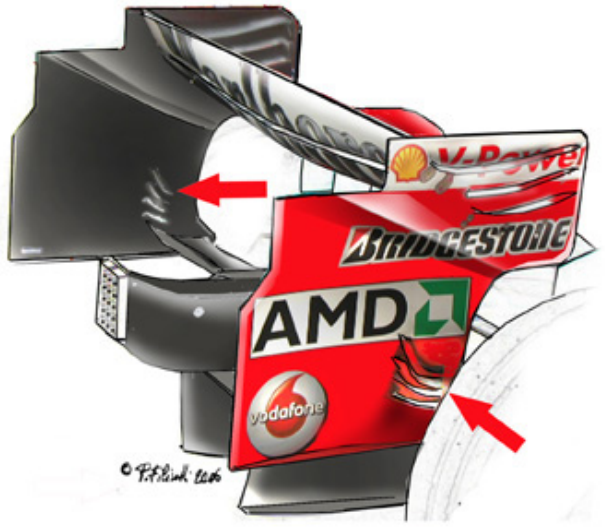
Giorgio Piola

Formula 1

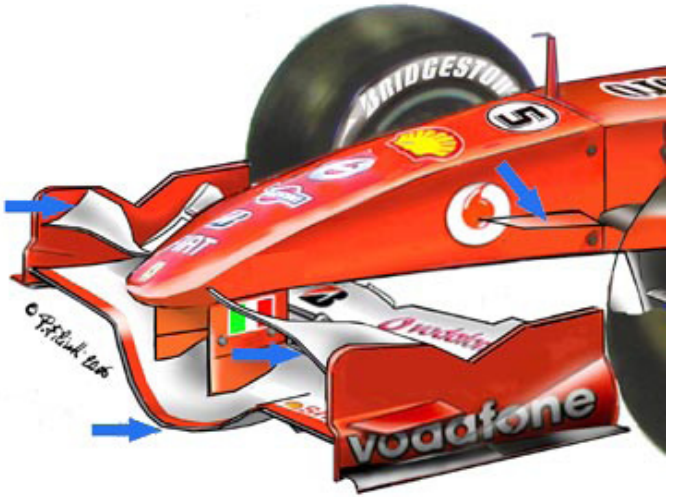
technical analysis
2006-07

ΑΗΦΡΕΝ



Ferrari 248 F1 - rear wing endplates

Part of Ferrari's revised aero package for Bahrain. The endplates previously sported large slits in their upper section. Now they have small ones in their lower section instead, complete with small, upward-curving fins. The function is similar to before - to reduce turbulence generated by the rear wheels, by helping the boundary layer of airflow passing between the wing and the endplate to detach more quickly, hence cutting drag.

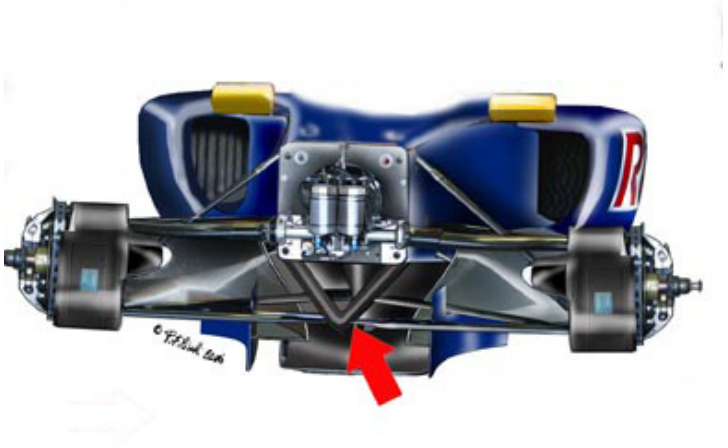


Ferrari 248 F1 - front wing development

For Bahrain, the 248 F1's front wing features a deep-spoon shape in the centre of the main profile, replacing the additional box wing seen below last year's nose. To make what is effectively a double-decker wing, this is coupled with two additional profiles connected to the endplates either side on the nose cone. The endplates themselves are different - the front section of their top edges are now almost flat, not steeply angled as before. Finally, a small fin is added either side of the nose, just in front of the suspension's upper wishbone pickup point. This acts as a stabliliser and airflow splitter, reducing turbulence in this area.

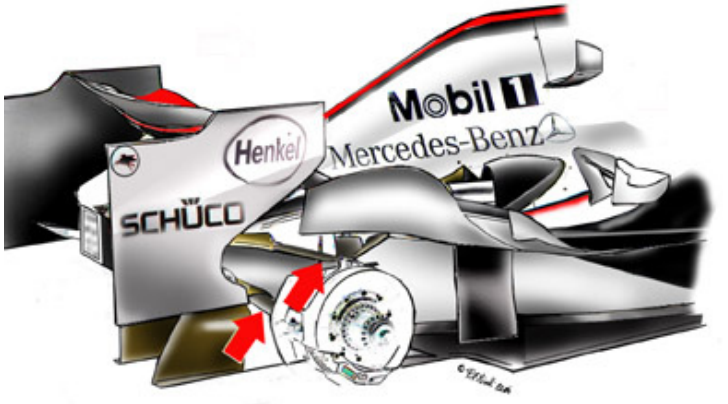
Renault R26 - wide nose

It is interesting to note that sometimes teams adopt solutions no longer used by the team that originally introduced them. Red Bull's current V keel is one example. The wide nose on the Renault is another. A very similar one was used by McLaren last year, but abandoned in favour of a much narrower design for the latest MP4-21. The advantage of a wide nose section is related to the potential increase in downforce generated by the larger surface area.



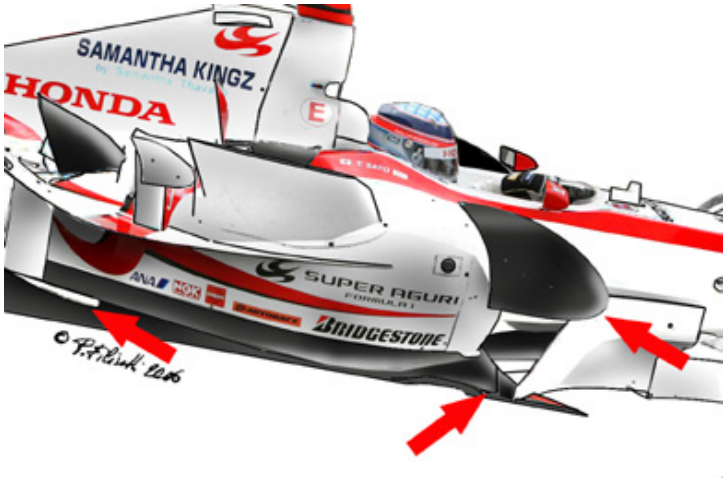
Redbull RB2 - V keel

After proving its worth on the Renault R25 last year, Red Bull have adopted a V keel solution for 2006. The solution is particularly good - when coupled with the RB2's high nose - at improving aero efficiency in the area under the chassis close to the splitter. The airflow encounters less interference with the V keel, even if it is not quite as efficient as the no-keel concept introduced by McLaren last year and now seen on several 2006 cars.



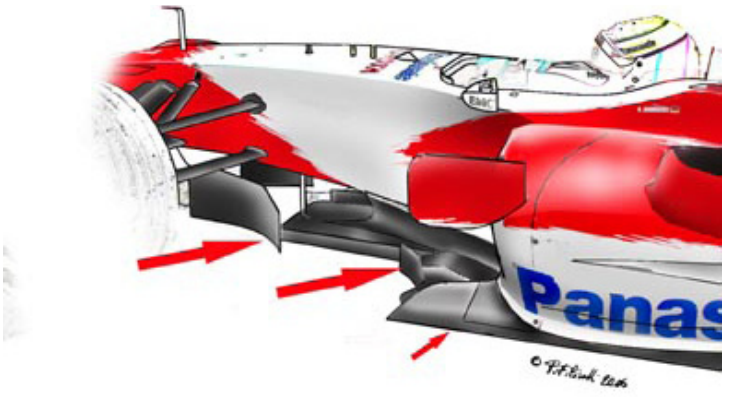
McLaren MP4-21 - rear-suspension

Kimi Raikkonen was last on the Bahrain grid thanks to a right lower wishbone failing on his rear suspension during qualifying. There are no heavy suspension loads or high kerbs at Sakhir and the failure was down to a manufacturing fault. It does, however, draw attention to the extreme design of components on the MP4-21, with the dimensions of many reduced to the maximum in a bid to save weight and minimise any negative impact on the car's aerodynamics.



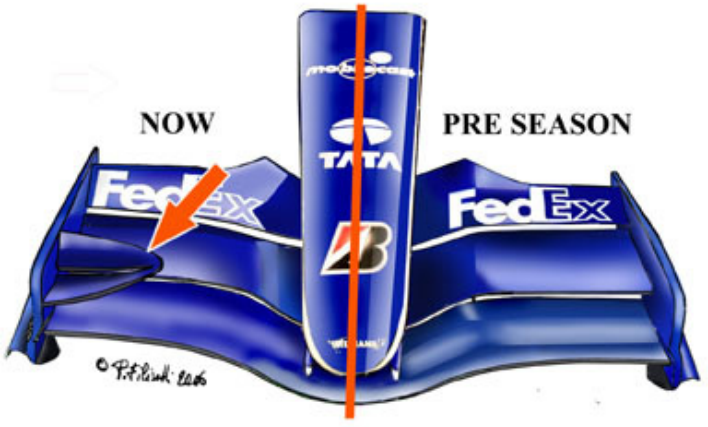
Super Aguri SA05 - aero developments

This car may be based on a 2002 Arrows, but in Bahrain it was already showing aero developments not dissimilar to features seen on other 2006 cars. The sidepods shrink under the body and sport a huge winglet at the front, resembling that on the Honda RA106 (right arrow). At the rear there is a large flip-up with a pillar connecting it to a smaller, secondary flip-up (left arrow). The barge boards have also been revised, with small fins at their lower edge (centre arrow) to improve airflow management under the car.



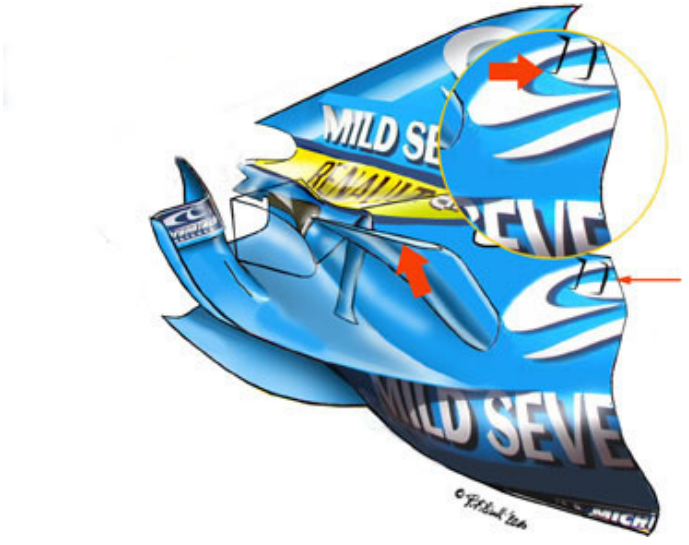
Toyota TF106 - revised turning vanes

The area of the TF105 illustrated is complex and designed to improve the efficiency of the bottom of the car and hence raise downforce. That additional downforce helps to get heat into the tyres more quickly - not a big issue in Malaysian temperatures, but one that is believed to have troubled the team in pre-season testing. There are three main elements (red arrows) - a large, vertical barge board immediately behind the front suspension and then two sculpted turning vanes behind it.



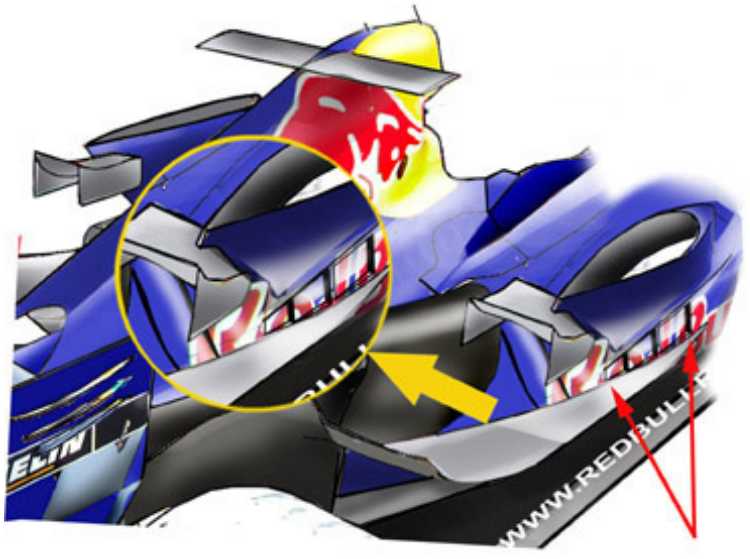
Williams FW28 - front-wing ears

Introduced in Bahrain, this change takes on more significance at Sepang, where downforce requirements are higher. Two inner ‘ears’ are attached to the inside edge of the endplates (red arrow). These are a development of the fins seen in a similar position on last year’s FW27, but they now have a wider role. Look closely and you discover they are divided by a horizontal slit, in effect creating two tiny wing profiles, or a double flap. The two ears work in the same way as a double-decker front wing, but are more efficient at raising the speed of the peripheral airflow, hence increasing downforce, with a minimal drag penalty.



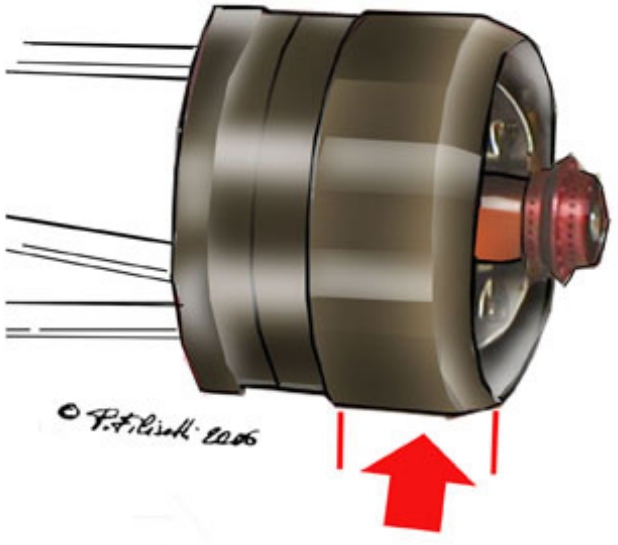
Renault R26 - additional venting gills

Renault, like most teams, have improved the cooling capabilities of their car for Malaysia, to help guarantee engine reliability in the hot and humid conditions. A couple of additional venting gills have been placed at the top of the sidepod (small arrow and magnified area), requiring no change to the sidepod’s profile, and asymmetrical cooling chimneys have been added (large left arrow). Such minimal modifications for Malaysia highlight the reduced cooling needs of the new V8 engines over last year’s V10s.



Red Bull RB2 - additional venting gills

Malaysia is the hottest race and it is normal for teams to improve their cars' cooling capabilities here. Additional vents normally appear on the sidepods to better dissipate the hot air coming from the radiators. Despite the RB2's much-publicised cooling problems in pre-season testing, the RB2 sports just a few additional venting gills underneath the venting chimneys (red arrows and magnified area). These gills are not only efficient, but also neatly integrate into the bodywork design, closely following the sinuous profile of the sidepod.

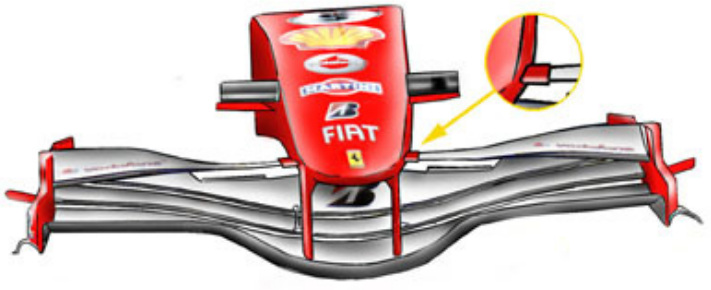


Ferrari 248 F1 - brake cooling drums

This interesting feature used in Malaysia is an evolution of similar devices seen on cars last year, but Ferrari have taken it to its extreme. The cooling drum not only covers the brake disc and calliper, preventing heat being transferred to the wheel rim, it also creates a seal of sorts with the wheel itself. It completely fills the space inside the wheel rim, not only improving brake cooling, but also dramatically reducing the vortices generated by the rotation of the wheels, hence making this area more aerodynamically efficient.

BMW Sauber F1.06 - front wing endplates

For Melbourne, the team introduced a revision to the front wing design seen in Bahrain and Malaysia. The main profile is largely unchanged, but the endplates now feature an upward-curving fin (yellow and detail), which closely resembles the one adopted on last season's Sauber. This fin reduces turbulence and hence improves the airflow passing close to the front wheels. This solution is likely to be alternated with the original flat fin over the course of the season, depending on how tight and twisty the circuit. The small change may provide an overall aero efficiency gain of around three percent.

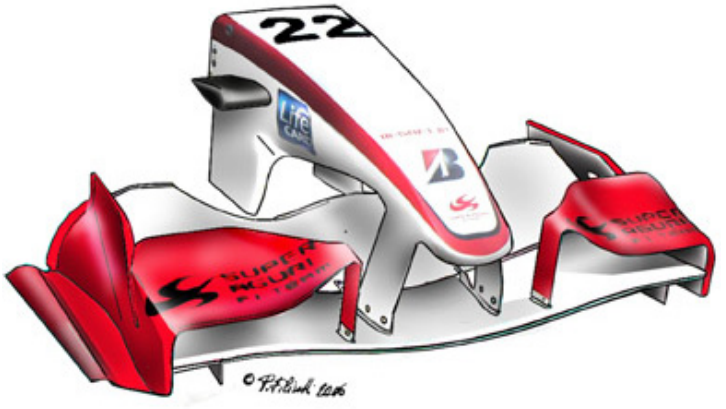


Ferrari 248 F1 - revised front wing

Ferrari's front wing was the subject of much discussion at the last round in Malaysia. Onboard TV shots showed the upper profile bending downwards at speed, opening up a gap between the wing element and the nose cone, prompting many to question whether this constituted a moveable - and hence illegal - aerodynamic device. In theory this design should help push back the car's centre of aerodynamic pressure. This means the rear would run closer to the ground, increasing the available downforce created by air passing underneath. Furthermore, the front end would become slightly more understeery - and hence controllable - at high speed. Such principles are no huge secret, but only the top teams are likely to find ways of designing structures that may flex at high speed, but still pass the relevant FIA tests. Nothing illegal was found on Ferrari's car at Sepang, but for Melbourne reinforcements have been applied where the upper wing profile meets the nose (see detail), making for a more rigid connection.

