at Orlando airport following the Daytona 24 hours in January. Why, I wonder, does motor racing not attract that same support? Why are we in a position to lament the rising age of audiences and the dwindling numbers? I have written before about the need to attract a younger audience, and won't do so again this month. The question is: what can the sport do to help itself?

If you want people to attend races, you have to give them a reason to do so

At a round of the GT Sprint series in Slovakia, Hans Reiter, the man who develops Lamborghinis for endurance and sprint racing for years, had a few suggestions. The first was that the race organisers take time out of their schedules to spend the day sitting in the stands. 'Then,' said Hans, 'they could work out how much they could charge for this.' Formula 1's support race schedule in Europe includes the Porsche Supercup, GP2 and GP3. Occasionally World Series by Renault pops up, and that's enough to keep the spectators, who pay hundreds of pounds each (one girl in the office paid £130 for her British GP tickets, plus camping, plus travel. Glastonbury Festival was better value for money, she says).

In Slovakia, a place that features a lovely little racetrack and which is a new market for European racing, there was only the FIA Ladies Lotus Cup to support the GTs. The racing was close, and highly entertaining in both, but between races, the track was deserted. There were off-track activities, including a couple of tanks and a car that rolled over on something resembling a spit, but there was very little to keep the crowds entertained.

That is not to criticise the organisers – the GT Sprint series is growing, and organisers have invested heavily in television rights to increase audience. But the bottom line is that, if you want people to attend, you have to give them a reason to do so.

Darren Cox, head of motorsport at Nissan, suggested that the crowd be allowed to drive the track in their own cars, suitably chaperoned of course. It would cost very little, and would provide at least something to do in 36-degree heat and uncovered grandstands. (Question: would it be less dangerous to have the crowd drive the track than leave them in the stands under the sun?).

The next stage, suggested Reiter, was for the FIA to take a stronger stance with regard to the sporting regulations. 'We need uniform sporting rules between all the championships,' says Reiter. 'I don't see why that is not possible. I see differences in the technical regulations, yes, but I am frustrated because it feels as though we have never got on to our feet.

'The FIA is not strong enough. The FIA needs to dictate sporting rules at least.' It is unacceptable, says Reiter, that for example in one series a time penalty is awarded for success in a previous race, in another, weight. 'The show of motor racing is 10 times better than football, but football fans all think that their sport is fantastic – they know the players, they know the rules,' he says.

Audience figures are falling across many championships and series as competition for Saturday afternoon attendance hots up, with football and shopping the prime competitors for Saturday afternoon time. 'If our local fire brigade has a barbecue we get 5000 people, which is more than we have here,' says Reiter, 'so you have to ask yourself what the hell are we doing wrong?

'In football you cannot see the players, you cannot see the ball, they score a goal and you miss it but the fans love it. It is a party and it starts one hour before the game, so they are entertaining the people.'

People will spend money to be part of the show, to interact, and motor racing needs to be part of that market. The audience today is looking for value for money. Do today's racing weekends really deliver this?

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