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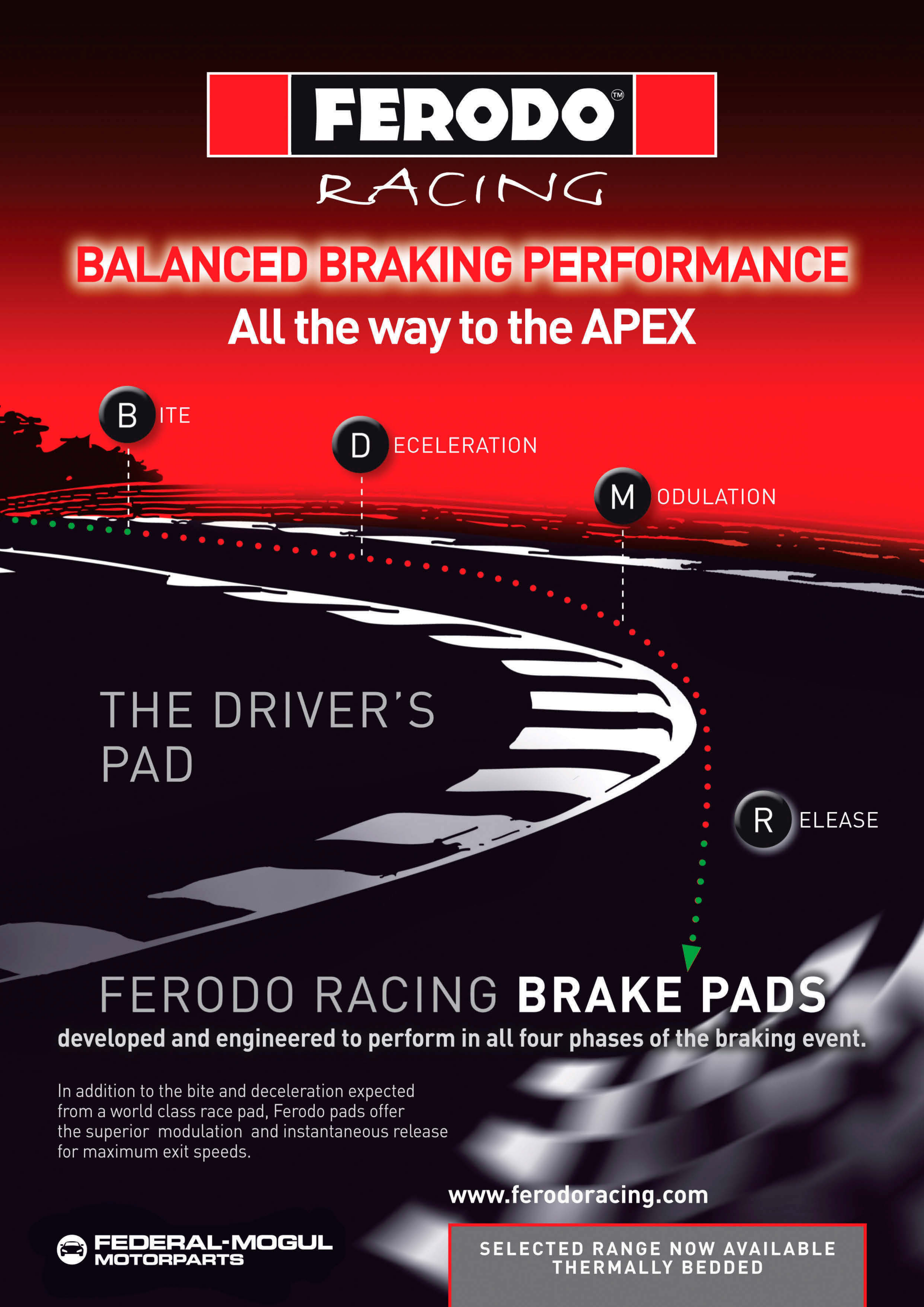
Plus Ligier's LMP3 challenger

New series on engine technology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Ground Effect

Revealed Why the reintroduction of ground effect aero can reinvigorate F1

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DRIVING TECHNOLOGY INTO POLE POSITION
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INTERNATIONAL

Volume 22 Issue 11
Published September 2015
The next issue will be published in early October 2015
ISSN 1356-2975

SUBSCRIPTIONS
Subscriptions from Racecar Graphic Ltd
841 High Road, Finchley, London N12 8PT
Tel +44 (0)20 8446 2100
Fax +44 (0)20 8446 2191

Overseas copies are sent via air mail
Special offer 12 issues for the price of 10
12 issue subscription UK: £45.00
Europe: €97.50, US/Canada: US$127.40
Rest of World: £75.00
All major credit cards accepted. Cheques and money orders only in Pounds Sterling payable to Racecar Graphic.

BACK ISSUES AVAILABLE:
8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178
Price including post & packing:
UK: £5.50, Europe: £6.50, Rest of World: £7.55
You can pay by cheque or credit card but please note the minimum on Switch & Delta is £14

Race Tech (ISSN: 1356-2975) is published monthly by Racecar Graphic Ltd.

Cover image: Bloxham/LAT

Design & Production:
Maluma Design Associates,

Printed by Warners Midlands plc

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EDITOR
William Kimberley

CONTRIBUTING EDITORS
Andrew Charman
Matt Youson

CONSULTANT EDITOR
Mark Skewis

EDITORIAL ASSISTANT
Scotty Whitelaw
Thiam Loong Ser

PHOTOGRAPHY
LAT

ART EDITOR
Paul Bullock

WEB MANAGEMENT
Joomlaholics.com

ADMINISTRATION/ SUBSCRIPTIONS
Vikki Amour

SALES EXECUTIVE
Mike Norman

COMMERCIAL DIRECTOR
Maryam Lamond

PUBLISHER
Soheila Kimberley

DRIVING TECHNOLOGY INTO POLE POSITION
RACE TECH
INTERNATIONAL

841 High Road, Finchley
London N12 8PT
Tel: +44 (0) 208 446 2100
Fax: +44 (0) 208 446 2191

www.racetechmag.com

Time to ponder

IT'S not often that I touch upon the death of any driver or anyone for that matter as I feel that as a technology magazine, such tributes have little place in the publication although that does not mean that the pain and remorse in many cases remain unfelt. However, I feel compelled to write about what happened to Justin Wilson because it has opened up the issue of closed canopies on single-seaters and the growing call to go that route.

First reaction to the accident was to question why on earth canopies had not been introduced in IndyCar following the crash that took Dan Weldon's life in 2011, and indeed there have already been calls for such action following Wilson's. It also comes after a spate of lurid accidents with cars somersaulting and doing backward flips in IndyCar where fortunately the drivers went unscathed.

However, there is a downside to canopies, including the fear of many drivers about being trapped in their cars in an accident, perhaps with the car on fire, the canopy getting jammed preventing the rescue marshals from extracting them from the vehicle and things like that. There is also the factor that if debris bounces off the canopy its flight is haphazard and uncontrolled, perhaps leading to it flying into spectator areas, so there is a great deal to think about than just installing canopies on single-seaters.

Because of the mercifully few fatal accidents we have in motor racing, we tend to remember those who do die or are seriously injured, and such is the safety of cars nowadays, it tends to be when a driver is struck by something. If you were to do a risk assessment, bearing in mind the tens of thousands of miles raced by the thousands of drivers over a season around the world, that what happened to Justin Wilson, Dan Weldon and Felipe Massa, who fortunately survived, the chances of death or severe injury by flying debris are actually rated very low, although in the close racing experienced in IndyCar those chances do increase.

There is now quite rightfully a call for an IndyCar safety review. It needs to be done to show that the governing body cares and is on top of things, but hopefully it will not make a kneejerk reaction and that it will take stock and take into consideration all aspects of such accidents and the implications if the decision is made to go for completely or even semi-closed cockpits. I also hope the review will be widespread and take into account the drivers, the team owners, Dallara, Honda and Chevrolet, and, as important as anyone else, the rescue marshals – the first responders – who have to deal with the situation firsthand.

Finally, I really would like to salute Justin Wilson because he had signed up to having his organs donated in such an event and evidently this act has saved six people. He may have passed on, but through his selfless act he lives on. RT

William Kimberley
EDITOR

Justin Wilson

Renewed calls for single-seater canopies

William Kimberley

POCONO RACEWAY, PA: British driver Justin Wilson has died from injuries sustained in an IndyCar race at Pocono Raceway, Pennsylvania. He was caught up in the shower of debris and hit on the head by what appeared to be a nose cone. He was immediately rendered unconscious and ploughed into the barrier. He was airlifted to hospital but never regained consciousness.

His death has again opened up the question of safety in IndyCars, the memory of Dan Weldon's fatal accident in 2011, still fresh in many people's minds, leading to renewed calls for a review of safety in the sport. It has also opened up the possibility of canopies being fitted to single-seaters, as reported in *Race Tech* 168 (November 2014).

As reported by Andrew Charman, the IndyCar series was considering mandating a canopy structure on its cockpits to protect drivers more effectively from head injuries caused by flying debris. It had been on the agenda ever since the death of Weldon when his helmet struck a debris fence pole. Since that time there have been a number of lurid incidents with more recently cars somersaulting and flipping backwards, fortunately without death or severe injury to the drivers.

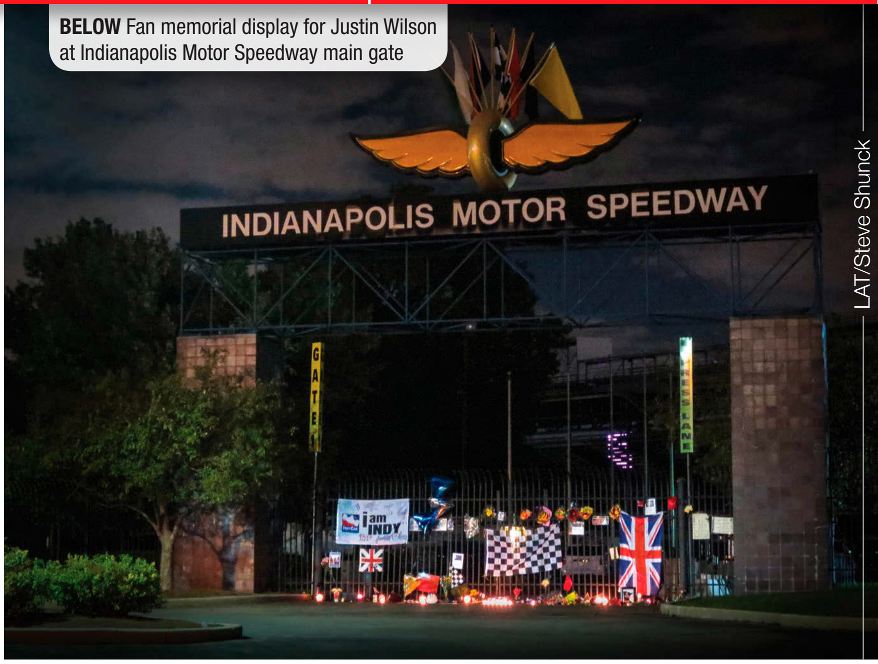
IndyCar president Derrick Walker, who coincidentally had already given notice that he was stepping down from the job at the end of August (see story below), had considered the fitment of a partial canopy ever since joining the series in mid 2013 and had talks with chassis manufacturer Dallara but it was thought that modifying the current DW12 to accept a canopy would be more challenging than designing one into the next-generation IndyCar chassis, scheduled for introduction in 2018.

As he told *Racer* magazine's David Malsher in May, he had come out against an enclosed canopy following research into it, this was partly due to the chances of a driver becoming trapped if the structure became distorted or was upside down after an accident.

"The fact is, it's the front portion of the cockpit directly in front of the driver's

LAT/Gregg Feistman

BELOW Justin Wilson who fell victim to a horrendous crash sequence that took his life



BELOW Fan memorial display for Justin Wilson at Indianapolis Motor Speedway main gate

LAT/Steve Shunck

helmet that is the part that's doing all the work, the screen if you want to call it that. Debris doesn't tend to go up and then straight down. The bit above the head in a closed cockpit is about aerodynamics, not safety. So I'm more in favour of building a stronger, higher screen from the dashboard area, to deflect parts coming at the driver. It's not a failsafe system – there isn't one, because every system has its drawbacks. However, it is a big step forward from the current arrangement."

Andretti Autosport team-mate Ryan Hunter-Reay addressed the subject soon after the accident, saying that the cars were inherently dangerous with the open cockpit with the head being exposed. "Maybe in the future we can work toward some type of canopy. We've seen some concept renderings of something that resemble a canopy — not a full jet fighter canopy, but something that can give us a little protection but keep the tradition of the sport."

Former Marussia driver Max Chilton has also called for the introduction of closed cockpits, saying that the motor racing community has to push for their introduction in open wheel categories. Chilton, who now races in the Indy Lights series beneath IndyCar, drove for Marussia in 2013 and 2014 and was the team-mate of Jules Bianchi when the Frenchman suffered a serious brain injury when he collided with a recovery vehicle at the Japanese Grand Prix last season. Bianchi died from his injuries in July.

"The cockpit area, our heads, is the one vulnerable area left on the car," Chilton told Sky Sports News. "The rest of the car is amazingly safe now. This is going to push forward a new design in closed cockpit racing.

"It's very rare but recently – as I know far too well losing Jules this year – it's happened too recently, for the second time. It's something we've got to get a hold of. I know it was a freak accident but there's definitely more we can do. It's always a freak accident which is going to get you and I want to find a way, with the racing community, that we can get a hold on it, and try and reduce the numbers because there's been too many recently."

However, some of the criticisms of closed canopies include fears that movement is restricted and worries about being trapped if a car is upside down or on fire, or if there are problems with peripheral vision, so opinion is divided among drivers although they are broadly in favour of keeping open cockpits.

Former Formula 1 driver and team owner Eddie Cheever believes that progress needs to be made on the issue. "I think it is time that solutions are looked for and I think that it is time that the drivers got together and came up with a few ideas and I sincerely hope that some progress will be made on this issue," he told ESPN.

Wilson's death has also led to the suggestion that open wheel racing should be banned on high-speed oval tracks where tightly packed cars can reach speeds up to 230 mph (370 km/h). RT

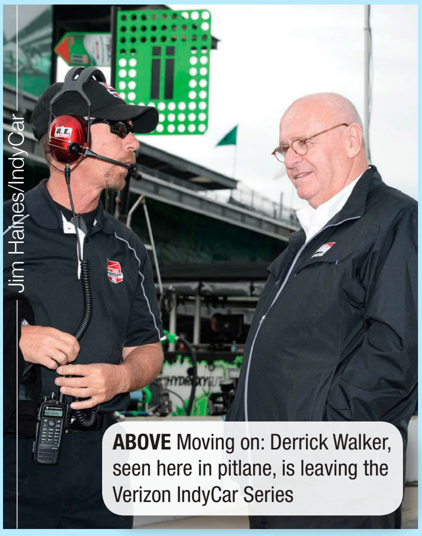
IndyCar in search for race chief after Walker quits

Andrew Charman

INDIANAPOLIS, IN: The Verizon IndyCar Series is searching for a new competition head after Derrick Walker announced he will leave the championship on 31 August after the end of the 2015 race season.

British-born Walker, who started his career in the 1970s with the Brabham Grand Prix team, has been IndyCar's president of competition & operations since mid-2013. However, his departure is not entirely unexpected as he had been under pressure during the 2015 season particularly over the troubled introduction of manufacturer-specific aerodynamic kits, which saw several dramatic crashes and urgent specification changes during the weeks leading up to the series' blue riband event, the Indianapolis 500. He was also criticised by teams who thought the kits were too expensive, while blame for the initial lack of performance of the Honda kit compared to the Chevrolet equivalent was also laid at the door of the governing body. He is also known to have had his department budget radically cut in 2015, and agreed with US media suggestions that he had been "spread too thinly".

IndyCar is yet to announce its successor to Walker, who plans in the future to concentrate on a Tudor International Sports Car Series team that he owns. IndyCar has been consulting team owners on requirements for the role. RT



Jim Haines/IndyCar

ABOVE Moving on: Derrick Walker, seen here in pitlane, is leaving the Verizon IndyCar Series

NASCAR aero trials remain a drag

Andrew Charman

BROOKLYN, MI: Attempts by NASCAR to improve overtaking with aerodynamic changes appear to need further work after two races with a 'high-drag' aero package produced little change in the number of passing moves.

The series governing body specified races at Indianapolis on 26 July and Michigan on 16 August for tests with the new package. This consisted of a nine-inch rear spoiler with a one-inch 'wicker bill' – a vertical flap – fitted to its leading edge. Also included were superspeedway-style rear fascia extension panels, a two-inch leading edge on the front splitter, and a splitter extension panel of 43 inches.

The amount of passing seen in the Indianapolis race was considered little changed from previous events at the 2.5-mile track, current Sprint Cup champion Kevin Harvick dismissing the day as "a huge science project that probably didn't really change that much."

The Michigan race was dominated by Matt Kenseth, leading 146 of the 200 laps, and most passing appeared to be confined to the laps immediately after restart from caution periods. Following the Michigan race drivers appeared loath to comment on the aero package but it was clear that while cars could close on rivals ahead, passing them was far more difficult.

NASCAR's executive vice president and chief racing development officer Steve O'Donnell admitted to SiriusXM NASCAR Radio that the Michigan race package had not performed as hoped. "We've said repeatedly with each and every package we've put together, we want to look at the ability to pass throughout the field and the ability to have multiple lead changes at the front and we didn't get that on Sunday."

A low-downforce package, used at Kentucky on 12 July attracted much more positive reviews and will be tried again at Darlington in September. Before the Michigan race NASCAR announced that there will be no trials with specific aerodynamic packages during the 10-race 'Chase for the Championship' that will close the 2015 season.

However, the Chase race at Talladega on 25 October is likely to see some changes to the specific "Restrictor Plate" rules that are applied to superspeedways in a bid to keep speeds in check. These changes are likely to be in response to the dramatic finish-line accident that befell the car of Austin Dillon at Daytona on 5 July. His car was sent flying violently into the debris fence, injuring five spectators in the process.

* NASCAR mandated a dual outlet duct on the right-side window of Sprint and Xfinity Cup cars before the Michigan race to provide extra ventilation for the cockpit. The move followed several instances of drivers feeling ill after the first race with the high-drag package at Indianapolis, due to less air passing under the car. RT

Matthew T Thacker/Toyota Racing

LEFT No pass: The closest rivals generally got to Matt Kenseth at Michigan was following restarts from caution periods

Opel signs up for TCR Touring Cars

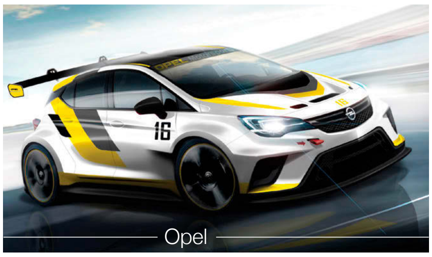
Andrew Charman

RUSSELSHEIM, Germany: Opel has joined the growing manufacturer involvement in the TCR International Series by confirming that it is to develop a race version of its next Astra OPC – known as the Vauxhall VXR in the UK – to the TCR technical regulations.

The car will be unveiled at the Frankfurt Motor Show and testing is expected to begin in October. As per the regulations it will use a 2-litre turbo engine, Opel quoting power figures of 330 bhp and torque of 410 Nm.

As per the concept of TCR detailed in last month's *Race Tech*, the car will be built in a production run by Opel Motorsport, for sale to customer teams competing in TCR at international, regional and national level.

According to Opel Group CMO Tina Müller, touring car racing has always been an important part of Opel. "The philosophy of the new TCR series corresponds to our idea of customer racing – we want to give ambitious privately owned teams a platform for exciting sport at reasonable costs," she said at the announcement of the car.



Opel

ABOVE Signed up: Opel's new Astra OPC will join the TCR International Series next season

TCR International Series founder and promoter Marcello Lotti has welcomed Opel's announcement, which takes the manufacturer count in TCR to six. "We are very pleased with Opel's decision," Lotti said, adding; "We knew they were seriously evaluating the TCR concept in the latest month, and now the announcement that the new Astra is being developed in TCR-spec makes us very proud and adds another premier automobile brand to the TCR world." RT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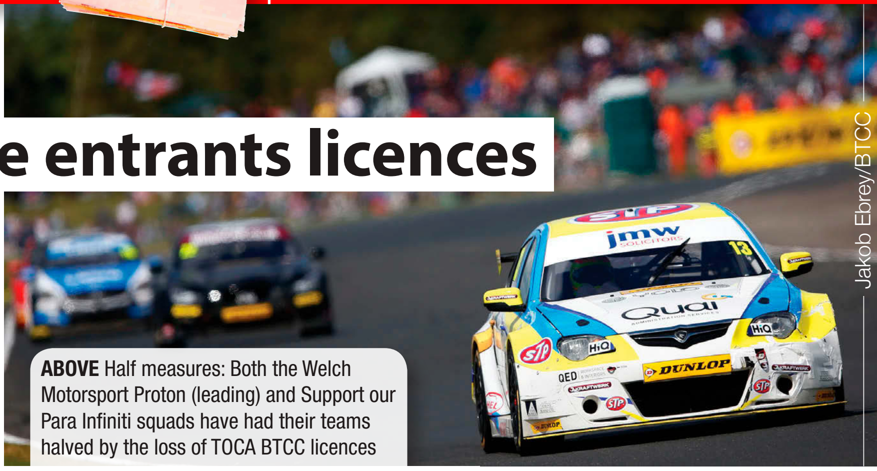
BTCC teams lose entrants licences

Andrew Charman



ABOVE Half measures: Both the Welch Motorsport Proton (leading) and Support our Para Infiniti squads have had their teams halved by the loss of TOCA BTCC licences

LONDON, UK: The British Touring Car Championship has carried through on its threats to remove the entrants' licences from teams who do not compete in sufficient rounds of the championship. In order to enter the series, teams must be in possession of a TOCA BTCC Licence (TBL) for each car. This commits the team to entering every meeting of the championship and only making a maximum of one driver change per season, except in cases of force majeure.

First to suffer the loss of a licence was the Support Our Paras team, which had planned to run a pair of Infiniti Q50s in 2015. Only one car appeared at the Brands Hatch opening round driven by Derek Palmer while the second car was debuted at Donington Park by Richard Hawken. However, for the next round at Oulton Park, he was replaced by former F1 driver Martin Donnelly, the team claiming force majeure.

The team then lost its support from Infiniti and at the next round at Croft it was announced that Max Coates would be the second driver for the remainder of the season. However, at Snetterton the second entry was withdrawn after Coates failed to find a budget. As a result, TOCA cancelled the team's second TBL.

At the same Snetterton meeting, Welch Motorsport withdrew its second Proton Gen-2 entry due to be driven by Andy Wilmot, claiming force majeure as a component supplier had not delivered in time. However, when the team then withdrew the car from the following meeting at Knockhill on 22-23 August, it too had its second TBL withdrawn.

The BTCC also confirmed that one of Rob Austin Racing's licences had been suspended after driver Hunter Abbott missed the Knockhill races in Scotland to attend the birth of his first son. The regulations dictate that a stand-in driver must replace a team's full-time entry if they are unable to participate in a round. RT

New engine joins BTCC grid

Andrew Charman

WROTHAM, UK: A new engine and car combination joined the British Touring Car Championship on 9 August when the Motorbase Performance Team debuted two Ford Focus NGTC Touring Cars with 2-litre EcoBoost turbo engines. The engines, based around Ford's latest road units, have been built up to the BTCC's NGTC regulations by the team's engine partners, Ford power unit specialists Mountune Engineering, and in conjunction with technical partners Pro Alloy, SamcoSport, Milltek and Specialty Fasteners.

Their debut in the 2015 BTCC was delayed to the sixth of the 10 race weekends due to Motorbase struggling to find a new title sponsor, following the ending of a six-year partnership with Wrigley's Airwaves at the end of 2014.

The two cars were immediately on the pace, driver Matt Jackson topping the timesheets in a full BTCC test prior to the Snetterton race weekend. Both cars secured points finishes at the meeting and showed enough promise to immediately suggest race wins are an achievable goal through the remainder of the season. RT

BTCC takes genius approach to track cleaning

Andrew Charman

CROFT, UK: NASCAR recently took a revolutionary approach to drying its tracks, culminating in the much more rapid and efficient Air Titan system, and now British Touring Car Championship organiser TOCA has focused on the problem of cleaning circuits following an accident or mechanical failure.

The catalyst, according to BTCC series director Alan Gow, was an incident during the September 2014 meeting at Silverstone when the engine in Sam Tordoff's MG failed comprehensively while the car was on the grid. Dealing with the large oil slick on the circuit that resulted not only significantly delayed the programme but resulted in great clouds hanging on the start-finish straight as cars ran through the cement dust put down by marshals to soak up the oil.

As a result Gow called for a clean-sheet approach to the issue of cleaning track surfaces and the BTCC has worked with Fusion Greenstar, a company that has developed road cleaning technology dubbed the Safe Genius. Rather than using cement dust and brooms to soak up spilled fluids and make them harmless, the Safe Genius employs mechanical suction technology, in the case of the BTCC system carried in the back of a specially adapted pickup truck.

While looking like an industrial vacuum cleaner, the system is equally effective at pulling liquids out of the track surface which can then be washed and returned to its original condition, with no residue such as cement dust remaining.

The team manning the 'BTCC Genius' pickup at rounds of the championship also carry industrial blowers that are used to remove physical debris, such as mud or dirt, or shards of carbon fibre bodywork, from the track after an incident. The system was piloted at the BTCC round at Croft on 27-28 June and officially launched at Snetterton on 8-9 August. It will be in place for all future BTCC meetings. RT

ABOVE Seven of the 10 teams have developed their own powertrain technologies, the Renault e.dams team's proving to be very competitive

Formula E gears up for season two

William Kimberley

DONINGTON PARK, UK: Following a combined six days of practice at Donington Park, ABT Schaeffler, which announced that it had Volkswagen as a technical partner, and Renault e-dams, with its new-for-2015 Renault Z.E.15 powertrain, have emerged as the front runners as Formula E heads into the new season. Season two will see a more open championship with teams encouraged to develop their own powertrain technologies and so most have focused on inverters, motors, transmissions and cooling systems. Not only will this ensure the racing remains highly competitive, but it supports the goal of Formula E of advancing the development of new technologies for electric vehicles and to bring those technologies, vital to sustainable mobility, to the attention of millions of people around the globe.

Seven of the 10 teams will use equipment of their own design or created in collaboration with their technical partners, but Team Aguri will continue with the original SRT_01E car used by all teams in the first season and Dragon Racing will partner with Venturi and run its VM200-FE-01. Andretti Autosport was one of those teams that had developed its own inverter and electric motor but struggled with the power conversion so at the end of August announced that it was going back to the drawing board and that it would be running season one's powertrain.

Both the ABT Schaeffler and Renault e.dams teams showed consistent pace in a variety of conditions over the various test days with ABT Schaeffler driver Lucas di Grassi breaking the electric car lap record with a time of 1m29.920s being set on the 170 kW new race power mode. For practice and qualifying, the power output is set at 200 kW.

The Schaeffler Group has become heavily involved in Formula E, treating it more than just a marketing exercise, and has developed the ABT Schaeffler MGU 01 electric motor, the focus being to achieve the best possible efficiency, high reliability and optimal thermal management due to modified cooling.

"Our motor has better torque and better efficiency than its predecessor," said Prof Peter Gutzmer, who as chief technology officer is responsible for the development at Schaeffler and was faced with a tight schedule. "The first meetings took place about 10 months ago and only half a year later the first parts were produced. The timing is tight, as always in motorsport, but we're on schedule."

Schaeffler also developed a new stiffer and more compact transmission that is coordinated with the motor that has been produced by Hewland according to special specifications. To achieve the goal of minimising the number of shifting events per lap, the engineers opted for a three-speed variant.

The suspension has also been optimised, the car now featuring higher stiffness and improved kinematics. The connecting link between all the elements is the newly developed software that manages the interaction between all the components. The perfection of its functionality has been one of the focal aspects of the tests.

"For us, it was clear from the beginning that we wouldn't do anything by halves. That's why we looked at all the areas released by the regulations and developed optimised solutions of our own together with our partners," said Prof Gutzmer.

"Electric mobility as a whole, including hybrid solutions as well as fully electric driving, will significantly define mobility of the future. The Formula E commitment is an ideal way of being at the forefront of this technology and sets an example – we want our engineers to push limits and to seek competition – in production just like in motorsport."

Away from the race track were further developments with Qualcomm Technologies showing off its new safety car, a BMW i8 but with an enhanced wireless charging system that delivers twice the amount of energy to the car's batteries per hour compared to last year. This approximately halves the full charge time, enabling the vehicle to fully charge in one hour. Employing Qualcomm Halo DD technology, with magnetic architecture optimisation, ensures higher coupling coefficients and drives lower system currents, higher efficiencies and the ability to support higher power levels. RT

ABOVE The safety car is an upgraded BMW i8 with an enhanced wireless charging system

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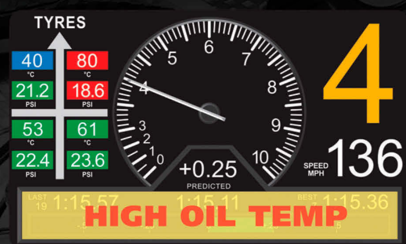

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TECHNOLOGY ANALYSIS

Fuel upgrades enhance Ferrari performance

Following Sebastian Vettel's win in Hungary, much of the performance gain was accredited to the fuel he was using. **William Kimberley** spoke to Shell's Guy Lovett to find out more

IN WHAT was a chaotic Hungarian Grand Prix, Sebastian Vettel took the chequered flag in a car that showed a marked performance improvement over the previous few races. As the season progresses, this is hardly a surprise, but part of the equation, and not one that is understood by many, is the fuel used.

