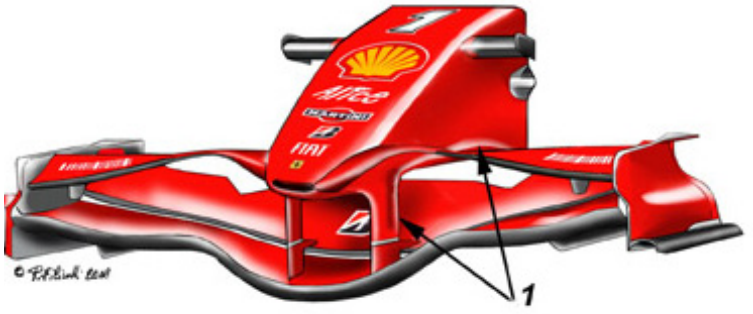
Giorgio Piola

Formula 1

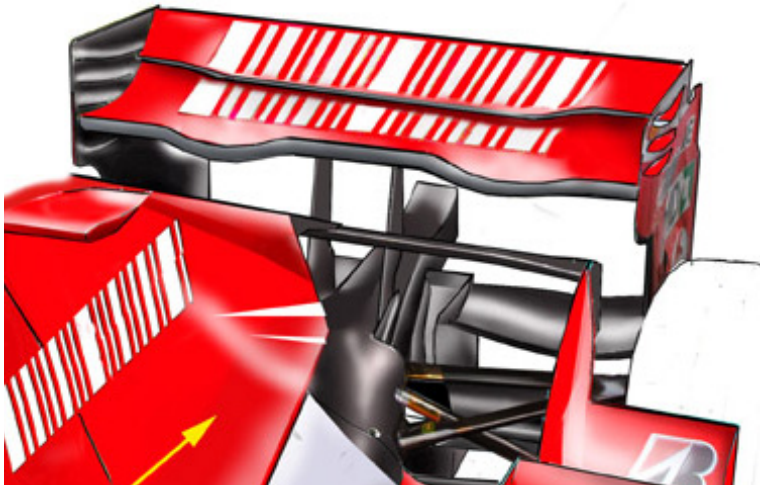
technical analysis
2008-09

ΑΗΔΡΕΑΣ



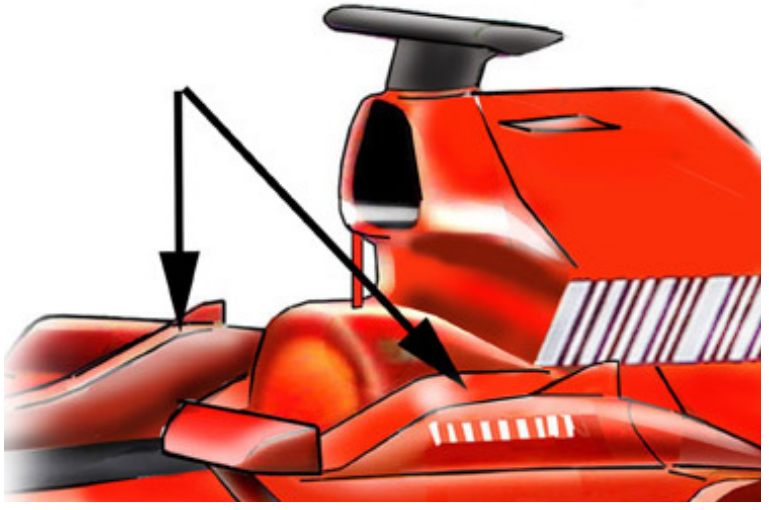
Ferrari F2008 - nose cone (07 January)

The F2008's nose cone appears visibly higher than that on the F2007, a result of the longer pillars that connect it to the front wing (1). The base of the nose is also heavily sculpted, thereby providing better management of the airflow passing underneath it, an area that is crucial to the car's overall aerodynamic efficiency.



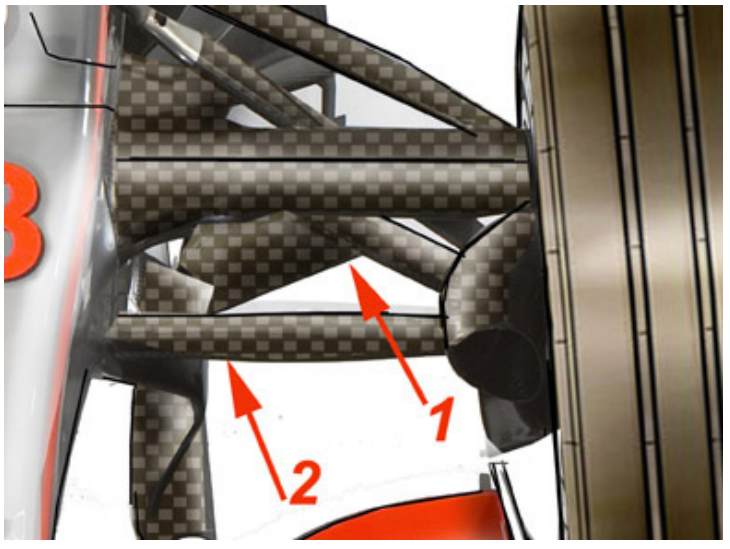
Ferrari F2008 - engine cover (07 January)

The new engine cover is slimmer than its predecessor, with the bodywork acting like a second skin, encompassing the engine heads and the airbox hidden inside (yellow arrow). This provides a cleaner airflow to the rear wing, increasing the wing's efficiency. This is even more crucial than in the past, following the traction control ban, as it will improve the car's grip levels.



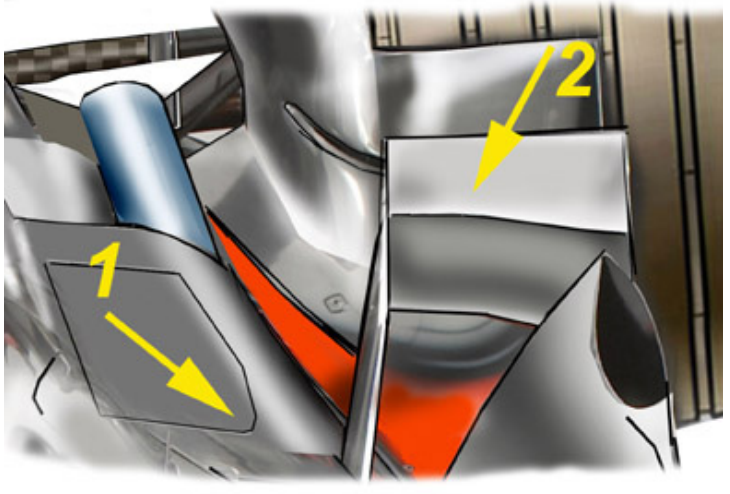
Ferrari F2008 - side protection (07 January)

The side protection around the driver's helmet (black arrows) is 15mm higher than on the F2007. This is partly because of new safety rules but is also the result of the chassis' slightly lower front section. The higher protection doesn't limit the driver's rear visibility since, as on the F2007, the rear-view mirrors are placed on the outermost edge of the sidepods.



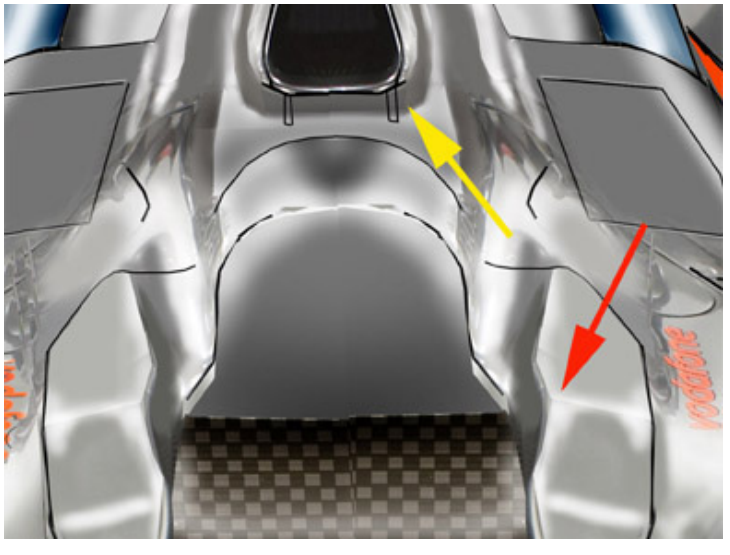
McLaren MP4-23 - front suspension (11 January)

The changes made to the car's front suspension are particularly interesting. As on the Ferrari F2008, the front of the chassis now higher than that of its predecessor, hence the quantity of airflow passing underneath the car has been dramatically increased. As a result, the team have angled the lower wishbone (2) downwards and increased the number of small sculpted winglets (1) underneath in order to manage the airflow more efficiently.



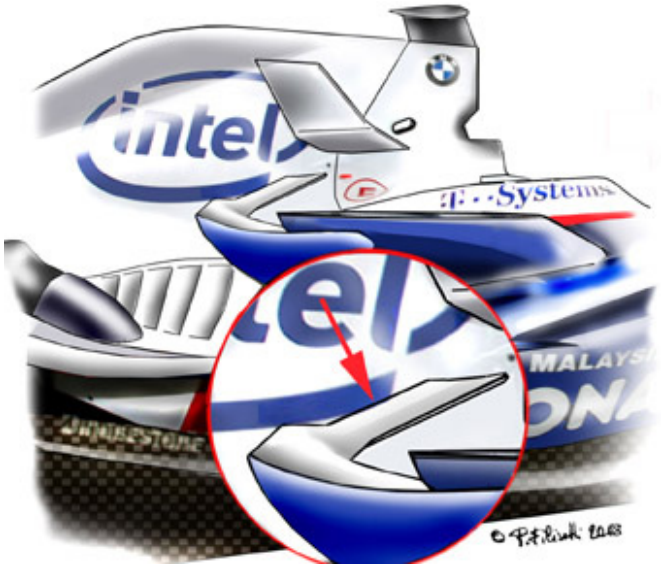
McLaren MP4-23 - rear bodywork (11 January)

Compared to the MP4-22, the rear of the car has been visibly lowered, with the exhaust pipes now placed further to the side. There are new movable covers (1), which could be replaced with cooling slits as the season progresses. The winglet behind the venting chimney (2) has also been refined. Rather than being curved, as on the MP4-22, the profile of its top edge is now completely flat. This increases the quantity and pressure of the airflow directed towards the rear wing, and uses the low pressure of the exiting hot exhaust gasses to accelerate that airflow.



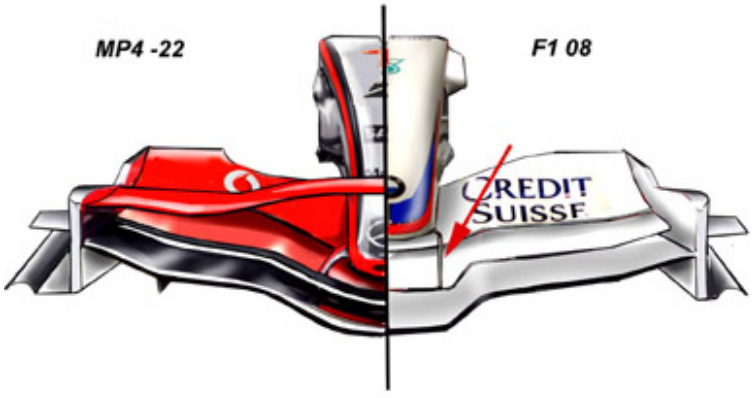
McLaren MP4-23 - cockpit area (11 January)

Major changes have been introduced to this area to improve the quality of the air directed to the car's rear wing. The engine air intake has been placed further behind the headrest and a sort of long splitter (yellow arrow), which continues towards the very slim engine cover, has been added to reduce the area's cross section and diminish disruption to the airflow. In line with new regulations, the side protection around the driver's helmet (red arrow) has also been heightened. This connects to the rear bodywork in a more abrupt way to minimise the additional drag it creates.



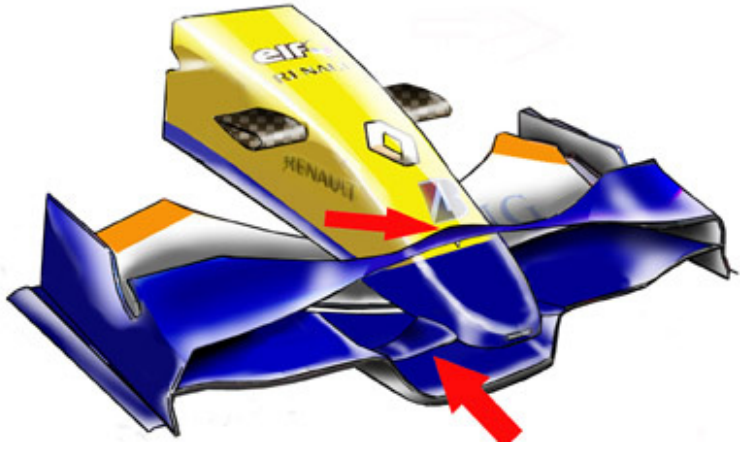
BMW F1.08 - front wing assembly (01 February)

It is interesting to note how all teams have transformed the front of their 2008 cars. To reduce drag generated by the pillars which connect the nose to the front wing, BMW Sauber(right) have adopted a similar solution to the one introduced by McLaren on the MP4-22 last year (left). Instead of connecting the pillars to the main profile, they are attached to the middle flap, thus reducing drag and improving the front wing's efficiency.



BMW F1.08 - side winglet (01 February)

Since its launch in January, the F1.08 has featured an interesting new addition in the form of a profiled winglet connected to the engine cover (red arrow). It is a development of a winglet previously placed at rear-axle level, but now moved forward to improve the F1.08's balance by helping to avoid the usual load transfers from the car's front to rear - and vice versa - when the driver brakes or accelerates.

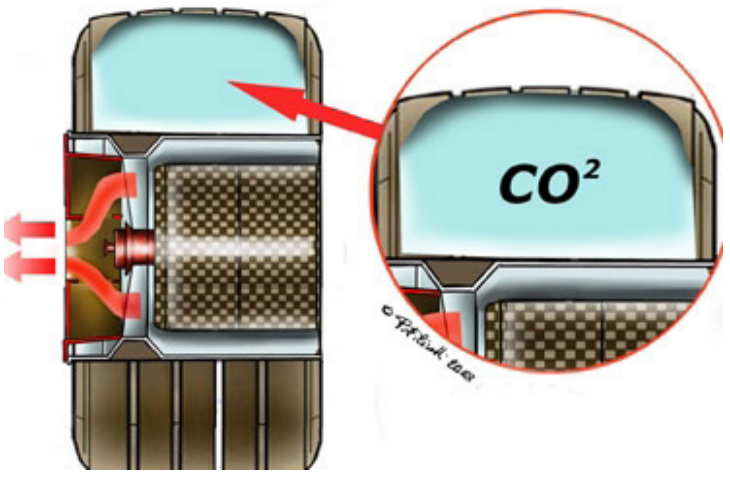


Renault R28 - front bridge wing (05 February)

In comparison to its predecessor, the new Renault's nosecone has been dramatically lowered and now features an additional bridge profile (top arrow). While the front of the chassis has been minimised, the surface area of the wing's main profile has been increased. In addition the pillars (bottom arrow), which connect the nose to this profile, have been dramatically inclined to an almost horizontal position to reduce drag and improve the quality of airflow passing over and underneath the front of the car.

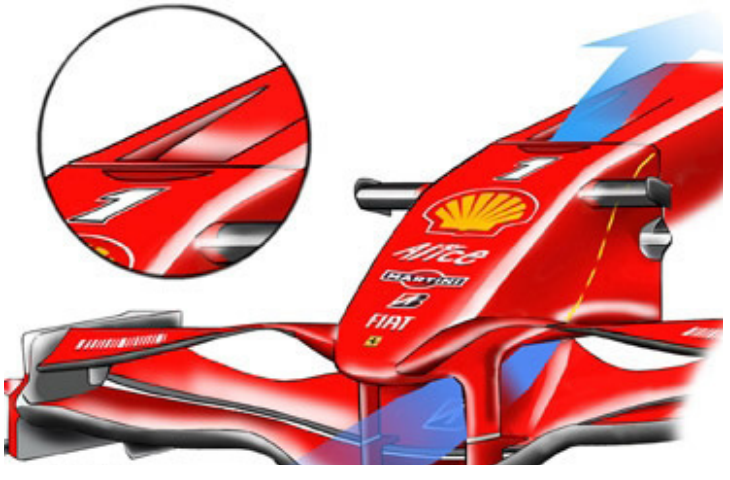
Renault R28 - sidepods (05 February)

When compared with last year's car, the R28's new sidepods have been transformed. The vertical fins (larger red arrow) no longer support the rear-view mirrors, making for a cleaner design and better airflow management towards the rear of the car. In addition the bottom edge of the sidepod's air inlets are much higher than before (smaller red arrow) to provide the radiators with cleaner airflow and reduce the effect of turbulence generated by the front axle and suspension.



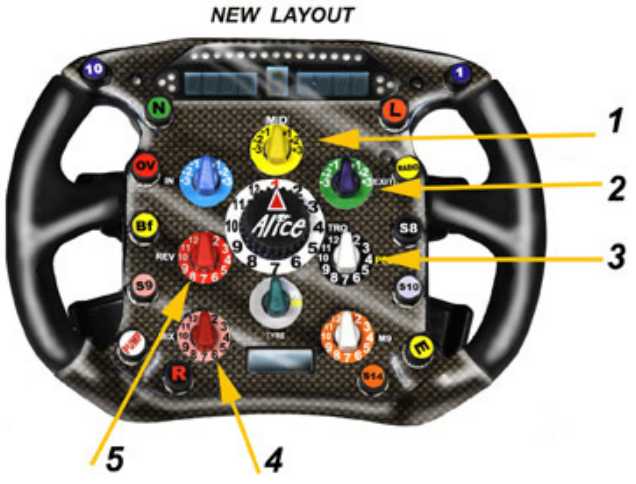
2008 trends - TC ban and tyre gases (28 March)

This became a hot topic last year, since part of the information at the heart of the McLaren 'spy scandal' was supposedly related to Ferrari's use of a particular mixture of inert gases, in particular CO2, to inflate their tyres. This year almost all teams are experimenting with different blends of gases (air, nitrogen and CO2 are all permitted) in a bid to negate the negative impact of the ban on traction control and engine braking control. The removal of these systems means more wheelspin at the rear and more locking up under braking at the front, which in turn leads to more sudden variations in tyre surface temperature. These sudden variations make it more difficult to keep tyre pressures constant - crucial to the car's handling - hence teams are seeking the gas blend whose pressure is the least sensitive to temperature changes.



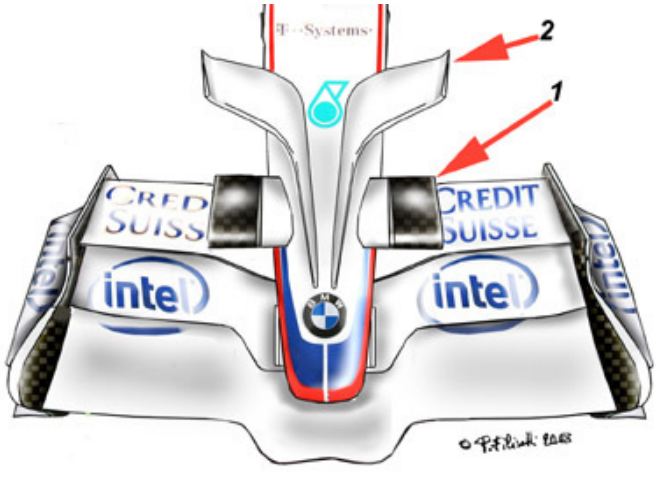
Ferrari F2008 - vented nosecone assembly (16 April)

During this week's test in Barcelona, Ferrari have introduced a dramatic new aerodynamic modification to the F2008's nosecone. An opening underneath the nose has been matched with two vents - one semicircular, the other similar in style to a NACA duct - on the top of the chassis (see inset) to create a conduit for air to flow through. This revision eases the passage of air under the crowded nosecone area (see blue arrow), thus reducing drag and minimising the turbulence of the airflow directed towards the F2008's sidepods. With a more aerodynamically-balanced car at their disposal, Ferrari hope to improve not just their performance over a single lap, but also their race pace, as both tyre wear and fuel consumption should be reduced too, giving the team even more flexibility in terms of race strategy.



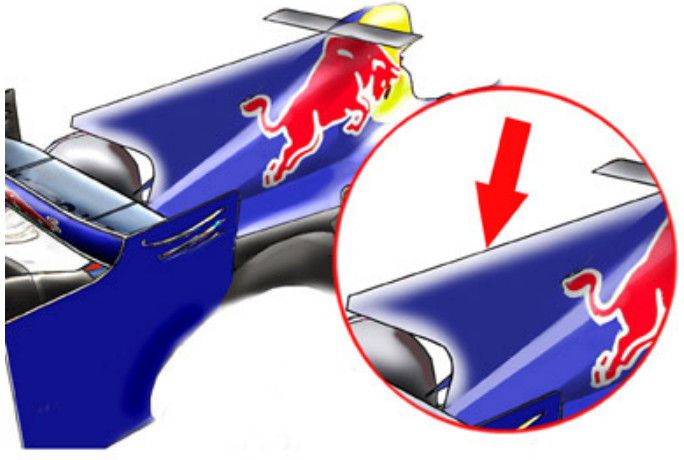
Ferrari F2008 - steering wheel revisions

With the F2008's overall balance looking strong since its debut, Ferrari have concentrated their efforts on the car's finer points. One interesting improvement has been the revised layout of the steering wheel's switches, which have been changed to better suit the drivers' preferences. The switch that manages the mid-corner differential set-up (1) has been placed at the top of the central column, while the switch for the corner entry differential set-up remains in the same position. The commonly-used control for managing the differential on the exits of corners (2) has been moved to the top right, while the 'mix' (4) and 'revs' (5) switches have been moved to the left-hand side, as they are used less frequently.