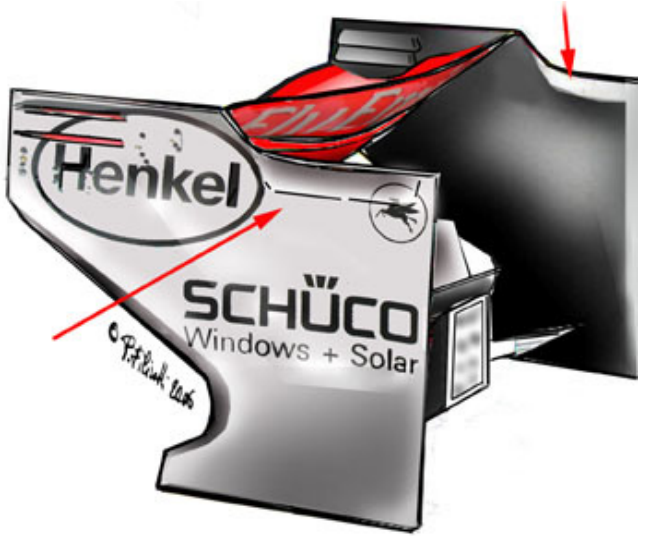
BMW Sauber F1.06 - rear wing

Another team invited by the FIA to make changes to their wings prior to Australia, BMW Sauber have revised the junction of the rear wing's endplates and its main profile and flap. The shape of the elements has not changed, but the connecting points between them (areas in orange) have been reinforced to prevent any unwanted flexibility and freedom of movement between them.



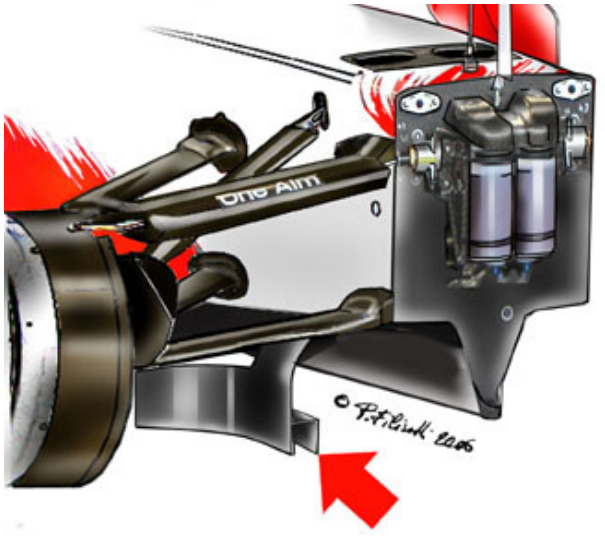
Super Aguri SA05 - double-decker front wing

It may only be an interim car, before the arrival of the team's 2006 machine later in the year, but the SA05 has already seen a fair amount of development since its debut. A double-decker front wing has been introduced in Australia. The additional upper elements are an integral part of the endplates, as on the Renault and Midland. This solution provides increased downforce with a relatively small drag penalty. A logical, straightforward change from a young team looking to quickly improve their performance.



McLaren MP4-21 - rear wing

Small changes for Melbourne following informal communications from the FIA post-Malaysia. The revisions are concentrated on the endplates, in the cut area just behind the flap (red arrows). This area is now bent slightly outwards, with reinforcement along the bend to restrict the flexibility of the endplate and the flap under high loads. The connecting points between the endplates and the main wing profile have also been strengthened accordingly.

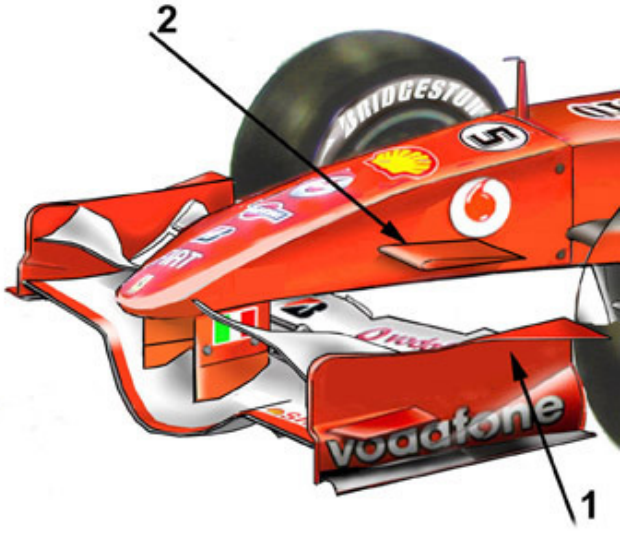


Toyota TF106 - front barge boards

An interesting, if minor, aero development spotted on the Toyota in Australia was changes to the barge boards, which sported an additional inner fence in their foremost section. This creates a channel which more effectively diverts the lower portion of the airflow, increasing the efficiency of the bottom of the car. Quick direction changes dominate the Albert Park circuit and here the revisions resulted in better stability and improved grip.

BMW Sauber F1 06 - revised front wing

A slightly different configuration for Imola. The double-decker concept has been revised, with the additional upper profiles shortened by around 5 cm, to reduce drag and improve top speed on this fast circuit. The key factor is the reduced surface area exposed to the airflow. The angle of the wing flap remains unchanged.

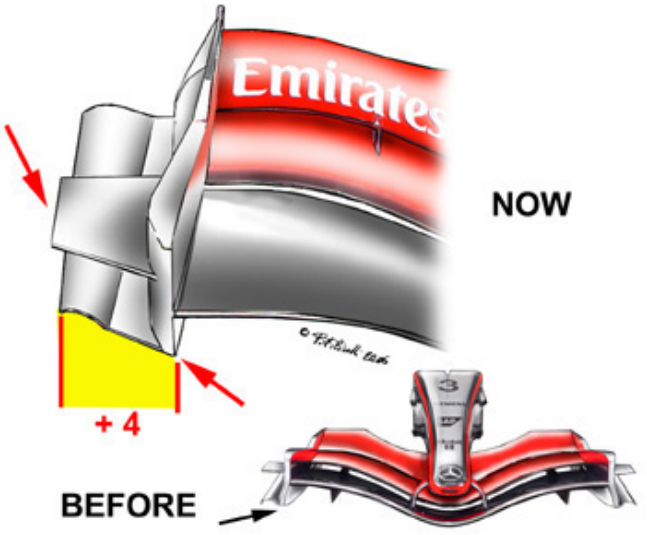


Ferrari 248 F1 - revised front wing

Part of extensive changes to the Ferrari at Imola, designed to improve performance and overall balance. New endplates sport a flat upper profile instead of the previous sculpted one, with a horizontal triangular fin at the rear (1). This improves airflow management close to the wheels. The additional fins on either side of the nosecone (2) now have a wing-shaped profile, which improves airflow efficiency between the chassis and the tyres. All these changes improve the quality of the airflow passing underneath the car, which is then extracted by the rear diffuser.

Ferrari 248 F1 - barge board revisions

Part of the revised aero package for Imola. Though the boards themselves look little different, the changes are in the cross sections of the winglets attached to them. The lower winglet has been slightly enlarged to better manage airflow passing under the car. The upper one is also slightly bigger, helping to split the airflow passing close to the sidepods. This cuts the vortices around the sidepod entrance, allowing more air to enter, hence improving the car's cooling capabilities.

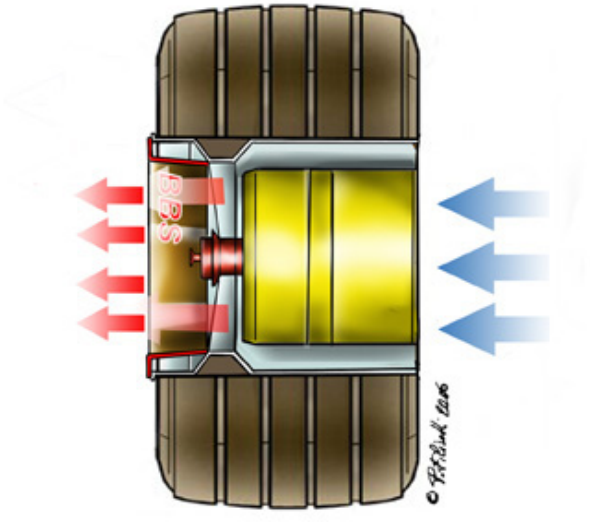


McLaren MP4-21 - revised front wing

For Imola, the width of the main profile has been reduced, while the horizontal section of the endplates has been increased by the same amount - around 4cm. The endplate change dramatically reduces the vortices created by the front wheels, while the reduced width of the main profile cuts drag, helping to boost top speed at the fast San Marino circuit.

Honda RA106 - revised front wing

An interesting change for San Marino. The base of the spoon at the centre of the main profile is flat. The profile then tapers sharply upwards away from the nosecone before flattening out. There is then an additional upward step before it flattens again as it joins the endplate. This design has evolved from a previous version seen last year in Japan, where the wave-like main profile formed part of a double-decker layout. This latest solution is intended to cut drag at the relatively high-speed Imola circuit.



Ferrari 248 F1 - wheel rim lip

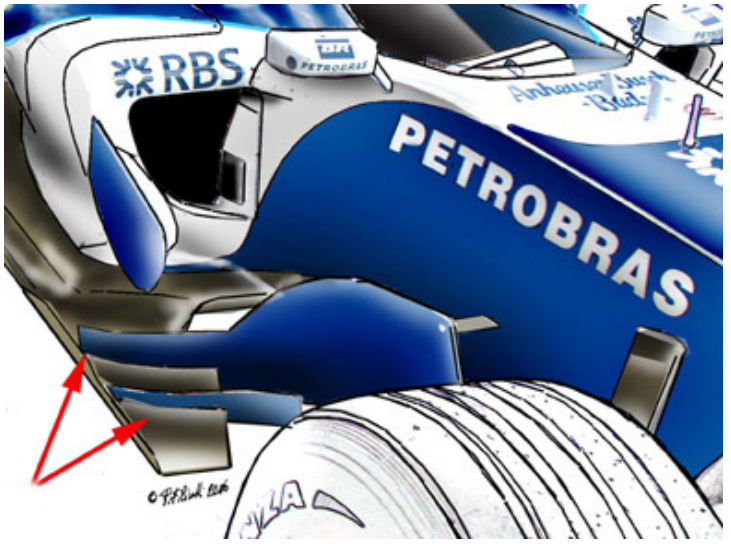
Since its introduction in Bahrain, the protruding outer lip (in red) on Ferrari's wheel rims has been the subject of much discussion, with rivals questioning whether it constitutes an illegal moveable aerodynamic device - the movement being the wheel's rotation. Ferrari say the lip is a functional part of the air intake system for brake cooling and that its profile remains the same, regardless of whether the wheel is moving - hence it is not effectively 'moveable'. Ferrari's brake cooling system has two main parts - an inner drum (in yellow) where cool air (blue arrows) enters, and an outer part where heat from the brakes (red arrows) is expelled.

Renault R26 - front-wing endplates

This change for Europe appears to follow a trend started by McLaren at the last round at Imola. The rear of the endplate is now completely vertical and flat, losing the round and protruding outer profile seen on the previous version. This revision improves the alignment of the endplate with the inner profile of the front wheels, lessening the turbulence when air passing over and underneath the wing impacts the wheels.

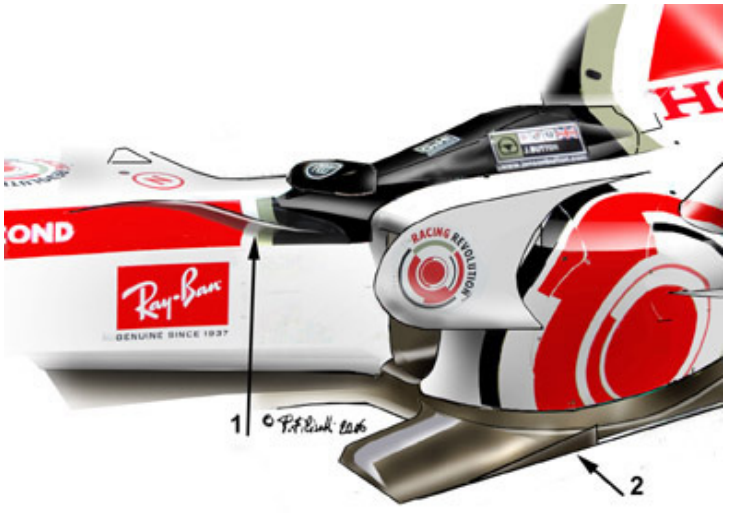
Toyota TF106 - wheel rim lip

An imaginative new feature for Europe.A carbon lip is applied to the outer face of the Toyota's rear wheel rims. The aim is to improve brake cooling - using similar principles to those seen on Ferrari's solution at the last round at Imola - while at the same time giving a minor aerodynamic gain by reducing turbulence near the rear wing. Unlike Ferrari's design, Toyota's does not extend to inside the wheel rim.



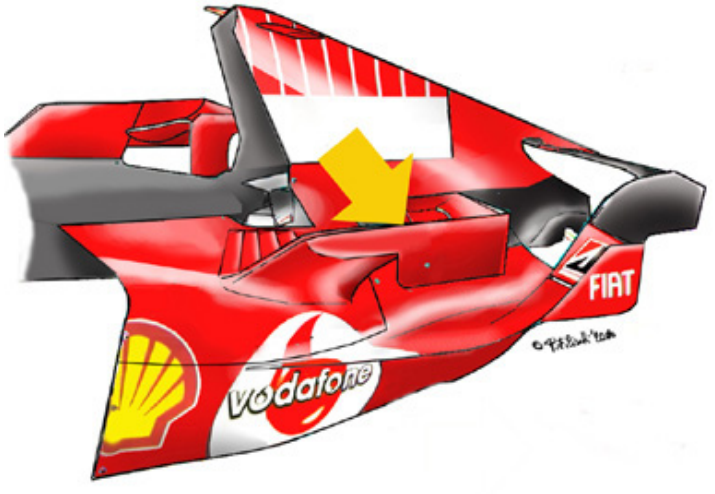
Williams FW28 - barge boards

A development for Europe is this additional small barge board (right arrow) in front of the main one (left arrow), connected to the protruding horizontal turning vane in similar fashion to a solution used by BAR last year. The small board improves the aerodynamics in this area by diverting a small portion of the approaching airflow outwards, cleaning up the main central airflow, hence making it more effective in the way it passes it under the car and the way in which it cools the engine.



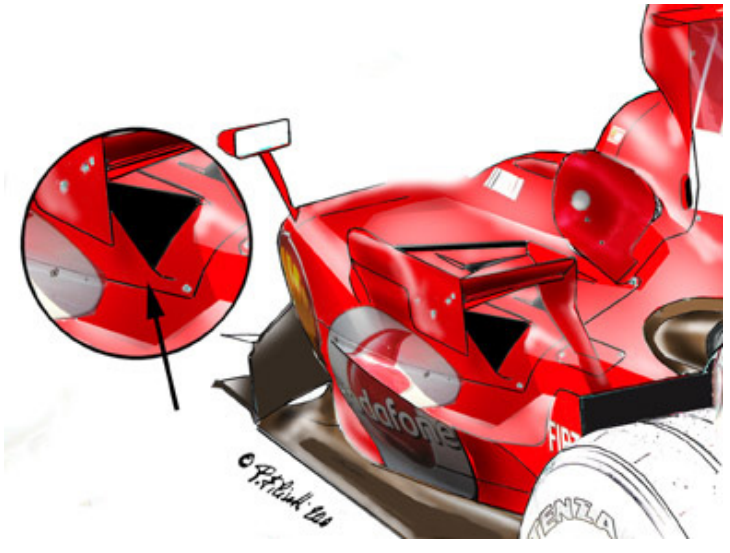
Honda RA106 - cockpit 'ears' and turning-vane fin

An interesting change for Europe is the addition of these unusual fins, or 'ears', (1) just in front of the Honda's cockpit. They extend as far back as the mirrors and are designed to better manage the airflow close to the chassis. They help to cleanly separate the upper airflow (passing over the car) from the lower airflow going into the sidepods to provide cooling. Another new detail is on the turning vanes, which now feature a triangular, vertical fin (2). This is another device to cut turbulence and hence enhance the aerodynamic efficiency of the bottom of the car.



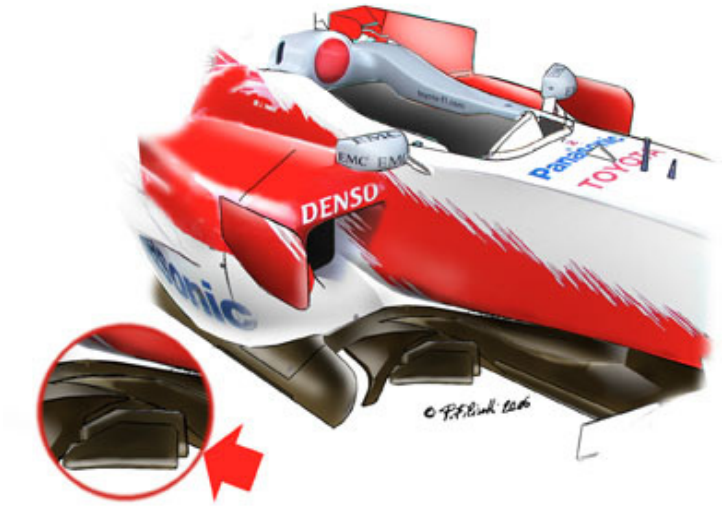
Ferrari 248 F1- winglets

At the Nurburgring, the winglets and the cooling chimneys on the Ferrari's sidepods have been combined into one single element, emphasising further their aerodynamic function. This 'fused' element works to split the airflow over the sidepod, sending the outer part outwards and the central part directly towards the rear wing, thus raising the rear wing's effectiveness.