Long gone are the days when a few gallons of five star from the pump are squirted into the fuel tank, that which goes into any top end racing car today is the result of months, if not years, of careful calibration to suit the specific engine. However, when press releases talk of step changes and incremental improvements, it is difficult to comprehend to the average person just what that means.

However as Shell's innovation manager Guy Lovett explained, it is all about understanding the process. "The step change has come from the growth in our understanding of the appetite of the new 2015 V6 engine for fuel. We saw from the early stages of working with Ferrari on the V6 concept that it was incredibly responsive to fuel as you would imagine it would be in a highly downsized, boosted, direct engine.

"So through last year we made some pretty good gains in terms of performance but really started to make some significant steps in the early part of this year and there's more to come, both this year and next."

The knock of the engine is one of the key challenges said Lovett. "It's only a small 1.6 litre V6 engine with a lot of boost which means that the temperatures within the combustion chamber are incredibly high and so the onset of knock is inevitable. One of the key protection factors against that is essentially the anti-detonation property of the fuel and that's quite rightly been one of our key fundamental design focus areas for our fuel formulations. It's not something that we've just invented yesterday but something that's also prevalent in road cars as downsized, turbocharged engines are things that we see on garage forecourts around the globe. It means that we've got a lot of history and a lot of expertise within Shell in optimising fuel.

"The knock aspect is one dimension and the other derives from the Sporting Regulations that have been put into place starting last year with the 100 kg fuel payload limitation per driver. This adds a different challenge to the mix because typically a component that's good for octane and anti-knock is not so good for energy density. What we want to try is to get as much energy into those 100 kg with as much anti-knock performance as we can.

"It's a sliding scale of energy density versus anti-knock properties, but it's one that's constantly changing, particularly this year as the engine manufacturers have the tokens that enable them to develop the engine within the season, so the hardware is developing and changing through the season. However, we work incredibly closely with Ferrari with perfectly synchronised development schedules and the teams work hand-in-hand to make sure we are fully exploiting the potential performance of the whole package rather than designing the fuel, oil and the engine in isolation and bringing things together because that would be sub optimal, so we co-optimise and co-engineer the whole system together to make sure that we're maximising performance where possible.

"All the technology and all the innovation that we work on with Ferrari in Formula 1 is shared with our equivalent production car fuel and oil colleagues. Apart from working in motorsport, my team is also working on developing next-generation fuels and lubricants for road cars so there's a massive amount of crossover of people, technology and expertise. Shell V-Power race fuel developed for Scuderia Ferrari, for example, uses 99% of the same type of compounds found in Shell road fuel so it's a proving ground and the fact that it is sport bringing that competitive edge means that we have to be at the top of our game and have to bring the latest technology as quickly as possible. Ultimately it's great for the consumer down the line because it channels all that technology in their direction." RT

ABOVE Sebastian Vettel discusses with Shell's Guy Lovett the intricacies of the fuel formulation that goes into his car

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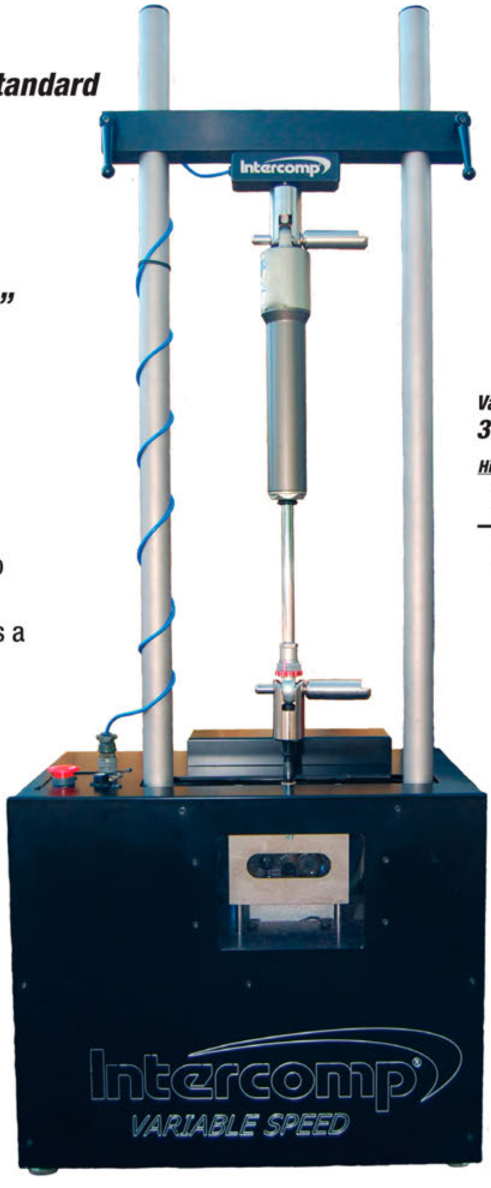

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IN BRIEF

THE Verizon IndyCar Series finally introduced its on-car LED scoring panels at the race on the Mid-Ohio sports car course on 2 August. The panels, tested before the season started and detailed in *Race Tech* 174, are mounted on each side of the faring below a car's roll hoop and show the position in which each car is running – in the picture above the car of Helio Castroneves is shown in seventh position.

HONDA'S IndyCar programme has been deducted 100 manufacturer championship points for engines failing to reach their specified 2,500-mile life cycle. IndyCar's rules specify a 20-point penalty for each engine being changed before completing the mileage, and five Honda engines were changed after the race at Iowa on 18 July.

NISSAN has announced that will not return to the LMP1 class of the FIA World Endurance Championship until it has resolved the technical issues that blighted the debut of its GT-R LM Nismo car at the 24 Hours of Le Mans. However, it will remain in a test programme until the technical issues with the car are resolved.

LATEST efforts by the organisers of the World Touring Car Championship to equalise the performance of competing cars have seen Honda, Chevrolet and Lada all relieved of weight in a bid to make them closer to the dominant Citroëns. For the next round in Motwgi, Japan on 13 September, the Honda Civics and Lada Vestas will race with base weight of 1,100 kg, 60 kg lighter than the French cars, while the RML-built Chevrolet Cruzes will be required to weigh 1,11 0kg.

DTM will keep on racing at the Nürburgring, in the fairly long term. A contract for the years up to and including 2017 was signed by capricorn Nürburgring GmbH (CNG) and DTM promoter ITR. Since its debut appearance back in 1984, DTM has contested a total of 69 races at the Nürburgring.

NASCAR has been rocked by the news that high-profile Toyota team Michael Waltrip Racing will not field a full-time entry in the Sprint Cup in 2016. The news came after Rob Kauffman, who co-owns the team with twice Daytona 500 winner and Fox Sports analyst Michael Waltrip, bought into Chevrolet team Chip Ganassi Racing. MWR lead driver Clint Bowyer has been told he can pursue other opportunities.

HAVING outgrown its old premises Nimbus Motorsport has recently relocated to a new purpose-built facility on the edge of the market town of Pocklington, East Yorkshire. Now in its 25th year of trading, Nimbus Motorsport, the distributor of thermal management products, race oils and fuels and other specialist motorsport products in Europe, has had a long search finding the right location. The new site was acquired in October 2014. Construction of the bespoke office and warehouse began in February 2015 and was completed ready for the move in June. Thanks to the design of the new facility, Nimbus can accommodate the storage of race fuels, a market that Torco Race Fuels and Fuse Fuel have been keen to develop with Nimbus Motorsport. Outside of motorsport, Nimbus has experienced major growth in the supply of products to vehicle manufacturers and the oil and gas industry. RT


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THE ROAD TO 2020

Environmentalism in motorsport - a quest for the impossible?

We are delighted that both **Ulrich Baretzky**, Head of Engine Technology at Audi Sport, and Formula 1 consultant **John Iley** have both agreed to be our Chairmen again, chairing what should yet again be a lively debate, judging by the interesting response we have so far received, including:

- After the important step of introducing energy based rules, the next step has to follow as soon as possible, which might mean a C02 limit, which are, of course, related to consumption but not just restricted to that. The introduction of fuels from renewable sources and other steps could give motorsport again a dramatic push, engaging young generation people and secure the attention of both spectators and industry.

- Back to the Future: do the fans really care about motorsport being globally relevant for the society at large or do they just want a recurring remake of the first 'Mad Max' film?

- The current F1 and WEC Regulations were built as a first step toward reconnecting motor racing with the road cars industry. Now let us think about the next step and try to define who the fans are today and who will be the fans in the near future.

We are delighted that the following have accepted our invitation to be Cabinet members:

Bernard Niclot
FIA Technical Director

Russ O'Blenes
Senior Manager, Performance and Racing Team, GM Power train

Reiner Mangold
Head of Sustainable Product Development, Audi

Gilles Simon
Engineering Consultant

Pascal Vasselon
Technical Director, Toyota Motorsport GmbH

Dialma Zinelli
Chief Aerodynamicist, Dallara Automobilia

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DISC-USSION

With the ERS soon capable of providing potentially all of an F1 car's braking, **Chris Ellis** ponders the role of the disc brake

Daimler

ABOVE Glowing brakes could disappear from F1 but the discs themselves will remain

SEVERAL of the leading F1 technical directors have recently been expressing new-found enthusiasm for regenerative braking, after their initial scepticism that KERS was just a PR stunt.

Given the power limits placed by the FIA on the initial KERS systems and the other energy recovery restrictions, it was reasonable for everyone to expect little impact on performance. And so it proved, until this year when the power limit was raised to 120 kW, which even in F1 is a non-trivial 150 bhp. If there is, say, 15 seconds of braking per lap, and the efficiency with which recovered energy can be returned to the car is better than 60%, then there's an extra 150 bhp available out of the 'power unit' (such a misnomer!) for up to 10 seconds, or 100 bhp for 15 secs, etc.

Now imagine a 2017 car with a thousand horsepower (peak) for acceleration, made up of 400 from the ERS and 600 from the engine. With reduced downforce, the peak braking power required might be 'only' 2,000 bhp, with the ERS initially providing 20% of the total, that percentage rising as the car's speed falls. So the presence of a strong and fully utilised ERS will reduce substantially the heat generated in the discs. In the limit, somewhere in the near future, the ERS will become capable of providing potentially all of the braking, and the incentive for doing so will be the extra acceleration it can provide. As the ERS becomes more efficient and powerful, the role of the engine will increasingly focus on overcoming drag, and it will be less involved in providing acceleration.

So do disc brakes disappear? Almost certainly not. For safety reasons, they will still have an important role to play. They have one key advantage – they usually degrade gracefully, unlike today's energy recovery systems which tend to fail abruptly and completely. Providing an ERS which can match the relatively high safety levels of conventional brakes is likely to prove difficult, expensive and the result is likely to be cumbersome.

We will probably see disc brakes gradually shrink in size and weight, but not in power. They will always operate, lightly, in parallel with the ERS, essentially to keep warmed up. The discs themselves will be sized to be capable of supporting a single braking event from high speed, necessary only in an emergency when the main braking system, the ERS, has failed. They won't need to be ventilated, or carbon-based. Perhaps titanium?

I have speculated previously that four-wheel drive and recovery would open up the possibility, once again, of inboard front discs, following the original example of the Ferguson P99 back in 1961. However, having thought this through, I believe the advantages of locating the discs inboard are minor in an F1 car when the cooling required diminishes significantly. Also, reducing unsprung weight in a vehicle with very little vertical wheel movement has a relatively minor effect on cornering performance. And there is a strong positive reason why the 'backup' brakes should be outboard. What if a driveshaft fails?

This will become as likely to happen during acceleration as braking, once the power and torque levels of ERS reach their full potential, so it seems sensible to keep the disc brakes where they are, particularly as they can become much lighter. Consequently, full emergency braking will remain available, no matter what has happened inboard. Assuming a flailing driveshaft hasn't taken out a brake line…

The challenge will be to develop a control system which will fully engage the disc brakes the instant a failure of the ERS during braking is detected. Don't ask me how, I'm just a systems engineer. We are paid to ask the difficult questions, not answer them! RT

FLOORED ARGUMENTS

If we want the next generation of Formula 1 cars to overtake each other on the racetrack, there's one area the 2017 rules need to focus on. Our **Expert Witness** – a knowledgeable insider – explains why F1 is poised to introduce a modern form of ground effect

No one area of aerodynamic car performance has courted more innovation, debate, discovery and controversy than the floor of the racing car.

The explanation for this is extremely simple: since the realisation of its incredible potential, it remains the single most efficient way of producing downforce on the vehicle – despite all of the regulatory efforts to militate against it. This is a pure function of geometry and physics. A combination of ground proximity, entry detail, large surface area and exit area expansion makes this a great opportunity to generate a large volume of low pressure with considerable control and minimal rearward-facing or drag-inducing components.

Such is the floor's influence that the rule frameworks governing the area vary hugely from one category of racing to another. Little wonder, then, that the issue has forced its way back onto the radar for 2017 as we discuss ways to improve the racing and the platform stability. As a device, unlike wings at the car extremities, it can smooth out or even harness rotational or disturbed flow, making it ideal to maintain a car's balance when running close together with other cars. If executed correctly, it will promote overtaking. You then have to ask two questions: 'Why was it ever taken away in the first place?' and 'What should we be doing going forward?'

FUNDAMENTALS

So what mechanism is actually happening here? Curvature or camber around an external aerodynamic surface creates a higher speed flow and lower pressure. But, following Bernoulli's principle, when that surface is moved into ground proximity, the area and volume for the air to pass through is reduced – this further increases the speed and lowers the pressure. Because of the much lower pressure, and the differential with the surrounding flow, there is the inevitable path to try and equalise this, one that can be blocked by sealing or diverting this leakage.

Geometry is the key control factor here. Most dominant is the exit area of the floor or diffuser: the larger or higher the exit area, the more the potential, hence this being traditionally used as a legality height. However the inlet detail, height from the ground, ramp angle, curvature, sealing and shape of the floor itself all contribute to this differentiating device. (See Figure 1.)

GROUND EFFECT

Wing profiles appeared on racing cars in the late '60s, but Peter Wright at March, BRM and then Lotus is widely credited with the successful application of 'ground effect': instead of adding wings to the cars, why not make the whole car the wing. The pioneering work was carried out at the Imperial College wind tunnel in London, newly equipped with

LAT

ABOVE Since the glory days of ground effect, the influence of the floor has been a constant target for legislation. Compare the proximity to the ground, the sealing, and the simplicity of the wings evident on this 1981 McLaren MP4-1 (left) with last year's Red Bull RB10, both pictured at Hockenheim

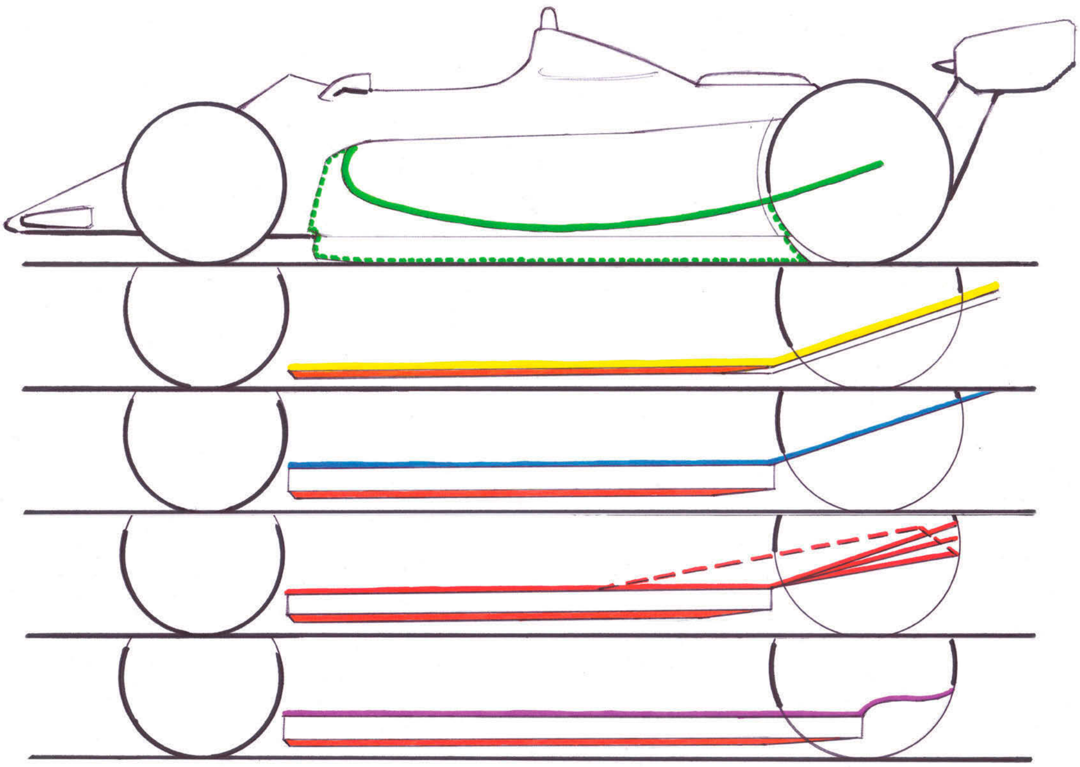


FIGURE 1 The five steps of F1 floor emasculation

1. Top/green: a full proper ground effect skirted wing car of the 1979 season

2. Yellow: flat-bottomed car of 1983-94, the 10 mm plank being added as a result of Imola

3. Blue: the 50 mm lifted step plane is added in 1995 to promote leakage

4. Red: 2005-2010, the systematic reduction of exit height apart from the double diffuser sat on top of the prescribed legality area (dashed) in 2009

5. Purple: today, a fraction of the height, potential or area compared to all the above

> ***"Unlike wings, the floor can smooth out or even harness rotational or disturbed flow, making it ideal to maintain car balance when running close together"***

a moving ground plane to better simulate the movement of the road underneath the car. The initial results were so impressive they were hard to believe and quantify, not least because the huge loads on the model were causing it to deflect and distort, a principle later harnessed for benefit…

In an unofficial experiment many years later I too have seen 'skirts' fitted during a wind tunnel test. The resulting smoke, model droop and huge over-load on the balance at the first two ride heights before we had to stop were impressive!

As those first F1 concepts found in the late '70s and early '80s, you can have too much of a good thing. Getting the curvature and ground proximity control right was challenging and, as with the wind tunnel model at Imperial, finding the structural stiffness and integrity to cope with the load increases was something that caught the initial designs out. Chassis stiffness, suspension members, spring rates, bodywork structure and even wheel design would all have to evolve significantly to cope. The other technological arms race was to find a way of successfully sealing the edge of the car to the ground, maintaining the low pressure created.

Staley/LAT

'SKIRTS' AND SEALING

Gordon Murray had realised there was aerodynamic benefit to be had from the floor already, having experimented with the sharp lower edges of his early Brabham designs generating downforce. The iconic BT46B 'Fan Car' was the extreme execution of this – the cooling fan also happened to evacuate the air from underneath the car, giving it phenomenal grip in the only race it won before it was declared illegal. Along with Dave North, Murray too understood that to maintain this suction beneath the car you somehow needed to seal it. A periphery of hollow flexible tubes was arranged under the edges such that when ▶

BELOW The larger or higher the exit area, the more the potential. The ground effect Renault and Ferraris of 1982 exploited such geometry to the maximum

LAT

ABOVE & INSET If the Lotus 79 (left) was the first car to take full advantage of ground effect, then Brabham’s BT46B fan car (right and inset) drove a spectacularly fast cart and horse through the regulations. To this day, the lesson curbs rule-makers’ enthusiasm for floor-generated downforce

> *"Those early cars were allegedly producing an incredible L/D of 10. A 2015 F1 car will have an L/D of around 3.5"*

in motion they would inflate to provide a balloon-like cushion seal to the track.

The solution created at Lotus, then widely copied up and down the grid, was to produce a 'sliding skirt'. Having initially experimented with brushes and skirts angled to the track, a vertical sprung system housed in the wall of the sidepod was arrived at. Made from stiff plastic with ceramic edges to prevent it from being worn away, the springs would allow it to remain in contact with the surface despite the changing height of the car and bumps in the surface.

It was not always reliable, however. The risk of a skirt jamming in the 'up' position after striking a chicane kerb would leave a driver completely unaware he had lost half of his car's downforce before he entered a previously flat-out section of corners.

In 1979 Williams produced their first 'ground effect' car, the Patrick Head-designed FW07, but despite the car's promise it wasn't challenging strongly for victory until legend has it they made a discovery at the pre-British Grand Prix test at Silverstone. It was noticed that the underfloor wing profiles had holes to clear the exhaust that would leak pressure from inside the car into the underfloor. A couple of pieces were fabricated overnight to seal these up and the car suddenly lapped over a second faster.

The dismay of opponents up and down the pit lane is apparently fondly remembered by Sir Frank. It was swiftly followed by a dominant first win for the team at their home race and by four more from the remaining six grands prix.

SAFETY AND FRAMEWORK

So here lies the difficulty of getting the scope of the rules right. With its power and efficiency, a ground-effect car (or one with a high proportion of load coming from the floor) can quickly outgrow the confines, run-off and safe speeds of a traditional circuit. The ▶

The answer to the overtaking problem

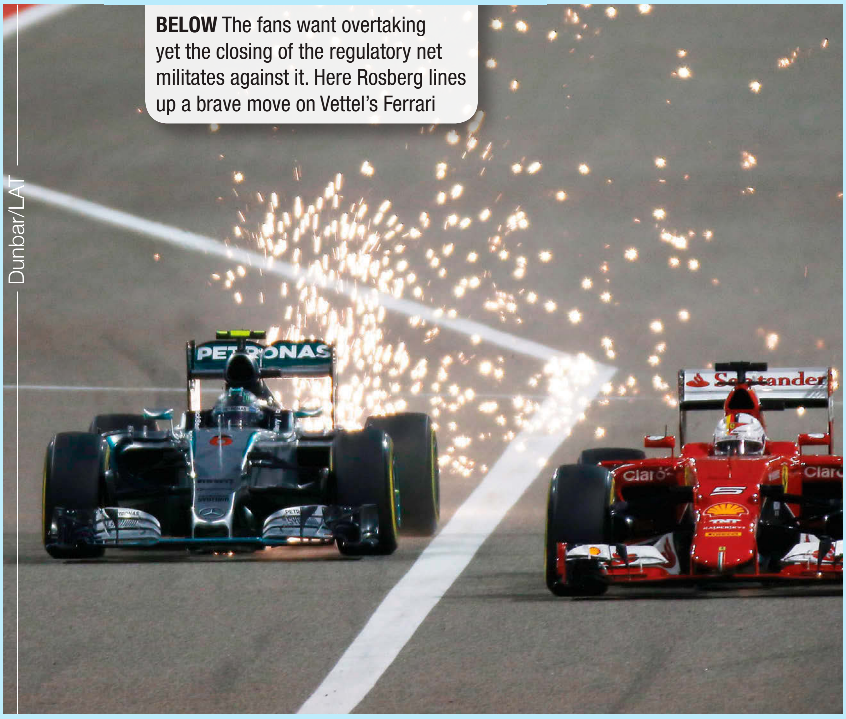
THE aerodynamics of Formula 1 cars have been emasculated over the years by the rule-makers forcing designers to rely too heavily on the front wings. If we really want our next generation of F1 cars to be able to overtake each other, then we need to stop wasting our time discussing gimmicks, like refuelling, and instead give some performance back to the floor.

The floor's geometry, if designed correctly, provides a far more robust mechanism to generating load than the highly incidence sensitive and increasingly complex and maxed-out arrays of wing elements on the current breed of F1 car. They are also critically less balance-sensitive, acting more or less at the car's weight distribution, so when following another car closely the loss is not only minimised, but not going to cause the car to understeer 'like a shopping trolley'!

The designers of those unregulated '80s cars quickly realised that with the performance of the floor being harnessed, the previously essential wings became much smaller, almost redundant, being used as trim tabs to fine-tune the aerodynamic balance of the car. Racing car aerodynamics is quoted as an L/D or a Lift/Drag ratio: the higher the number, the more efficient the car is. These early cars, with skirts, were allegedly producing an incredible L/D of 10, such was the contribution from the sealed ground effect, which in turn was 80-85% of the total vertical load on the car. For reference a current 2015 F1 car will have an L/D of around 3.5, with only about 25% of its load coming from the floor.

So here we are, 35 years later, with something like only a third of that aerodynamic potential. It's not really progress if you're an aerodynamicist… With our desire for increasing efficiency and better racing, the underneath of the car would seem to offer the best solution – if it's done correctly.

That's the big caveat because it's not just a case of putting a bigger diffuser on and everything being brilliant. You have to do proper homework on what geometry gives you a chunk of performance but does so in a stable fashion. If you end up with a car too low, or with very aggressive geometry, you can get into a stall situation where the performance is suddenly switched off and all of the load is lost in a tenth of a second. RT



BELOW The fans want overtaking yet the closing of the regulatory net militates against it. Here Rosberg lines up a brave move on Vettel's Ferrari

Dunbar/LAT

concept comes with a combination of much higher cornering speeds but also, because of the minimal drag penalty, or need for less efficient wings for downforce, high straight line speeds as well. Much depends on the size or shape of the floor permitted.

After 'skirts' were banned in 1981, there was an attempt to enforce a higher ground clearance in F1 to increase the leakage and reduce the floor benefit. This was then again neatly circumnavigated by Brabham by utilising hydraulic-actuated suspension. This achieved the required 6 cm clearance in the pit lane for measurement, but at the flick of a switch the car was back running close to the ground out on the track.

Then in 1983 the floor was no longer permitted to be shaped, but was instead flat between the trailing edge of the front wheels to the leading edge of the rear wheels. Instead of an underbody wing profile, this bred a new type of diffuser expansion system which has more or less remained until now.

This period also saw the initial use of engine exhausts, exiting directly into this new diffuser area of the floor to produce high-speed airflow and enhance suction further, keeping in mind, that like the fan car, this effect would be directly linked to engine speed. The behaviour of these flat-bottomed cars was difficult to optimise due to a long flat surface being particularly pitch- and ride height-sensitive.

There has been constant development aimed at improving the flow to this flat floor, spawning ideas like dihedral noses and barge boards, but perhaps the biggest improvement was active suspension. With its peaky performance, a traditionally-suspended car would have to be set almost rigidly stiff in order to make use of the optimum ride height for this configuration. Active suspension could artificially adjust the car's platform to compensate for its speed and load to ensure it was always sat at this very small window of optimum behaviour.

However, when this technology was regulated out in 1994, cars optimised around it were suddenly traditionally suspended again and incredibly difficult to drive. This was amongst a tragic catalogue of factors that influenced events at Imola that season. The governing body's response was swift – an in-season introduction of a uniform central longitudinal 'plank' that would by installation increase the minimum height the cars could run. Then for 1995 the addition of a 50 mm step plane, lifting the areas of the floor outside of 250 mm of the car centre line, removed performance and promoted leakage.

ABOVE & BELOW The FIA's response to tragedy at Imola in 1994 was the introduction of a central longitudinal 'plank' (demonstrated above by Damon Hill) that increased the minimum height cars could run. The device remains with us to this day (below)

> ***"I too have seen 'skirts' fitted during a wind tunnel test. The resulting smoke, model droop and huge over-load on the balance at the first two ride heights before we had to stop were impressive!"***

The next impact was felt in 1998 with the reduction in car and therefore maximum wheel width or Y position from 2000 mm to 1800 mm. This does not sound like much, but a cut of 100 mm per side moved the now grooved tyres and their detrimental wakes inboard, interfering heavily, particularly at the rear with the diffuser. This low down tyre squirt required extensive redesign of the floor, trying to recover the losses ingested.

Simple reductions in rear diffuser dimensions followed, diminishing the potential step by step: the starting position more rearward, reducing the exit height – 250 mm, 175 mm, 125 mm – all the time putting more and more emphasis on other devices to claw back the reduced performance. However in 2009, coupled to a huge rule revision, one or two teams – most famously and successfully Brawn – found a 'hole' in the floor regulations: the double diffuser was born.

In simple terms ambiguity in the bodywork definition, combined with utilising an enclosed hole, allowed a second large diffuser to be sat on top of the prescriptive standard ▶

> ***"The single most efficient way of producing downforce on the vehicle"***

diffuser. It is a concept mimicked by Nissan in this year's WEC, as revealed in *Race Tech* 173. Hearings at the FIA in Paris followed to determine if Brawn's interpretation was legal or not, the implications being considerable as car structure and fundamental architecture was required to make the maximum out of the concept. It was finally clarified as legal in season and the rest of the grid had to adapt, much to their disgust. The Brawns' advantage that year was not exclusively from the principle, but equally without it history may have been very different.

Scroll forward to 2010 and a different controversy, engine exhaust again being used for its high velocity, but this time not to energise, but to seal the diffuser from the disruptive rear tyre wake. This is done by blowing the plume at the correct angle onto the sharp floor edge inside the tyre. The resulting vortex sits between the floor and the ground, then blocks the tyre contact patch jet that would normally hurt the diffuser (see Figure 2).

The gains were considerable, but the governing body was not happy, the engine being used as an aerodynamic pump. For 2011 it determined that exhausts had to be above a certain height and pointing upwards at a minimum angle to prevent this. The teams responded with the 'Coanda Effect' channels or slopes, utilising the exhaust velocity to turn the plume back down to the floor as before, despite its more remote location and direction. (See Figure 3.)

