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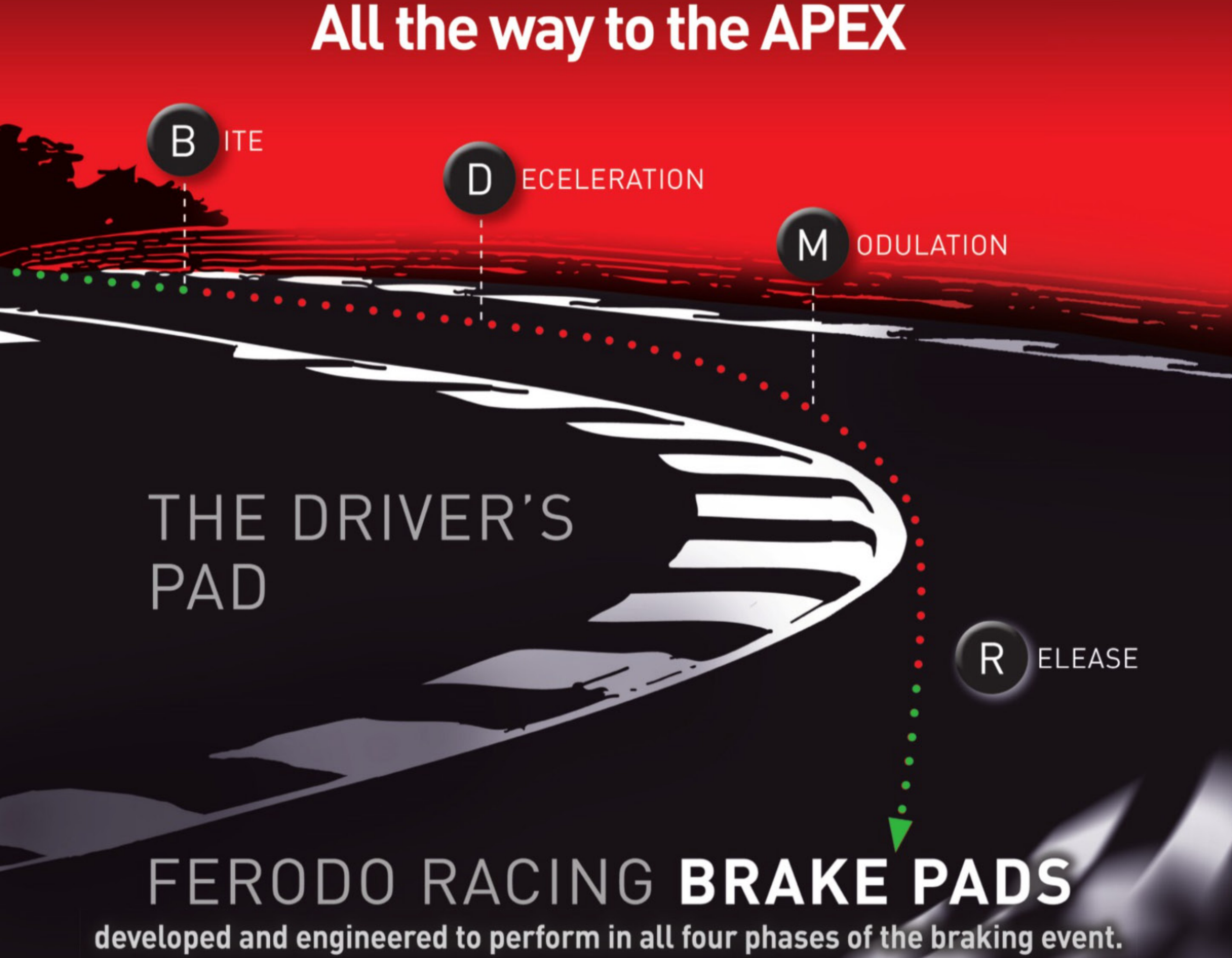

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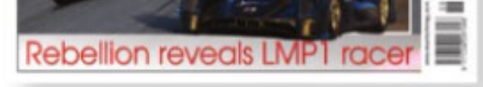

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The revolution gets underway

NOW THAT the first race is out of the way, it's time to take stock and consider just how it went. Firstly, just how great was it to see Porsche back as a mainstream contender for victory? To have three factory teams duking it out is fabulous and I think will lead to some epic races over the coming years. It also shows that for a championship to be successful, it needs to have manufacturer involvement although it is a precarious business basing a series on that premise because as we have seen too often in the past, if the decision is made to withdraw, then that's it, the team's gone, as we saw when Peugeot so brutally axed its team without any warning two years ago.

Having said that, just how great is it seeing Rebellion Racing having the courage to commission a new LMP1 car? Agreed, it is not actually taking on the factory teams as it is competing for its own championship, but there are times when it will be barking at the heels of a factory car which should be a real crowd pleaser – and as we know, nothing's predictable at Le Mans.

The second thing that can be considered after Silverstone is how the fuel flow sensors came out of it. After all the worries and concerns that were expressed on and off the record before the race, they seemed to perform, although rumour has it that at least one of the Audi accidents may have occurred as a direct result of one malfunctioning, but that is just a rumour and I really have no idea if true or not. To all intents and purposes, though, the fuel flow sensors worked. What was really encouraging was the grown-up way that the FIA handled what could have been a contentious issue. Throughout practice, qualifying and the race they made themselves available to the teams in case of possible sensor malfunctions and misreading. They didn't regard it as a black and white case of the sensor read-outs being infallible and the teams having to adhere to it no matter what. I suspect lessons were learnt from Melbourne and the Red Bull Racing incident.

There does remain the question mark about its reliability over 24 hours but I sincerely hope that it doesn't disrupt what is shaping up to be an epic race, even more so when you factor in the Nissan ZEOD.

The shame of the race at Silverstone was that it took place on Easter Sunday. That the weather was appalling cannot be helped but why on earth have a race on such a day? I am not taking a religious stance here but this weekend over all others in the UK is when families jump into cars and go and visit relatives and friends. Evidently, the Thursday before Good Friday is one of the busiest days on the UK roads. I bet there were quite a few who were caught up in the conundrum of upsetting family and attending Silverstone or deciding that maintaining the peace and staying at home was the better option.

Weather and date aside, though, it was a grand start to the new-look World Endurance Championship. As we stated on the front cover of our last issue, this is where the real revolution in motorsport is taking place – it was just a shame that the mainstream press – at least in the UK – could not care a less and instead were far more excited by Everton beating Manchester United in the Barclays Premier League. RT

William Kimberley
EDITOR

ABOVE Pre-season wet weather testing helped Toyota overcome the extremely wet conditions at Silverstone to finish first and second

New WEC regulations get thumbs up

William Kimberley

SILVERSTONE, UK: In what turned out to be such a wet race that it was stopped before the full distance had been covered, the Silverstone 6 Hours, the first round of the new-look World Endurance Championship, proved that the highly complex regulations not only are right but also work.

In the weeks leading up to the championship opener, there had been leaked stories about manufacturer discontent with the balance of technology formula and the fuel flow meters that were regarded by many as unproven technology. In the event, though, despite inclement weather that could have proved disastrous to such new cars, there were few problems. If there was misfortune, as in the case of the highly fancied two Audis, it was more driver induced than technical issues.

For Porsche, it was a case of mission accomplished with one of their cars finishing third, proving some doubters that their cars were not as slow or fragile as had been alleged. "Considering how complex this completely new technology is, it is very positive to have finished the race with one car," said Alexander Hitzinger, Porsche technical director LMP1. "The number 20 Porsche 919 Hybrid ran trouble free. We will have to have a long look into the reasons for the retirement of car number 14."

For Toyota Motorsport, though, it was a massive success, the new TS040s finishing first and second without any real issues. What had helped was the amount of wet weather testing the team had done before the first race, the experience gained proving to be important, especially when it came to the tyres.

"The wet weather tyres are much better in 2014 than they were last year and this seems to be a direct consequence of the narrower widths," said Pascal Vasselon, Toyota Motorsport's technical director. " While this in itself is not a surprise what has been is the magnitude of the improvement – they offer a much better warm up, far better grip and have superior aquaplaning consistencies. Going to narrower tyres has really made things a lot less difficult than it was previously with the wider tyres, something we had already experienced when testing at places like Paul Ricard and Vallelunga.

"The second major change in the wet for us was the benefit of the four-wheel drive system we now have on the car which really boosted traction out of the corners. Every time the drivers had the opportunity to drive in the wet in pre-season testing, their comments were really positive and they were extremely

ABOVE Toyota Motorsport technical director Pascal Vasselon was not only extremely satisfied with the new regulations but also in how they were policed by the FIA

impressed with the car's new global efficiency in the wet conditions."

One of the most contentious issues about the new regulations was the fuel flow sensor, as reported in the last issue of *Race Tech*. There were unofficial reports of unreliability and misreading, the sensors not giving true readings and tending to wander as time went on. However, in the viciously wet conditions of Sunday's race, they gave no cause for complaint as far as Vasselon was concerned.

"The fuel flow sensors worked very well," he said. "We have had absolutely no reliability issues and none failed, nor did we have any issue with their accuracy as all stayed within their one per cent prescribed range. There were a few secondary issues but these were dealt in a very efficient way by the FIA which took a very realistic and feet-on-the-ground approach with the situation. They were always available and gave us guidelines throughout the whole event to handle the situation in case the fuel flow meter would have gone wrong. So altogether, it went far better than expected without any major issues. On our part, we had absolutely no overshoot of fuel consumption or fuel flow and it went really well."

Vasselon summed up the general feeling in the paddock that the new regulations were definitely a major step forward and were good for motorsport, particularly endurance racing.

"To sum up, the new regulations are the best that can be imagined, even better than Formula One because they offer more freedom within the same logic of fuel efficiency but go several steps further in terms of concept," he said. "There are limits, of course, but also a huge amount of freedom so they work well.

"One of the possible weaknesses of the new regulations could have been the policing as they are more complex, so enforcing them is more difficult, and while we knew there were some risks, everything went well and it can only get better, so I personally would give full marks to the new regulations. Furthermore, something that was a very important item to us is that the balance of technology between gasoline and diesel is for the moment significantly better than last year." RT

BELOW For Porsche, third place at Silverstone was a good start for its LMP1 campaign

Honda Performance Development reveals LMP2 contender

William Kimberley

SANTA CLARITA, CA: Honda Performance Development will offer customer teams around the world the very latest in LMP2 closed-cockpit sports car technology next year, with the unveiling of its new HPD ARX-04b LMP2 coupe. The new design is a result of the continuing teamwork between California-based HPD and the UK's Wirth Research.

The ARX-04b is fully compliant with the new FIA/ACO LMP2 regulations, and exceeds the latest safety standards of the new enclosed-cockpit configuration. The proven 2.8-litre twin-turbo, direct injection, production-based Honda HR28TT V6 powerplant now includes a regulation compliant drive-by-wire throttle system and fresh air valve system, eliminating turbo lag and providing improved reliability and performance.

"We are very excited for our new HPD ARX-04b LMP2 Coupe to see the light of day, combining all of our successes in international sportscar racing with the very latest regulations for closed-cockpit prototypes," said Steve Eriksen, HPD vice president and COO. "Our production-based Honda HR28TT engine has powered all of our LMP2 sportscars since the ACO regulations set the new cost-capped direction in 2011, and since its introduction the 2.8-litre twin-turbo V6 powerplant has achieved some truly great successes around the world – including multiple engine manufacturer championships, victory at the Sebring 12 Hours and the 24 Hour of Le Mans, as well as powering the first LMP2 FIA World Endurance Champion. We are confident that our latest iteration of the HR28TT engine and its associated systems will satisfy even the most discriminating drivers and power the new HPD ARX-04b LMP2 Coupe to even greater successes around the world."

Additional features of the ARX-04b LMP2 Coupe include energy-efficient technology with low drag and high fuel efficiency while it has a cost-capped chassis that is fully compliant with ACO and IMSA regulations.

It also has an innovative Honda refuelling safety interlock system that is designed to reduce the potential for pit fires resulting from leaving the pit box with fuel hoses inserted and "quick change" front and rear bodywork while the engine installation includes a proven turbo mounting system and top exit exhaust that meets all ACO and IMSA noise regulations.

The ARX-04b will continue with the HR28TT powerplant, developed by HPD from the production Honda "J35" series of V6 engines currently found in the Acura MDX and RLX in North America, in addition to the upcoming 2015 Acura TLX. The racing engine continues to use more than 400 production engine parts, including the engine block and heads, crankshaft, direct-injection fuel system, valve train components, drive-by-wire hardware and even the stock Honda oil filter.

As part of their after-sales support services, HPD and Wirth will provide teams with technical assistance and bulletins, as well as additional options available for purchase. Additional bespoke options include driver-in-the-loop simulator sessions, data-logging, race and performance engineering, and MuRiTyre and Apotheca software.

"Wirth Research is proud of its history of consistently creating championship-winning prototype sports cars with and on behalf of Honda Performance Development. Using our pioneering CFD design techniques, we have created the all-new HPD ARX-04b LMP2 Coupe," said Wirth Research president Nick Wirth. "Not only is it a stunning-looking race car, we are confident that our revolutionary all-digital design approach will ensure that HPD's 2015 LMP2 Coupe customers will benefit from fielding the most aero-efficient, balanced and competitive LMP2 car on the 2015 grid." RT

BELOW HPD's ARX-04b looks set to be a strong LMP2 contender when it takes to the track in 2015

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Photos & Graphics: NASCAR

ABOVE Self-contained: the new, much more compact Air Titan 2 drying system

BELOW Dry line: the Mk1 version of the Air Titan was a great advance over the previous kerosene jet driers, graphically illustrated here at Phoenix earlier this season. Note the lorry carrying the compressed air generators at right

NASCAR's drying tech blows twice as hard

Andrew Charman

MARTINSVILLE, VA: NASCAR introduced a Mark 2 version of its Air Titan track-drying system at the Martinsville Sprint Cup meeting at the end of March.

The Air Titan was launched in February 2013, a system based on compressed air drying which proved both more eco-friendly and crucially much faster than the traditional method of using kerosene-burning jet engines mounted on trailers. Drying times were cut by 60 per cent and enabled several rain-affected races in the 2013 season to run on their planned day whereas previously they would have been postponed to the following day.

However, while the actual driers were towed behind Toyota Tundra pick-ups, they needed to be shadowed by articulated trucks carrying large generators for the compressed air.

The new system's power unit is far more compact, a single self-contained unit that can be mounted on the bed of a Tundra. This has allowed NASCAR to put in place up to 21 such vehicles at larger tracks.

The driers themselves have also been greatly improved. The blade capacity has been more than tripled compared to the original version and the drier can now deliver 2.6 times more air volume at a speed of 568 mph, while raising the air temperature by 70 degrees over ambient.

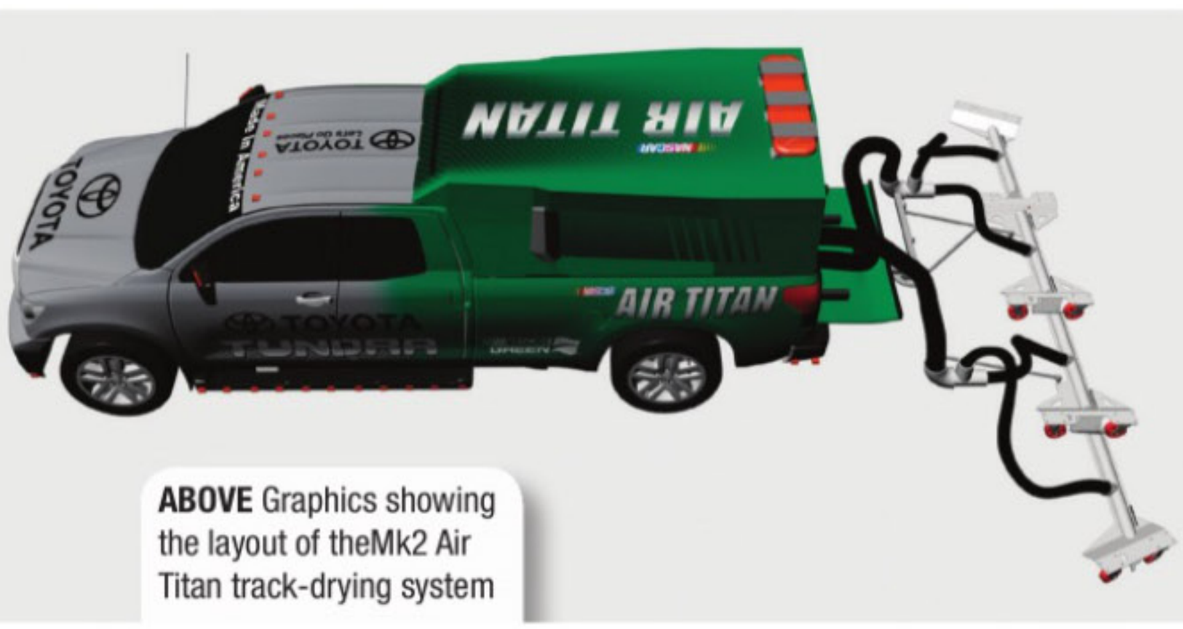
NASCAR hopes that with the combination of water removal and accelerated evaporation, the system will move closer to the ultimate goal, set in 2012, of reducing track-drying time by 80 per cent. The new system, NASCAR states, could dry a football field in 21 seconds.

The eco credentials of the Air Titan 2.0 are also being heavily promoted – it is quoted as consuming almost 80 per cent less fuel and emitting 80 per cent less CO2 compared to the Mk1 version.

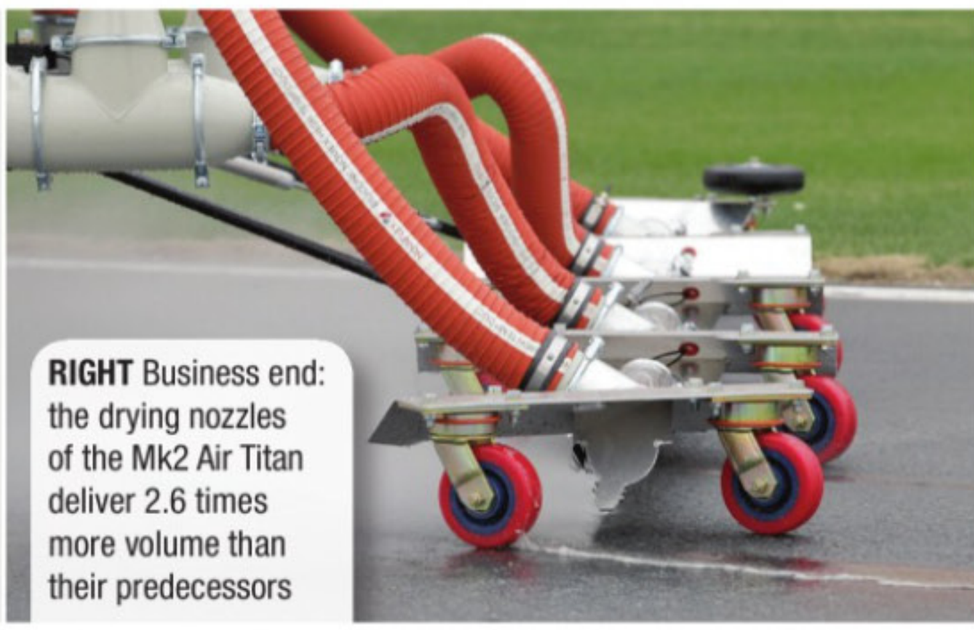
Unveiling the new system, NASCAR chairman and CEO Brian France commented that it creates the ultimate win-win-win for the sport, the fans and the environment.

"Air Titan 2.0 will help us more quickly return to racing, which serves our most important mission – the enjoyment of our fans," he said.

NASCAR vice president, innovation and racing development Gene Stefanyshyn added that the first phase of the Air Titan system had been an overwhelming success. "Based on our experience and learning, the staff at the NASCAR R&D Centre have worked tirelessly to develop Air Titan 2.0 – we will continue to innovate and develop the technology to further increase its efficiency and sustainability." RT



ABOVE Graphics showing the layout of theMk2 Air Titan track-drying system



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- 2013 Grand-Am DP Driver's Championship
- 2013 Grand-Am DP Team Championship
- 2013 Rally America Championship
- 2013 USF2000 Championship
- 2013 Indy Lights Championship
- 2013 Trans Am TA Championship
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- 2013 Daytona 500 - First Place
- 2013 Brickyard 400 - First Place
- 2013 SCCA Runoffs - First Place
- 2012 NASCAR Sprint Cup Championship
- 2012 Traxxas TORC Pro 4x4 Championship
- 2012 Traxxas TORC Pro 2WD Championship
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- 2011 USF2000 Championship
- 2011 Indy Lights Championship
- 2011 Trans Am Championship
- 2011 SCCA Runoffs - First Place

BELOW Defying gravity: Newer cars in the V8 Supercars Championship, such as the Nissan Motorsport machine of Rick Kelly, face engine changes

Photo: Nissan

V8 Supercars makes moves to equalise engines

Andrew Charman

MELBOURNE, Australia: The Australian V8 Supercars Championship has reacted to the arrival of more modern designs of engines in its series by taking measures to equalise their physical relationship to the rest of the car.

The cars of the Mercedes, Nissan and Volvo teams, all of which were encouraged into the series by the new-for-2013 Car of the Future regulations, run engines that are on average 30 kilos lighter than those in the cars from Holden and Ford, which have supported V8 Supercars for decades.

The Car of the Future regulations included a minimum engine weight of 200kg, approximately equivalent to the weight of the Holden and Ford units, but no restrictions on where the newer teams could place the ballast on the engine – by increasing the weight of bottom-end components such as the sump, for example, teams could keep the engine's centre of gravity low.

Now the championship organisers have measured each engine in the series to determine its centre of gravity. This is a measure V8 Supercars says it always intended to undertake as part of the Car of the Future programme but could not accomplish until all five manufacturers were competing.

Volvo has joined the V8 Supercars championship this season and immediately proved competitive, winning at the second meeting, the Australian GP support event in Melbourne on 16 March. Before the Tasmania 400 at Symmons Plains on 28-29 March, the Volvos were ordered to move 20 kilos of ballast from to a much higher location on the engine.

As *Race Tech* went to press, the championship organisers were set to announce changes to engine ballast location following the measurements, and these changes were expected to be in place for the ITM 500 meeting in Auckland over the weekend of 24-27 April.

While the changes are expected to be most significant for the Mercedes, Nissan and Volvo teams, V8 Supercars technical manager Frank Adamson told trackside media that they were not expected to result in major shifts in performance.

"There were two incumbent engines, a Ford and Holden, that were basically the same configuration – iron block, aluminium head, pushrod engine," Adamson said. "The centre of gravity of both those engines is – give or take – the same.

"However, the new engines are a different architecture with an aluminium block and aluminium heads – fundamentally a much lighter engine."

Teams will be advised as to where the centre of gravity of the engine needs to be located – the engine's placement in the car will not be a factor as under the Car of the Future regulations all engines are mounted at the same point.

"We'd like to see the changes made for New Zealand," said Adamson. "However, practicality will dictate – the sooner the better essentially." RT

DTM ballasts manufacturer victory hopes

Andrew Charman

WIESBADEN, Germany: If a driver wins a race in the DTM this season, rivals racing for the same manufacturer will feel the effect. The DTM has become the latest Touring Car series to introduce performance ballast, but in a very different, manufacturer-based format to other championships.

A car winning a race will have five kilograms of weight added to it for the next event, and so will any other car from the same manufacturer that finished in the top ten. Drivers from the winning manufacturer who finish outside the top 10 will be served with a 2.5kg weight penalty, while drivers from the second-finishing manufacturer will have their weight unchanged.

Drivers competing for the third-finishing manufacturer will lose weight of 2.5kg if they finish inside the top 10, or 5kg if outside the 10 best finishers.

Other changes include the reduction in the number of mandatory in-race pit stops from two to one, which must be taken after the first third of the race distance and is not permitted during a safety car period.

The softer compound rubber from tyre supplier Hankook can now only be used for half the race distance, and qualifying has been changed from a four to three-segment format. RT

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Photo: FIA WTCC

ABOVE New era: The 2014 World Touring Car Championship, seen here on its debut at Marrakech on 13 April, could have support series in the future

FIA plans national series to support WTCC

Andrew Charman

PARIS, France: The FIA is working on producing new regulations for national Touring Car series, with the aim of creating a ladder of progression in a similar format to that already established in single-seaters.

Currently the only Touring Car regulations administered by the FIA are those of the World Touring Car Championship, which made its debut in its new-for-2014 format at Marrakech, Morocco on 13 April. According to the head of the FIA Touring Car Commission Alan Gow, the national regulations should provide a stepping stone structure towards WTCC in the same way that Formula 4 and Formula 3 do to Formula 1.

Due mainly to their expense, the new WTCC regulations do not encourage adoption by national series in the way that the previous S2000 regulations did, at least in the earlier days of the formula before costs were driven up.

The news comes as the world series confirms that it is working on revising its own TC2 regulations, which allow the use of previous-spec Super 2000 cars in current WTCC events. There is a view to creating a feeder series to the WTCC that would run over the same race weekends and also in standalone events, much as GP2 runs alongside the FIA Formula 1 Championship.

When the feeder series was first mooted in March, newly-appointed WTCC head Francois Ribeiro suggested that a new category should be based around the 2.0-litre turbo engines that are used across several national series. He said that the new WTCC TC1 regulations are not intended for national championships or smaller teams, because they are too expensive.

"This is not surprising, because our goal was to have the best and most spectacular cars in WTCC, but there is a need for a simpler and cheaper class available for small teams and national series," he said.

At Marrakech, Ribeiro added that the support category should be aimed at privateers, be extremely cost-effective but run to the same sporting regulations as the WTCC to prepare drivers for the headline formula.

By far the most successful national regulations based on 2.0-litre turbo engines are those using the NGTC formula in the British Touring Car Championship, which is also run by Alan Gow. The BTCC has produced a record 31-car grid this season, teams commenting on the cost-effectiveness of the regulations which allow them to re-use spec components in successive seasons, even in new car bodyshells.

BTCC competitor Adam Morgan has done just that, transferring much of the infrastructure from a Toyota Avensis that he ran last season into the Mercedes A-class that he is campaigning in this year's BTCC.

Any move towards a new formula based around the NGTC regulations would almost certainly find favour in the UK. Speaking to *Race Tech* at the BTCC Media Day in March, series technical director Peter Riches said there is a need to see NGTC more widely adopted.

"We need another country to take up the formula, firstly to provide an outlet for secondhand cars and to keep the market going," he said. "Now the WTCC has gone megabucks, that will concentrate minds – as far as I understand the WTCC doesn't really want its cars dropping down the pack because they are too complicated and too expensive.

"It's over a million a year per car with travel costs to do the WTCC, so you have to say to a driver that with damage unless you have £1.5m, forget it – and they haven't got it. We're saying it will cost £350 to £400,000 to do the BTCC."

Riches confirmed that the BTCC has had interest from other countries in taking up its formula, but some still believe the NGTC regulations look a little expensive. "We have to get the message across as to how much the maintenance costs are down with our cars," he added.

It is believed that a national formula proposal could be presented to the FIA's World Council before the end of 2014. RT


Photo: BTCC

BELOW Success formula: could the NGTC regulations of the burgeoning British championship form the basis for future FIA formulae?

Tough start to WTCC

MARRAKECH, Morocco: The opening weekend of the new-look WTCC at Marrakech saw 18 of the 22 registered championship contenders make the first race grid. Two cars were eliminated from playing any further part in the meeting after contact with the street track's unforgiving concrete walls in practice, including lead contender Gabriele Tarquini's Honda.

A startline accident in race two further decimated the field, eliminating Tom Coronel's Chevrolet and Yvan Muller's Citroën. With the gap between the first and second rounds halved to just one week following the Marrakech opener being delayed by a week, Honda and Citroën faced a race against time to repair their cars for the round at Paul Ricard in France, but the damage to Coronel's car was too severe to rectify in time. RT

ABOVE False start: the damage to Tom Coronel's pristine new TC1 Chevrolet Cruze eliminated it from race two at Marrakech and the following weekend's meeting at Paul Ricard

In Brief

THE FIA has accepted an application from Gene Haas to enter a new team in the F1 world championship. The American NASCAR team owner's entry was granted after a lengthy evaluation process and the new squad now hopes to be on the grid for the 2015 season.

MEANWHILE Marussia Motors has announced that it has stopped making road cars and that all its employees in Moscow have left the company en masse. However, the Marussia Formula One team has pointed out that there is now no connection between the car company and the team and that the racing team is a separate legal entity called Manor Grand Prix Racing Ltd although it is owned by Marussia Communications Ltd, an Irish registered company, under the ownership of Andrej Cheglakov, who also owns Marussia Motors.