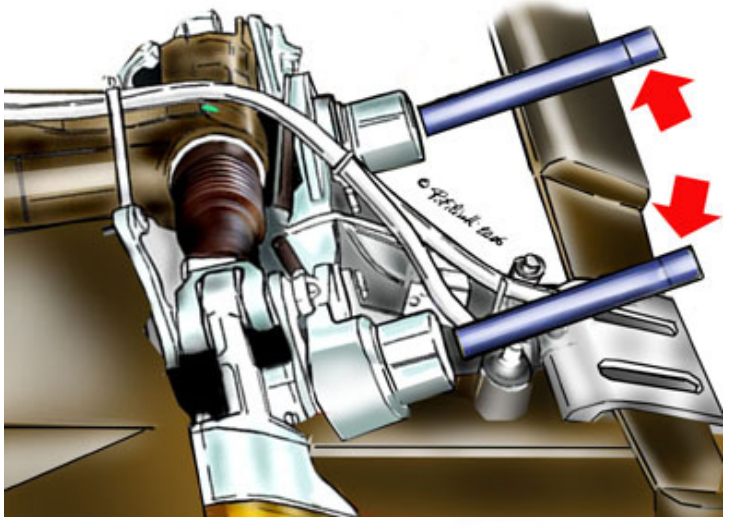
Ferrari 248 F1 - air vents

Along with the winglet/chimneys seen in Saturday's European update, these triangular air vents form another definitive part of Ferrari's latest aero package. Well hidden by the winglet/chimney combination, they dramatically improve hot-air extraction from the sidepods, allowing the engineers to lower the rear section of the car, including the exhaust. The resulting enhancement in overall aero efficiency has been shown in Ferrari's highly improved form in the last two races.



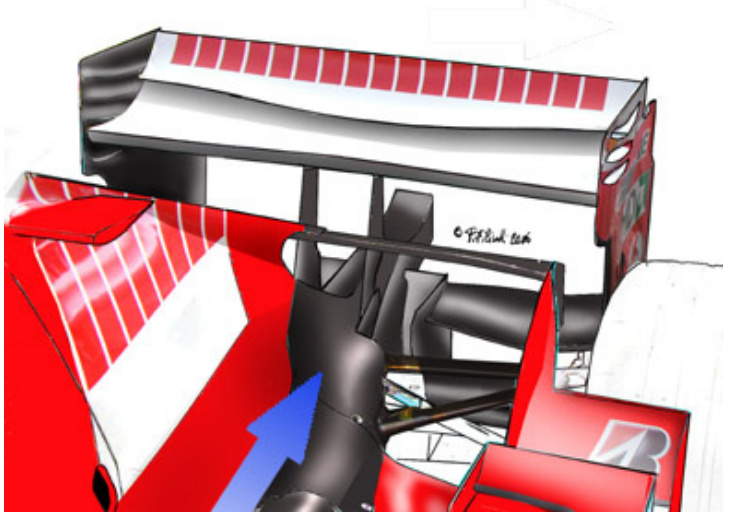
Toyota TF106 - turning vane development

A very small, but interesting change for Spain, Toyota have doubled up on the small vertical fins placed in front of the horizontal turning vanes that were introduced in Malaysia. The modification aids airflow management in this area, reducing turbulence, but more importantly improving the quality of the airflow passing under the car, hence increasing downforce without upping drag.



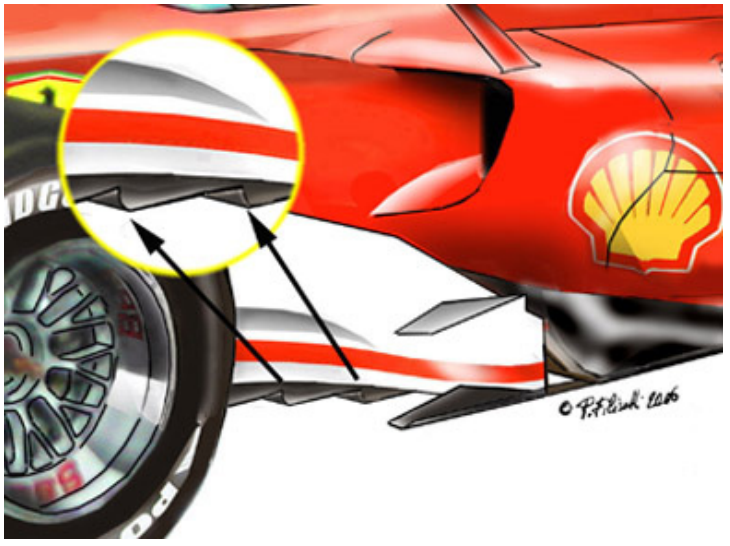
Ferrari 248 F1 - rear suspension

A slight geometry change in Spain, though the pick-up points remain the same, on the carbon fibre shell of the gearbox casing. The previous rotational dampers have been replaced with hydro-pneumatic items, which allow for faster set-up changes, with a wider and more precise range of settings. They also use longer torsion bars (red arrows), which are covered by two vertical fins in the rear bodywork (see previous engine cover drawing). These increase the stiffness of the overall suspension system and this is balanced with a softer damping-rebounding ratio.



Ferrari 248 F1 - engine cover and rear end

A closer look at the Ferrari in Spain reveals just how deep the car's aero development has been over the opening races of 2006. The engine cover and the whole rear area look visibly lower and narrower than on rival machines. The small black covers, resembling mini shark fins (blue arrow) on top of the gearbox, hide the very long torsion bars adopted on this car. That they can do this illustrates just how compact the 248 F1's design is in this area. The airflow management looks very clear, with the central section of air passing over the sidepods and feeding directly to the rear wing and to the top of the central diffuser section.

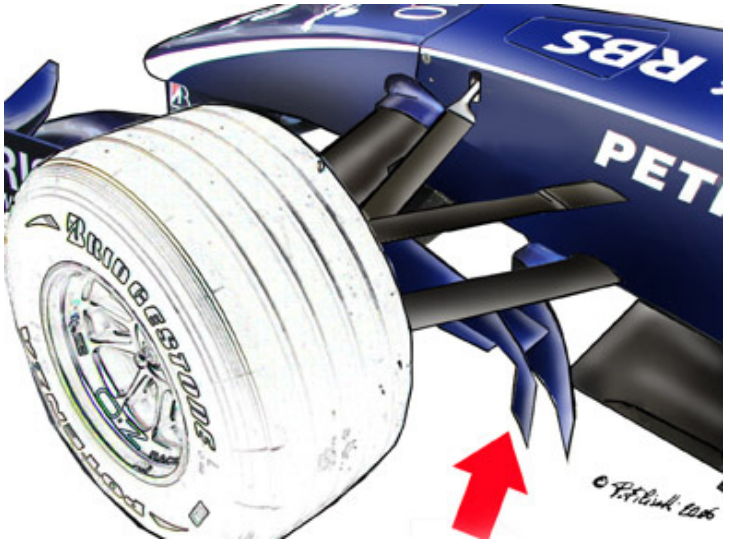


Ferrari 248 F1 - barge boards

Introduced for Europe and retained in Barcelona, this change can now be considered definitive. The saw-tooth profile at the bottom of the barge board now features two ‘teeth’ bending upwards to dramatically reduce turbulence, and therefore improve both cooling and airflow management close to the sidepods. This may look a small refinement, but in reality cutting turbulence is one of the main targets of all teams, as this phenomenon greatly affects the overall efficiency of the car’s aero package.

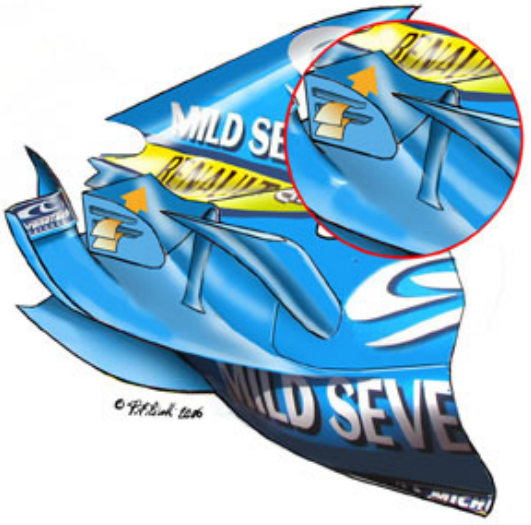
Renault R26 - rear wing analysis

Slight changes for Spain, with better airflow management helping to cut drag on this circuit’s very long straights. This is achieved by effectively reducing the sectional area of the flap and main profile (while retaining their original general design) through the main profile bending dramatically downwards towards its extremities, with the central section higher than the outer ones and supported by a tiny pillar.The flap, meanwhile, is completely flat, though of course its front edges bends downwards so as to maintain a constant gap with the main profile. The overall effect is one of sufficient downforce coupled with very low drag, the latter enhanced by the endplate side-slits that have been slightly modified to further reduce turbulence in this area.



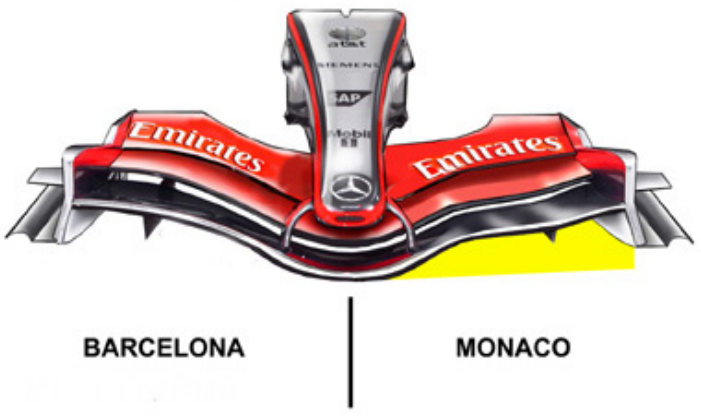
Williams FW28 - front barge boards

This area of the car is under constant development by all teams. It is crucial to correctly manage the airflow here, where you begin controlling the air that passes to the rear of the car, feeding the rear wing and the under-body diffuser, and the air entering the sidepods for engine cooling. In Spain Williams have doubled up on the vertical shields at front-suspension level to help divert away the turbulence generated by the front wheels.



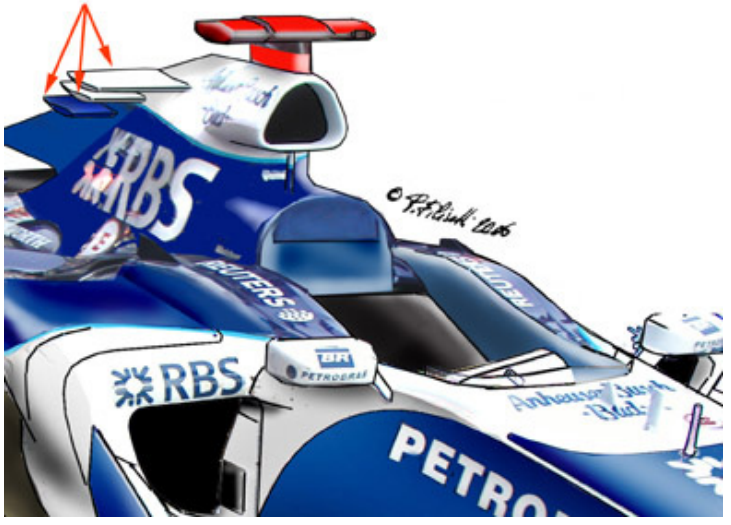
Renault R26 - winglet development

A slight change to the winglets on top of the sidepods for the high-downforce Monaco circuit. Their profile has a larger surface area – to generate more downforce – combined with a bigger endplate. Two horizontal slits in the endplate help to limit the increased turbulence caused by the element's enlarged dimensions.



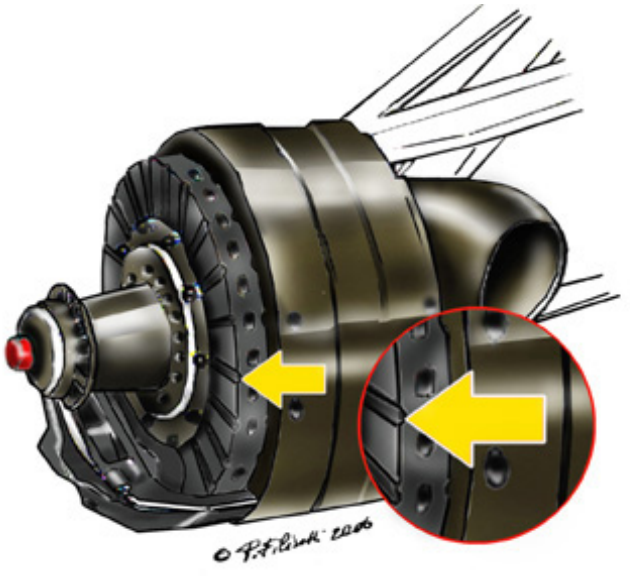
McLaren MP4-21 - front wing development

A brand new design for Monaco, with completely different main profile and flaps. The main profile now has a double curve as it extends away from the nose, with the outer extremities bending noticeably upwards. As a result the central spoon section is effectively widened, meaning more airflow over this area, hence greater downforce. The flaps are now much deeper, which also adds downforce. While the revised main profile is likely to be retained for many tracks, the flap changes will probably only be seen in Monaco and Hungary, both high-downforce circuits.



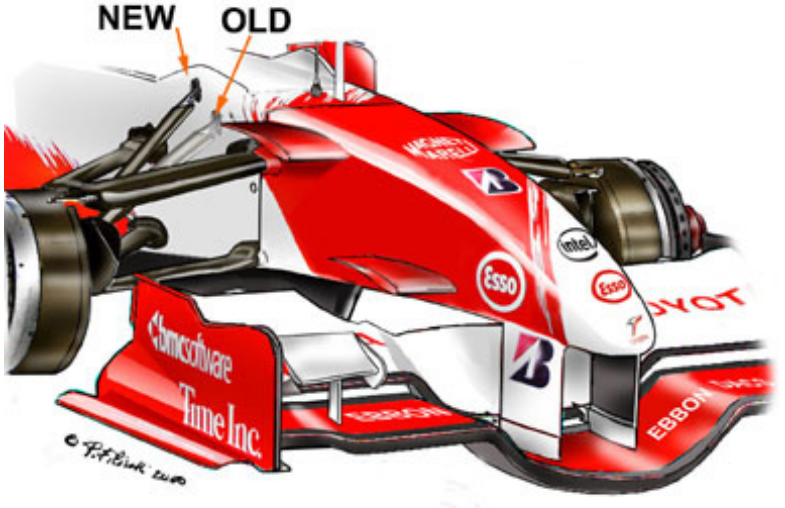
Williams FW28 - triple mid wing

Teams will use any method at their disposal to gain more downforce at Monaco. Williams have gone for a simple but effective triple mid wing on the FW28's engine cover. This not only adds downforce in the centre of the car, it also helps to manage airflow passing to the rear wing, hence increasing its efficiency.



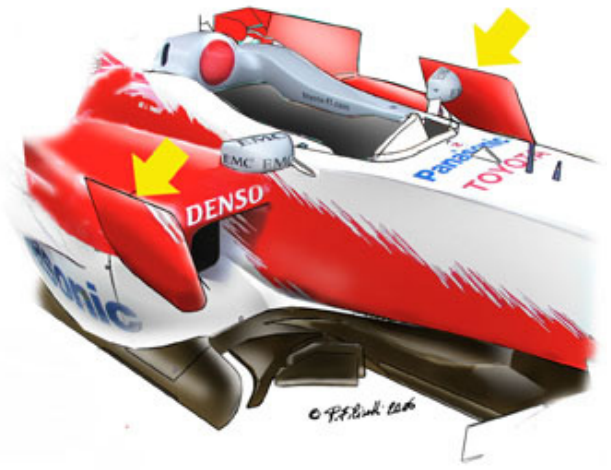
McLaren MP4-21 - grooved brake discs

Not strictly a new feature, but a key one at Monaco. Brake wear is not a problem here. Instead the low speeds mean the issue is keeping the brakes up to working temperature. The only heavy braking points are at the chicane after the tunnel, and to a lesser extent the Ste Devote and Mirabeau corners. With a lack of temperature, brake bite becomes a problem, as the surface of the carbon brake disc becomes smooth as glass, reducing friction between the pads and the disk, hence lessening braking power. To combat this, Montoya adopted discs with radial grooves that increase the bite rate between disk and pads, hence increasing the average temperature of the brakes.



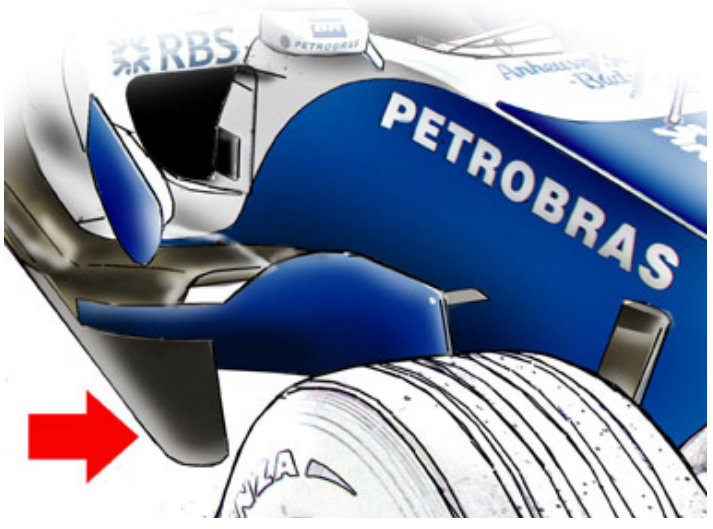
Toyota TF106 - B version

Monaco saw the introduction of Toyota's TF106B, a deeply revised version of the car that started the season, both mechanically and aerodynamically. One key change is to the front suspension geometry, aimed at improving the way the car works with its Bridgestone tyres (the team struggled to get them up to working temperature earlier in the season). The connecting point for the push rod link to the torsion bars and dampers inside the chassis is now much higher. This provides an increased damping rate and allows a slight reduction in camber angle. This allows the car to better exploit its tyres' potential, and improves its handling.