BMW Sauber F1.08 - nose winglets

This is, without doubt, one of the most radical solutions seen so far in 2008 and was introduced by BMW Sauber to try to optimise the F1.08's balance. The solution provides a better quality of airflow to the car's sidepod inlets and rear end, without generating a noticeable amount of downforce. The on-board camera housings (1) have been placed at a level where they redirect air towards the 'delta winglets' (2), thus improving the flow of air to the car's sidepods. This is especially important, as BMW Sauber have followed the trend to taper the car's sidepods at the bottom, with smaller inlets and radiators of a smaller cross-sectional area.

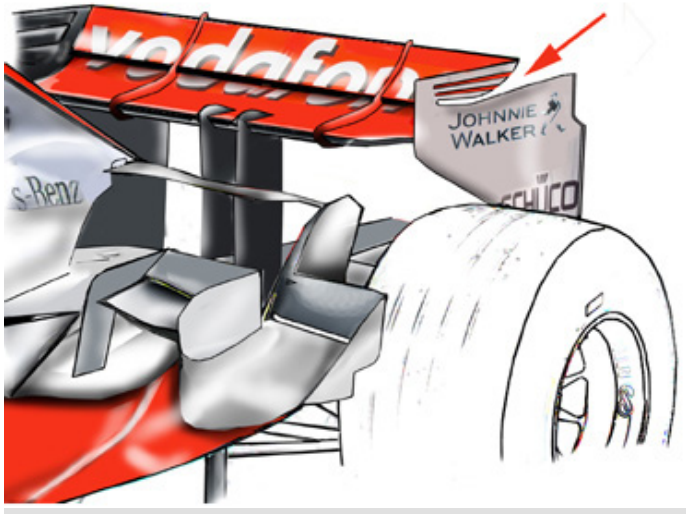


Red Bull RB4 - 'shark-fin' engine cover

During testing in Barcelona, Red Bull introduced a striking 'shark fin' extension to the RB4's engine cover (red arrow). The modification dramatically increased the surface area of this section and was introduced to provide better airflow to the rear wing and maximize the car's stability under braking. The new cover interacts in a very complex way with the rear-end aerodynamics of the car and its full potential has not yet been completely exploited. Such radical solutions are often hard to tune, though hopefully not so hard as to outweigh the benefits.

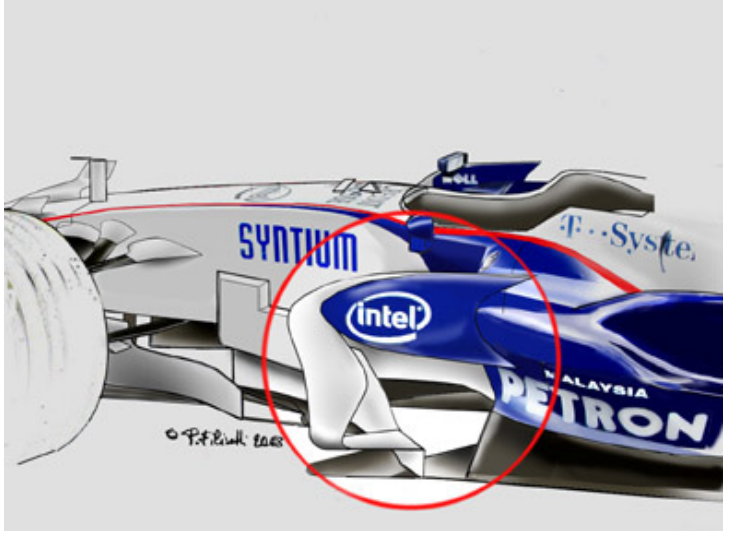
Renault R28 - barge board detail

It is interesting to note how quickly BMW Sauber's barge board solution for the F1.08 was adopted by Renault on their R28 (circled and red arrow). This area is crucial, as it manages the flow of cooling air to the car's radiators and can also be used to divert air towards the rear wing to create an almost continuous horizontal flow. Depending on the aerofoil configuration, this can generate significant amounts of downforce, without increasing drag.



McLaren MP4-23 - rear wing

McLaren's MP4-23 features an interesting rear wing, which has been deeply revised both in terms of its main profile and its endplates. These endplates still sport the now atypical horizontal slits, which reduce the turbulence generated by the impact of the airflow where they attach to the main profile. The endplates' flap (red arrow) also features a revised solution, similar to one introduced by Renault two years ago. On the MP4-23 the flap is separated from the rest of the endplates by a deep cut. This provides a cleaner exit for the airflow passing under the main sculpted profile. The efficiency of the rear wing and the overall driveability of the car has been thus increased, while the additional downforce is not negated by increased drag on the straights.

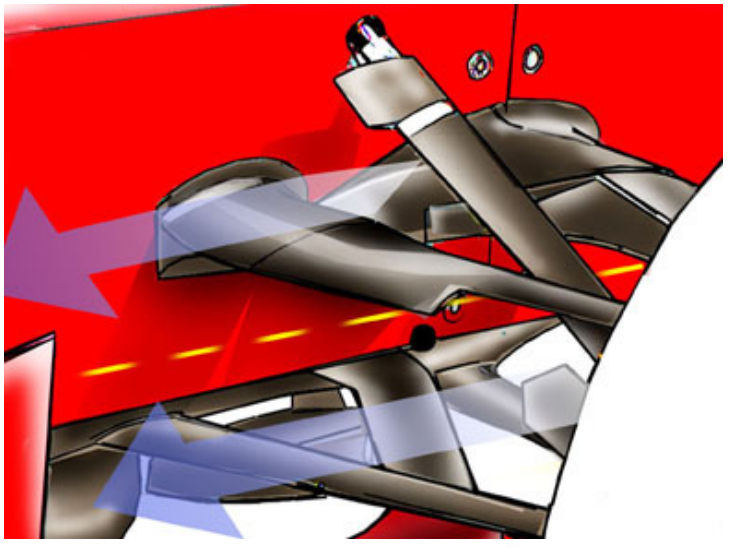


BMW Sauber F1.08 - barge board development

This solution (circled) was the first aero development the team applied to the car, even before the 'delta winglets' were added on the nose, and remains an important part of the car's basic aero package, after both wind tunnel results and CFD calculations confirmed its importance in increasing the efficiency and stability of the F1.08. The barge board development manages the airflow in the troublesome area in front of the sidepods. As well as providing the correct cooling, the solution directs the flow of air to the rear end of the car, in particular towards the main profile of the rear wing.

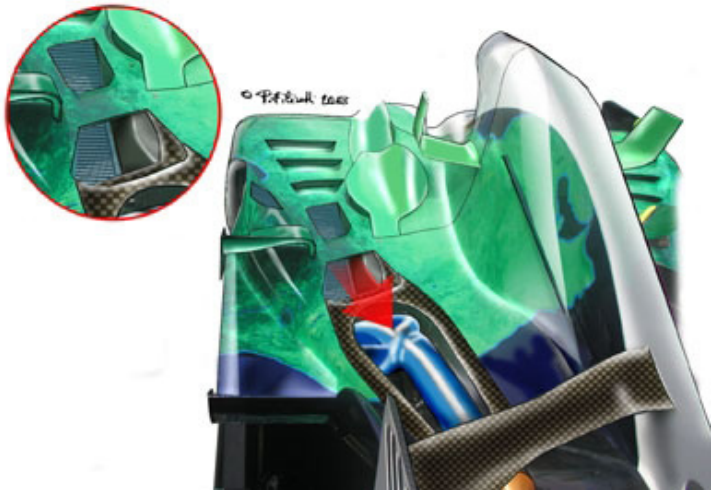
McLaren MP4-23 - front wing revisions

A small, but interesting change in Melbourne relates to the outer extremities of the bridge wing. They now feature a wider chord section than before, as well as long slits (arrow) to help generate the kind of suction effect normally associated with a more conventional flap-main profile assembly. The change provides slighty more downforce, without having to alter the chord and the angle of the bridge wing. Expect to see this solution retained for Malaysia next weekend.



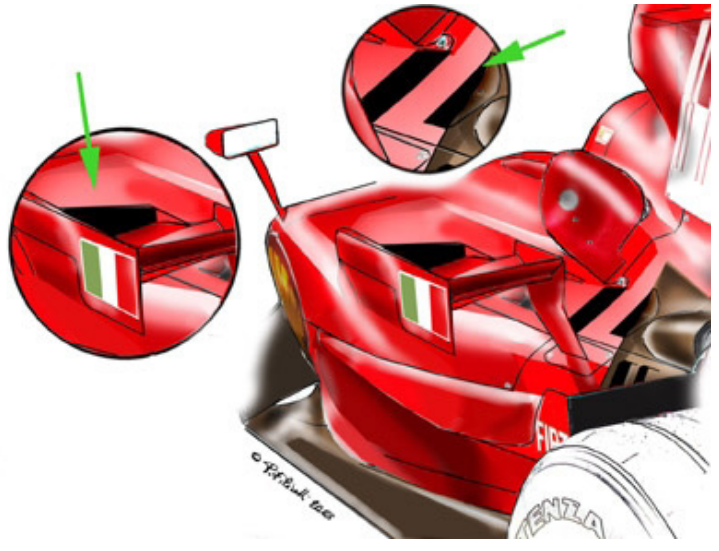
Ferrari F2008 - front-axle airflow management

Looking closely at the cars in the pit lane it is always possible to spot interesting concepts in the front suspension area, including fins, winglets and wing-shaped suspension wishbones. To find the most efficient aerodynamics in this area of a car, the F2008 is a good example. This section of the Ferrari is virtually divided into two parts, with the upper section (top arrow) managing the airflow passing over the sidepods, to feed the rear end's wing profiles. The lower section (bottom arrow), meanwhile, is directed towards the entry of the sidepods and the bottom of the car, feeding the barge boards placed just in front of the sidepods.



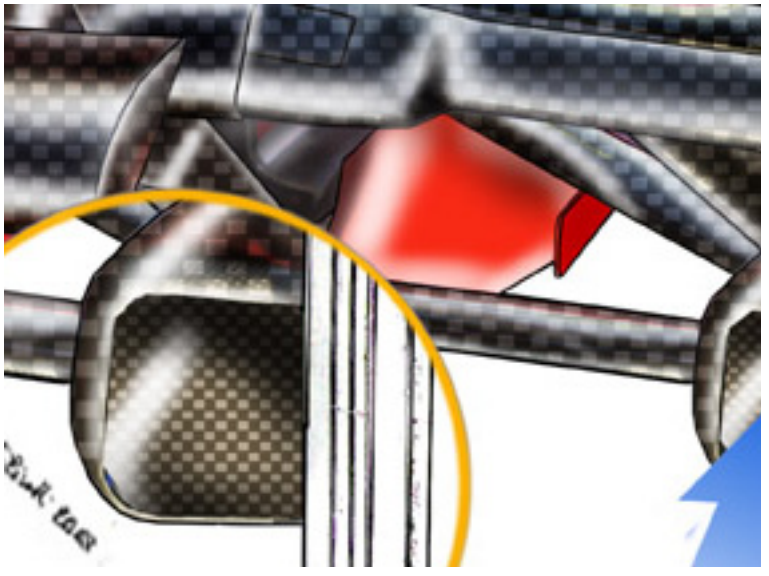
Honda RA108 - additional sidepod venting

Malaysia's tropical weather means teams face a cooling challenge. The high humidity hinders the correct flow of air through the car's radiators, so most squads try to find 'on site' solutions to guarantee the proper dissipation of hot air, without spoiling aerodynamic efficiency. Reliability is paramount, so even if the perfect compromise in terms of efficiency can't be found, radical solutions are often adopted. In the case of Honda, additional venting has been added on top of the sidepods by cutting big holes in front of the exhaust vents (inset). This improves the extraction of hot air from the sidepods (red arrow) and thus reduces the risk of the engine overheating. This precaution is even more significant if we consider the two-race engine rule.



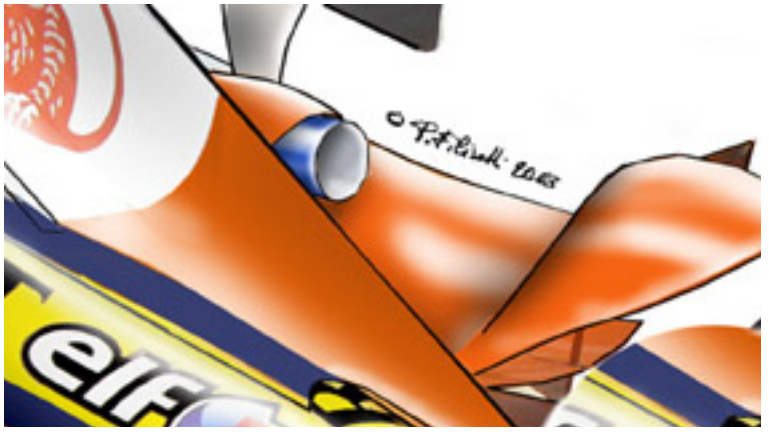
Ferrari F2008 - additional sidepod venting

The hot and damp Malaysian climate imposes special demands on all the teams to prevent overheating, especially of the engine. Ferrari had already adopted additional venting on the top of the F2008's sidepods, but these new slits (see insets), fit seamlessly with the original design. They provide a more efficient thermal exchange, while impacting as little as possible on the car's aerodynamic efficiency. Radical solutions adopted by other teams have hindered efficiency, as the hot air exiting through the new venting spoils the airflow directed to the car's rear wing and any winglets on the rear bodywork.



Ferrari F2008 - front brake ducts

In Australia the cars sported very small brake ducts, a trend that was totally reversed in Malaysia, especially at the front. The reason? In Melbourne there are no particularly long strong straights requiring hard braking at the end. Sepang has two, followed by tight hairpins. Although the rest of the circuit isn't particularly tough on brakes, the high ambient temperatures make cooling the discs and pads difficult. To avoid overheating problems during the race, all the teams increased the size of their brake cooling inlets. Ferrari's larger version, which will be retained for the next round in Bahrain, is illustrated here.

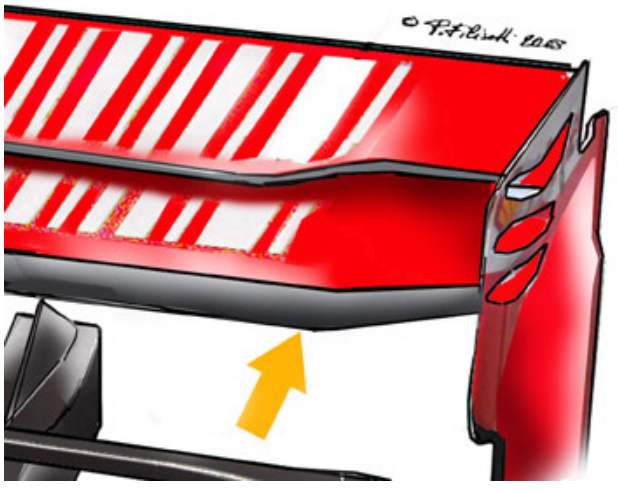


Renault R28 - rear damper cooling vent

Not strictly new, but very relevant in the heat of Malaysia, is the semicircular cooling vent placed over the R28's rear damper housing at the end of the very narrow engine cover. In 2008 the trend towards ever narrower engine covers has continued, in order to reduce the cover's negative influence on the airflow heading towards the rear wing. Such tight packaging makes cooling the elements inside the bodywork difficult. The dampers are particularly susceptible to heat, which could lead to malfunctions in terms of spring rate and rebound, or even blockages. The R28's special damper vent helps dissipate the heat in this particularly narrow and 'crowded' area.

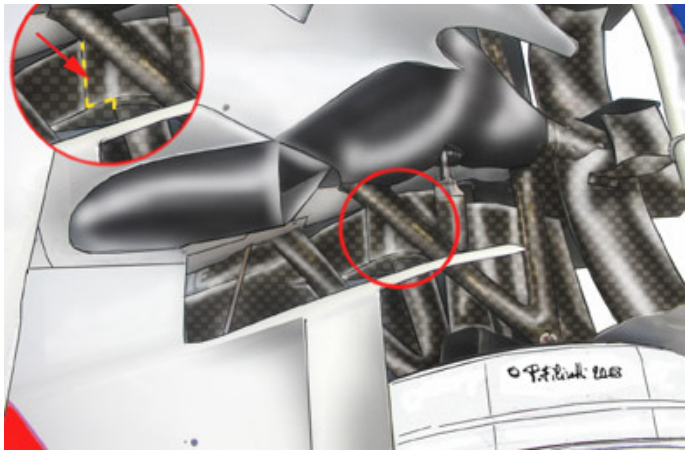
Ferrari F2008 - front wing development

Bahrain is a dramatically different circuit to the first two rounds of the year in Australia and Malaysia. Although it sports a very twisty central section, it's a medium-fast circuit with an average speed exceeding 220km/h. This calls for a completely different aero set-up, so as to maximise high-speed performance without losing the handling capabilities required by the Sakhir layout. Ferrari, who tested extensively here before the start of the season, have introduced a major revision to their front wing, giving it a deeply-sculpted outer edge (arrow) to its flap. This dramatically reduces drag, whilst at the same time improving the delivery of airflow to the sidepod inlets, paramount here as the high temperatures require highly efficient engine cooling.



Ferrari F2008 - new rear wing profile

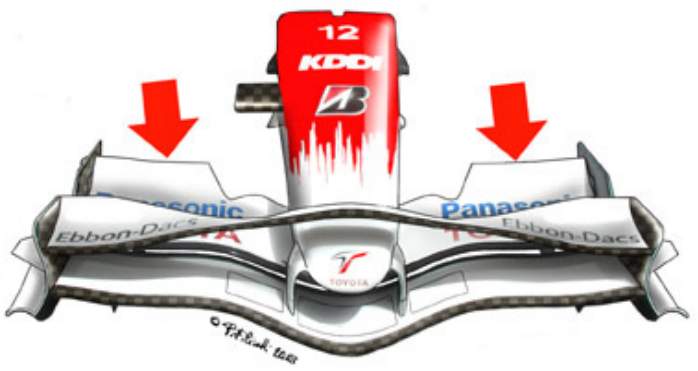
For the same reasons described in the article on Ferrari's front wing changes for Bahrain, the team have also introduced a new profile at the rear. It has a flat central section, with the outer extremities bending noticeably upwards (yellow arrow). The main advantage of this configuration is that it prevents the blocking of airflow in the section close to the endplates, reducing the drag this problem normally generates. At the same time, the flat central section provides sufficient downforce to guarantee rear-end grip, balancing it with the load produced at the front, so as to maintain appropriate handling.



BMW Sauber F1.08 - rear suspension detail

At the start of the season teams are always eager to get a close look at their rivals' cars and discover how their design concepts have been translated into reality. After its blistering start to the year, the BMW's secrets have come in for particular scrutiny. This car is, without doubt, very sophisticated, the result of an intensive aerodynamic study, both in the wind tunnel and using state-of-the-art CFD (Computational Fluid Dynamics) tools. Here we examine the F1.08's rear suspension, in particular its lower wishbone assembly, which has been cleverly integrated into the side channel of the rear diffuser. In fact, the section close to the pick-up point (where it connects to the gearbox) has a wing-profile shape, which cleverly follows the form of the diffuser itself (red arrow, yellow line). This ensures that airflow passing through this crowded area of the

car does not meet any major obstacle, hence improving air extraction from beneath the car and dramatically reducing drag.

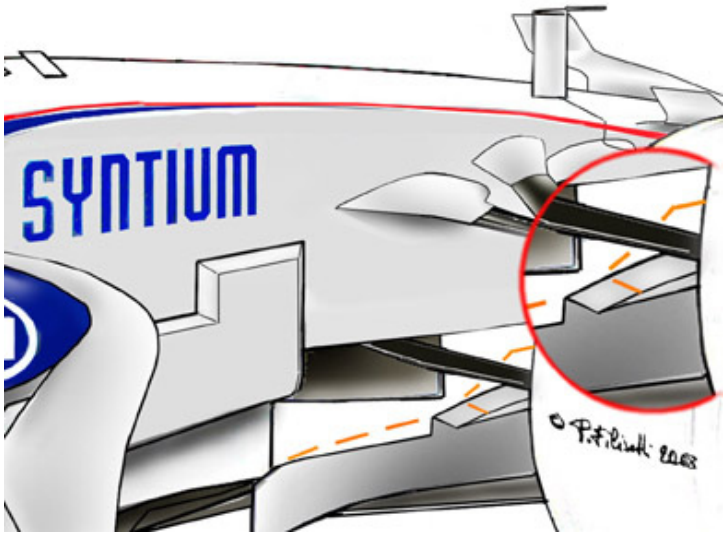


Toyota TF108 - front wing revisions

Along with Ferrari, Toyota were the other team to test in Bahrain earlier in the year. However, the Japanese team have taken a very different route to the world champions with their front wing revisions for Sakhir. Their design has a flap which is wider at its extremities (red arrows), ending with a completely horizontal profile (in contrast to the Ferrari's heavily sculpted shape). This configuration increases downforce, improving the car's front-end behaviour and correcting the understeer on corner entry that was an early problem when this car was originally launched. The TF108's balance now looks pretty good, providing smoother handling and translating into quicker lap times, as reflected in Jarno Trulli's P7 grid position.

Ferrari F2008 - cooling vent for rear dampers

In Malaysia we looked at Renault's semi-circular vent over the R28's damper housing. In Bahrain the Ferrari sported a similar, perhaps slightly more complex, feature. At the end of the F2008's very short and narrow engine cover we can see three separate vents (green arrows). The central one relates to a small gearbox radiator, placed above the gearbox case, between the two suspension rockers. The rockers are covered by a tight, thin, carbon fibre skin that wraps them in a way so as to help reduce as much as possible the dimensions of the rear bodywork. The two rounded side vents help extract the hot air that would otherwise increase the danger of overheating the suspension elements, especially the dampers and rockers. These carefully designed vents show just how vital attention to detail is in ensuring reliability.