AFTER AN impressive performance at the opening round of the Blancpain Endurance Series in Monza, Italy, the new Bentley Continental GT3 (above) is set to reintroduce the British marque to North American motorsports with Dyson Racing that will race a pair of Continental GT3s in the second half of the 2014 Pirelli World Challenge in preparation for a full season of competition in 2015. The new partnership returns Bentley to the racetracks of North America for the first time since 2003.

SPECIALIST oil developer and producer Millers Oils has agreed a technical partnership with Fortec Motorsport to develop advanced lubricants for its Mercedes Benz SLS AMG GT3 race car. Working together, Fortec Motorsport will provide Millers Oils with invaluable data across the season which will enable the company to develop bespoke lubricants for the vehicle, giving the team a competitive advantage in a tight series.

RICARDO has secured a multi-year deal as the sole source of racing transmissions for the Japanese Super Formula series. It will provide an in-house designed, manufactured and assembled racing transmission from its Leamington Spa facility directly to Japan where it will be assembled into the racecar by each of the series competing teams.

WILLIAMS Grand Prix Holdings has sold Williams Hybrid Power Limited from Williams' subsidiary, Williams Grand Prix Engineering Limited, to GKN Land Systems Limited in a multi-million pound transaction. This will see Williams Hybrid Power rebranded as GKN Hybrid Power. Under the terms of the transaction, Williams Grand Prix Engineering Limited will also receive additional consideration based on future sales and licences of the flywheel energy storage technology transferred with Williams Hybrid Power to GKN.

THE Formula E Championship has taken another step to prove its "green" credentials by announcing a partnership with Global Thermostat, a leading US carbon capture company. The intention is to reduce considerably the CO2 emissions generated by the series while jointly promoting sustainable technologies. Global Thermostat was formed in 2006 to develop and commercialise a unique technology for the direct capture of carbon dioxide from the atmosphere and other sources. Its unique process co-generates carbon capture and power using a low-cost leftover process heat as energy for the capture of CO2 which is then stored in geologically appropriate underground formations before being reused.

Personnel

Marco Mattiacci, president and chief executive of Ferrari North America, has replaced **Stefano Domenicali** as the F1 team's team principal.

It was revealed by Mercedes GP that **Bob Bell** resigned from his role as technical director at Mercedes in December last year. He will leave the Brackley-based team in November to pursue "new challenges outside the company", according to an official statement from Mercedes. The squad will scrap the role of technical director when Bell, who has held the position since April 2011, leaves. Executive director (technical) **Paddy Lowe** will assume Bell's responsibilities as part of a streamlined structure at Mercedes.

Trevor Knowles has left his position as the director of engine development at IndyCar to move back to the UK to take up a position as technical manager, Denso Sales UK.

Roger Griffiths, who was technical director at Honda Performance Developments for many years, has joined Andretti Autosport as head of motorsport development. His new role will cover all aspects of Andretti's motorsport activities, including the IndyCar ladder, Formula E and rallycross.

Former Indianapolis 500 winner and twice CART champion **Gil de Ferran**, who was appointed as Honda's IndyCar technical consultant last year, has had his role expanded to include all of Honda Performance Developments' racing activities in the USA.

VW Group motorsport chief **Wolfgang Dürheimer** is to become chairman and chief executive officer of Bentley Motors with effect from 1 June. He succeeds **Dr Wolfgang Schreiber** who will take up a leading position within the Volkswagen Group.

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WTCC'S NEW RECIPE FOR SUCCESS

The new breed of World Touring Car Championship racecars are bigger, noisier and more powerful. The only things quieter, reports **Anthony Peacock**, are the critics

THE World Touring Car Championship is undergoing something of a renaissance at the moment. And appropriately enough for the nation that invented the word, the man leading it is French.

François Ribeiro, motorsport director of long-term WTCC promoter Eurosport Events, doesn't miss a trick. Having taken over the reins of the championship at the start of this year, he is now leading it into a brave new era.

A bit like Formula One, some might think, with its recently arrived PUs, MGUs and ERSs: gadgetry to underline supposed ecological credentials. As one F1 team principal recently pointed out, there are now more snappy acronyms than actual drivers on the grid. Even the humble internal combustion engine, at the heart of the new F1 powerplants (as well as most others in this world) has been re-baptised the ICE to make it sound more Raspberry Pi generation.

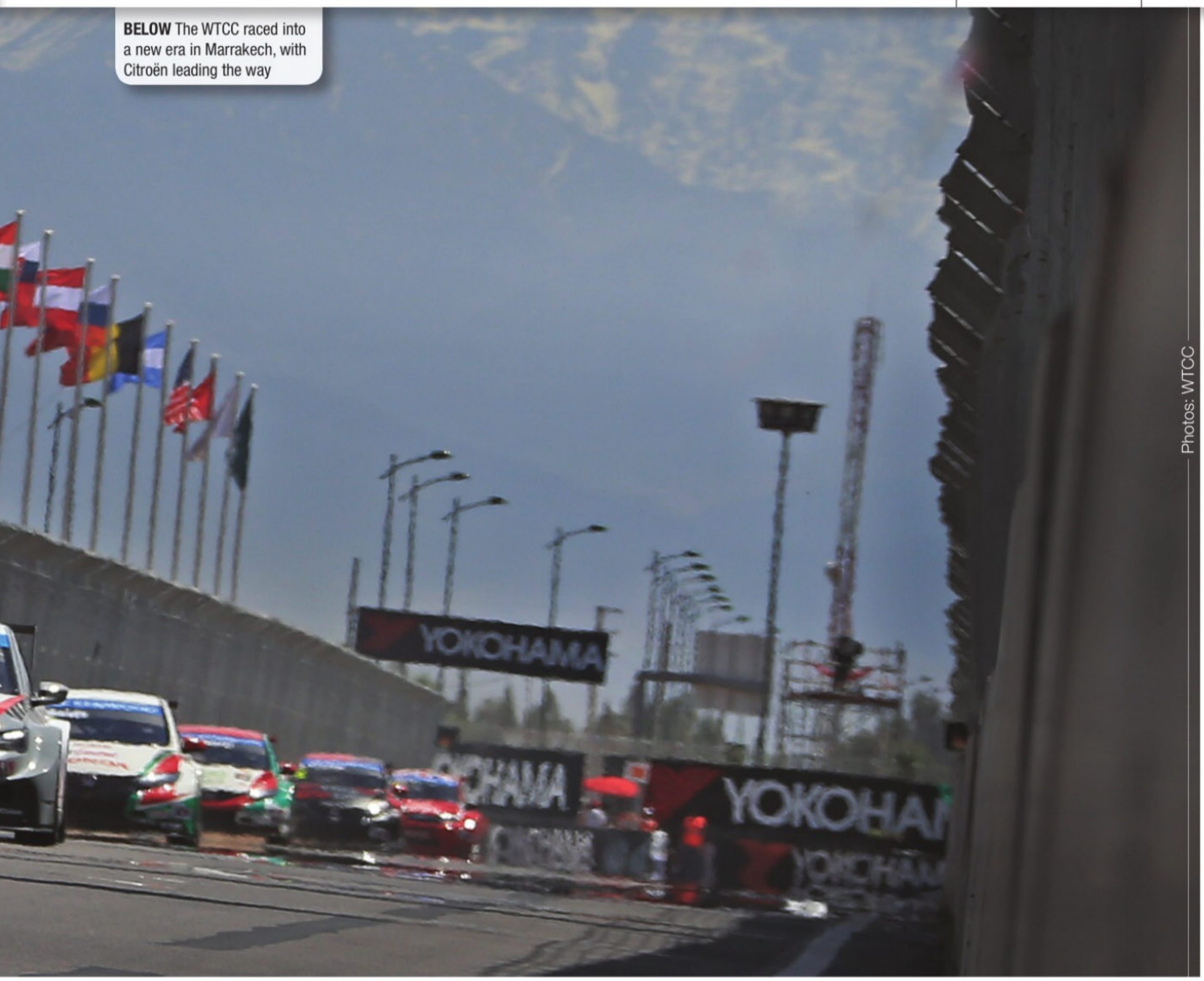
But Ribeiro insists that it is very, very different in WTCC.

"We've gone the other way," he says, with the hint of a grin that underlines how, behind the corporate acumen, there lurks a pure racer. "We've gone noisier. Bigger. More powerful."

Racing cars need to make people dream: a fact that is not lost on Ribeiro. "I stood next to the wall at the first practice session in Marrakech, the first time that the new TC1 cars had been out together," says Ribeiro. "When I heard them, it was fantastic. Proper racing cars."

Like Barack Obama, Ribeiro's sentences are short and to the point. A bit like the racing in the championship itself, whose motto is "real cars, real racing".

This year the cars have more power, with the inlet restrictor diameter enlarged from 33mm to 36 mm. They are also wider (1950 mm), lower (ride height is down from 80 mm to 60 mm), with bigger wings and greater technical freedom in other areas too, to create the headlining TC1 class that puts out 380 horsepower, with a 1100-kilogram minimum weight limit (down from 1150 kilograms last year). Carbon fibre bodywork panels help the teams hit that limit. While some engine components have a weight limit this year, the total weight for the engine is also a couple of kilograms lighter than it was before. The



BELOW The WTCC raced into a new era in Marrakech, with Citroën leading the way

Photos: WTCC

result is an impressive turn of speed: around 1.5 seconds per kilometre faster than the previous generation car.

Where cars' suspension was previously restricted to that of the base model, use of McPherson struts all round is permitted this year. The move adopts the same principles as the World Rally Championship, only with two-wheel drive. There are also bigger wheels, up from 17 inches to 18 inches, allowing space for bigger brake discs.

BIG STEP FORWARD

Keeping the system fair is the same performance equalising formula as before: as of the third event this year, for a lap time difference higher than three-tenths of a second, a weight handicap of 10 kilograms per tenth of a second will apply, up to a maximum of 60 kilograms.

Better aerodynamics, including flat bottoms and a 100 mm front splitter, have also opened up a whole new set of possibilities in terms of the racing. Before, the WTCC cars were a little too pedestrian for the truly epic circuits of this world – tending to be at their best on the tight and twisty tracks: one of the reasons why Macau remains such a showcase.

> *"Racing cars need to make people dream"*

Now though, it's different. "With the cars we have now, we can go to places like Spa and Paul Ricard and have a great race," points out Ribeiro. "You have to see it, but there's a really big step forward this year. It's very exciting."

To put that into context: we're talking GT3 pace here, so Porsches or Aston Martins. And now, thanks to the WTCC, Citroëns and Ladas too.

The arrival of Citroën – and nine-time world rally champion Sébastien Loeb has perhaps been even bigger news than the new technical rules in the WTCC. Put simply, it's a game-changer. The results from the opening round in Marrakech have fired their rivals an ominous warning shot.

"If you look at the way that Citroën have gone about things since they arrived, they have raised the bar," points out Ribeiro. "They've given teams coming into the championship a new standard to aim for. But most of all, you have to admire Sébastien Loeb: he's the real star. For him to set himself this challenge, at this stage in his life, is truly brave – when he has nothing to prove. And let's be honest, everything to lose."

It's a fair point, given that his team-mates ▶

are Yvan Muller – the most successful driver in the history of the World Touring Car Championship – and the highly-rated Jose-Maria Lopez, who has bags of touring car experience and was at one point formally announced as a Formula One driver, with the stillborn US F1 project.

There will also be a fourth Citroën at selected races, for Chinese driver Ma Qing Hua. Paradoxically he, as much as Loeb, was at the heart of Citroën's decision to enter the WTCC.

BUILDING A LOCAL FAN BASE

Consider this fact: China is Citroën's number one market in the world, in terms of vehicles manufactured. In 2013, the company sold 557,000 cars there, and manufacturing capacity will soon be raised to 950,000 per year.

Maybe that's not surprising given that 1344 million people live in China, give or take a few, but it's enough to make you think. Last year, the automotive industry as a whole in China grew by 19 per cent. In the same year, Citroën's presence expanded by 26 per cent.

It's a graphic illustration of how the booming BRIC (Brazil, Russia, India, China) economies are not just the invention of some well-intentioned business magazine. And guess what? The WTCC goes to two of those countries.

"Tell me something: how many other championships would allow you to run a third or a fourth driver from one of those countries for a few races and stand a realistic chance of winning?" asks Ribeiro. "WTCC allows manufacturers to build a real local fan base that is not possible in any other championship."

Qing Hua himself was given a few Friday practice outings by HRT and Caterham in F1 over the last couple of years – so it certainly wasn't going to happen for him there…

The chance to compete on a relevant global scale is what has attracted manufacturers to the WTCC: not to mention of course that the full budget to compete is reckoned to be around a third of what is required for the World Rally Championship, for example.

Despite this, the 1.6-litre inline, four-cylinder direct injection turbo engine technology is exactly the same: a deliberate choice according to Ribeiro. "Of course; this was an important consideration," he says. "If you are joining from the WRC, a lot of the hard work is done."

It's going to be fascinating to find out from ▶

ABOVE François Ribeiro is the man leading the WTCC's renaissance

ABOVE The TV offering will be revamped this year to reflect what promises to be a gritty battle. This is Yvan Muller's damaged Citroën in Marrakech

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ABOVE The TC1 cars feature more aggressive aerodynamics, Honda estimating that aero aspects had the biggest impact on the build of its new Civic WTCC

Citroën – which is engaged in both championships – where they feel the greater value for money lies. Certainly WTCC manufacturers enjoy better relations with their promoter – Eurosport Events – than is the case in the WRC, with Volkswagen actually walking out of one meeting with WRC Promoter (the new company appointed to do the job) and on the Rally of Portugal, manufacturers actually banning their drivers from talking to TV crews in a protest over image distribution.

"There's none of that in the WTCC," points out Ribeiro. "Here, the manufacturers are actively involved in every aspect of the decision-making process. In fact, hearing the feedback from Citroën is going to be very interesting as a point of comparison."

ABOVE With a star driver line-up, a sporty model launched and full order books, Lada is making the most of its WTCC launchpad

But he's keen to point out that manufacturers are not the be-all and end-all of the WTCC's existence. Quite the opposite. "Manufacturers come and manufacturers go," he says, with the world-wisdom of one who has been in motorsport for a while. "So you can't base everything around the manufacturers. Privateers have always been the backbone of this championship and they will continue to be so in future. And of course it's in the interests of the manufacturers themselves, and the sport, to have a healthy contingent of privateers."

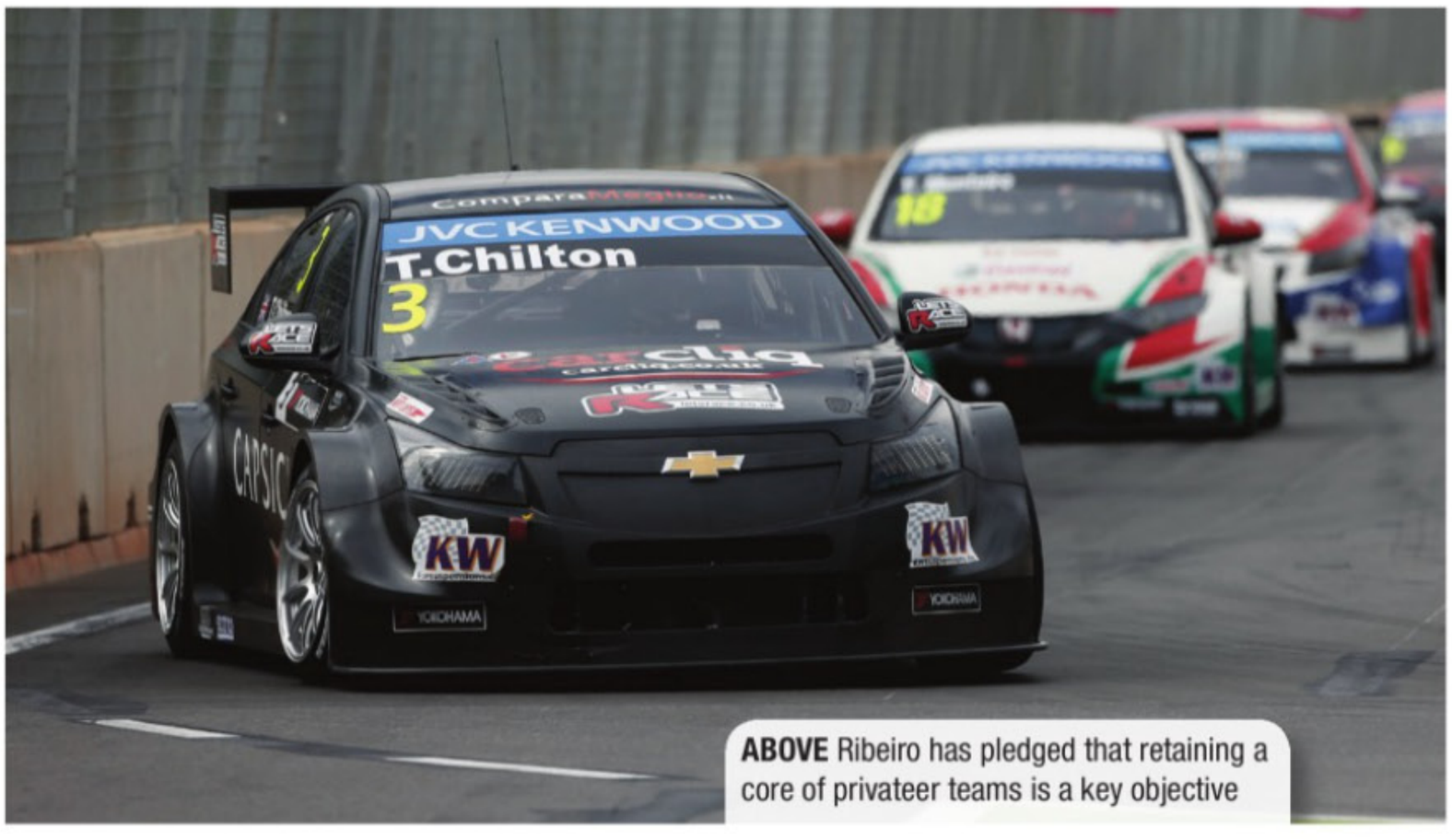
Nonetheless, while he won't be drawn on numbers and timescales, Ribeiro admits that there are "a few" manufacturers sniffing around the championship. "Some of them are established and some are completely new to touring car racing," he adds.

A PRIMARY MARKETING TOOL

Volvo has dipped in and out previously, and is one example, while there have also been a number of Japanese people spotted in the paddock who certainly have nothing to do with reigning manufacturer champion Honda. Renault has stated an interest. The new safety car this year is an Alfa Romeo 4C: coincidence? And it's also been suggested that the WTCC could be the ideal medium for some of the new Chinese manufacturers to make their first foray into world-class motorsport.

That fits in well with the spread that we see so far in the WTCC, which has very different meanings for each participant. For Citroën, it's the way to get a grip on crucial developing markets. For Lada, which is looking seriously competitive this year with its line-up of James Thompson and Rob Huff, it's a means to establish sporting credentials that never existed previously. On the back of its WTCC campaign, Lada has built its very first overtly sporting model for the domestic market: the Lada Granta Sport. And it's genuinely selling faster than Lada can build them: there's a waiting list of several months (which is long these days even by Russian standards). Thompson is deadly serious when he says he'll be disappointed if he doesn't bag a few podiums this year. If he does, that's going to sell more Ladas than any advertising campaign.

So we get to the obvious yet striking essence of the WTCC's appeal: it tangibly helps manufacturers sell cars. A lot of that is also down to the TV package: as well as being the promoter, Eurosport also happens to be the largest TV channel in Europe. Last year, 557 million people watched the WTCC: 8.9 per cent more than the previous year. In total, that figure involves 111 TV channels, 188 countries and 1176 hours of broadcasting. ▶



ABOVE Ribeiro has pledged that retaining a core of privateer teams is a key objective

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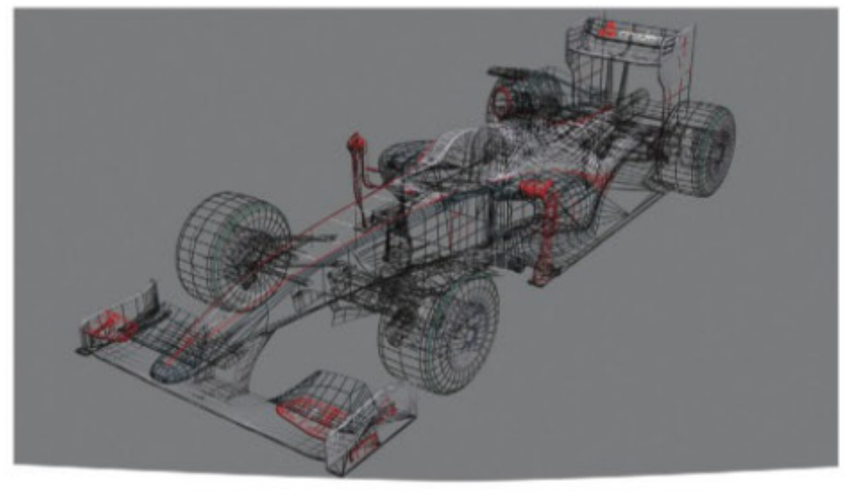

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LEFT Alfa Romeo is thought to be one of the big names monitoring the series. Is the new 4C Alfa Safety Car just a coincidence?

BELOW Nine-time world rally champion Sébastien Loeb is one of the headline acts. He also demonstrated in the opening round that he will be no pushover

In keeping with the new rules and more aggressive cars, the TV offering will be revamped this year to become punchier and gutsier, reflecting the gritty reality of what is often a contact sport, conducted at top speeds close to 300 kph.

Way more elegantly, Ribeiro describes the new approach as being "more cinematographic".

"We want the action to be even more direct, even more clear, to tell some stories and to give people something to remember," he elaborates. "Apart from that, we're not going to do much else to the TV product. Live TV has always been one of our hallmarks and it's successful as it stands."

There is one major change on the horizon though, which is all about TC2: the second-string class, which consists of the previous

> *"Loeb is a real star. He has nothing to prove. And let's be honest, everything to lose"*

generation 320 bhp World Touring Cars. These will soon be obsolete: both BMW and Seat Sport, for example, no longer make parts for the old-shape cars that are being run.

"That's the biggest thing we have to address urgently and we are beginning to do that," says the WTCC supremo. "Essentially: there are two routes we could go down. We could either create a simpler version of the TC1 car, if this is technically possible. Or we could look at a completely different new concept. This is something that we need to decide, but so far we are only one month in, so we're going to consider it carefully."

Behind him, there's an experienced team of people. While former WTCC general manager Marcello Lotti left at the start of this year "by mutual agreement" (as Eurosport wanted to centralise WTCC operations within the company), Eric Neve, Chevrolet Europe's

former motorsport director, returns to the championship as a consultant this year. Having overseen the most successful team of the modern era, he also knows a thing or two about what makes a successful series.

LIGHTS! CAMERA! ACTION!

"Even when Eric was with Chevrolet, all his suggestions at the working groups were aimed towards the benefit of everybody, rather than just his company," adds Ribeiro. "This vision is what makes him the perfect person for us."

One thing is for sure: at the moment, Ribeiro has something of a winning formula on his hand, which has walked the delicate line between capturing the zeitgeist of change without alienating the die-hard purists. Most importantly of all, the new-look WTCC has addressed the main shortcoming of the championship in its previous generation: a perceived lack of spectacle. Anybody who watched the opening two races in Marrakech (and occasionally winced) will know that action wasn't in short supply.

Incredibly, the new TC1 rules were originally intended for 2015, but last year it was decided to bring them forward to the start of this season. As a result, the teams had to condense what was intended to be 14 months' work into just four months. Yet somehow they managed it, with a full complement of cars on the grid in Morocco.

"It's the start of a new era," is how Ribeiro summarises it: of course he's right, on both counts. Yes, it's a new era. And yes, this is only the start. RT

BAD NEWS FOR THE CHIMPS!

Niki Lauda once famously suggested that even a chimp could race an F1 car equipped with electronic gizmos. Some fear the introduction of brake-by-wire for 2014 signals a return to 'driver aids'. Not so, insists **Dominic Harlow**

THE 2014 Formula One regulations have been a technical feast. So much so that it seems we almost don't know where to start when examining the interactions of the new systems and strategies that have brought about what is, after all, such a large increase in overall vehicle efficiency.

An example of this that early on flew almost under the radar, and has taken up its place in the 2014 lexicon of jargon relatively late in proceedings, is the system that has become known as Formula One's BBW.

Pre-season testing seemed to spark the first real flurries of interest outside of the sport, after drivers mentioned problems with this part of their car (amongst the myriad other issues that they contended with, no doubt). There were many for whom this remained a concern as they boarded flights to the first race, asking perhaps whether it was necessary to add yet more complexity to the 2014 cars on top of the new Power Units. It's likely that as we progress through the season there will be significantly more mention of this part of the new cars, and not always in the form of a complimentary debrief, too.

Although quite a departure from the relatively stable and simple braking systems of recent years, the return of a kind of BBW warranted only one paragraph to be added to Article 11 of the Technical Regulations, and some minor alterations within an earlier part of the same section. This is probably why it has been somewhat in the shadows in terms of how it has come about, and what it is doing.

It is not by any means a new technology and this has led some to recall the ABS systems of early nineties Formula One and DTM cars and to fear that this latest incarnation will be just another driver aid. What is new this time, however, is the application. In these circumstances it is not only enhancing vehicle safety, but also contributing to efficiency by working with the ERS to increase harvest potential and reduce fuel consumption.

Perhaps some confusion has been caused by the acronym BBW itself, which is obviously derived from DFBW, a phrase first coined when technology from the Apollo programme began to be used by aircraft designers. Whereas the benefits of a greater separation of control inputs and actuators in aircraft are physical, in terms of weight and packaging as well as greater control authority over less stable aerodynamic designs, in this case we are talking almost exclusively about the controllability enhancements possible for the rear hydraulic braking system of our 2014 Formula One car.

When trying to understand the future, it usually pays to understand the past; this scenario is no exception! We must recall the workings of the 2013 KERS generation of Formula One cars, and the gestation of the 2014 Technical Regulations to explain where we have arrived at in the present day.

The root of the first problem BBW is trying to address is that the KERS system, the ERS system and any similar hybrid PU energy store will have a finite storage capacity. In Formula One this capacity is naturally set by regulation. When this limit is reached, energy recovery must cease and since the rear axle supplies the torque required to turn the MGU-K in both cases, there results a step change in this axle torque resisting the motion of the car.

Clearly a similar thing happens in the event

Jargon-buster

BBW – Brake-by-Wire
DFBW – Digital Fly-by-Wire
KERS – Kinetic Energy Recovery System
PU – Power Unit
ERS – Energy Recovery System
MGU-K – Motor Generator Unit - Kinetic
MGU-H – Motor Generator Unit – Heat
ICE – Internal Combustion Engine
ABS – Anti-lock Braking System
PRV – Pressure Relief Valve
SECU – Single 'Engine Control Unit'

BELOW & INSET Pre-season gossip about brake-by-wire was further fuelled when Kamui Kobayashi's Caterham ploughed into the pack at the first corner in Melbourne. The driver was cleared by the FIA stewards' review of the data. Not so the BBW…

of an unexpected system shutdown. It is well known that in the KERS cars of 2009-13 the driver would make a standard adjustment to hydraulic brake balance if his KERS failed, usually about 3% to the rear. This enabled him to stop the car without asking too much of the front tyres, as a result of the lack of MGU-K rear axle retardation. Fortunately the magnitude of this shift was such that even unexpected failures could be coped with and I don't recall a car ever suffering a dramatic front wheel lock and accident due to such an issue.

Back in 2010 or before, when what would become the 2014 Technical Regulations began to take shape, the increased energy recovery rate (quoted as a power of 120 kW) and therefore torque required from the MGU-K quickly triggered a realization. It would no longer be possible to rely on a small adjustment to a mechanical brake balance system, or driver skill to deal with the change resulting from the MGU-K suddenly ceasing to recover energy from the rear axle.

> ***"Some fear this will be just another driver aid. What is new this time, is the application: it enhances vehicle safety but also contributes to efficiency"***

Hence early drafts of the regulations simply referred to an ERS Brake Valve, which may act to reduce rear brake pressure from that generated at the pedal and must be a standard part fitted in a defined manner. This is rather like the water system PRV, for example. Working in this way it could immediately be opened to allow sufficient hydraulic brake pressure to the rear calipers to offset the reduction in braking torque from an ERS shutdown.