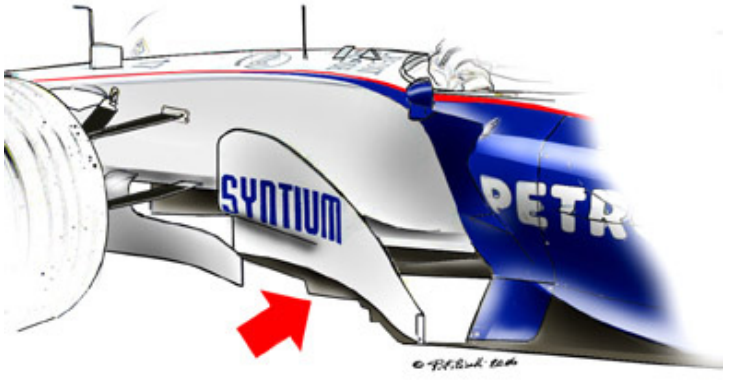
Toyota TF106B - sidepod winglets

At Silverstone, these updated winglets in front of the sidepods are a further addition to the revised car introduced at the last round in Monaco. They are larger than previous versions, following a trend set by Honda. This change suits the requirements of the British Grand Prix circuit - medium to high downforce coupled with minimal drag - but is also likely to be a definitive update that will remain for the rest of the season.



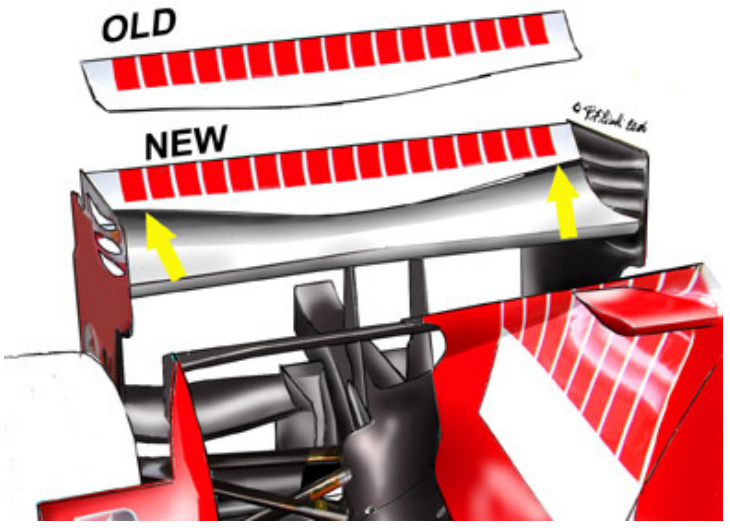
Williams FW 28 - turning vanes

The area immediately in front of the sidepods is a crucial one in terms of a car's overall efficiency. At Silverstone Williams have reintroduced a solution seen on last year's car - a narrower and more pointed turning vane, profiled like a wing, replacing the squared flat one used more recently. In addition, the small barge board in front of the main one has been removed to reduce turbulence. These changes improve the aerodynamic balance of the car at high speed, the compromise being a slight loss of stability in slower corners.



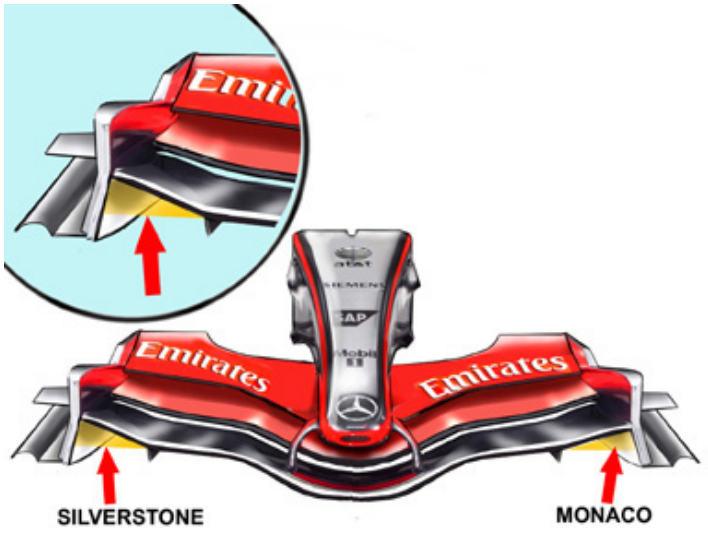
BMW Sauber F1.06 - revised barge boards

A small but useful change for Silverstone, these elements now feature a saw-tooth profile at the base, similar to the design used by Ferrari. This substantially ups the effectiveness of the barge boards, by dramatically reducing the vortices generated in this area, hence improving the aero efficiency of the bottom of the car.



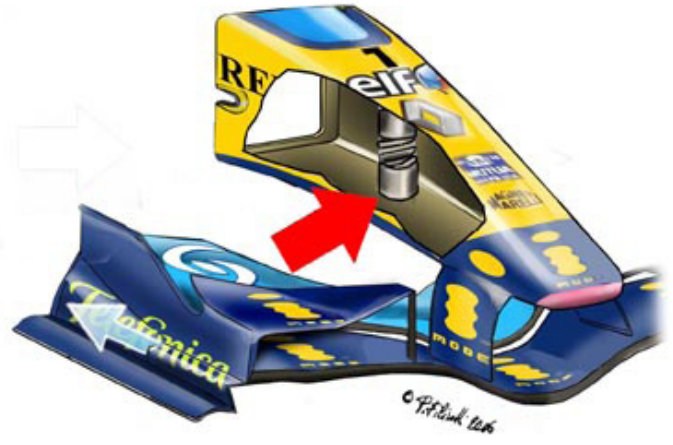
Ferrari 248 F1 - rear wing

A slight revision for Silverstone, based on a medium downforce configuration. The new flap keeps essentially the same profile, but with a reduced cross sectional area at its extremities. This is to reduce drag on the straights, while maintaining adequate downforce to be of use in the track's twistier sections.



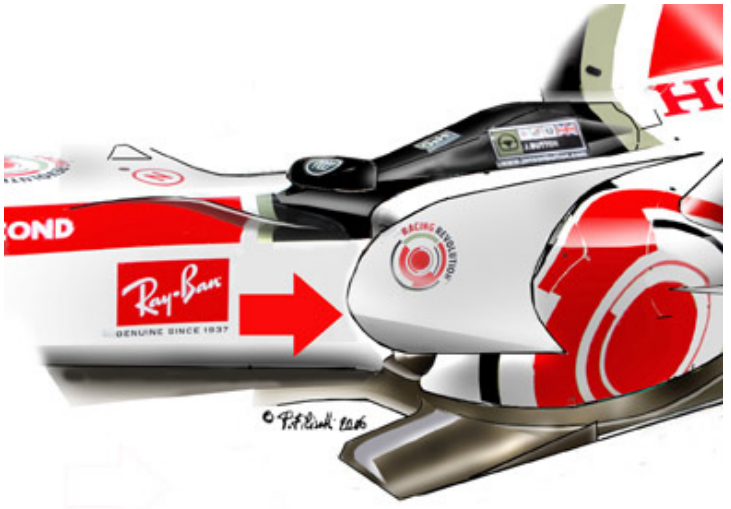
McLaren MP4-21 - front wing

As in Monaco, in Britain the McLaren sported a double-S profile to its front wing, with the outer extremities bending upwards. Here, however, that upward bend was even more extreme, creating a greater gap between the wing profile and the ground, so as to reduce the pitch sensitivity of the car at high speed. Such a change is very useful on a medium to high speed circuit such as Silverstone.



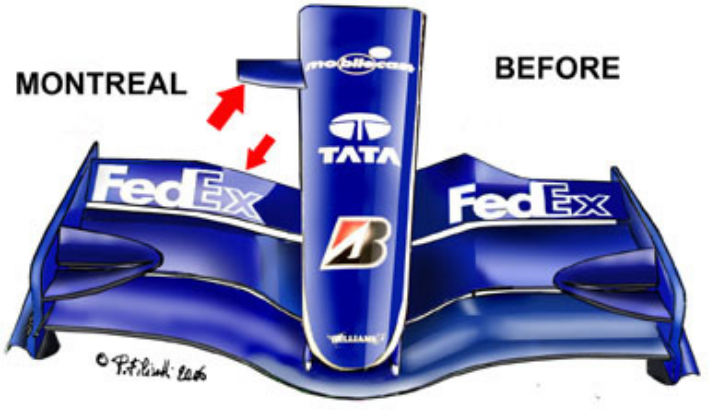
Renault R26 - internal nose damping system

Last year the 'secret' in Renault's nose was a metal plate which acted as ballast at its tip. This year, the team have developed the concept further with a sort a vertical damper whose function is to reduce the sensitivity of the car's front end to load variations between high low-speed sections of a track. It also reduces the effects of rebound when riding kerbs and pitch sensitivity. Overall, it helps the car to maintain optimum balance more of the time, hence allowing it to use its tyres more efficiently.



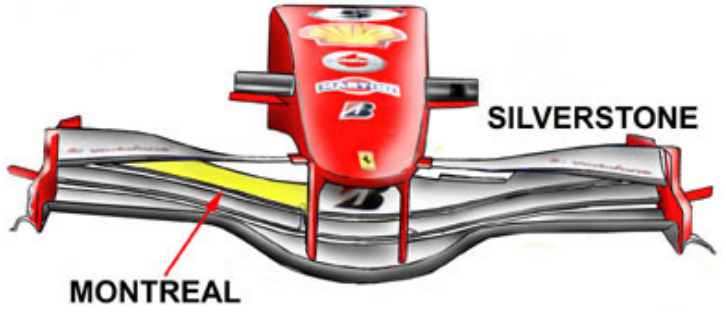
Honda RA106 - larger sidepod shields

This area of the Honda is continually being revised. In Montreal the 'shields' in front of the sidepods are dramatically larger, longer and higher. These elements seem able to provide better airflow management in this area of the car, with the Renault featuring a similar device here. The car's design in this area is critical to its overall aerodynamic balance, so changes here have the potential for large gains when a team gets it right - or significant losses if they get it wrong.



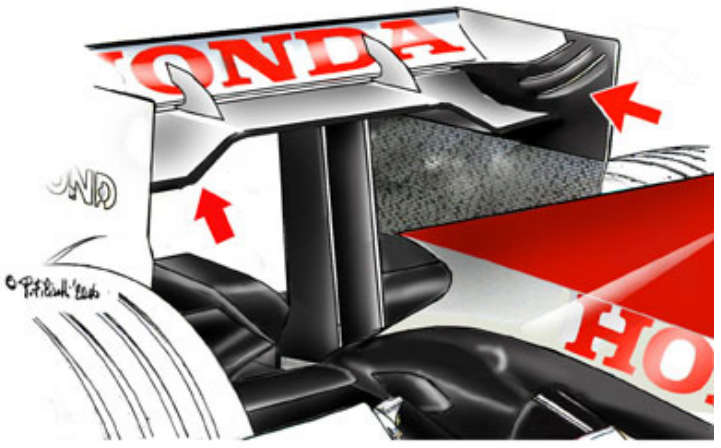
Williams FW28 - side winglets / revised flap

Some interesting aero changes for Montreal, aimed at increasing downforce on the circuit's twisty sections, without affecting top speed on the fast parts. Among them are these horizontal winglets at the top of the nose, not dissimilar to those on the Toyota and Renault. These reduce turbulence around the front upper wishbones, and clean up the airflow passing towards the rear of the car. The front wing also has a different profile to its top flap, which is now reduced in width in the central section to cut drag on the long main straight.



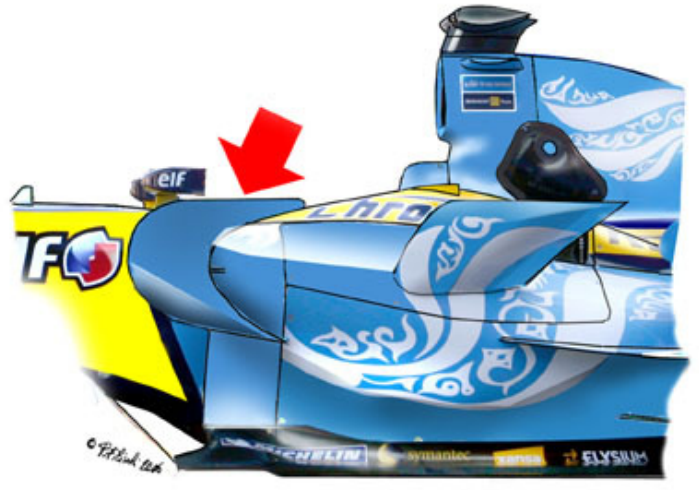
Ferrari 248 F1 - revised front wing

Part of an extensive aero development for Canada is this front wing, featuring a completely different flap, which guarantees an adequate downforce level (very useful in the twisty section of the track characterised by a sequence of almost continuous corners), while also reducing drag - very useful on the very long straight prior to the start-finish one. To reach this target the new flap has been reduced in area, but maintains a curved profile. The downforce level should be roughly six percent less than the previous solution, perfectly adequate for this track.



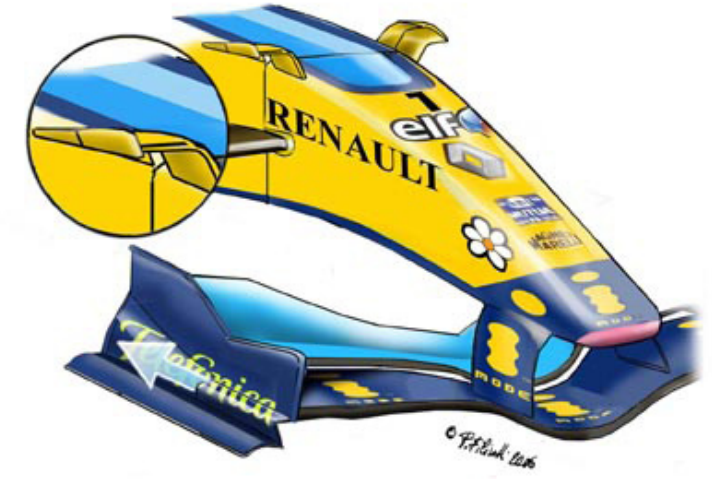
Honda RA106 - revised rear wing

An interesting change for Canada, which was tested extensively at Monza just prior to the race. The wing's dramatically curved main profile is much lower in the centre than at its extremities. This increases airflow pressure in the middle of the wing, while simultaneously improving airflow management either side, working in combination with the wing's sculpted endplates. These feature two slits, with the flap attached to the endplate in a similar fashion to that seen on the Renault. This solution appears ideal for Montreal, providing adequate downforce to the rear of the car, while also reducing drag over the side sections.



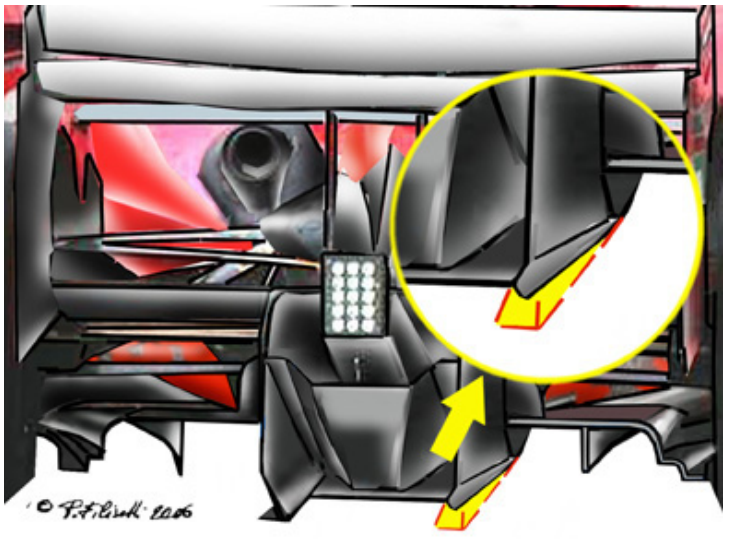
Renault R26 - revised sidepod shields

Another change for Canada is these bigger shields in front of the sidepods. The change may not be a particularly original one - Honda are among the other teams to carry similar revisions in Montreal - but it is certainly an important one. They improve airflow management over the sidepods - a key area in terms of the car's overall aerodynamic balance - with big gains possible if the team get it right.



Renault R26 - double nose winglets

Renault continue to develop the dominant R26, with 16 small changes for Canada according to the team's engineers. Some are clearly visible - like these nose winglets - while others are more subtle (but no less effective), internal revisions. The nose winglets have been doubled up to increase their effect. They improve airflow management immediately in front of and over the upper suspension wishbone, cleaning up the airflow directed into the sidepods and towards the rear of the car. This helps overall aero efficiency by reducing drag and turbulence.

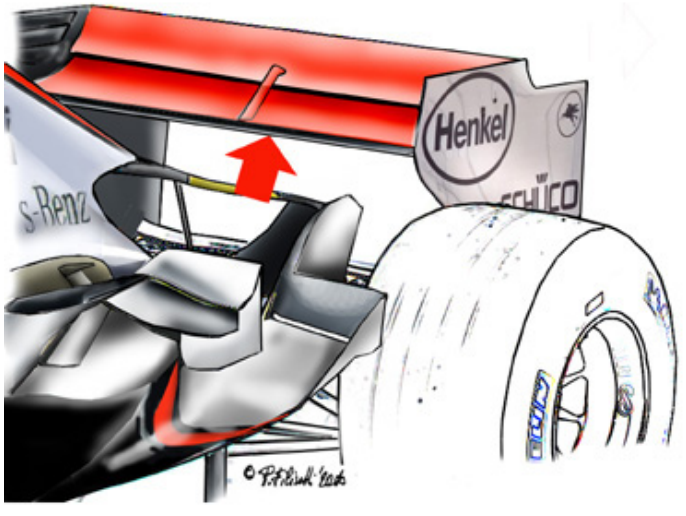


Ferrari 248 F1 - diffuser

For Indy, the diffuser's side walls have been dramatically revised. Gone is the knife-edge profile at the base of the central section and in its place is a small, upward-curving lip. The diffuser is no longer parallel with the ground over its entire length. Instead it bends upwards, reducing the impact of the airflow with the sides of the main channel. This increases air extraction from the bottom of the car, improving the stability of its rear end.

