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Formula 1 2015

Your guide to the regulations and the cars on the grid

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Changing times

Racecar Engineering looks at the season's key regulation changes and what they mean

By SAM COLLINS

At first glance, there is little change for the 2015 Formula 1 season, especially when it comes to the rulebook. There have been barely any changes over the winter, and the few that there have been introduced do little to affect the overall design of the car. Changes regarding the noses and the size of the front impact structures have led to the front of the cars looking different, and visually the rest of each car looks similar compared to last year. As always, however, there is more to the story.

In 2014 the FIA introduced revised rules relating to the height of the front impact structures, but an unintended consequence of this was the 'adult entertainment' look of the front of the cars. They were widely ridiculed and for 2015 new, much wider front impact structures were introduced, as well as a more gradual gradient on the nose itself and the front of the chassis.

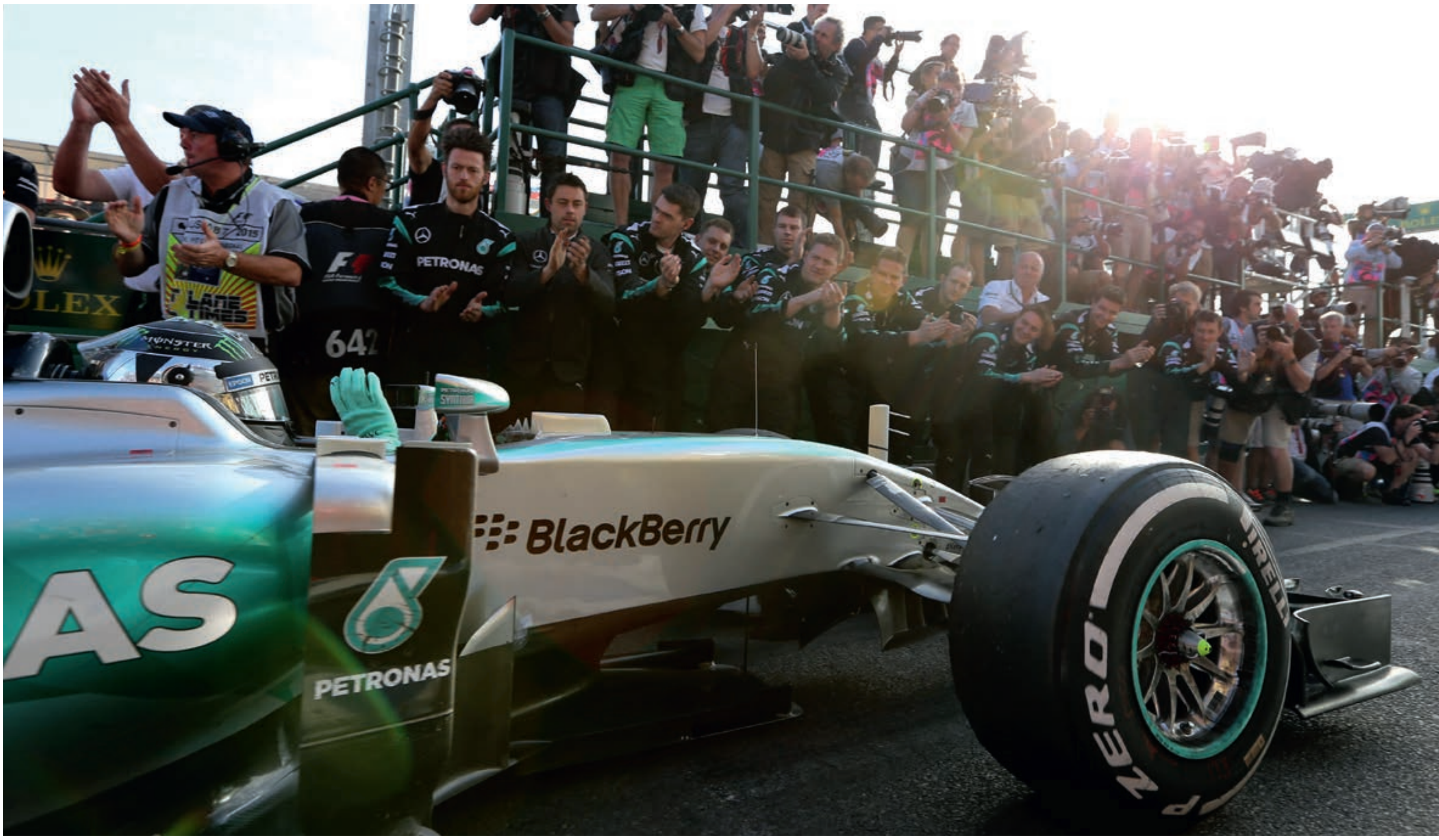
'An awful lot of work had to go into the nose,' says Pat Symonds, chief technical officer for Williams. 'At first glance, the regulations look quite innocuous, but in reality there is a lot of work there. The new front bulkhead and nose geometry had much more of an impact than we had initially anticipated and the effect on the aero was profound. The team has worked hard on pulling back the deficit these regulations have made for us. It is about the balance of aerodynamic solutions that can structurally get through the crash test too. Aerodynamically we wanted quite a short nose, but you want quite a long nose to get through the crash test, so there was some balancing to do there.'

New nose sections

This season sees a wide range of solutions of nose design on display throughout the pit lane. Teams such as Ferrari, McLaren, Sauber and Toro Rosso have all opted to use wide, long noses, where the tip of the front impact structure sits forward of the leading edge of the front wing. Others, such as the Mercedes and Lotus, use shorter noses that sit behind the front wing. With both solutions, the new wider front impact structure sits in the area where teams want to get as much air under the nose as possible, so they are all experimenting with different ways of achieving this. The Lotus twin tusk design of 2014 has been outlawed.

'The noses were an aerodynamic loss,' James Key, Toro Rosso technical director admits. 'It changed the flow in that area and as a result I think noses will be a development item this year, perhaps more so even than last year. We have things in the pipeline in that area that will improve things. Whether everyone will devise the same solution remains to be seen, but there is a lot more to come.

'We crash test at Cranfield and there have been a lot of visits there, and not just us either, to the point that our car will look totally different by the start of the season.'



Mercedes continued the dominance of the 2014 season by opening the 2015 season with 1-2 finish, with some rivals suggesting that the Silver Arrows are now even further ahead

Another consequence of the revised nose section is that a number of teams, including Ferrari, Sauber and McLaren, have revised their 'brake cooling' aerodynamic elements and the wheel design itself. Some, including McLaren, have also used so-called 'blown nuts' to optimise flow around the front wheels and in the wake of the front wing endplates.

The nose changes have also had a major impact on the packaging at the front of the cars, especially on the front bulkhead which traditionally houses the inboard front suspension pickups, the torsion bars, dampers, master cylinders, steering rack and a number of electronic components. However, this area has been substantially reduced in size on a number of the 2015 cars, and it has led some teams to explore unconventional solutions, particularly in terms of the suspension. 'It's a big packaging exercise,' says Key. 'We had a very strict rule of giving the engineering guys the surface and saying everything has to fit inside that, and they achieved everything we asked of them. At the moment the suspension is quite conventional, with torsion bars and dampers, but we have a lot of ideas, a long list of stuff. But we have not put that on the car yet.'

A more major but almost invisible rule change has had a huge impact on the suspension systems used in F1. Part-way through the 2014 season, the FIA announced that it felt that some, if not all, of the hydraulically interconnected suspension systems used in Formula 1 were illegal. The governing body felt that the systems infringed article 3.15 of the technical regulations and that they constituted a moveable aerodynamic device. Strictly speaking, the systems did not breach article 3.15, but no team felt it worthwhile to test that stance and all of the teams removed the systems with immediate effect. For 2015 they have now formally been banned with the addition of the wording 'any specific part of the car influencing its aerodynamic performance must remain immobile in relation to the sprung part of the car.' This could also conceivably outlaw McLaren-style suspension 'blockers'.

Different approaches

With this rule change, and the packaging demands at the front of the car, many teams are taking the lessons learnt in the years leading up to 2014 with the hydraulically interlinked suspension, and are applying them in a different way. The Marussia team had developed something 'different to anything seen in F1 before' for its stillborn MNR1 2015 design, while others are rumoured to be developing systems that drop torsion bars altogether.

Some other relatively minor safety rule changes have also been introduced in the wake of Jules Bianchi's crash at Suzuka last season. In 2015, the Zylon anti-intrusion panels, which are bonded to the sides of the monocoque, have been extended upwards and rearwards.

With so few rule changes, the teams and power unit manufacturers have been working hard on understanding the lessons of 2014 and optimising their cars around the power units.

The only major rule change in terms of power units is the reintroduction of variable inlet trumpets, a feature that could be used to improve efficiency and flatten out the power curve somewhat. It is a technology that is thought to feature on all of the 2015 power units and is a subject which we will cover in greater depth in a future edition.

When the new engine formula was introduced at the start of last season, it allowed for annual updates to the power unit on a gradually descending scale, eventually arriving at a fully frozen specification by 2019 (see V23N11 for full details). Each year until that point the manufacturers can present a set of updates to the FIA for their power units which would then be homologated for the season to come. After homologation each year, no

'With so few rule changes, the teams and manufacturers have been working hard on optimising their cars around the power units'

updates other than those made for the reasons of reliability, safety or cost would be allowed. The trouble is that, for some reason, the FIA failed to publish a homologation deadline in the 2015 rules, which the manufacturers have now deemed to be tacit allowance to gradually phase in updates as the season goes on.

In 2015, up to 48 per cent of the power unit can be replaced (subdivided into 32 tokens), with the only elements of the design to be fixed being some dimensions including cylinder bore spacing, deck height and bank stagger, the air valve system and some aspects of the crankshaft design, so some manufacturers are clearly planning to bring in new parts during the year within that 48 per cent allowance. Mercedes has used the largest amount of its allocation going into the season with 25 'tokens' used, Ferrari has used 22 and Renault just 20. As a result of this Honda will be allowed nine development tokens during the season.

Despite this, Mercedes has claimed that its PU109B power unit is essentially all-new, despite the rules seemingly stating that they can only be 48 per cent new. 'I don't think there are many parts carried over from last year, I think the majority of parts are changed either for performance or reliability,' explains Andy Cowell, Mercedes AMG HPP managing director. 'This power unit is completely new. If you look at the table of tokens you can change a lot. Combustion is down as three tokens for example. Changing that means a new cylinder head, piston, valves, injector and some associated parts, all within those three tokens. So when you think about it, the 32 tokens are actually very, very generous. Coupled with that, you can change anything for reasons of reliability, and everyone has to do more miles. Basically in 2015 everyone can change everything, because of the 32 tokens and the reliability increase required to go down from five power units to four.'

This has left the teams able to focus on integrating the power units better, leading to the cars featuring smaller cooling apertures as more efficient ways to cool the cars have been found and introduced. For example, Ferrari has changed the type of radiator cores it uses.

Top: The Renault equipped Red Bull branded teams have struggled to get the best out of the power unit again
Above: A small change in the rules relating to the shape and size of the front impact structures has had a major impact on overall car air flows

Another consequence of the new nose regulations is that packaging the front suspension has become a much tougher job

'The reduction in cooling is really just a case of second time around the loop – the heat rejection and cooling requirement numbers for the engine have not changed, it is just a case of looking through everything again and optimising', adds Adrian Newey of Red Bull.

In terms of transmissions, little has changed year on year, with each gearbox still having to last for six races. 'We count it as 3300km,' explains Xtrac's technical director Adrian Moore. 'This is made up of 250km on Saturday, and 300km on Sunday. Of course, not everybody does this as it depends on how far they run on Saturday morning and how far they get in qualifying and the race, but that is our target. The eight homologated gear ratios were designed to be in the gearbox for this mileage.'

One change to the 2015 sporting regulations means that teams can no longer make changes to their gear ratios during the season. 'Last year teams were allowed one instance of a ratio tooth count change during the season, i.e. in effect they could decide to change some or all of their eight homologated ratios for up to eight different homologated ratios', Moore elaborates. 'They were also allowed five jokers, where they could change ratios from a sealed gearbox to identical items without penalty. In 2015 the ratio tooth count change is no longer allowed, and neither are the jokers.'