As the regulations were developed, and a specification for this part was sought, an alternative course of action arose which closed on the problem from two sides. Firstly, based on the way rear axle torque was to be controlled for propelling the vehicle, a similar control should be possible for retarding it, whilst – in the way that traction control is precluded – also ▶

FIGURE 1 Brake-by-wire

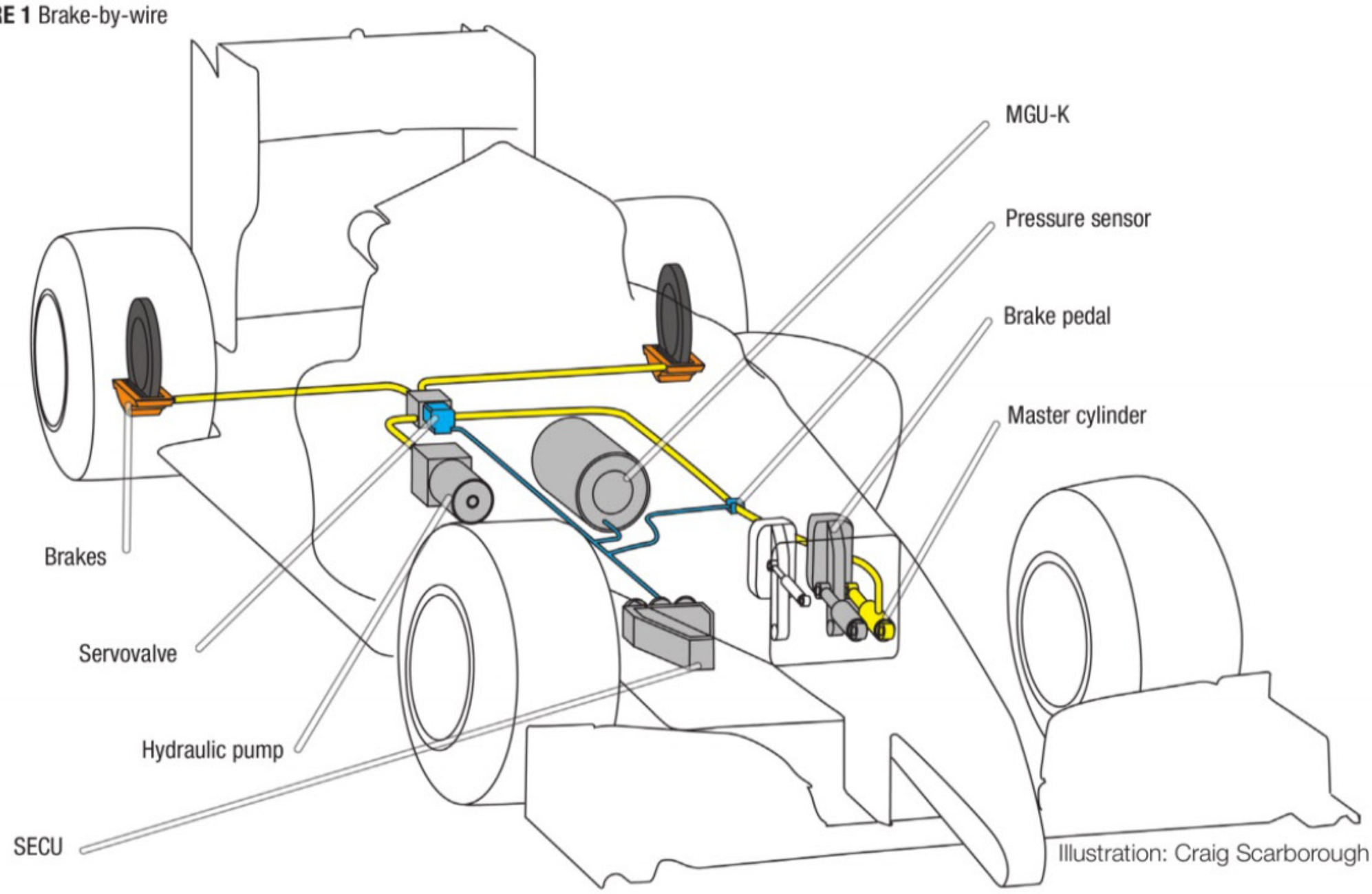
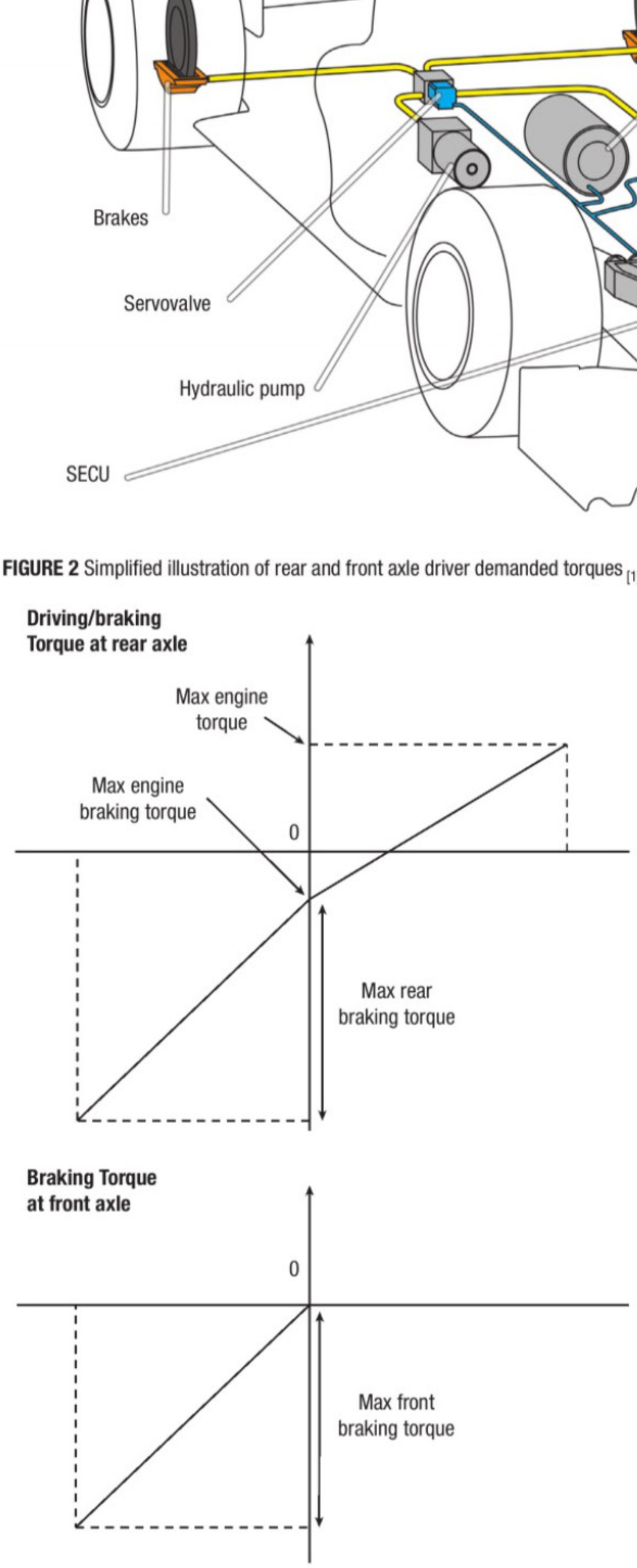


FIGURE 2 Simplified illustration of rear and front axle driver demanded torques [1]



prevent any form of ABS (and ideally also any suspicion of it). The benefit would be in better harvesting of energy by the MGU-K and greater vehicle efficiency, as well as opening some interesting technical green fields.

Secondly, there is an inherent drawback with simply placing a valve in the rear hydraulic brake system and choking off pressure to reduce the rear brake torque at all times until a problem occurs. It is wasteful of effort, requiring a greater pedal force for a given deceleration (ultimately costing fractions of lap time). It will also feed back into the front brake system through the brake pedal, which effectively connects both front and rear systems via the driver's foot.

Incidentally, the first brake bias adjuster that many come across in motorsport is the Automotive Products bias valve, which does exactly what we are discussing here by using a variable orifice to choke flow to the rear calipers. Similar and related hydraulic devices have been used front and rear in Formula One for years to shape the brake balance characteristic with pressure to suit certain car characteristics, but I digress!

A solution that was prevalent in the late '90s, before being banned, is the active balance bar. It gets around the issue of wasted effort, so seems suitable for this application, but again has a downside: it changes the force in the front brakes at the same time as it alters the rear, meaning an uncomfortable sensation for the driver.

With these alternatives ruled out, the brake-by-wire concept came to the fore. It was even considered for the full car (likely sparking some familiar musings about the pros and cons of mechanical against electro-hydraulic power steering systems), but it was ultimately adopted as the solution for the rear axle only in 2014. If successful in its current guise then maybe a full car system would be a logical next step and the PAS question could also be reviewed again.

It is worth noting that, despite the magnitude of authority required of the system, it is not in fact mandatory due to the

[1] Lap Time Simulation with Transient Vehicle and Tyre Dynamics., DP Kelly, PhD Thesis "Cranfield University School of Engineering Automotive Studies Group" 2008.

FIGURE 3 Maximum brake torque capability and balance calculations

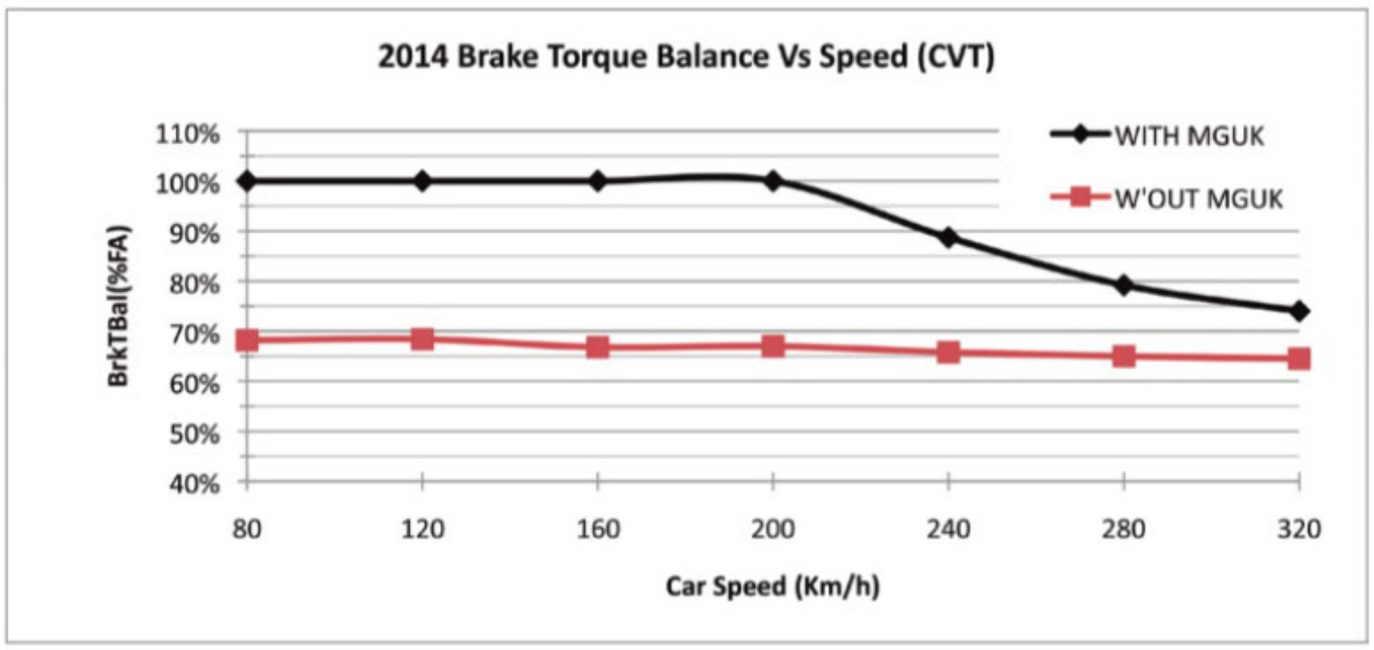
Vehicle Parameters		
		Unit
CXT	0.85	
CZT	3.00	
AB	42.5%	FA
Area	1.45	m^2
μ Tyre	1.5	
ρ Air	1.225	Kg/m^3
Car Mass	700	Kg
g	9.81	m/s^2
Wheelbase	3.50	m
CoG Z	0.2	m
CoG X	1.89	m
Tyre ERR	0.32	m
ref. NEng	11450	rpm
Meng brk HS	-20.0	Nm
MGU-K T x E	-190.0	Nm
Disc Eff Rad.	0.128	m
Disc μ	0.40	
Vcar HS	**310**	Km/h
Vcar LS	**120**	Km/h
TransRatio HS	4.5	:1
TransRatio LS	11.5	:1

Calculated Values		
		Unit
Df High	19757	N
Drag High	5598	N
Df Low	2960	N
Drag Low	839	N
Max Glong HS	-6.63	g
Max Glong LS	-3.15	g
Glong Brk HS	-5.82	g
Glong Brk LS	-2.15	g
WgtTr FA HS	4860	N
WgtTr FA LS	1950	N
WgtTr RA HS	-5705	N
WgtTr RA LS	-2289	N
MaxT FWH HS	-3940	Nm
MaxT FWH LS	-1528	Nm
Max T RWH HS	-2247	Nm
Max T RWH LS	-749	Nm

Brk Bal Range		
		Unit
Brk Bal T	63.7%	FA
WITH MGUK		
PU RA T HS	-936	Nm
Brk RA T HS	-1311	Nm
Brk T Bal HS	**75.0%**	FA
PU RA T LS	-2417	Nm
Brk RA T LS	1668	Nm
Brk T Bal LS	**100.0%**	FA
W'OUT MGUK		
PU RA T HS	-89	Nm
Brk RA T HS	-2158	Nm
Brk T Bal HS	**64.6%**	FA
PU RA T LS	-12	Nm
Brk RA T LS	-738	Nm
Brk T Bal LS	**67.4%**	FA

Note: CVT Transmission, Drag assumed to act about CoG, No anti-forces, No Tyre model

	WITH MGUK	W'OUT MGUK
Vcar (Km/h)	Brk T Bal (%)	Brk T Bal (%)
80	100%	68%
120	100%	68%
160	100%	67%
200	100%	67%
240	89%	66%
280	79%	65%
320	74%	65%



List of Abbreviations:
CXT – Coefficient of Drag
CZT – Coefficient of Lift
Df - Downforce
AB – Aerodynamic Force Balance
FA – Front Axle
RA – Rear Axle
CoG – Centre of Gravity
ERR – Effective Rolling Radius
Neng – Engine Speed
Meng – Engine Torque
Brk – Braking
HS – High Speed
LS – Low Speed
Vcar – Car Speed
T – Torque
WgtTr – Weight Transfer
FWH – Front Wheel
RWH – Rear Wheel

wording in the regulations: 'may be', as opposed to 'must be'. Some teams are very likely to have run cars without this system early in winter testing to avoid adding further complexity and burden to their technical efforts. This could have helped gain early mileage against those who paralleled introduction with the rest of the very new cars. Which development solution works out best remains to be proven and will also have been very dependent on the PU suppliers' progress.

In explaining the circumstances that took us to the widespread adoption of the rear axle brake-by-wire system, we have touched on some numbers for brake balance shift. To be a bit more rigorous, a better understanding can be found by some simple vehicle dynamics calculations.

To start, as introduced above, we should consider the rear axle torque as a continuous value in both a positive and negative direction and as something demanded by the driver through his inputs. The demand is satisfied by a combination of torque from the ICE, MGU-K and rear hydraulic braking system.

We can then construct a simple model using the regulations limits for ERS and some typical values and assumptions for various other car parameters to evaluate the maximum braking capabilities of the front and rear axles in terms of torque, and the proportion between front and rear. If this calculation is evaluated at two speeds, for example in an end of straight braking case and at the entry to a low-speed corner, we can also see the range of hydraulic brake torque balance required if we are to use the maximum recovery power of the MGU-K during braking and cope with the overrun torque of the engine. Dealing with this as effectively as possible is our efficiency criteria, as it means we can harvest the greatest possible energy from the rear axle.

We can quickly see from Figure 3 that with a 2014 car you don't actually need conventional rear brakes below around 210 km/h or thereabouts! Further, the brake balance change as a result of the MGU-K will be a minimum of approximately 10% if it is used at its full capacity. Because the MGU-K torque limit is set by regulation and referenced to gearbox input shaft speed, transmission ratio has an effect and here we have assumed a CVT to simplify the calculations. Ten per cent would certainly be too large a change to deal with quickly in the failure case without a special system. Quickly plugging in some 2013 numbers will ▶

> *"If successful in its current guise then maybe a full car system would be a logical next step"*

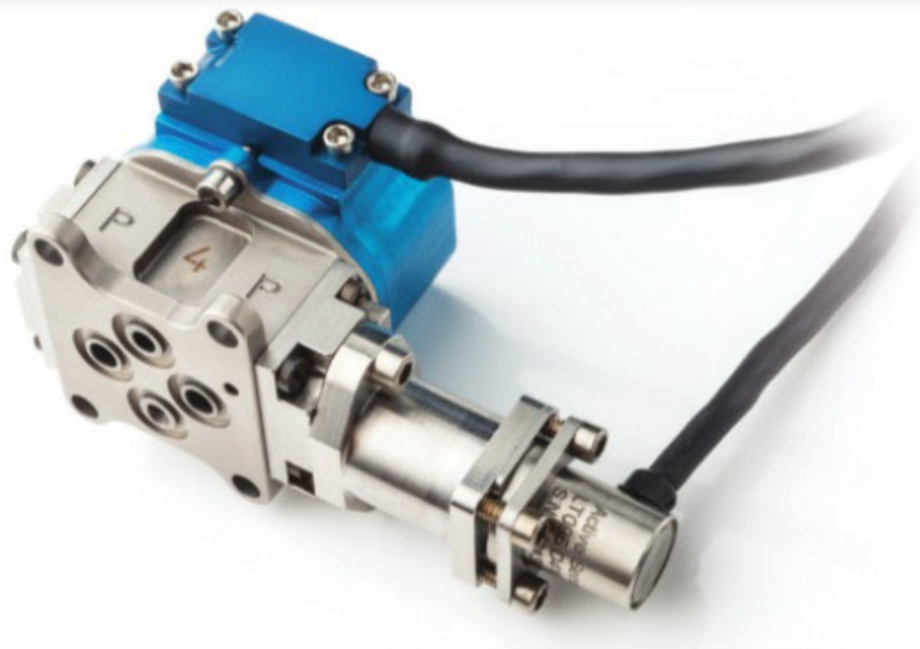
give us the 3-4% shift mentioned previously, validating our model.

The red line on the graph shows that the overall limit retardation torque balance for our vehicle does not vary greatly with speed, shifting gently forward as weight transfer lessens but compensated for by the reducing downforce. Also evident then is that without being able to reduce the rear brake disc torque to maintain our ideal front to rear axle torque relationship, on which this calculation is based, we would lose a chunk of energy recovery potential. Below approximately 210 km/h and as was also the case in 2009-13, it is necessary to control the torque balance entirely by reduction of the ERS recovery power.

Further efficiency improvements are offered in the added ability to offset engine overrun torque effects that in turn means FCO or fuel cut overrun strategies can be applied. Clearly we do not want to burn fuel pushing against the brakes and MGU-K, so this is a useful benefit handing us a kilo or two back from the all-important race fuel quantity.

So the system will deal with comparatively large shifts in axle brake system torque balance and give us greater energy recovery potential. That is before we consider how we might use it, along with our other rear axle torque modifiers, to affect car balance. (Remember, of course, that any kind of differential braking or torque vectoring – another nineties throwback – is most definitely not allowed.)

In practice the implementation of the system is probably the least understood area. It is known that the teams have to write control software and parameterise the system in some way. One can also ▶



ABOVE & BELOW Moog's E024 Series miniature servo valve can be harnessed in the BBW system. The integral Linear Variable Differential Transformer (LVDT) position sensor allows the valve spool position to be continuously monitored. The failsafe system will send the pump's hydraulic pressure to the brakes, except in the case of a failure when the valve moves to allow the master cylinder to operate the brakes

BELOW Sauber was among the teams that confessed they were struggling to optimize BBW at the start of the season

Photo: Sauber

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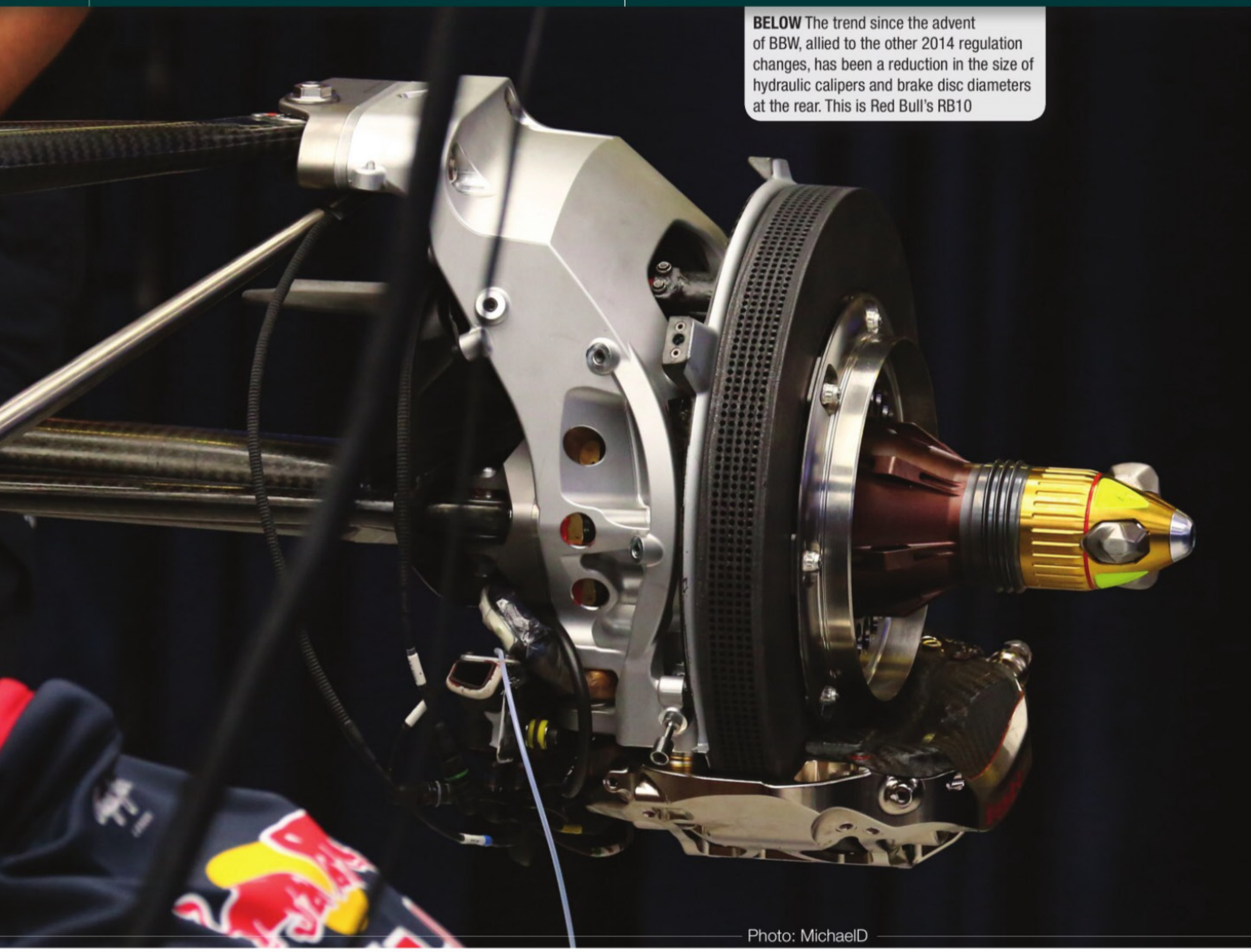

BELOW The trend since the advent of BBW, allied to the other 2014 regulation changes, has been a reduction in the size of hydraulic calipers and brake disc diameters at the rear. This is Red Bull's RB10

Photo: MichaelD

see from the regulations that (as a failsafe and to prevent unscrupulous designs) a rear master cylinder of similar size to the front must still be fitted.

The software architecture for the 2014 version of the SECU code was devised by a specially formed Electronic Systems Working Group. It was here that the issues of allowing adequate torque control to achieve the objectives of the new power train, whilst not permitting traction control or similar driver aids, were thrashed out.

The specification for the 2014 Torque Management strategy simply and cleverly defines braking as a driver torque requested by the brake pedal (as in the earlier illustration). Through using the front brake pressure generated in the master cylinder together with the front brake disc temperature, a target torque can be calculated from a known, probably dyno test-generated, friction characteristic. The target rear axle torque is calculated via a table of front brake pressure against axle brake torque balance. This value is passed to the torque coordinator to put into effect through MGU-K and rear hydraulic brake pressure control. The calculation is of the following form:

TBrakeDriver = ((1/rBrakeBal) – 1) x THydBrakeF

> ***"The output of the Torque Coordinator is kept honest by the FIA Torque Monitor, ensuring there is no unintended use of the brake hydraulic torque demand"***

The output of the Torque Coordinator is kept honest by the FIA application within the same box, which contains a Torque Monitor, thereby ensuring that there is no unintended use of the brake hydraulic torque demand. To change the brake balance now the driver need only alter a rotary switch or menu map selection via the steering wheel. This does, of course, permit some useful freedom for varying the resulting braking characteristic around the lap. No doubt some interesting solutions will be seen.

The hydraulic designs of the systems in use will vary, but will probably include a Moog servo valve and, if necessary, hydraulic power sourced from the car and fed to a second rear master cylinder. Given that hydraulic power is concentrated at the rear of the car, the system will probably be housed in some suitable real estate between the pedal box and rear axle and ideally not exposed to extremes of temperature and vibration. This season's larger sidepods ▶

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will likely suffice. There will be a PRV that ensures if pressure falls sufficiently within the rear brake line, it can be replaced by that generated by the conventional rear master cylinder.

Of course there are still failure modes to consider, notably of the sensors associated with the front brake system, or of the front system itself (therefore generating no pressure signal). But as with a conventional system, multiple failures that lead to complete loss of braking are extremely unlikely and will be mitigated by redundant sensors where necessary.

FIRM PEDAL

An interesting side effect of a practical dead-end in the hydraulics after the conventional rear master cylinder is that the brake circuit can be very stiff. In practice there might be those who include a compliance to give a realistic pedal feel, but past experience with power brake systems of yesteryear suggests drivers just love a firm pedal; they would quite happily push against a bulkhead if it created the proportional stopping power.

We have said this is not new technology and, in order to understand the hydraulic implementation of the system, a good example is available on a Honda motorcycle, the CBR600rr fitted with

Photo: Tee/LAT

ABOVE Lotus tech director Nick Chester admitted in Bahrain that a need to get to grips with the BBW system on the E22 remained one of the Lotus drivers' biggest complaints

e-CABS [2]. The aim for the Honda designers was to centralize the masses of the various brake system components in the bike. They therefore located small valve blocks at the brake levers, and small hydraulic power packs (which in our case could be the car's hydraulic system) in the frame, with a control unit managing the pressures.

The fluid passes from the power pack back through the valves to the calipers to allow the bike to brake in the event of a system failure, and small accumulators or 'stroke simulators' give the rider feel. The added advantage is that you can implement ABS readily in this particular case.

As they touched down at Melbourne Tullamarine, their Business Class cabins brought to a gently rumbling but comfortable halt, most drivers and engineers will probably have known in the back of their minds that a brake-by-wire system was responsible. For such a long trip many will have been aboard an A380 aircraft that features 'BTV', or Brake to Vacate. The system is so intelligent that the pilot can actually pre-select the nearest taxi-way (wide enough for its generous wingspan) that it can brake and turn the aircraft onto at just 10 knots in the smoothest possible way on a wet or dry surface. This has replaced the older auto-brake systems offering just high or low grip settings.

About two million people a month are transported by the expanding A380 fleet, so it certainly seems about time that Formula One puts aside those last reservations, follows suit, and again puts itself in the hands of BBW technology. RT

BELOW Brake to Vacate, the brake-by-wire system on the Airbus A380, was designed to optimize braking efficiency and has the potential to reduce runway occupancy by 30 per cent

Photo: Airbus

[2] Honda Motorcycles e-CABS System Brochure, 2013.