VERDICT & MESSAGE

The huge performance from the floor has made it the clear priority for teams over time and they have pushed the boundaries of legality, interpretation and tolerances. Engineers quickly find a way of recovering the losses of reduced scope or dimensions when the original intent was to make a considerable drop in downforce. This, understandably, has made those running the sport nervous of teams' ability to exploit the intent, but also the high cornering and straight line speeds have created concern over safety and circuit design. ▶

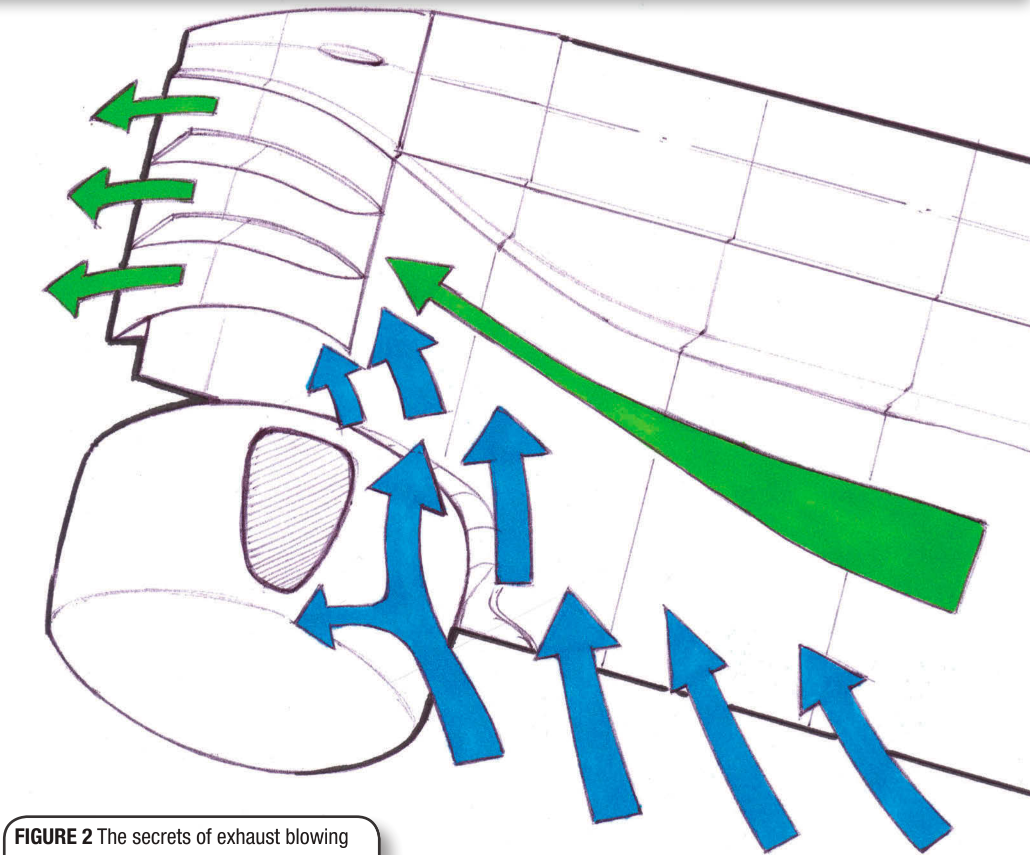
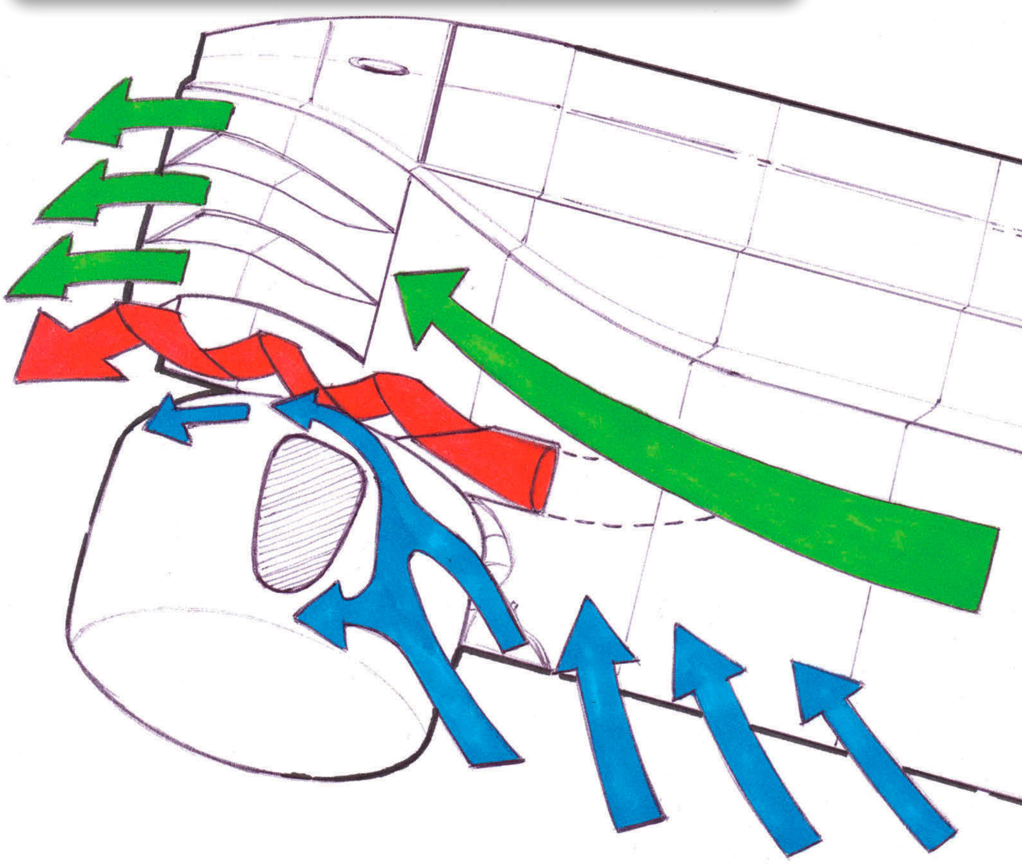


FIGURE 2 The secrets of exhaust blowing

ABOVE A standard stepped floor of 2010. A combination of the low pressure underneath, the lifted sides and the blockage and detrimental 'squirt' of the rear tyre all reduce the potential of the floor (green) with the inwash from the side (blue)

BELOW An exhaust-blown floor of 2011. By blowing the high-speed exit gas from the tailpipe at the right angle onto a delta edge, a vortex can be spun up (red) that sits inside the tyre, outside the diffuser and under the floor. This then acts as a virtual 'skirt', blocking the tyre squirt and leakage (blue) and much improving the floor potential (green). It also adds load itself, it being a high-velocity vortical flow sat underneath the car. At its peak ON to OFF this could be up to +/-30%, which led to some interesting driving techniques, fuel consumption and throttle maps

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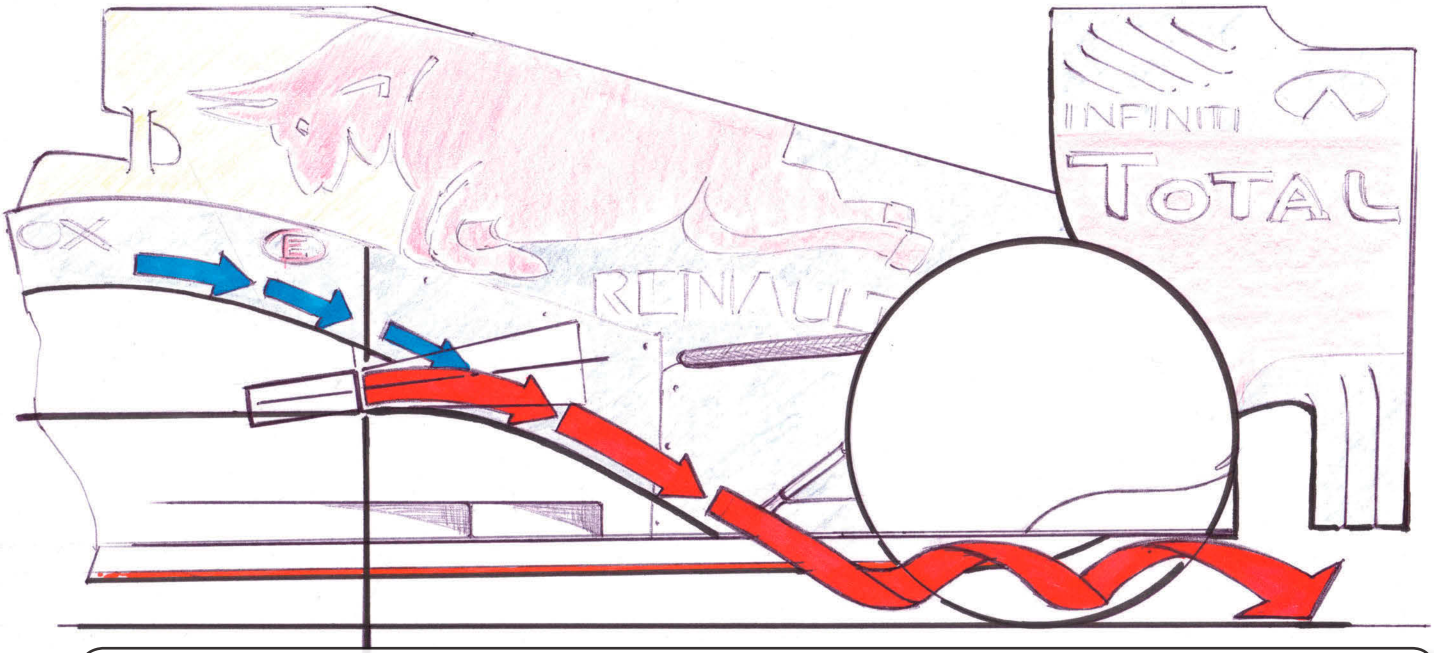

FIGURE 3 Coanda Effect
In 2012 the FIA came up with a new forward, high, angled up, round, parallel for a distance and even a cone of bodywork exclusion for the exhaust tailpipe position to prevent blown floors. However teams discovered that even respecting all this they could turn the flow down and along a surface back to a floor edge, spinning up the diffuser-sealing vortex (red), using top deck shape and devices (blue). The Coanda Effect was more difficult, complicated and expensive, but almost as good as before

However, because of the mechanism it uses to create load, ground interaction and low pressure below the whole central part of the car, the floor is the most stable and predictable performance factor, least affected by the wake of the car in front. Therefore, with the 2017 rules under consideration, I would urge the governing body to give sufficient power and scope back to the floor, along with components such as rear tyre and wing size (frontal area), to maintain a sensible drag target.

So are we talking a return to 'ground effect'? Yes and no. Some have been quick to don the nostalgia goggles and take up the term – it could maybe be bracketed as such, because we are considering interaction with the ground to enhance performance – but nobody is advocating anything like the level of performance, the 'bells and whistles', most would equate with the glory days of ground effect.

The revisions must, of course, be mindful of the car stability issues we continue to see in IndyCar and the WEC in yaw or spinning conditions.

At some point, we should get away from penalising efficiency. For as long as we do so, technical talent is forced to find more expensive, less direct ways of trying to achieve the best answers that were there to start with. That approach isn't exactly the paragon and proving ground for performance innovation that motorsport should be. RT

AP

IndyCar

ABOVE & BELOW IndyCar's opening up of aero freedom this season and some of the spectacular incidents to which it led, offered a timely reminder of the need for research into benign floor characteristics. The governing body quickly mandated that a hole be cut in the floor (below) to reduce performance technical analysis

Giorgio Piola

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A GUESSING GAME? PART 1

After 120 years most engine builders are selecting the camshaft valve event timing based on a combination of experience, dyno test results and a big dose of guesswork. But shouldn't we have moved on from there? **David Vizard** investigates power-critical valve event criteria – what works, and why?

of experience and liberal application of what is often known as 'common wisdom'. Unfortunately the engine design factors that affect what is optimal for each individually built engine, even when it is largely of the same type and similar specification, are only minimally understood or appreciated by the performance engine building community at large.

ALTHOUGH we tend to think of race engines having twin cams and four or more valves per cylinder, the truth of the matter is that there are far more two valve single cam race engines in the world today than any other type. Indeed most of those are two valve per cylinder single cam pushrod V8s. Unlike their more complex brethren, these simple single cam (or SOHC) engines all suffer a common, and usually negative, camshaft characteristic. That is, other than cam advance or retard, whatever is ground on the cam is what the engine has for valve events.

In other words, the overlap generated by the intake and exhaust duration and the Lobe Centreline Angle (LCA – see Figure 1 for definition) are fixed.

For an engine with a single cam, the spacing of the valve events is fixed: if the event timing is less than optimal it either means making do (not something I subscribe to) and accepting that whatever the dyno shows is it as far as output is concerned, or testing one or more cams. Without some knowledge of factors influencing optimal valve events, the determination of such can take a lot of costly and time-consuming testing and numerous and equally costly cams.

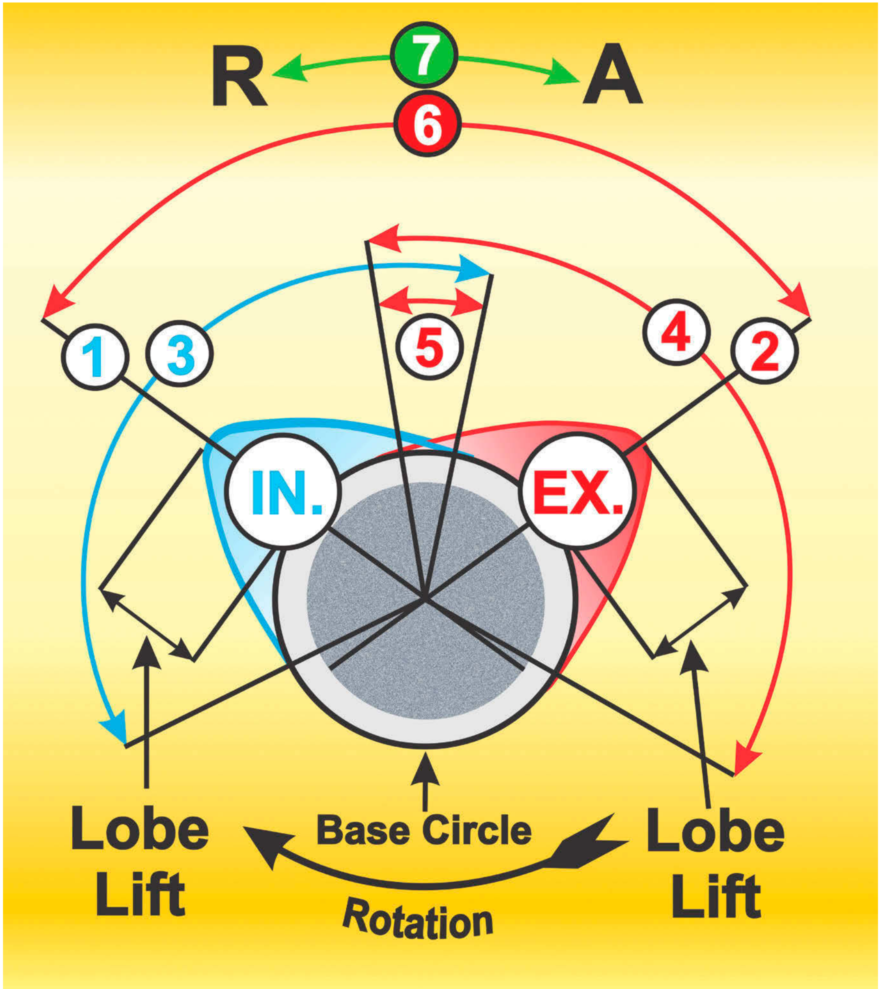


FIGURE 1 Here are the various cam parameters being discussed. The most important are the intake (1) and exhaust centre lines (2), the LCA (6) and its relation to cam advance where all events happen earlier (A) and retard where they happen later (R). The intake duration (3) and the exhaust duration (4) have their position on the cam controlled by the LCA (6) (also known as the Lobe Separation Angle) and this positioning along with the duration involved dictates what the overlap (5) will be

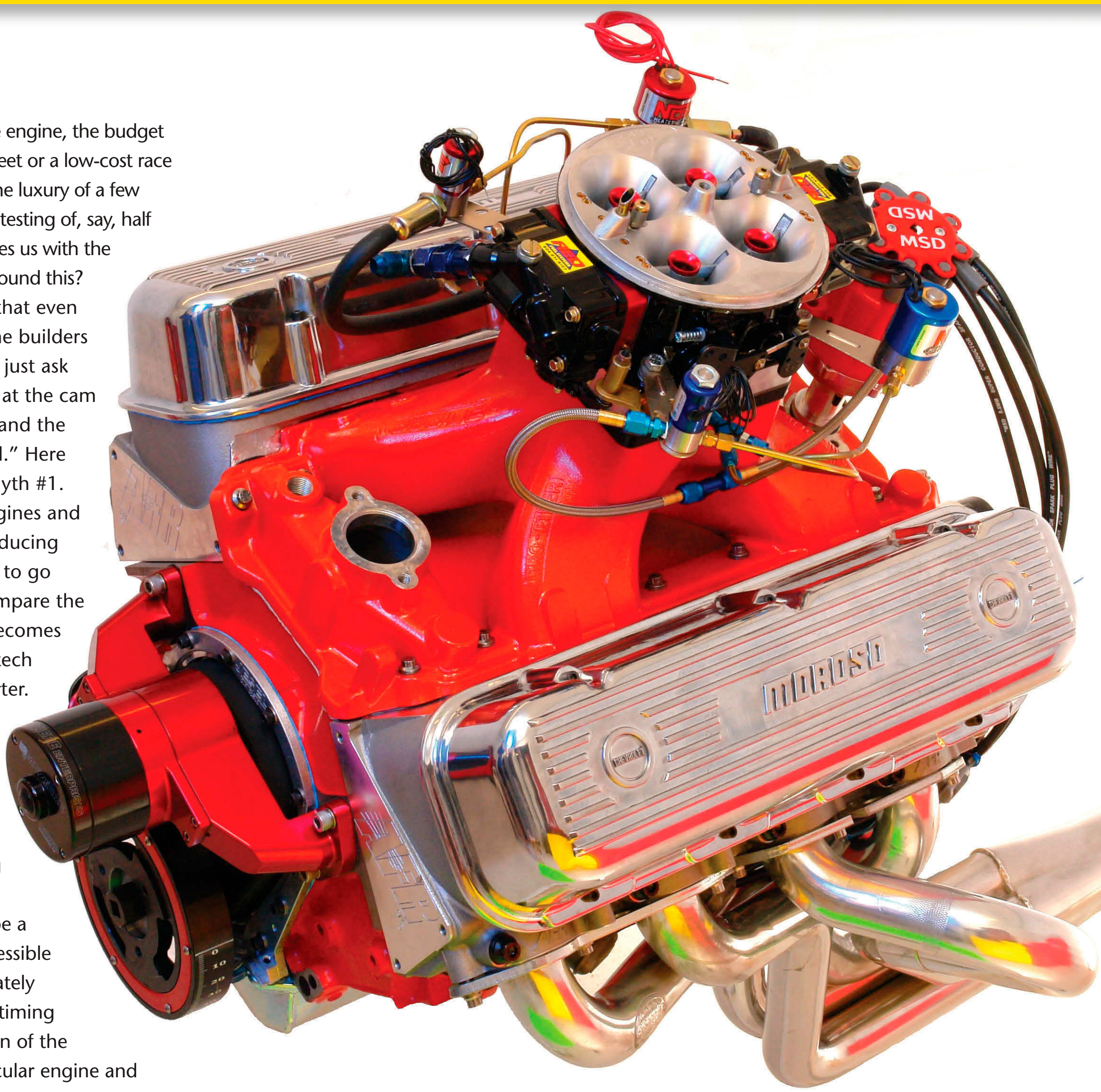
COMMON WISDOM?

In many instances single cam performance engines are built with cams that have event timing that is the engine builder's sum

Unlike a well-funded race engine, the budget to build a performance street or a low-cost race engine rarely extends to the luxury of a few days on the dyno and the testing of, say, half a dozen cams. So this leaves us with the question: is there a way around this?

I am sure at this point that even many experienced engine builders would simply say, "Well, just ask your favourite tech man at the cam company you deal with and the problem is largely solved." Here goes what is probably myth #1. If you dyno test your engines and swap cams until it is producing strong enough numbers to go public with, and you compare the first cam to the last, it becomes evident that calling the tech man is almost a non-starter.

Whereas the cam industry at large has a substantial number of cam designers who are not just good, but exceptional, at designing dynamically sound lobe profiles, there seems to be a near zero number of accessible experts capable of accurately determining what event timing will ensure the production of the best output for the particular engine and application involved. I am sure they are out there but, with over 50 years' experience building and dyno testing engines, I have yet to find one that is able to consistently produce top results.



ABOVE This Vizard-built 492 cubic inch displacement (8,064 cc) big block Chevrolet engine is totally street drivable with an idle speed of 650 rpm. Its output is 784 hp and 688 lbs-ft of torque – all achieved on 87 octane (R+M/2) service station fuel. The key to its success is cam event timing that best suits the engine's design parameters

This is (or more accurately was) a factor very important to me as it could possibly be the making or breaking of my career. Unlike most engine builders I am in somewhat of a unique, and for most, unenviable position. I build engines that target top results and then explain, in detail, to the public at large, how it is done. In other words, and unlike almost all other automotive tech writers, I am totally responsible to a very substantial and critical public audience for the functionality of the material I deliver.

If I am to stay in business, then every month will call for at least one hi-tech engine build that is at least as effective as its equivalent top professional build. In my business this means that, in effect, every month I have to compete against all-comers in terms of usable tech delivered to the reader. It only takes a few months not meeting this goal for a 'show better how it's done tech writer' to be out of business.

As far as making horsepower went, I had one major asset favouring my power-seeking efforts. I constructed my first flow bench to better modify heads for 'A'-Series engines during May of 1958. So by the time I did my first engine build feature in 1969 I already had over a decade of flow bench experience. So having a good handle on what worked in terms of induction, heads and exhaust was well catered for but, when it came to valve events, it was almost like stepping into a black hole.

I asked questions concerning valve event timing of a number of the then-world class cam designers on what I might try for a particular build. Ironically, I was worse off after this as no two answers were the same. Though this may come as a surprise, the situation has not changed that much to this day.

If you find that hard to believe then try, ▶

ABOUT THE AUTHOR David Vizard will, over the next few months, be writing a series of 'hands-on tech' articles for Race Tech. Subject matter will be across the board.

David, a championship-winning engine builder/engineer currently has over 53 years of developmental airflow and dyno testing experience on which to draw for editorial material. He has consulted for various F1 entities as well as Aston Martin, Ford, Chrysler and GM to name but a few. He has also authored almost 4,000 magazine articles, 36 books and over 40 patents.

for a single cam engine, calling around for cam spec recommendations. The chances of getting two cams of like spec are almost as much of a long shot as winning the lottery. With differences that are typically seen one thing is undeniable: they can't all be right!

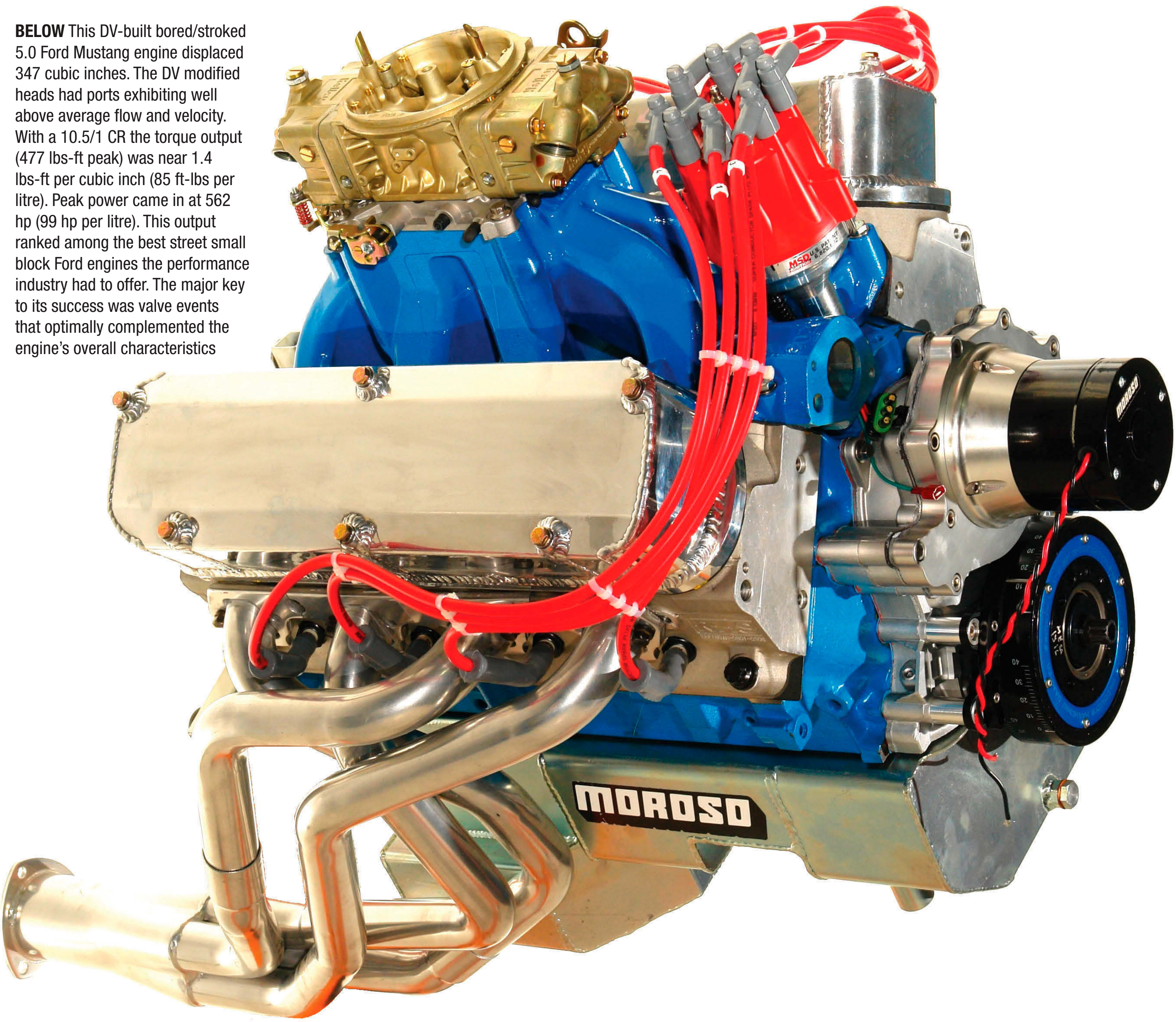
The foregoing situation was one I was confronted with almost from the outset of my engine building/journalistic career. Very early on I could see that, as would be so for a race-winning engine builder, any success I may have as a tech writer of worthwhile standing within the professional engine building community could very well hinge on my camshaft expertise.

Although my venture into the world of race cam technology began in 1960 with the installation of a BMC 544 cam in my 948 'A'-Series engine, it really did not start to take off until my association with the late Harvey Crane in 1967. At first Harvey and I collaborated on small cam test projects but by 1980 my situation in regard to the production of magazine tech features had changed out of all proportion to that of 1967. I now had a comprehensively-equipped shop in Riverside, California.

> ***"It matters little how dynamically sound the cam profiles are if they open and close the valves at the wrong time"***

To do my tech features I had not only a computerised dyno and flow bench but also a seat and guide machine, mill, lathe, extensive porting and welding facilities and so on. Indeed all the equipment that a real tech writer should have to verify what performance product manufacturers claim of their wares.

Where the start of the real cam event technology occurred was late 1984 when Harvey offered to fund a project to test not just a dozen or so cams but hundreds. The test engines were three small block Chevrolet units of 310, 355 and 406 cubic inches. I built a number of head selections with differing valve sizes and combustion chamber volumes so that each engine displacement's event timing ▶



BELOW This DV-built bored/stroked 5.0 Ford Mustang engine displaced 347 cubic inches. The DV modified heads had ports exhibiting well above average flow and velocity. With a 10.5/1 CR the torque output (477 lbs-ft peak) was near 1.4 lbs-ft per cubic inch (85 ft-lbs per litre). Peak power came in at 562 hp (99 hp per litre). This output ranked among the best street small block Ford engines the performance industry had to offer. The major key to its success was valve events that optimally complemented the engine's overall characteristics

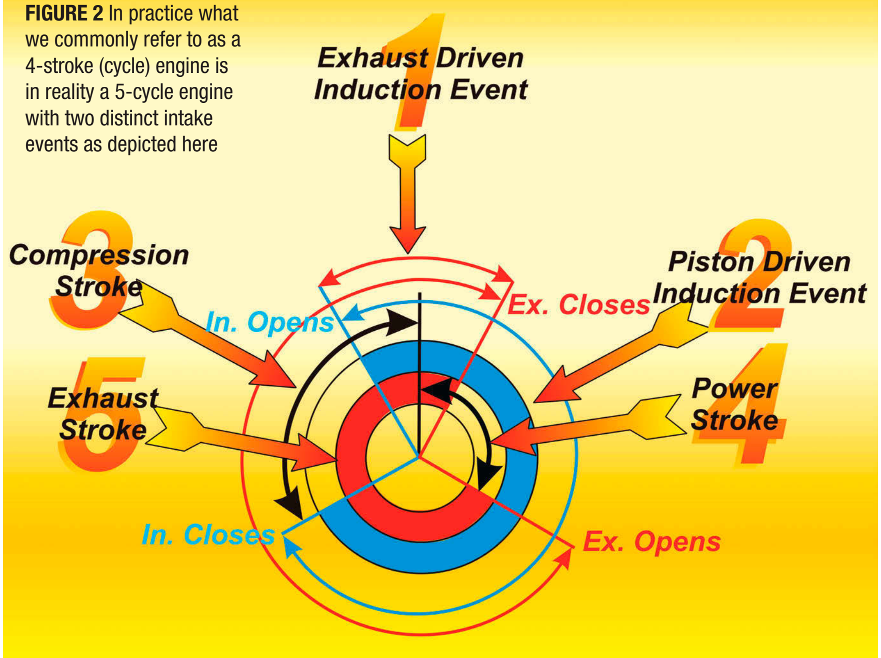


FIGURE 2 In practice what we commonly refer to as a 4-stroke (cycle) engine is in reality a 5-cycle engine with two distinct intake events as depicted here

could be evaluated with different CR and flow characteristics.