Far too often in the world of sportscar racing, an erroneous statistic is repeated claiming that the winner of Le Mans does more running in one race than a grand prix car does in an entire year. When looking at the gearbox it is clear that this is not the case. 'With our ultra high specification gear design, materials, heat treatment and finishing processes the gear ratios are intended to be durable for at least the 3300km,' Moore claims. 'In 2014 the winning Le Mans car completed 379 laps in the race, which is 5165km. Comparatively an F1 car's gearbox is sealed for 3300km, which is actually more than 60 per cent of a Le Mans distance– significantly different to a few years ago when F1 gearboxes were overhauled after every race.'

More compact rears

But despite the stability of the regulations it appears that few, if any, of the teams have carried over their transmissions from 2014. One notable trend in 2015 is toward very tight rear ends on the cars, to the point where McLaren has dubbed the MP4-30 the 'Size zero racing car'.

This is an area of focus for almost every team and has led to not only revised transmissions but also substantially different suspension layouts. 'The suspension is very different,' Key reveals. 'We heavily revised what we did last year for both aero and suspension reasons. With suspension you have the structural stuff, like compliance levels, but aero wants to have the thinnest possible elements, whereas structures want the thickest possible. You have to look at all of it, the mechanical grip,the ride and the platform control. Suspension has a huge aero influence so you have to go round a loop of how to optimise things, and we have done that more with this car than ever before.'

Some teams have gone even further and Force India has replaced the torsion bars at the rear with a new hydro-mechanical system, it seems likely that these changes were made for packaging reasons.

Overall, though, it seems that all but one of the 2015 racecars taking to the grid is a mild evolution of the same teams 2014 concept, just with a great many detail refinements, and not a few very small innovations. The only exception is Manor – turn to page 24 to get the full lowdown on their 2015 car.

'Any specific part of the car influencing its aerodynamic performance must remain immobile in relation to the sprung part of the car'

Mercedes W06

POWER UNIT:
Mercedes PU106B Hybrid

The Mercedes W06 Hybrid has a largely evolutionary design with many major concepts carried over from the dominant W05 Hybrid. However, almost all of the components have been refined in some way with many detail changes both visible and under the skin.

'It is an evolutionary process and this also includes the regulations themselves. Relative to last winter, these have remained reasonably stable into 2015. Some changes will be more visually obvious, of course, but the devil is in the detail. Beneath the covers there have been a raft of developments from both a chassis and power unit perspective – all aimed at creating a car that is safer, more efficient, more reliable and ultimately faster. With the Hybrid era still very much in its infancy, there is plenty of scope for innovation. The challenge at this stage is to find the key areas for performance gain based not just on what we have learnt a year further down the line, but also on where there is room for exploring new and innovative sources of competitive advantage,' Mercedes F1director Paddy Lowe told the press.

The new Mercedes power unit features a slightly larger plenum compared to the 2014 version, to accommodate the new variable inlet trumpets, something that is claimed not to have caused any great packaging issues. Meanwhile the V6 engine features an entirely new exhaust concept, which seems to have done away with the pulse converter concept seen on last year's power unit and adopting a more conventional layout.

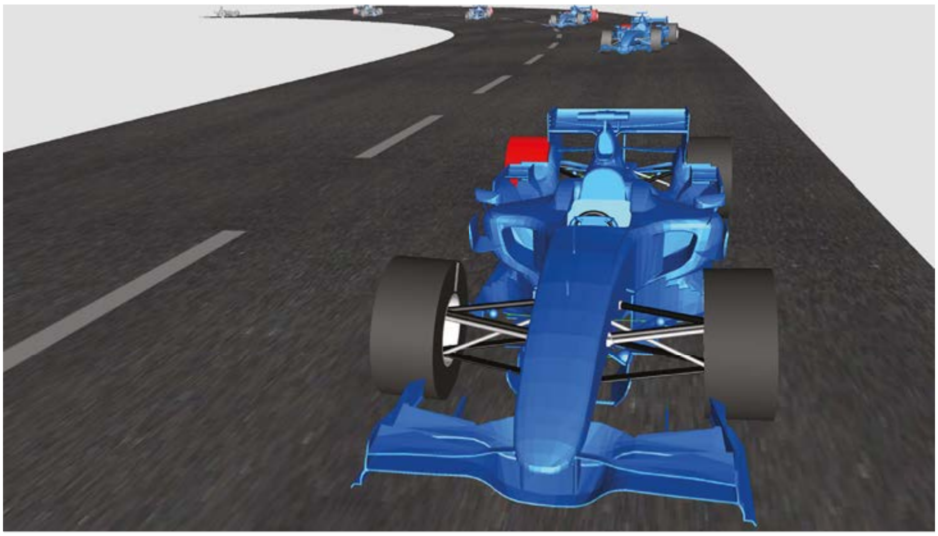
In terms of the chassis, the car has carried over many concepts from 2015. For example Mercedes has carried over the lower front wishbone concept from the W05 which blends the two legs together in a single shroud in a solution vaguely reminiscent of a Tyrrell design of the 1990's, although that was employed on the upper wishbone.

One area of change can be seen on the roll hoop, which has a single very small support behind the drivers head. This is a significant change from the 2014 design which featured two much larger supports. Losing material from the roll hoop is a key objective for many teams as it is a heavy component mounted at the highest point on the car. This is a great example of how the Mercedes engineers have analysed every element of the car and made many small refinements.

The Mercedes is still the class of the F1 field by some margin and it seems that only Ferrari have a realistic chance of catching them.

SIMULATION, NOT ESTIMATION

One of the biggest shifts within motorsport in recent years has been the emergence and reliance on simulation solutions, fuelled by the rapid development of technology and increasing testing restrictions.



As restrictions on testing have been introduced across many series, Claytex finds that engineers are more driven to use simulation. Within the simulation field itself, one of the biggest changes has been the desire to use one common model across the team; within the design office, trackside tools and driver-in-the-loop systems.

Our simulation solutions are built on the open standards of Modelica and FMI and provide a powerful, multi-domain modelling capability that can simulate the whole vehicle as one integrated system. This enables the whole system to be optimised rather than working on the different elements in isolation and hoping this delivers a good overall system performance. Dymola provides the core simulation capability and is used extensively in Formula 1, NASCAR and IndyCar.

Williams FW37

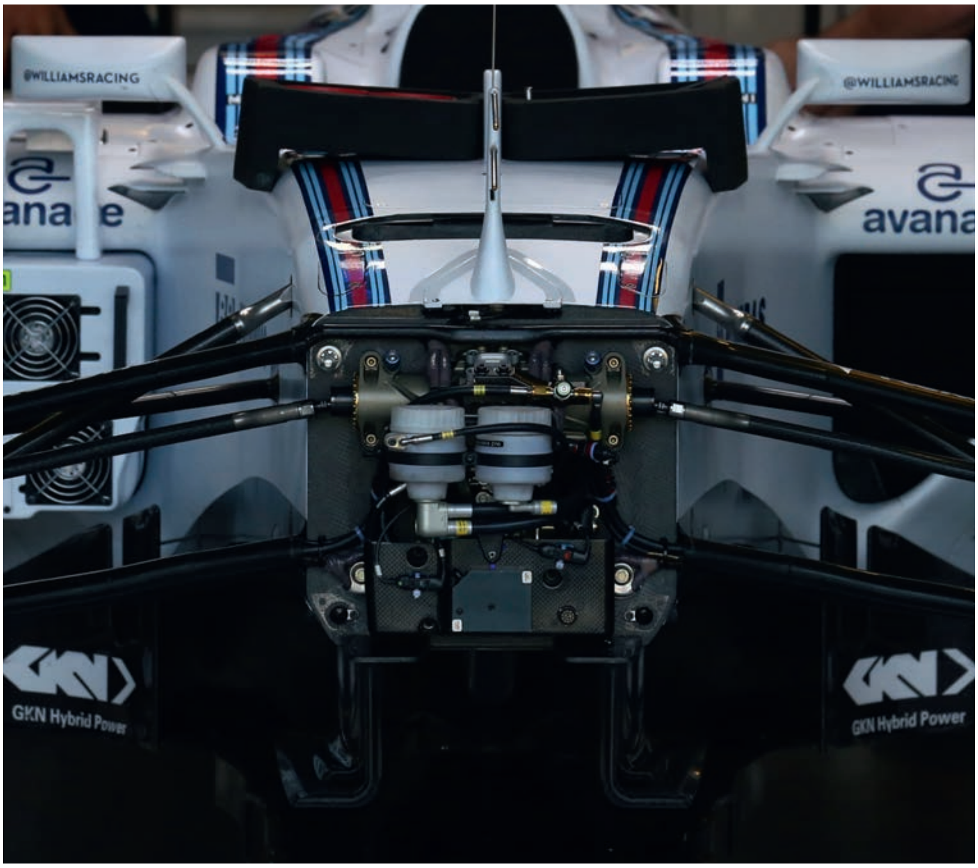
POWER UNIT:
Mercedes PU106B Hybrid

'The notion for the FW37 was to look closely at the FW36 and its performances,' says Williams chief technical officer Pat Symonds. 'We then went about recognising what had worked well and identifying and resolving the areas that we felt needed to be improved. Although the aerodynamics of the car were impressive there is always room for improvement particularly as we handle the new 2015 nose regulations '

The design of the FW37 has stemmed from the performance of the FW36 but the conceptual ideas came about long before the 2014 successes. 'The first conceptual stage of the FW37 came before the FW36 had even turned a wheel in anger. The main element to this is fully understanding the rule changes and how they will affect the design of the car. From here we can then start to see if our ideas will fit within the new regulations.'

'The desire to beat Ferrari to third place in the Constructors in 2014 meant we pushed our development through to late autumn, but the size of the team is now at a point where it was able to sustain this development while still working on the FW37. We felt we came up against design barriers in the FW36 and so took the opportunity to remove those barriers for the benefit of the performance. The FW36 carried a reasonable amount of ballast, so we were able to make alterations to the design for added performance without the fear of adding excessive mass.'

The FW37 roll hoop concept largely carries over from the FW36 with the main duct for combustion air almost identical to the 2014 design. Both cars also feature an additional cooling duct behind the main hoop though the duct on the FW37 is slightly larger. The whole concept dates back at least to the FW35,



with the twin forwards support and the overall combustion air intake shape, despite Williams switching from a Renault V8 to two different iterations of Mercedes V6.

Overall the concept of the 2015 Williams seems to be simply one of addressing all of the shortcomings of the 2014 car while sticking largely with the same concept.

Williams is once again very strong and believes that it can match Ferrari this year, if not the Mercedes works team. 'What I see is a huge change in mentality at Williams over the space of 12 months,' says Rob Smedley, head of vehicle performance at Williams. 'It now believes it can out develop any other team. The wind tunnel is doing a fantastic job with the amount of performance they are bringing to the car and the guys in mechanical design have done an immense job. Once again we have a safe, reliable and well-balanced car.'