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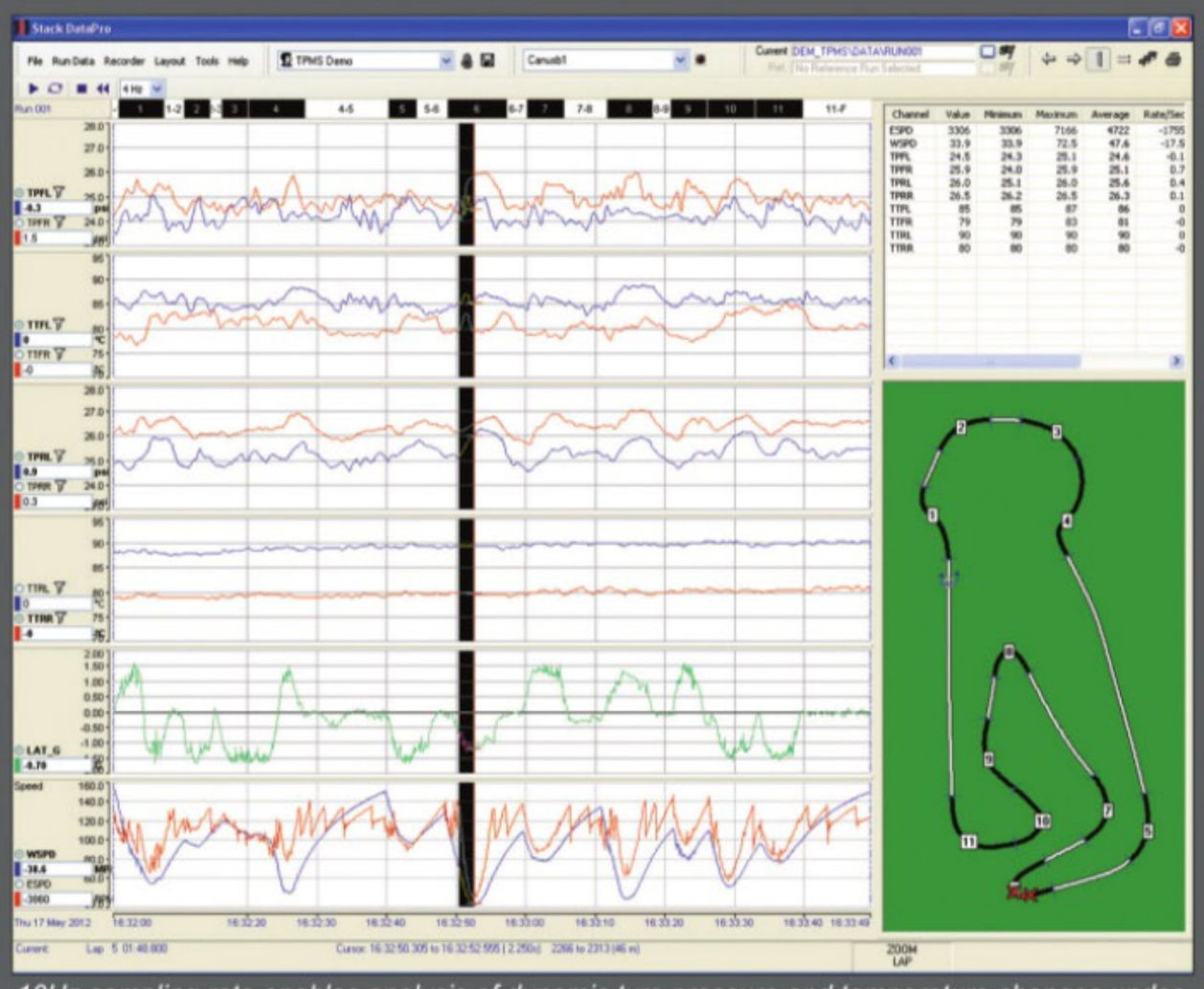

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The FIA's technical experts are engaged in a never-ending battle with engineers who push the boundaries. **Matt Youson** goes behind the scenes with F1's scrutineers

POACHERS VS GAMEKEEPERS

THE black-and-white chequered flag is a potent symbol of motor racing, the ubiquity of which has long-since transcended sport. It's a universal symbol of completion, a sign that the end of the road has been reached – unless, of course, you're one of those people for whom the chequered flag simply represents the beginning of the busiest part of the day.

It marks the end of the race in so much as it's the point at which drivers stop racing – but the result isn't finalised until the official classification is signed off by the stewards of the meeting and published. And this doesn't happen until the scrutineers are satisfied that those taking the chequered flag did so in vehicles conforming to the sporting and technical regulations of the day. It's a simple provision but one which can cause a disproportional level of… angst.

Such was the case at Formula One's season-opener, the 2014 Australian Grand Prix. Rather than tales of Mercedes dominance or a champagne-drenched debut for McLaren rookie Kevin Magnussen, the mainstream press was filled with process stories; reporters angrily decried the length of time taken to deliver the official result.

Something has to be done screeched the opinion pieces, oblivious or uncaring of the modern realities in which scrutineering isn't simply a matter of passing bodywork through gauges and checking the driver's helmet for the correct sticker. That era has long-since passed into memory – but the 2014 F1 technical specification has many

Photo: Mercedes GP

ABOVE The duel between Lewis Hamilton and Nico Rosberg reached a thrilling climax in Bahrain. As the drivers wound down, the hard work was just beginning for the FIA technical team

BELOW FIA technical delegate Jo Bauer at work

Photos: James Moy

looking back fondly on the happy days of 2013 when F1 cars were unsophisticated buckets in comparison to what they have become over the winter. 2014 has raised the bar, putting F1 firmly back at the technological pinnacle of motorsport – but with that comes an increased burden on the small FIA technical team who make sure the plaudits gathered on-track are justly deserved. "It is," says FIA technical delegate Jo Bauer, "a different world."

The task of scrutineering and assessment is one with no beginning or end. The technical department are among the first to arrive at a circuit, setting up their weigh-bridge, portable fuel analysis lab, electronics lab and myriad other systems. In the run-up to a race weekend they operate as an informal calibration service, allowing teams to check references and ensure they start the weekend running legal cars. The practice and racing sessions feature the usual conformity checks, random sampling, sealing and software-locking activities, to be followed, naturally, by post-race scrutineering. This process, newspaper sneers aside, is a rapid snapshot, doing the minimum necessary to sign-off on the race result as swiftly as possible. The days and weeks following see a deeper analysis of race data: the officials, like the teams, are ▶

ABOVE Alan Prudom, leader of the FIA's software analysis operation, admits to feeling like a taxman: "Teams find a loophole; we close it. They find another!"

slowly increasing their understanding of F1's new packages.

"The software department collect the data for analysis between the races," confirms Bauer. "It's impossible to do those checks [at the circuit] because that would mean the stewards would not receive the reports until about four days after the event."

The story of 2014 so far has been the new hardware under the engine covers. Increasingly that hardware will be pushed into the background as the battleground switches to software development. Unlike the homologated hardware, which – notwithstanding the triple caveat of reliability, safety and cost – is now fixed, software development continues unabated and is seen as key to unlocking the full potential of the power units. It's also an area of considerable interest for the scrutineers, with the standard ECU, according to Olivier Hulot, the FIA software analyst responsible for it, being rather less standard than it has been in previous years.

AMAZING EFFICIENCY

"The V8 was a well-understood technology. It was settled, had been around for years and the software inside the standard ECU was the same for everyone," he says. "The new power unit requests amazing efficiency levels and the challenge we faced when looking at the regulations was to allow the engine suppliers and teams to achieve that efficiency. It drove us to give them a bit more flexibility.

"There is still a lot that is standard – everything not related to the new power unit, for example – but for the new technology we are allowing the teams to develop some software."

It's worth noting that the aspirations for the new hybrid are very different to those of the V8. The old engine was a thoroughbred racing unit with a specification that would reward designers according to the standard criteria of power output, weight, efficiency, reliability, CofG, driveability etc. The new unit has to do all of that, but also fulfil the remit of developing hybrid technology in ways hopefully relevant to the outside world. That aim doesn't mesh neatly with standardised software.

"The challenge was to allow them [the engine manufacturers] to achieve the efficiency we're asking for but not drive them in a specific development direction," continues Hulot. "If we imposed standard software – even for the [IC] V6 – that would have driven them in one direction and not left them sufficient freedom. It would have been a real shame to start the programme with something like that."

Of course design freedom goes only so far, there are limits – and F1 designers are usually located teetering right on the edge of those limits with one foot beyond the pale and a hungry look directed at the far horizon. "Dare I say they push the boundaries?" offers Alan Prudom, leader of the FIA's software analysis operation. "It's an ongoing battle in which we could be quite accurately described as playing the part of the taxman. They find a loophole; we close it. They find another loophole and so on. The goalposts are always moving, sometimes slowly, sometimes rapidly – luckily we can respond fairly rapidly. It's a job that's always interesting."

ABOVE & BELOW FIA software analysts Olivier Hulot and Andy Leitch (below)

Prudom states the early months of 2014 have been relatively quiet in this regard, teams being more concerned with reliability than adventurism. "But I'm sure as the season progresses they will start to look for loopholes or grey areas to exploit. As before we will respond as we need to – it's never boring!"

One area that has and will continue to be very active is the interaction between the various components of the new Energy Recovery System (ERS). This is the domain of software analyst Andy Leitch. ERS operation comes with a whole raft of parameters from the amount of power the MGU-K can supply, to limits on the amount of energy that may be taken into and out of the energy store. There are maximum voltages and maximum speeds for the turbocharger.

"It's a bigger job [than KERS] but essentially just a more complicated version of what we had before: evolution rather than revolution," says Leitch. "There's also quite a bit more work because teams are submitting newer versions of software a few days before the event. Of course it would be easier if we could limit the number of software versions during the season and spread those out – but especially this year it's quite reasonable for a team to be making a lot of software changes between each race."

One of the primary concerns for the FIA is to ensure the integrity of the 'sandbox' model. Not all of the data acquired from a car is allowed to freely interact. Instead various systems must operate independently of one another, staying within their own prescribed sandbox. "One of our policing methods is restricting how many parameters [teams] have access to in each individual programme," says Leitch. "The whole system is based around sensors being connected through one piece of software which we control, and then allowing certain parameters to be available for various other functions that can't talk to each other.

"There's a lot of work involved in responding to queries about that. We're asked questions like, 'Is it legal for me to use car speed as an input into the brake balance controller?' (it isn't). Another favourite is, 'Can we use lap distance?' Generally that wouldn't be allowed because lap distance tells you where you are on the circuit and would allow teams to pre-configure systems and set the car up for individual corners."

Queries aside, much of the monitoring job is done in real-time and frequently involves highlighting parameters heading out of tolerance. It is a perennial issue for ▶

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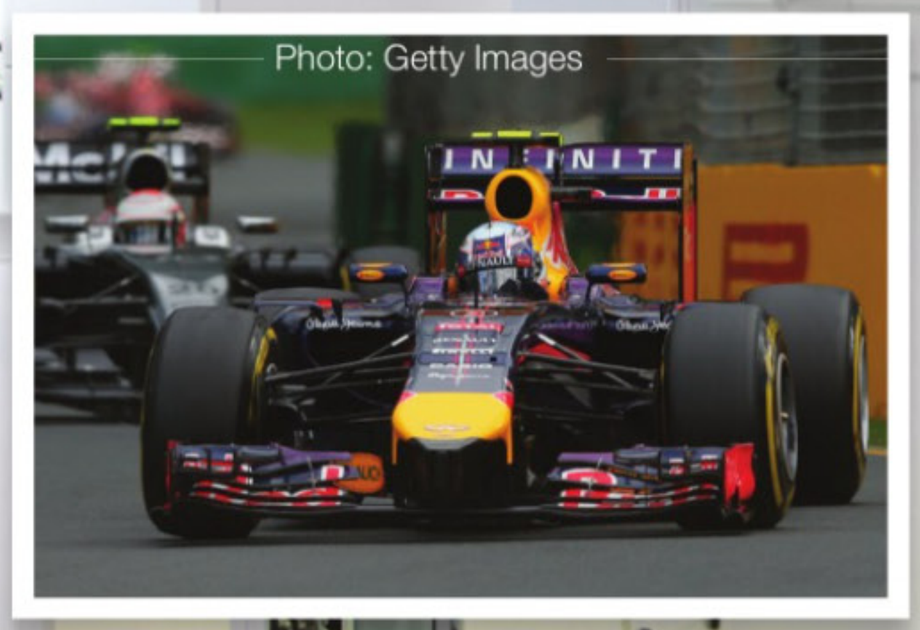


ABOVE & INSET Pete Tibbetts' work as an analytical chemist normally takes place in the background. But the fuel flow meter controversy, which saw Daniel Ricciardo excluded in Melbourne (inset), has thrown an unwelcome spotlight on the FIA's entire technical team

F1 that nominal values tend to be ignored and tolerances tend to be exploited. It's a particular bugbear for the FIA.

"I'll look at the data from both [practice] sessions on Friday and sometimes you'll see a team is getting close to the limit," says Leitch. "Of course they tune their system to get as close as possible so if there is a figure of 120 kW ± 1%, they'll run their system at precisely 120 kW +1%. We'll go to see them at that point, and say they're in danger of going over the limit and ask them to keep within the specification."

Measurement of voltages and currents is carried out with sensors specified by the FIA and monitored both in real-time and also via data downloaded after the session. In case of a sensor failure, teams provide a copy of the fall-back model they'll use in its place. "I'm also responsible for verifying that the model looks real and is within sensible parameters," says Leitch. "We have to ensure a team is not going to gain an advantage by deliberately making a sensor fail in order to use a model that's favourable."

While software is a matter dealt with in the background, front and centre this year has been the issue of fuel. Peter Tibbetts is best recognised as the co-driver of the F1 Safety Car, handling radio comms while Bernd Mayländer concentrates on the driving. Tibbett's primary task, however, is as the FIA's fuel analyst. While fuels are homologated, there isn't a limit on the number of fuels a supplier can submit – meaning Tibbetts is one of the busier people in the F1 paddock. "Normally we would homologate between 20 and 40 fuels each season, as fuel companies are constantly developing fuel," he says. "It's particularly busy when we have new regulations, as we do now.

"Of course with the turbos the fuel composition has changed quite a lot. The regulations have not altered but a turbocharged engine works better with a heavier, more dense fuel, so there are a whole range of new compositions for this year, added to the constant development of slightly different fuels for hotter climates, cooler climates etc."

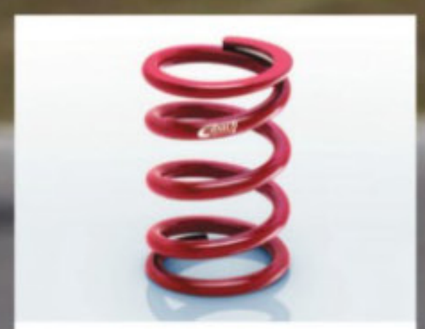
BIG TICKET ITEM

The big ticket item for Tibbetts this year has not, however, been fuel as much as it's been the new fuel flow sensor, required to police the 100 kg/hour fuel flow limit. "Rather than use a little turbine, the sensor we employ uses ultrasonics, so that in the event of a catastrophic failure, it won't stop the fuel flowing," he says. "Pre-season we were very busy calibrating the meters and at the track we have to check the sensor mounted in the tank carries the correct FIA seal and is calibrated with the correct fuel. With teams having more than one pre-approved fuel for the season, and a sensor being calibrated against two or three of them, we have to make sure the correct calibration line is put into the software."

Another thing for Tibbetts to measure is density. "Teams can, intentionally or unintentionally, change the density of their fuel by, for example, leaving a drum cap off and letting it evaporate," he explains. "If we maintain the same fuel flow calibration but the density has risen, then they'll use a greater mass of fuel than would theoretically be allowed. So now, when I take fuel samples for analysis, I compare the pattern of the fuel and the components within it to the reference – but I also measure the density, which cannot rise by more than 0.25%."

In the post-race mêlée, when fuel samples are being taken and data pulled off cars, there's also the rather old-fashioned task of measuring bodywork. It is, concedes Bauer, "Much easier and quicker to check." The technical delegate does, however, point out the importance of the software and hardware side of his team working in harmony. "We need to support each other, the software and the hardware department, to get through the workload. Previously the workload after the race would normally take five hours after the chequered flag. I think in 2014 we expect, at least at the start, for it to be seven or eight hours before we have finished, but we really need to learn by doing it."

So far this season the scrutineers have managed to beat their predictions and get reports to the stewards while teams are still packing down their garages. Set against the indignation of the media kept from their beds, flights and, occasionally, barstool, is the sense in the FIA garages of a difficult job being done well. Doubtless practices will normalise over time but the current feeling is that the 2014 season is Formula One at its most complex – whichever side of the chequered flag you happen to be working on. RT



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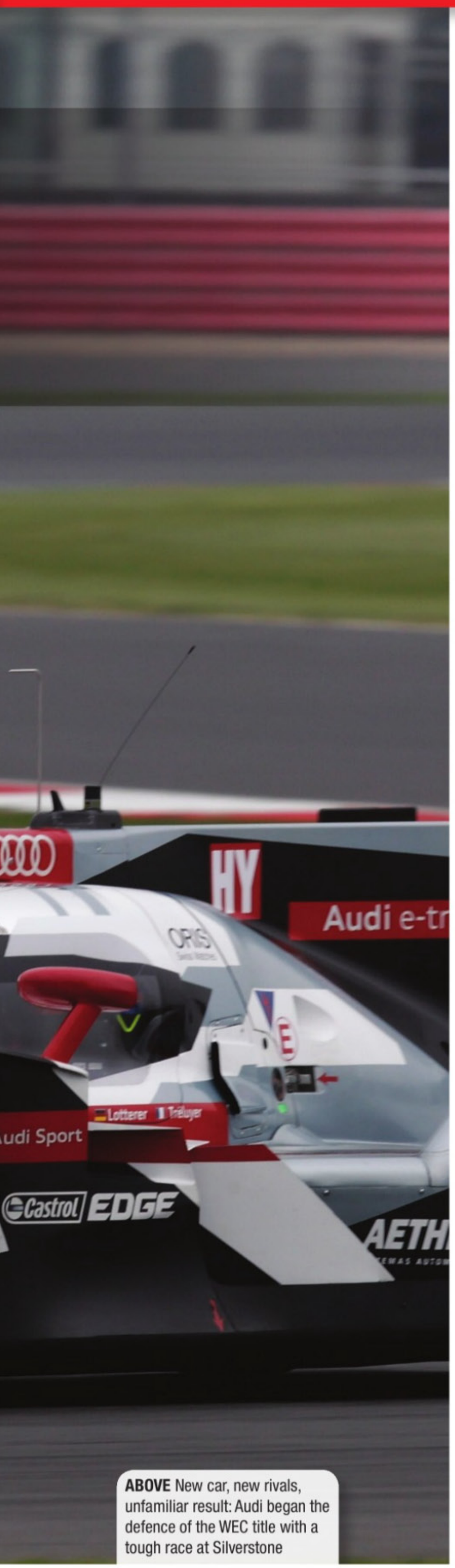
THE CASE FOR THE DEFENCE

Photos: Audi Motorsport



ABOVE New car, new rivals, unfamiliar result: Audi began the defence of the WEC title with a tough race at Silverstone

Audi defends its WEC and Le Mans crowns with a new R18 e-tron quattro that, as **Craig Scarborough** explains, took many people by surprise

AUDI entered the 2014 WEC campaign on the back of a period of dominance, but this year brings both new rules and competitors. Surprisingly, the team has chosen not to go aggressively after more pace and power, but has kept to its formula of a single Energy Recovery System allied to a turbo diesel engine. A case of resting on its laurels, or playing it safe in the hunt for more success?

AUDI'S STRATEGY

Faced with a major technical challenge, allied to concern at the return of Porsche into LMP1 and the continued threat from Toyota, it seemed that Audi might need to step up its spending this year to see off the opposition. Yet head of Audi Sport Dr Wolfgang Ullrich surprisingly suggests this has not been the case, insisting, "This didn't change what we planned to do."

However, he admits there's a threat out there and feels the team has reacted to it. "It will be different in the races, as we have one more strong competitor," he says. "But we've tried to make a car that is performing on the highest level – reliable and using the new rules in a good way to be efficient as possible."

The quest to make the cars more efficient is mirrored in the team's internal organisation, Ullrich affirming that the budget and resources are no greater this year: "This is similar. We have the same group of people that worked on the project and it didn't change too much from last year's."

Indeed the group of engineers engaged on the new e-tron quattro are part of Audi's home-grown technical team. It's a proud boast from Ullrich. "They started doing the rally cars, then they moved to the IMSA GTO cars in the USA, then the DTM and the Super Touring cars," he says. "In 1997 we took the step from touring or rally cars. They had always been based on existing road cars; now we had to do a real prototype [the R8] with just a white sheet of paper and a centreline."

This team has built the 2014 R18 to a new set of rules and, despite similarities in concepts and appearances, Ullrich insists this is not a re-optimised 2013 car, suggesting, "It's a completely new car. There is not one part from last year's car."

The 2014 WEC LMP1 category has far-reaching rule changes. They introduce an equivalency formula for power units, where the manufacturer teams have to run Energy Recovery Systems (ERS) and the matrix favours more power from ERS than from hydrocarbons.

These changes notwithstanding, Audi has elected to stick with the same ERS philosophy as raced last year, with its ERS working on the front axle, providing part-time four-wheel drive. This, of course, is in contrast to its two big rivals, with Porsche and Toyota both running two ERS systems. Ullrich is unperturbed: "We know that the others go for different concepts, but this was the idea behind the rule book and makes it more interesting than ever."

> ***"This is not a re-optimised 2013 car. There is not one part from last year's car"***

Audi's approach mirrors the road car division's brand values of four-wheel drive and economic diesel engines. Rather than these technologies being forced upon Audi Sport, Ullrich suggests it's a direction they have found themselves. "We have worked out this concept because we are sure that this should be the most efficient way of doing it," he says, adding that the LMP1 powertrain programme will lead on to Audi's commercial products: "We are convinced that we offer efficient road cars, therefore it is a must for us to show for the future that we can develop an even more efficient car. By following the basic TDI concept with an additional electric hybrid that you can buy on a road car, this is the next step that is going to come."

It could be argued that Audi has tied itself into a power unit concept that will lack ▶

power compared to its rivals' multiple ERS set-ups. With such strong opposition, can Audi risk not having parity in the horsepower stakes?

When the question, "Is a single ERS solution going to be competitive this year?" is put to the head of Audi's LMP1 programme, Chris Reinke, he explains the team's thinking: "In endurance racing you always have to evaluate how much you can gain from the extra risk you take. Evaluating the complete matrix of options we have available, we opted to take the safe route for this year."

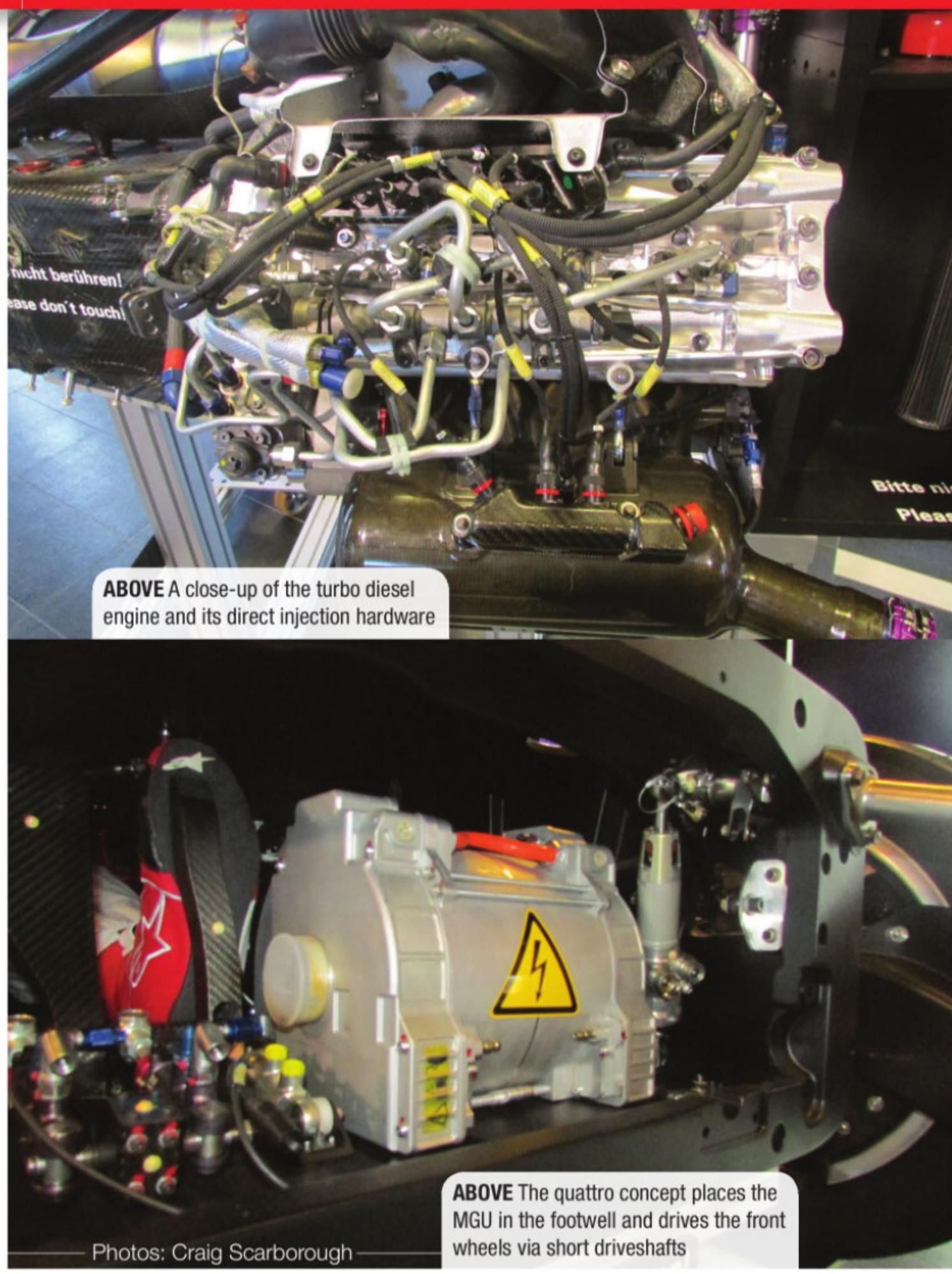
Therein, perhaps, lays the answer: the legacy of Audi's string of Le Mans and LMP1 wins is the maturity of a reliable powertrain and effective chassis. Porsche and, to a lesser extent, Toyota have yet to reach Audi's levels of reliability. Perhaps the team is planning a shorter-term strategy, not to over-develop the car but to win by consistency rather than outright pace.

PLAYING IT SAFE

For 2014 this makes complete sense. With the wind behind their sails from 2013 and their challengers likely to be struggling to make complex new powertrains reliable, it could be the way to secure more success.

Yet this is a short-term view, as rivals will soon mature and reap the rewards of a technical package with greater potential horsepower. Which then begs the question of what's the next step for Audi beyond 2014? Its single ERS package lacks the horsepower of multiple systems, so can it remain competitive with just 2 MJ per lap or will it have to step up to one of the other LMP1 energy and power categories with another ERS installed?

As explained in Race Tech issue 162, the LMP1 regulations have changed significantly for this year. ▶



ABOVE A close-up of the turbo diesel engine and its direct injection hardware

ABOVE The quattro concept places the MGU in the footwell and drives the front wheels via short driveshafts

Photos: Craig Scarborough

FIGURE 1 APPENDIX B: VALUES OF ENERGIES AND POWER FOR LE MANS

		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	157.2	147.0	143.3	139.5	138.0
Max Petrol Flow	kg/h	100.9	94.3	91.9	89.5	88.5
Petrol capacity carried onboard	l	68.3	68.3	68.3	68.3	68.3
Fuel Technology Factor AV	-	1.074*	1.074	1.074	1.074	1.074
Fuel Technology Factor Pmax	-	1.088*	1.088	1.088	1.088	1.088
K Factor	-	1	0.987	0.987	0.987	1
Diesel Energy	Mj/Lap	146.4	138.7	135.2	131.7	128.5
Max Diesel Flow	kg/h	84.6	80.2	78.2	76.1	74.3
Diesel capacity carried onboard	l	54.3	54.3	54.3	54.3	54.3

The amount of releasable energy per lap will be limited in the proportion of length of circuit relative to the length of Le Mans circuit multiplied by factor 1. 55.
The amount of fuel allocation per lap will be limited in the proportion of length of circuit relative to the length of Le Mans circuit multiplied by factor 1.11.
* Calculated from estimated "Diesel privateers" BSFC calculated from Best in class Manufacturers Diesel BSFC data using same ratio than between Best in class Manufacturers Petrol and Best in class Privateers Petrol BSFC data

Photo: Craig Scarborough

ABOVE & RIGHT The new cockpit dimensions are designed to improve the driver's position and vision (above). Visibility on the older car (right) was poor due to both the A-pillars and lower roofline

The power unit is based on the power and energy matrix (Figure 1), the chassis/tyres are narrowed and the cockpit greenhouse is taller for better visibility, amongst other safety changes.