In addition to this an adjustable cam drive was installed and each engine was externally modified to make cam changes as rapid as possible. Indeed with the 'production line' setup used, a cam change could be made in less than 20 minutes from shut down to start up. In something less than two years these tests produced over 8,000 meaningful combination test results.

About a year or so later I headed up a design/test programme for Kent Cams. At my California shop and with considerable assistance from Dave Mountain (Mountune Race Engines), Mike Parry (Race Techniques) and David Anton (Advanced Performance Technology), tests, over a two-year period, evaluated over 11,000 meaningful combinations in a variety of engines. I am ▶

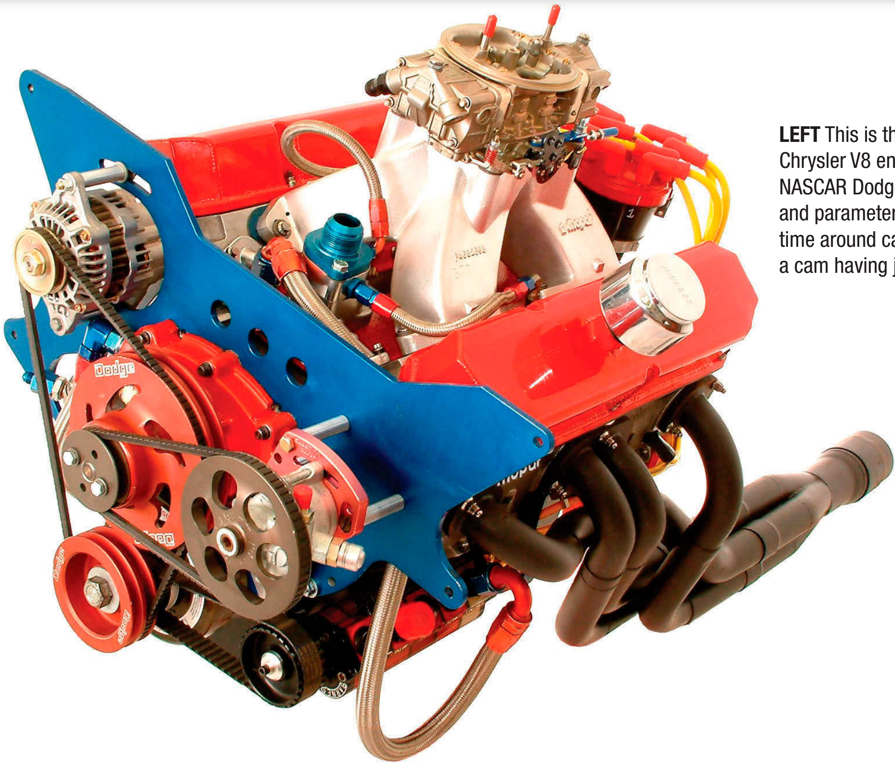
ABOVE Increasing the engine's displacement by virtue of a longer stroke (stroker) crank is a popular way to increase torque output. Unfortunately it is often the case that as little as 50% of the increased displacement is fully utilised because the cam selected does not reflect the engine's new gas dynamics characteristics. Matching the cam's event timing to the engine's new requirements can easily double the torque gains of a stroker crank

What is a 'Test Combination'?

WHEN first confronted with the number of cam tests done most people question if the time was available to do so many tests during the timespans involved. However the test engines were built explicitly for the purpose of testing cams and doing so in a speedy manner. These engines were equipped with electronically-controlled carburetion, so mixture changes could be done from the dyno console. The same applied to ignition timing. Mixture was tracked by means of O2 sensors in each exhaust pipe. This is being pointed out to show that an optimal setup was always in force when tests were run.

The cam test 'combinations' referred to in the main text do not represent the number of cams involved but rather the number of cams times the number of ways they were tested. A test 'combination' would involve the selection of the test cam and this would be installed 4 degrees retarded with say a 1.5/1 ratio rocker valve train. Tests would then be run with the cam first at the 4 degrees retard, then 2 degrees and so on until the peak output was found which would typically be between 2 to 4 degrees advance. After this the intake rockers would be changed to 1.6/1 and the tests run again.

Once that series was complete the exhaust rocker ratio would be changed to 1.6 and the test series re-run. So for one cam up to 15 test combinations could be run. In practice it is easy to see that some tests were way off the pace, so would be aborted. This typically resulted in some eight to 12 tests per cam. Once a series of cams had been done, the heads would be changed and the entire series run again and so on. After extensive testing with one engine displacement, another whole series was done with a different displacement engine. RT



LEFT This is the first and to date only 350 cubic inch (5.7 litres) Chrysler V8 engine I have built. It is intended for my restored 2003 NASCAR Dodge Intrepid. The cam was selected using the principles and parameters discussed in this feature. The result, from a first time around cam selection, was 93 lbs-ft per litre and 703 hp with a cam having just less than 300 degrees of off-the-seat duration

quoting the numerical extent of these tests to make it clear that what you are about to read is based probably on more tests than has been done by any single group within the performance industry. The reason I make this point is that some of what you are about to read goes contrary to commonly accepted practice.

EVENT MISCONCEPTIONS

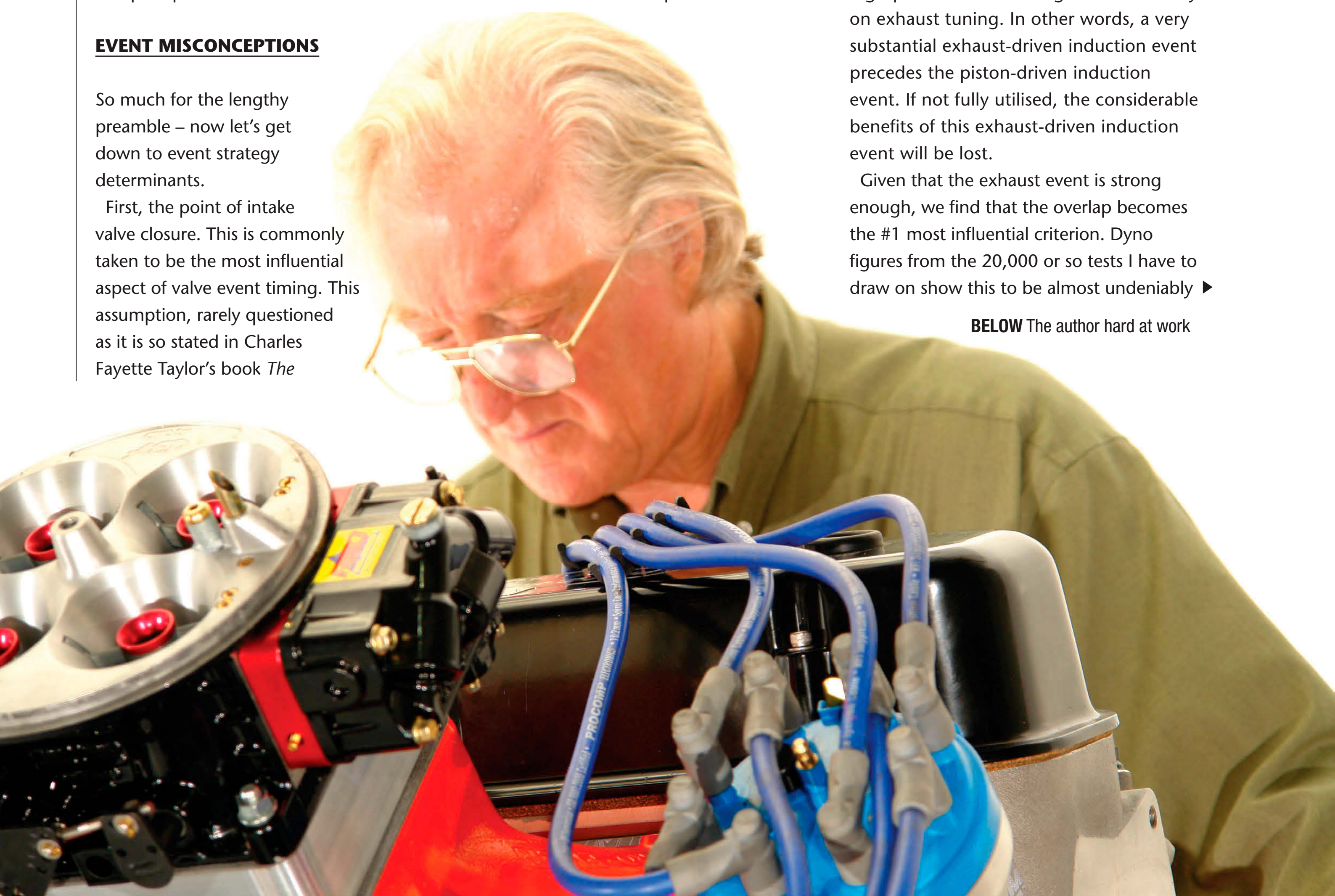
So much for the lengthy preamble – now let's get down to event strategy determinants.

First, the point of intake valve closure. This is commonly taken to be the most influential aspect of valve event timing. This assumption, rarely questioned as it is so stated in Charles Fayette Taylor's book *The Internal Combustion Engine*, is not even close to being so for the kind of engines being discussed here. Taylor's work was mostly in connection with big, low rpm, aero engines with little or no exhaust tuning effects. A modern high-performance engine is far from such. During the overlap period, pressure waves well below atmospheric act as a powerful induction source, starting well before the piston begins what we commonly refer to as 'the induction stroke'.

Indeed for a well-specced pushrod engine with a cam of anything more than about 285 degrees duration, the exhaust-driven induction event draws harder on the intake port than does the piston at peak velocity down the bore. Some numbers here to make the point. While demonstrating the value of port and 'in-cylinder' pressure measurements during one of my seminars at the University of Northwestern Ohio, the 525-inch big block Chevy test engine showed 8 psi below atmospheric in the combustion chamber at the overlap TDC point prior to the commencement of the induction stroke but only 1 psi below atmospheric when the piston was at peak velocity on its way down the bore.

Although the pressures differ from engine to engine, any well-tuned/developed high-performance NA engine relies heavily on exhaust tuning. In other words, a very substantial exhaust-driven induction event precedes the piston-driven induction event. If not fully utilised, the considerable benefits of this exhaust-driven induction event will be lost.

Given that the exhaust event is strong enough, we find that the overlap becomes the #1 most influential criterion. Dyno figures from the 20,000 or so tests I have to draw on show this to be almost undeniably ▶



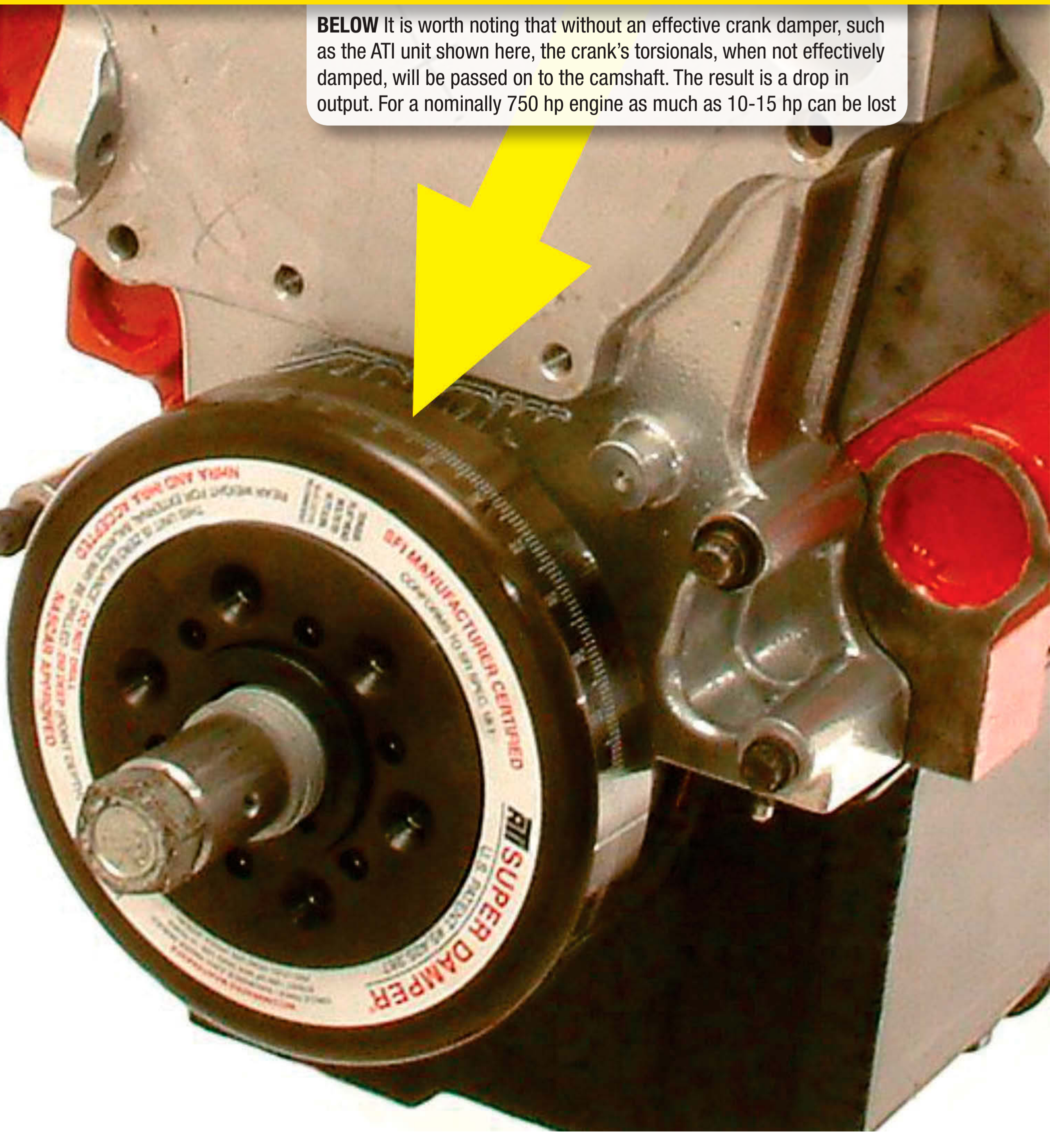
BELOW The author hard at work

so. To put it into perspective, dyno tests have demonstrated a two-degree change in the Lobe Centreline Angle (LCA) of a single cam engine (which gives a four-degree change in overlap) brings about output changes between 400 and 600% greater than simply extending or shortening the intake closing point by four degrees.

It is this belief concerning the intake closure point importance that brings about so many far less successful builds of what the performance engine building industry commonly refers to as 'stroker motors'. Based on the commonly held intake valve closure strategy, many stroker motors are built with cams having a greater delay to the closer point ABDC than their smaller displacement shorter stroke kin.

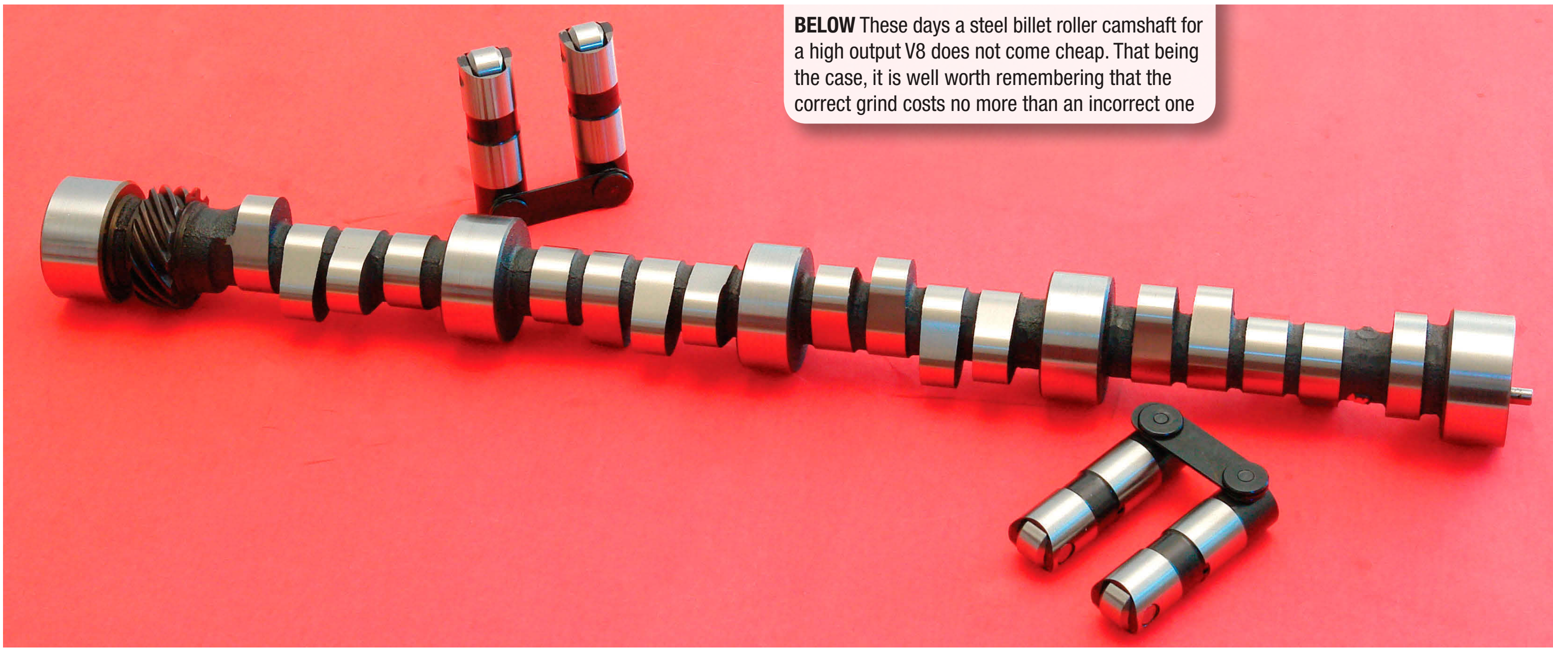
What should have been done here is to tighten up the LCA so a greater amount of overlap was given. While the extended time to closure may bring about an increase in top end output, it totally fails to capitalise on the torque potential of the extra displacement.

The foregoing concerning delayed closure versus a re-appraisal of overlap brings about a point well worth keeping in mind and it goes like this. If the induction stroke is not optimised during the first half of the event, there is *absolutely nothing* that can be done to redeem it in the second half. This fact alone should be proof enough that our primary focus should be on what goes on during the overlap and what proportion the overlap is in relation to the complete valve event duration.



BELOW It is worth noting that without an effective crank damper, such as the ATI unit shown here, the crank's torsionals, when not effectively damped, will be passed on to the camshaft. The result is a drop in output. For a nominally 750 hp engine as much as 10-15 hp can be lost

The question now is: 'what does it take to get optimal events virtually the first time around?' The answer is the COS-Cam program. For those in dire need of a cam spec before the next edition of Race Tech hits the news stand, Google COS-Cam (Computer Optimized Spec-Cam) to access this program. But COS-Cam will only give you answers – it won't explain the 'whys'. For those who want to know, the engine parameters that principally affect the cam spec will be detailed in the next instalment. RT



BELOW These days a steel billet roller camshaft for a high output V8 does not come cheap. That being the case, it is well worth remembering that the correct grind costs no more than an incorrect one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DREAM MACHINES

LMP3 is quickly establishing itself as the first rung on the endurance racing ladder. The category may be new but, as ACO technical director Vincent Beaumesnil tells **Chris Pickering**, the dream has long been cherished

All photos: ELMS

ABOVE Beaumesnil: high hopes for the new formula

WHAT is it about endurance racing that makes it such a magnet for gentleman drivers? Dot com billionaires, investment bankers and Hollywood stars alike are drawn to the category like well-heeled moths to a particularly bright flame.

Perhaps, even for individuals moving in such rarefied circles, it comes down to access. Unlike the Monaco Grand Prix or the Indy 500, it is relatively realistic for a well-funded amateur driver to aspire to a spot on the grid at Le Mans. Unlike the pint-sized professional drivers, weaned on protein shakes and karting competitions, many only take up the sport later in life. South African businessman Jack Gerber, for example, was 68 when he raced at Le Mans in 2013, clinching a spot on the GTE-Am podium in the process.

It's this disparate bunch of overachievers at which the new LMP3 class is squarely aimed. In fact, teams are limited to no more than one 'Platinum' driver per car and those that do have a professional on their squad must have at least one 'Bronze' driver (without a 'significant motorsport record') to balance them out.

"LMP2 is becoming very professional now, so we wanted something that would provide the first step to Le Mans," comments Automobile Club de l'Ouest technical director Vincent Beaumesnil. "The LMP3 concept was an idea we'd had in our minds for several years. We wanted to go in a similar direction to the LMPC Formula Le Mans car but improve the concept."

First and foremost, improving the format meant making it cheaper. An initial cost cap of €195,000 was set for the complete turn-key car, although this was subsequently raised to €206,000 – largely due to fluctuations in the pound and the yen (the engine eventually being sourced from Nissan in Japan, while the gearbox comes from Xtrac in the UK). Clearly that's not pocket money, but it's comfortably less than any new mid-engined Ferrari, which seems like a bit of a bargain, when you consider that the finished product resembles an LMP1 car in miniature.

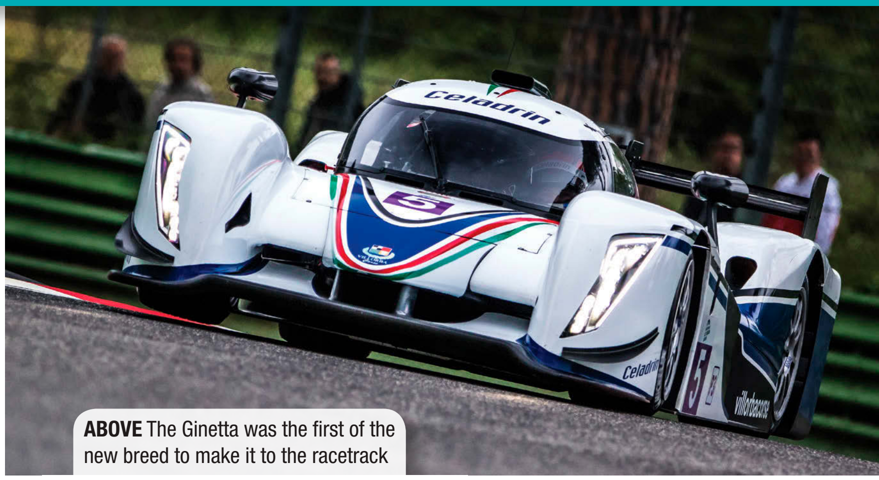
Closed cars are becoming very popular with gentleman drivers, but the comparison is more than just skin deep. Some aren't even allowed to compete in open cars for insurance reasons, but the LMP3 monocoques are crash-tested to the same rigorous standard as LMP2.

In order to control costs, it was decided the new formula should use a single engine supplier. A tender was put out, based on a target power figure of 380 bhp. Initially, the plan was to use a Nissan V6, but as things progressed it became clear that more power would be needed and a new target of 420 bhp was set. Fortunately the Japanese company's parts bin was able to provide a V8 that could meet this figure with ease, without any increase in upfront cost or servicing requirements.

Armed with a fixed cost of €60,000 for the powertrain, complete with gearbox and electronics, the ACO could finalise the budget and specification for the finished car. The decision was taken to allow multiple chassis manufacturers to enter the category, but to cap the headcount at just four.

"For sure, we had to push the constructors because they would like things to be a bit more expensive, but we had to balance that with the teams, asking them what they considered to be an affordable budget for the top level of endurance racing," comments Beaumesnil.

He expects a full ELMS season in LMP3 to cost around €400,000 per car. That's less than half the cost of a GTE or LMP2 season. Nonetheless, he sees LMP3 as having a clearly defined spot in the hierarchy – one that's unlikely to poach drivers from the other categories within the ACO portfolio:



ABOVE The Ginetta was the first of the new breed to make it to the racetrack

> ***"A full ELMS season in LMP3 will cost around €400,000 per car. That's less than half the cost of a GTE or LMP2 campaign"***

"I think that LMP3 will attract drivers from other championships so they can start their career on the way to LMP2 or GTE, but I can't see it going the other way round. Our aim is to get more cars on the grid."

Alongside safety, reliability was one of the key requirements. "We wanted an engine, gearbox and electronics package that would be low cost and very reliable," says Beaumesnil. "With this engine it should be possible to run two complete ELMS seasons without a rebuild."

By using a large, relatively low-stressed naturally aspirated engine the ACO has effectively future-proofed the series. The target is to be around two seconds a lap quicker than the GT cars on a typical ELMS circuit (leaving the new cars approximately three seconds adrift of LMP2); if that's not enough, or if the finished cars have trouble setting that sort of pace, there's always the option of turning the wick up on the V8.

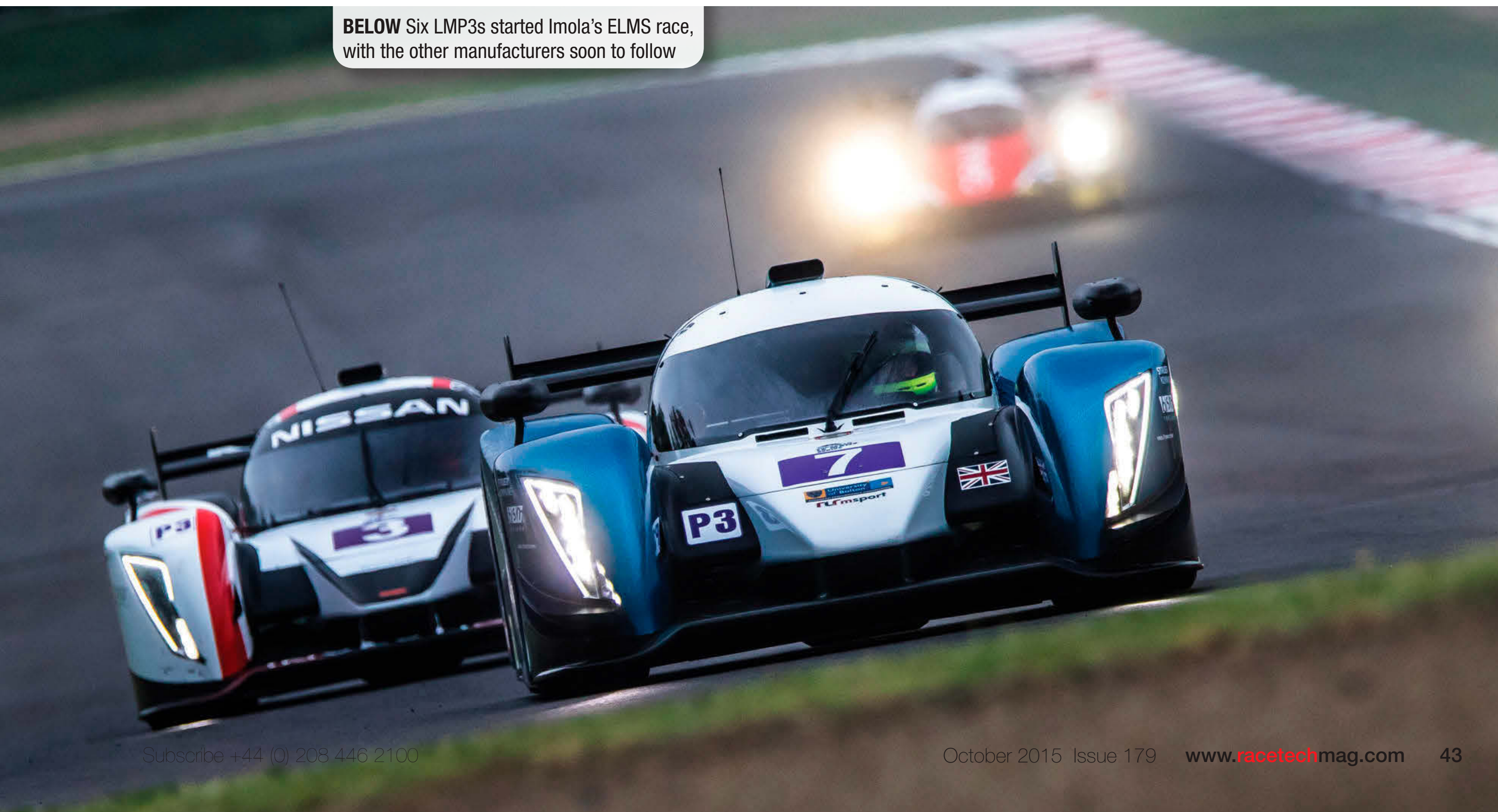
"The big advantage of this engine is that we could increase the power if we needed to," says Beaumesnil. "You have to bear in mind that at the moment we only have one LMP3 car racing; by the end of the year we will have three cars racing and we'll be able to take a proper decision on whether we need to increase the performance for next year. The problem is, every time you increase the performance, you reduce the life and increase the cost, so we're not keen to do it. But if we need to, we can."

That also begs the question of how to set the relative performance of the cars on the LMP3 grid. And the answer – at least for now – is that the ACO won't.

"The philosophy we discussed with all the constructors was that we wouldn't use a balance of performance," says Beaumesnil. "We're pretty convinced that the cars will be very close, but if we have one car that's much more competitive than the others then we could look at changing some parameters on that car. It's exactly the same in LMP2 – if someone turns up with a car that's had twice as much money invested in development we can slow it down, but if the situation is the other way round and one of the cars is very slow then we will not slow down all the others."