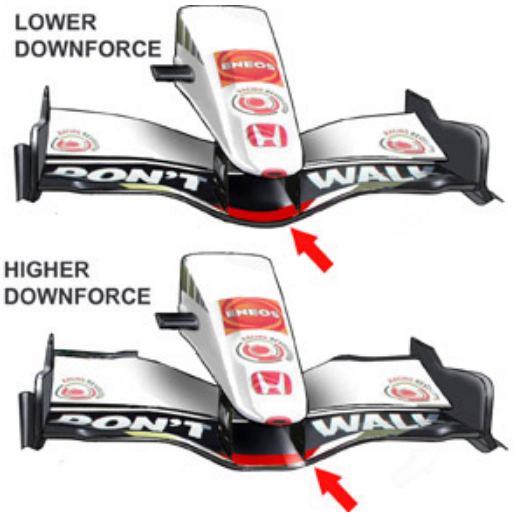
Renault R26 - rear wing

One of the changes Renault have brought to the North American races is this rear wing, with a revised wing profile, flap and endplates. The profile is now flat, rather than bending downwards at its extremities. This helps reduce drag, with minimal downforce loss. The endplates lose their wide slit, a change partly related to the stringent rules on wing flexibility, but also one that works particularly well with the latest flat wing profile.



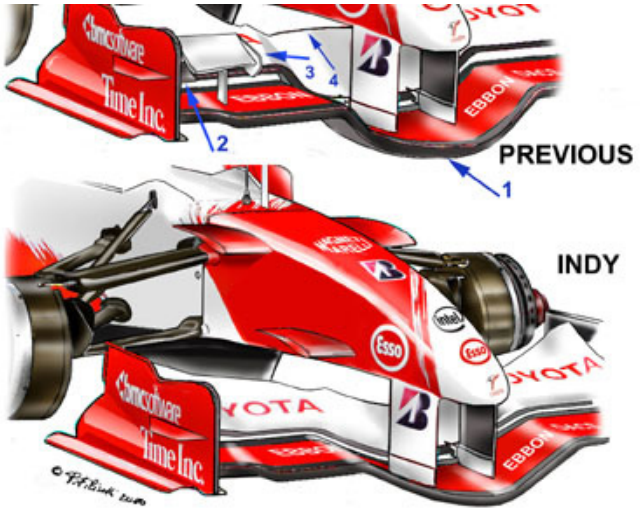
McLaren MP4-21 - rear wing

A new version for Indianapolis, featuring a completely flat main profile and flap. This provides less downforce, but at the same time reduces drag, hence improving top speed on the long straight. To guarantee adequate grip, especially in the slow infield section, both front and rear wings feature high flap angles.



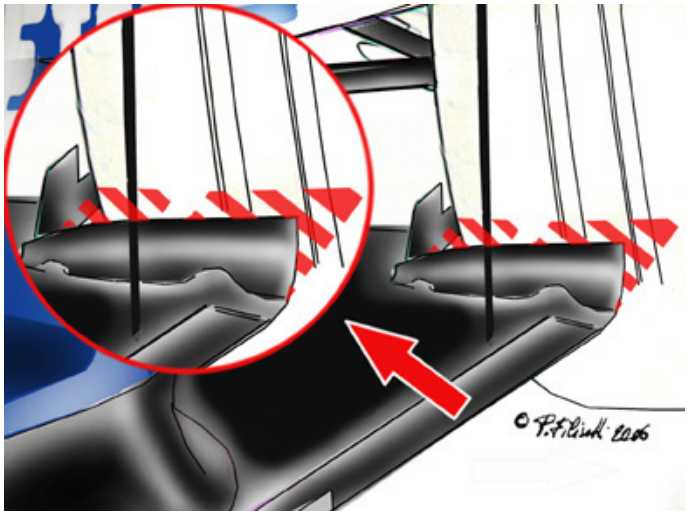
Honda RA106 - front wing comparison

Honda have tried two configurations at Indianapolis, a low-downforce one giving more straight-line speed on the main straight, and a high-downforce one providing more grip in the twisty infield section. The low-downforce version features a deep but smooth curved spoon profile at its centre, together with a flap with a reduced cross section and without any kind of gurney tab. The high-downforce version sports a squared deep spoon profile and a wider cross section to its flap, which also has two small gurney tabs at its extremities.



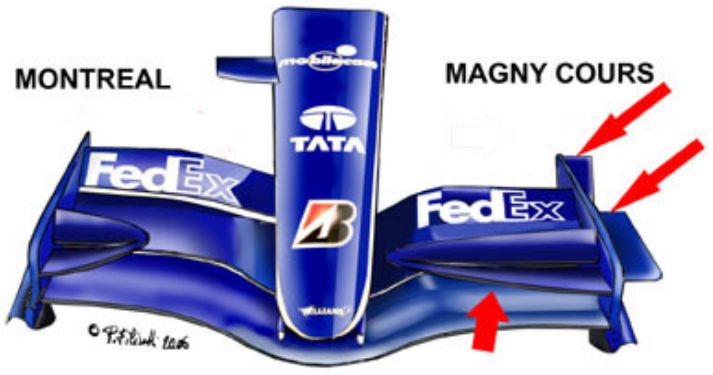
Toyota TF106B - front wind development

A heavily revised version for Indy, designed to increase the car's high-speed performance, reportedly one of its weaker points to date. Compared with the previous design, the spoon profile (1) is now wider and slopes down less abruptly than before. The small winglets (2) on the inner edge of the endplates have been removed, as have the T-winglets (3) on the main profile. The flap (4) is also different, being reduced in area and less curvaceous than its predecessor. All these revisions reduce downforce, but dramatically improve top-end performance - as shown by Jarno Trulli's drive through the pack to fourth place in the race.



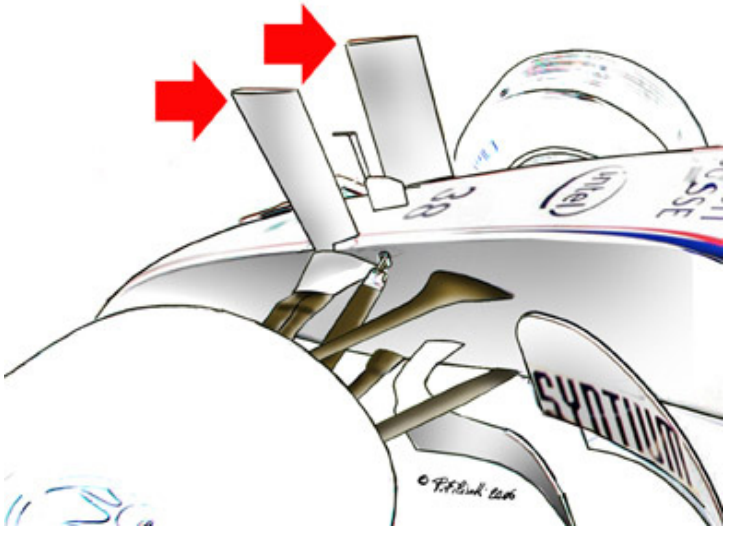
BMW Sauber F1.06 - rear tyre sensor

It is common practice to monitor tyre temperatures, but after last year's events in the US, it was seen as even more important at Indianapolis this year - not only to ensure safety, but also to try and extract maximum performance from the tyres. During practice all the teams constantly monitored rear tyre temperatures in order to get a clear picture of their condition and wear ratio, while at the same time seeking the optimum compromise between the rubber's performance and reliability by varying suspension and aero settings.



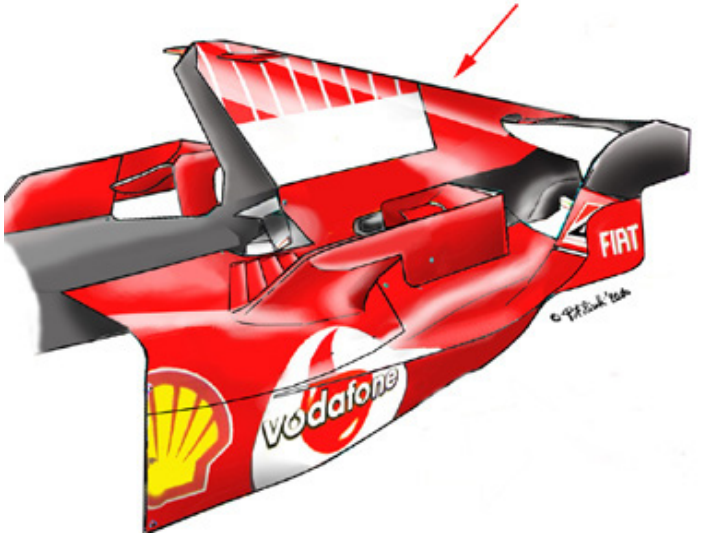
Williams FW28 - front wing development

After the revisions in Canada, the front of the FW28 sported further changes in France. A single flap replaces the previous double design and the additional winglets over the main profile have increased in length, almost reaching the side of the nosecone. The endplates now feature mid-height horizontal winglets, similar to those seen on the McLaren, and an additional triangular fin has been added at the rearmost upper edge of the endplate, similar to that on the Ferrari. The endplate changes help reduce turbulence while also slightly increasing downforce at the wing's extremities.



BMW Sauber F1.06 - vertical nose fins

This radical-looking aero solution was used in the last test at Jerez and then adopted for France. The two vertical fins on the nose, around 40 cm high, give the car an unconventional look, but fall within regulations regarding bodywork height. Their purpose is to improve stability and efficiently direct airflow towards the central and rear sections of the car. The concept is similar to that of the 'ears' on the Renault nose, but BMW Sauber have taken it to the extreme to increase its effect.

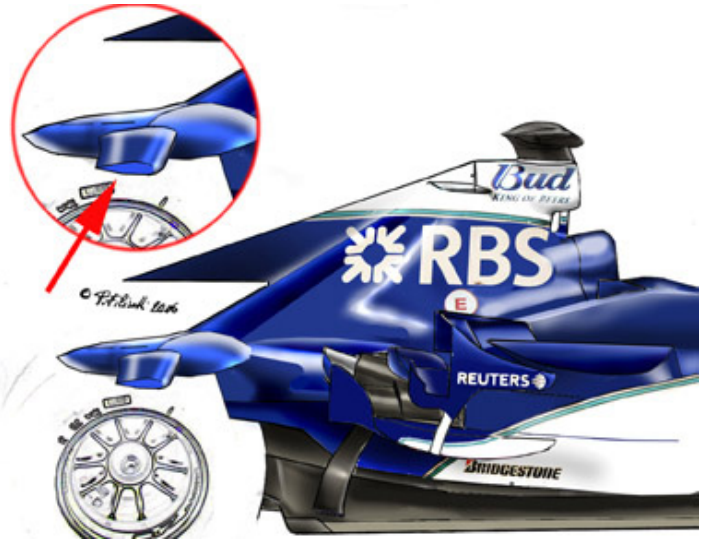


Ferrari 248 F1 - engine cover

In the Jerez test prior to France Ferrari tried out numerous developments for forthcoming races, but only a few were adopted for Magny-Cours. One was a new engine cover, the second major revision of this part since the start of the season. In line with other teams, its top features a vertical fin which dramatically reduces its cross sectional area. This allows for a cleaner airflow towards the car's rear wing, hence improving the wing's efficiency.

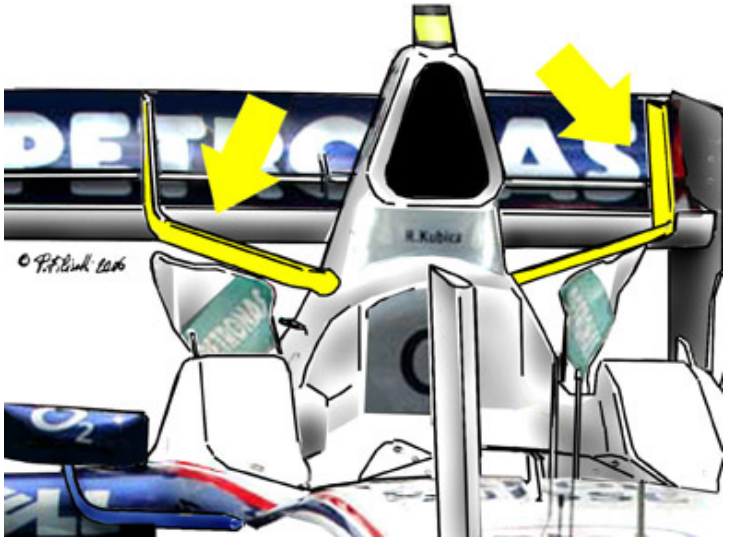
Honda RA106 - front wing development

After the developments seen in North America, Honda sported a completely revised front wing at the next round in France, with a design seemingly following recent trends set by Williams and McLaren. The two additional profiles (upper arrows) are very similar in shape to those on the Williams, with the horizontal slit dividing the profiles in two in what is almost a 'wing-flap' assembly. The extremities of the main wing profile (lower arrows) are now even higher than in the US and Canada. The provides better management of the car's front-end pitch sensitivity and the greater distance from the ground, in conjunction with the two additional profiles, helps reduce turbulence in this area.



Williams FW28 - rear-end aero development

Introduced a couple of races back and again present in France, this bodywork evolution can now be considered definitive. The Williams engineers have tried to cut turbulence generated by the rear suspension elements by adopting this extended suspension cover over the push-rod link. The cover, which features a small wing profile on each side of the car, speeds up airflow over this area, improving air extraction by the diffuser, hence improving the diffuser's suction effect.



BMW Sauber F1.06 - horn wings

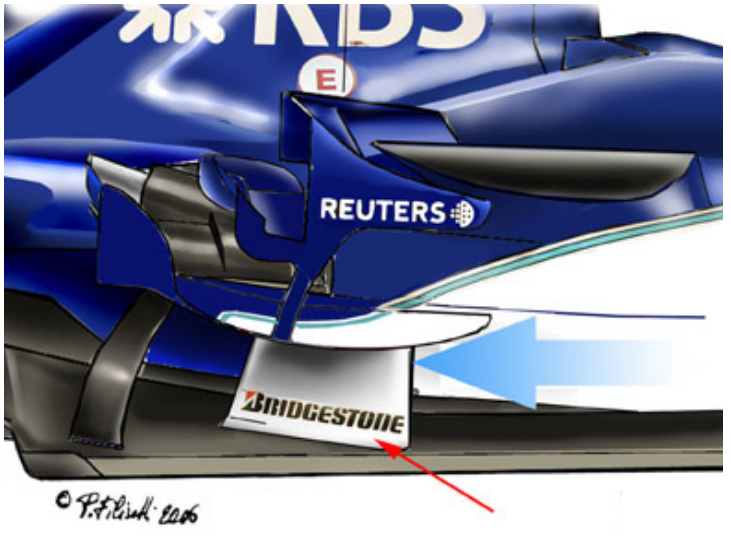
Along with the striking vertical nose fins they added in France, the team also added two 'horn' wings, similar to those on the McLaren, behind the driver's head. They are the only team so far to follow McLaren's lead on this solution, the main function of which is to improve the overall aerodynamic balance of the car through the wings' central position. They modify the airflow directed towards the rear wing, improving its efficiency and raising downforce levels.

Renault R26 - revised front wing

Part of a comprehensive new aero package, Renault adopted this revised front wing in Germany, with the additional upper profiles now longer and more curved, and attached directly to the nose cone, in a similar fashion to the Ferrari. This increases downforce, and losing the small vertical pillar that previously connected them to the main profile makes the design more efficient, allowing a clearer path for airflow moving towards the rear of the car.

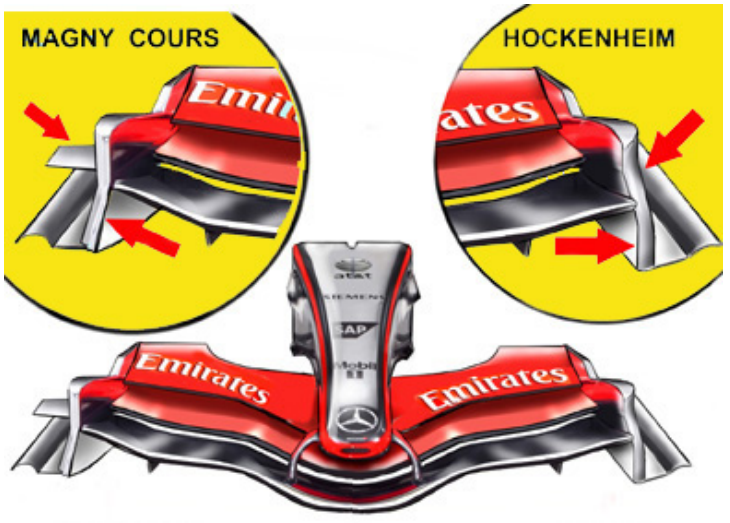
Renault R26 - mass damper system

Not new, but the subject of much controversy in Germany, the damper takes the form of a free-moving mass inside a vertical spring. Its function is to reduce the sensitivity of the car's front end to differing load variations between high- and low-speed sections of the track, and to counteract the negative effects of rebound over kerbs, so as to keep the car perfectly balanced and hence - indirectly - improve its aerodynamic efficiency. The FIA has contested its legality on the basis that no parts exerting an aerodynamic influence may be mobile. However, the German stewards found no problem with it - a decision the FIA has appealed against. Hence, Renault could race with the system this weekend, but are thought unlikely to take the risk.