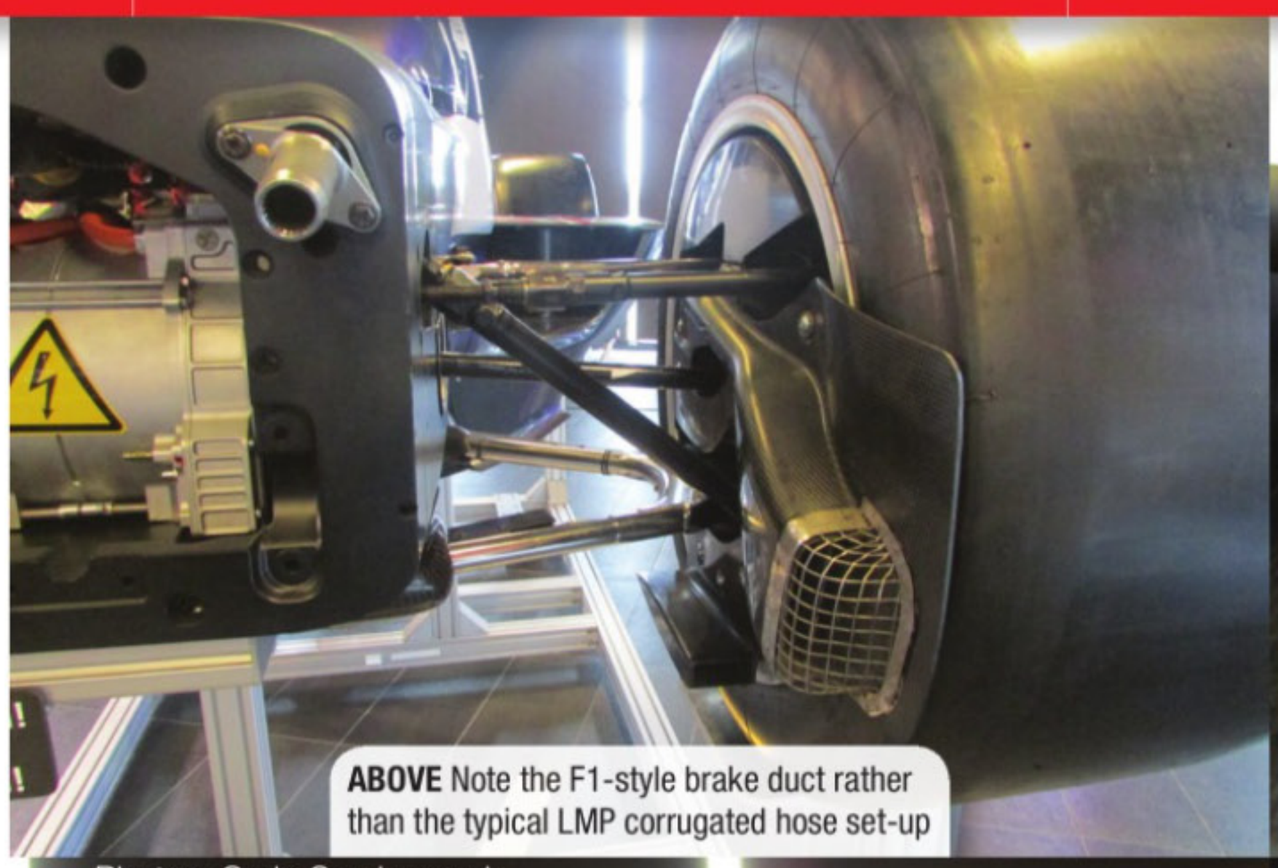
Audi has elected to follow its existing turbo diesel direct injection engine direction, its 120-degree V6 enlarged to 4.0 litres, up from last season's 3.7 litres. Audi officially states that this, "Provides the optimum balance between efficient energy use, size, weight, energy conversion efficiency, responsiveness, driveability and a favourable operating strategy – combined with durability, which is the basic prerequisite for success at Le Mans."

Very few other details of the engine itself have emerged. It is still a mono turbo setup, despite the exhaust outlets being split to create a pair of outlets either side of the car's dorsal fin.

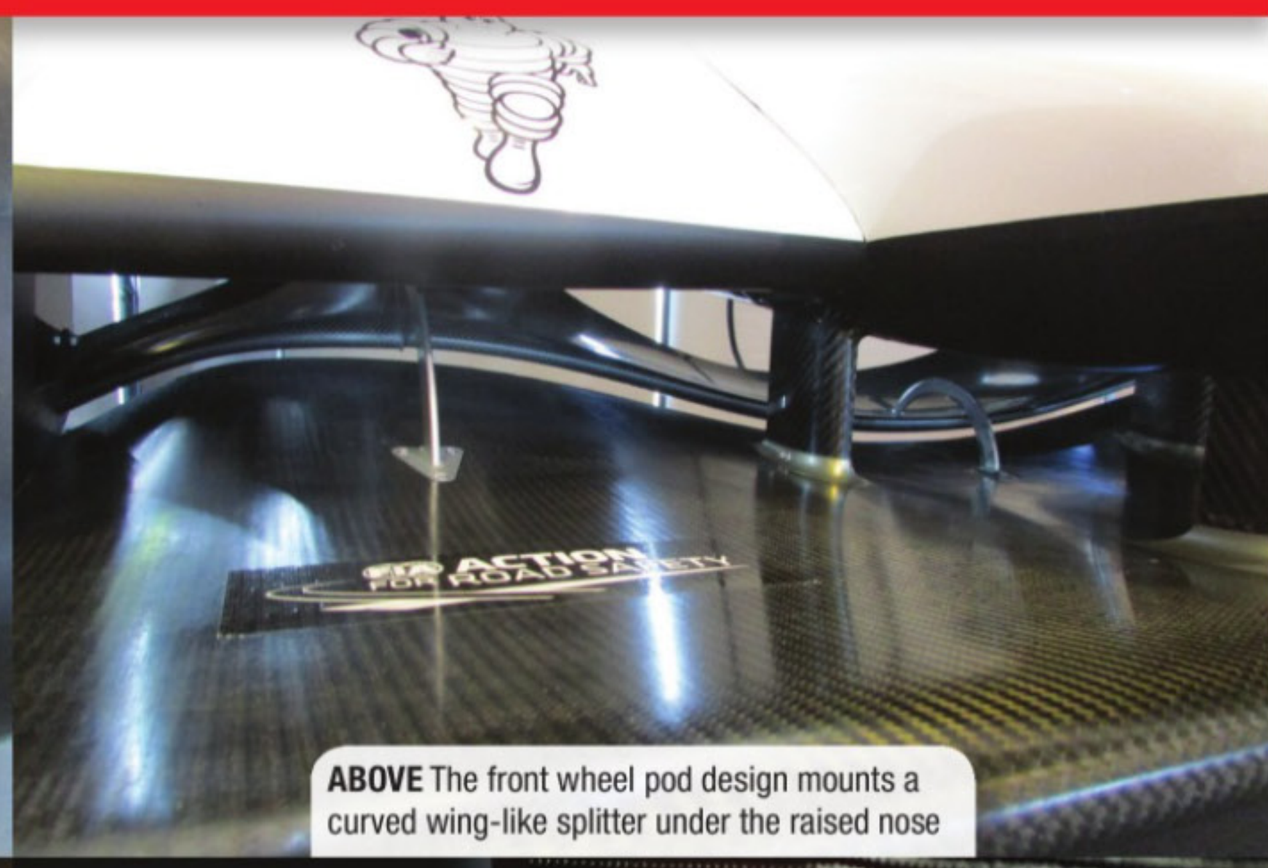
The decision to run a single ERS places the car in the second category of the power and energy matrix. This allows 2 MJ of released ERS energy to be used per lap. Rivals with an extra ERS on board can run at least double this amount. Being in the 2 MJ category also defines many other aspects of the car's design. The total weight of 870 kg and fuel capacity of 54.3 litres will affect the chassis's design, while the new for 2014 instantaneous fuel flow rate is set at 80.2 kg/hr.

As in F1, this fuel flow rate will be monitored by a Gill ultrasonic sensor, homologated by the FIA. Equally, as in F1, this has not been a completely smooth introduction, as testing so far has shown. Reinke explains: "We started in the fall, ▶

ABOVE The R18 combines the strengths of matrix LED headlights with the new laser light concept for a precise spread of light in front of the car



ABOVE Note the F1-style brake duct rather than the typical LMP corrugated hose set-up



ABOVE The front wheel pod design mounts a curved wing-like splitter under the raised nose

Photos: Craig Scarborough

ABOVE A pleated conical air filter resides inside the scoop on the roof

ABOVE Audi retains a swan neck mount for the rear wing. This area has been lightened this year

when they were available on the test benches. We have had them on the car since the beginning of the year, but always temporarily, as they were rarely available. Whenever they were available, we had them on the car. They have got better; we see that they are really increasing this technology and are getting better in control. But we are still on the way and are not there yet."

Audi's energy recovery system also follows the format of last year. An MGU sits inside the footwell and is connected to the front wheels via short driveshafts. Energy is stored in an electric flywheel setup mounted inside the cockpit.

Audi works closely with a number of third parties on its power train, both Bosch and Akropovic being prime examples, as is Williams Hybrid Power (WHP). Yet the flywheel is not a WHP-developed part, as Reinke points out. "The development is at Audi, but it's manufactured at Williams, so it's a similar setup to that we have chosen before." The flywheel's storage is up from 0.5 MJ in 2013 to quadruple that this year, at 2 MJ. Electricity flows between the MGU and flywheel storage via the power control electronics, which are also mounted inside the cockpit and cooled by air.

Bolted to the rear of the engine is the new 7-speed gearbox, using Megaline electric shift actuation. This sits within an Audi-developed carbon fibre casing, with titanium inserts for the highly-loaded areas.

The suspension follows the format of 2013, with pullrod operation of low-mounted coil over dampers at the rear and pushrod-operated torsion bar/damper at the front. Alloy uprights mount Brembo brake callipers, surrounded by complex carbon fibre brake cooling ducts. Sophistication in this area is on a par with F1: the brake ducts both enclose the inner face of the wheel rim and the outboard face of the brake disc, thus acting as aerodynamic improvements as well as ducting cool air to the brakes.

ABOVE & BELOW Audi has worked hard on the cockpit ergonomics, moving important controls such as the clutch to the steering wheel (above), where the older car featured a three-pedal setup (below)

Photo: Craig Scarborough

Throughout the car the aerodynamic solutions are increasingly advanced. Being an efficiency formula, aerodynamics still have a part to play. "The car has much less drag, again to contribute to the overall efficiency of the package," Reinke explains. The aerodynamically efficient front splitter and underbody are key areas for downforce development, while the rest of the air-licked surfaces are designed for low drag.

The now common front wheel pod design mounts a curved wing-like splitter under the raised nose. For Audi this 'wing' sports two elements and even allows for adjustment of the flap element's angle of attack. By regulation front wheel pods are narrower for the new spec tyres and are revised with a rear-facing exit duct to vent air from within the wheel arch. At its front, the nose ▶

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tip is narrower too and supports the front splitter with four pylons.

Along with the revised wheel pod, the vanes forming the flanks of the sidepods are new too, with far more of a fence formed along the lower edge to deter air passing up from the front wing from spilling under the floor.

Unexpectedly, Audi has split the exhaust outlet into two, the siamesed outlets exiting either side of the dorsal fin. Its design team exploited a blown floor concept last season but legislation demands that a more benign solution be adopted on this car.

Due to regulation the cockpit glass area is 20 mm taller and meets the new ACO visibility templates. Above the cockpit area is the wider air inlet for the turbocharger. This duct also houses the conical air filter, accessed by a removable panel.

With the rules freeing up the rear wing to extend the full width (now 1900 mm) of the car, the rear wheel arches are also subtly different. With the rear wing no longer extended by means of a loophole in the bodywork regulations, the vertical endplate now intersects with the outer edge of the rear wheel arch.

Forming part of the aerodynamic shape, the monocoque is also new for 2014. As well as the new glasshouse area, the tub needs to incorporate an FIA-specified Zylon anti-intrusion panel along its sides. In addition, rules require that the car must sport an impact-tested rear crash structure for the first time. Part of this can be seen projecting from the rear of the car and mounting the rear tow hook, which is rather unceremoniously held in place by tape.

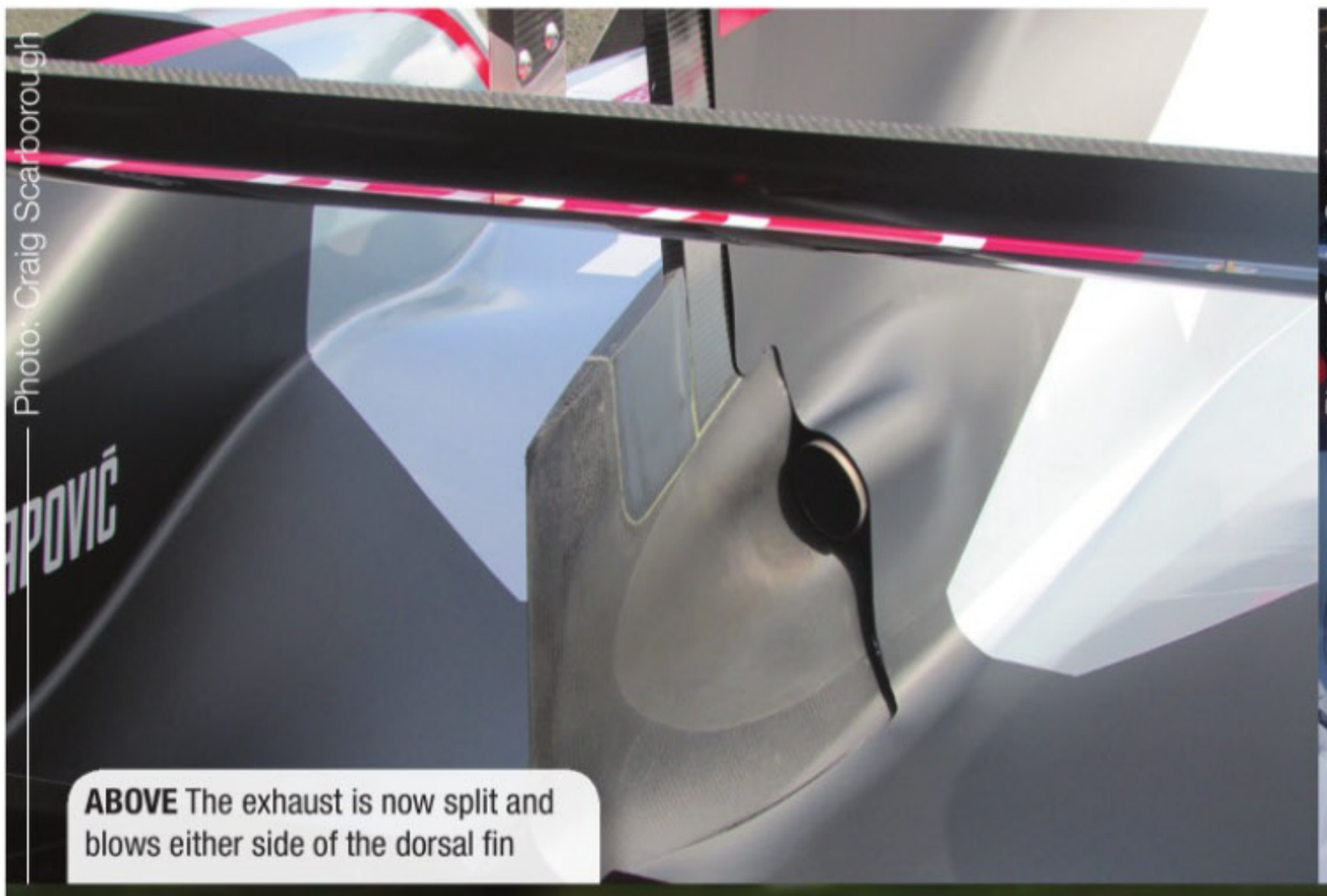
Photo: Craig Scarborough

ABOVE The exhaust is now split and blows either side of the dorsal fin


Photo: Craig Scarborough

BELOW Radio, telemetry and GPS aerials on top of the engine cover

ABOVE The R18 tested with the controversial fuel flow meter whenever it was available, but you still sense there could be trouble ahead…

BELOW The new crash structure, produced from carbon fibre-reinforced plastic, protrudes from the rear of the car

"With such strong opposition, can Audi risk not having parity in the horsepower stakes?"

With its heavy diesel engine, ERS and safety additions, meeting the 870 kg weight limit was, Reinke admits, "a challenge as always."

A further part of the safety changes has been the revised, more upright seating position. Along with the new visibility templates, this is aimed to give the driver better view out of the cockpit. Before now the driver's view from a laid back driving position and narrow windscreen was limited and should now be increased. So should the Audi drivers' visibility at night, with the eight-element LED lighting system now augmented by the Laser Light system. On 'high beam' this system aims a powerful light at the corner's apex, the blue laser light being emitted behind a yellow phosphorus crystal lens. This provides a more natural low-glare light, that doesn't blind other drivers ahead.

Beyond that the drivers have an OLED CCTV-style rear view screen inside the cockpit and a revised steering wheel set up. The new wheel and dash layout are more ergonomic, to keep the driver's hands on the wheel. Down in the footwell there is no longer a clutch pedal, but paddles instead on the steering wheel.

READY FOR BATTLE

Despite not introducing a second energy recovery system, Audi has gone a long way in developing the R18 for this season. Whether this approach of focusing on reliability and underlying pace, rather than greater power gains, will be rewarded, largely depends on its rivals' success. At Silverstone, in the opening round of the World Endurance Championship, some of the answers started to become clearer. Le Mans looms... RT

DAVID VERSUS THE GOLIATHS

When we think of LMP1, it means Audi, Porsche and Toyota but doing so is to ignore perhaps the most enigmatic team in the pits, especially now it has a brand new car to its name. **William Kimberley** reports

WHILE Audi, Porsche and Toyota are the focus of attention in the new-look World Endurance Championship there is an independent team that has had the temerity to take them on to the extent of even commissioning its own car. While it will be racing in its own part of the championship, it will always have the works cars in its sights.

The company tasked with designing, developing and producing the R-One for the Anglo-Swiss Rebellion Racing team is ORECA, which is no stranger to producing cars for Le Mans. However, it has been some years since it set out to produce one for the LMP1 class.

The project began at the end of April last year when Alexander Pesci, Rebellion Racing's team principal approached ORECA to build a LMP1 car for the new regulations that were coming into force this year.

"While our design was a clean sheet, we had already done an LMP1 study four years ago," says David Floury, ORECA's technical director, "so we already had some conceptual ideas, but to be honest, there was very little carried over from then into the new car. It was a question of very carefully reading the rulebook and bringing everything together as efficiently as possible as time was short."

The essential thing, says Floury, was to have clear targets from the outset of the project, and to stick to them as the project progressed. However, one of the constraints was the budget as Rebellion Racing is a private team with obvious limited funding compared to the mega bucks spent by the factory teams.

"It was an enormous challenge for us," says Floury, "because producing such a car in less than 12 months was a big undertaking. If you compare what we did to the big manufacturers who typically take 18 to 24 months to produce their cars, along with all the people they have at their disposal, I think it is quite an achievement in what Rebellion Racing and we have done. Special thanks must go to Christophe Guibbal, the

Rebellion R-One suppliers

Brakes:	Brembo
Clutch:	AP Racing
Power steering:	KYB
Dampers:	PKM
Fuel cell:	ATL
Electronics:	Cosworth
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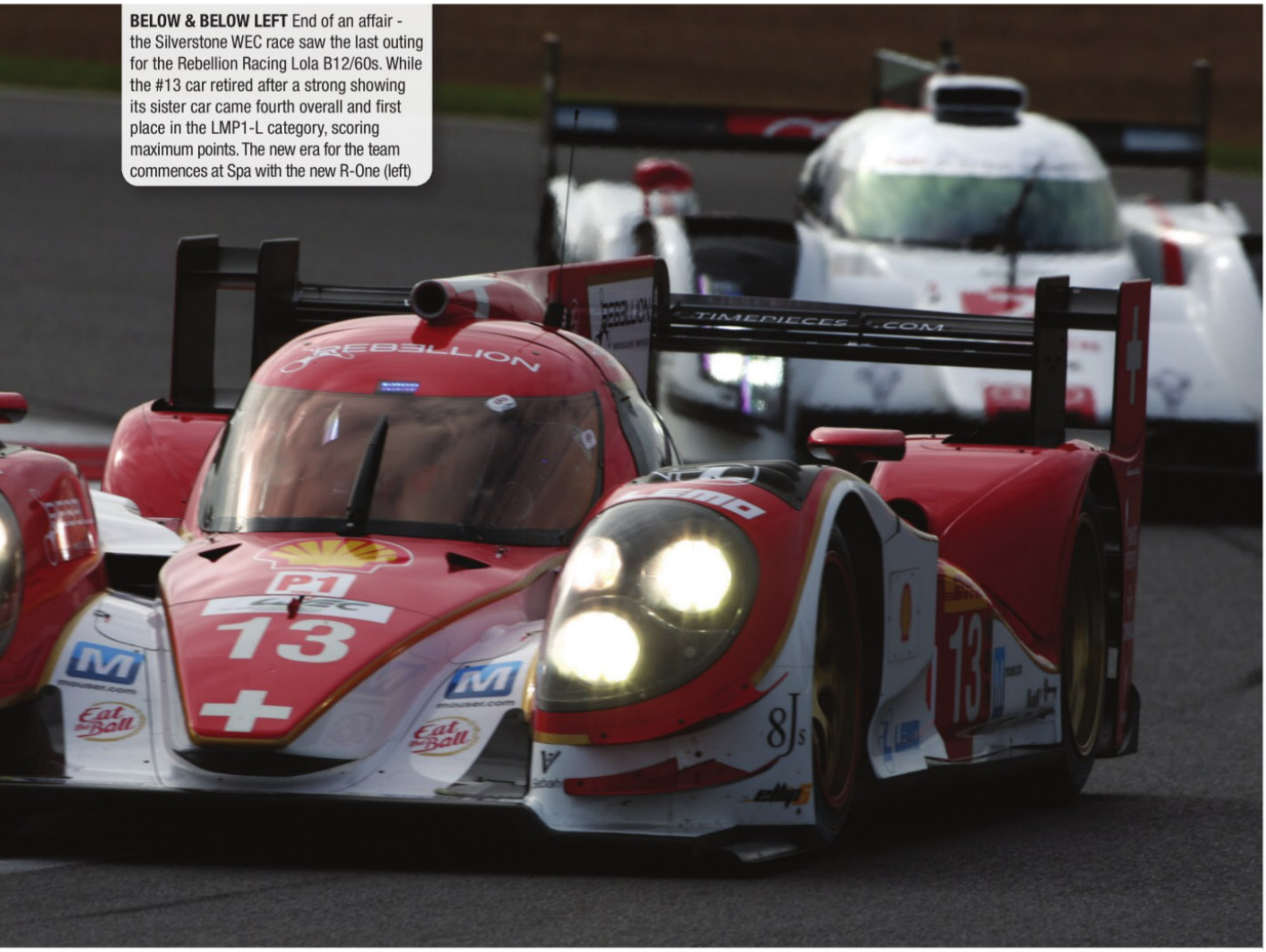


BELOW & BELOW LEFT End of an affair - the Silverstone WEC race saw the last outing for the Rebellion Racing Lola B12/60s. While the #13 car retired after a strong showing its sister car came fourth overall and first place in the LMP1-L category, scoring maximum points. The new era for the team commences at Spa with the new R-One (left)

project leader and head of design at ORECA, and his team for the incredible job they did along with the Rebellion mechanics led by Garry Richardson."

After reading the rulebook, the first stage for ORECA was doing a great deal of simulation. "It was important that we kept an open mind at this stage to decide what the targets should be."

While it has been the powertrain that has changed most radically in the 2014 regulations, the entire car has undergone sweeping changes. While they may look the same as last year – as the FIA wanted – there have been changes to the width, the car being 10cm narrower, the height of the cockpit and several safety features that have had to be incorporated.

"We initially focused on a low downforce package as that is what is needed for Le Mans and while not ideal for Spa, the penalty for doing so isn't that great, but then with a gap to September for the next WEC race, we can develop a few more bits and pieces to suit the following tracks we'll be visiting. From the outset we've designed the bodywork to accommodate different packages as the aim is to make it easy to adapt to each circuit we visit."

RELYING ON CFD

One of the things about ORECA is that is does not use wind tunnels but relies entirely on its CFD capabilities. "We have used Star CCM+ for quite a long time and have built up an expertise in that area while the software itself has also evolved. We have done a great deal of correlation between our simulation and track data to the point that we only need to do CFD. However, if our resources were greater then for sure we would do some wind tunnel testing. With limited resources, though, CFD is a far more efficient tool."

This also applies to other tools that a factory team would automatically use but which are a luxury for privately funded teams, so things like K&C testing were not considered. "While putting a car on such a rig is a good idea, it can lead to a complete re-design if the figures do not correlate, so it means that we had to try and get the design right first time. It meant that we do quite a lot of calculation of the components to ensure that we do get everything right first time."

Floury was determined that the car should go through the homologation tests at first attempt as time was tight as was the budget, so there was no room to manoeuvre. What added to the burden were the new safety features that the new car had to incorporate ▶

to comply with the 2014 rules.

"As a private manufacturer there is a lot of cost implication which wasn't totally foreseen because not all the rules were in force when we started the project, so it's been quite tough. However, the good news is that we succeeded passing all the tests which was quite a relief because on such a tight schedule and budget having to redo them could have been a real setback."

THE POWERTRAIN OPTION

As with the Lola that the team has been running in LMP1 up to Silverstone, the R-One will be powered by the Toyota V8, a decision made quite early in the process as it was one that ORECA knows very well and considered to be well proven. "When you start such a project, and you look around, there is much talk of great engines available. However, when you really investigate it, you soon find out that not many have actually run on the dyno, so the Toyota V8 was a logical choice for many reasons. It's proven and available which when you are on a very tight schedule means that you can focus on the car's development rather than spending time sorting out any different issues on the engine. It's also quite a good customer one as it's efficient and light and is a really good package.

"Also to take into consideration was the fact that the Rebellion Racing team and Toyota have been partners for quite a long time so there is a strong relationship between the team and the engine people while we at ORECA have a strong relationship with TMG."

While all the pre-season talk was about the fuel flow sensor, Floury takes a sanguine view. "It's not necessarily an easy situation with the fuel flow sensor, but it's like everything when you try to innovate as it's not always easygoing at the outset. However, I don't think you can develop these fuel efficiency regulations without this kind of technology. For sure there is some development to do but I think it's all part of the challenge and it's pretty exciting to have these new regulations in place. I think it's pretty good seeing that the cars are doing similar speeds to last year but using 35 per cent less fuel. It's really quite a great achievement."

While the R-One uses an Xtrac gearbox, it is far from an off-the-shelf item as Floury explains."We have a very strong relationship with Xtrac and have worked with them to develop a brand new gearbox that will become available to other customers. It's also ready for hybridisation in the future. We worked very closely with Xtrac on this and they've done a brilliant job and we are quite happy with the results."

While Xtrac works very closely with the factory teams, as it has done for years, it has always produced a customer LMP1 gearbox, although that is currently a pretty small market. However, it has not stopped the company from developing the P1159 gearbox that has been specifically designed for the 2014 LMP1 regulations. Based on the very successful series of P164, P229, P529 & P1059 gearboxes, it can trace its origins back to the Le Mans winning BMW of 1999 and winning Bentley of 2003.

This 7-speed transverse gearbox has a sequential gearchange system operated by either a conventional pnuematic shift cylinder, MegaLine's new direct drive e-motor or MegaLine and Xtrac's new P1154 integrated valve actuator (IVA) gearchange. In a reduced specification version the gearbox is also suitable as a 6-speed box for LMP2.