Top: The Mercedes power unit installation on the Williams
Above: A look at the tightly packed front bulkhead

Force India VJM08

POWER UNIT:
Mercedes PU106B Hybrid

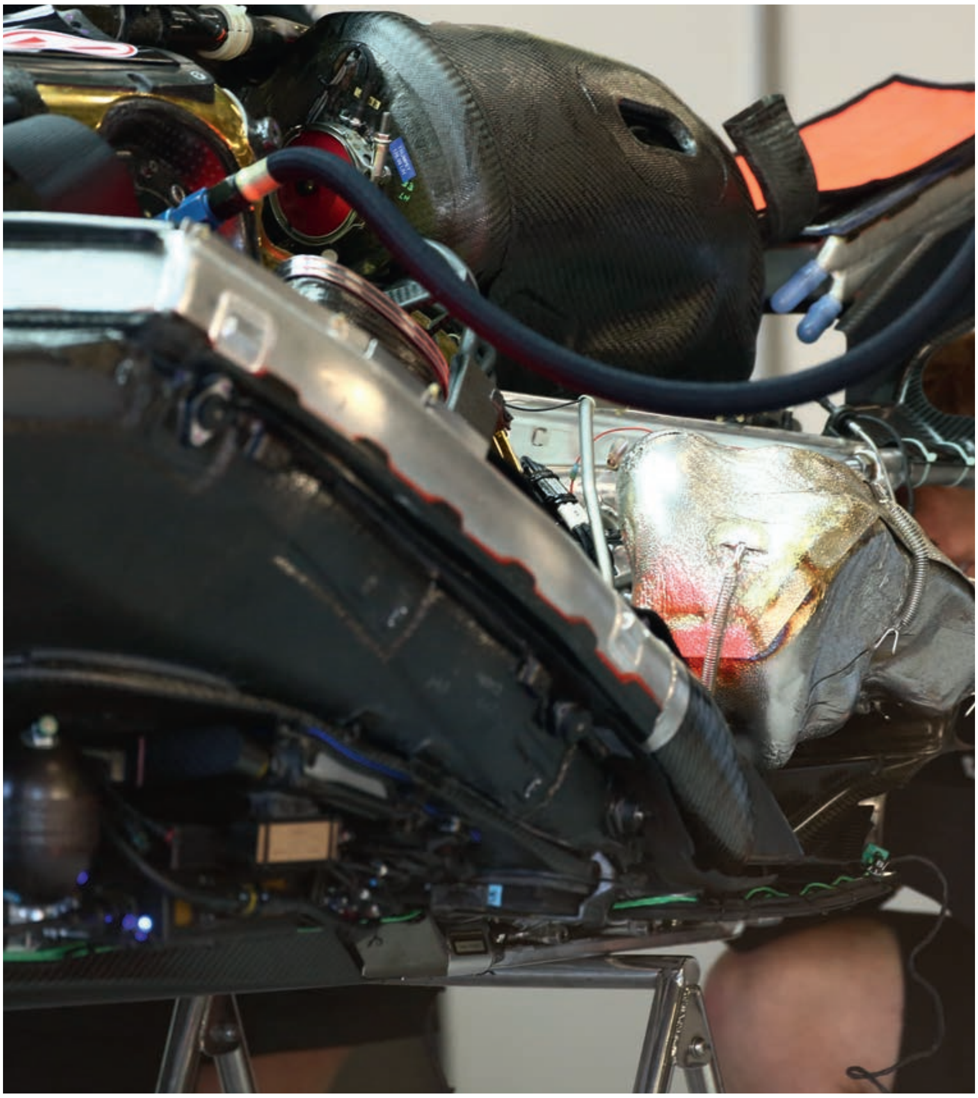
The Force India VJM08 made its long overdue track debut at the final pre-season F1 test, held at Barcelona. The car had been delayed for a number of issues mainly thought to relate to late or non-payment of bills to technical suppliers. Rumours of no fuel tank, chassis, crash structures and electronics did the rounds, and allied to the legal wranglings of the team's ownership some began to wonder if the VJM08 would ever materialise.

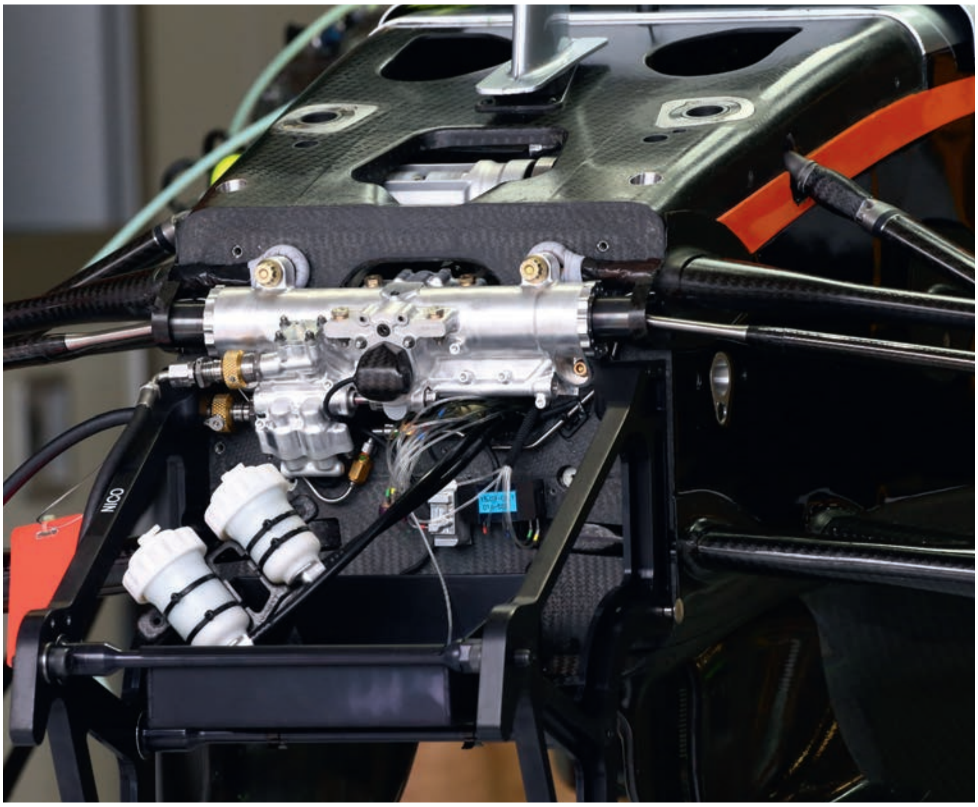
Andrew Green, Force India technical director explains: 'This year, our focus is mostly on refining and developing the package we had in 2014. We are looking forward to building on what we learnt in 2014 about the VJM07: we understood the car's strengths and weaknesses and we aim to build on the former and fix the latter. This has been the goal.'

The reasons for the delay are not clear and the team has yet to be forthcoming about the rumours, but it is clear that with a car on track the reported financial woes are not at the top of the agenda anymore for now. One of the rumoured financial issues related to the state of the art wind tunnels at TMG in Cologne – Toyota has not commented on the issue but media reports that access to the wind tunnel is restricted have been widespread. The VJM08 is the first Force India developed at a larger scale. 'Working solely in the TMG wind tunnel will help our development significantly, and having the ability to run 60 per cent models will represent a massive step forward in fidelity of the data we receive, and this in turn will improve 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's a challenge designing and building a new model in a very short time frame, 'Green continues.

Beyond the wishbone shape the suspension on the VJM08 looks conventional externally with a pushrod actuated front layout and a pull rod rear, however the team claims to have moved away from a conventional torsion bar as a springing medium at the rear and a has replaced it. 'Underneath the skin there is a completely new rear suspension layout with a new hydro-mechanical system replacing the original torsion springs. This will allow us to explore new setup configurations for the rear of the car and will also enable set up changes to be made much more quickly in the garage. Put very simply it's another tool for our engineers to use trackside during race weekends,' Green explains.





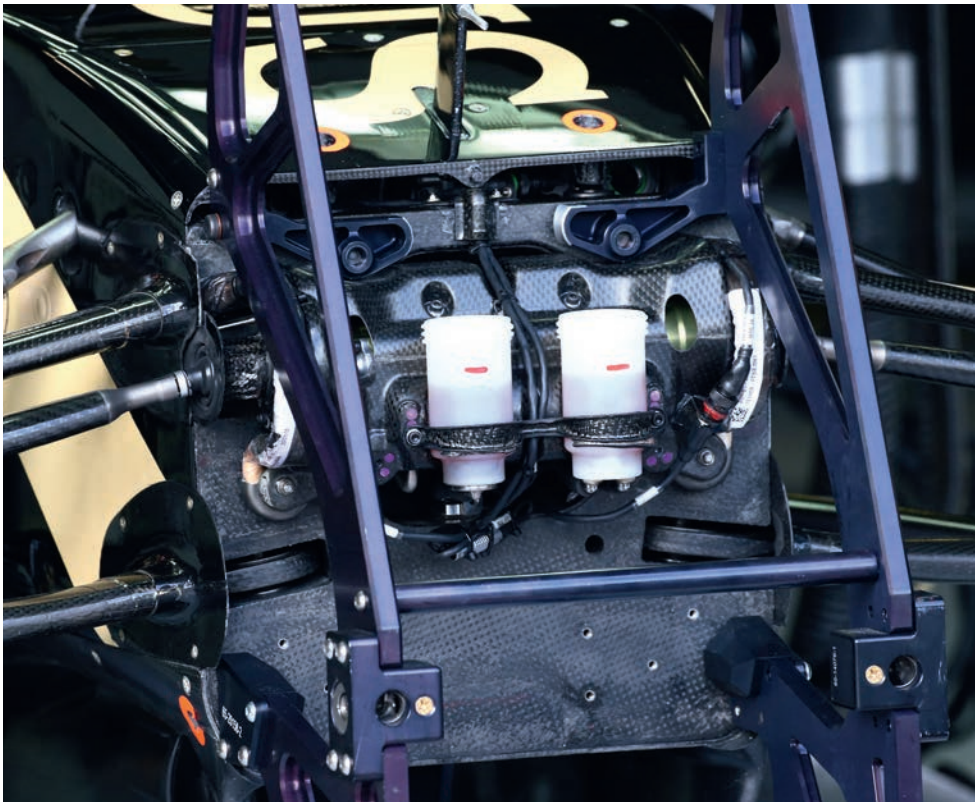
Top: Mercedes has revised its exhaust solution for 2015, as can be seen here on the Force India
Above: With the bodywork removed the shape of the front of the chassis is clear to see

Lotus E23 Hybrid

POWER UNIT:
Mercedes PU106B Hybrid

'The E23 Hybrid represents a massive step forward for us,' Lotus technical director Nick Chester enthuses. 'It's no secret that we struggled with last year's car so we've targeted every area that caused us an issue. We've made strong progress in the wind tunnel as well as in areas such as packaging and cooling. We expect the E23 to perform far, far better than its predecessor. In terms of what's new, obviously a massive change for us is a new power unit supplier. We made this change as it looked, and looks, to be the one area of the car which could bring us the greatest performance gain. It's not just performance, but reliability and drivability as well as packaging and cooling too. The E22 did deliver good figures in the wind tunnel, even if it was difficult to unlock its potential, so we've paid more attention to making the characteristics of the car more adaptable. In terms of the suspension, we were delivered something of a blow last year when the front-rear interconnected suspension was outlawed mid-season. The E23's suspension design is specific to the updated regulations so we're not trying to update a system originally intended to work a different way. We learnt a lot in many areas of the car over the course of 2014 so there are many lessons which have been applied. We know we've made a significant step forwards. We won't know how our car will fare in relative terms until we're out in action at a Grand Prix, but we certainly expect to be much more competitive than last year.'

The Lotus E23 was a late arrival at winter testing due to issues during its build, but



the design that eventually rolled out was, as Chester alludes, very close in many areas to that of the E22. This is something that can be clearly seen by looking at the shape of the roll hoop, which appears identical on both cars.

Reliability issues prevented it from really delivering on its potential in Melbourne, but Chester is still confident that the car will deliver strong results this season. 'It's a brand new car and there is quite a lot of aero development work to do; we will be pushing developments all through the year for it. We are happy as we have a good platform to work from. The drivers enjoy driving the E23; they find it is a consistent car 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,' he explains.

Top: Little has yet been seen of the Mercedes installation in the Lotus
Above: Some of the suspension components are mounted on top of the chassis and under the vanity panel on the E23

Red Bull RB11

POWER UNIT:

Renault Energy F1-2015

The Red Bull RB11 had no formal launch due the car's delayed build, and just as the media started to speculate that the team did not have the car ready for the first test it rolled out in a dazzle ship livery.

Chief Technical Officer Adrian Newey says: 'The design of the RB11 has been very much about understanding what we learnt from last season, which was a big regulation change as far as the power unit is concerned. Then there's the packaging that goes with that and setting about optimising the car from those lessons.'

Chief engineering officer Rob Marshall adds: 'There are some changes that affect the shape of the front of the car but beyond that most of the changes are under the skin. We've identified the areas where we can make improvements and we've worked hard on these. There won't be a lot that's visible to the naked eye but a lot of hard work has gone into the hidden bits.'

A large part of that work has involved improvements to Renault Sport's Energy F1 power unit, updates that have been made in closer collaboration with the team. But it is a relationship that shows signs of souring rapidly after reliability and performance issues saw the RB11 perform badly in Australia, with vibrations from the V6 engine apparently damaging transmission components.

The RB11 appears to have a much smaller level of cooling than either the RB10 or the Toro Rosso STR10, which has a near identical engine installation. Its sidepod cooling ducts are extremely small compared to other cars, including the Toro Rosso.

The 2015 Renault power unit features a number of revisions. 'We have made some fundamental changes to gain performance and reliability. We have upgraded every system and subsystem, with items that will give the most performance prioritised. The principal changes

involve the internal combustion engine, turbocharger and battery. The ICE will have a new combustion chamber, exhaust system concept and variable trumpets, as permitted by the 2015 regulations. The compressor is more efficient, while the energy recovery systems are able to deal with more severe usage', Rob White of Renault explains.