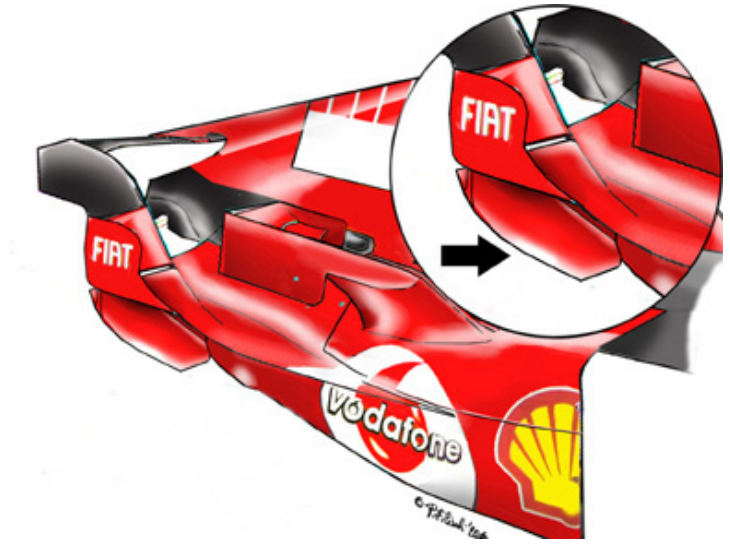
Williams FW28 - vertical side splitter

An interesting development in Germany is this vertical splitter just below the upwardly-curved flip-ups on the side of the car. It has two functions. Firstly it strengthens the flip-up structure. Secondly, it acts as a splitter in a crucial area, increasing the speed and pressure of the airflow passing close to the lower-rear section of the sidepod. As a result, this dramatically aids the rear diffuser's efficiency at extracting air from the bottom of the car, in turn raising downforce and ultimately grip.



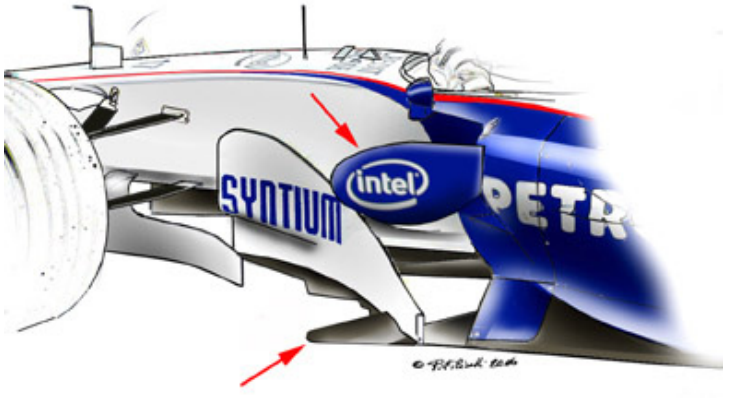
McLaren MP4-21 - front-wing development

An evolution in Germany, which in some ways seems to be going in the opposite direction to recent developments. The wing's endplate is completely different to that at the last race. Its profile is now vertical at the top as opposed to the bottom, with the bottom, not the top, sloping outwards. And the previous horizontal upper fin on the endplate is gone. This is because the new shape provides the effects of reduced turbulence and increased downforce previously supplied by the fin.



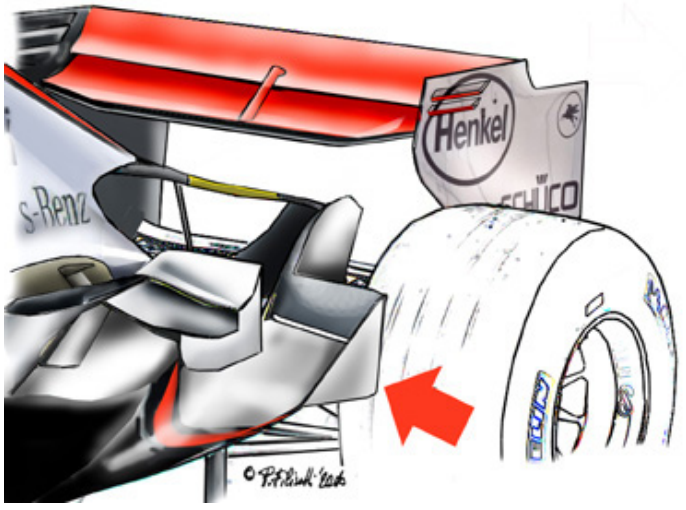
Ferrari 248 F1 - additional rear flip-ups

A small but effective aero change introduced in Germany - ahead of a new rear diffuser expected at the next round in Hungary - is this extra flip-up under the main one in front of the rear wheel. This adds a significant amount of downforce close to the rear axle, providing valuable extra rear grip, hence improving acceleration out of corners. This in turn helps the management of tyre wear, by reducing the amount of sliding when downforce levels are low at slow speeds.



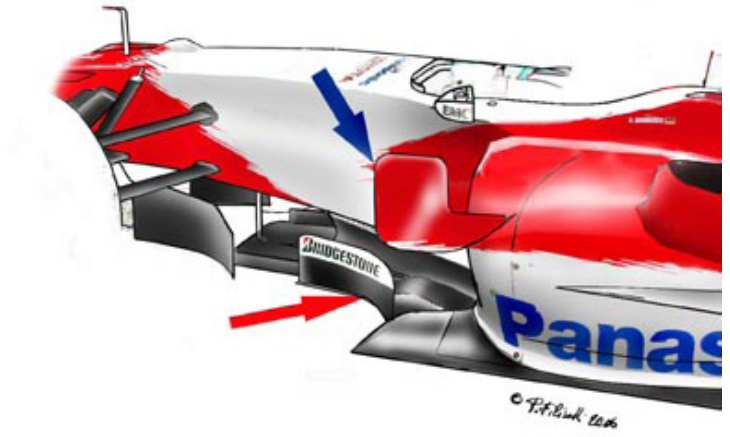
BMW Sauber F1.06 - winglets & additional turning vanes

Continuing the seemingly endless aero development of the F1.06 are some interesting changes in front of its sidepods. A new winglet (upper arrow) has been added at the front, clearly inspired by those on the Honda and Toyota, dramatically improving the continuity of airflow passing over the sidepod, and aiding cooling by diverting airflow more effectively into the air inlets. The winglet's endplate, with its rounded profile, acts as a splitter. The bargeboard (lower arrow) has also changed and now sports a forward-protruding, horizontal turning vane, similar to that seen on the Williams and Honda. Its connection with the bottom of the sidepod has been thickened and widened to cope with the increased downforce generated by the addition of the turning vane.



McLaren MP4-21 - rear end changes

Due to the high downforce requirements of the Hungaroring, the rear wing's flap sports a high incidence angle, while the outer ends of its main profile bend upwards to increase airflow pressure close to the endplates. This raises downforce, and the small drag penalty is of little consequence here. Another interesting change, first seen at the last round in Germany, is the wider vertical endplates connected to the flip-ups in front of the rear wheels. These raise downforce indirectly, by increasing the speed and pressure of airflow hitting the rear wing's lower profile.

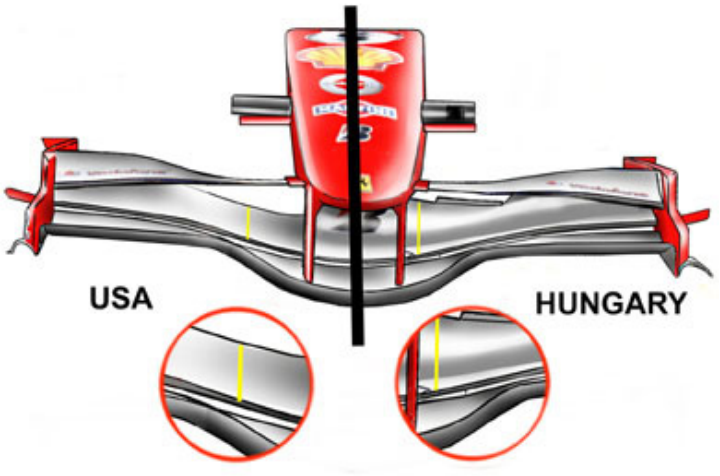


Toyota TF106B - turning vanes and winglets

In Hungary the winglets in front of the sidepods have been changed for the third time this season. The vertical endplates are completely different to the previous version introduced at Silverstone, sporting a rounded front edge (blue arrow) to reduce the drag caused by vortices generated between endplate and sidepod edge. A further change is the wider vertical turning vanes (red arrow) connected to the horizontal fins in front of the sidepods. The vertical shields are higher than before, increasing the airflow diverted into the sidepods air inlets, aiding cooling in hot weather conditions.

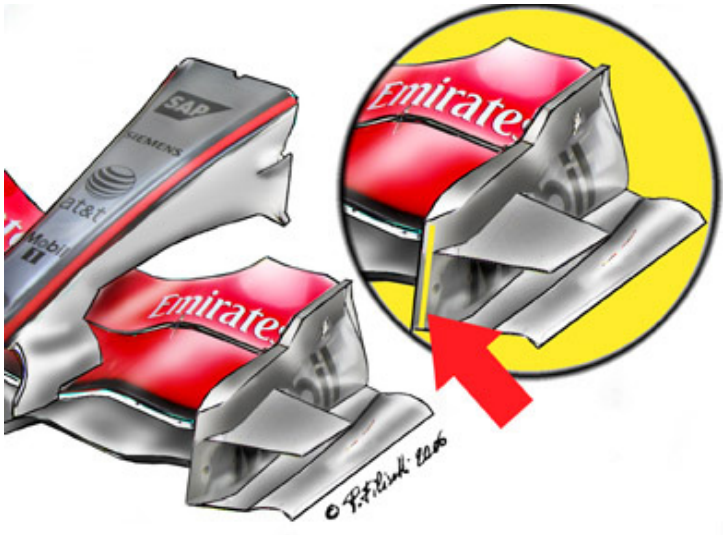
Honda RA106 - front-wing development

Hungary sees Honda's sixth major front wing revision. As the illustration shows, it is very different from the previous design introduced at Magny-Cours, which has a very different layout to the Hungaroring. The wing now sports a much squarer central spoon profile coupled to a wider flap, to produce maximum downforce on the twisting Budapest track. Drag does inevitably increase slightly, but this is not a big issue due to the low terminal speeds here.



Ferrari 248 F1 - front-wing development

A comparison between front wings used in the US and Hungary illustrate the differing requirements of the two tracks. Indianapolis features one very fast section - the final banked turn and long main straight - and one very slow section - the winding infield. The US wing thus has a smaller flap with no Gurney tab, reducing the overall downforce generated, but also guaranteeing a high top speed. For the slow, twisting Hungaroring the accent is on generating enough grip to the tyres. Hence the wider flap, with Gurney tab, to increase maximum downforce.



McLaren MP4 -21 front -wing development

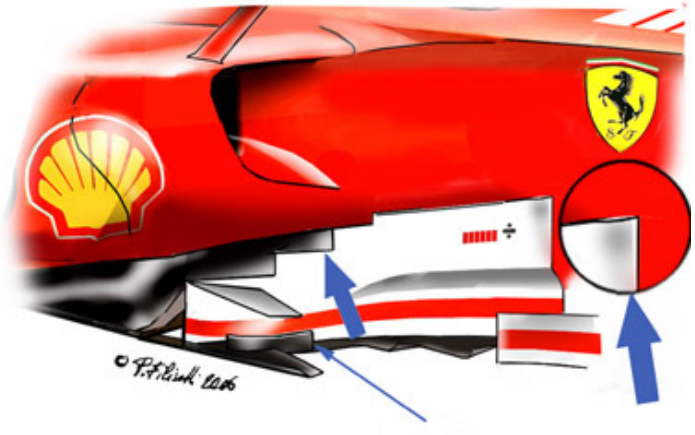
A further development of the endplates, used only by Pedro de la Rosa in Hungary. The leading edge is completely vertical, losing the curves seen on the previous version. This model was specifically designed for this track, in order to provide a better front-end balance. However, Kimi Raikkonen preferred the feel of the earlier German Grand Prix version, so stuck with that - on a twisty track like the Hungaroring, a driver understandably goes with the option that gives him most confidence in the car's front-end behaviour.

Toro Rosso STR01 - wheel rim shields

As seen earlier in the year on the Toyota and Ferrari, in Hungary Toro Rosso introduced rim shields for their rear wheels. A carbon lip is applied to the outer face of the wheel with the aim of improving brake cooling, whilst at the same time providing a minor aerodynamic gain by cutting turbulence near the rear wing. As on the Ferrari, the shield extends inside the rim.

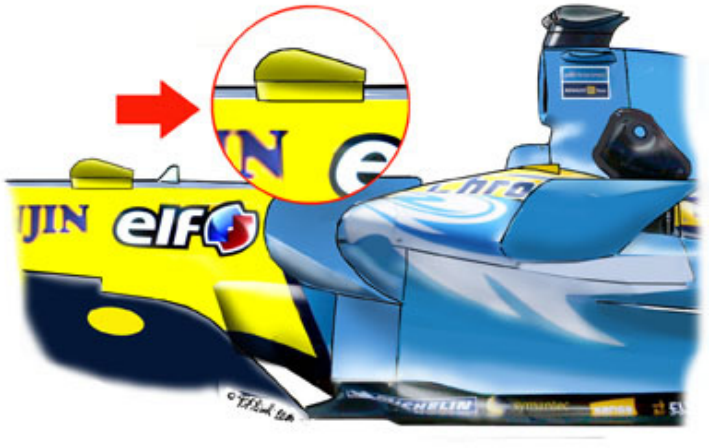
Ferrari 248 F1- rim shields

Ferrari first introduced these at Imola, to help extract the heat generated by the rear brakes. The lip of the shield separates the hot airflow from the rim walls, helping to stabilise tyre pressure by limiting the effect of the brake heat. In Turkey the concept is pushed further, with a wider lip section reducing the size of the central air vent. This improves air extraction still further by decreasing turbulence generated by airflow close to the wheel. It also slightly improves aerodynamic efficiency in this area.



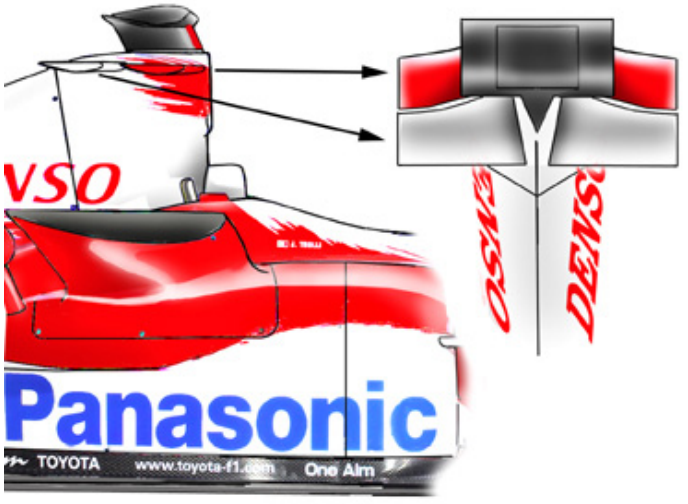
Ferrari 248 F1 - new barge boards

This evolution was tested before the French Grand Prix, but only used for the first time in Turkey. The barge-board profile has changed dramatically, especially the top of the shields. These now feature a clear saw-tooth profile towards the rear, while the front edge has lost its rounded top corner in favour of a sharp, vertical edge (see detail). Another addition is the small, vertical fin (lowermost arrow) right in front of the main profile, connected to the horizontal turning vane, which helps improve airflow management in this area. These changes continue the detailed refinement of the aero package ahead of the forthcoming Monza race, where aero efficiency on the long, fast straights is paramount.



Renault R26 - additional chassis 'ears'

After the outlawing of their mass dampers prior to Istanbul, Renault have introduced several aero changes in Turkey to better balance the car. These additional 'ears', positioned immediately ahead of the cockpit, are similar to those mounted further down the nose at front-suspension level. Their function is to improve the stability of the car's front end, as well as helping to manage the airflow directed to the rear. The target of better aero balance and front-end behaviour is the same as that obtained using the mass damper.

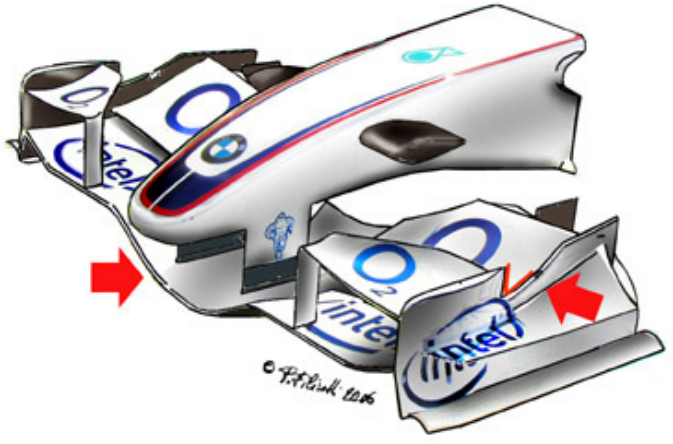


Toyota TF106B - sculpted mid wings

After the triple mid wing seen in Hungary, Toyota move to a double for the lower downforce requirements of Turkey. Viewed from above, you can see the sinuous shape of the front mid wing bending rearwards, while the rear one features a delta shape, reminiscent of the wings of the famous Concorde plane. Such intricate detailing of these elements shows just how important they are in managing airflow directed towards the rear of the car. They improve stability and increase the load generated by the rear wing.

Toro Rosso STR01 - front wing

In Turkey, Toro Rosso are the latest team to adopt the double-decker wing, first introduced by Renault last year and since adopted by others in various forms. The upper profile extends from the inside edge of the endplate, exactly as on the Renault. The benefits of this solution are better handling and sharper front-end response, both the result of the additional downforce, which is generated without any significant increase in drag.