"We originally began looking at a new gearbox to comply with the 2014 regulations in 2012," says Adrian Moore, Xtrac's technical director. "We have a very longstanding relationship with ORECA and have supplied the gearboxes for its LMP2 and LMPC cars, which are very successful in particular in the US, so when they won the Rebellion Racing contract to develop ▶

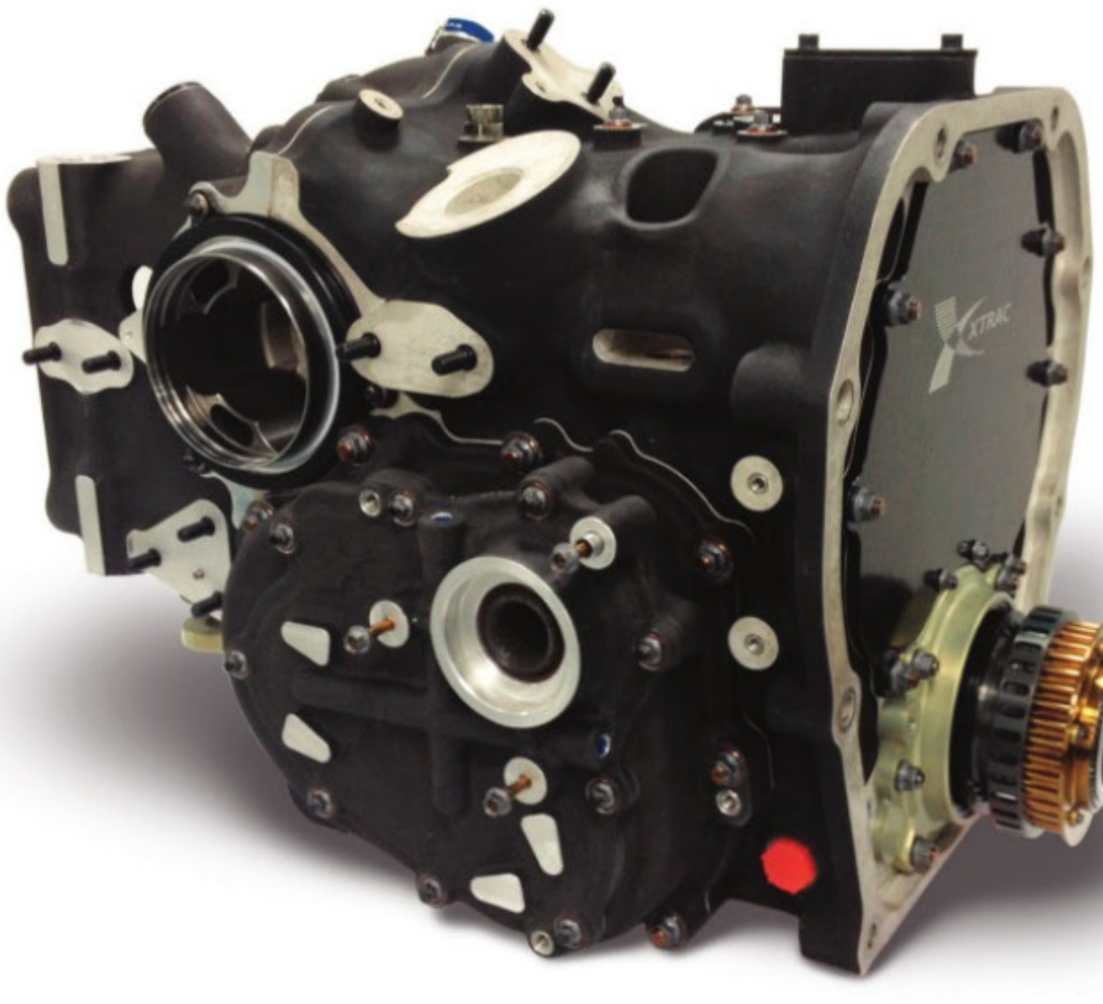
BELOW The R-One, seen here in a test session at Paul Ricard a few days after the Silverstone race, is really very distinctive

and build the R-One, they became the launch customer for the 1159 gearbox. Apart from being optimised to suit this car, it also meant that they could get involved in certain aspects of the specification such as the suspension pick-up points, although that is not to say that it couldn't suit other cars as well.

"It's also specifically designed to pass all the crash regulations, including the rear impact tests that are new for 2014 which it successfully achieved. It has also been designed so that is can be used as a 6-speed box in LMP2. If the FIA ever instigates rear impact tests for LMP2, then this gearbox is uniquely ready."

It has also been package protected for LMP1-H with a hybrid system should it be required in the future. "It means that there is a gear drive input system on the front of the gearbox that isn't physically on the R-One gearbox as it doesn't need to be, but it's been designed and ready to go on when necessary. It means that we can mount an electric motor in the gearbox. The oil system, the gear system, the gearing, the ratios – everything – has been designed to allow that to happen."

As a result of Xtrac working with Tata Steels, formerly Corus Engineering Steels, over very many years, it has developed a range of ultra high-strength steels with XM023 being found for some of the most highly loaded parts in the P1159 gearbox. "It was originally developed in Formula One by us but because it's this is a customer gearbox it does also feature our slightly more conventional high-specification material XVAR1."



Gearbox Specification

- 820Nm (590lbf ft) maximum engine input torque (depending on specification).
- 1st and 2nd layshaft gears are integral, 3rd to 7th are slide on with a wide range of available ratios.
- Gearbox casing material is magnesium RZ5 and all casting joint faces have 'O'-ring seals.
- Rear cover to suit 2014 LMP1 regulation compliant rear impact structure (RIS) loads.
- Tether mounts to suit 2014 LMP1 regulations.
- Differential is a limited slip plate type with a choice of settings and externally adjustable pre-load.
- Straight cut gear ground final drive. 13:46 to 19:39 are available as standard.
- Clutch shaft to suit customer installation is included.
- Full form ground Klingelnberg input bevel set.
- Xtrac manufactured output flanges are included to suit 38mm diameter roller size Tripode joints.
- Lubrication is via recirculation lubrication pump or optional three stage dry sump oil system.
- Most components are manufactured in Xtrac's own grade of steel (X36C). Bevel sets, final drives and pinions are manufactured in Xtrac's vacuum melted steel (XVAR1), using the post heat treatment gear grinding or hard cutting process for greater accuracy and longer life. Highly stressed components are shot peened. Xtrac's ultra high specification steel XM023 is used for gear ratios.
- Gearbox weight: 66kg (145.5lb) (dependent on specification).

The gearbox offers the following benefits

- Light, positive gearchange with polynomial barrel tracks.
- Dedicated suspension and rocker post detail.
- Quick change gear ratios.
- Cost-effective, reliable solution
- Gear ground and super polished ratios (Xtrem process).
- 2014 LMP1 rear crash, side push off and tether load regulation compliant.

Options summary

- Casing material in aluminium L169.
- Xtrac Viscous Combined Plate (VCP) with a choice of settings.
- Alternator drive and mounting.
- Assisted gearchange system (AGS).
- Bellhousing.
- 6 speed gear cluster.

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WOULD BOLT KEEP HIS BALANCE?

Photo: Nissan

ABOVE He's the fastest man on the planet and loves quick cars. Nor, you suspect, would it take Usain Bolt very long to object if motorsport's 'Balance of Performance' rules were applied to athletics!

If 'Balance of Performance' restrictions were applied to other sports, they would be considered a joke. So why, asks **Chris Ellis**, do we have them in motorsport?

THE International Association of Athletics Federations recently announced a new regulation for the 100-metre sprint at the forthcoming 2015 World Athletics Championships in Beijing. Each athlete must wear a belt containing weights which will be inversely proportional to their position in the heats.

To prevent hanging back, anyone failing to cover the 100 metres in less than 9.8 seconds will be disqualified. The IAAF explained that it wanted to make the races more exciting by balancing the performance of the athletes. Usain Bolt was not available for public comment…

Of course, the paragraphs above are complete nonsense (think April 1), but what is actually happening in some parts of motorsport is almost as absurd and unsporting. Yes, it's the so-called 'Balance of Performance' regulations that are loathed by most participants and hidden from most spectators.

Arguably this is at its worst in Formula One, where the technical regulations are now so detailed and restrictive that clauses to penalise cars with a performance edge aren't needed! As just one example, engine bore size must now be 80 mm, no more and no less. So this effectively fixes the stroke and the valve sizes as well as most of the crankshaft dimensions. Which then means the exhaust and inlet manifolds and the rest of the engine will be similar across all the cars. So effectively a committee in the FIA has designed a standard engine, and the manufacturers just need to build slightly different versions of it.

Now think of the massive waste of talented engineers' time spent on trying to squeeze the last bit of fuel efficiency from an engine where they have almost no room to innovate. If the FIA is going to insist on imposing an essentially inferior design, can we please have a single engine manufacturer, and stop pretending we have anything better? And save a lot of money? Or, more sensibly, make the engine

Photo: WEC

regulations much more flexible, and let some of our most innovative engineers prove what the best engine configuration is. This is now the case with the latest Le Mans regulations, so why not Formula One?

In general, the 2014 Technical Regulations for Le Mans and the World Endurance Championship are a definite improvement. For example, regenerative braking can now reach its full potential because it can be applied to all four wheels, in and out. However, there is one obvious peculiarity, the FIA's 'punishing of the virtuous' with the fuel flow limits imposed on the LMP1-Hybrids.

In 1791, the Marquis de Sade published his novel, *Justine*, or *The misfortunes of Virtue*. Apparently the idea lives on, because the FIA has added a sadistic twist to the latest regulations covering energy recovery in the WEC. Appendix B of the Technical Regulations basically says that the more successfully a car recovers energy, the less fuel it may use. A simplified version of the appendix is shown at the top of this page. The main problem is the reduction in maximum fuel flow for the most efficient cars.

Let's run a 'sanity check' on the 'balance' set by the FIA between the fuel energy allowed per lap and the amount of recovered energy that can be used. Appendix B of the Le Mans 2014 Technical Regulations states that the 'petrol energy' allowed per lap for cars without energy recovery is 157.2 MJ, while only 138.0 MJ is permitted for those cars returning the maximum allowed 8 MJ of recovered energy.

APPENDIX B LE MANS 2014 LMP1 FUEL FLOW LIMITS

Releasable Energy	MJ/lap	<2	<4	<6	<8
Max Petrol Flow	kg/hour	94.3	91.9	89.5	88.5

Non-hybrid LMP1-Ls are allowed 100.9 kg/hr, 14% more than a '<8'. At other circuits, the releasable energy limits are raised by 1.11 times the *relative* length of the track. For example, max releasable at Silverstone will be 5.36 MJ per lap

> ***"From a technical perspective, the World Endurance Championship has become the pinnacle of motorsport"***

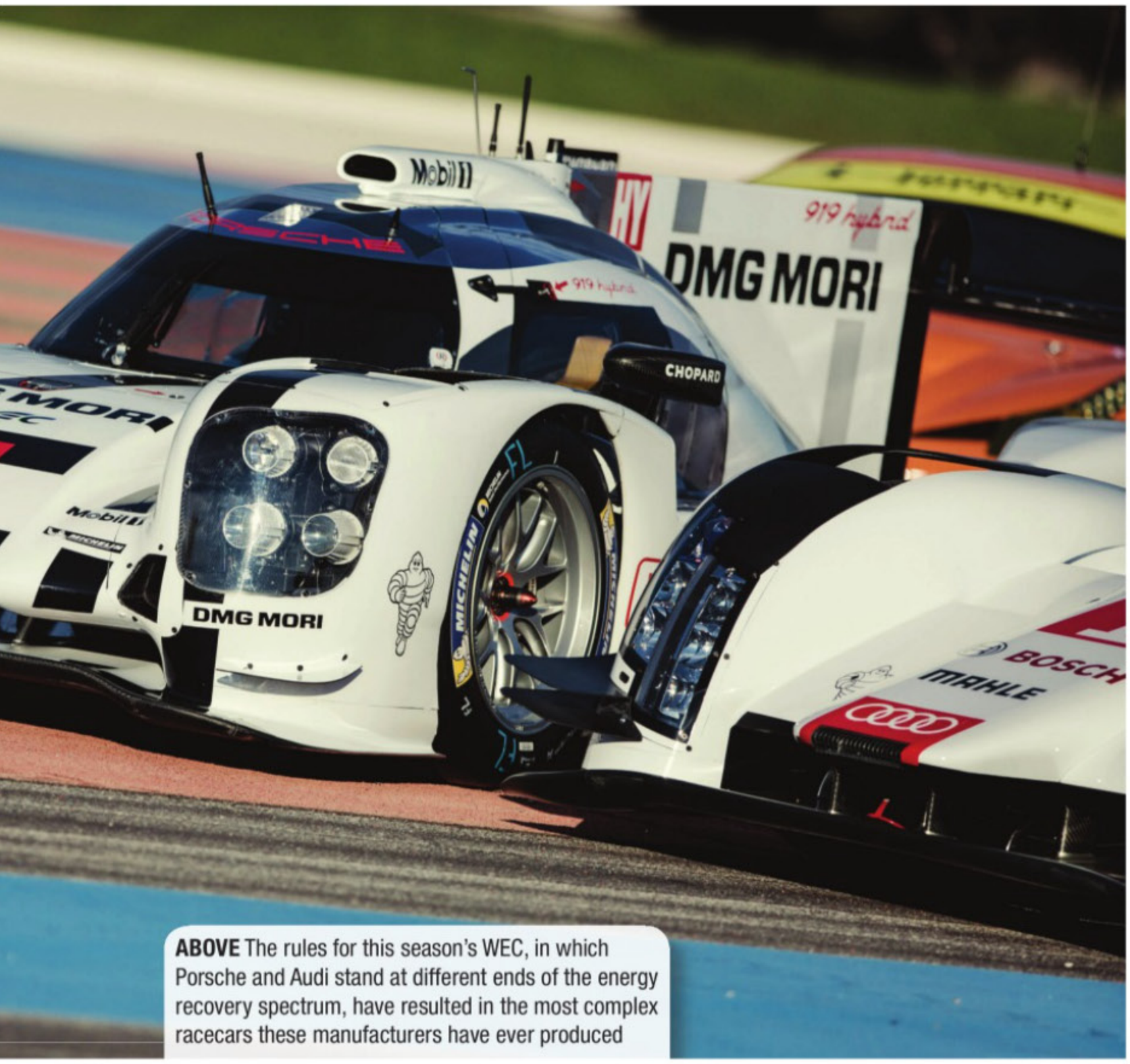
Of course, the 19.2 MJ per lap difference in fuel allocation is the total energy in the fuel, before conversion into mechanical energy and waste heat, etc. For a non-hybrid to get the equivalent 8 MJ from its extra petrol will require an engine efficiency of almost 42%. Consequently a hybrid LMP1 should have a slight lap-time advantage, but only slight, because it has to be heavier. Of course, a non-hybrid will have to refuel more often, but it can 'afford' a faster top speed, when required.

So there is a *slight* advantage from adding all that expensive energy recovery technology to an LMP1, but for some reason the FIA has chosen to make it so small that it will probably make all but the richest and most PR-focused teams stick to non-hybrids. One possible reason for imposing this 'balance-of-performance' constraint might be: 'forget real motor racing – this is about entertainment and spectacle. The last thing we want is someone out in front and pulling away!'

Or is it simply the 'tall poppy' syndrome yet again, perfected over 200 years ago in Paris? It certainly doesn't make any logical sense, or political/PR sense, because almost no one would dispute the positive societal value of energy recovery and its relevance, now that there are millions of hybrid road cars. So what could possibly be the rationale behind setting a limit on its use in racing? It must be an indirect reason, given the strong and obvious arguments for maximising its use.

Perhaps there is a fear in the FIA that no limits would allow the richest teams to buy their way to victory (as usual?), and that limiting the technology is easier to impose than capping the money. It can't be a concern over excessive performance, because top speed is still mainly a function of peak engine power, not ERS power, and this is now limited by fuel flow control. Acceleration will be improved, but it will still be significantly less than in F1, given the difference in weight limits.

It could be the wretched precautionary principle, so beloved by bureaucrats who don't understand the technologies they delude themselves they 'manage.' But that can't be the case in the FIA, where they *do* know what they are doing. Maybe the 8 MJ ▶



ABOVE The rules for this season's WEC, in which Porsche and Audi stand at different ends of the energy recovery spectrum, have resulted in the most complex racecars these manufacturers have ever produced

limit is a sensible upper bound for the first year, but it had better be raised substantially for 2015 or we really will have a ridiculous constraint on innovation.

Perhaps the FIA thinks it needs to demonstrate its measures are reducing the fuel consumption of racing cars, but this is probably only of real interest to the bureaucrats in Brussels and Washington, who are paid to understand Appendix B and the other indicators, and should be satisfied with them. The actual fuel consumption figures achieved at Le Mans, and in F1, will only improve from 'very bad' to 'bad' relative to those of high-performance road cars, so will not (and should not!) be bandied around. But this doesn't matter, because the car-buying public already knows that hybrids save fuel.

The real PR objective of racing hybrids against non-hybrids is to demonstrate that hybrids can provide both performance and economy, unlike the first generation of hybrids. There is no one 'perfect' solution, and no common requirement; most car buyers will choose hybrids that favour economy over performance while others will want offerings that provide economy most of the time, but with real performance available when needed. The potential buyers of 'performance hybrids' are the target audience for the WEC and Le Mans.

The economy argument in favour of road hybrids is already widely accepted. The next few years will prove the 'economical performance' case, with evidence provided by cars such as the McLaren P1, Porsche 918 and La Ferrari, and reinforced by the LMP1-Hs of the WEC. The key message is they are more economical than equivalent non-hybrids at normal road speeds (obviously!) and faster than them round any track, from the Nordschleife downwards. A suggestion: to simplify matters a little for spectators, why doesn't the FIA simply reserve the LMP1 category for hybrids in 2015, and let LMP2 be the class for non-hybrids?

It's the fuel consumption of the cars sitting outside the homes of the many millions of TV viewers that really, really matters. Everything else is relatively trivial. The societal objective of F1 and WEC should be to help convince their massive global audiences that hybrids are the way ahead.

The apparent message that the FIA balancing of performance will be sending this year to the majority of followers of the World Endurance Championship and Le Mans is that hybrids deliver only a small performance advantage over almost-identical non-hybrids. Only a tiny percentage of the world audience will know that, with a small change to the software of the hybrids' fuel flow meters, they would be able to out-accelerate the non-hybrids and match their top speeds. Why would the FIA want to hide the fact that hybrids deliver better performance on a 'level racetrack?' Don't ask me!

IN THE NAME OF ENTERTAINMENT

The usual reason given for 'Balance of Performance' regulations is to make the racing closer and presumably more entertaining. Technical measures are introduced which are intended to make the lap times of all the competing cars almost identical. But think for a moment. Is the 100 metres most entertaining when there are four or five runners in a photo finish? No, we hope to watch a couple of great runners battle it out in front over the last 30 metres, and see one of them set a new record. And does anyone object when the winner of the marathon enters the stadium alone? No, they cheer like crazy!

In motor racing, there is another reason why most insiders despise 'Balance of Performance' and what it represents. Effectively, it's a message to all the engineers and mechanics that, no matter how inventive, competent and hard-working they are, they're wasting ▶

BELOW The Balance of Performance often masks the true speed of GT racecars

Photo: WEC

their time and money trying to make their cars faster. Which is ethically wrong, in an allegedly *competitive* sport. George Orwell said that sport is 'war without the bullets', and motor racing certainly is. Now imagine an archangel saying to Sir Hugh Dowding, 'You can't use radar, because the Germans haven't got it yet…' Farcical.

There is also the problem of ensuring Balance of Performance works properly. If the balancing measures haven't been set correctly, the complaints will be loud, and there will be suggestions of hidden agendas. That much was underlined by the first TUDOR United SportsCar Championship race at Daytona, where the unification of sportscar racing's warring factions was overshadowed by a big gap in performance between the Daytona Prototypes and the LMP2s. Consequently IMSA introduced significant changes in time for the second race at Sebring, with more likely to follow.

see the controversy now being played out not just at Le Mans but in the streets of Paris, with the recent serious air pollution being blamed on diesel cars.

France has an abnormally high diesel-car population, brought about by a lower level of tax on diesel fuel. It has been alleged that this was done to ward off competition from Japanese manufacturers. Now, at last, there is an acknowledgement by the French authorities that this was a big mistake. It will be fascinating to see how long it takes the FIA to realise the party line has changed. It will also be interesting to see, in perhaps 20 years time, the full impact on the health of the French people.

As an example of how far off-track some categories of road-car racing have got, take a look at the table below, which shows the BoP parameters in LMGTE last year, for some of the cars.

A smart 12-year-old would take less than 20 seconds to work out that the Ferrari must

BALANCE OF PERFORMANCE LM GTE

	Weight kg	Restrictor mm	Fuel tank litres	Wing/roof gap mm	Gurney flap mm
Aston Martin Vantage	1,215	29.7	95	0	15
Corvette C6.R	1,250	29.2	90	25	25
Ferrari 458	1,235	28.3	85	100	25
Porsche 997 GT3 RSR	1,215	29.6	90	0	25

Consider a knowledgeable spectator's reaction watching a WEC race where BoP has been applied to the racing versions of several different GT road cars, so that the relatively slow cars now appear as fast as the quickest cars in their category. It's not F1, so he is here to watch the cars race, not the drivers. He probably can't name more than 10 of the drivers, and he doesn't know which driver in each team is actually driving which car. It's about the *cars*!

But the cars don't seem to be racing, just taking part in a high-speed parade! Creeping into his mind may be the suspicion that the race is probably fixed, because the BoP 'levers' offer regulators an opportunity that some of them may not be able to resist.

Anyone who has watched, over the years, the efforts to ensure a diesel-engined car would eventually win Le Mans will be suspicious of all attempts to introduce BoP. It masquerades as 'fairness' but usually ends up being anti-competitive.

The diesel hegemony on the racetrack has caused no end of wrangling between the gasoline and diesel factions. It's interesting to

be the fastest car in the real world, before the application of any BoP. So the answer to the key question – 'which car is fastest?' – has already been answered by the FIA well before the cars fire up, in the BoP table! Then what's the point of watching them race? Let's go to the beach!

EXHAUST ENERGY RECOVERY?

In F1, the current (pi) limits on kinetic energy recovery have deliberately been set to ensure exhaust energy recovery must be implemented to make a car fully competitive. This despite EER being almost impossible to cost justify on a road car unless most of its mileage is spent cruising at over 100 mph. 'Fat chance, even in Germany!' I hear you mutter. EER is on some big trucks, but not a single car model. If it made economic sense, we would have seen it on a turbogenerator version of the Prius years ago.

The FIA is correct to suggest there is valuable exhaust energy going to waste from a racing engine averaging 400 kW, say. If 5% of that can be recovered, it effectively increases the


Photo: Tee/LAT

power from the engine to 420 kW, a race-winning advantage. Recovering roughly 6 MJ/lap, it will approach the 8 MJ limit without any help from regenerative braking. Sounds great, and on a road car cruising at a near-legal speed on a highway, a 5% reduction in fuel consumption looks tempting, but only if most of your miles are at high speed. Again, if exhaust energy recovery could be cost-justified on road cars, we would have it already…

In assessing possible LMP1 designs capable of responding fully to the new regulations, we came up with an approach which avoids the cost and complications of implementing exhaust energy recovery. What follows is a high-level description of the thinking behind the design of the car's energy recovery system.

For most cars, kinetic energy recovery is the most rewarding source of energy, and this is particularly true of racing cars. The new WEC regulation allowing regenerative braking on both axles increases the energy potentially recoverable by at least 50%. As an example, assume a peak motor/generator power of 150 kW at the rear and 200 kW at the front, for both braking and acceleration. If the engine peaks at 500 bhp, the total power available for acceleration will be over 960 bhp, or close to

ABOVE & BELOW F1 monopolises the headlines but its restrictive regulations mean the WEC (these are Audi's homologation forms below) is a more likely nursery for road-relevant innovation

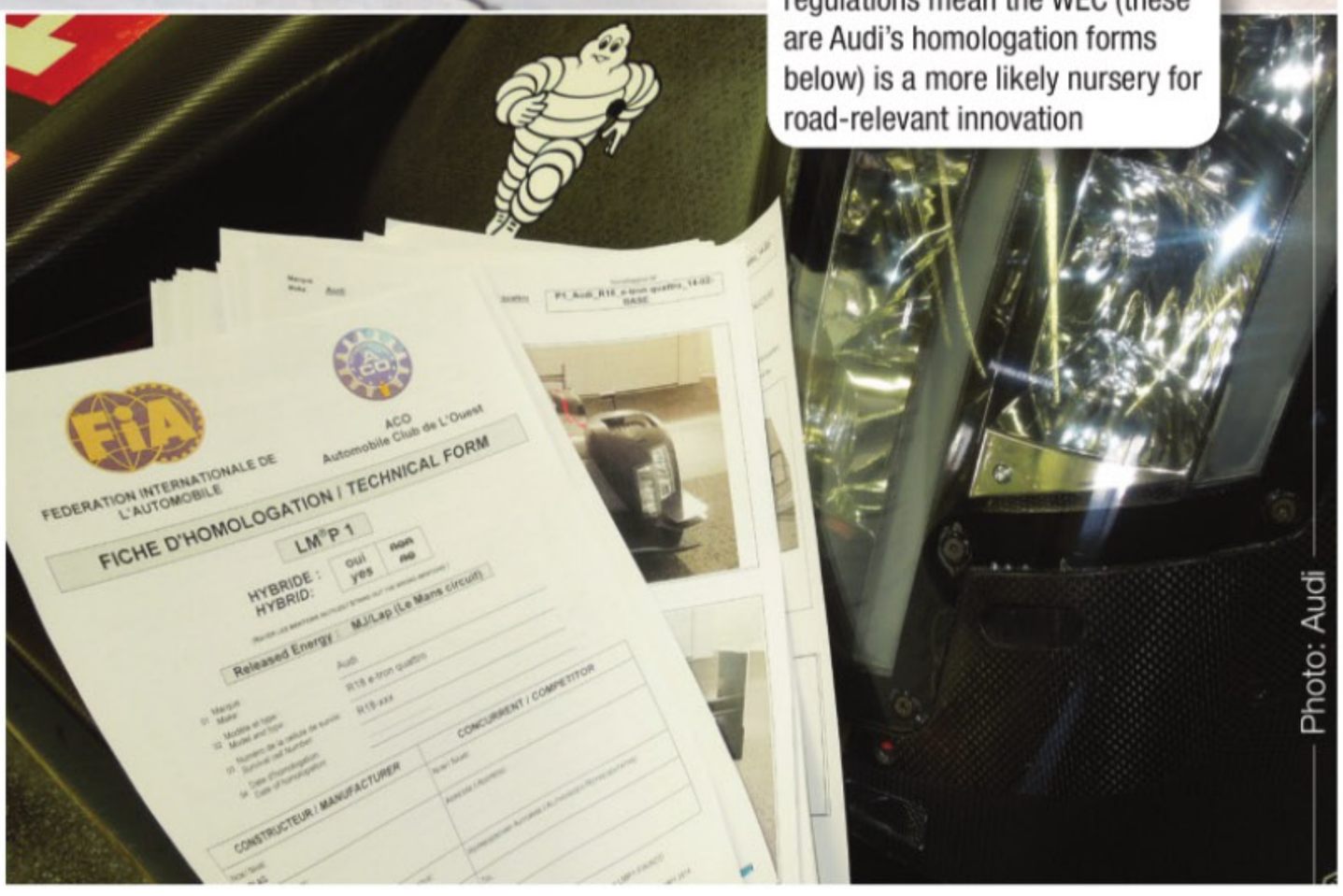


Photo: Audi

1,000 bhp per ton. Adequate, then.

If the regenerative braking system is at least 60% efficient there is sufficient total braking time round a complete lap of the Sarthe circuit to recover all of the energy the car is permitted to release from its ERS each lap. So there is *no* need for an exhaust energy recovery system and its cost, complexity, weight and plumbing. At least, not until the innovation-limiting 8 MJ limit is lifted.

Interestingly, Audi announced in March that it had initially intended using exhaust energy recovery but that testing had revealed that the net benefit didn't justify the potential risk to reliability, so the Audi LMP1s will run with just kinetic energy recovery this year. Presumably Audi's decision was also influenced by the logic set out above, and the cars will run with the 2 MJ/lap limit.

However, Porsche, also part of the VW Group, will adopt the 6 MJ level. Is this VW exploring both ends of the spectrum, because it can't see yet where the optimum is either, under these weird regulations? Of course, in the real world there is no limit, and 10 seconds of an extra 400 kW will be more than enough to demonstrate dominance.

The latest over-regulation of the engines in Formula One could have demolished the traditional defence of motor racing that it leads to innovations for road cars. Fortunately, the minimal constraints in the WEC regulations are likely to generate some novel solutions in pursuit of low specific fuel consumption.

For example, the Porsche 919 LMP1 has a V4 engine, to reduce friction. There will be no surprise if a road version of this engine finds its way into a hot variant of the 911 (Turbo-Electric?), with the precedent of the four-cylinder 912 back in 1965. This will help confirm that the principal societal justification for motorsport, the flow of innovation from track to road, is still valid.

A more radical innovation may be the use of five strokes rather than four. The idea of a 5-stroke engine is not new, but the focused need to reduce specific fuel consumption now makes it very attractive. What is a 5-stroke engine? For Le Mans, imagine a V6 with two conventional cylinders per bank, with an expansion cylinder between them. The novelty is that there is no combustion in the middle cylinder of each bank because the exhaust gases from each combustion cylinder are fed directly into the middle expansion cylinder, where additional work is done, yielding higher efficiency.