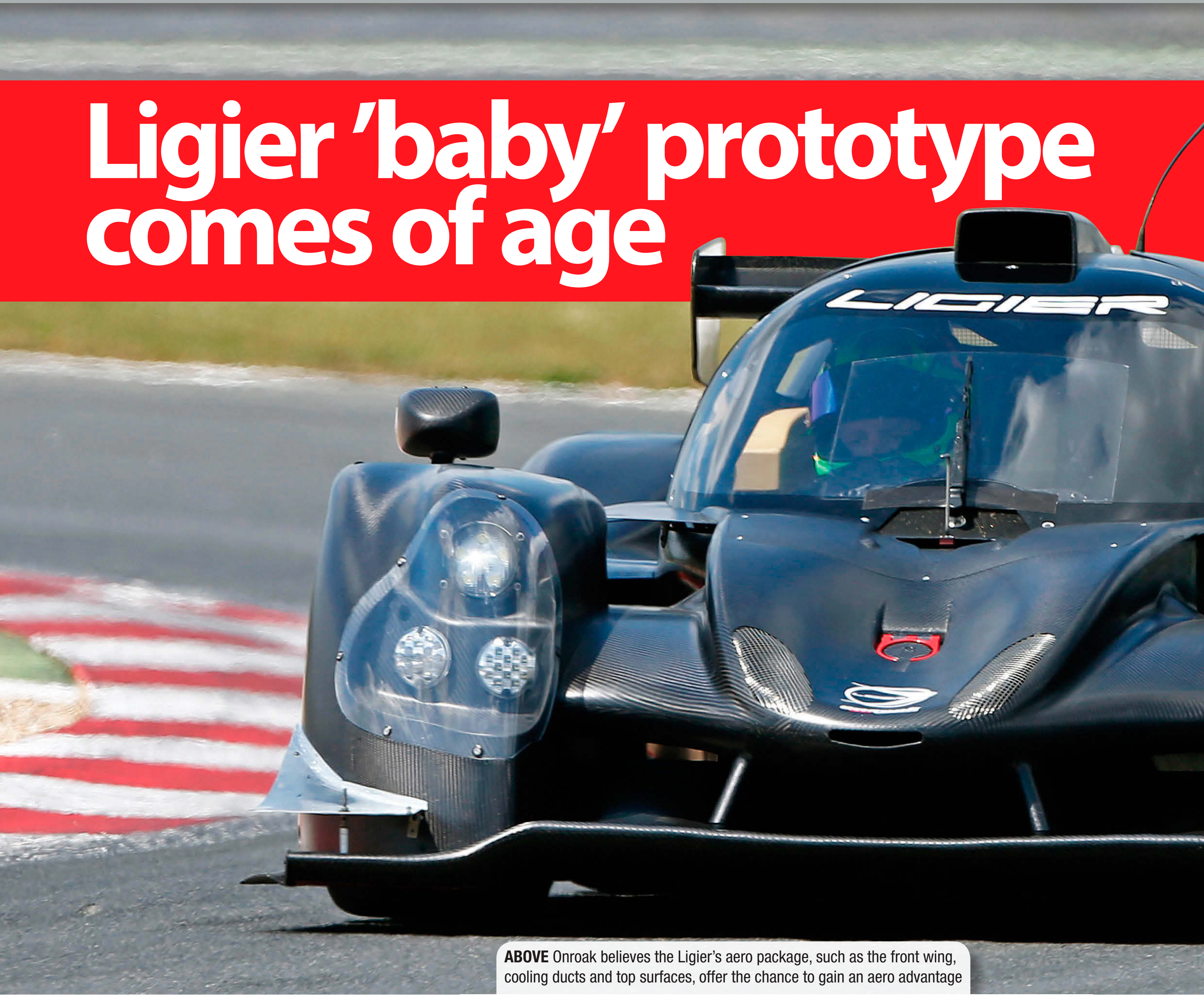
If that situation were to arise, Beaumesnil says the ACO would look into various ways of slowing the car down; depending on the circumstances it could take the form of a weight increase, power reduction or less downforce. For the moment, though, no such intervention is planned.

"We are very happy with the success of LMP3 in its first year," he concludes. "We know that quite a lot of teams and cars are expecting to come. We will take the experience of the last races [of 2015] to make some decisions before next year, but from there we are reaching the target to be the first step on the endurance racing ladder. It's a big success with four constructors now building cars and we will select the fifth and final manufacturer by the end of September." RT



BELOW Six LMP3s started Imola's ELMS race, with the other manufacturers soon to follow

Ligier 'baby' prototype comes of age



ABOVE Onroak believes the Ligier's aero package, such as the front wing, cooling ducts and top surfaces, offer the chance to gain an aero advantage

With Onroak's LMP3 challenger pounding the test track ahead of its competition debut, **Chris Pickering** examines the latest racecar in the Ligier bloodline

WHAT you see here is Onroak Automotive's answer to the new LMP3 category. The Magny Cours-based company is effectively the engineering arm of OAK Racing and the new car is the latest product of its tie up with the legendary Ligier brand.

Unveiled at the Le Mans 24 Hours earlier this summer, the Ligier JS P3 is only the second LMP3 car to break cover. Aimed at gentleman drivers looking for a route into top level endurance racing, the new formula is subject to a stringent cost cap of €206,000. For that, the manufacturers must provide a complete turn-key car, including engine and gearbox.

Onroak began investigating the idea of an LMP3 car as soon as the ACO announced the category, but it wasn't until the end of 2014 that the project was given the green light. "It wasn't clear for us whether or not the project was viable under the cost cap," comments Onroak Automotive technical director Benoit Bagur. "The price is very low for the level of engineering that goes into the car. It was clear that you'd need to sell a lot of units to make it practical, but in the end we decided to go for it."

The JS P3 comes a year after the competition debut of its big brother, the JS P2, at Le Mans 2014. Visually, you can spot the family resemblance, but there's next to no carryover of physical parts. The LMP3 rules and the cost cap don't allow for some of the more exotic technologies seen on the LMP2 car. Plus, the dimensions are somewhat different – overall length is the same at 4,650 mm, but the maximum width allowed in the class is 100 mm less than LMP2 at 2,000 mm, while the interior volume of the safety cell has to be significantly larger. This means a lot of LMP2 parts – the monocoque included – simply wouldn't fit.

Where the two are linked is a shared design philosophy. "The concepts that we've used, particularly for the aerodynamics, owe a lot to the JS P2," says Bagur. "Our experience

from the P2 helped us to develop the P3 quite quickly, although there's less latitude in the rules for the aerodynamic package, which also makes it simpler."

The ACO has likened the creation of LMP3 to 'completing the pyramid' of endurance racing. So would Bagur and his colleagues be tempted to follow suit with an LMP1 contender of their own? He laughs. "That's our dream – one day to be in LMP1 – but even for LMP1 Lite we'd need to have support from an engine manufacturer or a major sponsor to make that happen. At the moment, the cost is too high to be financed internally. We are ready to do this, but we could not go it alone."

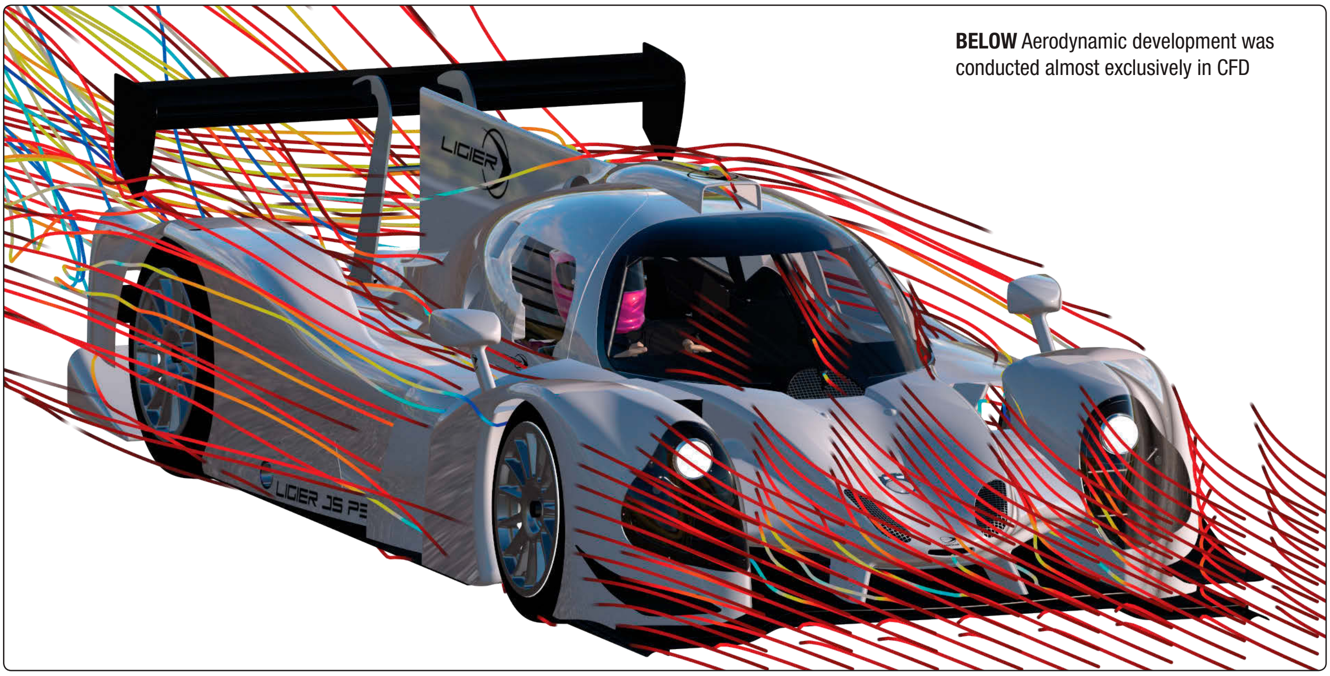
AERO OPPORTUNITY

Although LMP3 has elements of a spec series – notably the single-make engine – there are areas where the manufacturers can eke out a competitive advantage. Bagur believes the greatest of these is the aero package.

"Compared to LMP2, the biggest difference in terms of performance is the underside of the car," he says. "It's completely flat in P3 and the rear diffuser is very simple. Also, you only have one plane on the rear wing. But the rest of the aero package is pretty free. The front wing, the cooling ducts and the top surfaces give you a similar scope to LMP2."

From the front axle centreline to the start of the rear diffuser, the underside of the car largely consists of a single reference plane. At the back, the diffuser must not start more than 415 mm ahead of the rear axle centreline. It must end level with the rear bodywork, rise no more than 200 mm relative to the reference plane and feature vertical sides. It doesn't take an aerodynamicist to spot that these regulations effectively pre-define the design of the rear diffuser.

While the choice of aerofoil section for the rear wing is free, it must use a single element, with a fixed ▶



BELOW Aerodynamic development was conducted almost exclusively in CFD section the whole way across its length. There are guidelines as to the volume that the wing and endplates may occupy and little freedom to do anything clever with the support struts or the positioning. Along with the flat floor regulations, these measures greatly reduce the aerodynamic complexity of the LMP3 cars compared to their bigger brothers.

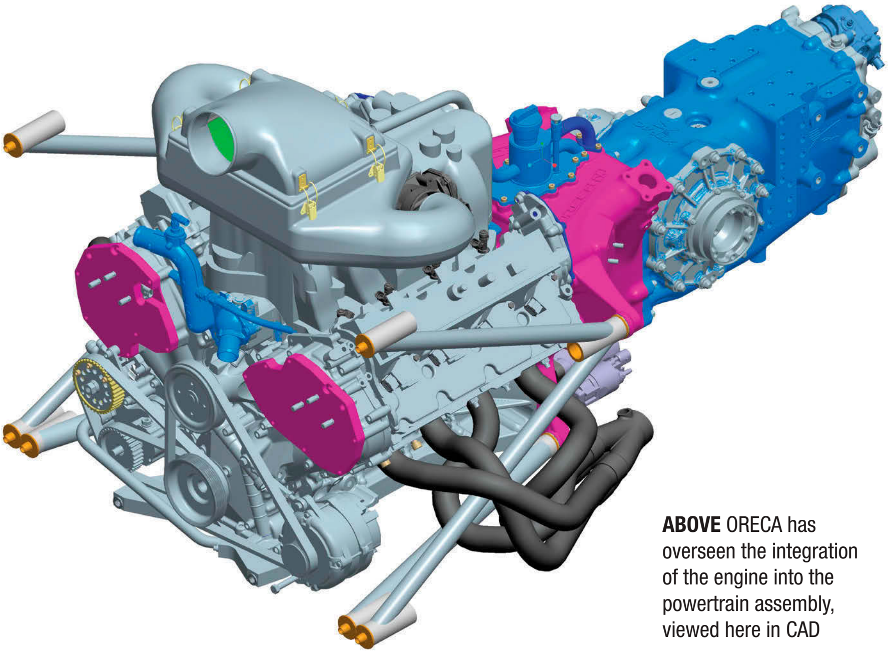
Virtually all of the aerodynamic development for the JS P3 was conducted in CFD, with Onroak's design department working closely with simulation specialist Exa, Bagur explains: "We didn't do any wind tunnel work at all on the P3, because there wasn't the time or the money. Then once we had the first car running we did some straight line testing on the track."

Like the bigger LMP cars, the rules dictate that LMP3s feature mandatory cutouts in the bodywork above the front and rear wheels. These are designed to mitigate the risk of the car rolling over, by preventing a build up of high pressure within the wheel arches.

Similarly, the now-familiar 'prototype fin' can be seen running down the spine of all LMP3s. Its function is the same as ever: at high yaw angles, when the flat surface of the fin is turned towards the airflow, it acts like an air dam, creating an area of high pressure on the upper surface of the bodywork. This helps to push the car down onto the track, resisting the overturning moment otherwise created by low pressure along the top edge of the bodywork.

Whereas LMP2 cars all now use a one-piece carbon tub, with the roof integrated into the monocoque, the P3s use a steel roll cage allied to a non-structural roof. For commercial reasons, the ACO wanted the LMP3 cars to be capable of running as bona fide two-seaters, which explains the larger cockpit volume.

The chassis must be built to the same safety requirements as LMP2 and ultimately pass the same crash tests. It is a conventional carbon fibre monocoque, which looks much like any other prototype tub, apart from the supersized aperture for its two-seat capacity.

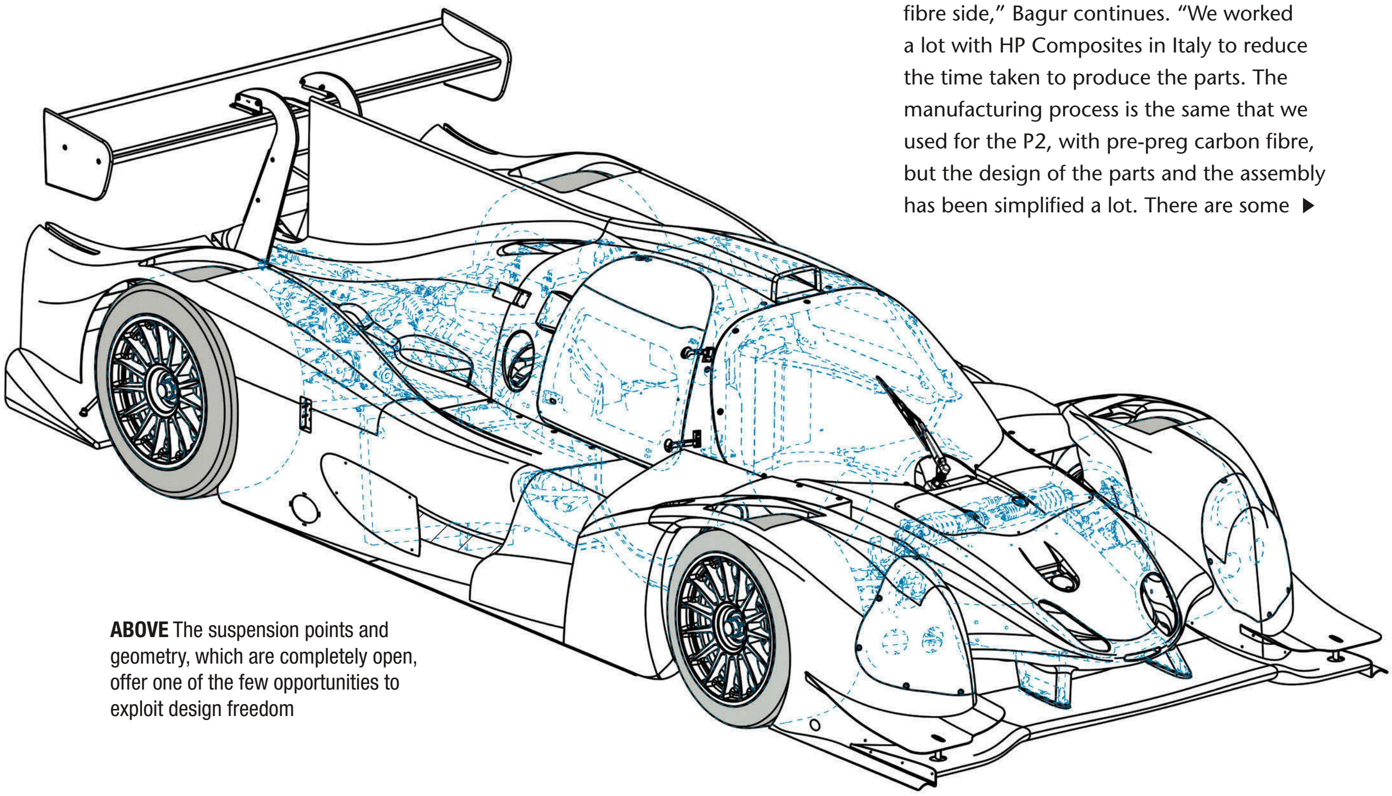


ABOVE ORECA has overseen the integration of the engine into the powertrain assembly, viewed here in CAD

BIGGEST CHALLENGE

Bagur says the biggest challenge in the design was meeting the cost cap, particularly with the original weight target. "The minimum weight started out at 900 kg – the same as a P2. To start with, we weren't sure if it was possible to reach that weight within the cost cap," he says. "After we finished the design it turned out that the engine and gearbox unit was 30 kg more than originally planned, so the ACO increased the minimum weight to 930 kg."

Nonetheless, balancing the budget hasn't been easy. "We've tried to reduce the production costs, particularly on the carbon fibre side," Bagur continues. "We worked a lot with HP Composites in Italy to reduce the time taken to produce the parts. The manufacturing process is the same that we used for the P2, with pre-preg carbon fibre, but the design of the parts and the assembly has been simplified a lot. There are some ▶



ABOVE The suspension points and geometry, which are completely open, offer one of the few opportunities to exploit design freedom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compromises in external geometry and when we need to glue parts together we simplify the design to make things easier."

In terms of mechanical design, one of the best opportunities to exploit freedom in the technical regulations comes with the suspension. "The front and rear axles are completely free in terms of design," comments Bagur. "Okay, everybody uses double wishbones, but the suspension points and geometry are completely open."

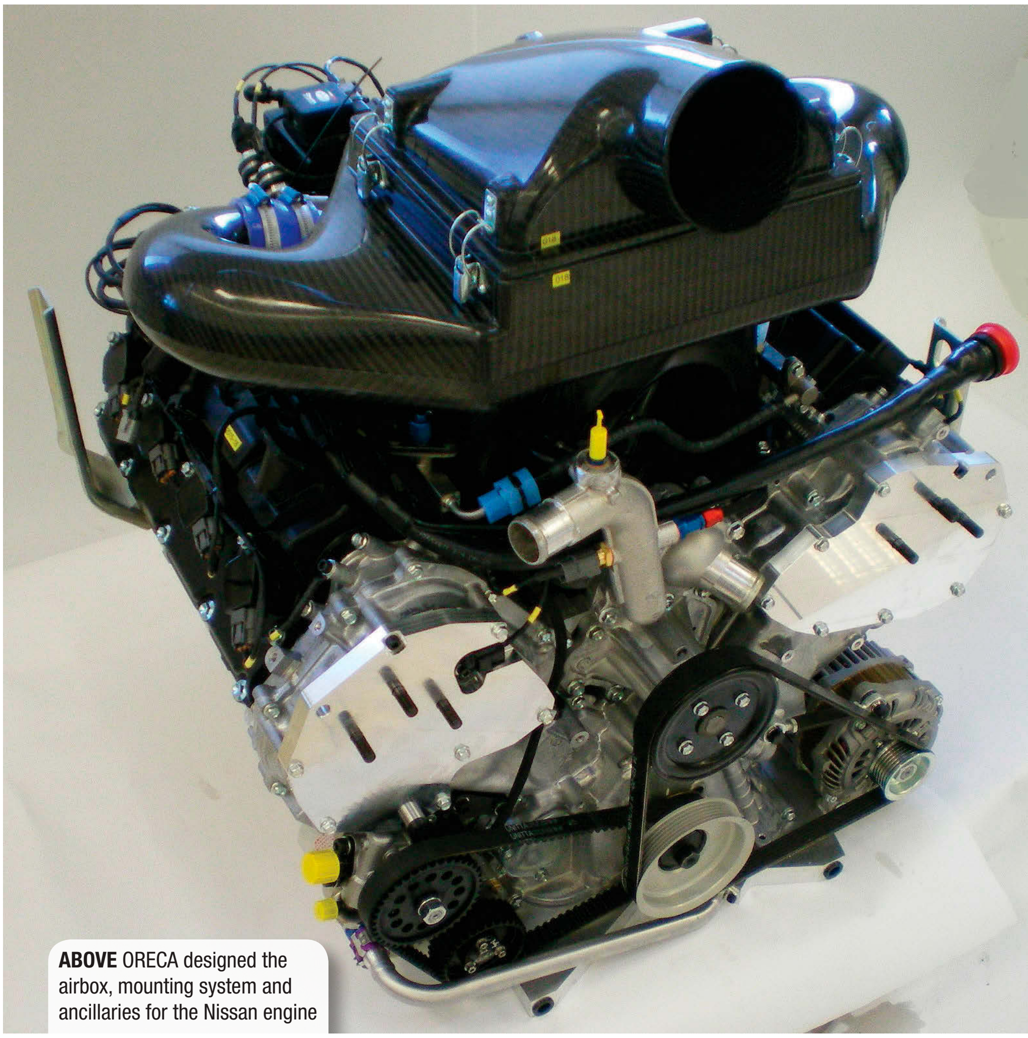
The suspension is pushrod activated front and rear, with 3-way adjustable dampers from French firm PKM Consulting and coil springs used in favour of the more expensive torsion bars found on the JS P2. The package is completed by adjustable anti-roll bars and a third element front and rear to control heave.

The geometry of the JS P3 comes from a combination of Onroak's LMP2 experience and targets set to get the best out of the new Michelin tyres (12.5 inches wide on the front and 13 inches on the rear, running on 18-inch magnesium rims all-round). The philosophy on things like anti-dive and anti-squat, plus roll centre locations and camber compensation, borrows heavily from the JS P2.

LMP3 cars might not produce the same sort of lift and drag figures as their bigger brothers, but they're still proper downforce cars, capable of generating quite high cornering loads. Consequently, power steering is mandatory. Unlike their counterparts at Ginetta, who've gone for an electric system, the Onroak engineers have opted to use hydraulically-assisted power steering. "The advantage of an electric system is that you can vary the setup without changing the hardware, but it costs a lot more," notes Bagur.

Comfort and ease of use were very much in mind when the Onroak Automotive team designed the JS P3. "With the focus on gentleman drivers we wanted to make the car very easy to drive," comments Bagur. "We needed to make sure it wouldn't spin if you made some small mistakes. Perhaps it's not the best setup for a top driver, but we wanted to make sure a gentleman driver could get as close as possible to the top times. If you make a very aggressive car the difference between a gentleman driver and a professional can be a lot more extreme."

There's also the question of accommodating the drivers. Professional racers tend to come from a karting background with a stature to match, but this isn't always true of gentleman drivers, many of whom only get the chance to race later in life. Designed with a wide safety cell, giving plenty of room around the chest and legs, plus an adjustable pedal box, the JS P3 is said to comfortably accommodate drivers from 5ft 2 up to 6ft 4 and 17 stone. It also features a relatively recumbent driving position, making longitudinal g easier to manage.



ABOVE ORECA designed the airbox, mounting system and ancillaries for the Nissan engine

Cockpit temperature is another major factor in preventing fatigue. The LMP3 rules state that: *An effective simple and efficient ventilation and/or air conditioning system must be installed*. Onroak's response is a carefully designed system of vents to supply cool air to the driver.

"We used CFD to ensure we would have plenty of airflow through the cockpit," explains Bagur. "You can have a lot of flow through the car, but if that doesn't run past the driver, the effect isn't so useful. We also worked with Stand 21 on a project to improve ventilation of the driver's suit and helmet."

POWERTRAIN

Following discussions with the ACO, ORECA won the tender to supply engines for the LMP3 series. Drawing on its experience of working with Nissan on other projects, ORECA approached the Japanese manufacturer, initially with a view to using a V6. This tie up promised a convenient technical solution, plus it was felt that Nissan, with its enviable track record in LMP2, would be a good name to have on board.

ORECA switched its focus to Nissan's VK50 V8 after the power target was upped to 420 bhp. This 5-litre unit produces 390 bhp in standard road-going form underneath the bonnet of the Infiniti FX (produced by Nissan's luxury sub-brand). In limited-production FX Vettel Edition guise (yes, *that* Vettel) the road car engine actually equals the LMP3 variant's output.

The development on the base engine was carried out by NISMO in Japan, although most of the internal parts are taken

Ligier JS P3 suppliers

Design	Onroak Automotive
Engine design/manufacture	Nissan/NISMO
Powertrain servicing/engine preparation	ORECA
Gearbox and bellhousing	Xtrac
ECU and data logger	Magneti Marelli
Paddleshift compressor	Megaline
Clutch	Sachs
Brakes	Brembo
Steering rack	Woodward Precision Power Steering
Dampers	PKM Consulting
Composite parts	HP Composites
CFD consultancy	Exa
Driver cooling	Stand 21
Fuel tank	ATL
Steering wheel display	Cosworth Electronics

straight from the road car production line. Components like the crankshaft, pistons and conrods are carried over unmodified. Elsewhere, the variable valve timing system has been removed, the cams reprofiled and the compression ratio increased. ORECA, meanwhile, oversaw the integration of the engine – designing the airbox, mounting system and ancillaries.

"You can compare the engines in this category to something like the Porsche Cup," comments Serge Meyer, director of ORECA's engine department. "In order to control the costs we wanted to keep the short engine – reciprocating assembly, cylinder block, cylinder heads – completely standard. And to do that while maintaining reliability is easiest if you have a large capacity. It's the cheapest way to get the performance."

As road car designs are becoming more optimised in terms of weight and packaging, it is getting harder to find suitable mounting points for competition use. The engine fixes directly to the bulkhead as a semi-stressed member, but the ORECA package also includes a pair of tubular steel A-frames.

"We wanted to keep the complete inlet manifold and we had to add an airbox, but this wasn't easy because the space under the engine cover is pretty tight," comments Frédéric Eymere, manager of the design office for ORECA's engine department.

ORECA was also given the job of sourcing the engine management system. "We have a very good relationship with Magneti Marelli and we use the company's electronics in LMP2 so it was an easy decision for us," says Eymere. "Thanks to the car's CAN network it was relatively straightforward to get the Magneti Marelli ECU to talk to the Cosworth steering wheel display."

ORECA will also oversee the servicing of the engine. For the transmission, teams have a choice of carrying out the work themselves or going to either Xtrac or ORECA. NISMO's endurance tests have shown that the engine is more than capable of meeting the 10,000 km rebuild target, but it's unclear exactly what the refresh will involve.

"Currently, the only engine to cover that sort of mileage has done so on the bench, so it's difficult to say exactly what the rebuild will require," comments Meyer. "It's likely we will replace most of the internal components, but we will definitely keep the block and heads."

These parts will arrive in a servicing kit supplied to ORECA by Nissan. It's a similar situation for the initial build, where the engines will be shipped to ORECA as a comprehensive kit of parts.

BRIGHT FUTURE

Onroak's order books are already filling nicely, with the first Ligier JS P3s expected to reach customer teams in the autumn. Meanwhile, the factory is carrying out its own tests on-site at Magny-Cours.

"I think we'll be more or less in the middle between the P2s and the GTs," comments Bagur. "It's a long time since ACO-spec GTs have visited Magny-Cours, but from what we know we think the gap to the GTs would be about three seconds."

That estimate compares well to the ACO's original performance targets and the current engine configuration should leave plenty in hand for the future. Thanks to the surfeit of LMP1, LMP2 and GTE entries, it's unlikely that the LMP3 cars will end up running in the Le Mans 24 Hours any time soon. But this new class certainly has the potential to launch careers for drivers heading in that direction and the Ligier JS P3 is bound to seem like an attractive proposition. RT

ABOVE The P3 put through its paces at Magny-Cours

IN SEARCH OF THE 'WOW' FACTOR

The clamour for change in motorsport has been deafening, but what do we do? Ditch all thoughts of efficiency, or keep limits but give engineers technical freedom? **Sergio Rinland** investigates

MUCH has been said in the last 15 months about Formula 1's lack of good health, its falling TV figures, reduced grandstand viewers, and dwindling sponsorship money. Depending on who you speak to, each problem has a different culprit: from CVC's greed, to lack of noise of the engines; from not enough power, to all the cars looking the same; and from the public not being willing to travel far to watch, to the expense of competing driving the small teams out of business.