'The 2014 unit was already well placed in its centre of gravity, however we have tidied up the packaging to give greater ease of integration into the chassis. Additionally many systems and functions have been rationalised and simplified to further ease the task. In short, there are very few carry-over pieces between the 2014 and 2015 power units,' he says.

Renault used the fewest update 'tokens' during the winter so a substantial upgrade to the power unit is expected in the first half of the season. This could transform the on track performance of the Red Bull RB11.

Top: The controversial engine installation on the RB11
Above: Red Bull appears to have copied the metal front bulkhead first seen on the Marussia MR03

Toro Rosso STR10

POWER UNIT:
Renault Energy F1-2015

'The car is a real mix of very different approaches in some areas, while also refining and developing what we felt were some of the more solid philosophies of the 2014 car,' says James Key, Toro Rosso technical director. 'It will look quite different by the time we get to Race 1 and we've got several very new ideas which have gone into it. The team is exploring these ideas for the first time, which makes this an interesting project. We've pushed the limits of timing much more with the STR10 than with past cars and we're dealing with it really well. The noses were an aerodynamic loss which changed the flow in that area and as a result I think noses will be a development item this year, perhaps more so even than last year. We have things in the pipeline in that area that will improve things and there is a lot more to come.'

The Toro Rosso utilises many shared transmission and hydraulic components with Red Bull Racing as well as the general engine installation. But the bell housing and main case are unique to Toro Rosso and made in Italy. All-new rear suspension mounts to that gear case, and while details of that are not yet clear Key hints that it is a major area of development.

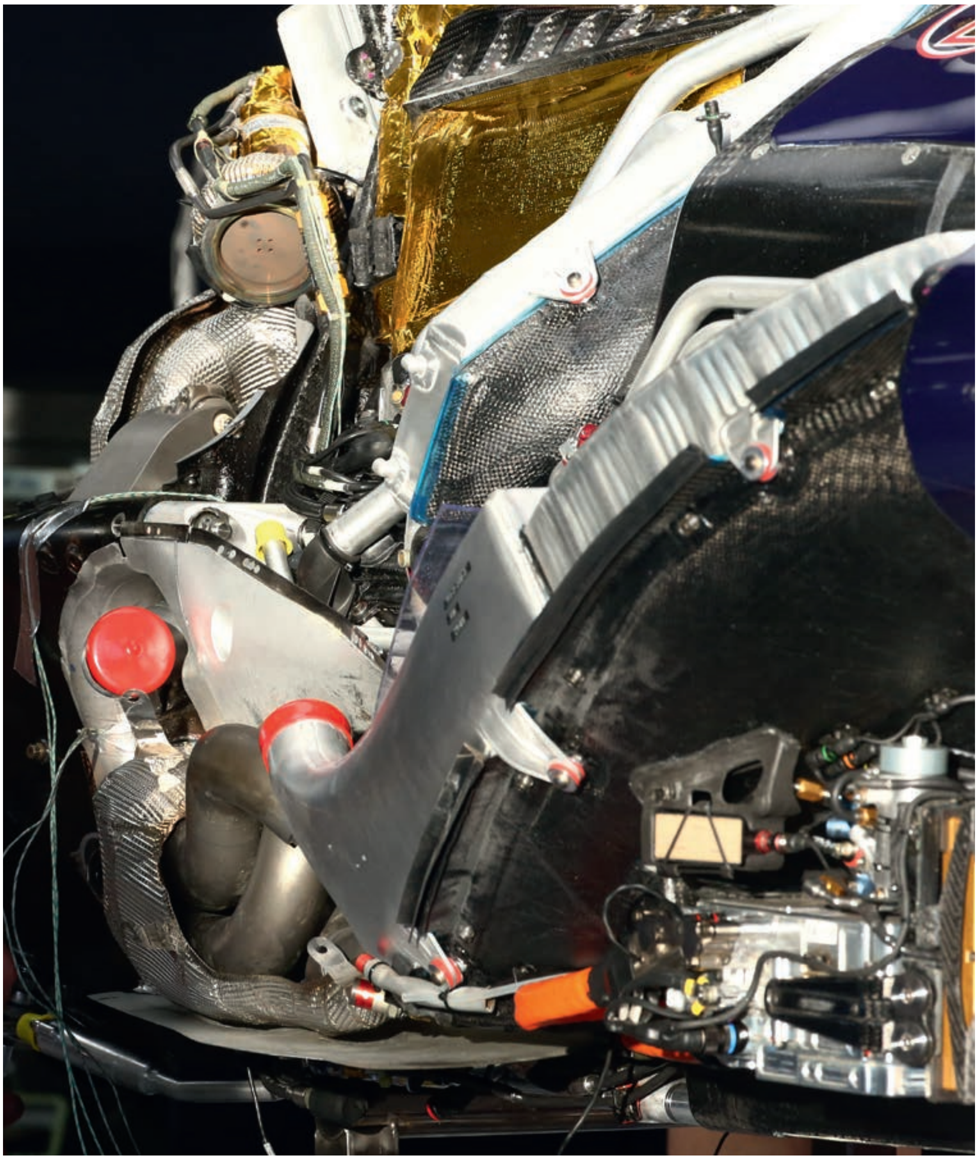
Toro Rosso has made a major step with its cooling system design and is employing a new type of radiator core on the STR10.

An immediately obvious feature on the Toro Rosso is the huge duct mounted on its roll hoop. In reality there are actually five separate ducts. The uppermost duct in the roll

hoop feeds combustion air to the Renault V6, while the large duct beneath it feeds a heat exchanger mounted right at the top of the chassis (and visible in the pictures on these pages). A much smaller duct is located directly behind the driver's head and this is thought to cool some electrical systems.

Finally on the outer edge of the roll hoop there are two small cooling ears feeding air to the rear of the engine bay. This cooler concept has been seen on previous STRs.

The Toro Rosso was upgraded substantially ahead of the Australian Grand Prix and appeared to be a match for its sister team Red Bull, but it also suffered significant issues with its Renault power unit, something that is beginning to spoil the relationship between the French supplier and the team's Austrian owners.



Top: Renault has revised the exhaust layout on its V6 engine
Above: The STR10 bulkhead is compact but largely conventional

Ferrari SF15-T

POWER UNIT:
Ferrari 060/3

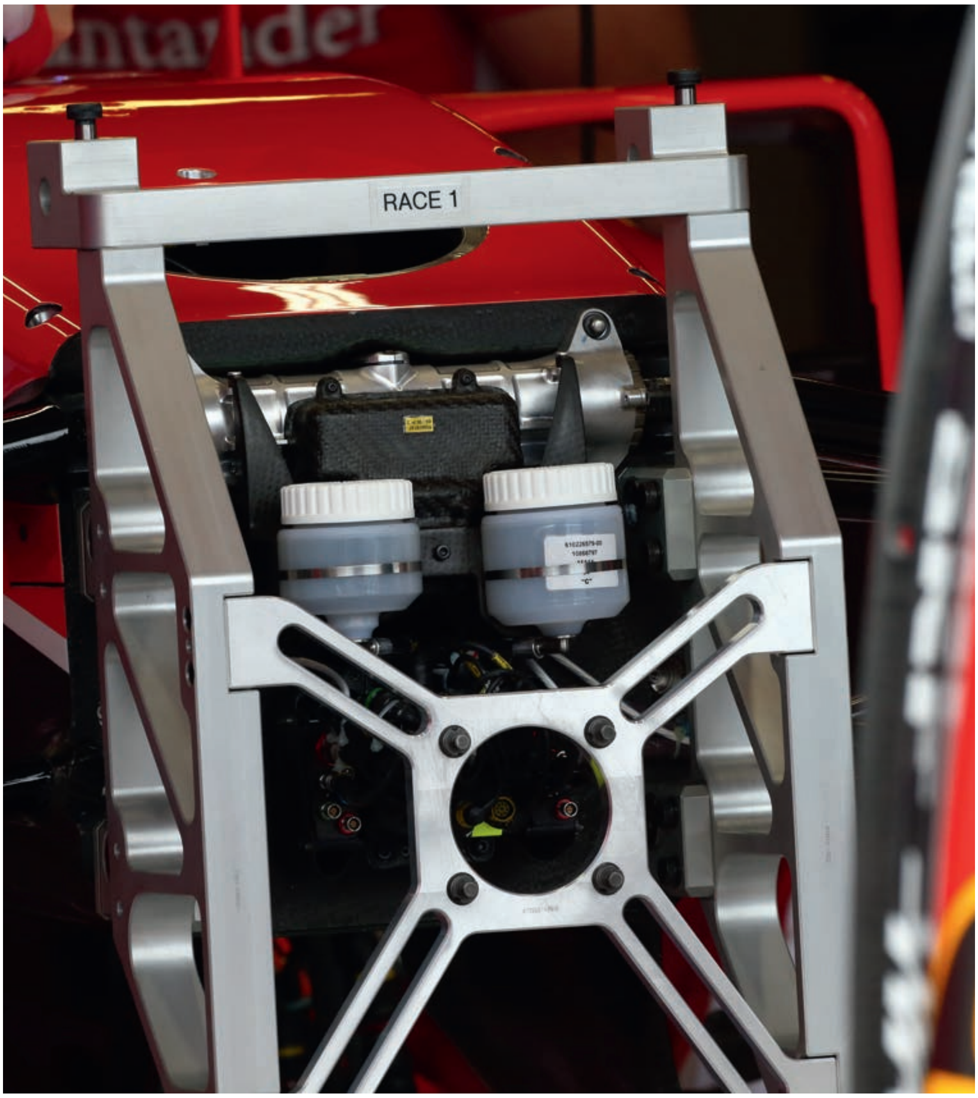
Ferrari has clearly made a major step forwards with its SF15-T. After a terrible 2014 season a number of key staff were fired, demoted or otherwise replaced and it seems to have worked – the new car was immediately on the pace and Mercedes publicly stated that it expected to be caught by the Italians during the season.

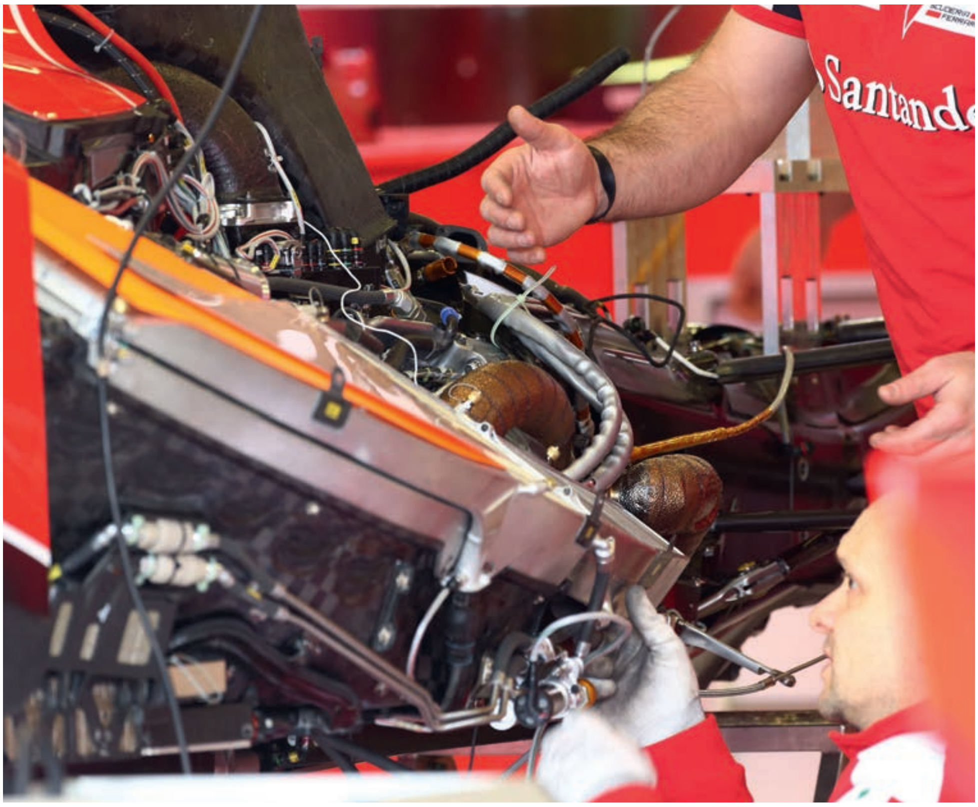
Overall the SF15-T is a continuation of the concept seen on the F14-T, although Ferrari will hope that many of that car's short comings have been resolved. One issue the Ferrari power unit had in 2014 was that it was over weight and did not produce enough power, but the minimum weight increase of 11kg over 2014 will certainly help in that department. The car also features an entirely new exhaust concept with the pipes sitting out wider from the engine block than they did in 2014, and the turbocharger has also apparently been redesigned entirely.