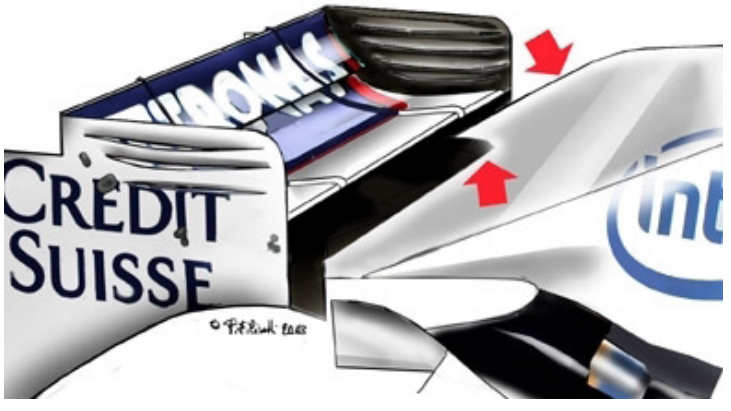


BMW Sauber F1.08 - front barge board development

As Sakhir is a medium-to-fast track, it is important to minimise the drag generated by the various aerodynamic surfaces impacting the airflow passing over the car. Even the smallest parts can produce drag that affects a car's straight-line performance, hence BMW Sauber's changes to the barge boards immediately behind the F1.08's front wheels. The vertical shields are now lower at the front (yellow dotted line indicates previous shape) and the small horizontal fin has been extended rearwards, so as to better direct and split in two the airflow exiting from beneath the front wing. This change may seem small, but it reduces turbulence noticeably at high speed.

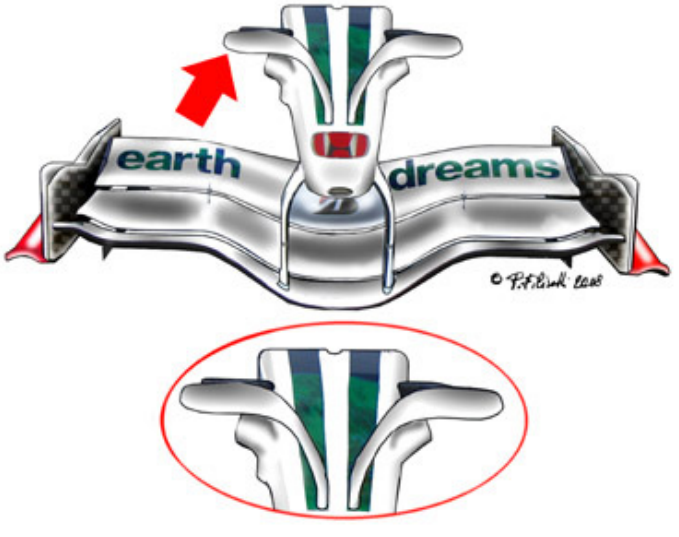
Renault R28 - engine cover shark fin

Renault have also included a heavily revised engine cover as part of their pre-Spanish Grand Prix aero updates. This full-height shark fin profile (circled) is almost identical to the one introduced by Red Bull before the season's opening race. This revision has been made to improve the car's rear-end efficiency and balance, and improve its straight-line stability at high speeds. This addition, according to a Renault engineer, is not just for the Barcelona race but will be used for the season's remaining races, albeit with ongoing development changes.



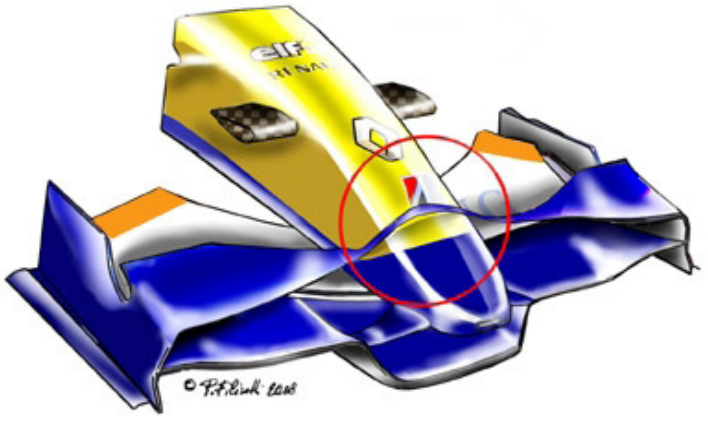
BMW Sauber F1.08 - shark finned engine cover

Since last season it seems most teams have found from their wind tunnel and CFD (Computational Fluid Dynamics) aerodynamic testing that elongating the engine cover provides clear advantages in terms of rear-wing efficiency. By improving the quality of airflow directed towards the rear wing, the fin increases downforce and allows the squads to run lower rear-wing angles, enhancing the car's top speed. BMW Sauber have adopted this philosophy with their 'mini' shark fin. Similar in style to the one found on McLaren's MP4-23, the rearmost edge of the fin curves steeply downwards (top red arrow) and ends with a jagged cut (bottom red arrow).



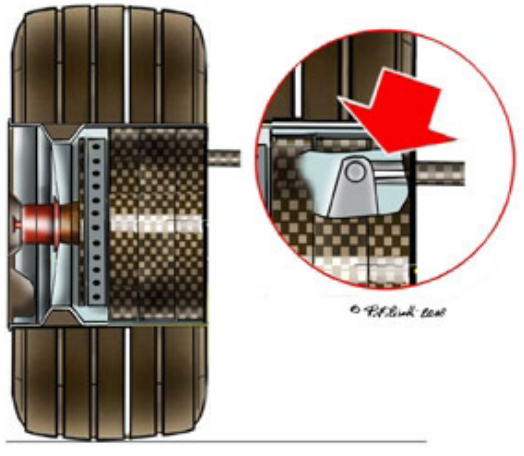
Honda RA108 - 'elephant ear' nose wings

This solution, debuted in Spain, is Honda's radical-looking interpretation of the nose winglets introduced by BMW Sauber to optimise the car's balance. They don't generate significant downforce, but instead help divert airflow horizontally, improving the quality of the airflow directed to the car's rear end and to its sidepod inlets. Honda, like BMW Sauber, have followed the common fashion this year of dramatically narrowing the lower section of the sidepods, reducing both the cross-sectional area of the inlets and the surface area of the radiators within. This reduction makes the effective channelling of airflow into the inlets even more crucial for effective cooling.



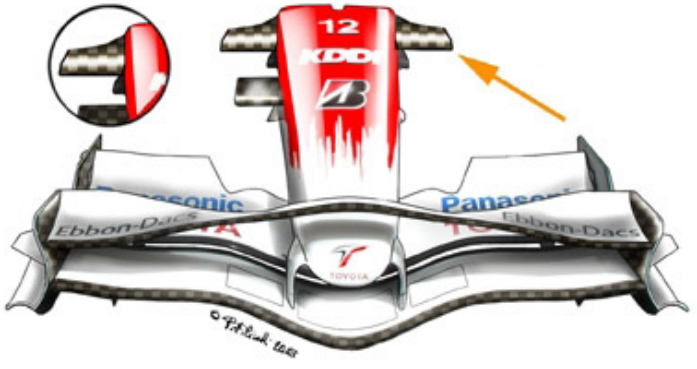
Renault R28 - revised bridge wing

This change forms part of Renault's revised aero package for Barcelona. The upper profile now sports a semicircular central section (circled), which has increased the gap between it and the top of the R28's nose. This helps to reduce any blockage of airflow in this area and also means the depth of the upper profile's outer extremities can be increased, producing a more relevant downforce load without increasing the flap angle. This solution is particularly effective on long straights where top speed is important, but also works well on twisty track sections, where front-end sharpness is paramount.



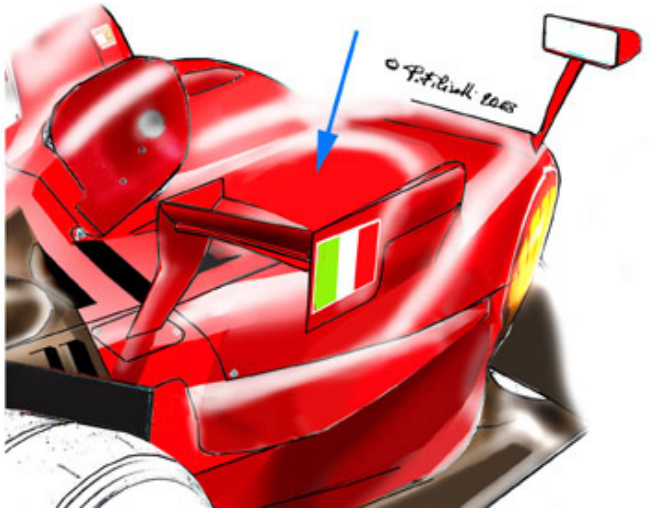
McLaren MP4-23 - Kovalainen wheel rim failure

McLaren suspect Kovalainen's huge accident in the Spanish Grand Prix was the result of a failure of the forged magnesium wheel rim. The exact cause of that failure is as yet unknown - a stone or some other debris getting into the wheel is the primary suspect, while other possibilities include an unusually heavy impact with a kerb or even a manufacturing fault. What is known is that the failure caused the tyre to suddenly deflate and almost certainly destroyed the steering linkage (inset), making it impossible for Kovalainen to steer the car, with the left wheel completely out of control.



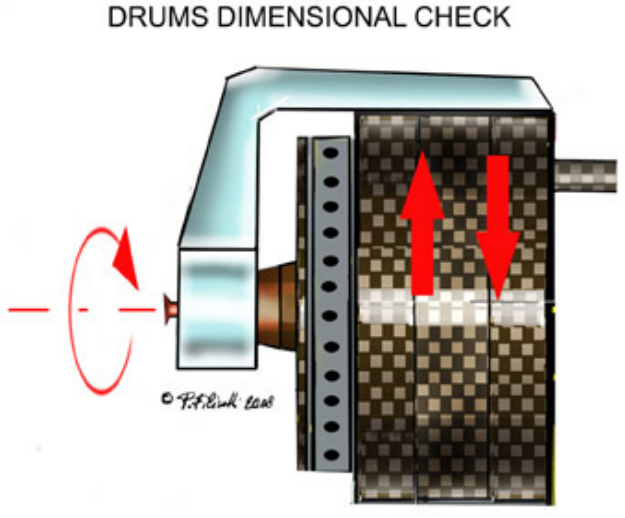
Toyota TF108 - nose winglets

As part of their aero update for Barcelona, Toyota included two wider-than-normal winglets on either side of the TF108's nosecone (yellow arrow and inset). In principle, these are similar to the 'elephant ear' nose wings adopted by Honda. Rather than increasing the overall amount of downforce load, they direct the airflow towards the sidepod inlets and the car's rear end more effectively. It is a solution that works particularly well on tracks like the Circuit de Catalunya, with long straights and fast corners but, while front-end stability was markedly improved, both Toyota drivers decided to revert to the standard solution for the race itself.



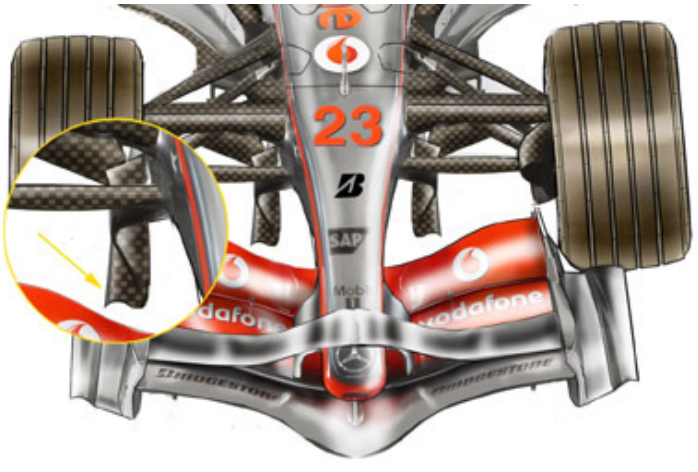
Ferrari F2008 - reduced cooling vents

For this year the Turkish Grand Prix has moved from August to May and the lower temperatures mean teams can afford to reduce the number of cooling vent slits on their cars' sidepods. In the case of Ferrari, the F2008 sports only half the number of upper vents it would in high-temperature configuration (blue arrow indicates where the additional slits would be). This change slightly improves the car's aerodynamcic efficiency, especially on Istanbul Park's long straights.



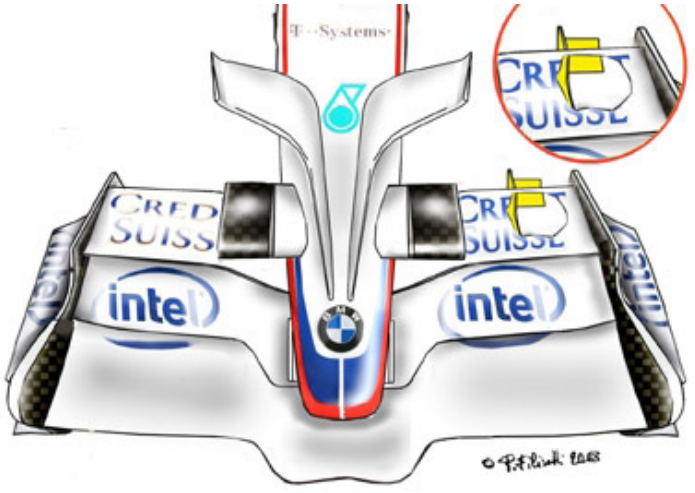
McLaren MP4-23 - brake drum dimension checker

Following Heikki Kovalainen's dramatic accident in Spain - caused by a wheel manufacturing fault leading to continuous contact between the inner side of the rim and the carbonfibre brake drum - in Turkey, McLaren have been using a special device to monitor the drum's dimensions. The device (silver) is attached to the wheel nut and rotated around the circumference of the brake drum to check whether, after use, there is significant dilation of the drum due to the heat generated under braking. The gap between rim and drum is purposely tiny to ensure maximum aerodynamic efficiency, but it also means that even a small dilation could potentially cause contact problems.



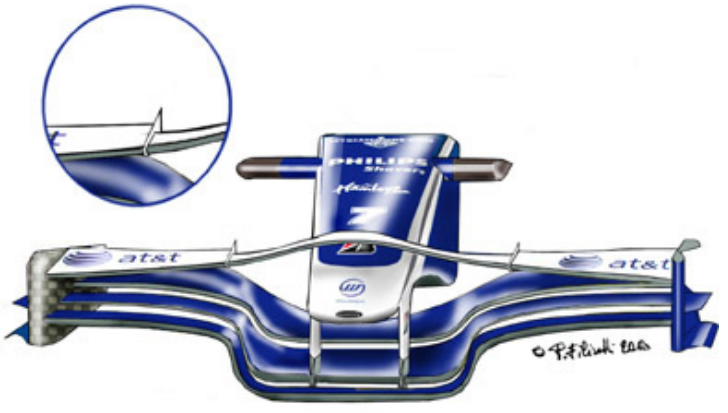
McLaren MP4-23 - front barge board development

On all the cars the front end plays a crucial role in terms of aero efficiency and even the tiniest detail can make a big difference. One example in Turkey is the small barge boards on the McLaren, placed just under the front suspension's lower wishbone, which feature a horizontal arched section (yellow arrow). The height of this arch has been increased, providing a more pronounced channel for the airflow around the lowest section of the barge boards. This generates a sort of Venturi effect that not only provides slightly more downforce, but more importantly speeds up the airflow in this area so as to increase the extraction of air from under the front wing's main profile, hence improving its efficiency. It's a solution very different from Ferrari's vented nose, but one whose function is almost the same.



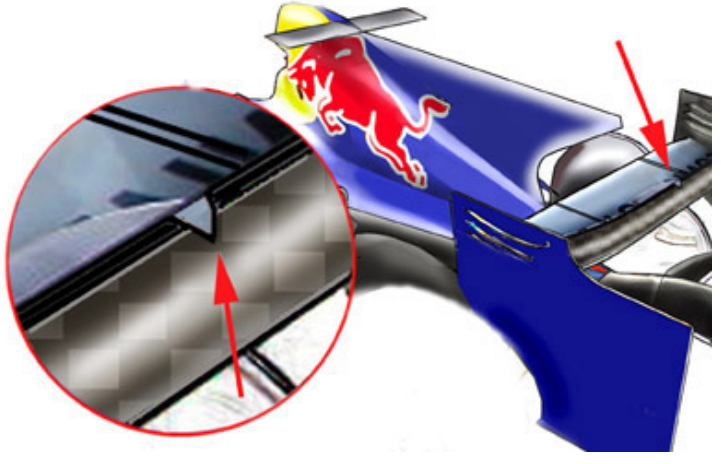
BMW Sauber F1.08 - front wing development

Although only a small development, BMW's introduction of long vertical fences (yellow detail) under the F1.08's front wing is interesting to note and similar to a solution introduced in 2007. In addition a horizontal winglet has been placed on the rear section of the fence towards its upper edge. The fence splits the airflow passing near the upper flap, while the additional small winglet prevents the air from passing too close to the element thereby reducing drag and turbulence.



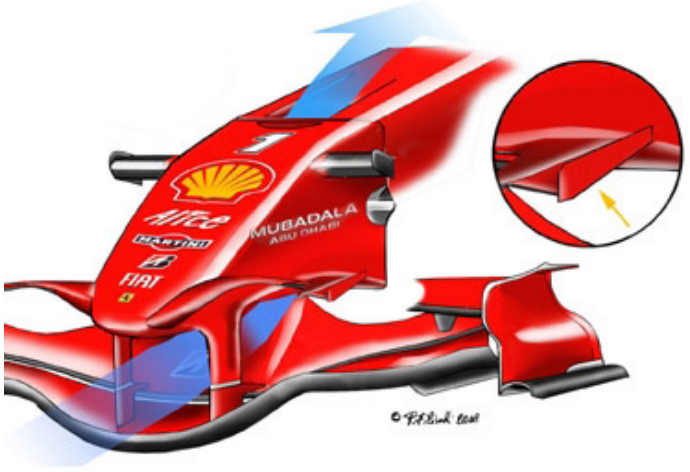
Williams FW30 - revised front bridge wing

Introduced in Turkey, this solution is an evolution of the aero package debuted at the last round in Barcelona. The upper profile of the wing is now divided into three sections by means of two small vertical fences. These allow a slight increase in the profile depth of the two outermost sections of the wing (inset), producing more downforce without having to increase the flap angle (and hence drag). It's particularly effective on a track like Istanbul Park, which requires strong top-speed performance on the long straights, but also sharp front-end handling in the circuit's twistier sections, including the notorious Turn Eight.



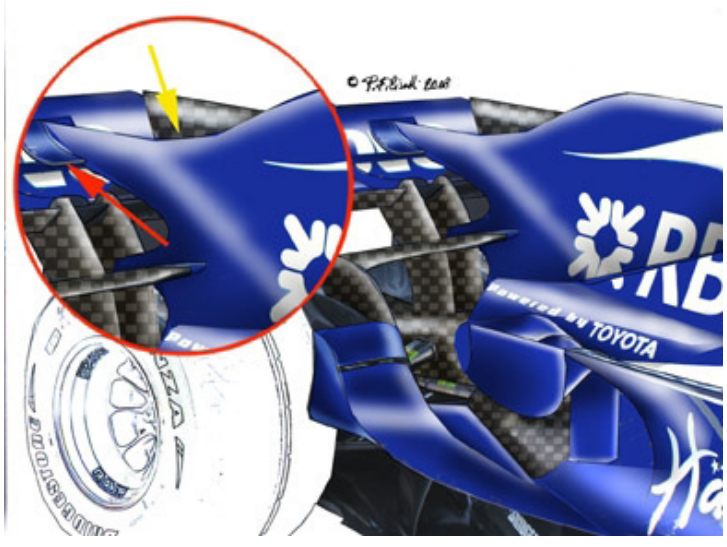
Red Bull RB4 - V-cut on rear wing flap

A small but interesting change was introduced on the RB4 in Turkey, following on from the big aero overhaul debuted at the previous round in Spain, and it's one that will play an even more relevant role at the next race in Monaco. A deep V-shaped cut was placed in the middle-top of the rear wing flap, providing a vent for the high-pressure airflow impacting the wing profile in this area. Its purpose? To reduce the increased drag generated on the straights when running the kind of high flap angles essential on a tight, twisty circuit like Monte Carlo.



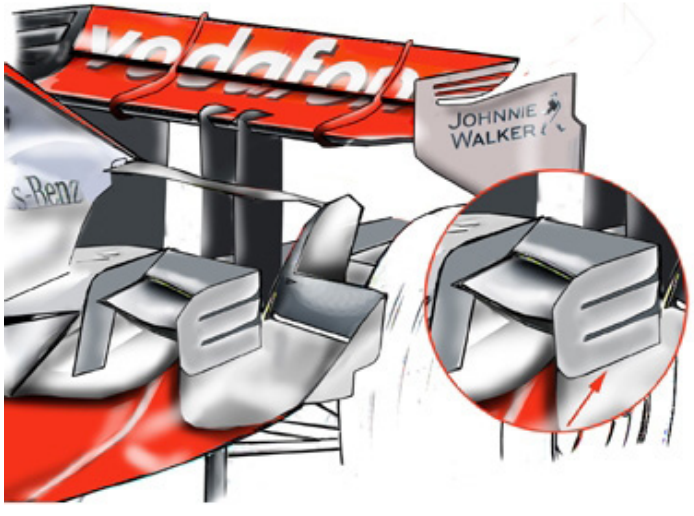
Ferrari F2008 - nose hole development

For the second time in three races, Ferrari have utilised their vented nosecone assembly in Monaco. The solution, which improves the car's overall aero balance, works best at high-downforce tracks like Monte Carlo, and the Italian team have further refined it with the addition of two triangular, inclined winglets (inset) at the base of the nosecone. These are designed to help divert away turbulence generated by the front-wing pillars and hence enhance the efficiency of the bottom hole.