Bernie Ecclestone proposed to go back in history and use noisy V8 engines with 1,000 bhp, regardless of consumption and efficiency.

Max Mosley, on the other hand, proposed to open the rulebooks and allow freedom. I like that, albeit with some constraints!

Some suggested going to wider tyres, or prohibiting wind tunnels. (More prohibitions? Come on!) Others still want to bring back refuelling – as if, all of a sudden, fuel is no longer flammable and poses no risk!

At the same time, Jean Todt and the FIA have been conspicuous by their silence.

Steve Jobs was a genius, no doubt, and he never asked the public what it wanted. He simply created a product which, when the public discovered it, they could not live without. That is the kind of vision we need in Formula 1 and motorsport in general: create a product with the 'wow factor' which, when discovered, would render all its followers hardcore fans, as was once the case.

So how do we do this? We need to ask fundamental questions, some as basic as: 'What is the purpose of motorsport?' and 'Who are the customers?'

The first question has several answers:

- To create an exciting sporting spectacle
- To ignite passion
- To showcase, develop and promote the latest automotive technologies

The answers to the second question are painfully obvious:

- The fans
- The automotive industry
- The sponsors

To create an exciting spectacle and to ignite passion, we need to see gladiatorial fights and overtaking – but as a by-product of skills and diversity, not as a false advantage that one can have and the other cannot defend, as is the case with DRS. For that we need diversity of machinery. Which brings me to the core of this article.

As I said, I like Max Mosley's proposal. He always likes to throw a pin-less grenade into the arena and see what happens.

My proposal (for the top three motorsport disciplines: F1, LMP1 and IndyCar) is similar to Max's, taking into consideration that there is a limit on the speed cars can circulate on the current circuits, without becoming lethal weapons. Hence, we need to set some limits: the biggest contributors to performance are power and aerodynamic downforce.

Those are the performance outcome of complex technologies and machinery, so we need to limit their outcomes, period, but we do not need to limit how to achieve them.

So far, in the history of motorsport, the rule-makers believe that dictating how to design and build cars can limit those two aspects. Nowadays Formula 1 rules dictate every aspect of the engine design, down to its centre of gravity! Then they get a surprise when someone produces an engine with not only more power than the opposition, but a lot more power than the governing body thought possible.

It's the same with aerodynamics: the rule-makers believe that if they dictate where to

Mauger/LAT

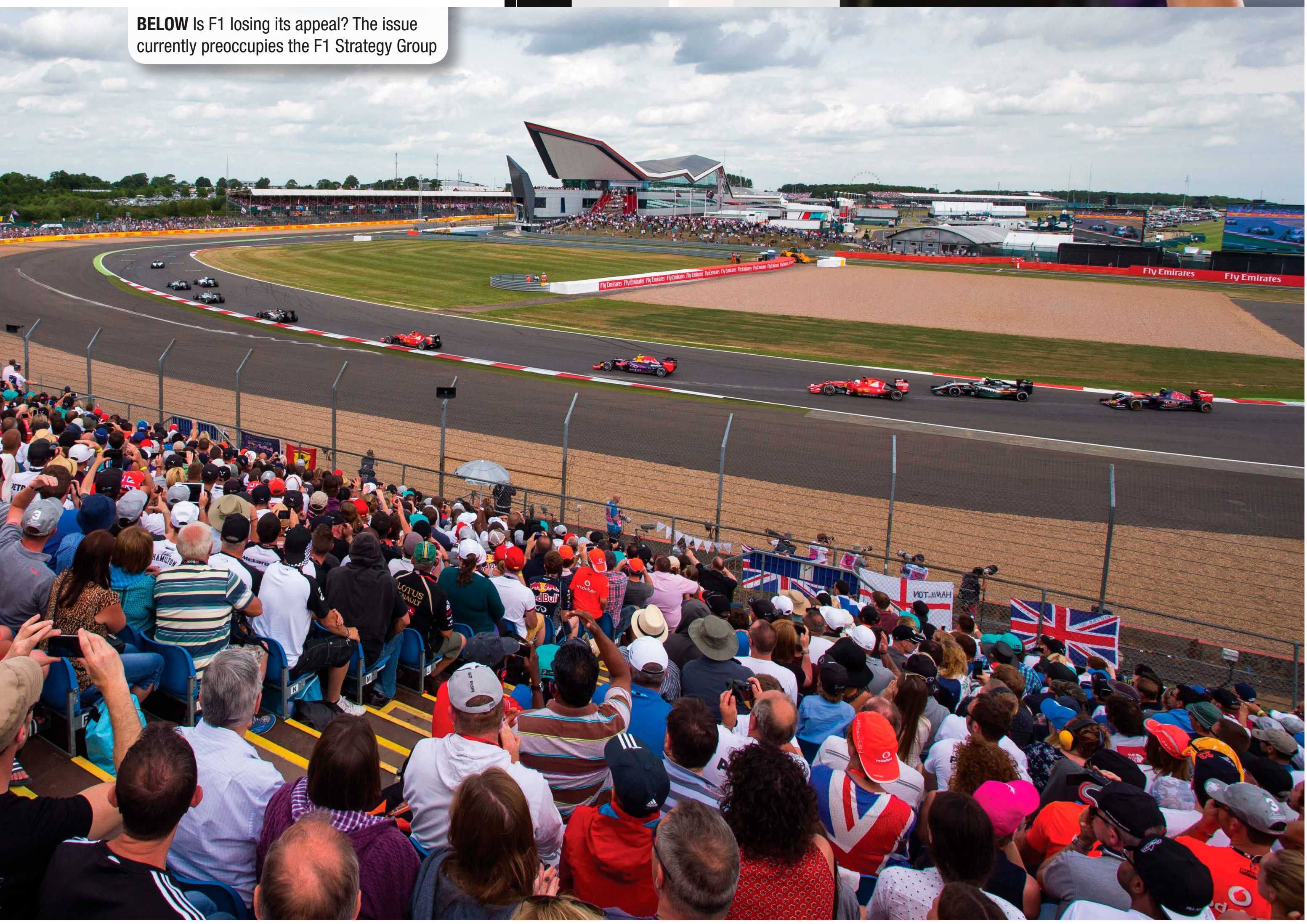
put bodywork and where to prohibit it, they will limit the amount of downforce a car can generate. Then they get another surprise when the cars generate a lot more than they thought possible and, worse still, it is then increased race by race; or someone surprises them even more with a concept like the Nissan LMP1 because the designer thought 'out of the box' into an area the rule-makers had not thought possible.

With the highly sophisticated simulation tools we have today, finding those two limiting factors is not a difficult task. All that we need is to decide what lap times and speeds we consider spectacular and still safe.

From the powertrain or power unit (as it is called today) point of view, the LMP1 rules are very close to what I would propose. The ACO/FIA limit fuel flow to restrict instant power and limit the amount of fuel used during the race, then let the engine designers come up with the best idea they can. But they still risk a power escalation beyond their plans. This is because even ▶

Apple

ABOVE Should motorsport follow the example of Apple's brilliant creator?



BELOW Is F1 losing its appeal? The issue currently preoccupies the F1 Strategy Group if the rule-makers are very competent engineers, they will never achieve the level of knowledge and ingenuity of a group of engineers who ponder how to get more power (or downforce for that matter) out of the limitations, day-in and day-out.

In LMP1, as well as in F1, the rules also limit the amount of electric energy which can be re-deployed from the brakes and the exhaust. My proposal is simple. If what we are trying to limit is power, then limit power, not how to achieve it. We have the tools today to measure torque, hence power, at the driveshafts for example, with great accuracy, so my proposal is a small stretch of what the ACO rules are and a further stretch of what F1 rules are:

ABOVE Mosley: toss grenade and retreat!

- Limit the power put down on the road (instead of limiting the fuel flow, as today)
- Limit the energy consumption per lap and race (be that from fuel and/or electric energy)

Leave freedom on:

- The architecture and design of the power unit (similar to the ACO rule today)
- The amount of energy to recover and re-deploy

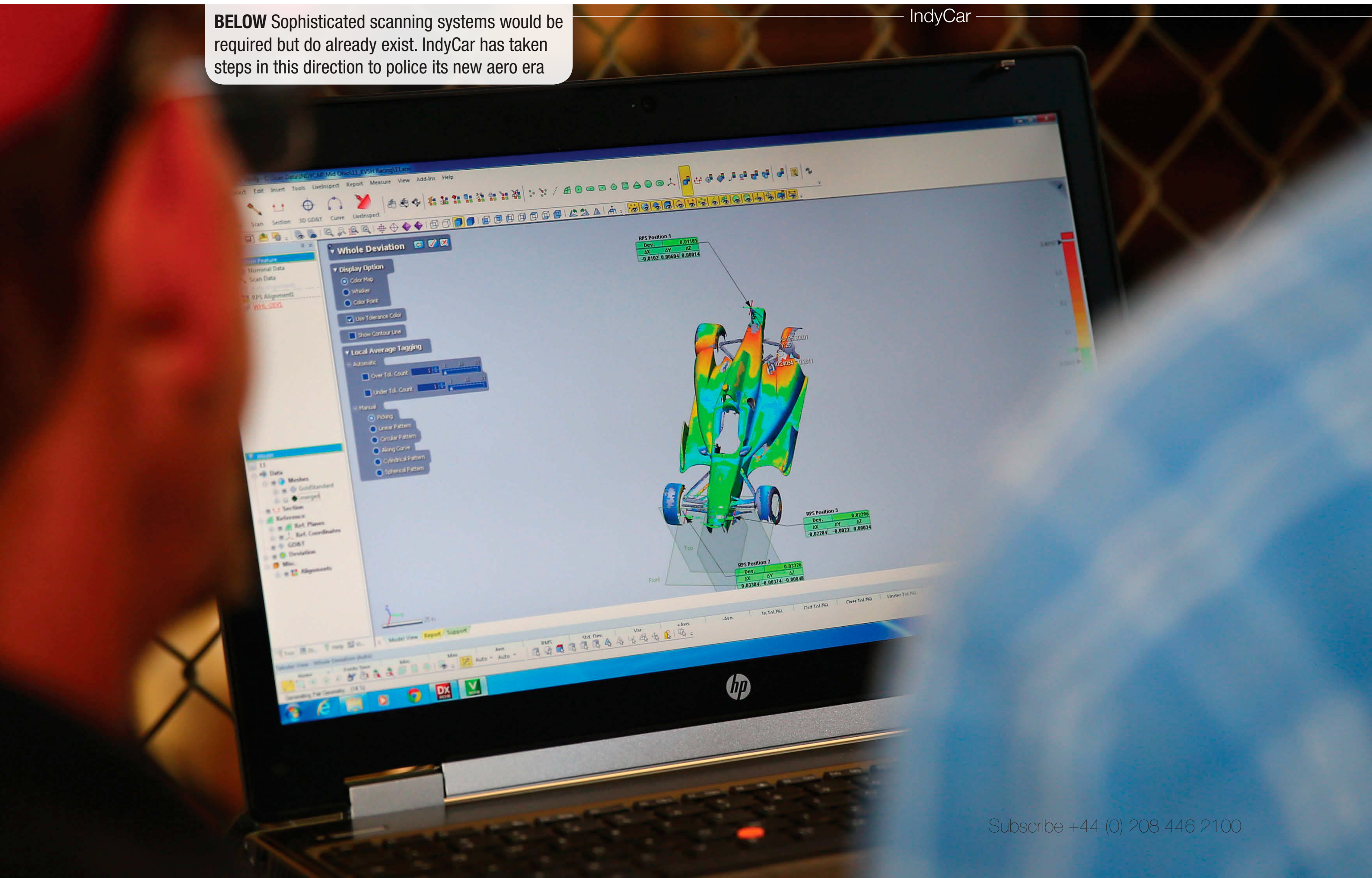
With rules like this, you leave the door open to innovation in the quest for efficiency. If teams use less fuel than the amount allowed, great, we have made a major contribution to the automotive industry by developing efficient powerplants and ticking the box of one of our customer's needs.

With these rules, we will also create exciting qualifying where fuel efficiency is not a factor. Yes, the power output is limited, but that makes it a race of chassis/aero performance and driver skill. Then, come race day, the tables can be turned upside down, making it very exciting when fuel efficiency comes to play an important role, ticking the box of the other customer's need, the spectator. You will not need 'reverse grids' or DRS to create artificial overtaking.

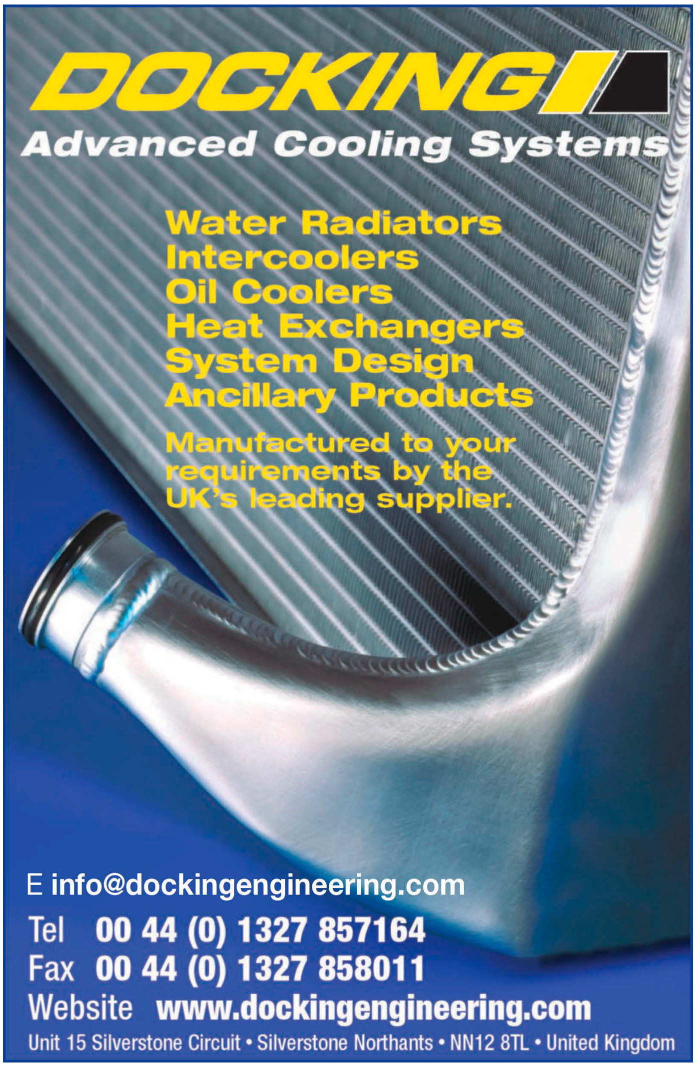
Also, and not an unimportant factor, by measuring power at the wheels directly, cheating is virtually ruled out.

As an analogy, imagine you would like to control the water flow from the River Thames into the sea by building a dam in Oxford… ▶

IndyCar



BELOW Sophisticated scanning systems would be required but do already exist. IndyCar has taken steps in this direction to police its new aero era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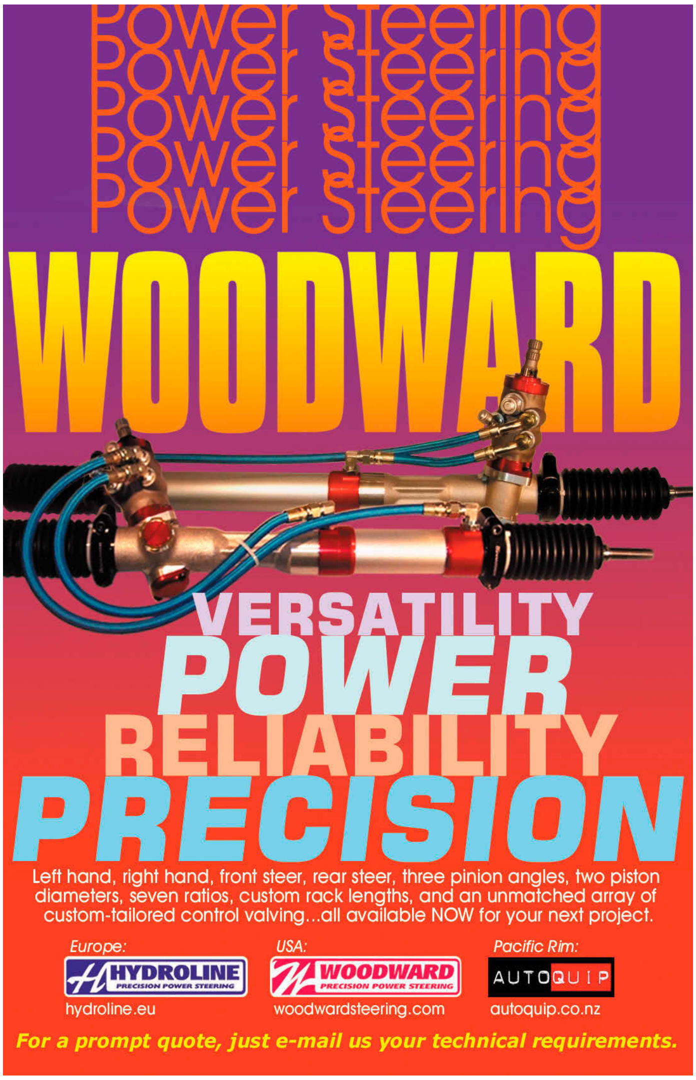
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Sam Bloxham/LAT

ABOVE The new rules could be the key to the sort of diversity we usually see only once a year at Le Mans, where the different classes race together

You wouldn't, would you? You would build it at the mouth of the river! Well, the same concept can be applied to engine power control. Instead of controlling the fuel that goes into the engine, you control the outcome you want to limit in the first place: the power at the wheels.

As a by-product, the costs involved in the design and development of these power units will not be more expensive than today (LMP1 is an example of that theory). And because the R&D is focused on high efficiency and reduction of fuel consumption, the costs will be perfectly justified by the R&D departments of the big OEMs, more than just developing processes and training engineers.

OPEN UP ENERGY RECOVERY

I also propose to open up the energy recovery systems. This will promote the development of energy storage systems (batteries, super-capacitors or flywheels) to cope with the amount of energy available, and only its weight and packaging will be the limiting factor. Because the power output is limited, the competitor will do its own BoP of using recovered energy or fuel to power the car or a combination of both as they see fit.

Here there is another factor adding to the spectacle because some competitors may choose to use their available energy in different ways and on alternative parts of the track, i.e. out of slow corners, or in the middle or end of a straight, adding to the performance diversity.

Limiting downforce is a bit more cumbersome to control, but with today's technologies, not impossible. My ideal rules would limit the amount of downforce a car can generate, limit the box dimensions where the car fits in and obviously retain all the safety and cockpit rules as today, plus minimum weight. However, give the designers freedom to create a car to generate that permissible amount of downforce with the best efficiency they can.

With the current state of CFD technologies, the governing bodies can design a 'virtual wind tunnel'. There every competitor would have to test their car to measure downforce on a design of experiments devised to cover most eventualities of speed, ride heights, roll and yaw.

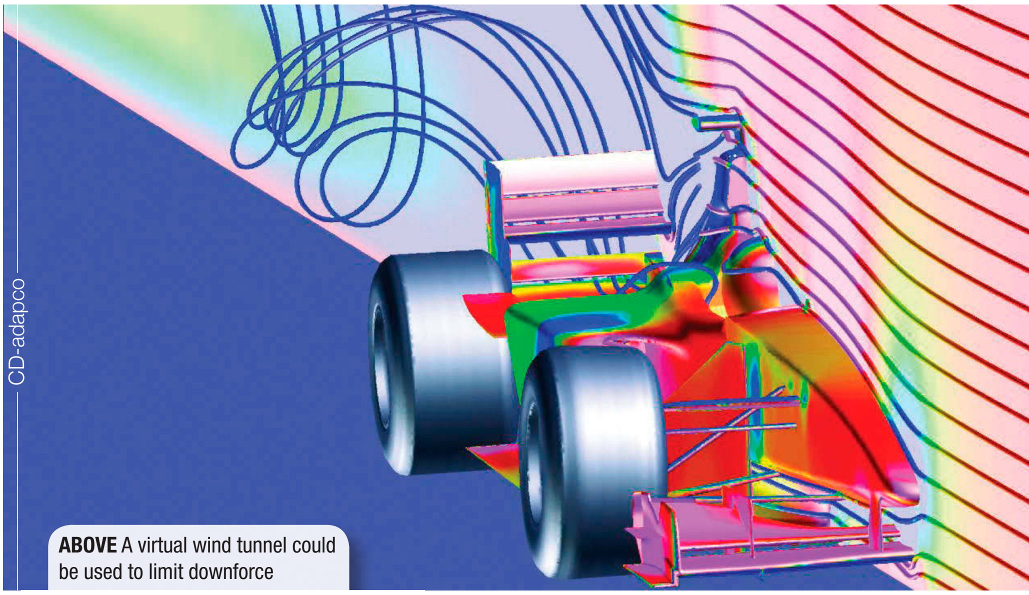
Once the competitor can prove that their design cannot generate more downforce than allowed, the governing body will homologate it and that is what the entrant can build. We could envisage that a competitor could homologate two or three different designs per year, to promote continuous improvement, but only as far as drag is concerned. Here again we have made another major contribution to the automotive industry by developing aerodynamically efficient shapes and tools, ticking that customer's needs box again.

To police potential cheating, the governing bodies will have to take to the racetrack a sophisticated scanning system (that exists today!). They would scan every car and make sure that the bodywork at the track coincides (with certain tolerances) with the homologated shape.

This proposed rule system will be self-controlled as far as spending money is concerned, because of the laws of diminishing returns plus the homologation system. The biggest beneficiaries of all that spending will be the spectators, the automotive industry, the sponsors, and the final user of cars on the road. A win-win situation, I believe.

These rules will promote diversity not only of forms but also of performance, where even if the lap times will be close, there will be diversity in where on the track that performance is at its peak. Thus we could create the kind of racing we only see at Le Mans due to the five different categories competing for the same piece of tarmac.

If and when the speed and performance progress is deemed too high, all that the governing bodies have to do is adjust their power and downforce limits, which again will not incur a cost escalation as is the case when rules change significantly to control performance today. Moreover, diversity of designs will make cars attractive to the fans. Again, another box ticked. RT



CD-adapco

ABOVE A virtual wind tunnel could be used to limit downforce

PERFECT STORM

As the turbulent quest to define the future grand prix car continues, **Chris Ellis** considers what the ideal solution might be and how we find it

WITH the headline 'IT'S THE PITS', *The Sun* newspaper recently devoted a full page to Formula 1. The key quote from Damon Hill was, "We're at a place so deep with complexities you need to start again with a clean sheet of paper." I was pleased because I had already begun pestering Race Tech's management to let me write this article, which focuses on how to derive new F1 regulations that deliver more entertaining cars. This article concentrates on what a theoretically 'perfect' Formula 1 car might be like, and how to find out.

Define 'perfect', I suspect many of you are thinking. We could start by asking the

Staley/LAT

BELOW Will we have found the answers to F1's ailments by the time the next generation of F1 cars race away from the grid in 2017?

drivers. But a driver is not usually allowed to tell us what's wrong with his car, because of his secondary (or is it primary?) role as a PR spokesman for his manufacturer.

On several occasions, I have asked, "What do the drivers think?" and been met with incredulous stares, and sometimes comments as cruel as, "They don't think, or they wouldn't be driving." My amateur psychologist's reaction was that these were attempts to rationalise the speaker's lack of the balls and/or skills needed to succeed behind the wheel. I write this as someone who had to give up competitive driving because I was too aggressive. So mine are the opinions of a failed driver. And successful systems engineer.

At last, a former world champion has spoken out, free of the usual constraints. We need the opinions of the real experts, the ones who actually know what would make a 'perfect' F1 car. And soon. Fortunately, Stirling Moss has already suggested the key formula – "increase power; reduce downforce", the central technical theme of this article.

Before the British Grand Prix, the BBC ran a video of Moss and Lewis Hamilton playing with a pair of Mercedes W196s (see photo) at Brooklands. Near the end, Hamilton says, "I like the sound of the V12; it's my favourite." Regular readers will be familiar with my arguments for the return of V12 engines to F1, so it's nice to know the best driver in the world understands the main trackside reason why V12s should return, even if he was listening to a straight-eight at the time! It seems even he is not infallible. So it would be wise to seek the opinions of several leading drivers, to gather a consensus that *is* infallible.

Perhaps the Strategy Group should arrange a 'private weekend' for a small group of leading drivers (the Drivers' Committee, or DC) to spend some quality time together, focused solely on defining the driving characteristics (NOT the tech spec) of the ideal F1 car. The drivers will probably show a preference, predictably and reasonably, for gradual rather than binary responses from the cars near the limit, allowing them to drive closer to the cars' limits. They are almost certain to endorse 'more power, less downforce', resulting in faster acceleration and slower cornering. 'Fewer buttons' is a certainty, as is 'fewer pit stops'.

Races cannot be won in the pits, only lost, so most drivers loathe them. Refuelling pit stops have been banned since 2010, and almost no one misses them now. I think the drivers will favour being able to complete a race with no pit stops, provided they have been nice to their tyres. Try explaining forced tyre changes to a bright eight-year-old – "but that's silly, Grandpa!" Team principals may enjoy tyre strategy games; for the rest of us, tyre changes are only entertaining when they go wrong.

Several technical directors should also be invited, but purely as advisers, just to ensure the laws of physics remain respected. The technical directors will have the opportunity to shine later, when they work out how to transform the drivers' concept into reality. The commercial considerations and the detailed regulations can wait. They will be for the full Strategy Group to agree, once the cars have been defined.

Obviously, the Strategy Group will need to guard against bias. For example, some of the teams using Mercedes engines are, understandably, already resisting changes to the engine regulations, and will almost certainly oppose the removal of the fuel flow limit.

So who ought to be in the first DC meeting to decide what the theoretically perfect Formula 1 car should be? My choice for chairman would be David Coulthard, and not just because he has the right initials! His experience and success as a driver and his skills as a communicator make him an obvious choice. And then it occurred to me that the fact that he is not one of the current F1 drivers is a positive advantage, because he's under no-one's thumb. So far as I know… And that applies to others, like Hill, Villeneuve and Mansell.

So perhaps the current drivers should ▶

Coates/LAT

ABOVE Hands up if you have any ideas what the next car should be like…

Griffiths/LAT

ABOVE Coulthard: ideal head of the Drivers' Committee?

BELOW Moss and Hamilton on the banking in the Mercedes-Benz W196 streamliner and monoposto: F1 made a crucial choice between the two configurations

Daimler

Etherington/LAT

ABOVE Fewer buttons will be one of the results of the drivers' consensus

be left off the list of potential invitees to Mr Ecclestone's 'party of the year', before the Strategy Group chooses who gets an invitation. These famous drivers, above all others, will also be able to speak for the spectators. Just imagine the contents of their fan mail over the years. Oh, and Stirling Moss might be graciously pleased to attend…

There is another practical reason. The current drivers almost certainly could not be available for detailed discussion until the end of the season, and probably into next year, given their other commitments.

F1'S BIG CHOICE

The photo of the two W196s also illustrates the fundamental choice that was made in F1 back in the fifties between open-wheel and streamlined cars. The two cars are almost identical mechanically, but look very different. Imagine what F1 cars would look like now if the rules had gone the other way. Yes, almost like Le Mans/WEC cars, complete with narrow bubble cockpits, so narrow the latest WEC cars now look like single-seaters. Which they are, for most practical purposes, except the regulations still pretend they are two-seaters.

The decision to require open-wheeled cars in Formula 1 basically signalled that the fuel efficiency of the cars was a secondary consideration, reducing weight was critical: "Just leave the mudguards off, dear boy." Decades later, this led to cars with drag coefficients as high as 0.9, very close to that of the legendary barn door! But let me be clear: I'm not advocating a return to 'streamliners', simply highlighting the absurd way the current regulations force the engine manufacturers to spend fortunes on developing very efficient engines to put into very inefficient cars. And these engines are completely useless for anything else. No wonder each engine costs so much! So away with PR-based fuel flow limits, because no one outside Brussels cares a jot. And probably no one in Brussels: they're not daft.

The reaction of TV viewers to the changes will be crucial. Simply put, grow the viewer numbers and the sponsors will come. And the manufacturers. Yes, racing is a useful training ground for talented young engineers, but the real value to winners like Mercedes and Porsche is in marketing their brands, particularly to younger viewers before they chose their first fast car. If there are more spectators and bigger TV audiences, that's all the sponsors and manufacturers will need to convince them to keep funding the sport.

Formula 1 needs smart regulations. Without them, we will get more DRS-type 'solutions', and excessive g-forces will cause new types of accidents. Consider this: the Strategy Group has already set a target of a five-second reduction in lap times as the key to making F1 more appealing to spectators. Quite why they believe this will deliver has not been revealed. This shows how even the best players can get things wrong if they only spend a few minutes thinking through the consequences. In reality, 95+% of spectators don't care if F1 lap times are significantly more or less than the previous year's numbers, provided they remain significantly quicker than the lap times of any other formula.

Spectators pay extra for seats near the corners, because this is where most of the action will be, and it's where the cars are at their slowest. But a faster lap time implies less time negotiating corners, assuming top speeds are constrained for safety reasons. So each spectator will see less action, not just in terms of time but because overtaking will be even more difficult, and ▶

consequently less frequent. Paradoxically, what seems obvious, faster racing, is actually not going to deliver what most spectators want – more action. But slower cornering combined with faster acceleration should deliver a better spectacle, without reducing lap times. And it will make racing a little safer, for drivers and spectators. The idea that F1 cars need to corner faster than any other series is rubbish, clearly. It's who laps fastest that counts, everywhere.