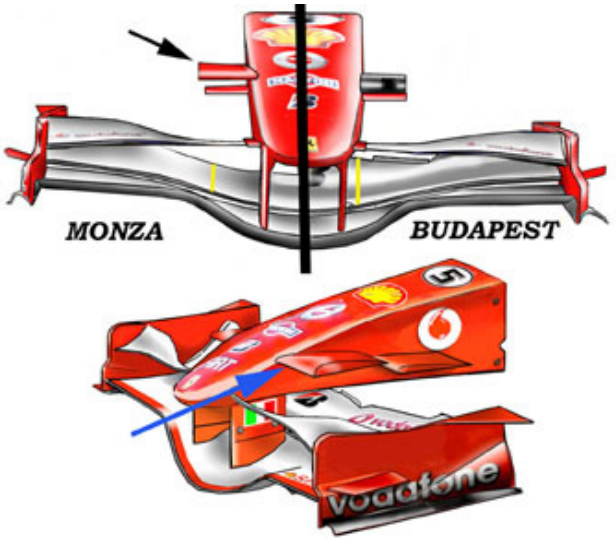


BMW Sauber F1.06 - front wing development

Further modifications for Turkey as part of the ongoing development on the F1.06. The main profile is different, with a deeply rounded central spoon. The top edge of the endplate has changed too - it no longer slopes continuously downwards, but instead has a sharp cut with a vertical edge in the middle, just at the level where the rear edge of the upper profile connects. These changes improve the sharpness of the front end of the car, and slightly increase downforce, as part the mid-level downforce configuration used in Istanbul.

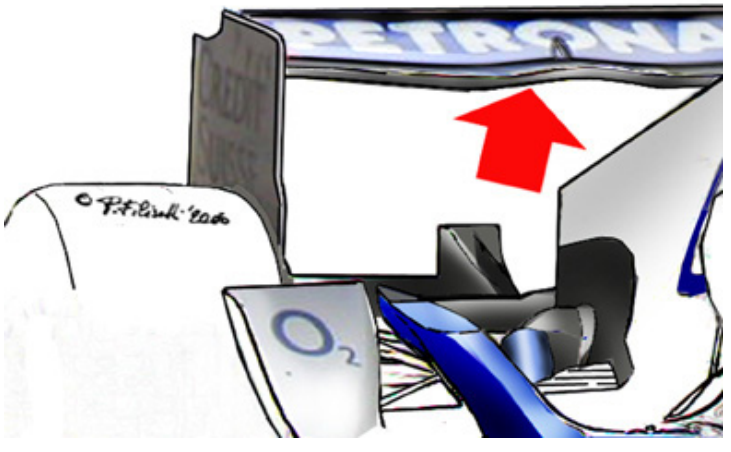
Ferrari 248 F1- rear wing

This has been dramatically revised for Monza, to keep the balance with the similarly modified front wing. It features a high position for the main profile and a very narrow flap, which has a very low angle to reduce drag as much as possible on the long straights.



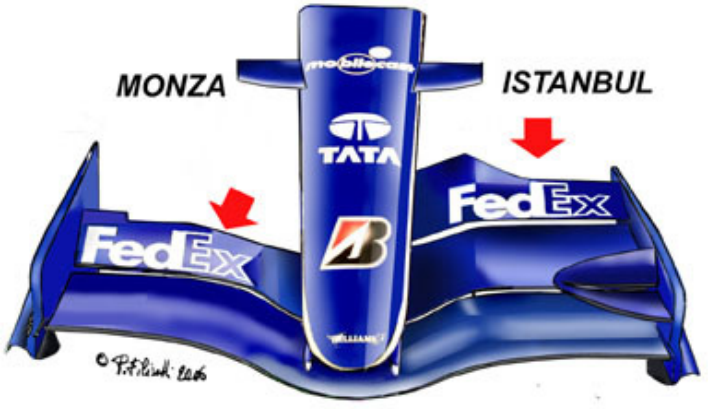
Ferrari 248 F1 - nose winglets and revised wing

At last week's pre-Italy test at Monza last week, Ferrari introduced a number of aero changes specific to this unique low-downforce track, the fastest on the Formula One calendar. To guarantee a sharp front-end turn-in into corners, two clearly visible horizontal winglets have been added to the side of the nosecone (blue arrow). The small amount of downforce these generate aerodynamically stabilises the front of the car approaching corner entry. Of course, the front wing has also been altered, adopting a single flap with a reduced section. Here it is contrasted with the high-downforce wing used in Hungary.



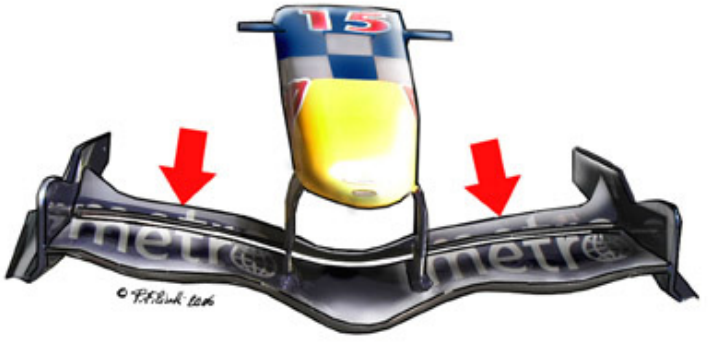
BMW Sauber F1.06 - rear wing

An interesting change for Italy is the rear wing's very particular main profile, which features an apex of sorts at its centre, with slight bends towards its extremities. Such a profile assures a reasonable amount of downforce (compared to the minimal amounts usually found as part of a Monza set-up), but is very efficient in terms of cutting turbulence and drag, as the airflow finds little resistance from the wing's side sections.



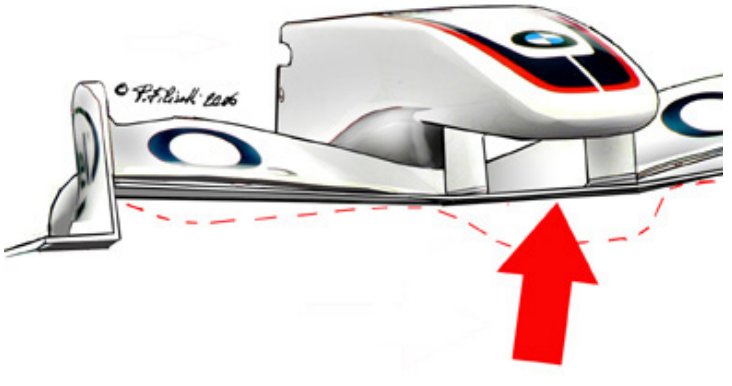
Williams FW28 - front wing

Williams, like all the other teams in Monza, are sporting dramatically reduced wing profiles. The front wing changes are particularly striking, especially the reduced section of the flap, which is now a single design as opposed to the double seen in Istanbul. Furthermore, the additional winglets connected to the inner edge of the endplates have been removed. As a result, the downforce generated by the new assembly is dramatically lower than usual, but so is the drag, a factor paramount in achieving the high top speeds needed here.



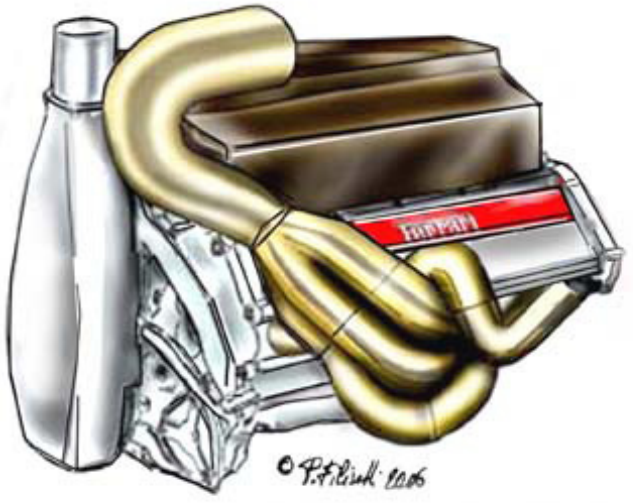
Red Bull RB2 - front wing

Like the other teams in Monza, Red Bull have reduced the section of all their wing elements. What is notable on the RB2's front wing is the extent of this reduction - to almost zero. Only the extremities feature a slightly wider section in relation to the rest of the flap. The downforce generated by this configuration is much less than the standard one, but it's not an issue on this high-speed, low-downforce circuit.



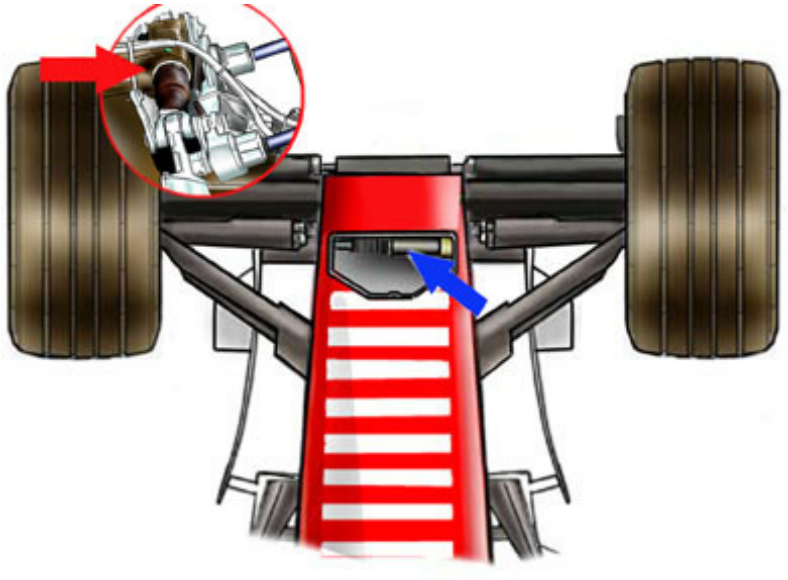
BMW Sauber F1.06 - front wing

Rather than just minimising their front wing design like many of the other teams in Monza, BMW Sauber adopted a completely new main profile. Gone is the usual sinuous shape and deep central spoon profile, replaced by an almost flat design, with the side sections bending only slightly downwards towards the centre. The change proved very effective in gaining extra top speed on the main straights - as proven by Robert Kubica's third place.



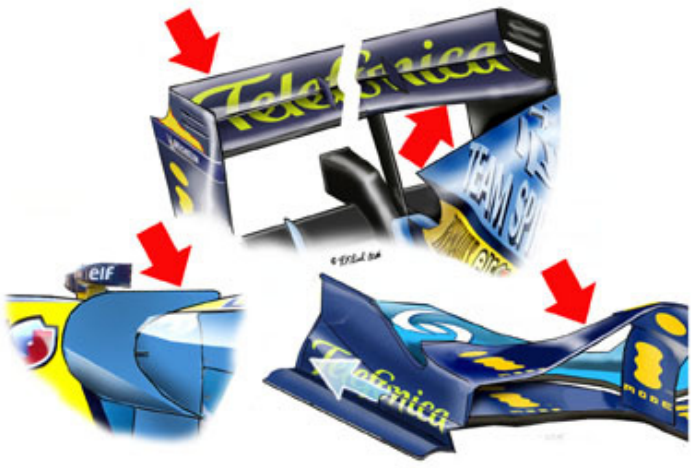
Ferrari 248 F1 - engine improvements

Ferrari's recent strong form has been largely attributed to aero and tyre improvements, but development of the 056 engine - the most reliable V8 in the second part of the season - has also been key and will again play a vital role in China. Shanghai is a stop-go circuit, with plenty of acceleration and heavy braking at either end of the two long straights, plus an almost Indianapolis-like infield. Top speed along the back straight will be paramount, as will low-end torque in the twisty section. As a result, the 056 will sport many subtle changes for China, aimed at improving both top-end power and driveability at lower revs. In combination with suspension revisions, these will help with effective tyre-wear management, and should prove one of Ferrari's main strengths.



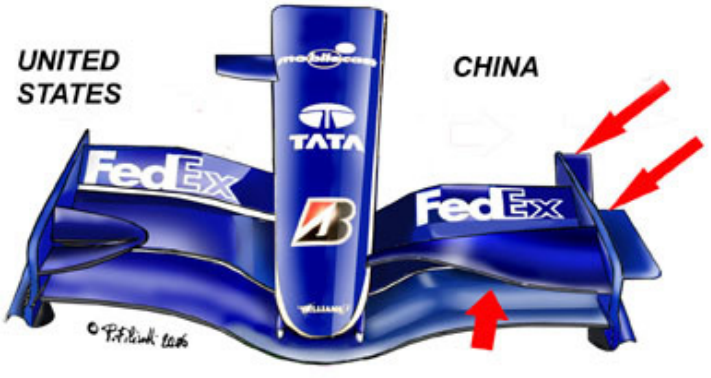
Ferrari 248 F1 - suspension-tyre package

Another Ferrari strength in China will be the 248 F1's suspension package, which along with improved engine driveability, will greatly assist tyre-wear management - in combination with Bridgestone tyres featuring a low degree of hysteresis. This means the rubber is better able to adapt to variations in asphalt roughness - the lower the hysteresis, the lower the tyre wear and the higher the top speed. Such tyres work well with the 248 F1's suspension, which was revised in the summer to better exploit the tyres' potential performance and to enhance their durability. Front and rear suspension follow the same principle, with a central transverse damper, plus horizontal rotational dampers, coupled with torsion bars (see detail). Not only is this layout extremely compact, it means stiffness settings can be changed extremely quickly - very useful in rapidly determining the best set-up, especially during qualifying.



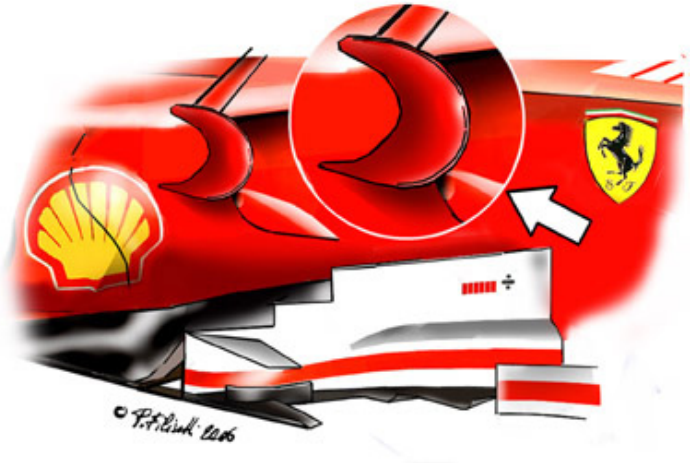
Renault R26 - aerodynamic package

Following the banning of its mass damper, the R26 seemed to lose its edge slightly. In Monza it seemed back in good shape, though the Italian track isn't the most demanding in terms of lateral load transfer and rapid direction changes. Nevertheless, the car looks well balanced aerodynamically, which will be key in China - for reaching a high top speed on the long straights using low-profile wings, while at the same time retaining good handling in the twisty section. The aero package for Shanghai is a development of that used at the not-dissimilar Indianapolis circuit, especially the rear wing (China set-up left, previous set-up right). The front wing should follow the configuration used in Turkey, but with slightly different wing angles. So, aero balance - assuming they get their tyre choice right - will likely be Renault's main strength in Shanghai. The question mark - after Alonso's retirement in Italy - could be the power and reliability of their RS26 engine.



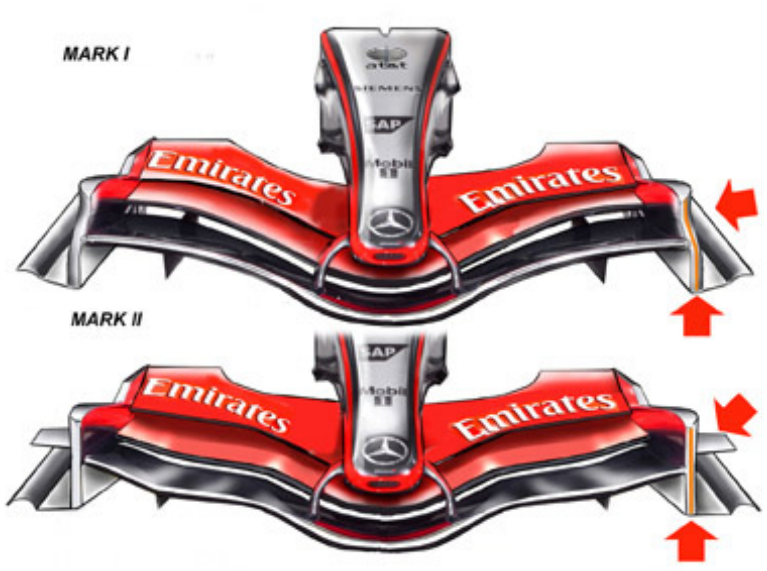
Williams FW28 - front-wing development

Another evolution for China, with dramatically curved upper profiles connected to the nosecone at their inner edge, in a similar fashion to the Renault's. The endplates are the ones introduced in France, with two horizontal airflow splitters - one halfway up in the centre, and one at the upper rearmost corner. There is a clear difference between the design concept of this package and the one used at Indianapolis - despite the fact that the two circuits' layouts are extremely similar.



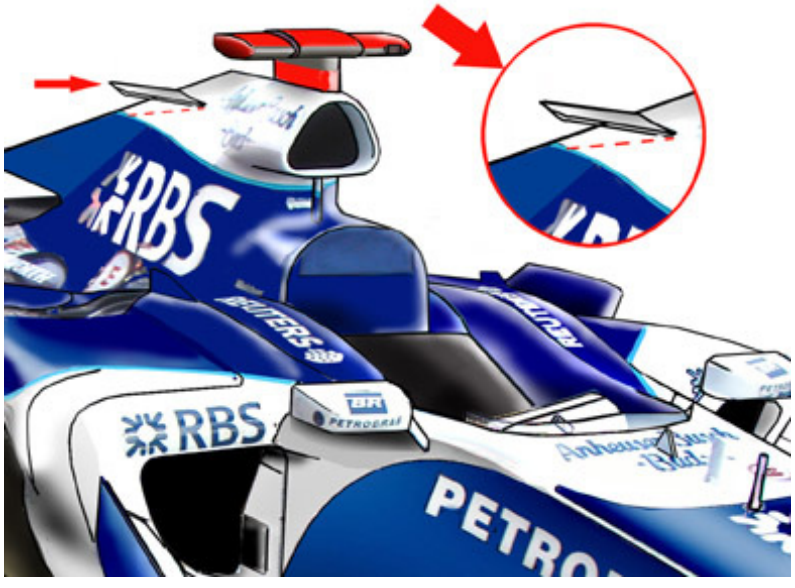
Ferrari 248 F1 - additional 'horn winglets'

New for China, as part of Ferrari's never-ending aero development, but already seen on other cars such as the Renault and the Honda, is this additional device - part of the airflow management in the crucial area in front of the sidepods. These elements' function is to split the airflow in two parts, the upper part directed towards the rear wing, and the lower part directed onto the lower section of the sidepods and the car's stepped bottom. This helps reduce turbulence, generate some additional downforce, and improve the whole aerodynamic efficiency of the car's rear end.