Williams FW30 - long shark-fin engine cover

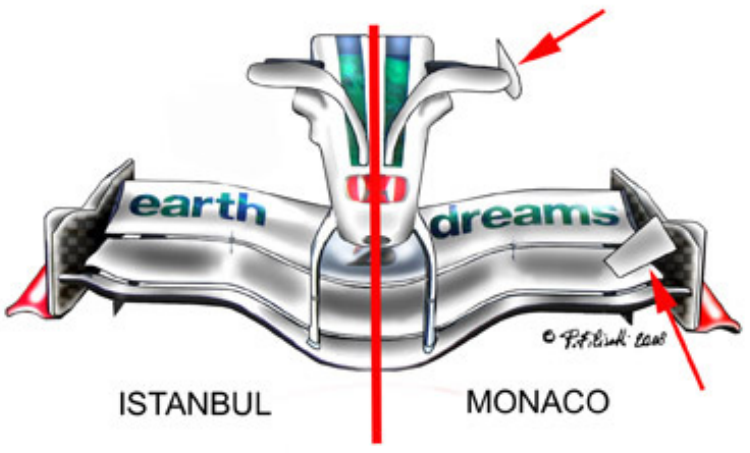
At Monaco high downforce is key and to improve the FW30 in this respect, Williams have followed the trend set by Red Bull and followed by Renault and Toro Rosso by introducing a shark-fin engine cover. The fin is very long and extends towards the rear wing, eventually tapering down to draw level with the main wing profile (yellow arrow). It increases the efficiency of the rear wing and provides a huge amount of downforce. Attached to the rearmost tip of the fin is a small winglet (red arrow) which is designed not to add downforce but to keep the cover stable and prevent the fin from bending.



McLaren MP4-23 - slitted sidepod winglets

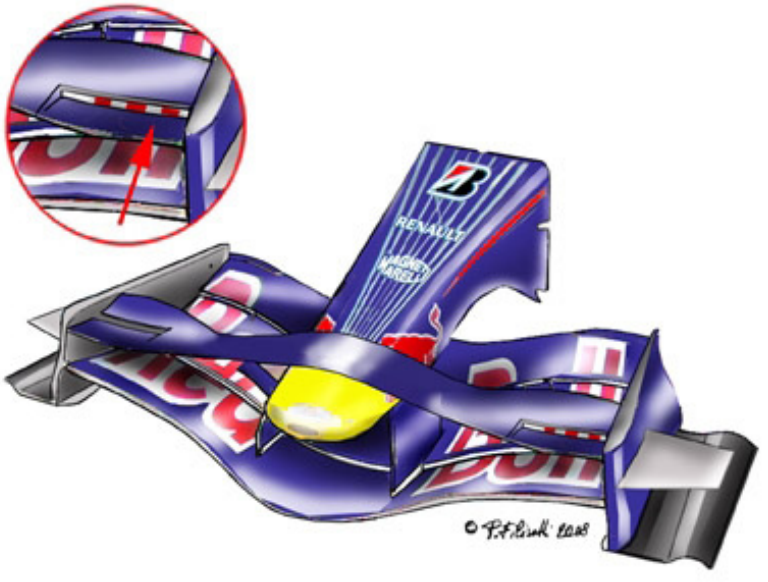
Compared to last year's McLaren, the MP4-23 boasts a longer wheelbase and a slightly revised layout and weight distribution. Changes to its aerodynamics, however, have been much less radical and more of a refinement of those found on its predecessor. For Monaco the British team have added side slits (inset) to the endplates of the car's sidepod winglets. Similar to a revision introduced by Renault last year, they are designed to reduce any extra turbulence generated by the larger Monaco-spec winglets - and consequently ensure maximum downforce gains.

Honda RA108 - front wing development

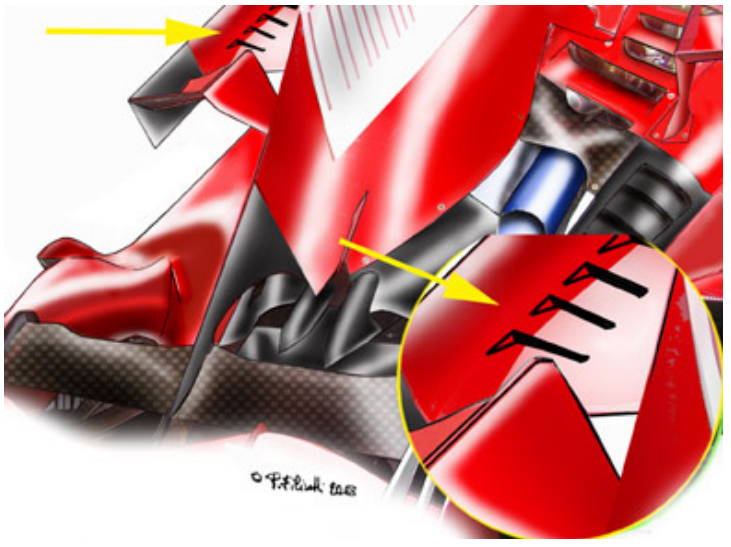


For Monaco Honda introduced a series of small changes, in various areas of the car. A couple of the most interesting were to be found at the front (compared here to the configuration from the last round in Turkey). Two inclined trapezoidal winglets were added to the inner face of the front wing's endplates (lower arrow), not to increase downforce, but to better control the airflow directed towards the flaps of the wing and the front suspension elements. The extra winglets work in conjunction with the 'elephant ears' added in Spain, which for Monaco featured a small rounded endplate on each side (upper arrow). These two changes helped the front-end sharpness of the car's handling - crucial in the confines of the Monaco streets.

Red Bull RB4 - front wing revision

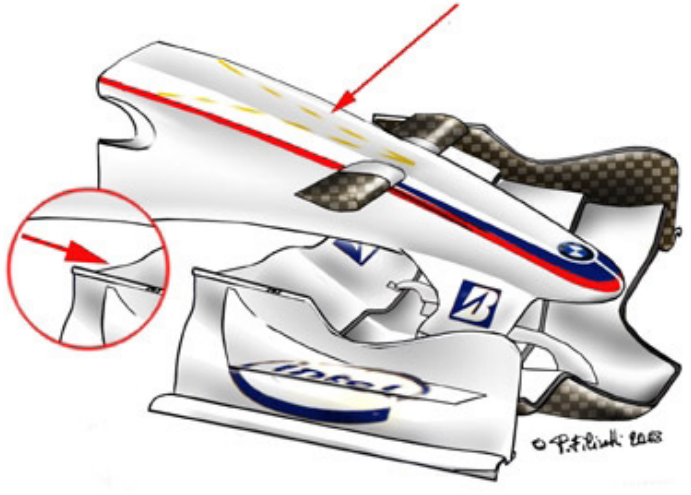


For Monaco Red Bull revised the bridge profile of the RB4's front wing. The central section was flattened and broadened, while the outer extremities were widened and now feature a long deep slit (see inset). These changes were adopted to increase the level of downforce at the car's front end. The slits boost the pressure of the airflow passing through them, which in turn improves the efficiency of the front wing's two large flaps.



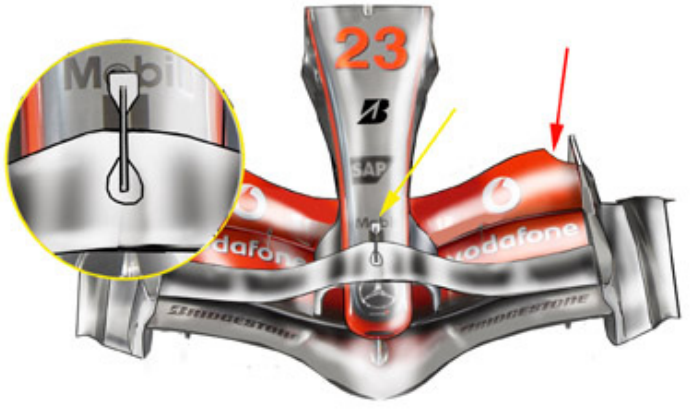
Ferrari F2008 - additional venting slits

In Monaco, Ferrari added small venting slits to the chimneys on the top of the sidepods to aid cooling (yellow arrow and inset). Although in Canada the average speed is much higher than that of Monte Carlo, the hotter temperatures plus the track's long straight and twisty section make it sensible for the Italian team to keep the slits in place this weekend.



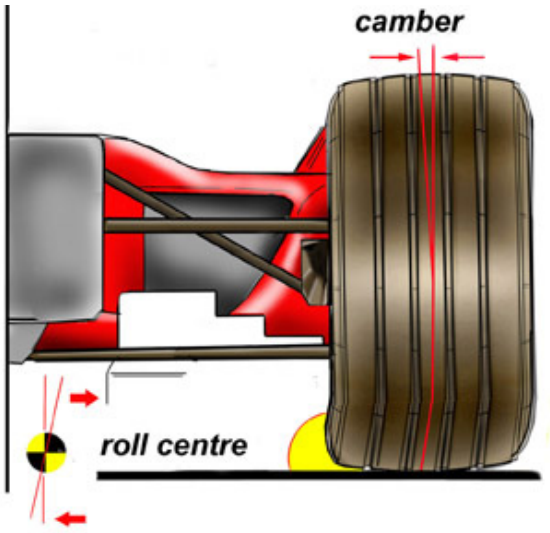
BMW Sauber F1.08 - nosecone development

Canada isn't considered a special track in terms of set-up, but for the first time this season BMW Sauber have dropped the distinctive 'boomerang' winglets on the F1.08's nose (yellow dotted line shows their previous position). They have been removed to aid top speed, particularly on the long final straight, the end of which provides one of the track's few overtaking opportunities. Another interesting change is to the outermost part of the rear flap (inset), which now features an inclined top edge, mirroring the profile of the wing's entry edge. This provides a small increase in flap surface area, enough to help sharpen front-end handling on corner entry.



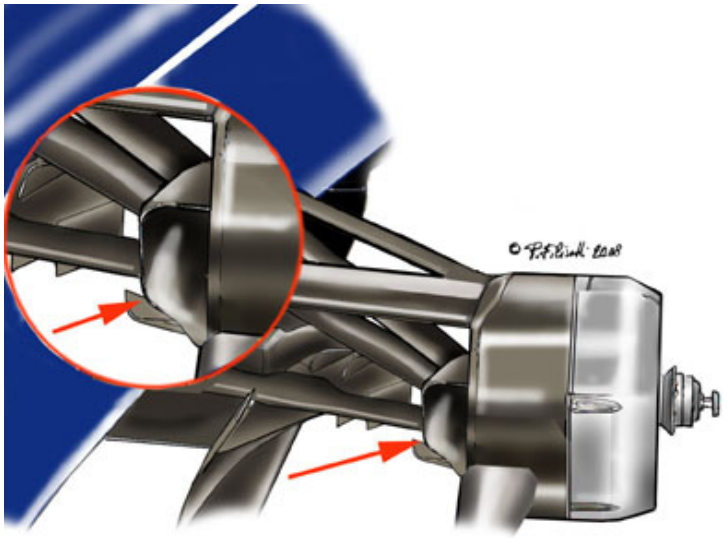
McLaren MP4-23 - bridge-wing support; flap revisions

Prior to the Canadian race, the FIA reinforced the rules related to flexible wings, in particular the front bridge wings, which are now a feature on most cars. The teams were told to provide additional support to the central section of the wing, by connecting it to the nosecone, and to reinforce the parts of the profile that could flex under aerodynamic load. In Montreal a flexible wing would provide a clear advantage, as it would mean less drag on the straights but higher downforce in the twisty sections. Instead of adopting a central pillar connecting the central section of the bridge wing to the nosecone, McLaren have utilised a tiny arched profile connecting the nosecone to the upper face of the bridge wing (see yellow arrow and inset). This solution appears to be less disruptive in terms of aerodynamics while still preventing the wing from flexing. Another change to McLaren's front wing, to adapt it specifically to Montreal, was deep, rounded cuts at the outer extremities of the rearmost flap (red arrow). These help reduce drag on the very long straight before the final corner.



Ferrari F2008 - the secret to riding Montreal's kerbs

One of the distinctive elements of the Circuit Gilles Villeneuve are its high kerbs. To set a fast time all the drivers tend to ride the kerbs, but what is interesting is how smoothly the Ferraris seem to be able to attack them. This is a result of the F2008's suspension geometry, in particular at the front, where it has been heavily modified from last year. It features a very low roll centre that allows the use of reduced camber angles (see red arrows). This not only increases the tyre's contact patch with the tarmac, it also reduces roll, thereby making the chassis move less and diminishing the rebound caused by riding the kerbs. The use of a third element damper also helps dissipate the energy generated by hitting the kerbs, reducing the subsequent chassis oscillations. In summary, the changes provide a more stable car, with a much sharper front end for Montreal's particularly rapid direction changes.

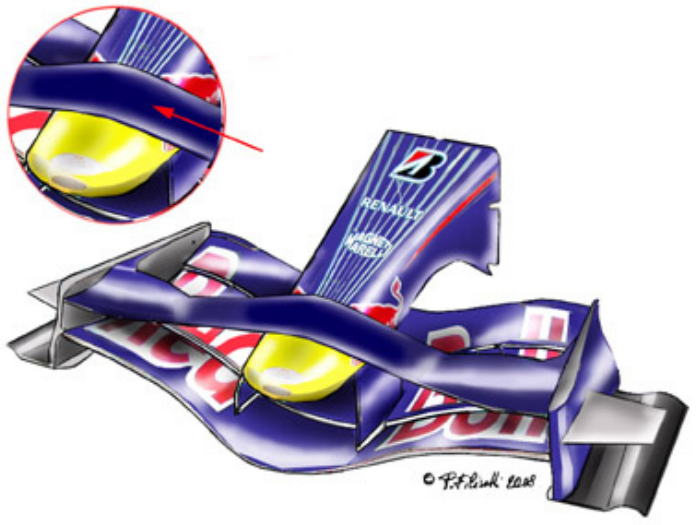


Williams FW30 - enlarged brake ducts

Montreal is the most demanding track of the championship in terms of brake wear. Specific compounds are used for discs and pads and finding a solution that effectively controls wear whilst also keeping the brakes within an acceptable temperature range is paramount. To this end, all the teams introduced enlarged brake ducts to optmise cooling of the discs and calipers. Those on the front of the Williams (inset) featured a small winglet at the base (red arrow) to help channel airflow directly to the caliper, thus reducing its working temperature.

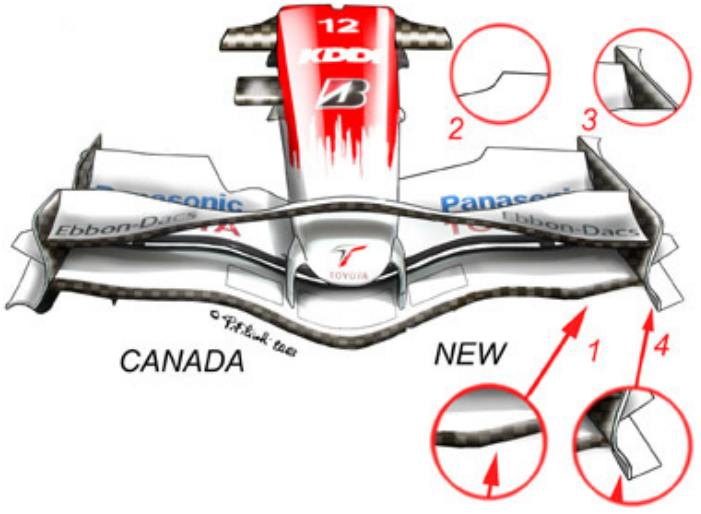
McLaren MP4-23 - rear wing revisions

Montreal requires medium to low downforce levels and to achieve this teams reduced both the main profile of their wings and the angle of the wing flaps. McLaren adopted an interesting rear wing that featured a main profile raised in its central section, with its extremities bending slightly downwards towards the endplates (right arrow). This solution generated not only less downforce, but also much less drag compared to the previous configuration. Also interesting to note was the horizontal plate (left arrow) linking the two vertical pillars, ensuring adequate stiffness in light of the pillars' increased height.



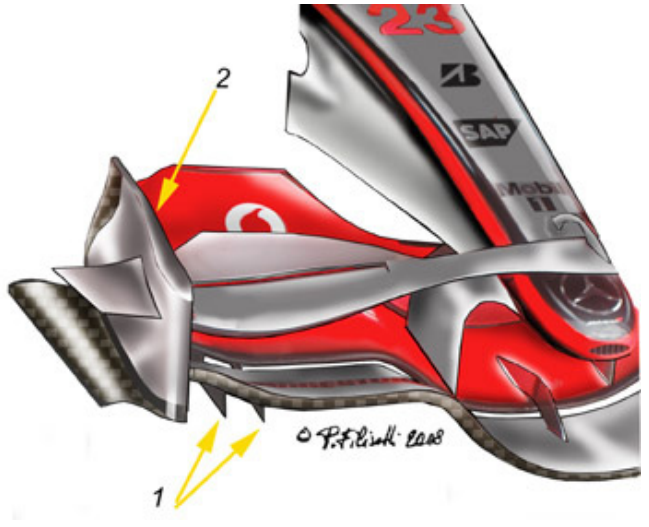
Red Bull RB4 - bridge wing modifications

At the last round in Montreal Red Bull modified the RB4's bridge wing to prevent it from flexing, to comply with the latest FIA rule clarifications. For Magny-Cours, the team have revised the central section of this element (see inset). By increasing the depth of the bridge wing (red arrow), the team can boost downforce without altering the angle of the flap. In this way the car can still perform well at top speeds on the long straights, while at the same time have a sharper front end, better able to cope with the French track's twisty sections.



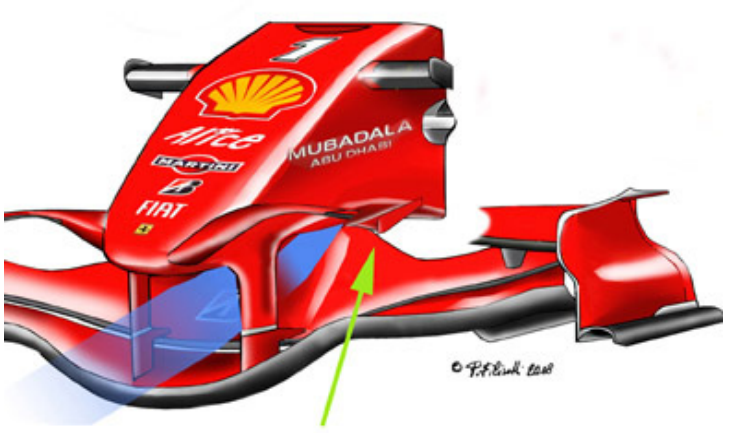
Toyota TF108 - front-wing development

Like most teams, Toyota have introduced several aerodynamic refinements on its car for France. Although visually subtle, the number of small changes is impressive. On the TF108's front wing, for example, there are four differences to the one used in Canada. The main profile (1) features a more curved profile, with its extremities bending upwards more obviously towards the endplates. The rear edge of the flap has also changed (2), featuring a wider section, slightly reducing towards the centre, but still sporting an increased area compared to the previous version. The endplates now feature a completely different lower section, with a flat, knife-edge outer section (4) instead of the previous arched shaped one. The top-rear section of the endplates has changed too (3), now being flat and sporting a triangular, horizontal winglet on its rearmost edge, so as to better divert and split the airflow close to the front wheels, thus reducing turbulence.



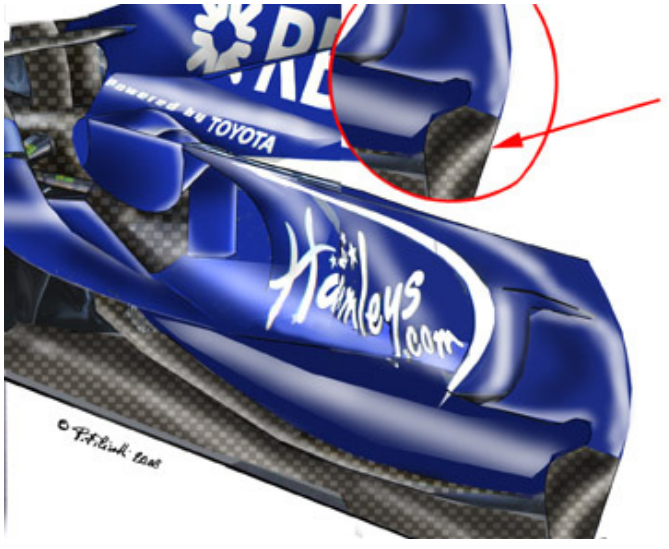
McLaren MP4-23 - front-wing development

McLaren have introduced a deeply revised front wing in France. Underneath the main profile, two close vertical fences (1) have been added near the outer edge to divert airflow outwards, hence cleaning up the airflow beneath the profile's central section. In addition, the endplates (2) have been revised. Instead of the sculpted ones seen in Canada, they now feature a flatter, knife-edge profile, which has reduced the overall width of the wing profile and flaps. This new version of the wing is expected to be a permanent change, as the revisions are not only suitable for this track.



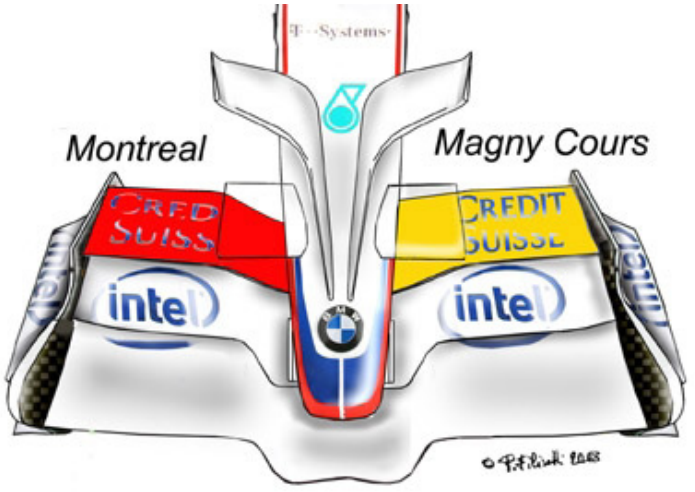
Ferrari F2008 - revised front wing

Ferrari have revised the F2008's front wing for France, in particular the central section of the flap (green arrow) which has been altered to improve the performance of the car's nose hole, increasing air extraction from underneath. The flap has been deepened to increase the quantity of airflow and to allow the team to use lower flap angles. This means less drag on the straights, but still maintains adequate downforce for the twisty sections of the track, improving the sharpness of the F2008's front end still more.