Conclusion: excessive downforce reduces entertainment, and it's dangerous. In the limit, it would effectively turn most circuits into banked ovals. Excessive downforce is the result of prescriptive regulations, which result in massive and expensive efforts to get around them, rather than having specific limits that are easy to measure, and that everyone understands. So downforce naturally increases over time, if not specifically limited.

It is beginning to reach levels where fighter pilots need g-suits. If there is a further increase, brought about by 1,000 bhp engines and clever aero, we will see levels never felt by drivers before. Imagine for a moment a 2017 F1 car with too much engine power and too much downforce, as already proposed by some. It starts braking for a corner from 250 mph. It can now generate over 7g because of the high speed and deficient downforce rules. The driver is slightly off-colour, so greys out and slackens his pressure on the brake pedal. Then he fails to turn in, and the car goes straight on, at 160 mph, through the barriers and into the crowd. If it could happen, it will. And it only has to happen once. See Le Mans, 1955.

> *"Formula 1 is entertainment. Worthy is for wimps, and Formula E"*

Stirling has suggested the basic remedy already. Expanded, it means an absolute limit on downforce, absolute to save wasting valuable aerodynamicists' time on finding the last few Newtons, and let them focus on reducing drag instead. Also, allow more total power for acceleration, but with *less engine power* to stop top speeds from becoming really dangerous, given lower drag from less downforce. Big increases in power from the Energy Recovery System will deliver faster acceleration, which will compensate for slower cornering. And slower cornering will allow the drivers to show us how skilled they really are, not just that they know where the DRS button is.

Ideally, there should be no power or energy-per-lap limits on Energy Recovery, but I think this should be seen as an eventual goal, with escalating limits year on year, in order to prevent the very rich from winning almost every race, like now. Of course, sensible limits on both power and downforce will result in a levelling of the contribution to victory the cars make, and an increase in the impact the best drivers can make on the results, particularly if cornering is slower and takes more skill. Which is what almost all the spectators and

BELOW An increase in power from the ERS would make for the ideal combination of fast acceleration out of slow corners

Staley/LAT

ABOVE Larger diameter wheels with lower profile, durable tyres have already been tested at Pirelli's behest

Pirelli

the best drivers want, right? And FOM? Also, car development and component costs will be lower, although some drivers may be paid even more. This should result in more teams in credit at the bank, and, perhaps, names like BMW and Infiniti entering the fray. But that's for later. First, mouth-watering, screaming, beautiful cars!

Note I wrote '*theoretically* perfect F1 car'. I am not suggesting that all of the possible changes need to be introduced and certainly not in one go. But there does need to be a good understanding of the ultimate objective before the first steps are taken, so that everyone has a clear focus, and every step is in the right direction. Those determining the new regulations should then be able to see more clearly the consequences of the practical compromises required in the real world.

In the minds of most spectators and viewers, Formula 1 is mainly about the *drivers*, while the World Endurance Championship is basically about the *cars*. So the LMP1s of the WEC should be the first home of really clever technology, while Formula 1 should offer drivers and spectators as 'level a racing track' as possible, to allow the relative skills of the drivers to dominate.

For example, energy efficiency is key in the WEC, but relatively (*relatively*!) unimportant in F1, see open wheels. Excessive fuel weight is probably a big enough penalty for high fuel consumption in F1, without insisting teams waste tens of millions on perfecting specific fuel consumption. Costs could be constrained by eliminating limits that are there for ill-conceived PR purposes. The fundamental reason why Mercedes are boringly quickest at the moment is they have been more successful than the other engine developers in extracting the maximum power within the 100 kg/km fuel flow limit, which is basically an indirect way of limiting top speed. Yet another unintended consequence of trying to be cunning with the regulations, rather than direct, open and honest. One positive result of openness should be more fans who understand what is going on. Today, many openly admit they don't. Which I find sad. Particularly as I don't, some of the time!

As a basis for discussion, I suggest a 2g absolute limit on downforce, with dynamic monitoring and stop-and-go penalties for infringement. FIA-supplied force sensors on all four corners of the suspension could provide the necessary monitoring input. Ten years ago, there may have been reasonable doubt that this could be achieved, but not now. Delete from the regs all the detailed prescriptive nonsense defining the precise wing profiles, etc. Clean the cars up, and let them look beautiful again.

There is nothing about emissions in the WEC regulations (might hurt diesels?) or in F1. It would be silly if there was. So why get fanatical about maximum fuel flow? To limit power. So why not limit power directly, and cut costs?

Here's a prediction, to get your juices going. The (carefully chosen) technical directors will take the drivers' concept, and propose the following to the Strategy Group.

- 3-litre naturally aspirated V12s, limited to 600(?) bhp. "My car has an F1-based engine."
- No exhaust energy recovery, to save costs and because it's only cost-effective on big trucks.
- High levels of kinetic energy recovery, initially limited to 300 kW (400 bhp).
- Four-wheel drive and recovery, because it's what some supercars have already, and more will have it soon, and the cost benefit will be superb common software for road vehicles.
- Larger diameter wheels, with lower profile, durable tyres.
- Downforce limited to 2g(?)
- Safety considerations will demand NO limits on testing, given the combination of novelties.

To summarise: let's focus first on defining the perfect F1 car. Above all, it must be sensational. Formula 1 is entertainment. Worthy is for wimps, and Formula E. Formula 1 cars must help the drivers entertain us. Right now, they don't. But this should be easy to fix, see above. Provided the Theory of Natural Stupidity doesn't intrude… What's that? Early days yet, it's still a new theory. But initial experiments suggest we may be onto something. Basically, it seeks to explain how a collection of intelligent individuals can end up running an organisation that has a reputation for making one stupid decision after another. I am sure you have your own examples… RT

FIFTH COLUMN

William Kimberley examines the fierce battle for fifth position and, with it, a seat at F1's top table

WHILE all eyes look at who is winning the Formula 1 Drivers' Championship and to a lesser extent the Constructors' Championship, the principal focus for the midfield teams is on which one of them is going to finish fifth. This is because it is the entry ticket to join Ferrari, McLaren, Mercedes, Red Bull and Williams at the top table – the F1 Strategy Group – that helps derive and formulate medium and long-term plans.

The current temporary holder is Force India F1, which replaced Lotus F1 Team at the start of the year following the latter's disastrous showing in2014. After the Belgian Grand Prix at Spa, though, the stakes could not be higher: Lotus stood fifth with 50 points, Force India had 49, then Scuderia Toro Rosso with 35 and Sauber F1 on 23.

Of these four, as things stand, Sauber F1 looks the outside bet. While the first three races of the season were encouraging, and certainly an improvement on last year, the team's performance has dramatically tailed off, the cars falling further down the grid as the others have caught up and overtaken the Swiss outfit. While no-one will talk about it, its financial situation has meant that it often has to prioritise outside contract work at its Hinwil base, much to the detriment of its own team.

This could perhaps be illustrated by Felipe Nasr who complained after the Belgian race to the *Globo* correspondent that following similar problems in Canada and Austria, he had "basically only three wheels because of the completely wrong brake balance." It was a criticism, it has to be said, that was firmly rebutted by Sauber F1 technical boss Gianpaolo Dall'Ara. However, it illustrates the point about lack of development.

Conversely, Scuderia Toro Rosso, which has successfully evolved out of its parent Red Bull Racing into a tight-knit, highly focused team, has come along in leaps and bounds, although the early season results were not too promising. While not all of its early misfortunes could be laid at the door of Renault, were it to have had a Mercedes power unit, it might well have been closer to, or even ahead of, both Lotus and Force India.

"Our car this year is fundamentally different to last year's that had its strengths and weaknesses, but which had several strong directions that we could incorporate into this year's car," says technical director James Key. "We were also massively ambitious on the aero side."


ABOVE Don't adjust your TV sets: this really *is* a Force India challenging a Mercedes for the lead

Force India

BREAKTHROUGH

Despite qualifying regularly in the top 10, the two drivers always seemed to miss out on scoring good points in the first half of the season through no fault of their own, setting the team's cause back. The turning point seems to have been Hungary. The 12 points scored by Max Verstappen for his fourth place, followed by four more for his eighth position in Belgium, despite having a grid penalty, perhaps provided the breakthrough that the team expects will allow it to close the gap to the two Mercedes-powered squads.

"We set out to improve our championship position significantly this year so it's been disappointing as we've come away from too many weekends without the points we expected to get," admits Key, "but things have turned around and we are now getting into a regular points-scoring position."

Of the two Mercedes-powered teams, it would seem that Force India has the advantage. It was late off the blocks due to lack of pre-season testing but has quickly caught up with the mid-season updates, while Lotus, despite the highly encouraging third place earned by Romain Grosjean at Spa, is hampered by a lack of resources.

Lotus F1 Team has nevertheless staged a resurgence this year, especially after the dreadful season it experienced in 2014. A change to the Mercedes power unit has helped, but while this has been a step forward, the two steps back have been created by a lack of funds. Alan Permane, ▶

ABOVE The celebrations in parc ferme illustrated how important Grosjean's podium was to a beleaguered Lotus outfit

Hone/LAT

its trackside operations director, was quite explicit in his interview on Sky TV straight after the Belgian race that the team was operating on a shoestring. He said that where it used to have six gearboxes, it now had only three, and so on.

The team has also had to fend off threats to wind it up, one of the latest being from Xtrac although a last-minute agreement was reached. It also had the ignominy of its cars and equipment being impounded by bailiffs immediately after the Belgium Grand Prix following a dispute with last year's reserve driver Charles Pic.

All this puts Romain Grosjean's strong third place in Belgium into perspective. Given the resources of Mercedes or Red Bull, there is every indication that the team could take the fight to the works efforts.

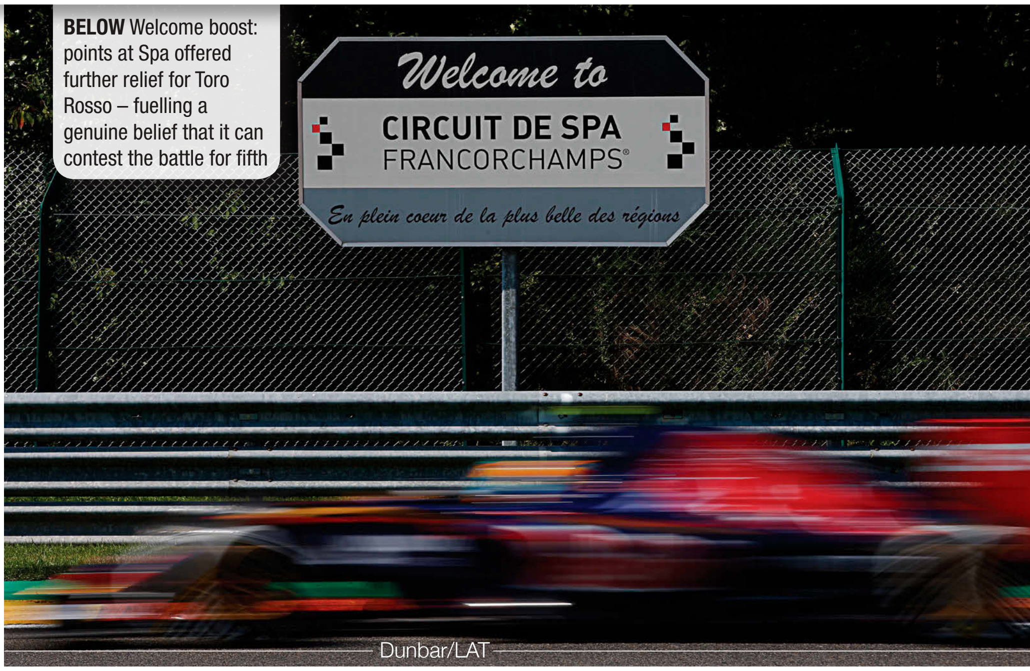
At the start of the season, technical director Nick Chester was cautiously optimistic about Lotus' prospects having swapped from Renault to the Mercedes power units. "We had what looked to be a solid car although everything about it has changed from last season to this but we now had the same power unit as the reigning World Champions and were excited by that," he enthused.

"Its installation was compact and efficient, which gave us benefits such as the way we organised our cooling system. This, in turn, helped with the packaging at the rear and some aerodynamic benefits along with that.

PUSH TO THE LIMIT

"We also spent some of the pre-season testing exploring the E23's suspension geometry and it has a lot of effect on the balance of the car in the middle of the slow-speed corners. We're also continually making the car less sensitive for the drivers so it's easier to extract performance. The drivers now enjoy driving the car, finding it consistent as they are able to push to the limit quite well. It's great to have this basis to work from as it means that we can focus on adding performance."

However, the first race set the tone for much of the first half of the season. "In Australia, the car's performance was pretty good from the outset and was good to drive," says Chester. "The drivers were happy and they were able to work the tyres quite well. The performance was definitely there for qualifying as we got both cars into Q3 but in the event, the race was disappointing with both drivers retiring. Without that we were in a position to have scored a good chunk of points.



BELOW Welcome boost: points at Spa offered further relief for Toro Rosso – fuelling a genuine belief that it can contest the battle for fifth

Dunbar/LAT

> *Perhaps the battle for fifth is an audition for the works Renault deal?"*

"Our aim was to be fighting regularly in the top 10 and while it was fair to say that it was going to be very difficult for any team to regularly take the battle to the reigning champions, as they were so far ahead of the opposition last year, there was likely to be a good chasing pack. We expected to be right in the mix with this, but that wasn't the case. After Spa, though, we know that we have a competitive package and so can try and consolidate that fifth position in the championship."

However, it is up against Force India which is equally determined to retain its fifth position. While it had a slow start to the year, it has not suffered from as many non-finishes as Lotus, although it has not really been challenging for podium positions either. As with Lotus, Spa has given the team a real shot in the arm, Sergio Perez's opening laps in the race, including the attack on Lewis Hamilton to try and take the lead, proving that the car is on an upward trajectory although the Mexican driver was critical of the car's performance.

"Fifth place and 10 points is a good result," he said after the race, "but we just lacked the pace to really fight for the podium today… We were racing some quick cars and it was hard to fight off [Romain] Grosjean and [Daniil] Kvyat, so it's clear we need to analyse our performance and see where we can improve."

Having said that, the mid-season updates have dramatically improved the car's performance, and more are in the pipeline. "The VJM08, this year's car, was quite a major step for us as we had to lower the ▶

Tee/LAT

ABOVE The sparks weren't confined to the track, Lotus having its cars impounded in Belgium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> ***"We are now operating with 30 teraflops of computing power, a massive change compared to the 0.3 teraflops we had five years ago"***

front of the chassis and nose to comply with the regulations that were introduced at the start of this season," says technical director Andrew Green. "The net effect was that we lost downforce that we have since been trying to claw back. However, the differences are not just on the surface because underneath the skin there's a completely new rear suspension layout with a new hydro-mechanical system replacing the original torsion springs. This has allowed us to explore new setup configurations for the rear of the car and also allowed setup changes to be made much more quickly in the garage. Put simply, it's another tool for our engineers to use trackside during race weekends."

This is a reference to Koni, the team opting to use its FSD – Frequency Selective Damping – a patented advance in shock absorbing technology that offers firm control during cornering and large body motions. It also offers soft motion over rough roads and expansion joints. This combination comes from a unique multi-valve design that provides absorption and compression over different compression frequencies at the same time.

"We previously worked with Koni in 2009 and it was important to us that we created a technical partnership in this area in order to have access to its damping technology expertise," says Green. "So what we've done is to lay the foundations for future development and confirm the direction that was taken in drag. However, it is going to take a few races before we can gather all the data we need to understand everything."

WINDTUNNEL SWITCH

He points out that shifting work to the Toyota Motorsport GmbH wind tunnel in Cologne during the off-season was hugely beneficial. "The ability to run 60% models represents a significant step forward in fidelity of the data we received; that in turn has improved our correlation between the wind tunnel results and the on-track car data. The model itself has a significant increase in aerodynamic loading and it was a challenge designing and building a new model in a very short time frame.

"The tunnel, however, wasn't the only course we took to improve our performance. We also looked to increase our simulator programme in order to deliver a state of the art tool to help us develop more in the virtual world while also allowing us to explore new directions and developments. The combination of the new wind tunnel and simulator has also been aided by the ramping up of our CFD capabilities; we are now operating with 30 teraflops of computing power, a massive change compared to the 0.3 teraflops we had five years ago."

So as the second half of the season gets underway, there is all to play for, although an added spice is the fact that the Red Bull/Renault divorce now looks to be imminent with the French manufacturer deciding whether it wishes to remain in Formula 1, and if so, with which team.

Lotus, which is based at Renault F1's old premises in Enstone, looked to be the odds-on favourite but soon after the Spa race it became apparent that talks were taking place with Force India. Perhaps the decision will favour whichever team finishes in fifth place? The stakes couldn't be higher. RT

BELOW Lotus netted most points in Belgium but a ramping up of simulator and CFD capabilities, plus the ability to test 60% wind tunnel models, have all contributed to Force India's upturn in form

Force India

Image: Jakob Ebrey Photography

POETRY IN MOTION

Simulators are playing an increasingly important role in motorsport, from the amateur club racer to Formula 1. **William Kimberley** takes a look at some of the technology on offer

IN the 10 years since it was founded by Jürgen Fett and Diego Minen, VI-grade has become a leading provider of software products and services for advanced applications in system level simulation. It boasts that it delivers innovative solutions to streamline the development process from concept to sign-off in the transportation industry, mainly automotive, aerospace, motorcycle, motorsport and railways. Its goal is to bridge the gap between virtual prototyping and testing by providing best-in-class services and products.

"We provide solutions to help companies bridge the gap between virtual prototyping and physical testing, specialising in very advanced applications and, of course, motorsport is a very good example of that with cars being highly optimised to get best lap times," says Gabriele Ferrarotti, industry manager at VI-grade. "The important thing is that what's simulated is precisely replicated on the racetrack."

Specifically for motorsport, it has developed VI-Motorsport, a software environment for vehicle modelling and dynamic analysis. It helps racecar designers and track engineers predict vehicle performance when setup parameters are modified before the car is built and also in support of race events. The program is based on a faster-than-real-time simulation solver that can predict virtual car behaviour. It helps teams reduce the time needed to find the best setup for a given car on a given circuit and to explore more design variants in less time. It has been extensively validated against test data in various racecar series.

The program can create road data – both driver line and tyre contact profiles – starting either from GPS, laser or telemetry data measurements or from a fully analytical description. Its advanced driver model allows users to drive the vehicle model around the specified track and to find the limits of the car. Applications include suspension modelling and analysis environment to derive suspension curves, a detailed description of components such as dampers, springs, bump stops, anti-roll bars, aerodynamics and tyres.

Another popular VI-grade program is VI-CarRealTime, as used by Hyundai Motorsport and many others, which provides a vehicle simulation environment where the same simplified vehicle model can be used by vehicle dynamics and control engineers to optimise vehicle and control system performance. It enables Design of Experiments (DOE) and multi-objective optimisation studies to be performed quickly and easily.

It is also the only real-time solution available in the market that can export automatically and seamlessly a real-time vehicle model directly from Adams/Car. Similarly, VI-CarRealTime enables the sharing of component property files such as tyres, springs, dampers, and bump stops with Adams/Car. It provides validated models that can be used by controls and hydraulic engineers to optimise the controller design based on accurate vehicle performance and it can also be integrated with Matlab Simulink for control systems.

VI-Sportscar is a specialised simulation environment, based on Adams/Car technology, that allows for the analysis of a number of design alternatives of a virtual racecar and its subsystems on a test rig or on a given racetrack. The vehicle is driven on a two- or three-dimensional track profile by a sophisticated driving program which pushes the car to its limits.

A specialised and extremely fast quasi-static lap time prediction program is entirely linked to the model database.

ABOVE VI-grade's Driver-in-Motion simulator that moves on a flat surface, sliding on airpads

Validation is continuously performed in close collaboration with customers, and this helps improve the methods and the accuracy of the program prediction.

Following a partnership formed five years ago with MSC.Software, VI-grade also offers integrated multibody solutions based on MSC.Software's Adams technology. It is the world's most widely used multibody dynamics software, originally developed for the automotive industry but also taken up by the motorsport one as well.

Since then, the company has evolved from one providing software solutions to one that supplies hardware as well. Driving simulators have been around for years, many based on the same fundamental technology. However, VI-grade has taken a fresh approach and patented DiM – Driver in Motion – which has been designed by VI-grade and engineered and manufactured by Japanese company Saginomiya. It is a very powerful machine that uses nine electrically-driven actuators to deliver high performance and high quality motion to the driver.

The DiM tripod moves on a flat surface, sliding on airpads, which makes the simulator very reliable, silent and also extremely stiff. "It has reduced friction almost to nothing compared to the use of multiple rails, which also add cost, complexity, latency and noise while also penalising performance," says Ferrarotti. "The hexapod is built on top of the tripod which is simulating the higher frequencies up to 50 Hz and the cockpit sits on top of that.

"Our engineers went beyond the basic six actuator design of a simple hexapod to provide a larger workspace; high stiffness has been maintained in order for the system to be more relevant for low as well as for high frequencies, which characterise automotive chassis design. It means that it's possible to study both vehicle dynamics and ride on the same motion platform.

"It also allows the integration of all kinds of active car systems via hardware-in-the-loop and software-in-the-loop at the same time so that physical components such as control systems can talk to each other. So it's really ▶

BELOW Citroen's WTCC simulator uses VI-grade technology. Yvan Muller and José María López both agreed that the latter's use of the simulator had played a key role in beating his more experienced colleague to the 2014 WTCC crown

BELOW Porsche's successful LMP1 prototype has been developed with the use of the Driver in Motion solution

useful for doing 'what if' studies."

The nine degrees-of-freedom DiM platform has been designed in order to take full advantage of VI-MotionCueing, an innovative motion cueing strategy developed in collaboration with the University of Padua in Italy. The technology enables the extension of the motion envelope and the separation of low and high frequency contributions, which makes this type of motion platform suitable for both vehicle dynamics and ride studies.

"Our motion cueing is also based on a completely new approach that is focused on maximising perception by utilising the full DiM motion envelope," says Ferrarotti. "By focusing on the driver, seat displacements and accelerations, a more accurate and meaningful feedback is provided. It means that cars can be tested on circuits with laboratory-like consistency with different conditions being simulated."

Porsche Motorsport has been one of the first DiM customers, using the simulator to set its LMP1 cars up before the start of the season as well as testing and optimising them as the year has unfolded. Every circuit that the cars have and will race on in the World Endurance Championship has been digitally captured so that the drivers and engineers can enjoy extensive testing sessions. The fact that it worked well was reflected in Porsche's win at Le Mans.

"Of huge importance is that the data recorded on the simulator is obtained on a realistic track so that it can be compared with telemetry data," says Ferrarotti.

"The DiM solution meets our specifications and expectations for a system that complements our existing engineering process," says Dr-Ing Malte Huneke, manager performance LMP, Porsche Motorsport. "The driving simulator is a new, innovative tool for the development of our racing cars, starting from the new LMP1 prototype, as well as in the training process of our drivers, on different tracks and in different driving conditions."

The next stage of DiM development, says Ferrarotti, is developing a more sophisticated tyre model. "The challenge is now to put a reliable and accurate tyre model in real-time, so we are talking to the main tyre manufacturers and the providers of models to implement them in such a way that they can be run in real-time."

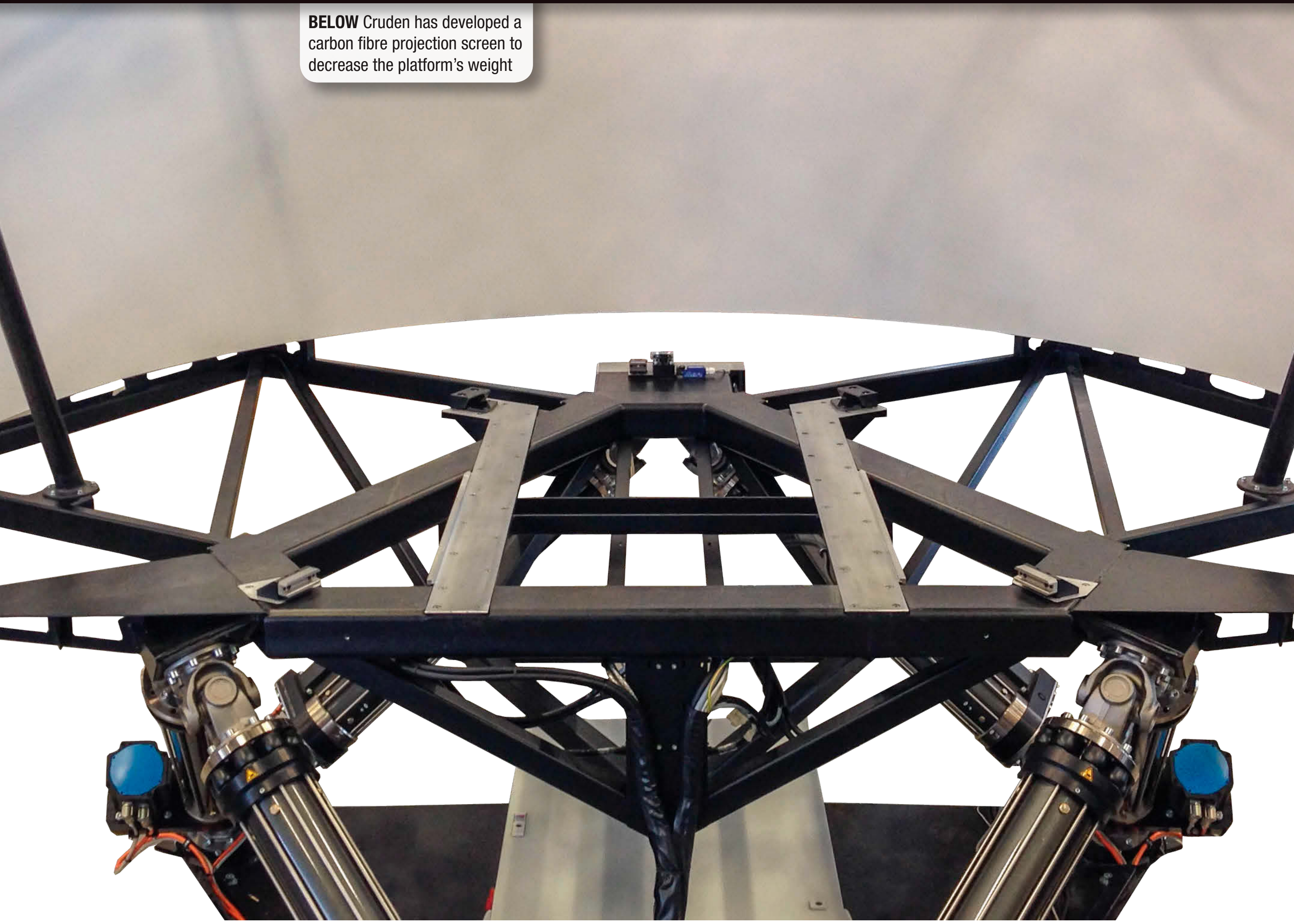
LIGHTWEIGHT REACTION

A consistent problem simulators face is reaction time. Due to their sheer weight, the pneumatics and hydraulics are not able to react in real-time, causing the reaction to be a delayed process. To overcome this, Cruden has developed a carbon fibre projection screen to decrease the platform's weight while also reducing the force and energy required to move the platform.

An additional new feature is the interchangeable driver cell which is proving to be particularly useful for those teams that run cars in different race series. The new design allows different cockpits from various racing series to be changed and fitted in around 30 minutes, without the need for specialist moving equipment. The simulator can also recognise which cockpit is in use by the joining pins as each one has its own unique arrangement.

Cruden has also addressed the issue of drivers not being able to feel all the vibrations coming through the vehicle by using actuators positioned around the driver's cell. These then produce vibrations through the chassis and adjust the height of the simulator accordingly to every detail of a track.

Late last year Cruden announced that it had developed a new approach to motion-cueing that combines vehicle side-slip angle and dynamic varying yaw pole. Following the introduction last year of enhancements to its ePhyse external physics package, which allowed new levels of motion-cueing customisation on its simulators, Cruden has recently presented its own interpretation of the interface. Adding vehicle side-slip angle and dynamic varying yaw pole to



BELOW Cruden has developed a carbon fibre projection screen to decrease the platform's weight

existing motion cues overcomes the limits of traditional acceleration cues. It is particularly useful in providing realistic feel of oversteer and understeer.

"There are limits to how well a motion-based simulator can cue acceleration on the longitudinal and lateral direction because the available space is used quickly and the feeling cannot be sustained," says Edwin de Vries, senior vehicle dynamics engineer at Cruden. "We understand that some vehicle dynamics teams, particularly in professional motorsport, need more.

"Our novel cueing method imposes the vehicle's side-slip angle – a signal that fits, unmodified, within the motion space – on the platform's yaw angle to avoid washout and high pass cueing filters, enriching the driver's handling perception.

"We can show a reduction of the latency of platform motion with respect to simulated vehicles; the yaw response is more crisp than with the traditional cueing," says de Vries.

With the new ePhyse add-on, Cruden's customers are able to bypass the standard cueing algorithms and command direct platform set points from within the Simulink environment; the motion base software continues to manage the system's inverse kinematics, workspace and safety aspects. This opens up opportunities for advanced cueing techniques like model predictive control or prepositioning.

LET'S RACE

Self-publicised as the first and most advanced Formula 1 racing simulator in the world, LetsRace, which is located in southern England close to Gatwick airport, at first sight appears to be little more than an entertainment centre for corporate events and the general public. However, look a little closer and it becomes apparent that there is far more to it.

To start with, it is the simulated motor racing arm of the Capsicum Motorsport group, the company that was set up by Grahame Chilton, father of former Formula 1 driver Max and current World Touring Car Championship driver Tom. Capsicum also owns Carlin, one of the most successful single-seater teams outside Formula 1.