In 2014 Ferrari openly admitted that it had compromised its power units performance in order to maximise the aerodynamic package, but the project was not a total success as its results showed. It now seems to have dropped that concept for 2015 in order to get the best out of the power unit.

The cooling package on the SF15-T also seems to be very similar to that of the F14-T, although the sidepod ducts appear to be slightly smaller in size. However, the overall shape and concept of the ducts is very similar when you compare the two cars. This reduction in duct size is to be expected as Ferrari's own PR material states that the SF15-T has an 'improved cooler matrix layout'. Optimising the heat exchanger position and detail design can indeed bring big gains but it is a specialist task which Ferrari has probably outsourced.

The SF15-T retains the pull rod actuated





front suspension used on the 2014 car, an approach attempted by McLaren and later dropped, but both the front and rear suspension kinematics have been overhauled to present the tyre to the road in a manner that allows better use of the Pirelli rubber.

Meanwhile the front and rear brake ducts have been remodelled to produce more cooling of caliper and brake disc while generating more downforce than their 2014 counterparts, something all teams have done to deal with the new wider front impact structures.

A look at the back of the car reveals a much more tightly-packaged rear end which allows more downforce to be extracted from the critical surfaces around the rear of the car. The rear wing family has been extensively redesigned to deliver stable performance in the corners while also producing a larger DRS effect on the straights.

Top: The front end of the Ferrari retains its pull rod suspension
Above: A substantial upgrade to the Ferrari power unit has delivered a step up in on track performance

Sauber C34

POWER UNIT:
Ferrari 060/3

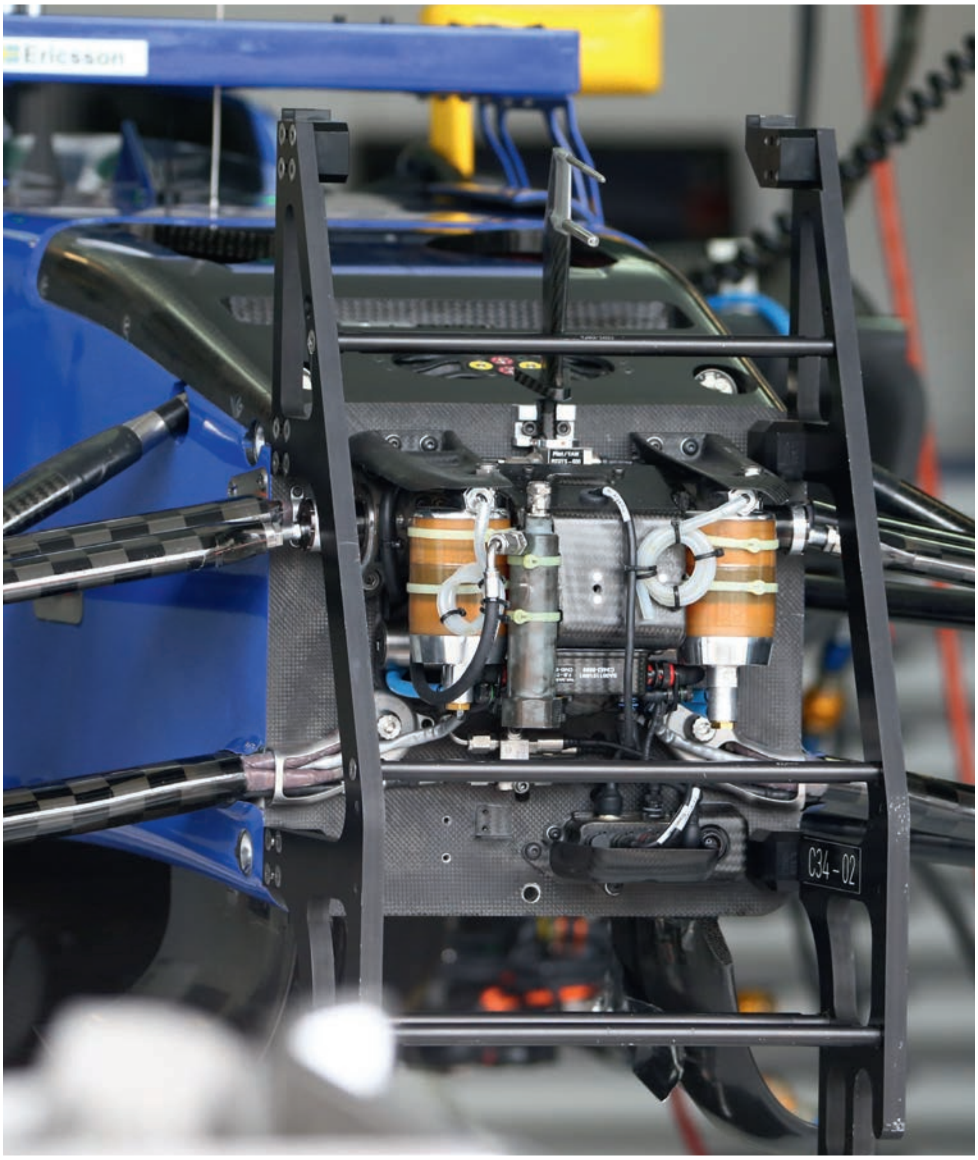
Sauber's 2014 season was a disaster. Its 2015 season began even worse, as financial woes reportedly saw the development and build of the C34 interrupted more than once and there was a distinct lack of optimism among Sauber's engineers. Then arriving at Melbourne for the first race saw a contractual dispute over drivers boil over into a situation where some senior team members could have been imprisoned and the teams cars impounded. It was fortunately resolved and Sauber managed to reap the benefits of Ferrari's much improved power unit in the race.

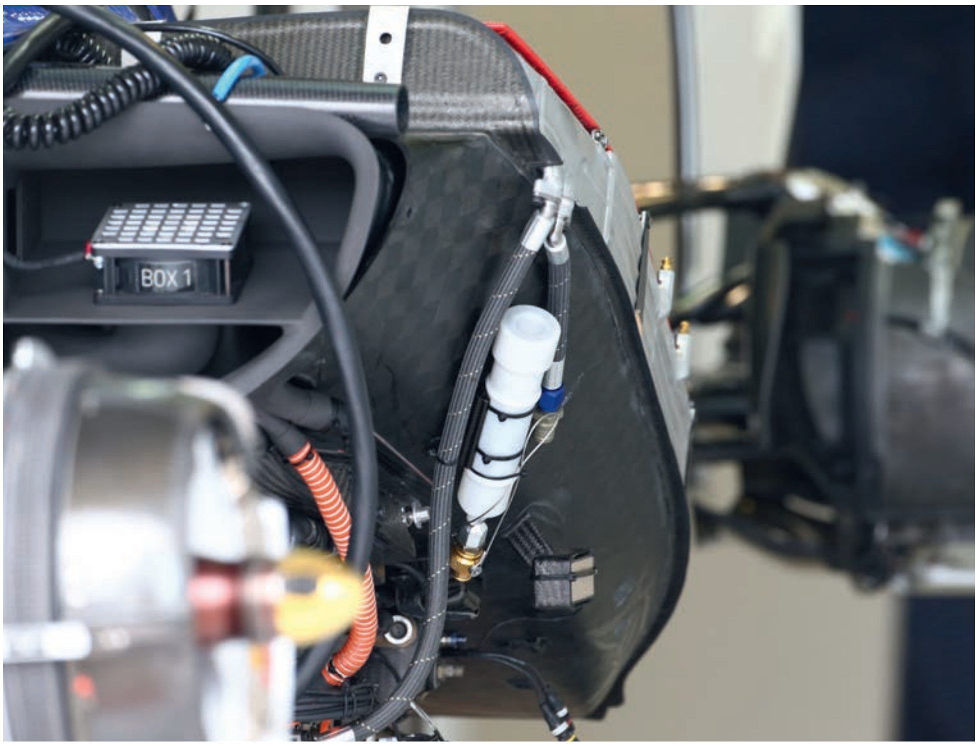
Sauber's engineers focused on three key areas on the C34 –performance in slow corners, weight reduction and braking stability. Overall, the aim of the car development project was to improve the balance of the car and its responses in particular through low-speed corners.

The car is a mild evolution of the C33, with the greatest visual difference being the nose section due to the rule changes detailed elsewhere. Notably the C34 nose is very long and low with quite a bulbous cross section.

The front suspension concept has changed little, with the springs and dampers again pushrod-actuated. However, the engineers put a lot of effort into improving the feedback from the steering for the drivers.

The sidepods of the new Sauber C34, however, are now slimmer than those of the Sauber C33, despite higher cooling requirements from the new power unit. This has been made possible by modifications to the attachment of the side crash elements. In addition, the architecture of the radiators, which are now positioned horizontally, has been fundamentally revised. The engineers also paid great attention to the flexibility of the cooling system, which can be adapted precisely – and individually for the various components – to the





ambient temperature and circuit characteristics. For example, small air vents on the side of the cockpit are only used in certain situations.

Beyond this, the rear section as a whole is smaller, which benefits aerodynamic efficiency. The exhaust tailpipe is again positioned centrally between two pylons, although they are no longer supported by the rear crash element, but instead by the gearbox housing.

The spring and damper elements at the rear axle are again pullrod-actuated, but otherwise this is a totally new construction with separate lower wishbone legs. In addition, the engineers worked on improving the mechanical traction.

The project seems to have worked, although perhaps some of the car's issues are masked by the poor performance of the Renault and Honda powered machines. The team has now got to fight to secure the budget it needs to allow it to continue to develop the C34 and maintain its position on the grid.

Top: The mechanical components on the front of the Sauber chassis are very tightly packaged
Above: New radiator cores have improved cooling efficiency

Marussia MR03

POWER UNIT:

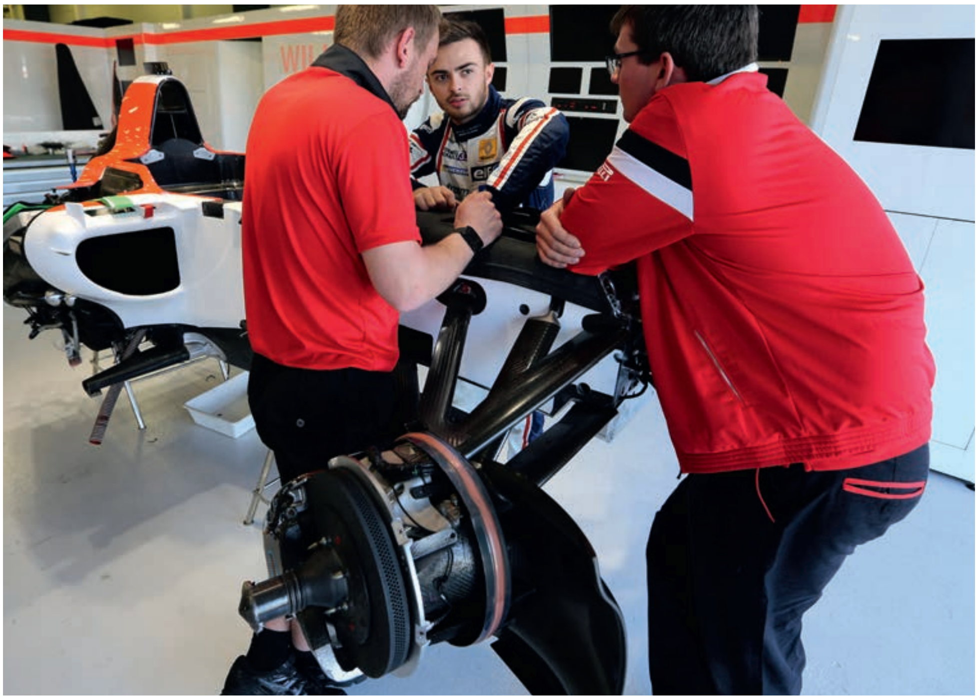
Ferrari 059/3

The Manor team arrived in Australia for the opening race of the 2015 season with cars based on the 2014 Marussia MR03's. The specification of them was something of a surprise, as in early January Manor had been granted a special dispensation not to run with the 2015 specification front impact structure and nose shape.