It should be possible to achieve 215 g/kWh or better on petrol, which destroys the case for diesel. So big trucks running on natural gas in 5-stroke engines may become the new norm, and all because of motorsport! Well done, FIA! For more details see: http://www.ilmor.co.uk/capabilities/5-stroke-engine

PINNACLE OF MOTORSPORT

From a technical perspective, the World Endurance Championship has become the pinnacle of motorsport. Formula One is now just 'full of sound and fury, signifying nothing' because its over-tight regulations prevent it from being the nursery for road-relevant innovation. Fortunately, the FIA has had the sense to balance the very restrictive F1 regulations with progressive rules for Le Mans and the WEC. Is this Balance-of-Regulations? RT

BELOW Electricity features everywhere in motorsport from fuel injectors to rain lights

A SPARK OF INSPIRATION

Chris Pickering looks at some of the latest developments in motorsport wiring harnesses

ELECTRICITY can be a wonderful thing. The odd soapbox aside, there isn't a racecar on the planet that isn't utterly dependent on it in some way. From the most basic spark ignition to the modern plethora of control units, actuators and monitoring systems, electricity is the lifeblood of a competition car. And that means it's vital to maintain the flow - not always an easy thing to do when the circulatory system in question is subject can be subject to a vicious combination of vibration, heat and electrical interference.

Fortunately a small army of businesses has built up around exactly that, providing the wiring and connector solutions needed to reliably and effectively deliver current where it counts. This month, we speak to a selection of these companies to get their views on the latest challenges and opportunities presented by motorsport wiring.


Photo: Coates/LAT

Deutsch

It's all change for 2014. The new powertrain regulations in Formula One and the LMP1 class of the World Endurance Championship have given a real boost to the development of wiring systems. "Anything with batteries and more electronic monitoring seems to require new connectors," observes Paul Webb, autosport sales and marketing manager for Deutsch.

For Deutsch, this has meant a surge in interest in the company's six-way ASX connector. Released last year, it proved a hit with teams in F1 and the WEC as the 2014 cars entered production. The demand appears to have been driven by the use of more sensor hardware on the cars, Webb explains. And he believes this has its roots in some of the recent cost control measures: "If you only have a certain number of lifed components to last you for a season then you really need to know what's going on with those particular units. The advantage with the six-way is it allows you to accommodate two sets of power, signal and ground pins, so you've got redundancy or you can run two sensors via the same connector."

The ASX-series has introduced several new features. For a start, while its predecessor the ASU relied on deformable rubber parts to hold the connector in place, the ASX uses a more tactile mechanical system. The coupling rings on the connector now require a twist over a ridge to click into position.

"We've been getting really good feedback from the teams who are using the ASX," comments Webb. "The mechanics really like the fact you get a positive click that you can hear and feel. It's possible to fit the plug into the receptacle completely blind - you can feel when the connector has clicked into position."

The ASX six-way is said to be the smallest and lightest connector of type. Each half weighs around 1.7 g and there's something in the order of 50 mated pairs in a typical 2014 Formula One car.

Like all Deutsch connectors, the contacts are made from a copper-nickel alloy with a gold plating. Webb believes this to be the most durable option under harsh conditions, but the company's R&D department has been investigating other options. "A while back we looked into brass, which is potentially cheaper to manufacture, but the contacts just didn't stand up to the same conditions," he comments.

Another trademark touch is the use of a unique fluro silicon material for the rubbers that provide the front and rear seals for the connectors. Mixed in-house using a proprietary recipe, the material is designed to produce the best possible resistance to substances like oil and brake fluid.

The connectors themselves are conductive, which means they can be fully screened against electrical interference if the wiring manufacturer is using braded wires. All it requires is a piece of heat shrink or a metal strap to connect the braiding to the outside of the connector. The downside, however, is that the braded wire adds extra weight, so it tends to be used sparingly in motorsport applications. "Braided wiring has been around for many years now, but it fell out of favour in last decade due to weight," explains Webb. "Since the introduction of KERS to Formula One we're starting to see it coming back a bit, though. NASCAR teams also use it for the crank sensor wiring on their engine looms." ▶

DC Electronics

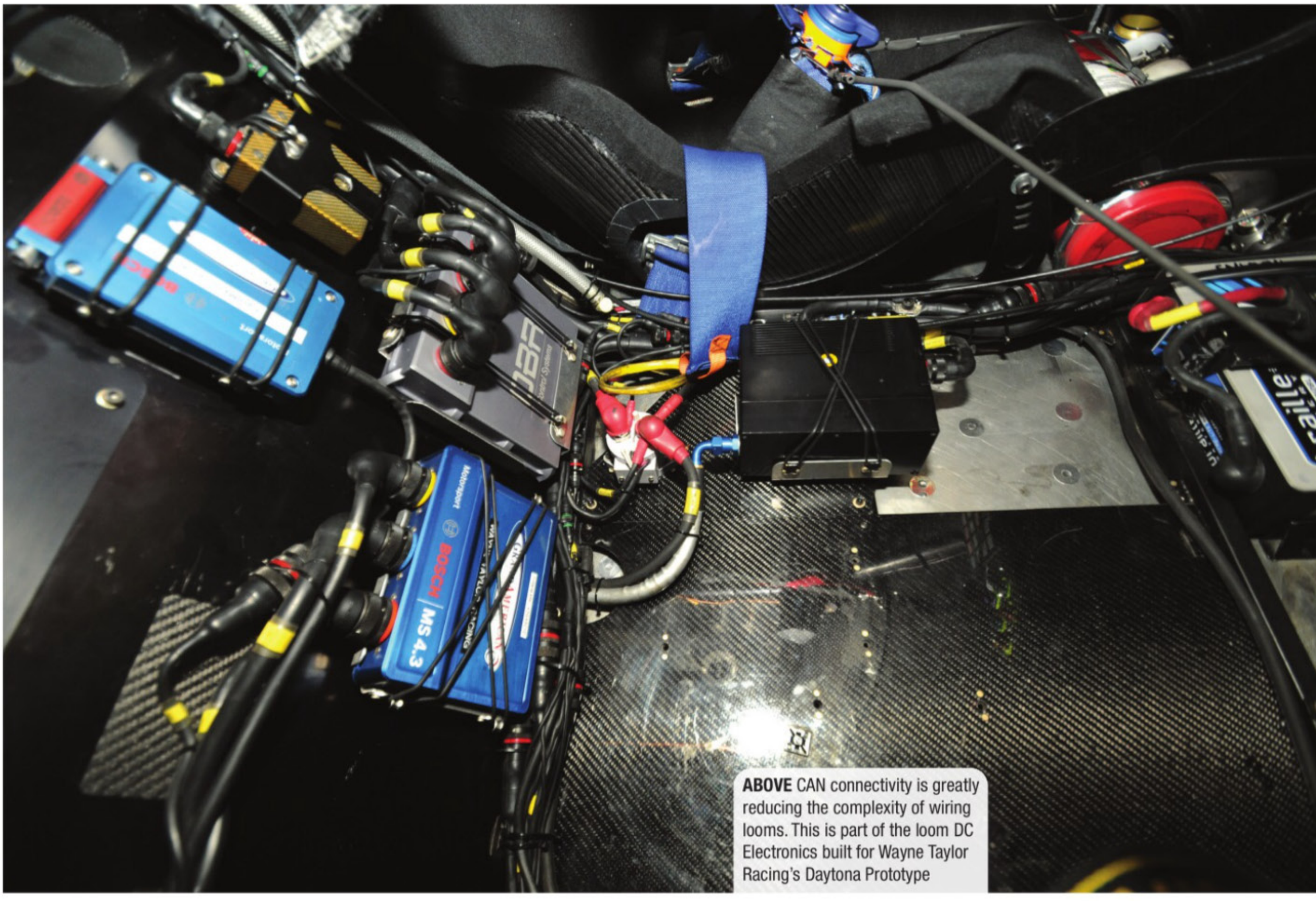
Across the motorsport wiring industry the trend continues toward weight reduction. And in most instances this is being achieved by the adoption of solid state power distribution systems and remote data acquisition data nodes reporting back to a central logger. Both concepts rely heavily on CAN bus technology, meaning the modern racecar is becoming more and more CAN-dependent, with intelligent devices being added to the network as required.

One of the advantages of this approach is that sensors and wiring harnesses can be added to the network as required, explains David Cunliffe, managing director of DC Electronics: "If you need to add temporary hardware to the car for testing, such as ride height or aero sensors, then it's possible to remove it from the loom come race day. This means the team gets the lightest possible harness and doesn't need to carry the weight of additional wiring."

The new 2014 Formula One rules have shown some of the limitations in traditional harness design when you add the two ERS (energy recovery) systems into the mix. "These motor/generator units can switch from delivering current in one direction when the car is under maximum acceleration to harvesting power under braking for storage at a moment's notice," explains Cunliffe. "The net result is a large power spike that can induce electro-magnetic interference into the wiring harnesses, which can show up as noise on certain data channels. Other issues coming to light have been the different engine vibration harmonics that can cause the premature failure of connectors if not suitably damped from vibration."

These new systems mean careful consideration must be given to the choice of cable, Cunliffe explains, such as shielding or the use of a twisted pair, and also ensuring a cable with a suitable dielectric strength is used to ensure the voltage cannot breakdown the cable's insulation.

Again, connectors are a factor. "As electronics become more and more reliable, the frequent Achilles heel for the electrical system is the OEM style plastic connectors chosen to mate the hardware with the wiring loom," comments Cunliffe. "These connectors are often chosen by the designer to give the racer a cost effective choice when investing in products for the race car. They're often mass produced with the sole intention of being mated to a car somewhere down the production line at the birth of a new model and never really designed to come apart again. We as racers are constantly pulling our vehicles apart to test, clean or repair meaning these connectors may repeatedly be pulled apart and over time wear sets in and the connection can become intermittent (often after less than 50 mating cycles!) Hardware designers are coming around to the fact that fitting a quality 'military' style harness and connector at the outset will actually give the product a much longer and more reliable lifespan on the track meaning the often perceived higher upfront cost is actually not as bad as it may seem." ▶



ABOVE CAN connectivity is greatly reducing the complexity of wiring looms. This is part of the loom DC Electronics built for Wayne Taylor Racing's Daytona Prototype

BELOW The new Souriau 8STA HD range of connectors combines high pin count with minimal size and weight

Lane Electronics and Souriau

Like their aerospace and military counterparts, motorsport connectors have to operate across an incredibly wide range of environmental conditions. Extremes of temperature, constant vibration and the presence of a wide variety of liquids come together to provide a stern test of the connector. At the same time, engineers are calling for increasingly complex harnesses fitted with connectors that are smaller and lighter, yet capable of offering more functionality. Higher currents, faster data speeds and more connections typically feature prominently on the list of requirements. It all adds up to a very demanding environment.

Souriau's latest entry into the market is the 8STA HD range of high density circular connectors. In this instance, high density refers to the number of contacts packaged within the compact shell of the connector, which Souriau claims is the smallest and lightest of its type currently available.

"The 8STA HD series provides up to 68 size-26 contacts using 24 to 30 AWG wire," explains Simon Hammerton, managing director of Lane Electronics, which is an assembling distributor for Souriau in the UK. "This allows a smaller shell size to be used for the same application saving both size and weight."

The 8STA HD range is derived from established military specifications MIL-DTL-38999 and JN1003. Each connector features a rugged aluminium body plated with conductive black zinc as standard. Seven shell sizes in seven layouts are available from size 02 to 14 and contacts are gold plated copper alloy with liquid silicone rubber insulators and seals.

Importantly, the new connectors are what Hammerton terms "scoop proof". This means the design prevents the pins from being bent or shorted during mating and incorporates a positive locking mechanism with locked colour indicators. They can handle 500 mating cycles, 300g shock for 3 ms and vibration levels to 147 m/s2, 10 to 2000 Hz. When mated, the connector meets the requirements of IP67 and can withstand salt spray and other motorsport fluids.

For space-saving, high density signal applications, Souriau has another solution. The microComp family is designed to provide a small, weight-saving crimpable miniature rectangular connector system, robust enough to withstand high vibration and shock levels, yet compatible with the latest high-speed data rates such as Gigabit Ethernet. "These connectors are up to 66 per cent lighter and up to 40 per cent smaller than traditional miniature rectangular connectors and are available with composite or aluminium shells," notes Hammerton.

The microComp connectors feature removable contacts for AWG 24 to 28 wires and the designs allow for panel and PCB mounting. Inside each example you'll find up to 104 contacts. Each is designed to withstand temperatures of up to 175°C and the male contacts are shrouded by the insulator to prevent them from being bent out of shape.

Of course, it's not just the design of the connector that's important. The motorsport industry can be legendarily demanding when it comes to component lead times and Lane Electronic's recent acquisition of bf1systems' connector arm has proved a considerable bonus, says Hammerton: "As an assembling distributor we have a virtually a limitless stock of parts needed to build the connectors as well as the facilities to assemble them on demand." ▶

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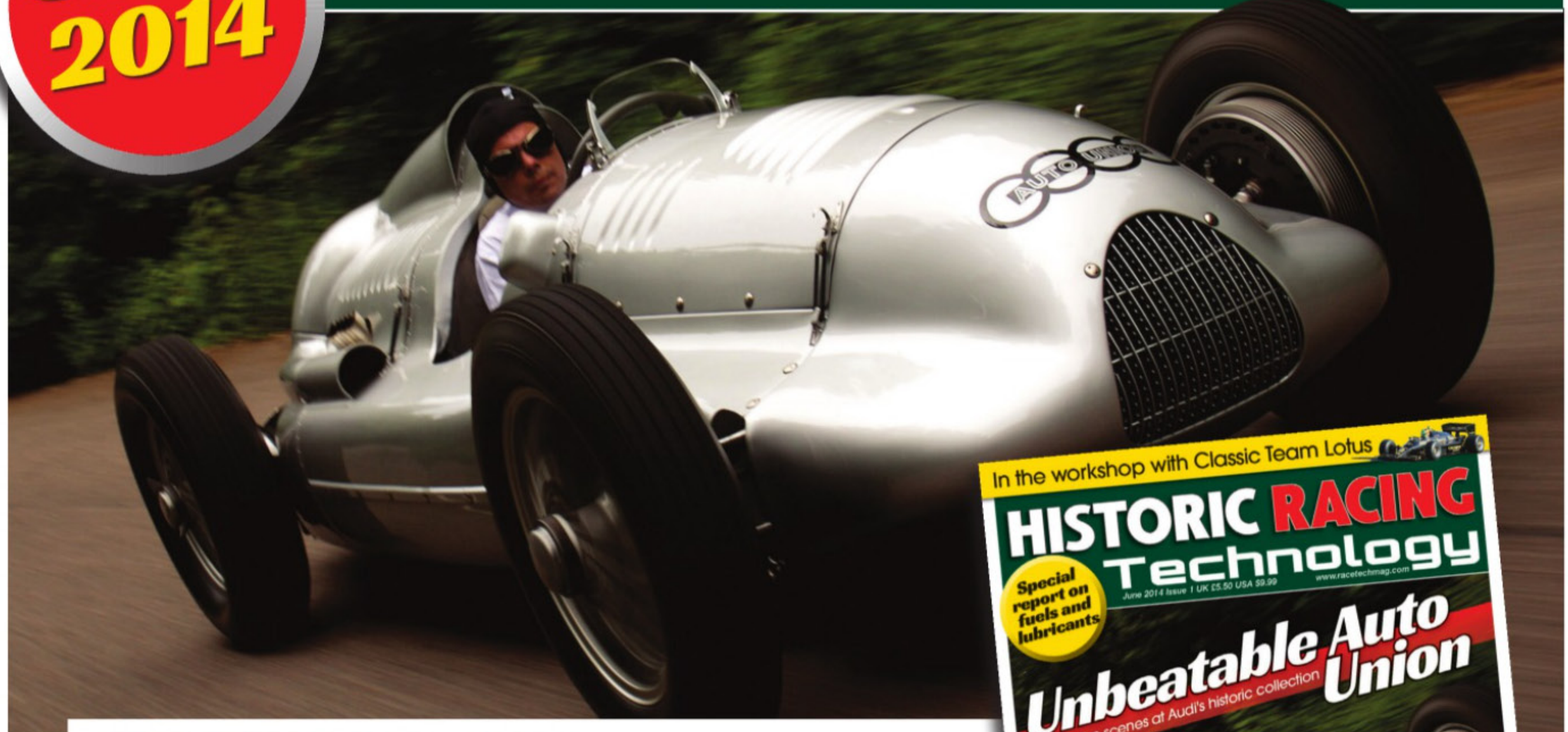
June 2014

June 2014 Issue 1 UK £5.50 USA $9.99 www.racetechmag.com



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Lemo

Following the trends towards miniaturisation and increased contact density, connector specialist Lemo has announced it will be extending its range of M-Series connectors with the new MM-Series.

Available with two, three or four contacts, the MM-Series is one of the smallest IP 68 connectors in the Lemo range. This small, lightweight family includes connectors suitable for cable diameters from 2 mm to 27 mm and configurations ranging from two to 114 contacts.

Lemo has worked closely with the Rebellion Racing team, which is once again contesting the LMP1 class of the World Endurance Championship and Le Mans. This year the team takes to the track with the new Rebellion R-One car designed by Oreca.

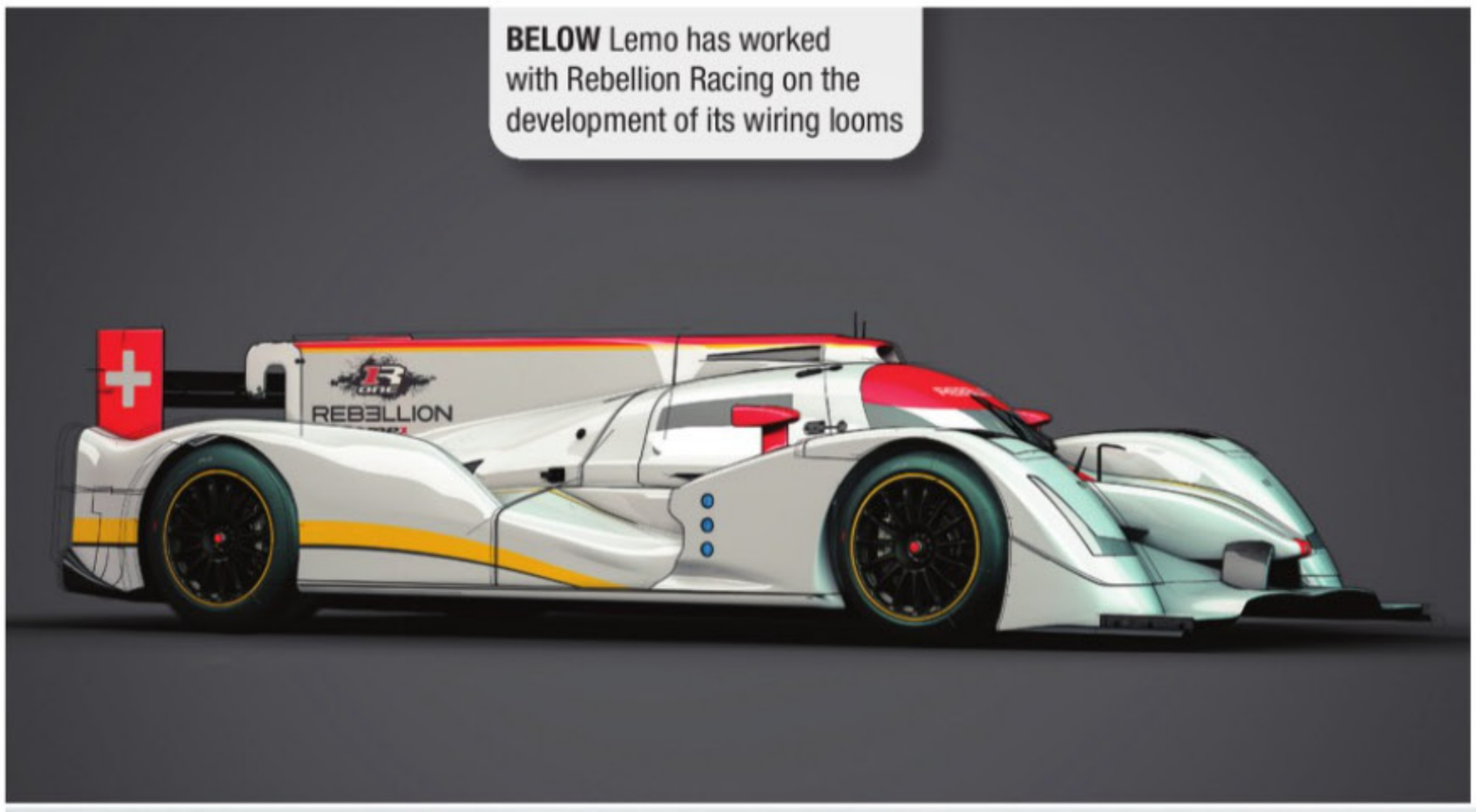
"The Rebellion R-one includes a lot of Lemo M-Series connectors - over 90 pairs per car", notes Billy Barbey R&D manager at Lemo's headquarters in Switzerland. "In addition, to help the technicians with the cabling of such connectors, we also offer various specific and simple tools in order to reduce the cabling time."

While Lemo offers a huge range of off-the-shelf connectors (the company says there are more than 50,000 product combinations) it can also produce bespoke connectors to specific requirements, explains marketing manager Serge Buechli: "If we don't have exactly what a customer needs, we can design and build a connector that meets those requirements."

Using state-of-the-art development tools, Buechli explains the company can evaluate product feasibility, including prototyping, in a matter of days or weeks, where traditionally it would have taken months.

The company has the facilities to work with both copper and fibre optic cables, with assembly plants spread across multiple continents - each equipped with the latest cable preparation, termination and test equipment. Every single cable assembly is tested for pin-to-pin electric continuity before it leaves the factory and high quality overmoulding is used to provide strain relief.

Quality control is another major factor. Most of the manufacturing processes take place in-house so Lemo has complete control over virtually the whole process. The company estimates that more than 90 per cent of the total procedures - from raw material to the finish product - takes place independently of external suppliers. ▶



BELOW Lemo has worked with Rebellion Racing on the development of its wiring looms

ABOVE Lemo has recently extended its range of connectors with the new MM-Series

Photo: Songasport Rally Media

BELOW Simtek has worked with a number of rally raid manufacturers, including Milner Off Road, where the company's looms are tested to extremes

Simtek

Over the years, motorsport has evolved its own specialist products and techniques which have enabled purpose-built competition looms to become ever more sophisticated. But when it comes to production-based racecars there are those who argue it can be advantageous to use OEM components.

Simtek UK (no relation to the '90s Formula One team) is a motorsport wiring specialist based in Lancashire headed by husband and wife team Jay and Ginny Simkins. Its customers have included Lotus, Ginetta, Bowler Motorsport and Milner Off Road Racing, covering disciplines from circuit racing to rally raid.

The company has extensive experience of all types of looms, but Jay believes there's a danger of overstating the importance of 'motorsport-grade' components in some instances. "A lot of our work has been based around companies who build competition cars out of road car parts," he says. "We've found that modern production connectors and components can be more cost effective than purpose-built motorsport items."

It's a highly contentious point, but one that Simkins is quite passionate about: "A batch of motorsport looms might be 10 units, but an OEM could produce a million cars. Even a 0.1 per cent return rate a serious problem in those sorts of quantities. You might not get some of the nice features of a motorsport connector like knurled backs or electrical shrouding but the quality can actually be very high. A lot of OEM connectors, for example, now have gold pins, just as you would in the bespoke motorsport connectors."

The lack of cable restraints on most OEM connectors can be a problem in high vibration environments, he concedes, but Simkins says there are various tricks of the trade that can be employed to overcome this to a large extent.

"Heat is rarely an issue," he points out. "If you look at some of the OEM packaging the environments can be as complex and as tight as you'd find in motorsport. The current twin turbocharged BMW M5 has pair of CAN-controlled throttle motors that live in the vee between the cylinders, where they're expected to sustain 120°C temperatures and those connectors on those motors are expected to work for 200,000 miles without being touched. The other thing is that OEM connectors are usually designed to carry quite a lot of current, so you rarely need to pair them up."

Interestingly, in one particular off road racing application where Simtek offers both motorsport and OEM-style connectors, Simkins says the customer demand for the OEM-style looms outstrips the motorsport looms by around 10 to one.

One of the major benefits of purpose-built motorsport connectors is their lightweight construction. Spec-for-spec youcan't argue with this, but Simkins points out that the top end looms can start to become deceptively substantial: "A few years ago we did a loom for a factory race team that came with a very prescriptive spec. It featured really light connectors, but they all had to have strain relief loops, screened cables with ground termination on the connectors using metal clamps, and Raychem boots. The whole thing, potted up with glue, weighed more than a production loom." RT

Success looms for students

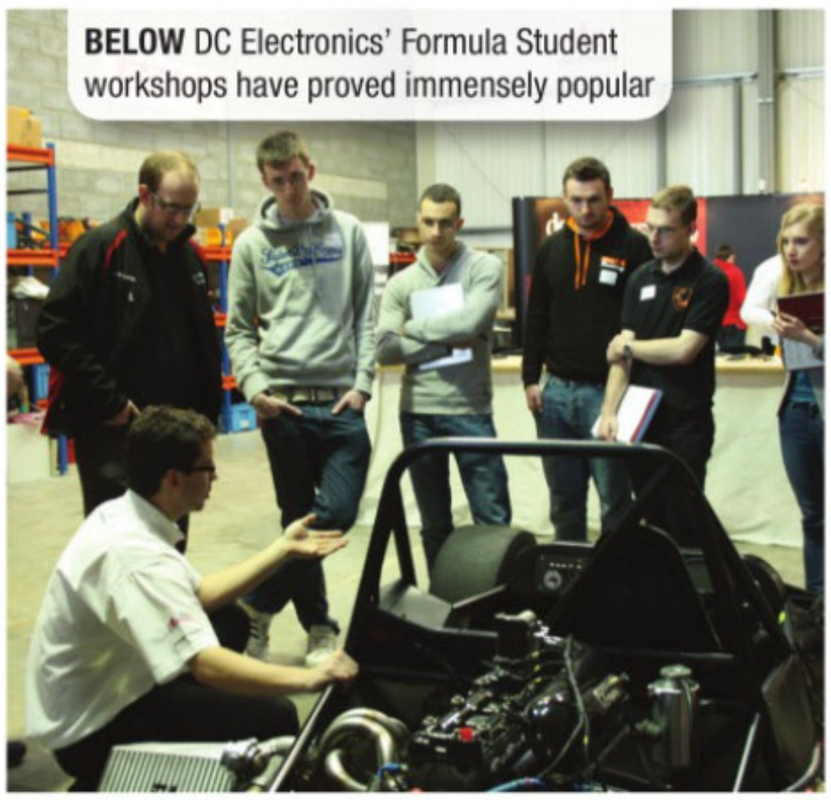
ACROSS THE motorsport industry there's now a concerted effort to get more aspiring engineers thinking about electronics and wiring harness design. There seems to be a general feeling that this immensely important skill isn't always given the coverage it deserves in the engineering curriculum.

"There are some very good courses out there in the industry now, but students aren't necessarily taught how to design a wiring loom at university," comments Jason English of Life Racing. As a design judge at the UK's Formula Student competition, English says he pays particular attention to the way the loom is designed and installed in each car: "It can be as important as the engine design and it should be designed in from day one. You wouldn't design an engine without a piston and rod assembly and I would deem it as important as that."

Jay Simkins of Simtek echoes those sentiments: "There's nothing worse than a beautifully designed car with hundreds of hours spent on the chassis and the aerodynamics that's then let down by a loom consisting of half a dozen wires strung together with some Scotch Locks and tank tape. You can't just leave it up to the CAD package: It's important to look at the where you're going to run the wires and consider how you're going to support them to reduce stress and movement in the wiring system."

DC Electronics organises free annual workshops for Formula Student teams, in conjunction with Deutsch and Race Tech. Based at DC Electronics' UK facility in Maldon, these cover the basics of wiring design including how to plan and lay out a loom, choosing the correct materials, and production tehcniques such as splicing, crimping, soldering and contra-winding.

"Formula Student provides an excellent opportunity for budding engineers to gain valuable experience, while benefiting from an insight into our experience in the industry," comments David Cunliffe, managing director of DC Electronics. "These workshops help the attendees to develop important skills which will aid their future career development." RT



BELOW DC Electronics' Formula Student workshops have proved immensely popular

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THE PAIN OF BODY-BUILDING

Graham Templeman and Rod Hill endure nerve-jangling moments in the workshop making the bodywork for their T5 Formula 750 build project

THE LAST installment left us at the exciting point where the T5's moulds were almost finalized and all that was needed was a little more work on the pattern for the headrest air intake. Well, it might not have been exciting for readers, but for us it was getting close to the culmination of a lot of work which could all go horribly wrong. If the moulds failed to lift cleanly off the pattern, we would be back at Square One and this was not a happy prospect!