It is also very well equipped with 10 full motion networked simulators. They are arranged in two rows of five, each single-seater car sitting on a modified motion bed – that has come from the medical industry – under which are three motors to drive it. There is also a ball screw and a nut and a very clever twin bearing design to allow the back to pivot independently of the front, and vice versa. The driver is confronted by three monitors that are aligned to deliver a single wraparound panoramic view.

Ensuring that everything is running smoothly for customers and teams alike is the responsibility of simulations engineer James Dover, who has a background in both motorsport and the computer games industry. He is currently upgrading the simulators to run on rFactor 2.

"Not only does rFactor 2 have upgraded graphics and a truly dynamic racing environment for the first time, it allows us to scale the motion bed control to the customer," says Dover. "So for the ▶

inexperienced person, who just wants to have fun, it might be set to low or even off; for the professional racing driver, it can be set at high."

The graphics run at around 150 frames per second (fps) and while the simulators have the capacity of running at 600 fps, Dover says that he has opted for the lower rate to avoid any possibility of motion sickness: "If a couple of frames were to be dropped and lost in translation, it's not picked up by the motion bed and it still moves. The human mind will realise that something's missing and it's that which causes the motion sickness; whereas at 150 fps, the display remains nice and smooth."

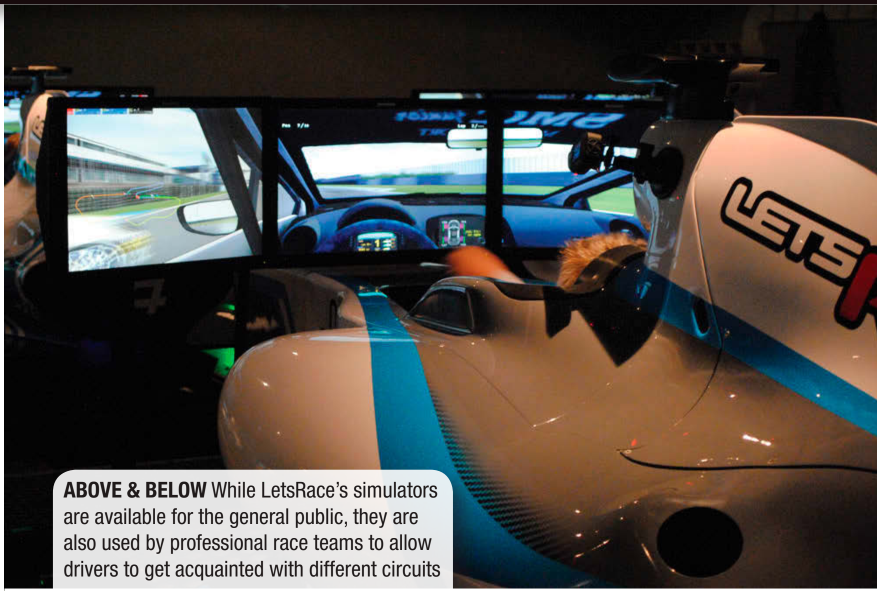
The car data is generally supplied by Image Space Inc (ISI), the Michigan-based company that has developed the rFactor racing simulation series which Dover says is pretty good straight out of the box. "We do have to change the basic setup for certain tracks," he explains. "For example, there's a very specific setup for Monaco because if you try to drive around with the setup you had at Spa, it probably wouldn't work. The steering lock's wrong, there's not enough aero, it's on the wrong tyres, the spring rates are wrong and the ride height's too low, so we have to go and change it anyway.

"Normally the only car changes we make are things like adjusting the ride height, tyre pressure and the spring damping rates. These make the car behave like we want it to, rather than trying to change the physics model itself.

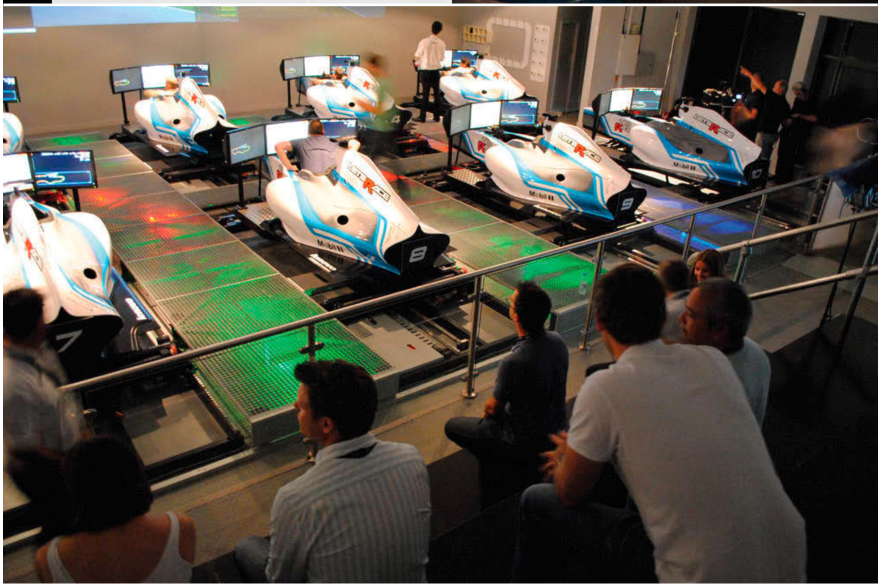
"However, if we need anything else specific for our simulators, we contact Adrian Quaife-Hobbs. He's our next door neighbour, runs Pro-Sim and has a vast data field, especially with things like GP2 and Renault 3.5 cars."

The relationship with Carlin is very close, the two companies working hand in glove with each other. "Carlin runs rFactor and has an impressive data field as well," he notes. "We sometimes collaborate with them to decide what the best thing would be. When they need help, I go there, and vice versa if I need help here."

When it comes to the professional driver, the most valuable commodity that LetsRace can offer is usually seat time. "A team can come here for a fraction of the cost of hiring a professional simulator," says Dover. "We don't have their steering wheel, pedal box or moulded seat, but for pure seat time to go and learn a circuit and get some sort of reference points, it's really good. For example, Max Chilton has been coming here to learn as many of the US circuits as he can, something he wouldn't really be getting at Carlin."



ABOVE & BELOW While LetsRace's simulators are available for the general public, they are also used by professional race teams to allow drivers to get acquainted with different circuits



Many of the circuits are released by ISI but then modified by Dover if necessary. "We can totally deconstruct the circuit and change it in the way that we want," he says. "For example, a large sausage kerb was installed on the second chicane at Melbourne that we didn't have on our model. That led to a lot of people cutting the chicane and getting faster lap times than were being achieved by the real cars, so we have remodelled it with the sausage kerb."

While the simulators are all single-seaters, LetsRace still has customers who are racing in GTs or other saloon-type cars. These include a couple of Fun Cup endurance teams that come for seat time. "They do 20 minutes in their Volkswagen Beetles and then tell us how they need to be modified to be as close as possible to the real thing," says Dover. "Sometimes it might be too much rear end grip, which then involves adjusting the ride height or taking air out of the tyres. We can also adjust the physics model, but that's only as a last resort as it gets a bit involved."

The data is robust enough to be used as a basis for setting up the real car, as Dover explains. "We can pull the data straight out of the model and give it to teams who can then take it away and do what they want with it. Nine times out of 10, especially with rFactor 1, the data pulled out about the ride height, damping rates and camber is somewhere close and a good ballpark starting place."

Conversely, teams can supply their own data which can be loaded into the simulators. "For teams that want to practice around a circuit, we do what they want to do," he notes. "So if they say, 'This is the setup we ran last year,' we can load it into the car for them and then adjust it following their driver's comments – even while he's in the car." ▶

TRACKDAY

As with the digital watch back in the day, as time moves on, so the cost of simulators comes down, *writes Scotty Whitelaw*. What was once just the domain of Formula 1 and NASCAR teams is working its way down so that they are now within the reach of pretty well every aspiring racing driver. Naturally some are better than others, and the technology involved in them is also widespread, giving the prospective customer a bit of a headache sorting out which gives the bigger bang for the buck.

Of all of the simulators I have been fortunate enough to use, a select few of them stand out from the rest and one such is The Simulator's 'TrackDay' system. One feature that is lacking in most simulators is the ability for the user to feel the precise road conditions, such as bumps and kerbs. This is one area where The TrackDay excels.

It utilises a hydraulic ram that moves the seat backwards and forwards and side to side, simulating the g forces when cornering, braking and accelerating. The driving experience is further enhanced by the use of four ButtKickers – silent speakers as seen in a surround sound cinema – located in each corner so that when the car is driven over a kerb, they create vibrations from that particular quadrant of the simulator that go through the chassis which the driver then feels. Along with these come engine tone, gearshift and other information that combined with the movement of the seat and the horizontal plane movement at the rear of the simulator all add up to give a very immersive experience.

Another area in which this simulator sets itself apart from many others is with its rear traction loss control system. Unlike others where the driver doesn't get the feeling of the back end stepping out until it becomes too late to salvage the situation, with The Simulator he does. "When a car oversteers, the front stays where it is and the back moves," says George Pilkington, managing director of The Simulator, "and that's precisely what happens in our simulator to create a perfect representation of oversteer. This is because the rear of the simulator moves in the horizontal plane and the front as in real life remains where it is on the track. Due to this motion, the driver is able to feel when the rear becomes unstable and so can react to it."

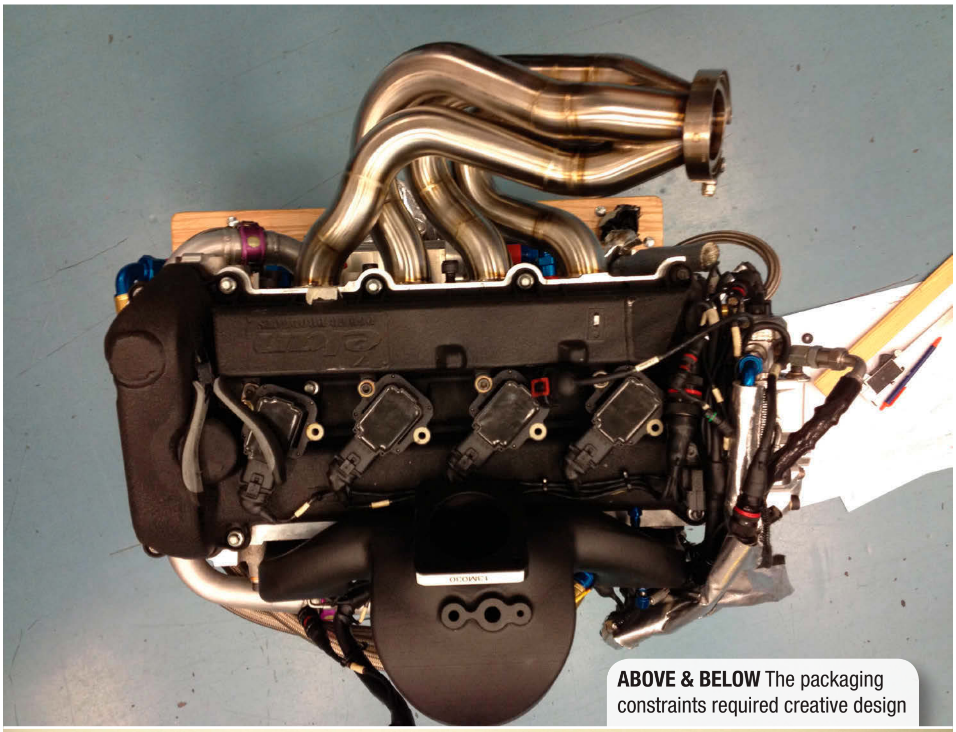
The TrackDay simulator can use both rFactor or iRacing software, says Pilkington, pointing out that every track and vehicle is laser scanned to ensure that no detail is missed. Due to this method, every change in transition or bump is accurate to within a thousandth of an inch.

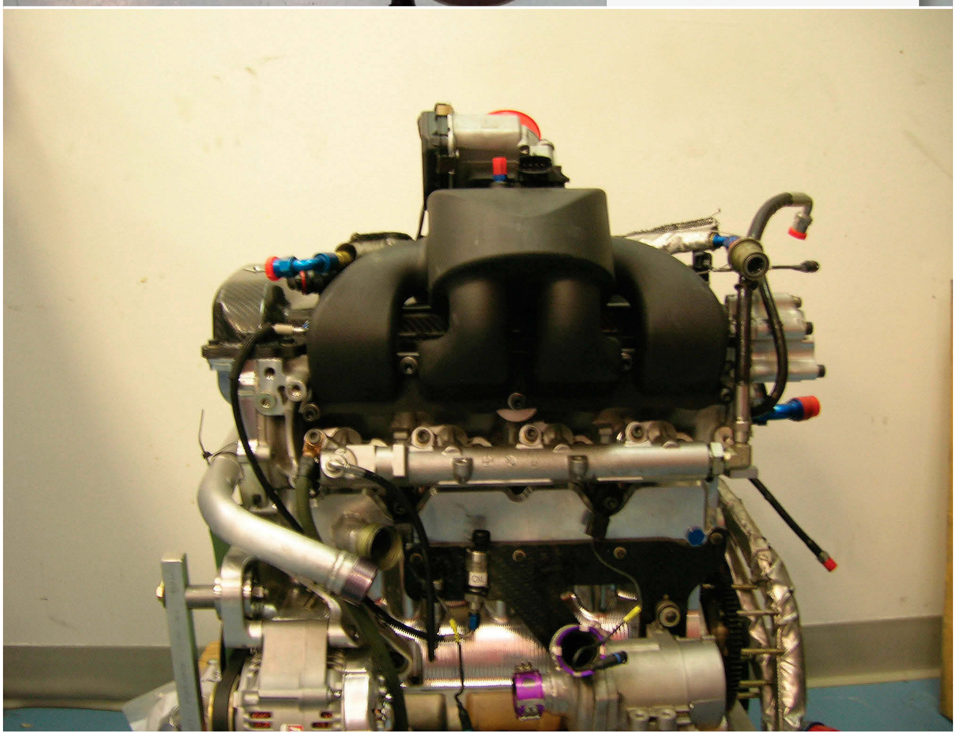
While the TrackDay simulator is superb for driver development, it is also very beneficial for engineers. iRacing has allowed different track data software to be linked up with its own Atlas and MoTeC, which enables teams to train race engineers on the system without having to run actual track days, thereby saving a small fortune. RT

BELOW Heading for Eau Rouge in The Simulator's 'TrackDay' sim

From nothing to racing in 105 days

How a revolutionary material helped develop a revolutionary car





ABOVE & BELOW The packaging constraints required creative design

THE introduction of the DeltaWing in 2010 brought radical innovation and efficiency to the racetrack, the engineering team pushing the boundaries of conventional design, heralding a revolutionary approach in motorsport. The new-look DeltaWing, now under Elan Motorsport auspices, that came about in 2013 continued to push the boundaries of efficiency, technology and innovation.

Part of this innovation could be found in the engine bay. In just 81 days, an engine had been created from virtually scratch apart from the Mazda cylinder head; just 24 days after that, it was racing at Sebring. What really helped in the mad scramble to bring it to fruition was the intake manifold that had been 3D printed.

Working with CRP USA, the US subsidiary of the CRP Group which is headquartered in Modena, Italy, design engineer Christian "Skitter" Yaeger designed and developed this item. It was 3D printed in Windform SP, a material that was robust enough to maintain its integrity in race conditions. The resulting component has been campaigned by the team since March 2013, gaining positive results and showing the tremendous potential for utilising advanced materials technologies in partnership with 3D printing.

PRINTING FROM CAD

"We could not have made this motor happen if we couldn't produce parts directly from CAD files," says Yaeger. "The biggest benefit is being able to print exactly what you need. We have eight odd-shaped ports in the head, and CRP USA was able to match them perfectly, with a knife edge in between.

"With the coupe version, we went slightly less wild and a little more conventional in our design. Over the past two years, the 3D printed manifolds have covered over 12,000 testing and racing miles, along with six

Dole/LAT USA

ABOVE Over the past two years, the 3D printed manifolds have covered over 12,000 testing and racing miles in the DWC13

hours per unit running on the dyno."

Prior to the production of the intake manifold, Windform had already proved itself to the DeltaWing engineers as it had been used on different parts of the cars, including the electronics enclosure and transmission seal covers with integrated pressurised oil feed passages.

As the engineering began a high-performance material was required to handle the heat and tension placed on the intake manifold. CRP USA introduced Windform SP, a composite polyamide-based carbon-filled material, to the DeltaWing engineering team for consideration. It has excellent mechanical properties and the added advantage of increased resistance to shock, vibration, deformation and most importantly, it is resistant to the absorption of liquids and moisture.

"The packaging constraints required by the location of the engine within the chassis requires some creative design," says Stewart Davis, CRP USA's director of operations. "The runner lengths attach at the base of the plenum and form a complex structure that would be extremely difficult to build without using additive manufacturing. Windform SP's toughness and heat deflection temperature allow the part to be built and then raced in the endurance series. The engine is run under boost, so it sees pressure variation in addition to the vibration, shock, and temperature changes associated with racing.

"The work done by Skitter and the DeltaWing/Élan Motorsports team is a great example of the application of Windform for a complex problem, and utilising additive manufacturing to push the boundaries in racing." RT

> ***"We could not have made this motor happen if we couldn't produce parts directly from CAD files"***

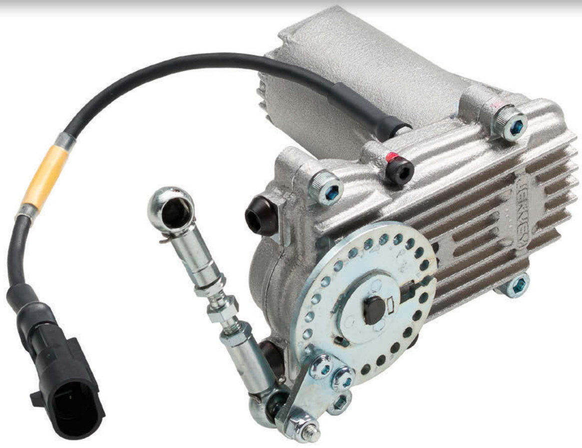
Pushing the boundaries

FOUNDED in 1970 by Roberto Cevolini as a company for high precision CNC machining in the motorsport sector, the CRP Group has evolved over the past four decades, responding to the demands of the international market and anticipating highly unique manufacturing solutions worldwide.

The group of companies that comprise CRP Meccanica, CRP USA, CRP Service, CRP Engineering and Energica Motor Company are nowadays run by CEO Franco Cevolini and Livia Cevolini, CEO of Energica Motor Company and marketing and sales manager of the group.

In the '90s CRP Technology started to adopt the technology of additive manufacturing for its customers, developing new materials such as Windform XT that has opened new doors for the various businesses. CRP Technology and CRP USA, for example, have rethought the use of 3D printing with Windform opening the path to fresh applications and new industries. The material can also be used for high-precision CNC machining, making what was impossible just a few years ago with traditional methods into a reality. RT

Highly configurable, innovative electronic throttle actuator



LEADING developer and producer of fuel injection throttle body and induction systems, Jenvey Dynamics, has launched its new electronic throttle actuator. The unit is highly modular, making it compatible with a large range of aftermarket independent throttle body (ITB) kits for road or race applications, and offers precise control over throttle actuation to help optimise induction systems. It provides durability, size and weight-saving advantages over OE alternatives and, at £495, is also cheaper and more robust than complex, bespoke fly-by-wire variants.

"We have identified the need for a highly configurable, fit-and-forget electronic actuator that is good enough to be used in international race series, yet is more attainable than often complicated, cost- or compatibility-prohibitive bespoke fly-by-wire systems," says Jenvey Dynamics managing director, Mike Jenvey. "The Jenvey actuator is competition-proven having completed its first 24-hour race on a GT car without issue, as part of a rigorous in-house testing procedure. We believe it is a perfect solution at an ideal time for international race teams, smaller scale set-ups or even track day and performance car enthusiasts."

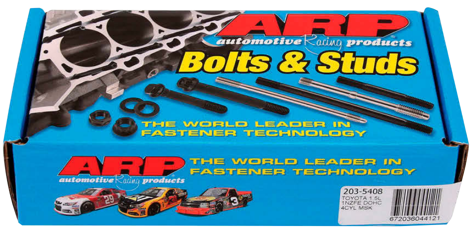
The benefits of electronic throttle actuation include: packaging; idle control, especially during warm up; autoblip with paddleshift transmission; launch and traction control; anti-lag; switchable pedal maps; controllable push-to-pass strategy; pit lane speed control; and variable bank-to-bank control.

The Jenvey Electronic Actuator offers the ability to closely monitor pedal position versus throttle position, improve throttle control and ensure active closure or power down to safeguard a valuable competition powertrain in the event of any component failure. The unit is tested to function in the temperature range of -20°C to 140°C, weighs just 500 grams and has a maximum torque capacity of 3600 Nm, allowing throttle opening times of less than 0.1 seconds from 10% to 90% throttle.

"The entire design, prototyping, validation and production process of each Jenvey product is handled in-house, which gives us complete control over specification and quality," continues Jenvey. "This means the electronic actuator is not only entirely configurable for common applications and with a range of fuelling options, but that bespoke work can be undertaken for unique or unusual applications or specific requirements for demanding race series."

The electronic actuator, which requires standalone ECU control, is compatible with all Jenvey ITB kits, including its new downdraft SFD and SFD taper kits for the popular Chevrolet LS3 V8 engine. RT

Specialist bolts and stud kits from ARP



ARP, the world leader in fastener technology, has just released a new Pro Series harmonic balancer bolt kit for Nissan 2.6-litre (RB26) applications. Each kit Includes one 8740 Pro Series (M18 x 3.500") bolt that is nominally rated at 200,000 psi tensile strength, one 8740 chamfered washer and a 1/2 oz pack of ARP Ultra-Torque fastener assembly lubricant.

The company's bolts are cold forged to ensure molecular integrity, heat-treated prior to thread rolling and machining and designed to exceed the OEM fasteners in strength and durability.

ARP has also just released a new Pro Series ARP2000 main stud kit for Toyota 1.5-litre (1NZFE) DOHC 4-cylinder applications. It includes a set of 10 ARP2000 main studs that are nominally rated at 220,000 psi, 10 8740 chrome moly steel 12 point nuts, 10 parallel ground washers and a ½ oz pack of ARP Ultra-Torque fastener assembly lubricant.

All Pro Series ARP2000 studs are centreless ground, heat-treated prior to thread rolling and machining, and designed to exceed the OEM fasteners in strength and durability. RT

Smart Port diverter valve kit for Nissan R35 GT-R

TURBOSMART has developed a range of products specifically for the Nissan R35 GT-R, the latest being the Smart Port diverter valve kit. Its drive-by-wire friendly staging technology works with the vehicle's standard mapping to deliver the best results for the car, giving the response of a plumb-back valve, with the high-performance benefits of a vent-to-atmosphere valve.

The Smart Port's unique piston is made from an aerospace alloy with a military-spec coating, reducing its weight and friction and resulting in improved valve response, better sealing and superior durability. This means the Smart Port will let the turbo spool-up faster, providing better performance, while reducing damaging compressor surge.

The versatile dual port configuration allows the valve to be easily transformed from the standard 50-50 plumb-back and vent to atmosphere, to fully recirculating or 100% vent-to-atmosphere, depending on the owner's preference.

The Smart Port is friendly to the vehicle's electronics while also being able to handle increased boost levels more effectively and for longer than the standard valve. Set up is simple, and it looks fantastic in the Nissan's engine bay. RT

Davies, Craig launches the new EWP130 electric water pump

DAVIES, Craig Pty has introduced a new lightweight alloy EWP130 (130 l/min or 35 US gal US/min) alloy electric water pump kit. When coupled to the new LCD EWP/fan digital controller, it continues to run-on after hot engine shut down thus eliminating 'heat soak' and extending engine life. Its configuration mirrors the highly successful EWP80 that offers a numerous selection of attachment options, including elbow and straight adaptors which can be bolted onto both the inlet and outlet for simple remote engine mounting.

The EWP130 will be supplied with one each of the new 35 mm straight and elbow alloy adaptors, 'O' rings and mounting hardware along with 2 x 3 mm rubber adaptor sleeves. The respective 38 mm alloy adaptors and 6 mm rubber adaptor sleeves are optional.

It is designed for universal remote-mounting across a diverse range of gasoline and diesel engines and is suitable for small to large capacity as well as 4WD engines. RT

Race-ready Clubsport custom suspension for GT-R

LEADING global Nissan GT-R tuner Litchfield has unveiled details of a sophisticated new track suspension package for the R35 GT-R. Working once again with Bilstein, the Gloucestershire firm has created a custom 'Clubsport' damper set-up which is suitable for both race and track-day work, while retaining enough adjustment and refinement for occasional road use. These new parts are from Litchfield's burgeoning range of chassis upgrades for Nissan's flagship sportscar.

Litchfield has already created a bespoke road-car damper package with Bilstein, which was the OEM provider for Nissan during the GT-R's development. This unrivalled access to chassis and setup data, and the resulting efficacy of that package, made that kit the best seller in the GT-R tuning market.

For this development, Litchfield went down a similar path, starting with a ClubSport package that Bilstein had developed for a one-make GT-R series run by Nissan's tuning arm, NISMO. To this, Litchfield's own suspension technicians worked their own magic with regard to spring and damper rates, with WTCC champion and Litchfield's in-house test driver Rob Huff on hand giving invaluable feedback and insight on how the car performed in all situations. In addition to damper rate changes, custom Eibach ERS race springs are utilised for optimum set-up.

The resulting ClubSport suspension package is a fully street-legal, TÜV-certified high-end coilover package that is also designed for uncompromising use in motorsport. The ability of these dampers is clear from the very high percentage of VLN racers that use this damper setup on the Nürburgring to great effect.

The 2-way adjustment system, complete with integrated reservoir, provides the necessary weight advantage for racing and club sport use compared to systems with external reservoirs. Rebound and compression force can be adjusted independently via the two easily accessible motorsport-proven aluminium adjustment wheels inside the vehicle. Ten positive detent adjustment positions for both bump and rebound enable the setup to be changed quickly and accurately at all times. The position of the thumbwheels on top of the struts makes damper rate changes much more efficient and easy than most other motorsport quality alternatives available for this platform.

With 10 x 10 clicks, a wide range of handling characteristics can be created in just seconds, allowing for instant back-to-back setup and testing. In combination with the supplied uniball supporting bearings, it is possible to select the suitable setup for the respective track, weather conditions and vehicle weight, as well as driver and tyre characteristics using the camber adjustment and the 100 possible settings. RT

BELOW Halcyon days: Jackie Stewart catches a slide at the Swedish GP in 1973, pursuing what would be the third of his three F1 crowns

LAT

Golden Years

Sergio Rinland ponders the heroes of the past and the fans of the future

SOMEONE sent me a video a few days ago called 'Grand Prix – The Golden Era' which had clips from the 1960s and 1970s with comments from Jackie Stewart, Stirling Moss and others of that time.

I love those videos and films; they transport me to the times when I fell in love with motor racing. Yes, as the film depicts, many of our heroes lost their lives for the love and passion of the sport. That was the dark side and perhaps why those guys felt to us like demi-gods.

The cars were simpler, so were the rules, but also the road cars of the era were simpler. Mechanics not only had to fit the cars and change their settings, they had to repair them during the race weekend. Technology was simpler, materials easier to understand. Looking at a car stayed sitting in its garage while the others are racing (as we saw with Jenson Button's McLaren in Bahrain) was unthinkable.

We, kids, understood the sport by reading the car magazines with some journalists knowledgeable enough to translate what they saw on the technical side for us. And we loved it for all those reasons. Also, we had not many options other than football, rugby or basketball. TV was only a few hours a day and our parents put limits on our use of those hideous black and white machines!

Times have changed… So have cars, both on the road and the racetrack. Cars of today still have similar mechanical bits to then, but electronics are in charge, not mechanics. The rules had to adapt but motor racing, instead of leading the automotive industry, has found itself overtaken and relegated to the role of a follower of road car technologies.

I love today's technology, maybe because I'm passionate about engineering as well as motor racing; I love the LMP1 Hybrids as well as Formula 1, even though – as you can read elsewhere in this issue – I do not much agree with F1's current rules. Motorsport, and Formula 1 in particular, has been a slave of television for the last 30 years or so, but that is also changing.

Kids today are no longer glued to their TV sets as they were a few decades ago. Instead, they are glued to their mobile devices. Motorsport insists on being a 'TV show' but things have changed so much that there are now so many more options for entertainment that this magazine would not have enough pages to enumerate. The average demographics of motorsport today are people in their 40s and 50s, and getting older by the year! The question is, how can we attract the kids of today and make them fall in love with motorsport?

When I was a kid, racing drivers got to be so by their own passion and determination; today's young drivers, at least the majority, seem to be living their parents' dream. No offence, but today you get more interviews with the parents than the drivers themselves, and they always speak about 'us', not 'him', which for me is disturbing.

So, the world has changed so much in the last 40 to 50 years that the motorsport model of the 'Golden Years' no longer applies. The governing bodies started to understand that racing cars had to resemble the road cars of today somehow to attract the traditional backer of the sport, the automotive industry. However, some of them have been tinkering with the sporting rules trying to make it 'exciting'; well, I just find it 'artificial'.

We have to find a different way to attract the young generation, go onto their turf, that is, give them the genuine article but in their time and space, not where we think it is. The young generation is attracted by being in contact with the participants and actors of the show, the drivers, mechanics, engineers, team owners, etc.

I'm not talking about 'Formula E's 'tweet-to-pass' – they shouldn't have the power to sauce up the show; that's the job of the cars and driver – but about them being able to voice their opinion (and be heard) as they do in politics and art.

If we don't evolve the show to get the youngsters involved, to interact with the sport, as they do with their other activities, they will just ignore us and the sport will die with us. RT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