It would of course be possible to modify the chassis to meet the 2015 chassis height and front impact structure regulations by making adjustments to the chassis moulds and reshaping the tubs.

However, the MR03 chassis moulds were sold off at auction and now reside in the collection of a enthusiast somewhere in England. This means that the above modifications would be near impossible without making up new moulds, something that the team simply did not have time for between coming out of administration in February and shipping the cars to Melbourne for the opening race in mid March.

Instead a very pragmatic approach was taken to the chassis – the 2014 specification bulkhead was left untouched, with the front suspension layout remaining unaltered from the late 2014 design. But a structural composite spacer similar in concept to that of the front of the DeltaWing LMP or the Nissan ZEOD was employed. At some 200mm in length the spacer allowed the team to fit a new nose to the car which appears to fully comply with the 2015 regulations. This, together with the required installation of larger anti-intrusion panels on the tub's side led to the car undergoing a series of new crash tests, which it passed.



Pictures: Manor arrived in Melbourne with a pair of modified Marussia MR03's fitted with 2014 Ferrari power units and transmissions, a number of issues prevented the cars from runnning however

But it is worth noting that the team is still in some difficulty with the chassis as it only has two available instead of the more conventional three or more. Marussia had indeed built three chassis but one of them was destroyed by Jules Bianchi in Suzuka during his near fatal accident at the Japanese Grand Prix.

The additional length of the car, with an unchanged wheelbase, will likely have an impact on the car's aerodynamic package which has probably not been fully evaluated, not least due to a significant lack of time – the team's 2014 wind tunnel model was dismantled to allow work on its 2015 design to get underway. The model, less its spine (owned by McLaren) now resides with a private individual in the UK. More on the evolution of that model and its current state can be found on the Racecar Engineering website and social media sites.

Compounding the lack of wind tunnel model the team may also lack data for both its 2014 and 2015 designs as when the Haas F1 team acquired the Marussia facility in Banbury, England ,it is reported to have acquired some of the team's data and IT assets, and that may include the team's CAD Data.

What the team has also seemingly lost is access to some of the software required to run the cars. The modified MR03's are fitted with 2014 specification power units as the team did not have time to develop an installation for the heavily-updated 2015 Ferrari V6 Hybrid.

'It's not simply a software issue,' the team's president Graham Lowdon explains. 'There are a lot of issues, none of which are a big surprise really when you consider the amount of work that's been required to get the team here in a very, very short space of time. I would say that the problems we're dealing with at present are not unusual for the task that we're doing, which is effectively setting up both trackside and on-car infrastructure for these cars to run.'

This led to the cars being marooned in the garage for the duration of the Australian Grand Prix meeting, but the team has stated it would get on track in Malaysia

The next hurdles that Manor has to navigate are the shortage of staff as many key personnel left last year to work in other teams. The other problem is how to qualify its cars within the 107 per cent allowance using its outdated power unit and sub-optimal aero package. However, one thing that it will have in its favour is reliability, as it will be using proven components.

McLaren MP4-30

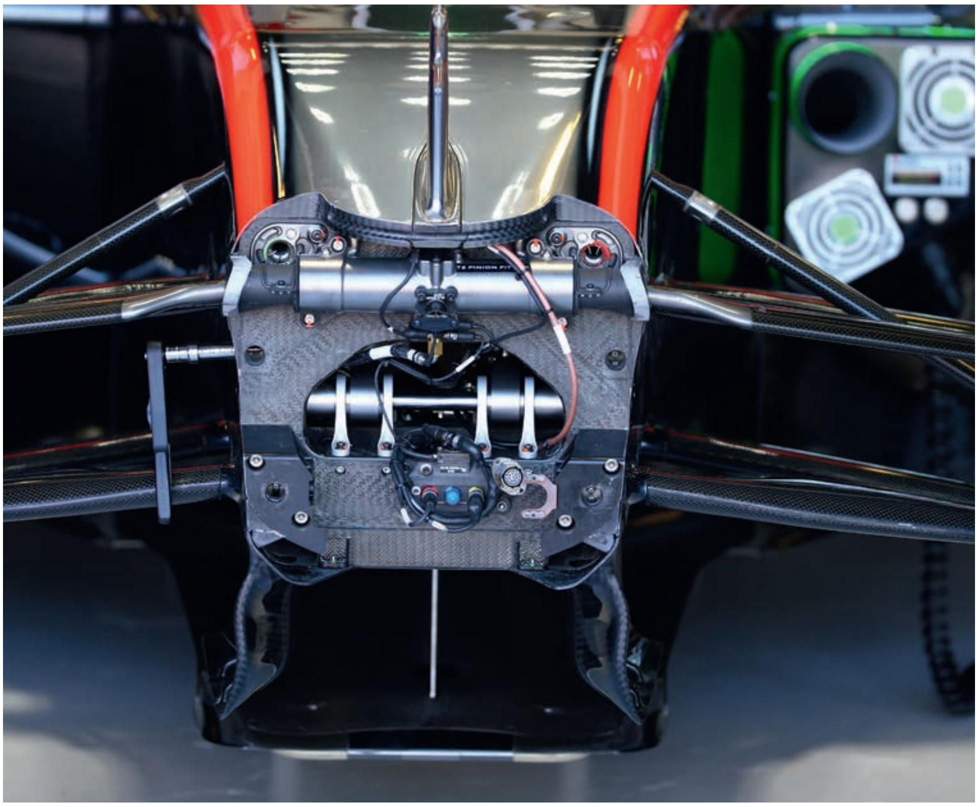
POWER UNIT:
Honda RA615H Hybrid

The McLaren MP4-30 is a clear evolution of last year's MP4-29. With a stable rule set the majority of the basic lessons from 2014 have clearly carried over but with the major difference being the Honda RA615H power unit.

'Our restructured and strengthened engineering departments have gained the conviction to embark on a number of changes of direction. With that in mind, the MP4-30 has been developed to provide us with the most effective and practical base package. It is a foundation – offering up a number of new exploratory development paths for our engineers, aerodynamicists and drivers to pursue during the season, and on into next year.

'The car has been aerodynamically developed over the winter, and the result is a pretty, elegant design with a refined nose-box solution, slimmed rear-end packaging – particularly around the gearbox – and the incorporation of an all-new power unit under its tightly contoured bodywork,' the team's official press release reads.

From comments made by Honda employees it seems that McLaren-Honda has adopted the same strategy that Ferrari attempted in 2014. The idea is to create the smallest power unit possible with the lowest cooling demand. This leads to a lower power output and better aerodynamics, however in Ferrari's case it simply resulted in a power unit that was overweight and underpowered, and the aero department failed to capitalise on the opportunity of the tighter packaging. If made to work properly this approach could bring significant gains in lap times despite having less power than the competition. But making it work, and making it work reliably, are very difficult to do and it means that repairs can take a very long time.



The Honda also seems to feature a very interesting turbo layout. The details of it are not yet entirely clear but the turbine appears not to be mounted at the same angle as the compressor meaning that the turbo shaft, which rotates at up to 125,000rpm must feature some sort of joint. If that is indeed the case then it is a hugely impressive piece of engineering.

The ERS on the car has caused a number of issues with reliability and it even reached the point where McLaren replaced Honda parts with their own designs at one stage in testing.

If Honda and McLaren can make the partnership work properly then a tight body car would certainly bring a substantial aerodynamic advantage and better lap times even if it means a reduction in overall power unit performance. But the unreliability shown in winter testing and the season opener in Melbourne suggest that there is still a lot of work to do.

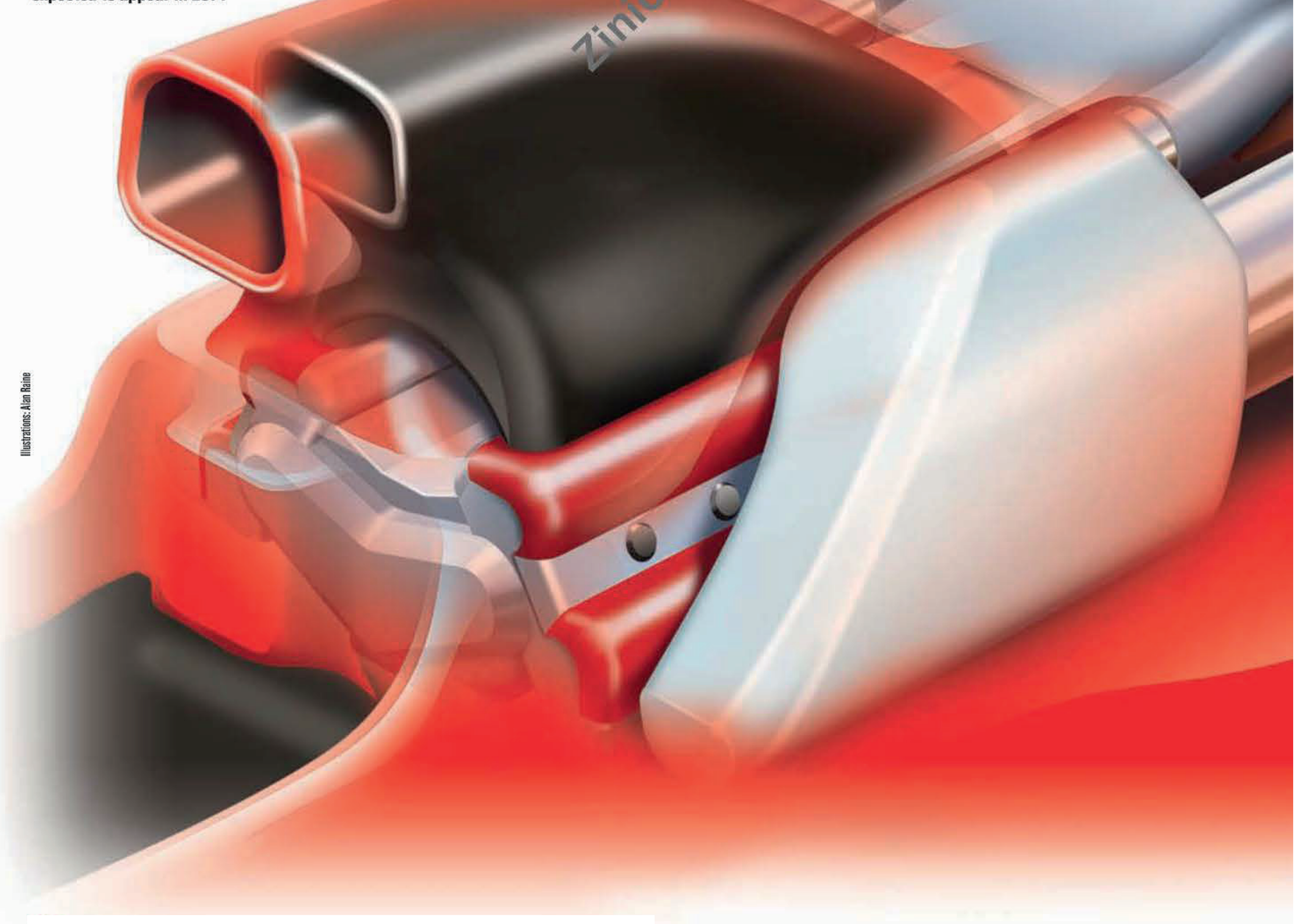
Top: A glimpse of the troublesome Honda V6, with its metal plenum
Above: The front of the MP4-30 is conventional but compact

2011 AD

Until the end of 2010, Formula 1 engines are 'functionally stabilised', with only minor changes being allowed from the engines that will race this year. They are naturally aspirated, 2.4-litre V8s, currently with a rev limit of 19,000rpm, and they must weigh at least 95kg. They already produce in excess of 750bhp.

The 2007 cars themselves are very similar to the 2006 machines, the key change being the exclusive use of Bridgestone tyres. In 2008 cars will become significantly wider, up from a maximum of 1800mm to a minimum of 1950mm (rising again to 1980mm in 2009), with a maximum width of 2000mm. The minimum total weight of the car (including driver) falls from the current 600kg to 550kg in 2008, and then rises again to 605kg in 2009. The two main changes already approved for 2009 are the imposition of a maximum downforce limit of 12,500N and the introduction of Kinetic Energy Recovery Systems (KERS). KERS, as currently defined, can only be connected to the rear wheels, and must deliver no more than 400kJ per lap at no more than 60kW (80bhp), which effectively means a burst (or bursts) of extra acceleration totalling less than seven seconds per lap. The braking power of a KERS is also restricted to a maximum of 60kW. While the 60kW limit on extra accelerative power may be prudent and sensible during the first season of a new technology, the other limitations seem to run counter to Formula 1's new focus on fuel efficiency and relevance to road vehicles. Even if these limits remain in force for 2009, it would seem sensible to remove, or at least raise them for 2010.