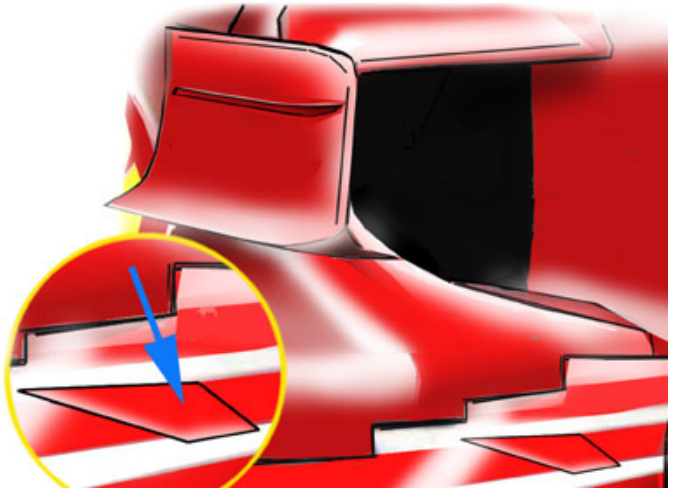
Williams FW30 - front sidepod winglets

Following the recent Barcelona test, Williams used a heavily revised version of their sidepod winglets in France. They now closely resemble those on the BMW Sauber, thanks to a curved, vertical fin (inset) that connects them to the edge of the car's stepped bottom. This solution has two main benefits. Firstly, it reduces the negative effects of the car's vibration on the winglet, making it less prone to 'flicking' the airflow in non-optimal directions. Secondly, it splits the airflow in two, helping the winglet to better clean up the airflow directed towards the rear of the car.



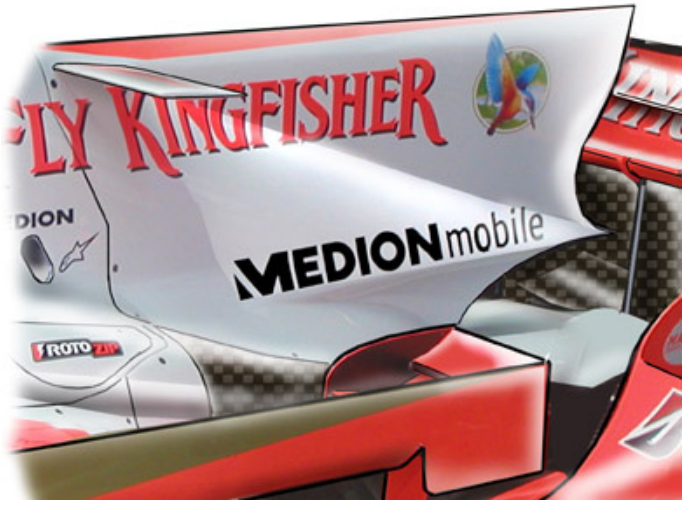
BMW Sauber F1.08 - front-wing development

In France, the F1.08 once again featured its distinctive 'boomerang' winglets and also sported a revised front wing. In comparison to its previous incarnation in Montreal (see area highlighted red), the depth of the wing's upper flap was widened at the centre (see area highlighted yellow). The team had brought both options with them to Magny-Cours, but after evaluating both during practice, they opted to use the revised version, which improved downforce at the car's front without noticeably increasing drag.



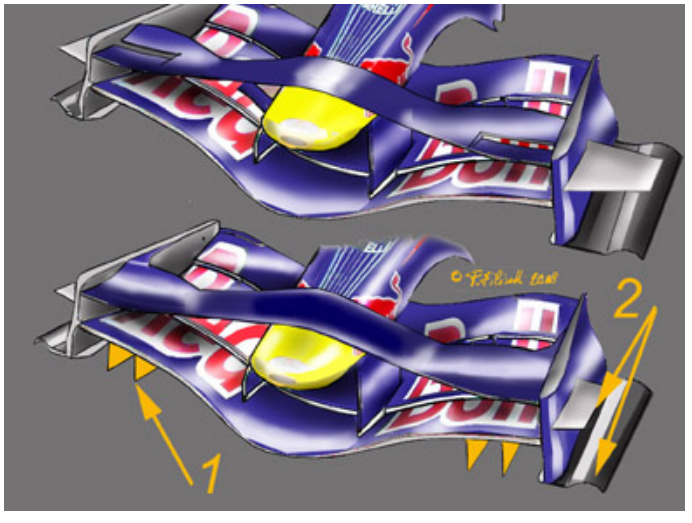
Ferrari F2008 - barge board development

Compared with Force India's extensive aero redevelopment for Silverstone, the changes to the F2008 look insignificant at first sight. But Ferrari have in fact developed many details of the car to optimise its already excellent balance for the specific demands of the British track. One interesting example is the addition of a tiny winglet on each of the bargeboards (see inset). Placed in the middle of the shield, the winglet (blue arrow) acts as an airflow splitter to better direct air into the sidepod inlet. At the same time it works in conjunction with the huge slitted winglets placed in front of the sidepod. This modification helps with the rapid changes of direction needed at Silverstone, by reducing turbulence - and the car's sensitivity to it.



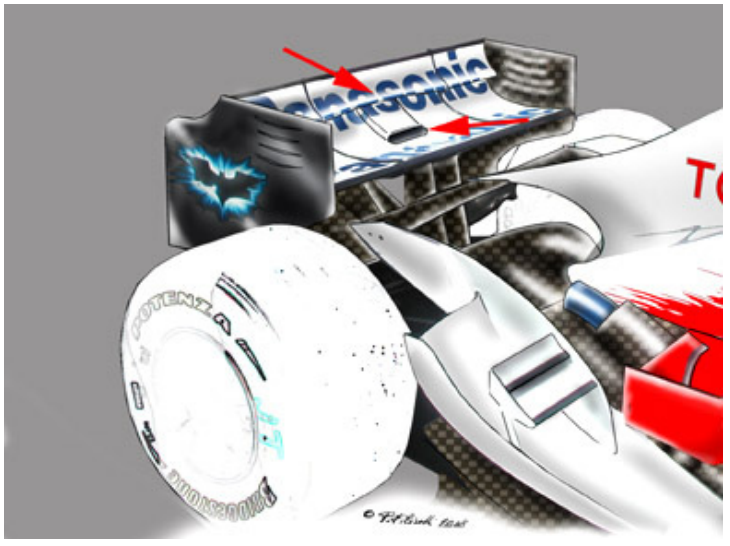
Force India VJM01 - shark fin engine cover

For Silverstone Force India have introduced a deeply revised aero package, which includes new sidepod bodywork and winglets. By far the most striking new element is the engine cover, which sports a huge shark fin, similar to those found on the Renaults, Red Bulls and Toro Rossos. The aim of this new addition is to improve the quality of the airflow directed towards the rear wing, increasing its efficiency in terms of increased downforce and reduced drag.



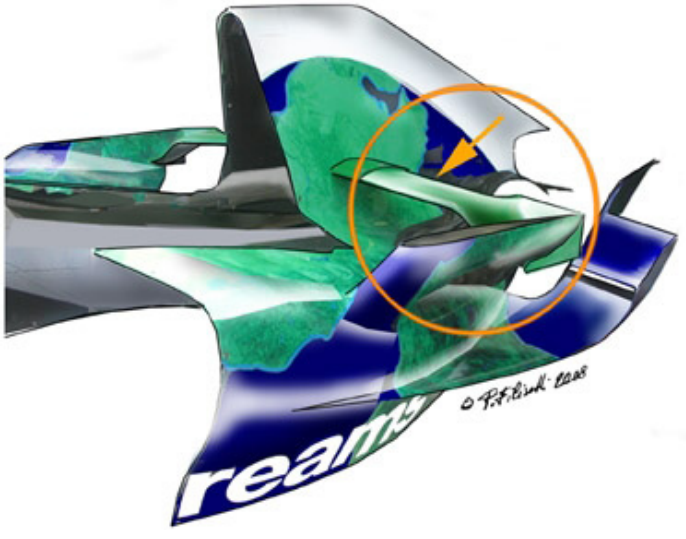
Red Bull RB4 - front wing comparison

During the test session at Silverstone ahead of this weekend's race, Red Bull evaluated a variety of solutions to improve the RB4's balance. One outcome of this intensive work was a revised front wing, as shown in the lower drawing (previous version above). This sports a different main profile that is flatter at its extremities and features two big vertical fences (1) to better manage the airflow passing underneath. In addition to this, the wing profile is wider than its previous incarnation. The endplates now sport narrower horizontal knife-edge profiles with arched extremities on their external lower edge (2 - right arrow), coupled with smaller horizontal winglets in the middle of the endplate (2 - left arrow).



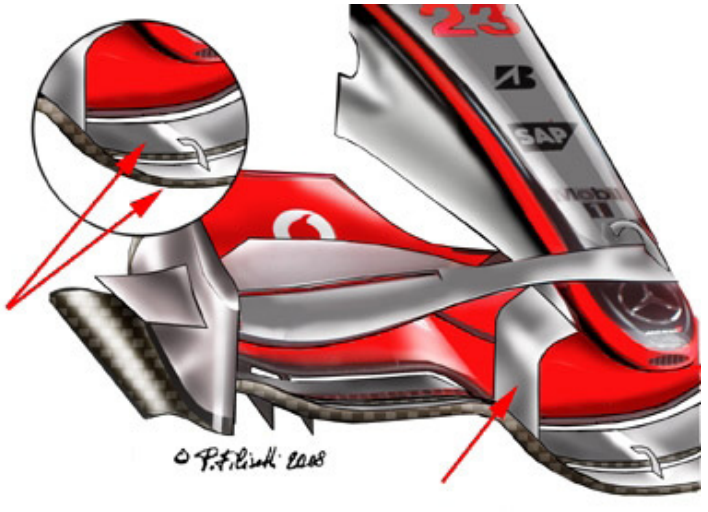
Toyota TF108 - rear wing development

Toyota have brought to Silverstone a modified slitted rear wing (red arrows). Though not entirely new, the wing features a completely revised flap, the depth of which has been reduced at its centre to minimise any airflow blockage. The lower portion of the airflow now passes through the slit, creating a sort of venturi effect that improves the extraction of air passing under the profile. The reduced depth of the flap enhances this effect, providing better stability thanks to the more stable downforce load.



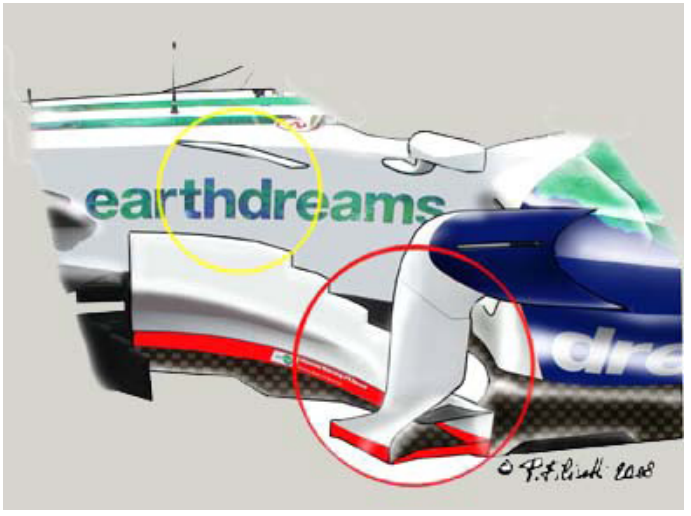
Honda RA108 - engine cover winglets

During pre-season testing back in February, BMW Sauber added two profiled winglets to the F1.08's engine cover. At Silverstone Honda have adopted a similar solution, adding two centrally-positioned wide winglets (see circled area and arrow) to the RA108's engine cover in an effort to improve the car's balance. The solution has an additional benefit of reducing load transfers between the front and rear when the car accelerates or brakes.



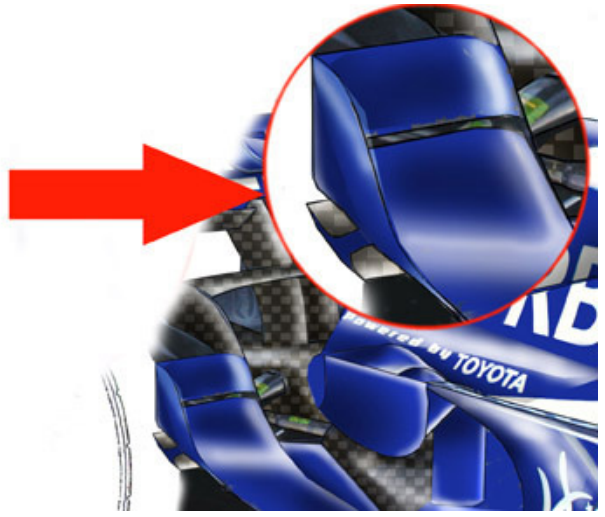
McLaren MP4-23 - revised front wing

Several interesting changes were introduced to the front wing of the McLaren for the Silverstone race. The wing's main profile has now been split (see inset), with a wider element at the back and a narrower one towards the front (see inset's arrows). The car's nose pillars are no longer attached to the wing's foremost flap but are now connected to the main profile's wider element (see right-hand red arrow). This new configuration increases downforce but more importantly diminishes the front end's sensitivity to load variations, thus improving the stability of its aero balance.



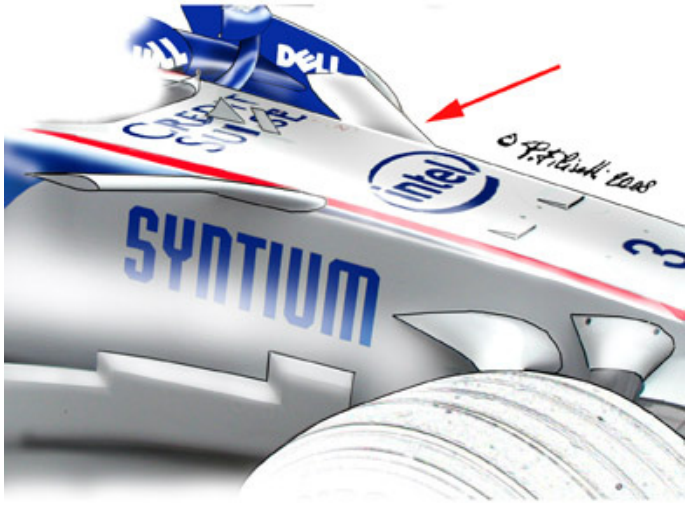
Honda RA108 - barge board developments

Honda have introduced a revised aero package in Germany. A curved vertical fin (red circle) now connects the boomerang-shaped winglet in front of the sidepods to the rearmost edge of the barge board. This solution is not dissimilar to one introduced by BMW Sauber at the start of the season and has two main advantages. Firstly it adds to the stiffness of the assembly, hence reducing harmful vibrations. Secondly it provides improved airflow management towards the rear of the car, hence raising the aero efficiency of the rear bodywork. Another part of Honda's Hockenheim revisions is the addition of two delta-shaped fins in front of the cockpit (yellow circle), similar to those on the Ferrari and Renault. Their function is to realign the airflow horizontally after it exits the front wing (normally at an incline of about 30 degrees), thus making it more useful to the car's rear-end aerodynamics, in particular winglets and the rear wing.



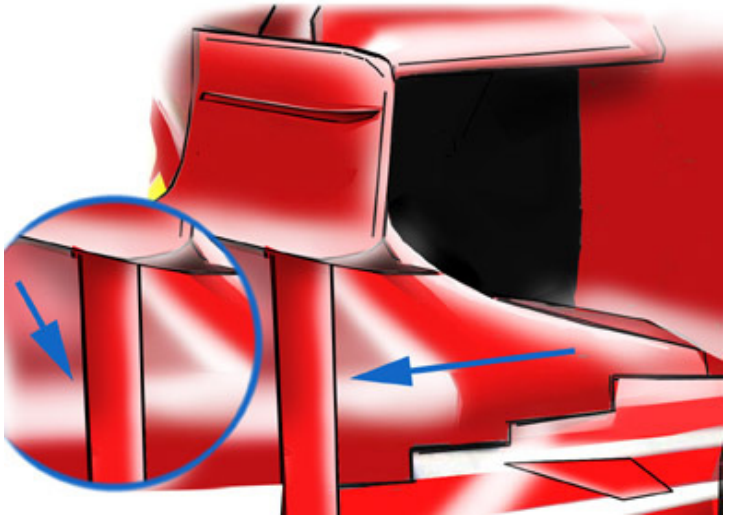
Williams FW30 - additional rear flip-ups

One a number of changes within a revised aero package that Williams tested at Hockenheim last week in preparation for the German Grand Prix is these updated flip-ups in front of the rear wheels. The vertical endplate is reduced in surface area and under the main flip-up there is now an additional smaller one, following a trend set by BMW Sauber at the start of the season. This doesn't increase downforce, but does dramatically reduce turbulence in front of the rotating rear wheels, making for much better aero efficiency.



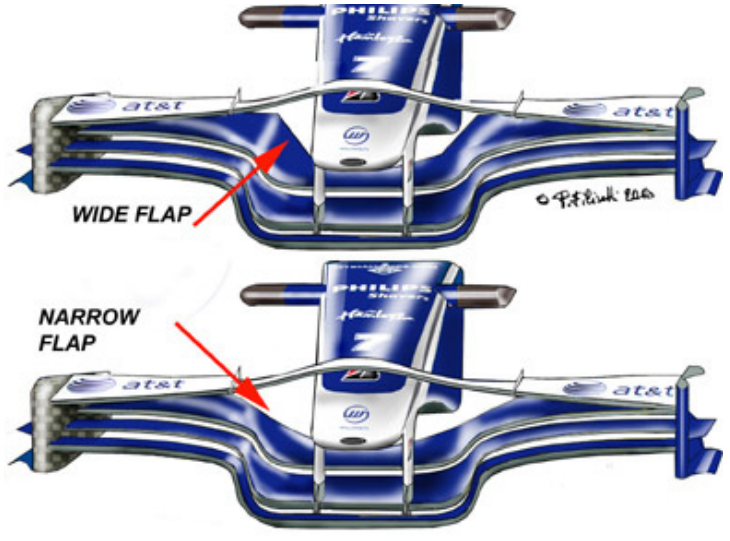
BMW Sauber F1.08 - cockpit winglets

Like Honda, BMW Sauber have introduced in Germany a couple of horizontal rectangular winglets on the top edge of the F1.08's chassis (red arrow) just in front of the cockpit. These work in conjunction with BMW's distinctive delta winglets further down the nosecone. The air passing over the car from the front wing normally flows at an angle of approximately 30 degrees, but the new elements redirect this flow at a more horizontal angle to help improve the rear-end aerodynamics. This in turn improves the sharpness of the car's front end and the stability of the aero balance from front to rear.



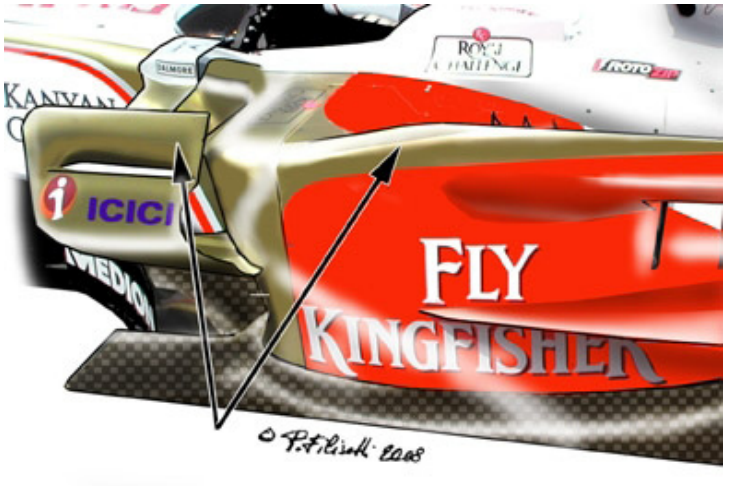
Ferrari F2008 - vertical sidepod fins

In Germany Ferrari have become the latest team to adopt a vertical fin (see blue arrow and inset) to connect the winglets placed in front of the sidepods with the rearmost edge of the car's barge boards. Also introduced by Honda here at Hockenheim, the fins decrease the vibrations of the sidepod winglets and better manage the direction of airflow towards the F2008's rear end.



Williams FW30 - front-wing development

Over the course of the German race weekend Williams adopted two separate solutions to the rearmost flap of the FW30's front wing. One change featured a narrower flap (bottom image, red arrow), while the other boasted a wider flap with a steeper profile towards its centre (top image, red arrow). While both solutions assisted in terms of drag, the second solution provided a greater level of downforce at the car's front end, and it was therefore left to the drivers to decide which configuration better suited their driving style.

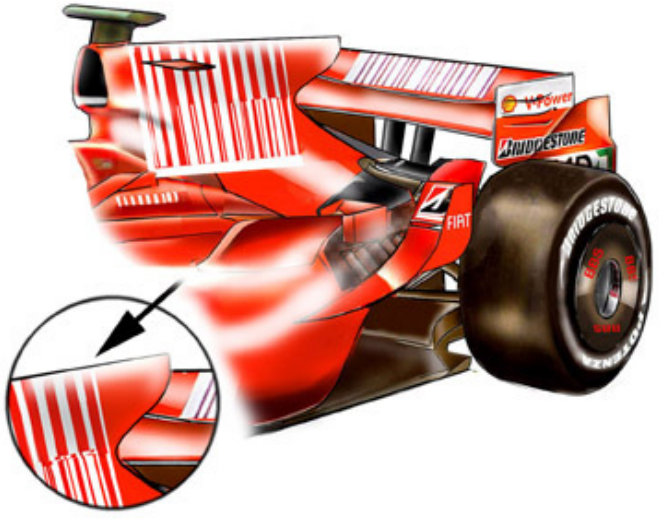


Force India VJM01 - sidepod winglets development

In addition to the extensive updates introduced by Force India at Silverstone, the team made some further changes ahead of the Hockenheim race. One of these revisions concerned the assembly of the winglets placed in front of the car's sidepods (see arrows). Instead of being connected to the sidepod chimneys, the new elements are separate and are connected at their lower edge to the sidepod and at their centre, with the help of an additional horizontal profile, to the rear-view mirrors. This solution minimizes drag and increases the stability of the winglets.