It is a tense time not only because of the amount of work invested up to that point, but also because the process is inherently risky. The mould goes over the pattern and as it cures, it shrinks on to it, making the fit tighter and the de-moulding more difficult. The pattern itself is not particularly robust, being constructed from foam and filler, and the finish was not applied in the clinical conditions that you would hope for with a proper paint job.

Then there were the two small undercuts in the main mould mentioned in the last episode. The usual approach is to turn the whole thing upside down, destroy the pattern and expose the mould. In our case the wood and MDF that formed the basis of the pattern were screwed or clamped to the chassis and since the engine and gearbox were in-situ, turning things upside down was not an option.

MOULD RELEASE

Working on the basis that prevention is better than cure, the pattern was given about 10 coats of wax. When using multiple coats, it is important to give the wax chance to harden off, so doing three coats in a day (at the start of the day, at lunch time and at close of business) is a good regime. You can get away with shorter gaps, but better safe than sorry. We backed this up with the tried, tested and not very trusted PVA release agent applied carefully with a sponge. This had been dipped into the liquid and squeezed almost dry.

The objective is to create as thin a release coat as possible and is analogous to wiping a table with a damp cloth: when the job is done, there is a slight, but visible wet coating to the table and on the mould. Done properly, the shine of the pattern is preserved and there is no smearing. It takes practice but when you get the hang of it, it is very satisfying. There is no downside to getting it wrong because poorly applied PVA can be wiped off with a damp cloth and re-applied.

TRIMMING AND REMOVING

Even with careful preparation, there is still the chance of the mould sticking to the pattern or the product sticking in the mould, so caution is needed. After green trimming (as soon as the newly-created laminate has solidified enough to be cut with a knife), it is best to leave the mould to cure for as long as possible. The two can be separated as soon as the mould is sufficiently cured (recognizable by a solid sound when rapped with the knuckles) but this is not good practice. The plot that shows curing percentage against time indicates that the bulk of the curing takes place in the first few hours, but that the process continues for a few days depending on temperature. And since there is always at least a small level of anxiety in the process, putting things off is easy.

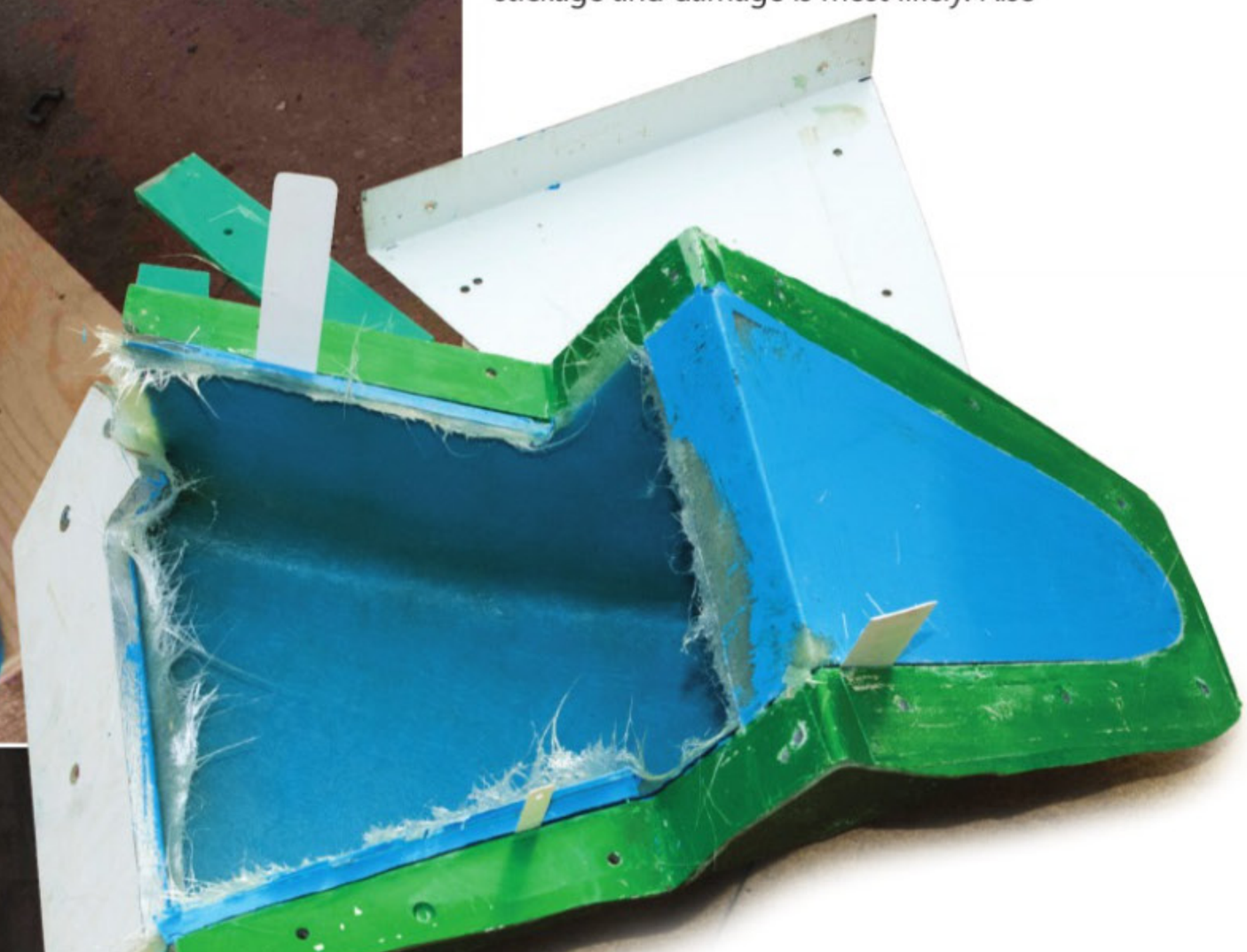
When the excuses have run out, the next step is to remove any loose pieces in the mould and to make sure that the edges are all free. The easy way to do this is to slide a thin piece of plastic along the joins to make sure that the seal is broken. At this stage the bond between two parts is disappointingly strong, so the next stage is to loosen this using whatever means are possible. The

ABOVE The T5's top body and nose

objective is to separate two surfaces and this is best achieved by sliding and peeling rather than straight tension.

Torsion is a very useful ally: it is possible to twist the mould and this will often be accompanied by the sorts of creaking and cracking noises that indicate that separation is taking place. We augmented this approach with strips of thin plastic and wedges made from half-inch thick polythene sheet.

It is best to avoid straight pulls of one part away from the other. For whatever reason this seems to be the circumstance in which stickage and damage is most likely. Also



ABOVE The nosecone prior to de-moulding. The floor was a loose piece that has been removed. Thin plastic 'pokers' have been inserted to break the seal

on the list of things to avoid is the rubber hammer. It is very tempting to give the large flat areas of the mould a gentle thump but this almost invariably results in star crazing in the mould at the point of impact and you will then have the benefit of this pattern on every product out of that mould.

A more gentle pressure by standing on parts of the mould can be helpful, but use this method sensibly. We are also told that air pressure works – putting a valve in the deepest part of the mould and giving it 100 psi – but it is not a technique that has worked for us. Another trick that never seems to work is the introduction of water between the surfaces in an attempt to melt the PVA coating. Luckily, we did not have to resort to desperate measures for removing either the mould from the ▶

BELOW The main mould after the careful application of the gel-coat. Space is at a bit of a premium!

> *"Stay in control of your temper. Firmness and strength win over violence every time!"*

pattern or the product from the mould.

However long the de-moulding takes, it is important to stay in control of your temper and not to resort to physical violence. Firmness and strength win over violence every time! Removing the body mould from the pattern took a couple of days of patient persuasion which involved simply walking away when things looked bleak.

There were small areas where the two had stuck but this was mainly because the bond between the pattern and the gel-coat was stronger than between the various layers of the pattern. Nearly all of the damage from small stickages was removed using plastic scrapers or thumbnails and any remaining blemishes on the mould were successfully polished out. As predicted, the products came out of their moulds much more easily and with no damage.

THE FINISH

The colour chosen for the main part of the bodywork is light blue but we had to give some thought as to how to achieve this. We could have made the bodywork in a suitable base colour (white is good because you can then mask off the squares for the numbers) and then give the whole thing a coat of paint. This would give us a good finish but involve an extra stage and add extra weight so we decided to go for the self-coloured glass fibre option and keep painting as a fallback position.

We used pigment in the gel-coat but opted not to use any at the laminating stage. Using clear resin for the lay-up makes it easier to control the quality of the workmanship: voids and air entrapment can be seen much more easily than would be the case if we had decided to use pigment in the lay-up resin.

The big benefit of using pigment in the lay-up is that it makes the laminate much more opaque. Without it, any unevenness in the application of the gel-coat can be seen in the finished product when the light is behind it. If the problem is not too bad, putting some paint on the back of the lay-up will cure the problem but by then you are in danger of getting back to the stage of painting and adding weight. In the event, the finish was satisfactory except for the sides of the cockpit so we got away with a quick aerosol spray job on the cockpit interior.

We had left some minor scratches on the moulds, knowing that it would be easier to polish them out on the finished product. This turned out to be the case. A few minutes with the polishing mop and some cutting compound brought up a very satisfactory gloss finish. The whole of the bodywork has not been polished yet – it seems pointless to bring it to a high gloss now and see it gradually scratched and battered as the rest of the work is carried out – so the polishing machine will come out again when we are much nearer to finishing the whole car.

ABOVE & BELOW Light transmission through the laminate (above) is minimised by painting the interior surfaces black (below)

LOOKING BACK

It is traditional when writing a piece like this to imply that everything went smoothly and that the end product achieved absolute excellence. The reality is that the products made were very satisfactory, but some small glitches were inevitable. The finish had already been mentioned and worked around. A major headache when laying up using bucket and brush techniques is the inclusion of air pockets. With clear resin, these can be easily identified at lay-up time, but there are things that you need to watch out for.

One problem is that the mat can fall away from the edge of the mould. This can be avoided by making sure that the surplus material above the edge is kept to a ▶

ABOVE Here the glass has failed to adhere to the gel-coat and was ground away and re-laminated

minimum and not getting things too wet. The bigger the overhang, the more likely that some part of the edge will fall away and need to be made good. Small gaps can simply be filled by dribbling a small amount of resin into the gap. Larger problem areas will need grinding back as far as the gel-coat and re-laminating.

Any sharp corner (such as a return edge) carries the danger of the mat lifting away from the gel-coat as soon as the operator looks away. One answer is to sneak back and catch the bubble unawares but more realistic is to use chopped fibre in any problem areas. They add slightly to the weight but improve the appearance no end.

Small bubbles are not necessarily a problem. If the gel-coat is thick enough at this point, you will probably never even notice the flaw. On the other hand, the first time that you put any pressure on it the gel is likely to break away and expose the laminate below. When this happens on a corner that is easily visible, it can be very annoying.

Sometimes the symptom is simply a slight wrinkling of the gel-coat because the bubble traps a styrene-rich atmosphere that is powerful enough to soften and wrinkle the gel-coat. In most cases the offending flaw can be cracked open, cleaned out, refilled with gel-coat and sanded back. This is a problem that we managed to avoid. The saving grace is that if you buy any professionally produced panel and inspect it carefully, you are very likely to see examples of these faults. So don't be too hard on yourself.

FITTING THE BODY

Since the pattern for the nosecone had been built on to the front crash box, getting it in the right place was relatively easy. Even so, we used the tried and tested method for fitting racing car noses of standing the chassis on a sheet of wood to provide a datum. If we were in Formula One, we would call this the reference plane. With the nose in place, the exact height of the body can be achieved by arranging small nylon bobbins to space the body from the frame. These will be held in place with silicone sealer. The body will be retained using the simple expedient of 5 mm button head and countersunk cap screws. This will be more long-winded than quarter-turn fasteners but much cheaper and easily replaceable.

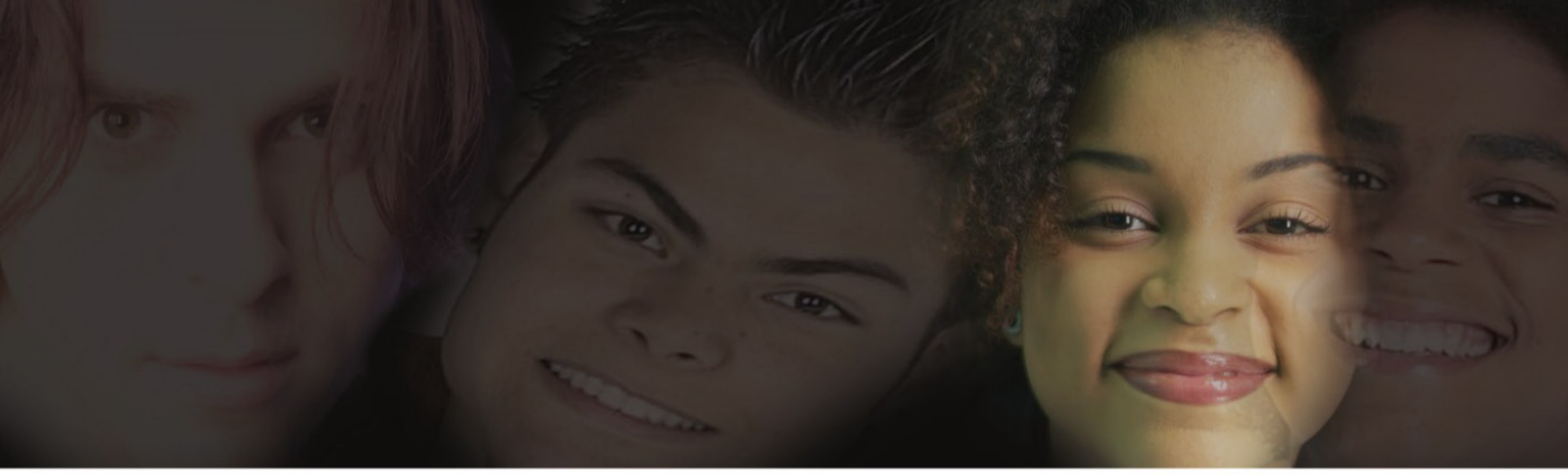
A quick trial fit showed that we would need to provide some means of aligning the top of the nosecone with the front of the main bodywork and a set of aluminium locating dowels and rings were quickly and simply manufactured on the lathe. The two bits of bodywork were carefully aligned using G-clamps, holes were drilled in the flanges and the pins and ferrules were temporarily fitted using a slurry of gel-coat and talcum powder prior to a permanent fixing using glass fibre and resin.

That got the job done for the time being but means that the flanges on the moulds will need to be modified to make it possible to replicate the spacing on all future products. Otherwise, doing this sort of hand-fitting will mean that each nosecone will fit only one top body – not an economical proposition.

The point of making the body at this stage is so that we have the panels against which we can manufacture the patterns and moulds for the rear wheel pods. Once the top and nose are fitted, the rear section can be sorted out. This will be permanently bolted into place and will form the rear crash structure and feed the rear wing loads into the chassis.

At the time of writing we are giving careful thought as to how to transmit the loads and a sandwich structure of glass reinforced plastic and 5 or 10 mm PVC foam is being considered. Experience shows that the cheaper polyurethane foam does a splendid job right up to the point of impact, when it separates from its outer skins and presents quite a difficult repair problem. So the satisfaction of a job well done quickly gave way to the need to move on to the next and, thankfully, final body-building phase. RT

ABOVE A selection of trimming tools



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Keypad option for GEMS PM2

GEMS has released a new control module for its CAN-based power management system. The PM2 module now comes with the option of an in-built keypad, which can be used to configure the system's control and monitoring strategies.

Acting as a central hub, the PM2 is designed to control a network of GEMS PM1 or PM3 power management modules spread around the car. These not only replace the switches, trips and relays of a traditional fuse box, but they can integrate with other systems on the CAN network such as the engine control unit or the car's data logger. Thanks to an intelligent monitoring system, the PM2 is also capable of flagging potential faults in the car's electrical system before they become critical, such as detecting the rise in current usage from a fuel pump or actuator that's about to fail.

Where previously the PM2 relied on a separate keypad, the new design can accommodate up to 20 buttons on its integrated 130 x 85 mm matrix keypad. LED lighting can be provided on up to 12 of these to give a visual reference of the functions that have been enabled.

As with the existing PM2 unit, the new module comes with two CAN 2.0 connections and one RS232 serial port. It features 10 switch or keypad inputs (matrixed to 25) and eight standard switch inputs. There's also an override switch input and a battery sensing function. RT

Fiesta ST gets the StopTech treatment

CALIFORNIAN brake specialist StopTech has released a new front-axle big brake kit for the 2014 Ford Fiesta ST. The kit provides a comprehensive upgrade that includes stiffer calipers, larger rotors, high friction pads, braided stainless steel lines and all the necessary brackets and mounting hardware.

The 328 X 28 mm floating directional rotors are taken from StopTech's AeroRotors range and mated to a pair of the company's ST-40 forged four-piston calipers. The mounting brackets are machined from billet aluminium with stainless steel studs. DOT-compliant stainless steel braided Teflon brake lines round out the kit, alongside StopTech's Street Performance brake pads. RT

Turning the tables

PIT PAL claims its aluminium work tables are the strongest in the industry with a 1,500 lb (680 kg) load capacity. They come in three sizes and each feature tubular steel locking legs that fold in for storage along with an aluminium hat channel for bracing. RT

Ram effect

SIX STEEL friction inserts lie at the heart of Ram Clutches' latest lightweight aluminium drag racing flywheels. Designed for single-disc clutch systems and developed as a direct-replacement for sintered iron or metallic clutches, the chief motivation for employing friction inserts is their resistance to warping or distortion. Ram says this helps to improve heat dissipation and improve durability.

Available for a range of small and big-block V8s, the new flywheels are said to offer a significant weight reduction over the standard items. Fully machined in-house from 7075 alloy, these flywheels use the same friction inserts as Ram's aluminium pressure rings.

Around the perimeter of the flywheel are a series of holes that accommodate tubular stands and press-in Grade 8 hardware to attach the pressure plate. This arrangement, which includes shims between the stands and the pressure plate, is designed to simplify ring height adjustment. What's more, to prevent wear while removing and reinstalling the flywheel, hardened inserts are used in the mounting holes. RT

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Photo: Staley/LAT

Making noises

There's a persistent groaning sound surrounding the F1 paddock. And it's not coming from the cars

EXPLETIVES from the drivers, fits of rage from the internet forums and even rumoured threats of legal action from the promoters. Not everybody, it seems, is happy with the sound of the new 1.6-litre turbocharged Formula One engines.

So concerned is the FIA that it has set up a dedicated working group to investigate the noise of the new engines. Much of the discussion now seems to be centring on the idea of revised exhaust regulations and perhaps even a standardised tailpipe design. Which, to be honest, sounds a little bit absurd for Formula One.

To start with, you have to ask what's actually wrong with the current soundtrack? The FIA estimates that the reduction in volume is around 11 dB. Due to the logarithmic scale used for sound pressure that means the volume is perceived as around half that of the previous V8s, but they're still reportedly pumping out 134 dB. That's comfortably louder than the average Metallica gig and not far from the pain threshold of the human ear.

Make no mistake, motorsport should be dramatic. And in a sense that means it should be loud, but perhaps not necessarily the cars themselves. This was demonstrated right at the start of the season during qualifying for the Australian Grand Prix, when Daniel Ricciardo put his Red Bull on the front row. Passing the line, his car might have been quieter than last year, but the roar from the crowd was audible for the first time in ages. And in that second the cheer that went up from the 80,000 or so Aussie fans was far more emotive than the pressure wave emanating from the Red Bull's exhaust.

Of course, the energy travelling down the exhaust pipe now has another important role to play, driving the turbocharger and the heat energy recovery system. It would be a very sad situation if mandatory changes, forced onto the teams in the name of making F1 more exciting, actually reduced the amount of energy available to the turbocharger and resulted in the cars going slower.

The next issue is the type of noise. For the musically minded, the current Formula One engines are around an octave lower than their predecessors. That's an unavoidable consequence of reduced engine speeds and reduced cylinder count, but it could be quite significant. At 18,000 rpm the old V8s were screaming - quite literally as it turns out - in a particularly sensitive frequency range for the human ear, tuned through millions of years of evolution to pick out the sound of crying babies. Bizarrely, it's just possible that the lukewarm response to the new engines is down to them not having quite the same grip on our parental instincts.

And that's assuming that people actually want the cars to sound like a swarm of angry bees. Progress is emphatically a good thing in motor racing, but from an entirely harmonic point of view I'd argue the sport has long since peaked. The days of snorting carburettors, manually blipped downshifts and rasping V12s are gone. Next to, say, a Ferrari 250 GTO, arguing whether 2013 Formula One engines sound better than their 2014 equivalents is like trying to pick your favourite traffic warden. This isn't the first time we've seen changes that affect the sound of the cars and yet until the start of this season everyone seemed to be coping just fine.

But perhaps the worst thing about the Formula One noise debate is that it's a distraction - some might even say a deliberate one - that has overshadowed the other events that are taking place. We've seen the biggest overhaul of the technical regulations in decades, a raft of new talent joining the driving ranks and several major court cases so far this season, yet much of the attention has been focused elsewhere. RT

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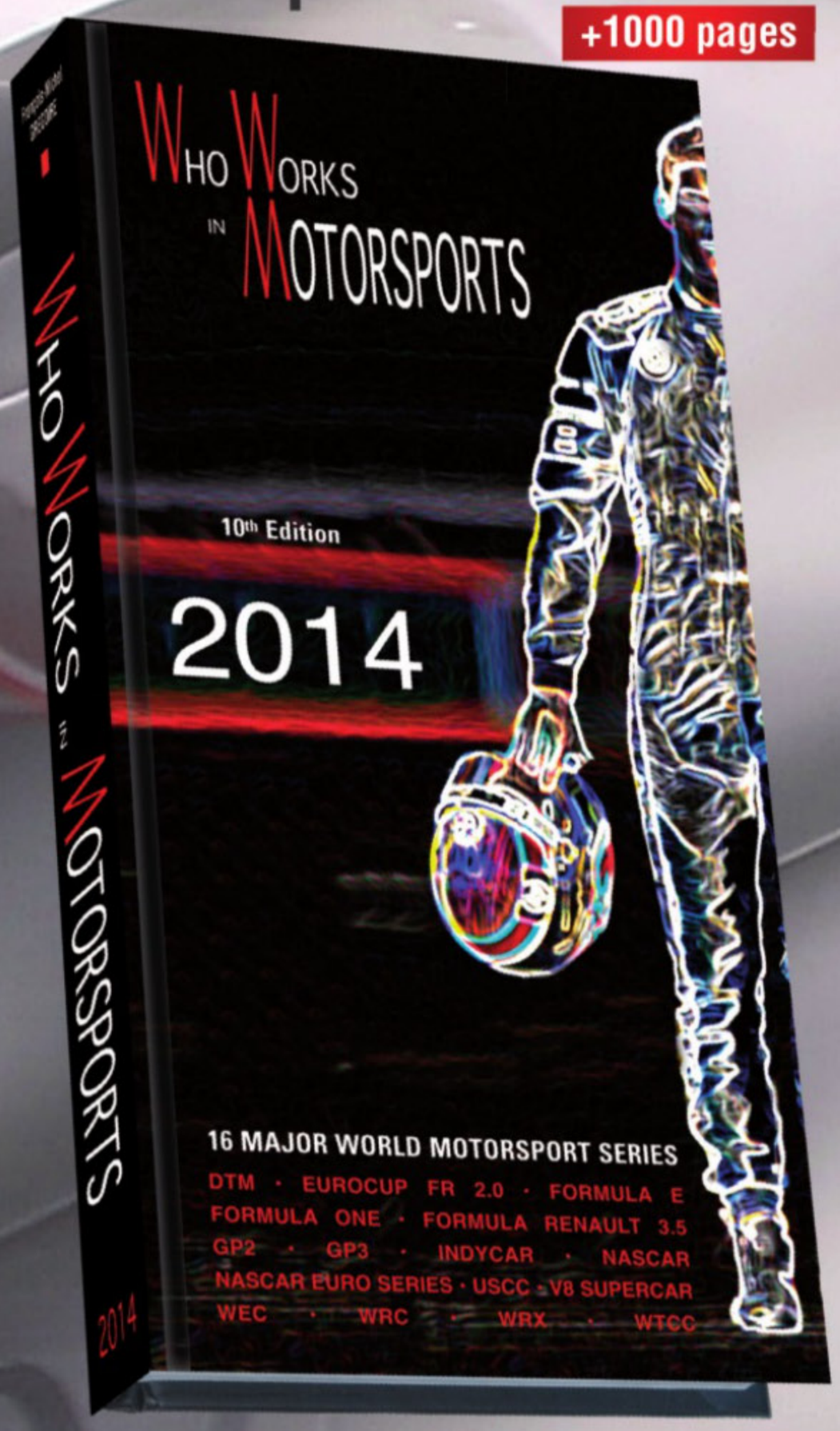

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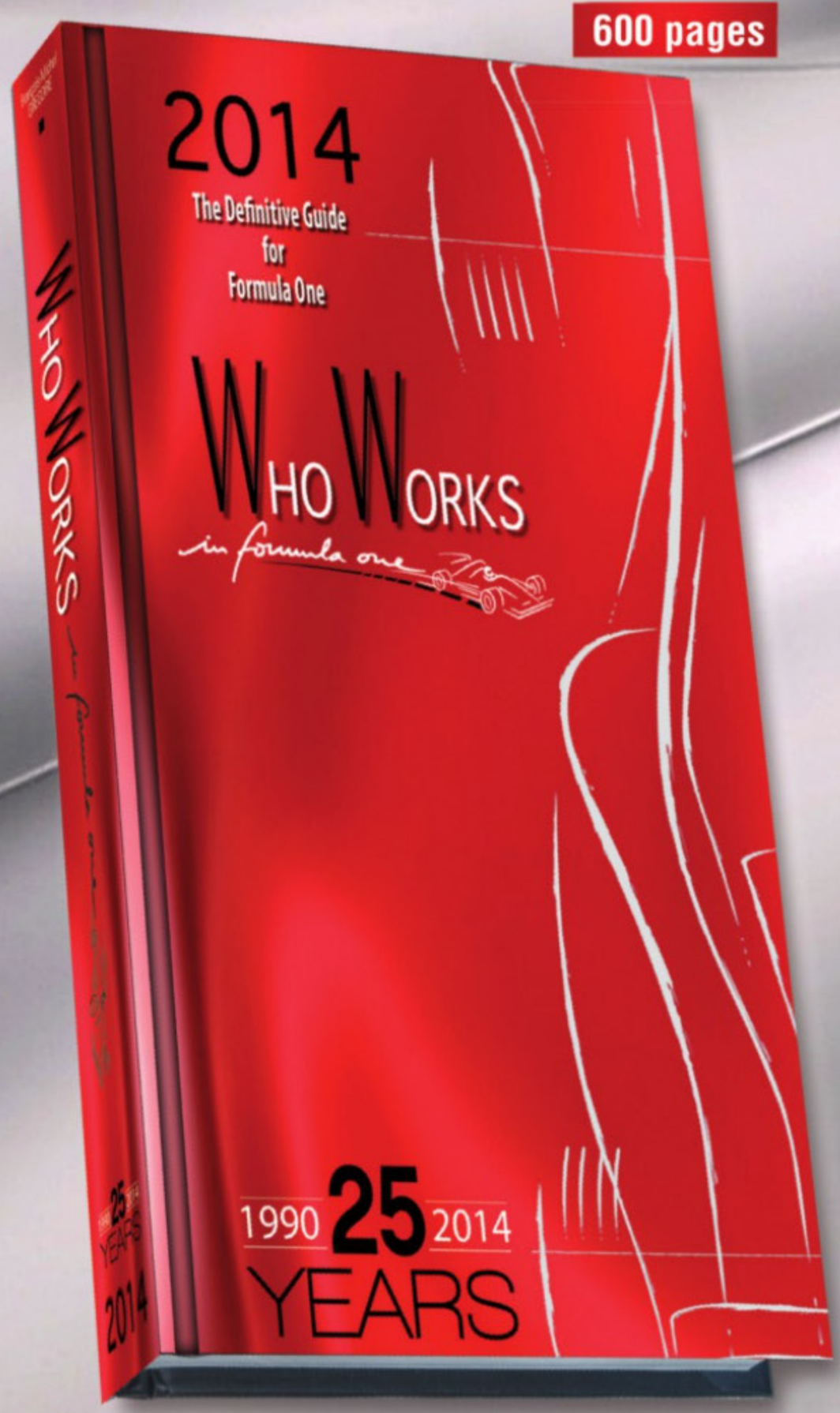

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