Artist's impression of the F1 powertrain as it is currently expected to appear in 2011

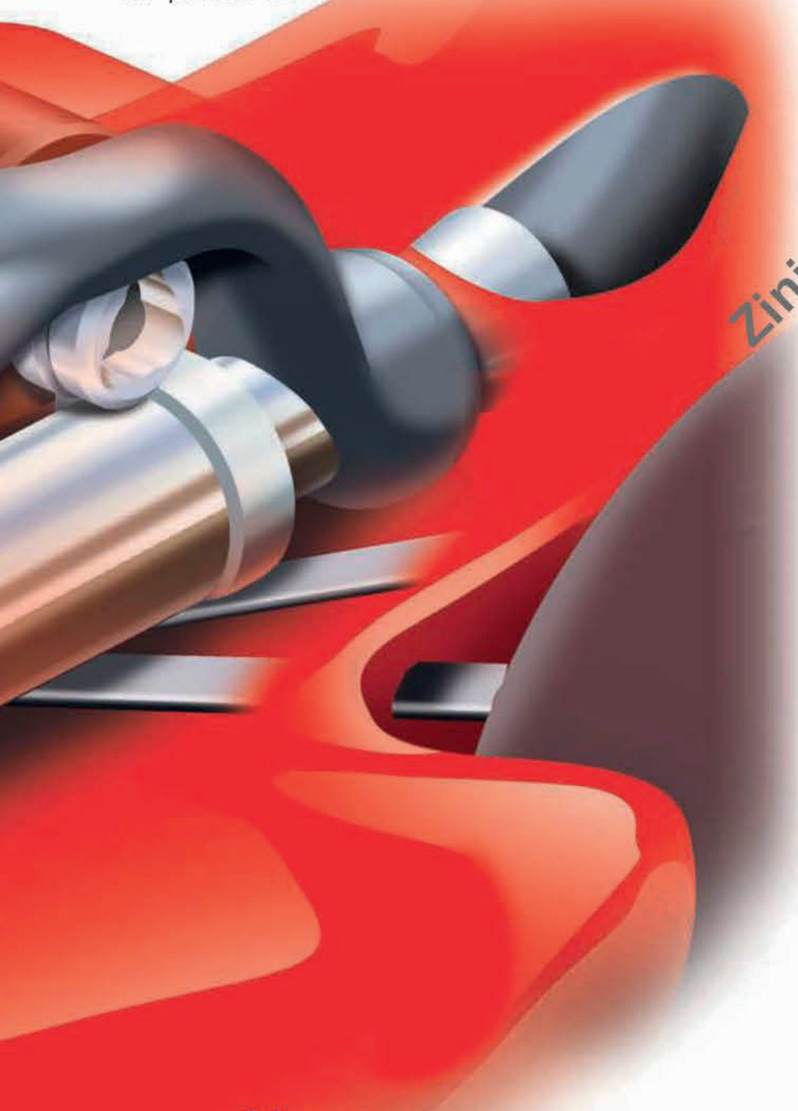


Illustrations: Alan Raine

With F1 under pressure to appear 'greener' and more relevant to road car technology, we look at what the future holds for F1 engine design

By **Chris Ellis**

In 2010, while the engines will remain stabilised at around 800bhp (allowing for the impact of biofuels), it was originally proposed to use two further sources of recoverable energy – the engine cooling system and the exhaust gases. However, it seemed increasingly probable that this move would be postponed a year to coincide with the new, less powerful 2011 engines, on the grounds of avoiding unnecessary cost and excessive power in 2010, and the FIA confirmed the postponement on 28 February. Note that both these additional energy sources can provide energy whenever the engine is delivering power, unlike the KERS, which can only collect energy during braking. In the dry, braking times currently never exceed four seconds per corner, and range from a total of just over 10 seconds to 20 seconds per lap, depending on the circuit, with a 2006 average of 14 seconds. The proposed reductions in downforce are likely to stretch braking times a little, but will probably not increase the average braking time per lap to more than 17 seconds. This highlights the importance of regenerative braking power once the nonsensical 400kJ limit is removed, because this will determine the total extra energy available for acceleration, given the inherent time limits on braking.

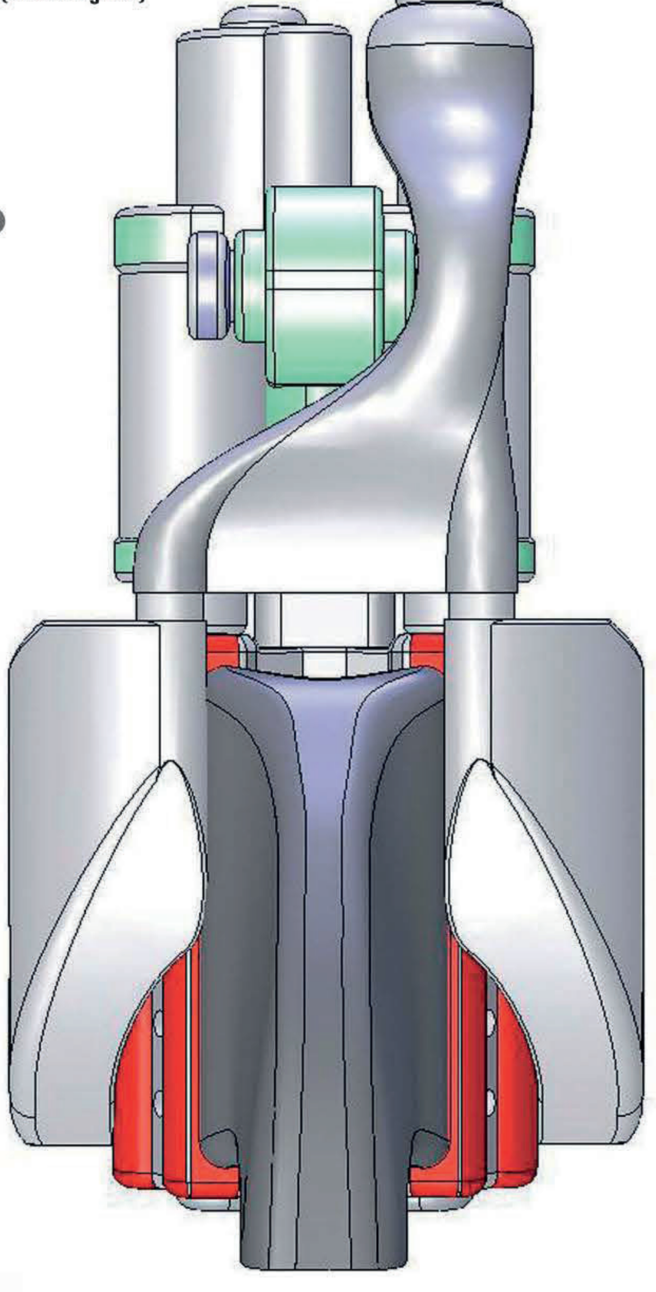


"EXHAUST ENERGY WILL BE MORE READILY EXPLOITABLE THAN ENERGY FROM THE COOLING SYSTEM"

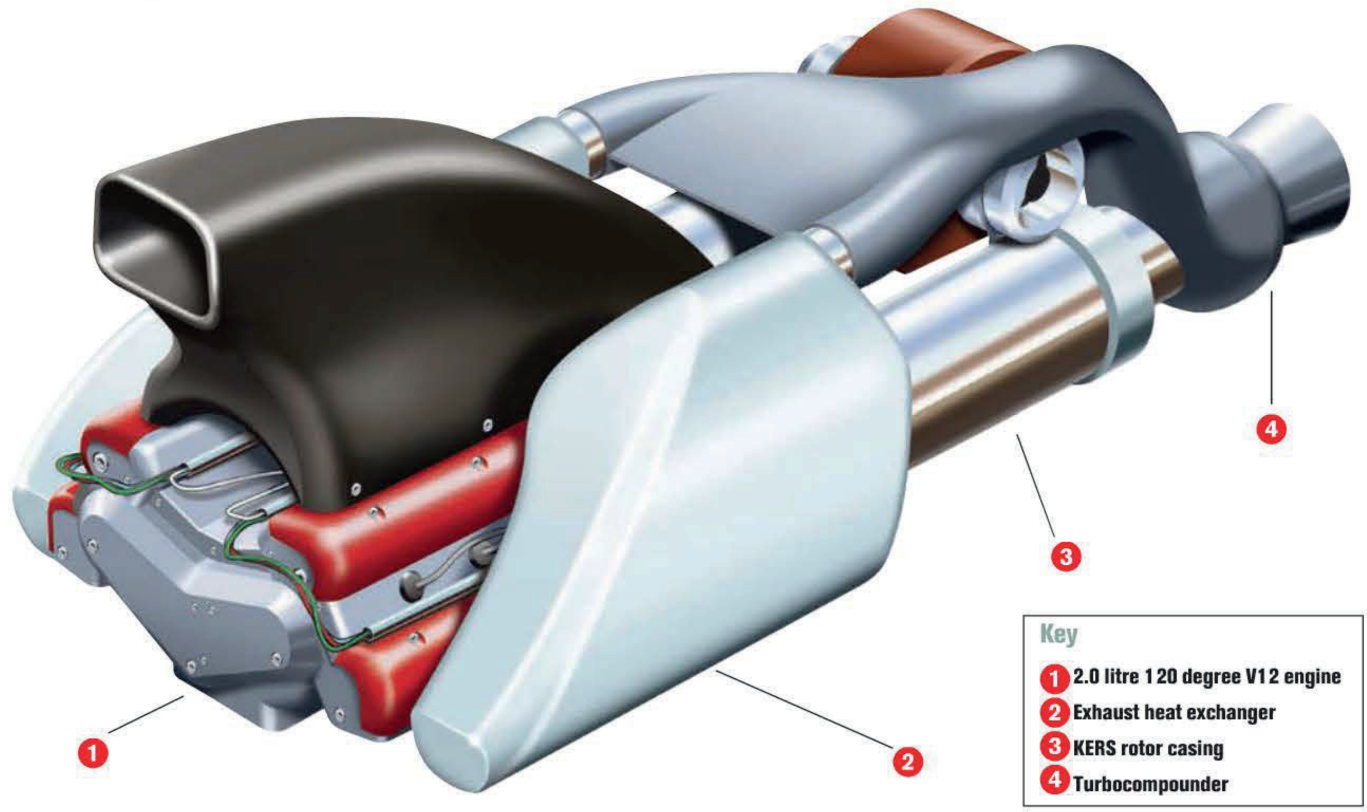
Energy exploitation

Because exhaust energy is available in a 'high grade' form – as a very hot, fast-moving gas – it is likely that it will be more readily exploitable than →

Plan view of the engine showing more clearly the location of the turbocompounders below the gearbox (shown in green)



2011 F1 powertrain concept



Turbocompounding will extract kinetic energy from exhaust gases and feed it back into the powertrain, likely without the need for a storage system. A second thermal energy exchange will transfer energy from the exhaust manifolds into a fluid medium, from where it will drive turbines feeding into the drivetrain

the energy from the cooling system. Exhaust energy recovery will probably be achieved in two ways. Some form of turbocompounding (see Debrief p6 for an explanation of this concept) will be used to extract a percentage of the kinetic energy of the exhaust gases and feed that energy back into the engine or transmission. Secondly, some form of heat exchange system will be used to transfer thermal energy from the exhaust manifolds into a suitable operating fluid, which will then be used to drive expanders or turbines feeding into the drivetrain. Because of the latency implicit in thermal transfer, there is an argument for the provision of some level of energy storage as well. Typically, the engine is at, or near, full power some 70 per cent of the time, but thermal energy can be extracted during the other 30 per cent as well, if there is a suitable storage system. On the other hand, turbocompounding is effectively synchronous with conventional engine power, and may not need a storage system.

The 2011 engine

The FIA and the GPMA have already outlined some of the principal features of a 2011 engine. It will be downsized, fitted with direct injection and will probably use a fuel mainly derived from biomass. Although turbocharging has also been suggested, it is far from certain that it will be required. While road cars will probably need variable boost turbochargers to provide efficient use of E85 (while retaining the ability to run on straight petroleum or any mix in between) this is obviously not a requirement for an F1 engine. Consequently, the 'efficiency' argument for using turbochargers in Formula 1 is relatively weak.