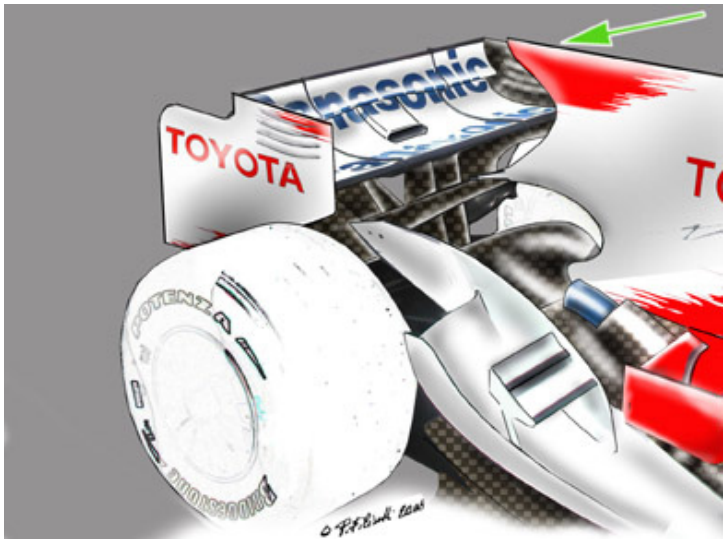
McLaren MP4-23 - nosecone winglets

These horn-like winglets halfway up the MP4-23's nosecone have been introduced by McLaren in Hungary. It's a solution not dissimilar to the 'delta' winglets on the BMW Sauber and one that provides a better quality of airflow to the car's sidepod inlets and rear end. It does this by improving the management of the airflow exiting the front wing. This doesn't directly increase front downforce, but instead improves the aero efficiency and downforce load in the central and rear sections of the car.



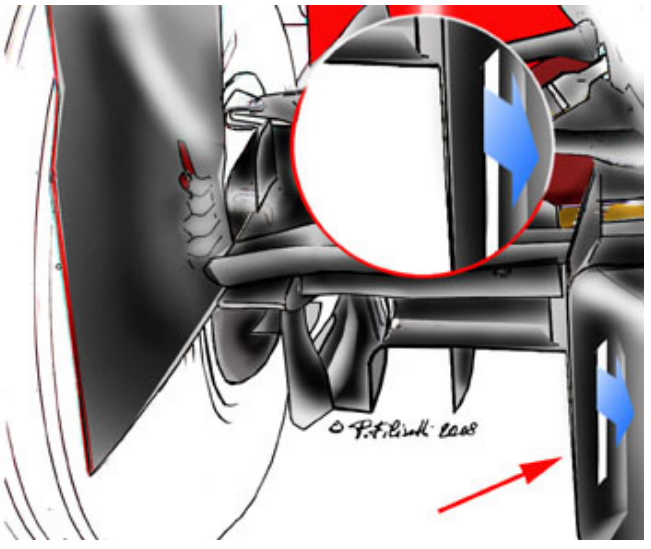
Ferrari F2008 - shark-fin engine cover

As part of their Hungarian aero update, Ferrari have included a heavily-revised engine cover. This full-height shark fin profile (inset) is almost identical to those already introduced by Red Bull, Renault, Toro Rosso and Force India. This revision improves the car's rear-end efficiency and balance, and to enhance its straight-line stability at high speeds. It better manages airflow close to the engine cover, and in particular reduces turbulence generated by spillage from the engine air inlets. This addition could well be used at the season's remaining races, albeit with ongoing revisions. With traction arguably the F2008's weak point at the last round in Hockenheim, even a small improvement in rear downforce should prove beneficial.



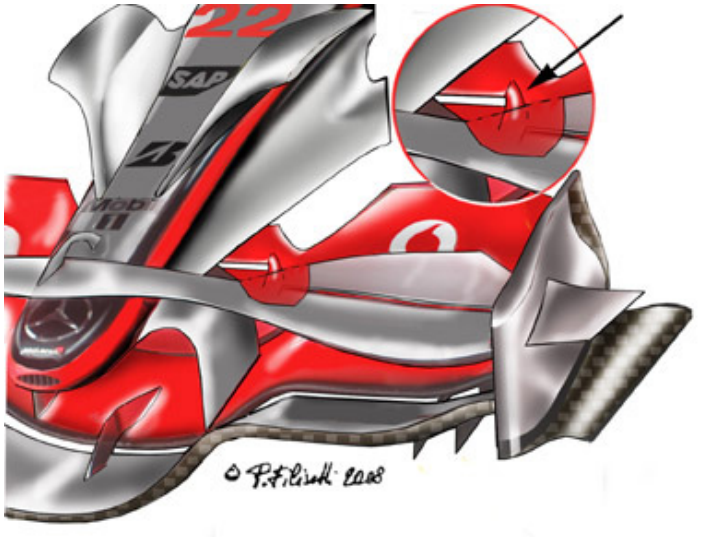
Toyota TF108 - shark-fin engine cover

Toyota were another team to introduce the now almost ubiquitous shark fin in Hungary, though it is not clear whether they will keep it for the rest of the season, given its late introduction, which also comes at a circuit with very specific set-up requirements. The concept - and hence benefits - is similar to that of the fins seen on other cars, with better rear-end aero efficiency and balance the major gains. The resulting improvement in downforce may only be small, but at the Hungaroring even that can have a significant and positive effect on handling sharpness and traction.



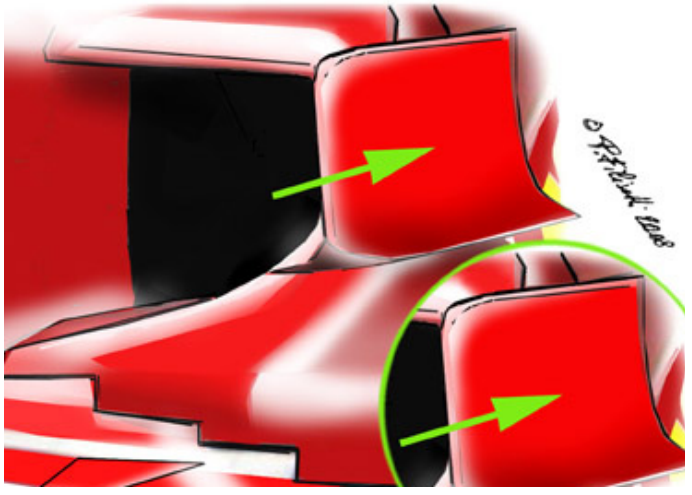
Ferrari F2008 - vertical slits in rear diffuser

A modification on the F2008's aero package in Hungary was this vertical slit in each side wall of the diffuser's central section. The increased pressure generated by airflow passing through the slits helps improve the extraction of airflow in that central section of the diffuser. This in turn helps to slightly increase the downforce generated underneath the car in this area, resulting in better traction - something that was lacking at the previous race in Germany. This change will almost certainly be retained for the remainder of the season, after it proved effective in improving the overall balance of the F2008.



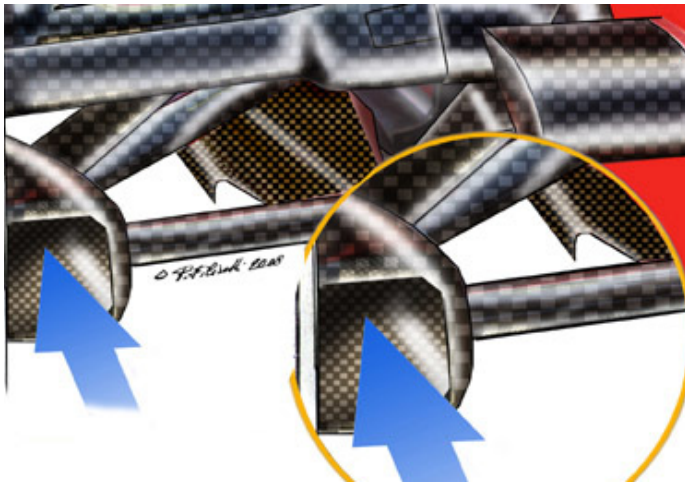
McLaren MP4-23 - slit in front wing flap

In addition to the new nosecone winglets that McLaren debuted in Hungary, the team also introduced this change to the rearmost flap of the front wing. It may be more subtle than the winglets, but is actually more important in terms of airflow management. In truth, the two revisions work in tandem. The slit (inset) in the middle of the flap helps to extract the air passing underneath and then to direct it towards the upper wishbones of the front suspension at an angle of around 30 degrees. That airflow is then diverted horizontally by the winglets on the nose. The higher negative pressure that the slit generates under the wing helps to improve the sharpness of the car's front-end handling.



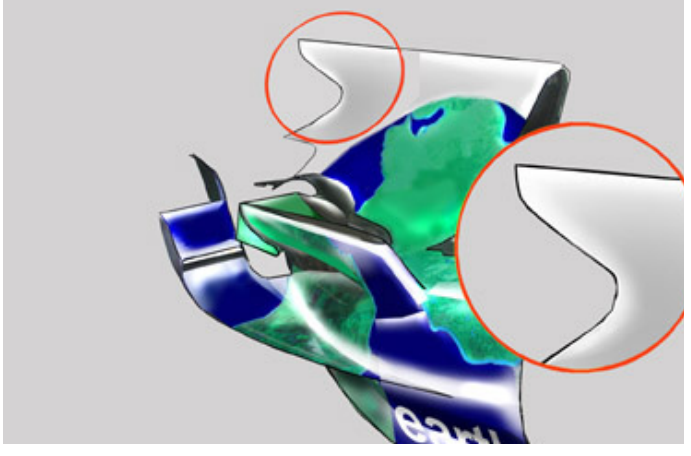
Ferrari F2008 - revised front winglets

Ferrari introduced a horizontal slit in their front winglets at last year's Belgian Grand Prix and then revised the design slightly in Japan. For the first time since then, the team have abandoned the slit in Valencia in order to increase the winglet's vertical surface area and thus maximise its ability to divert airflow. The function of the horizontal slit was to cut down on turbulence close to the sidepod inlets. The downside was a loss in quality and quantity of airflow directed towards the rear of the car. On a medium-fast circuit like Valencia, the revised vertical shields are more efficient in this respect, helping to extract the hot air from the top of the sidepod gills.



Ferrari F2008 - front brake ducts

In Valencia all the teams have increased the dimensions of their brake ducts, especially at the front. The reason for this is related to the very severe deceleration at the end of most of the track's straights. This makes the new circuit particularly tough on brakes and the high ambient temperatures make cooling the discs and pads very difficult. To avoid overheating problems, Ferrari have moved to the larger version of the F2008's ducts, only previously seen in Malaysia and Bahrain.

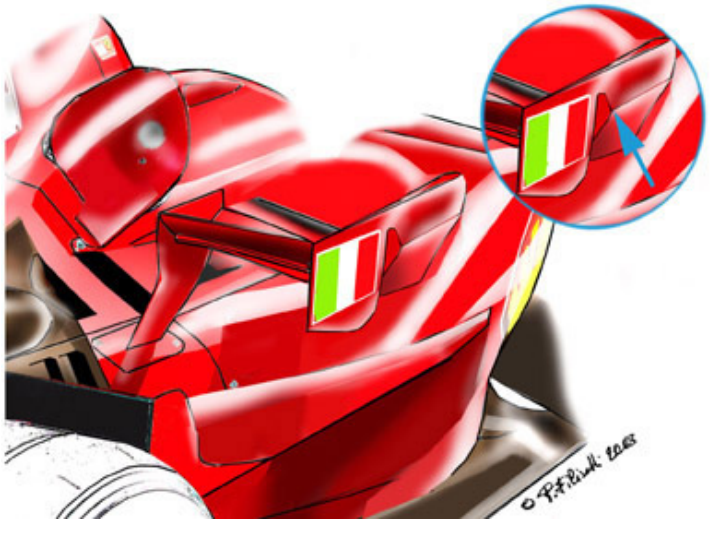


Honda RA108 - shark fin engine cover

Not strictly new - it was introduced in Hungary - but it is interesting to note that Honda, along with all the other teams that debuted this feature in Budapest, have retained it for Valencia, despite the obvious differences between the new Spanish street circuit and the Hungaroring. This solution provides better handling feeling to the drivers, a benefit considered quite important here on a new track, characterized by a slightly slippery surface and high kerbs, which are better avoided than driven over.

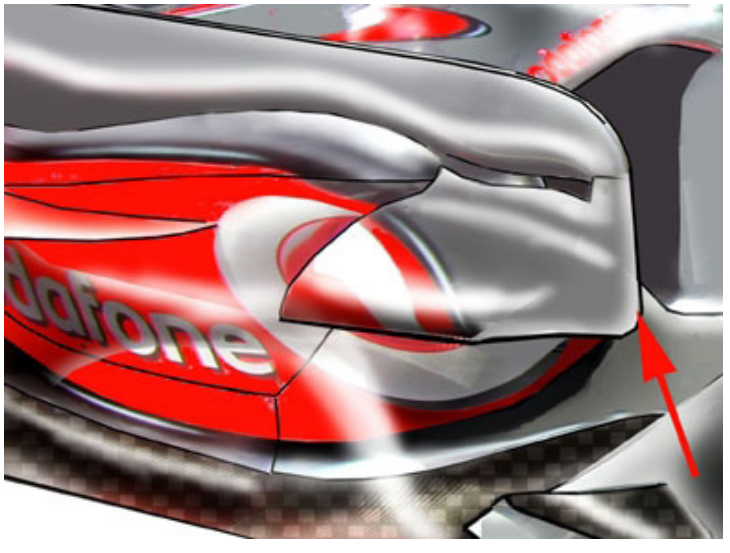
Red Bull RB4 - revised front bridge wing

An interesting change to the RB4 in Valencia is the introduction of a curved upper link (inset) connecting the bridge wing to the top of the nosecone, as on the McLaren. This solution guarantees adequate stiffness in the bridge assembly, so that it doesn't obviously flex. It also helps to cut weight, by allowing the use of a smaller bridge element, rather than a larger, stiffer item.



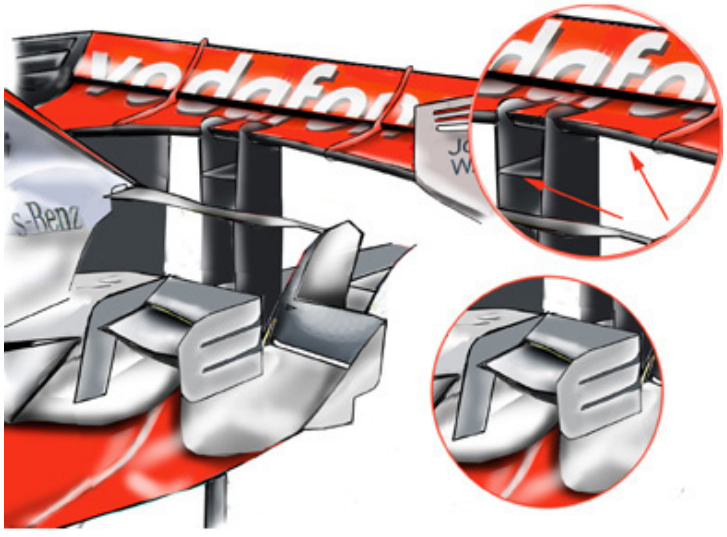
Ferrari F2008 - revised sidepod chimneys and winglets

These Valencia changes take on more significance in light of Raikkonen's engine failure. The inner side of the chimney featured a series of gills, similar to the solution used in Monaco, while the small endplates on the winglets were altered in profile (inset, blue arrow) to guarantee adequate, obstruction-free venting of hot air through the gills. This was in an attempt to assure the best engine cooling in hot and humid weather conditions. It should be noted that the chimney and winglet on the right of Raikkonen's car were damaged and torn from the bodywork during the accident with the fuel hose at his second stop.



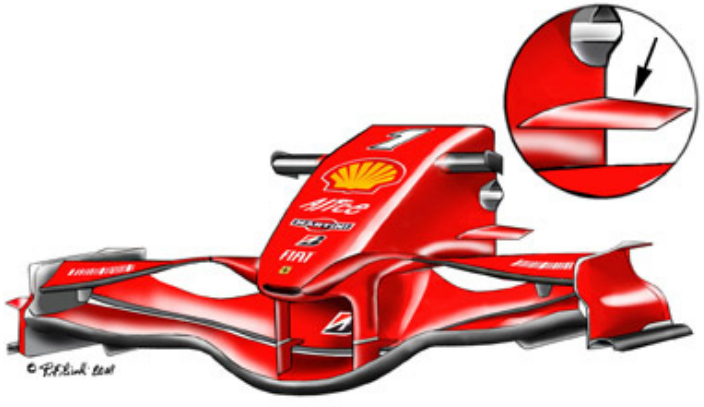
McLaren MP4-23 - revised front winglets

Like Ferrari, McLaren increased the vertical surface area of the MP4-23's sidepod winglets (see red arrow) in Valencia to maximise their ability to divert airflow. The winglets featured a completely vertical front edge as well as an increased height. This change increases the quantity of air diverted towards the car's rear end and also helps to improve the extraction of hot air from the top of the small venting gills.



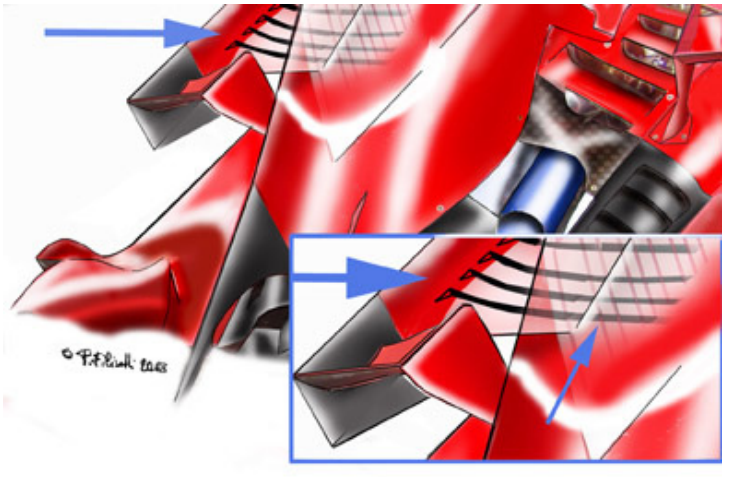
McLaren MP4-23 - revised rear aero package

For Spa McLaren have added side slits to the endplates of the car's sidepod winglets (lower inset circle). Similar to a revision introduced by Renault last year, and already adopted on the MP4-23 in Monaco, they are designed to reduce any extra turbulence generated by the larger Monaco-spec winglets - and consequently ensure maximum downforce gains. In addition, the rear wing sports the same configuration adopted in Canada, with the main profile raised in its central section and its extremities bending downwards slightly towards the endplates. This solution generates not only a medium downforce load, but also less drag compared to the previous configuration. This is important at Spa, where the very long straights highlight the car's top-end performance, while at the same time the more twisty sections emphasise the need for good traction.



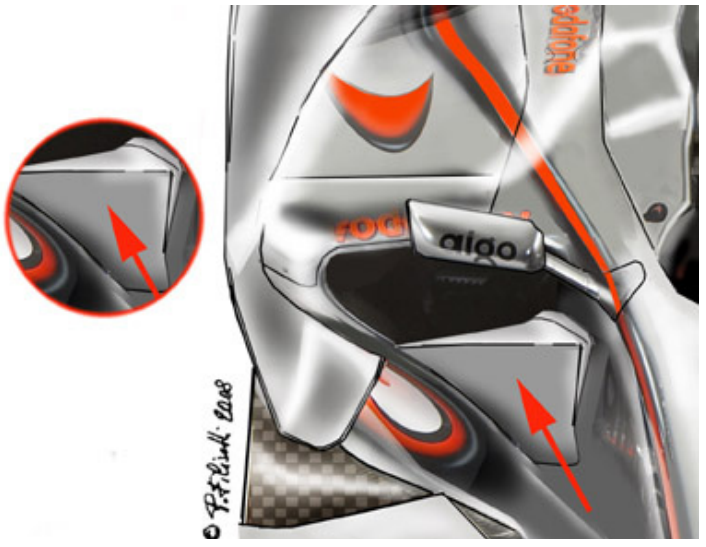
Ferrari F2008 - side nose winglets

Ferrari have introduced many subtle changes on the F2008 at Spa. One version of its nose cone sports an interesting, if small, addition. Winglets (inset) have been placed on each side of the nose cone just under the suspension's upper wishbone pick-up points. These have the important function of diverting airflow in a way that generates no turbulence close to the crowded section of the car around the front suspension elements. This is pretty important in terms of drag reduction on Spa's long straights. Without the winglets, the front wing angles adopted here would normally lead to airflow impacting directly against the suspension's upper wishbone, generating huge turbulence.



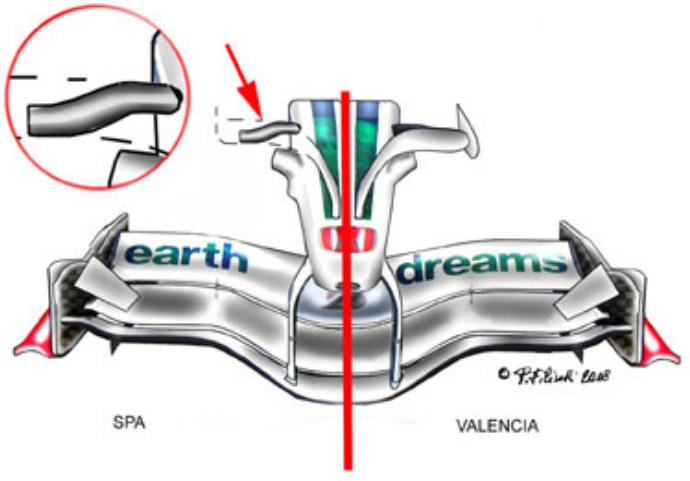
Ferrari F2008 - revised cooling gills

Ferrari seem to have gone in the opposite direction to McLaren at Spa in terms of cooling management, apparently increasing the F2008's capability in this area, despite the relatively low ambient temperatures. The venting gills on the inner side of the chimneys atop the sidepods have been extended. The profile of the gills manages the airflow passing over the sidepods so as to maximise its efficiency in terms of extracting hot air from the radiators. At the same time, this modification increases the pressure of this portion of airflow, making it more useful to the rear wing's lower profile, hence raising the overall efficiency of the rear wing.



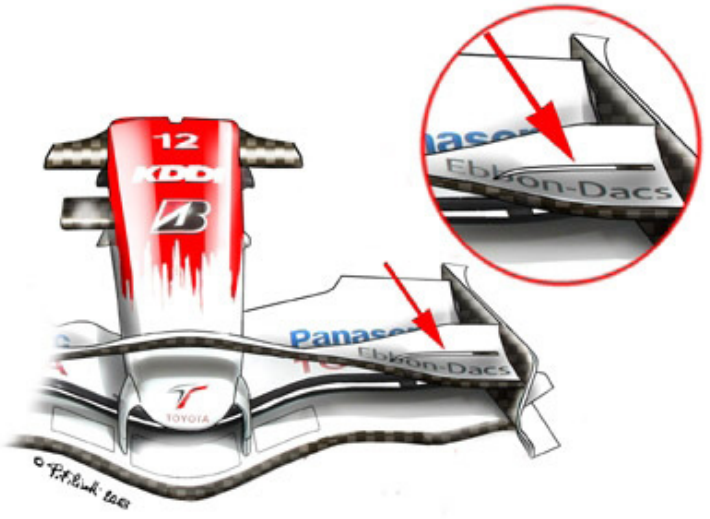
McLaren MP4-23 - reduced radiator inlets

The low ambient temperatures at Spa allow the teams to reduce the venting required for cooling, hence improving the aero efficiency of the cars. McLaren have been able to dramatically reduce their radiator inlets by applying a specially profiled bodywork addition in the lower section of the inlet. The reduction in the size of the openings helps reduce drag and turbulence immediately in front of the sidepods, aiding top-end performance on the Belgian circuit's long straights. Adequate airflow management ensures cooling efficiency is still maintained, hence avoiding any potential reliability problems.



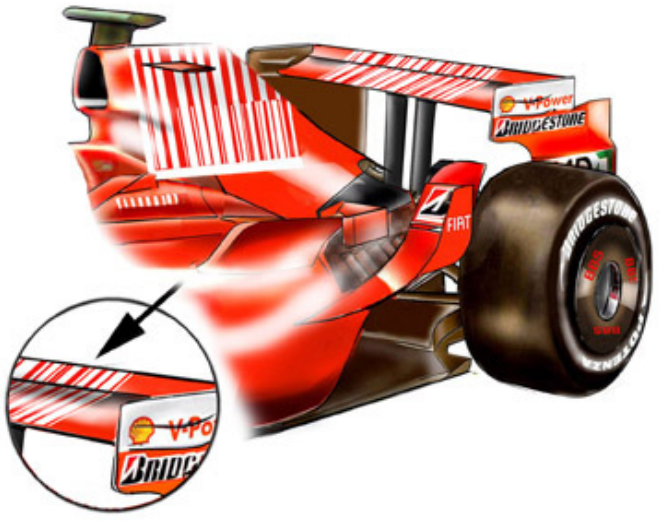
Honda RA108 - nose cone 'buffalo horns'

Honda introduced a visually interesting modification to the front end of their car at Spa. They replaced the standard (flat) onboard camera housings with curved ones that resemble those introduced by Williams at the start of the season. These elements clearly have an aerodynamic function, diverting airflow towards the horizontal. This makes the airflow more useful to the rear wing, particularly its lower profile, allowing the use of lower wing angles and reduced profile size - both crucial in the pursuit of increased top-speed performance.



Toyota TF108 - bridge wing slits

In Belgium, the TF108's bridge wing featured very long slits (see arrow and inset). Although Toyota did introduce this development briefly during a practice session ahead of July's German Grand Prix, this was the first time the team ran the feature for an entire race weekend. The slits are designed to generate a suction effect that helps to boost the efficiency of the front wing. But is unlikely Toyota will be run this development at the forthcoming Monza event due to the Italian track's unique layout.



Ferrari F2008 - sculpted front wing pillars

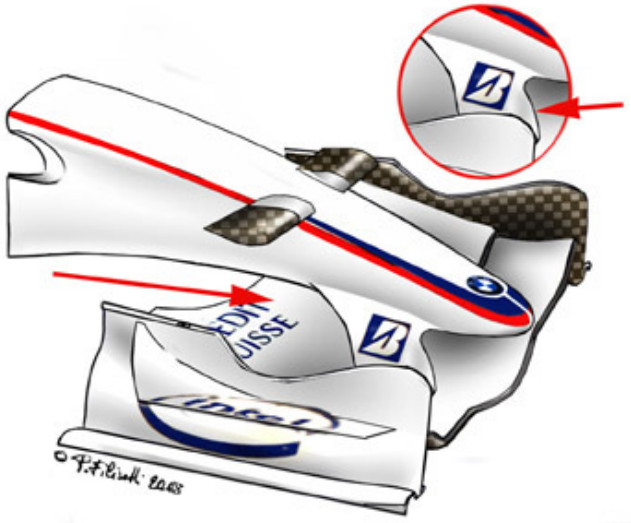
On a fast track like Monza even the most minimal change can boost a car's efficiency. For the Italian event, the F2008's nosecone has been slightly modified to feature sculpted front wing pillars (see inset). Instead of their standard straight vertical edge, the pillars are now curved at the front (see orange arrow). This minimizes the impact of the airflow against the pillars, reducing turbulence and thus helping to achieve a good aero balance, despite the smaller-than-usual flap on the front wing.

Ferrari F2008 - Monza-specific rear wing

The F2008's aero package for the high-speed Monza circuit features a small rear wing, with a very narrow upper flap and a very low incidence angle (see inset). This configuration helps to reduce drag, enhancing the top- speed performance of the car on the long straights, whilst just about retaining enough downforce for the chicanes inbetween.

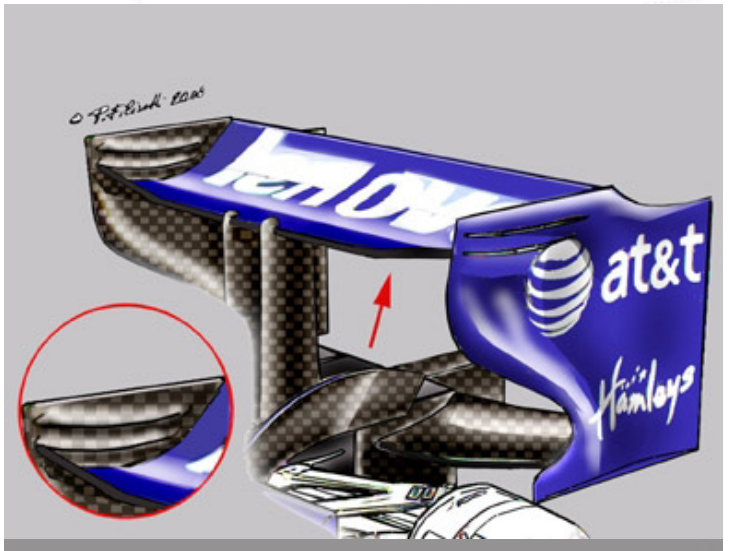
Toyota TF108 - Monza-specific front wing

As with all the teams, Toyota have adopted a specific aero package for Monza, with narrower main wing profiles and lower incidence angles on the flaps. At the front the standard bridge wing has been replaced in favour of this simple, single-profile design. It features a minimal, almost flat spoon profile in the centre, while the flap is reduced in depth and has rounded exit edges to reduce drag on the long, high-speed straights.



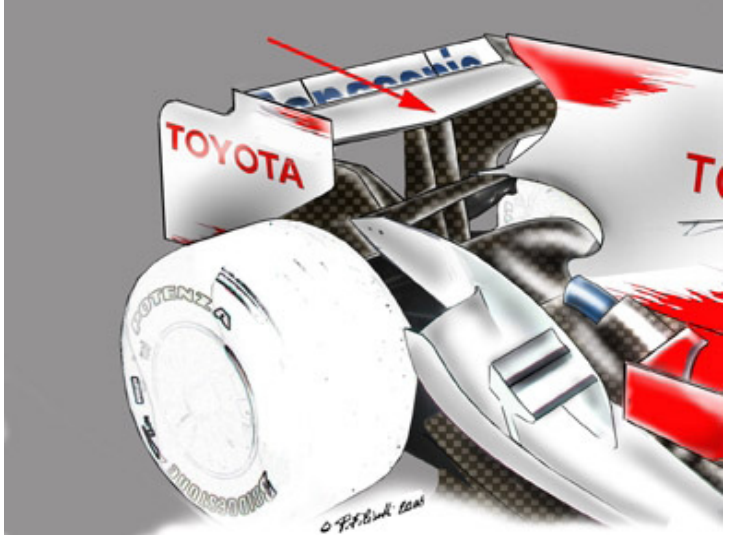
BMW Sauber F1.08 - Monza-specific front wing

Both the nosecone and front wing on the BMW were modified for the high-speed Italian Grand Prix. The nosecone pillars had a new profile, the leading edge sloping forwards (inset) rather than backwards, and the height of the pillars was reduced, thanks to the front wing's central spoon profile all but disappearing in favour of a far less curved design. The flap was a single element, instead of the usual double assembly, providing less downforce and - more importantly - a huge reduction in drag.



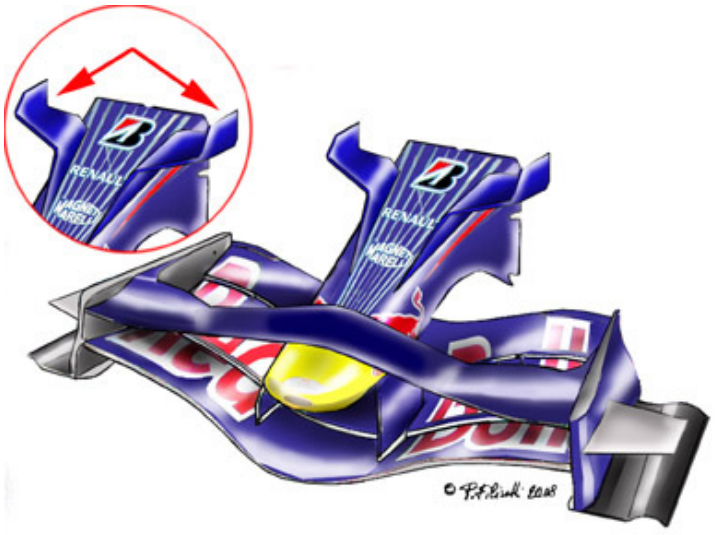
Williams FW30 - Monza-specific rear wing

Like all their rivals, Williams brought a Monza-specific rear wing to Italy. The FW30's wing featured a single profile, the extremities of which were bent upwards (see red arrow and inset). This configuration helped to reduce drag on the track's straights, while also providing enough downforce for the corners.



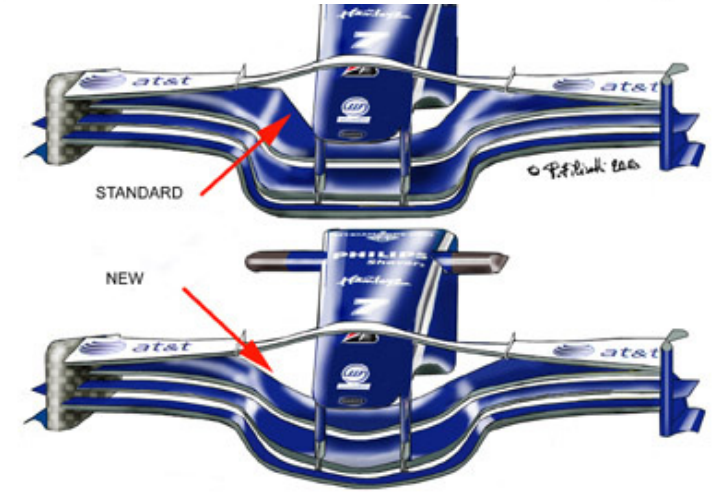
Toyota TF108 - Monza-specific rear wing

In Monza the Toyota TF108 sported an interesting rear wing. Most striking was the revised main profile, which featured a pointed entry edge (see red arrow), similar to the delta-profiled wings, which were common in the late 1970s and early '80s. This feature was designed to make the car more efficient by reducing drag and turbulence, whilst still providing enough downforce under braking and under acceleration.



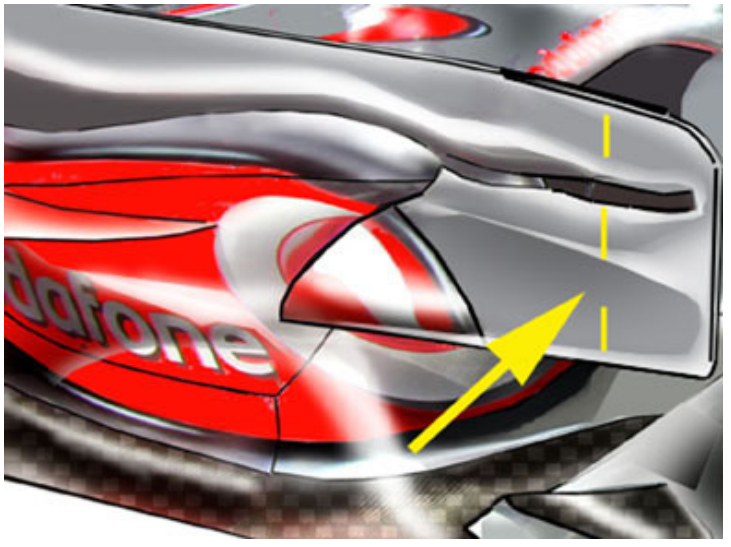
Red Bull RB4 - nosecone delta winglets

When BMW Sauber introduced this solution at the start of the season it looked very radical. It now seems less so, having inspired similar, if slightly differently shaped designs from Honda and McLaren. In Singapore, Red Bull have introduced an almost exact copy to help cope with the track's specific demands in terms of grip and balance. The revised nose provides a better quality of airflow to the car's sidepod inlets, which are particularly small on the RB4. It also helps improve airflow to the rear of the car, even if it doesn't generate a significant amount of additional downforce.



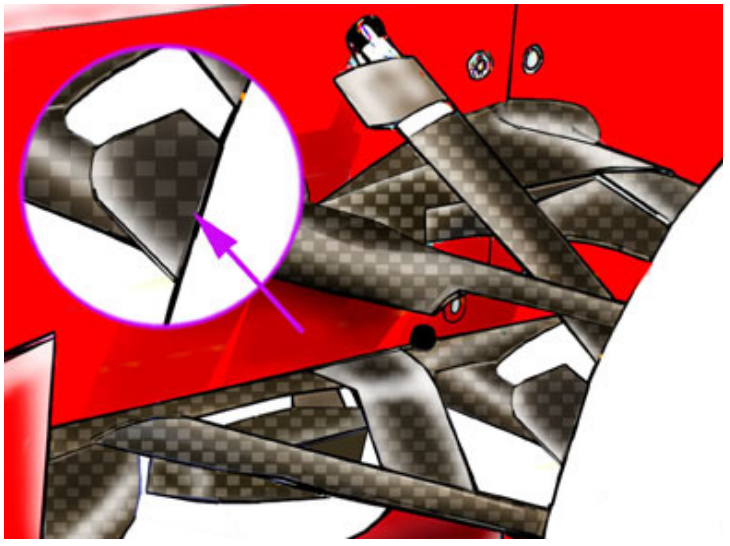
Williams FW30 - front wing development

One of Williams' two front wing options in Singapore is a newly revised version sporting a rounded central spoon profile, instead of the standard square one, and slightly raised extremities to the main profile and flaps. This configuration provides almost as much downforce at the front as the standard version, but is less sensitive to ride height variations - crucial at this circuit due to the inherently bumpy characteristics of its track surface.



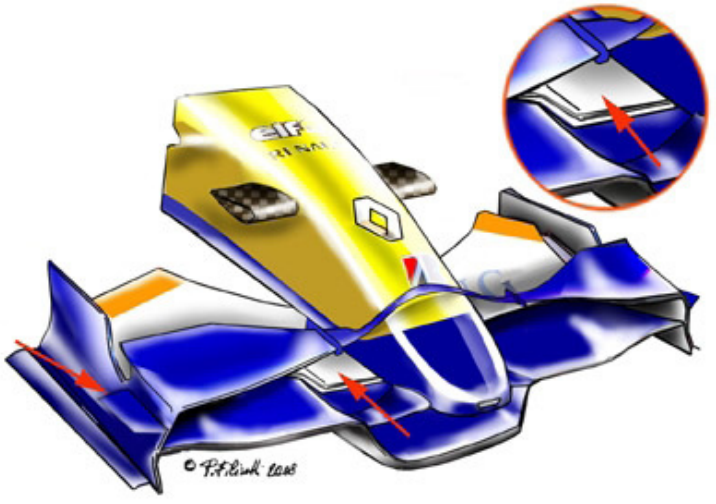
McLaren MP4-23 - sidepod winglet development

In Valencia McLaren increased the height of the sidepod winglets. In Singapore they have increased their length, bringing their leading edge forwards by around 12cm (area to right of dotted line). The main effect of this is to increase the efficiency and cooling capabilities of the MP4-23's very small radiator inlets - critical given the high temperatures and humidity here. The horizontal slits have also been elongated to minimise the aero disruption caused by the winglets' increased dimensions. The leading edge of the winglet is now almost completely vertical, increasing the quantity of air diverted towards the rear of the car, and helping to improve the extraction of hot air from the top of the sidepod's small venting gills.



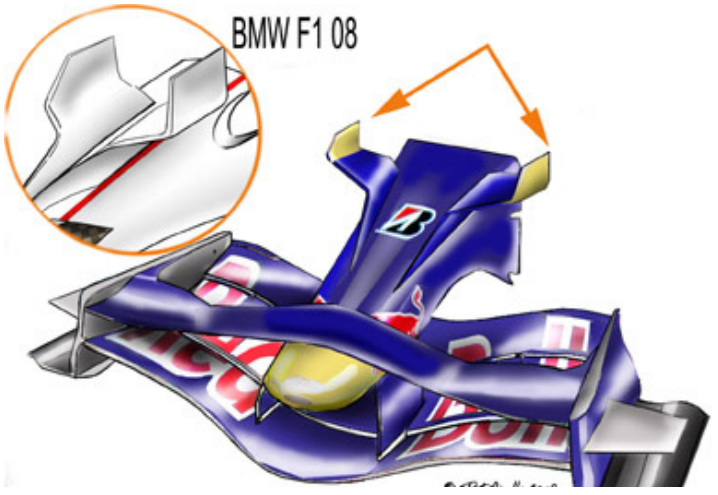
Ferrari F2008 - front wheel inner winglets

Ferrari introduced a number of subtle changes in Singapore to further optimize the F2008 package. One was to the winglets placed on the inner face of the front brake drums, just behind the air inlet. The previous, smaller version, with their slightly upward-curving profile, was replaced with this revised design featuring a completely flat profile and almost twice the cross-sectional area. The new winglets modify the airflow passing close to the inner side of the front wheels in such a way that it can then be better diverted into the radiator inlets by the winglets further back on the car, directly in front of the sidepods.



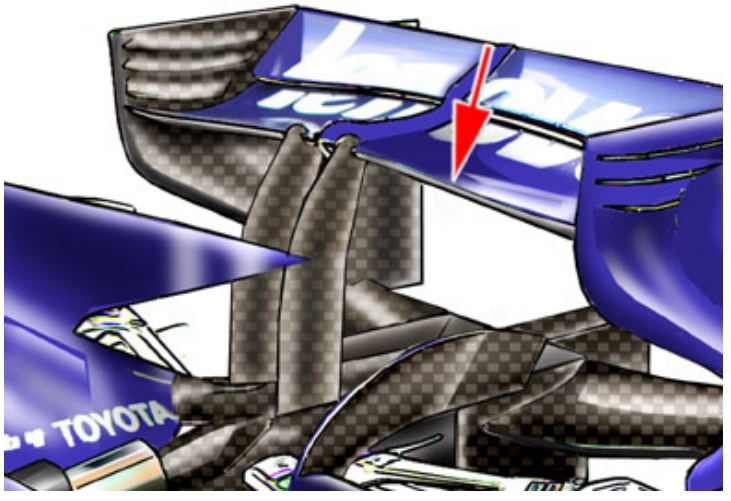
Renault R28 - front wing development

Even with the end of the season in sight, Renault have continued to develop the R28, and in Singapore the car boasted a revised front wing. The biggest change to the wing was to the flap, which sported a squared spoon profile (see central red arrow and inset), instead of the more rounded version seen on the R28 at the Monza race. The wing's endplates were also modified and featured small horizontal winglets (see left red arrow).



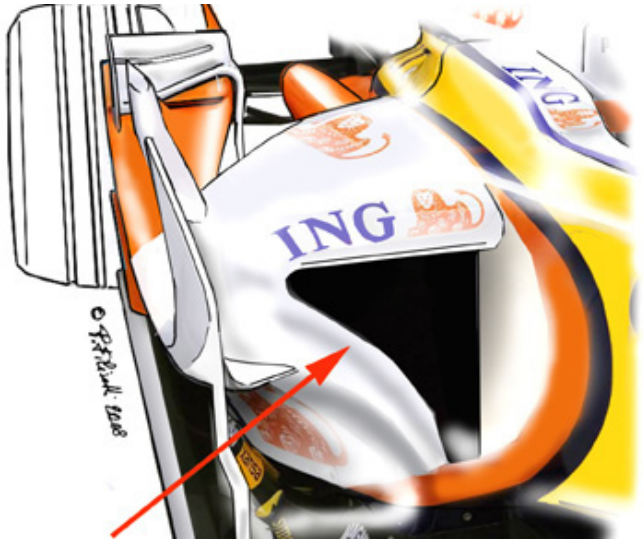
Toro Rosso STR3 - nosecone delta winglets

As both are designed and produced by Red Bull Technologies, Red Bull's RB4 and Toro Rosso's STR3 not only share design concept and parts, they also follow similar development paths. One race later than Red Bull, Toro Rosso have debuted these now-familiar horn-like winglets at Fuji. The concept, first introduced by BMW Sauber (inset), helps improve front-end balance as well as cooling. Here Toro Rosso have paired it with the widest version of their front bridge wing, typical for high-downforce tracks, with sharper front-end handling the main expected benefit.