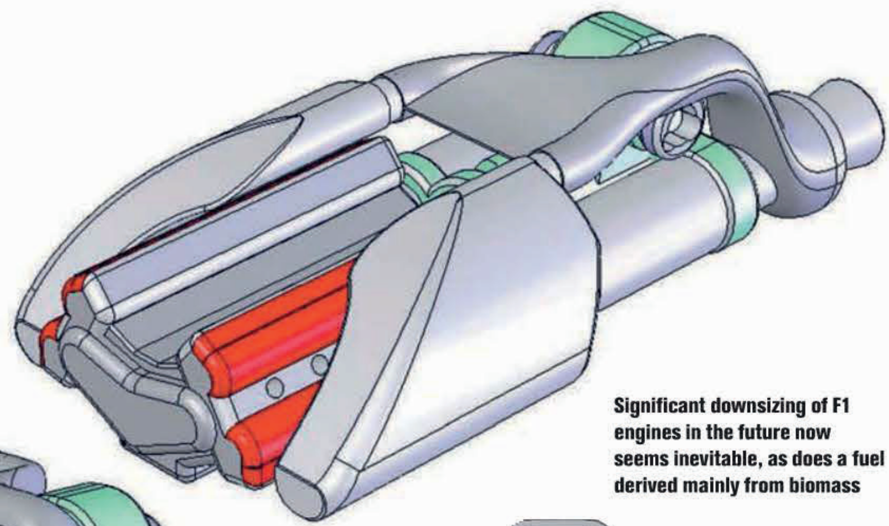
The main constraint on engine power is likely to be some form of fuel flow meter, which will presumably be set to limit the peak power of the 'core' engine. This will then be surrounded by energy recovery systems capable of adding substantially to the total power available. The FIA has suggested reducing downforce even further in 2011, from the level of 12,500N set for 2009. If this is the case then aerodynamic drag will also fall, potentially leading to an increase in top speed. If we assume, for example, that the 'core' engine is limited to around 600bhp, then turbocompounding might add 60bhp, the cooling system 40bhp and exhaust heat recovery 80bhp, giving an 'always available' total of 780bhp. To this will be added the occasional burst of another 140bhp or so from the kinetic energy recovery system, giving a 'surge total' of some 920bhp.

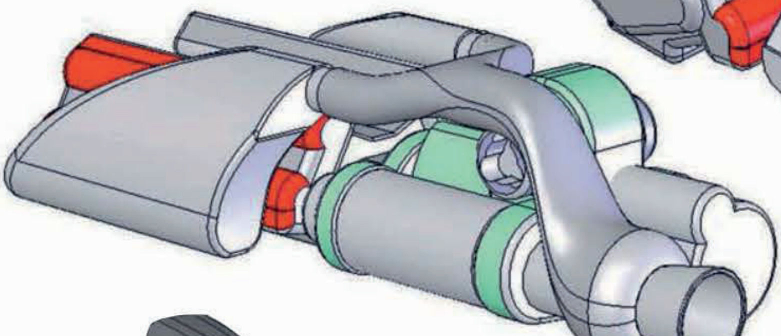
> **"ENERGY RECOVERY SYSTEMS CAPABLE OF ADDING TO THE POWER AVAILABLE"**

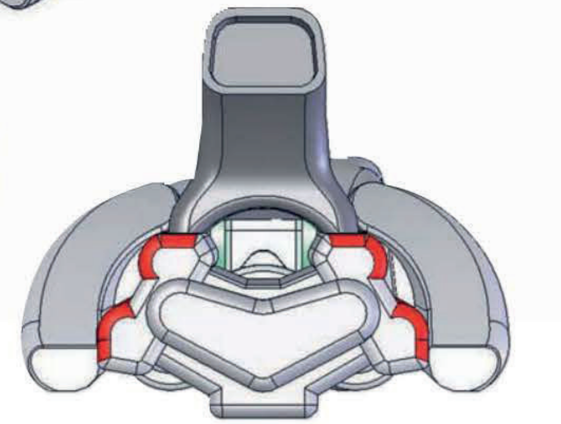
If the FIA's original plan to introduce both waste heat recovery and exhaust energy recovery systems (EERS) had gone ahead, then it is reasonable that the 2010 versions of the exhaust energy recovery systems would probably have been able to at least match their 2011 power outputs because they would have been running off a more powerful 800bhp core in 2010. This would have yielded a sustainable total of 980bhp in 2010, plus a further 80bhp from the KERS. Not only is this getting a little scary but it would have resulted in a noticeable drop in overall performance in 2011, which wouldn't have done the image of the new, energy-efficient engines any good at all. The obvious option was to postpone the introduction of the EERS until 2011, which has now been chosen. This has the additional merit of saving the cost of developing many of the EERS components twice over, once for the existing 2.4-litre V8s and then again for the significantly different 2011 engines.

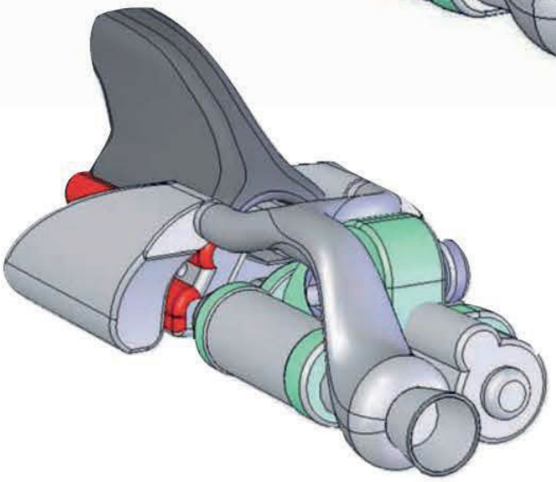
If the 'core' engine is going to need less than 600bhp to deliver a gross power level as high as that achieved by the 3.0-litre V10s of 2005, just how small might it be? The FIA has indicated a wish to keep peak engine speeds above 15,000rpm as, in their view, this is a defining attribute of Formula 1 engines. Consequently, significant downsizing of the engine might seem inevitable, particularly if it's turbocharged. This could go way too far,

> **"THE FIA HAS INDICATED A WISH TO KEEP PEAK ENGINE SPEEDS ABOVE 15,000RPM"**









Significant downsizing of F1 engines in the future now seems inevitable, as does a fuel derived mainly from biomass

judging by the previous turbo-driven engine regime, when 1.5-litre engines were producing over 1200bhp, which would imply an engine size of under 1.0-litre to deliver under 600bhp, unless there is little or no turbocharging.

From a spectator point of listening, it is the frequency of the engine note, not the peak engine revs, which screams 'this is a racecar', and the engine note is also a function of the number of cylinders. If the FIA remains committed to a peak of over 15,000rpm, then a very small (and arguably irrelevant) turbocharged engine will easily produce over 600bhp, unless the boost pressure is severely restricted. However, there is another approach possible, which should result in a more appropriate engine design, given the objective of relevance to road cars.

Road car relevance

The current 'stabilised' engine is a V8 of 2400cc with a maximum cylinder bore of 98mm, which implies a stroke of as little as 40mm. In a road car, a bore of 98mm would typically be found in something the size of a 5.5-litre Mercedes V8, which has a stroke of 90.5mm, while even a Renault 1.149-litre engine has a stroke of 76.8mm. Clearly, one of the reasons the current generation of F1 engines rev to 20,000rpm is because they have abnormally short strokes, keeping average piston speeds within reasonable limits.

Let's now explore what might happen if the stroke moves up to about 50mm, still way below the lower limit of what might be found in a sub-1.0-litre road engine, and the bore drops to around 80mm, typical of many four cylinder and smaller six cylinder road engines. If there are still eight cylinders, then the capacity would drop to only 2.0-litres. However, unless the turbocharger is almost purely decorative, this engine would have to be restricted to something like 12,000rpm in order to keep the peak 'core' power below 600bhp, which would not result in the desired frequency range. But a V12 running at 'only' 10,000rpm would produce the same frequency as a V8 at 15,000rpm, and sound similar to today's 19,000rpm engines at 12,600rpm. Keeping to the road-relevant bore size of 80mm, a stroke of 50mm would give a V12 a capacity of almost exactly 3.0-litres. For comparison, a '64 Ferrari 250 has a bore of 73mm and a stroke of 58.8mm.

A road car with a directly injected and turbocharged, 450bhp, 3.0-litre V12 running on biofuel and supported by a 200bhp KERS sounds very tasty, both in terms of performance and environmental friendliness. And a six-cylinder with the same 80mm bore and a 70mm stroke would be a 2.1-litre, and a four cylinder a 1.4-litre, meaning this might form the basis for road car relevance in the design of the race engines, with a similar combustion chamber across a large size range. Note also the single cylinder size lies in the 250-350cc range, generally believed optimal for 'sporty' spark ignition road engines.

Now consider a racing version of the roadgoing V12, but with the same extreme bore-to-stroke ratio as today, implying a stroke as short as 33mm with a bore of 80mm. This could give an engine capacity of just under 2.0-litres, certainly fulfilling the promise to downsize, but without taking it to the point where the engine becomes little more than a fuel/air pump for the exhaust energy recovery systems. Note that the FIA and the manufacturers could agree to a 12,500rpm limit to help contain 'core' engine power to less than 600bhp, yet still achieve this without sacrificing 'sound quality'. In fact, the exhaust heat exchangers will tend to act as resonators, more than compensating for the muffling effect of the turbocompounder(s), and resulting in a deeper, tougher, sound. Think NASCAR speeded up...

Another consideration is the preservation of Formula 1's position as the premier formula, in the face of 3.4-litre V8s in A1 GP able to deliver at least as much 'core' power. By encouraging or directing the teams to adopt V12s, rather than 'common' fours, sixes or eights, there will be no danger of Formula 1 losing its technical mystique, or its soundtrack. And at least three major players will feel Formula 1 will be endorsing their existing V12 road cars, maybe even four if Audi/VW buys into Formula 1 by 2011. After that, you can guarantee it won't take Honda long to catch up.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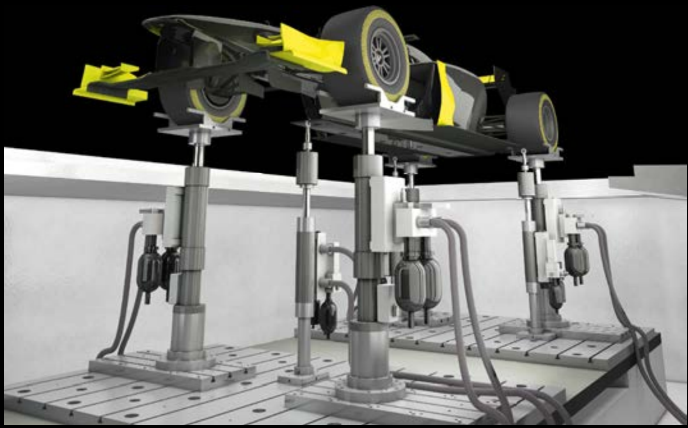

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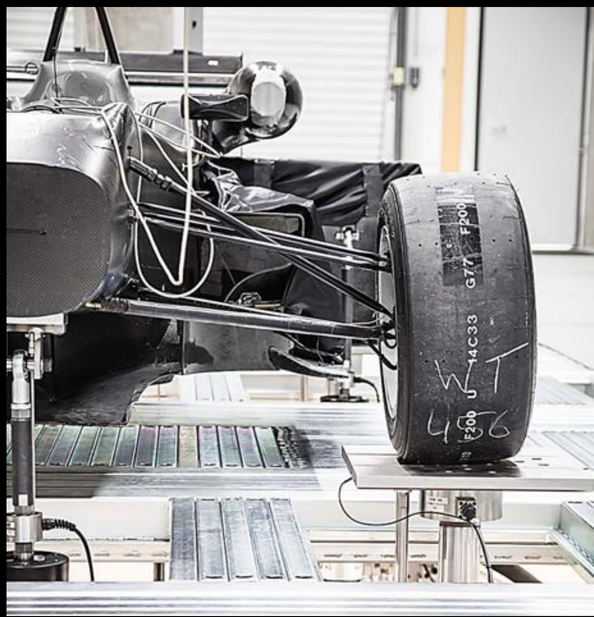

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