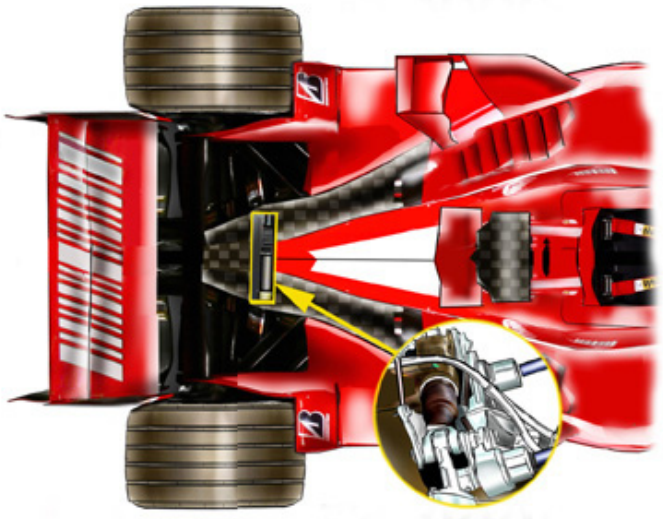
Williams FW30 - rear wing development

In Japan, Williams have introduced a modified rear wing, with a slightly revised main profile, featuring a steep curve in its central section (red arrow), close to its boomerang-shaped vertical pillars. This solution, coupled with the slightly narrower flap, improves the car's top speed at the end of Fuji Speedway's long straight, while also providing enough downforce in the slower sections of the track to guarantee the grip required under braking and the traction needed out of the corners.



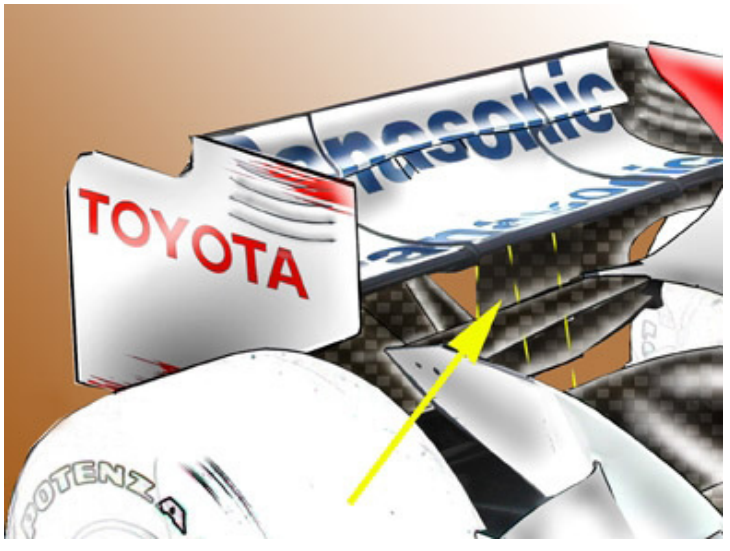
Renault R28 - revised sidepods

Most teams have stopped development work on their 2008 cars but Renault are an exception to the rule, bringing a heavily revised R28 to Fuji. The car's sidepods have been dramatically reduced in their cross section at the front, with the radiator inlets featuring a more tapered side profile (see red arrow). This change dramatically improves the aerodynamic effectiveness - and hence balance - of the car by reducing drag and improving the efficiency of the rear wing and diffuser.



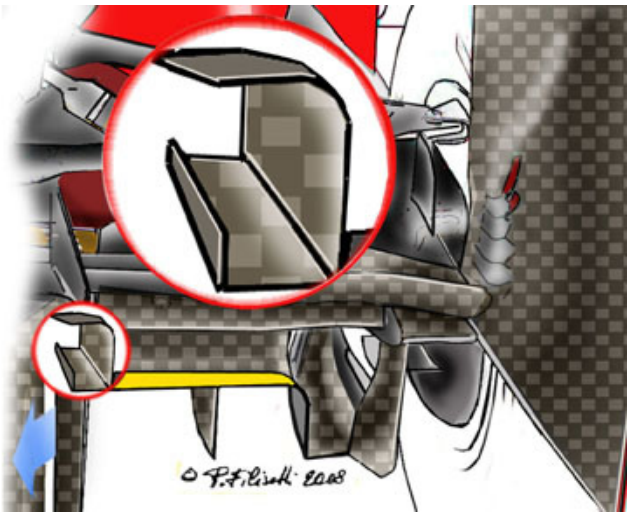
Ferrari F2008 - rear suspension development

Up until September's Italian Grand Prix, Ferrari were struggling with poor traction, caused primarily by the car's inability to warm its tyres (chiefly the rears) at a quick enough rate, especially in cool or wet conditions. This put the F2008 at a disadvantage in terms of acceleration, especially when compared with McLaren's MP4-23. At the recent Singapore race, however, the team seemed to have gone a long way towards solving the issue by adopting a softer, more progressive set-up for the rear suspension's third horizontal damper and its two torsion bars (see yellow arrow and inset). The third damper consists of a tungsten/wolfram (heavy metal) cylinder that rotates inside an outer casing, dissipating the inertia generated by the track's bumpy surface and kerbs. Better set-up of this device, together with an accurate choice of torsion bars, has dramatically improved the behaviour of the car, especially at the rear. In Japan, this was of particular help to Kimi Raikkonen, who prefers a very stable rear end in his set-up. (Felipe Massa focuses more on the car's front end.)



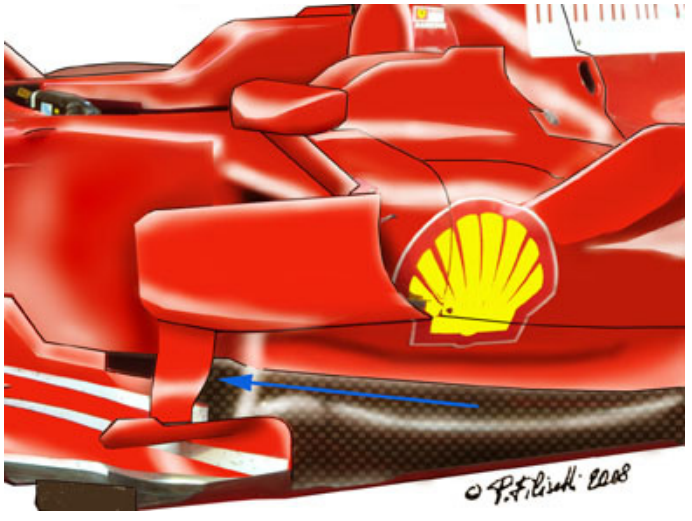
Toyota TF108 - revised rear wing

The TF108 sported a heavily-modified rear wing at the Fuji race. The central pillar (see yellow arrow) was removed, leaving the area between the upper and lower profiles completely clear. This change was introduced to take advantage of the Japanese circuit's 1.5-kilometre straight, by improving the extraction of air from underneath the car thanks to the accelerated airflow passing between the wing's upper and lower profiles.



Ferrari F2008 - rear diffuser development

The central side section of the diffuser (circled) has been made narrower, with its reduced horizontal base now ending with a vertical fin. In turn, the Gurney tab (in yellow) along the main exit edge of the diffuser has been extended towards the centre of the car. This change is to reduce the sensitivity of the rear end to ride-height variations by maintaining a constant down-force level regardless.

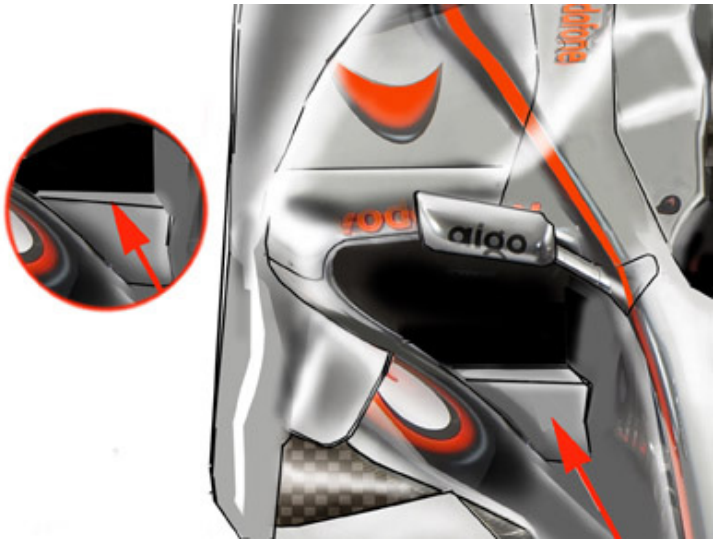


Ferrari F2008 - revised sidepod winglet fins

Ferrari has replaced the vertical fin (blue arrow) that connects the winglets in front of the sidepods to the rear edge of the barge boards with a heavily curved one. This results in less disruption of the airflow passing close to the winglet, dramatically reducing turbulence and generally providing better airflow management towards the rear of the car.

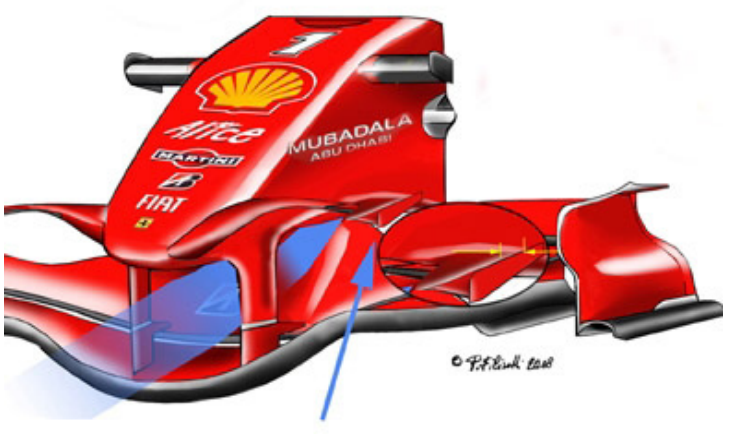
BMW Sauber F1.08 - front wing development

BMW Sauber have adopted a revised front wing assembly for the Japan and China races. The wing's main profile features a new lip, which protrudes to the rear. Visible thanks to its natural carbon fibre colour, this lip extends about 20mm under the flap entry edge (see yellow arrow and inset). Increasing the pressure of the airflow passing between the profile and the flap (and hence accelerating it), this modification helps enhance the efficiency of the entire barge board assembly, placed at both the level of the front suspension and in front of the sidepods. This slightly increases the level of downforce generated by the bottom of the car, without the team needing to adjust the angles of the flaps, and thus provides a more stable front end.



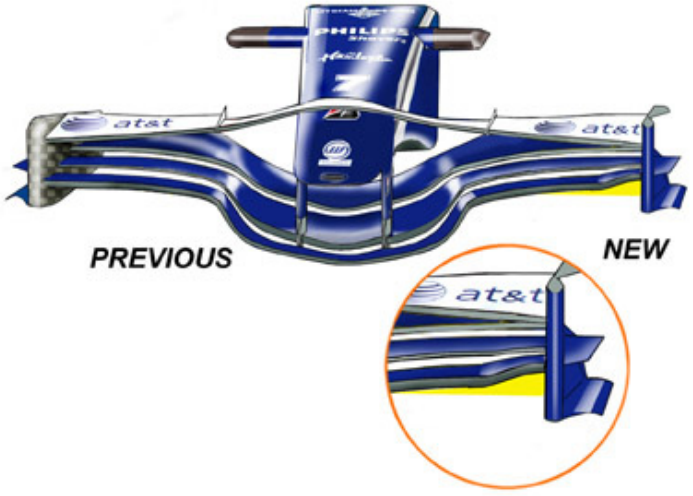
McLaren MP4-23 - reduced sidepod inlets

As in Belgium, in China the cross-sectional area of the McLaren's sidepod inlets was reduced, decreasing cooling capacity but increasing aero efficiency. At Spa the low ambient temperatures made this change feasible. In Shanghai it was possible - albeit to a slightly lesser degree - thanks to the cooling provided by the two long, high-speed straights. A specially profiled 'insert' was added to the bottom of the inlet, making the inlet smaller. This cuts drag and turbulence immediately in front of the sidepod, aiding the car's top-end performance on those long straights.



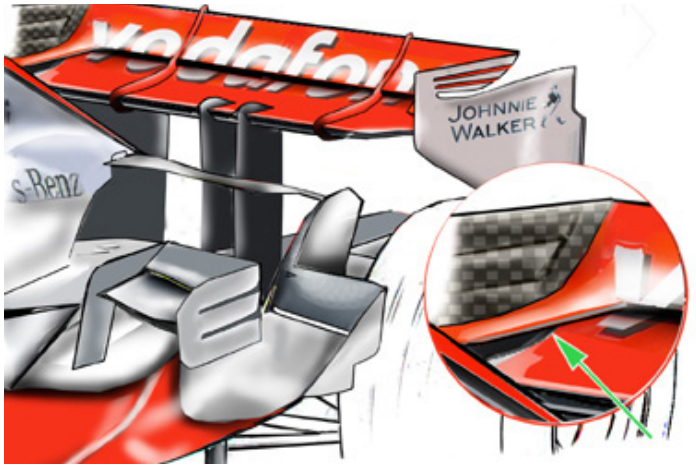
Ferrari F2008 - nose winglet development

The lower winglets (blue arrow) on the F2008's nose were introduced at June's French Grand Prix, but their width and positioning have changed over the past few months, depending on the front-wing flap used by the team. And in China, narrower winglets (inset and yellow arrows) were adopted because, thanks to Shanghai's long straights, the wider winglets weren't required to help supply the air inlet. Therefore, while the winglets keep their original function, they don't disrupt the airflow in this section of the car too much.



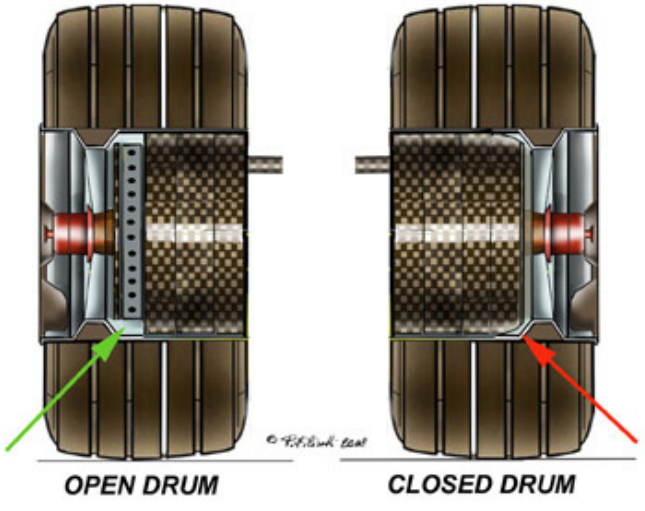
Williams FW30 - front wing development

For Brazil, Williams have modified the FW30's front wing. Both the main profile and the middle flap now feature a curved 'step' at their extremities (see inset and yellow highlighted area), instead of the previous straight versions. This change helps to improve the airflow in this area, increasing its speed and thus slightly increasing the pressure. This provides a downforce gain, without the need to increase the angle of the flaps, which would add drag, robbing the car of top speed.



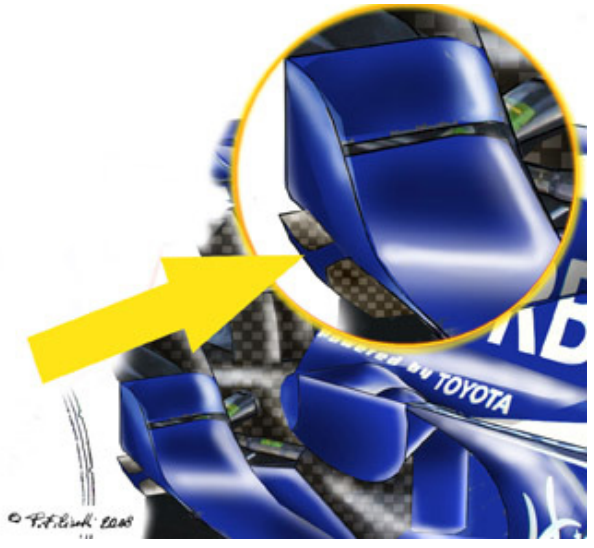
McLaren MP4-23 - revised rear wing

For the final race of the season in Brazil, McLaren have introduced a completely new rear wing. The flap has two outer extensions, which jut out to the main profile's entry edge (see inset and green arrow). Each triangular protrusion partially covers the main profile, thereby creating a channel for the airflow. In comparison to the previous version, the distance between the main profile and flap has been increased to generate higher pressure not just around the extensions but over the entire wing. The change allows the angle of the flap to be reduced so as to boost the car's performance at top speeds, whilst maintaining efficient levels of downforce through the slower sections of the anti-clockwise Interlagos circuit.



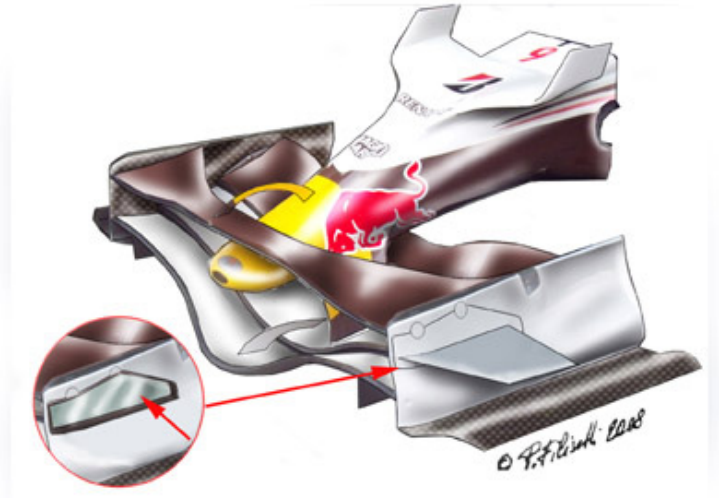
McLaren MP4 -23 - brake cooling drum development

Introduced a few races back and used again in Brazil is this evolution of McLaren's brake cooling drums. Previously the drums were open, with the brake disc not included within the carbon fibre cover, leaving the edge of the disc and its outer face open to the inducted airflow. Now the drum assembly has been completely changed, following a trend common to Ferrari and BMW Sauber. The closed drum reduces aero disruption, but does tend to increase the working temperature of the brake assembly, including the disc, pads and calliper. This increases the tendency for the front wheels to lock under heavy braking - noticeable in Brazil, where Hamilton flat-spotted a tyre in Friday's second session. McLaren have changed the material in the coupling between disc and pads, but it's not clear whether concerns have completely disappeared.



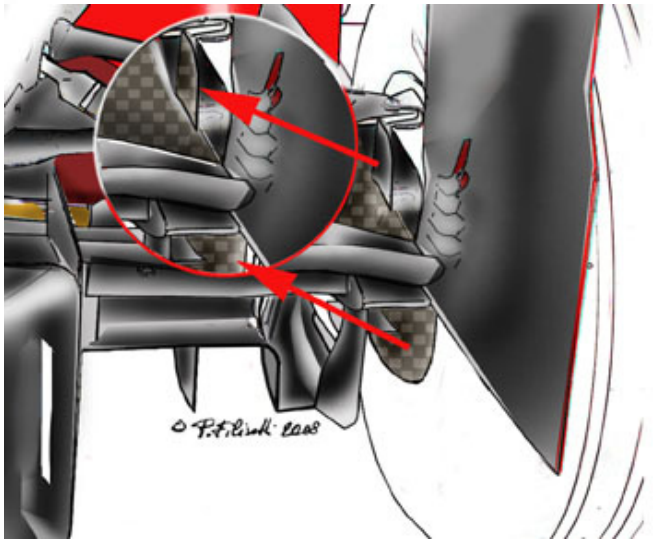
Williams FW30 - rear double winglets development

Not a big change, but this is just one of a many subtle modifications brought by the team to Brazil. The team wanted to find ways to increase downforce at the rear, without altering the angle of the rear wing, which is especially important at Interlagos as all teams need to improve straight-line speed for the long, uphill start-finish straight, whilst also enhance grip in the twisty sections of the Interlagos track. By slightly increasing the surface area of the additional winglet placed underneath the main flip-ups (yellow arrow), Williams hope they have improved the management of airflow close to the rear wheels, reducing the disruption caused by the wheels' rotation. This will improve aero efficiency particularly near the rear wing, providing some additional downforce.



Red Bull RB4 - front wing endplate ballast

Not strictly a change, but much more visible in Brazil thanks to David Coulthard's one-off white livery, was this interesting detail regarding Red Bull's placement of ballast in the front wing assembly. As on most cars, the RB4 has tiny blocks of wolfram/tungsten inside the wing's main profile, hidden from view within covered housings. But in addition to this 'standard' ballast placing, the RB4's endplates also have detachable covers which hide extra ballast housings (inset). The housings may look small, but the high density of the ballast metal means they can carry around seven kilograms. This allows the weight distribution of the car to be moved forwards slightly, improving its overall balance.



Ferrari F2008 - inner rear wheel revisions

In Brazil, Ferrari tried to optimize the F2008 to improve the car's aero efficiency, whilst reducing drag and turbulence. In the crowded area, close to its rear wheels, the F2008 sported revised versions of its inner fairings, which had been extended to completely cover the wheel rim (see inset's bottom red arrow). The cross section of the vertical winglet, placed above the suspension upright, was also increased (see inset's top red arrow). According to the engineers, these changes helped divert airflow in this area, in order to prevent it from disrupting the flow of air hitting the rear wing's lower profile.