McLaren MP4-21 - alternative front wing solutions

McLaren brought two solutions to China, their differences related to main profile and endplate. Both are an optimised mix of previous designs seen throughout the season. The Mark I version sports the original spoon profile introduced early in the year, coupled with the endplates adopted at Hockenheim. These endplates feature a vertical S-profile with a vertical bottom, and are missing the mid-height horizontal winglet seen on previous versions. The Mark II solution features the double-curve profile introduced in its definitive version at Silverstone, coupled with the completely vertical endplates adopted by De la Rosa in Hungary. The Mark I is slightly biased towards the fast section of the Shanghai circuit, the Mark II to the slower part. Both, however, provide similar amounts of overall downforce.



Williams FW28 - mid wing

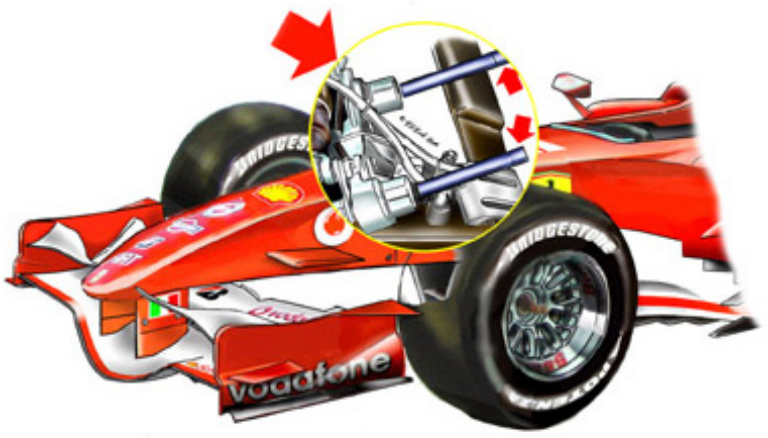
Another aero development for China is a new mid wing on top of the engine cover. It is new in that it is not horizontal, but instead slopes upwards. This makes it more efficient in that it generates a higher quality airflow to the rear of the car, with less turbulence. Being in the middle of the chassis, this device is genuinely helpful in improving the car's overall aero balance, without altering the loads at the front and rear.

Toro Rosso STR01 - rear wing

A brand new rear wing for China. The main profile and flap sport a curved profile at the centre, with the exit edge of the flap remaining completely flat. The endplates feature a drag-reducing cut at the rear of the top edge, similar to that on the Williams. They also have a long, vertical slit just behind the edge of the rear wheels - again not disimilar to the FW28.

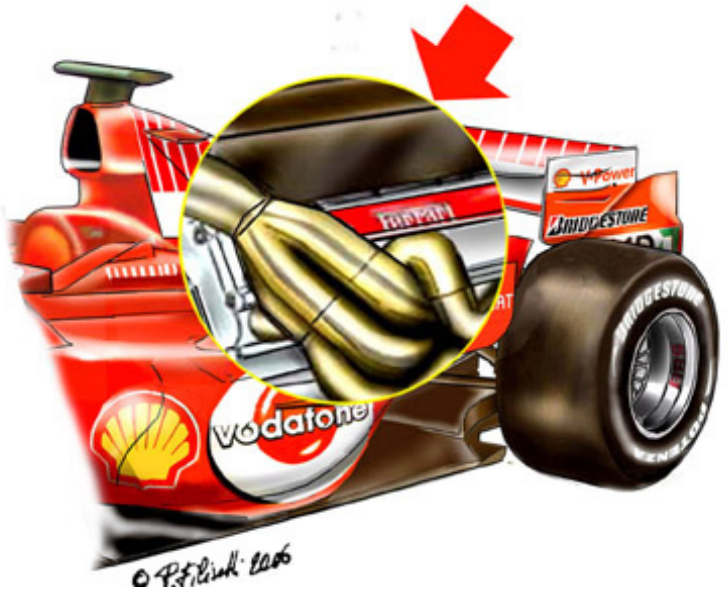
MF1 M16 - rear wing

Some new aero elements, as well as a new livery in China. The rear wing's flap is a new design, now bending forwards, noticeably so at its extremities, giving the wing a completely new cross-sectional profile specifically for this track. The result is improved downforce and reduced drag, to cope with the speed needs of the long straights as well as the handling requirements of the slow, twisty sections.



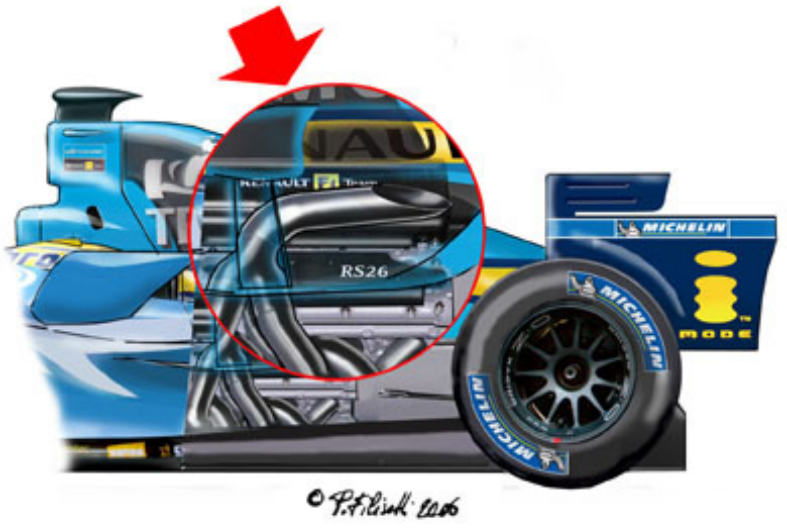
Ferrari 248 F1 - tyres & front suspension

Tyres will again play a key role in Japan, but in a different way to in Shanghai. The Suzuka tarmac is far more abrasive, hence tyre wear is a far bigger issue. That means suspension set-up - in combination with aerodynamics - is crucial not only in determining the amount of grip available from the tyres, but also the rate at which they wear. The excellent stability of the 248 F1 is a real advantage in this respect and its Bridgestone tyres should fit well with the demands of this highly technical track. The resulting package should provide very good handling through Suzuka's fast direction changes and the ease of adjustability provided by the 248 F1's compact suspension layout (see detail - central transverse damper, plus horizontal rotational dampers, coupled with torsion bars) will help the drivers fine-tune their cars to near perfection.



Ferrari 248 F1 - engine

As in China, in Japan Ferrari's engine and suspension will be among their car's main strengths, both playing a vital role in the overall balance of the chassis - something arguably even more important at Suzuka than in Shanghai. The engine obviously needs to be powerful, but also flexible and capable of huge acceleration from relatively low speeds. Thus torque takes precedence over output. That torque then has to combine perfectly with appropriate tyres, so that as much power as possible can be transmitted quickly and effectively to the ground.

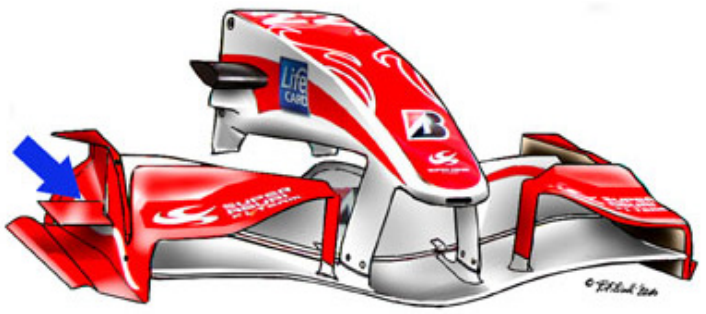


Renault R26 - engine

If Ferrari do have a minor power advantage over Renault, it shouldn't be too much of an issue for the champions at Suzuka, where torque and flexibility are more important than output. The power range of Renault's RS26 V8 should be increased to provide a smoother throttle response. This will not only make the car even more driveable, it will help reduce tyre wear, which can be high at this track due to its highly abrasive surface.

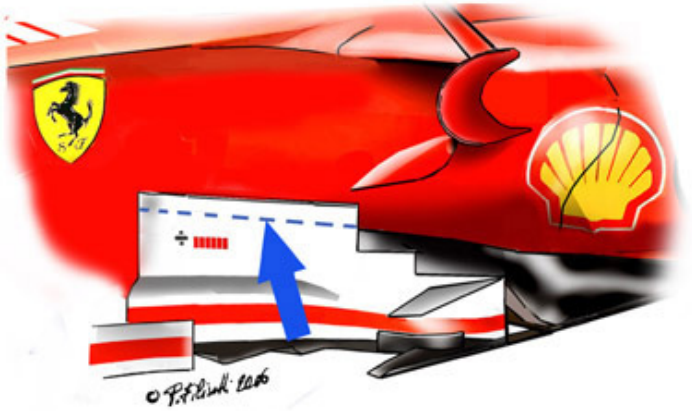
Renault R26 - aero package

You might expect Suzuka to be a tricky circuit for Renault, after the banning of their mass damper device. Its very fast direction changes require a perfectly balanced car, and quickly expose handling deficiencies. The good news for Renault is that, as in Shanghai, the R26's aerodynamic balance is strong. The aero package the team will use here is not much different from that adopted in China, but uses a lower downforce configuration, as average speeds are higher. The two sets of winglets on top of the nose (top-left, top-right arrows) have (with the exception of the high-speed Monza race, where a single winglet was used) been present since the mass dampers went, to help ensure adequate front-end balance. Another key element are the winglets in front of the sidepods (bottom-right arrow), introduced in Canada and since adopted by many teams, including Ferrari in China.



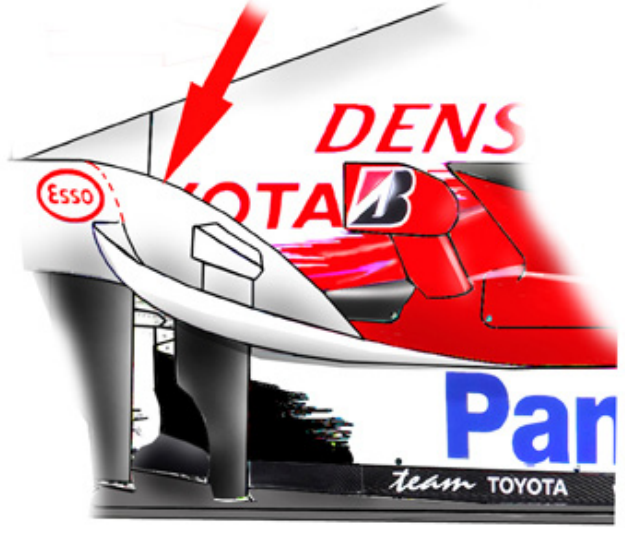
Super Aguri SA06 - front-wing development

The Super Aguri features a small but interesting change for its home race. The front wing now sports a horizontal profile at middle height on the endplate, located in a more rearward position than those on other cars. This element is sure to help in terms of turbulence and airflow management in front of the wheels, and it is encouraging to see a brand new team still pushing forward with aerodynamic development at this late stage of the season.



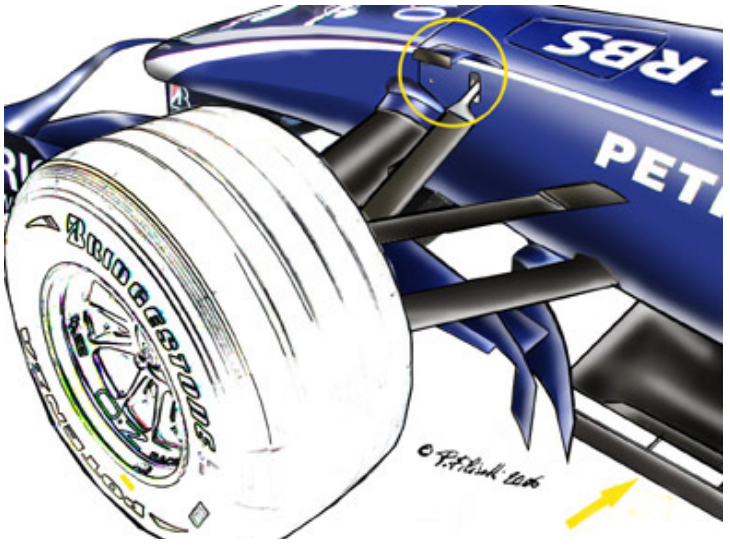
Ferrari 248 F1 - barge boards

One of the most heavily developed areas of the car, the barge boards have shown numerous changes over the season. The last one in Japan is small but significant and relates to a visible increase in the height (blue arrow) of the 'upper step' of the main shield in front of the boards. Varying the height of the saw-tooth profile helps in reducing turbulence and improving engine cooling relative to the varying needs of each track. The change is very subtle, but nonetheless relevant in terms of reliability - so crucial at this stage of the season.



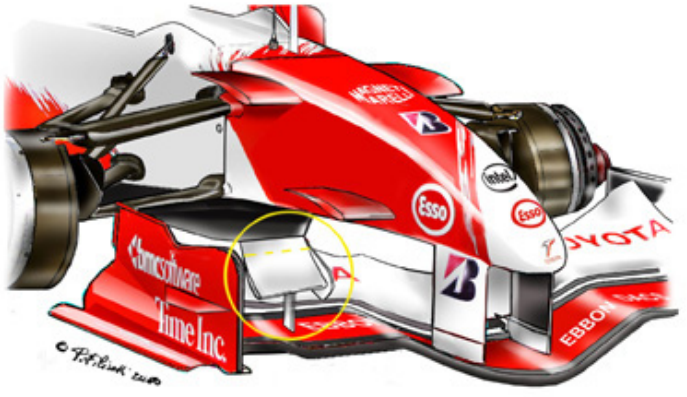
Toyota TF106B - rear fences

An interesting development in Japan is the elongation of the vertical fences connecting the rear flip-ups. These elements are now clearly longer than their original version, reaching the level of the winglets just behind the venting chimneys. More a refinement than a major change to the aero set-up, it adds to the Toyota-Bridgestone package, which proved highly competitive in Saturday's qualifying session.



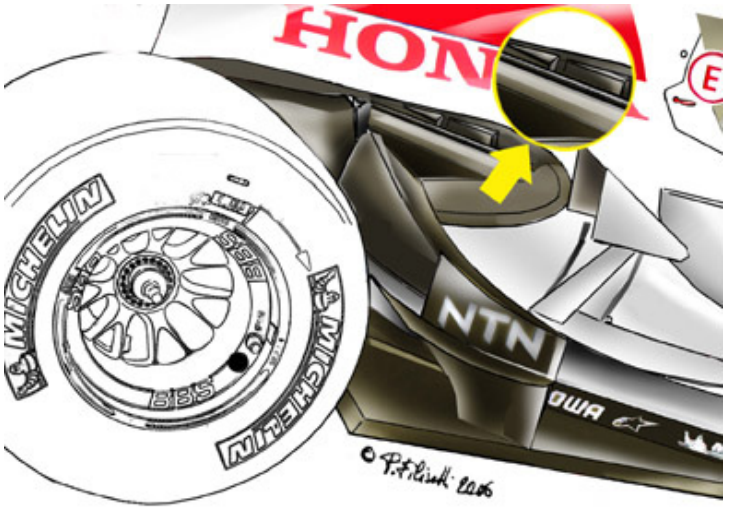
Williams FW28 - barge boards and ears

For Japan, a tiny vertical turning vane (yellow arrow) has been added parallel to the side of the splitter's foremost section. Both elements connect to the front barge boards and help improve the quality of airflow directed to the bottom of the car. This generates additional downforce and helps reduce pitch sensitivity. Related in function are the Renault-style ears on top of the chassis (yellow circle), first introduced in China last week. These reduce vibrations at the front end and split the airflow directed to the rear of the car in two, cutting turbulence and improving airflow quality, to the benefit of cooling and rear-wing efficiency.



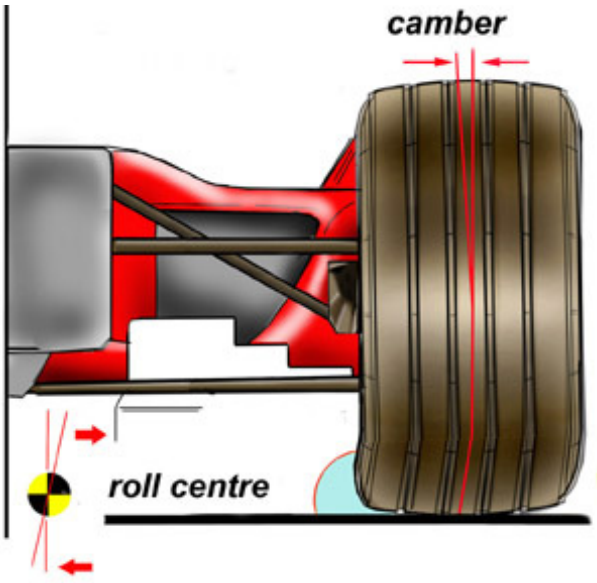
Toyota TF106B - front wing T-winglets

For Japan these have grown in size, with an increased cross section and a more curved side profile. This raises the amount of downforce produced with the tradeoff of some added drag. Their effectiveness has been shown in the ability of the Toyota to get the most out of its front tyres on the highly technical Suzuka circuit.



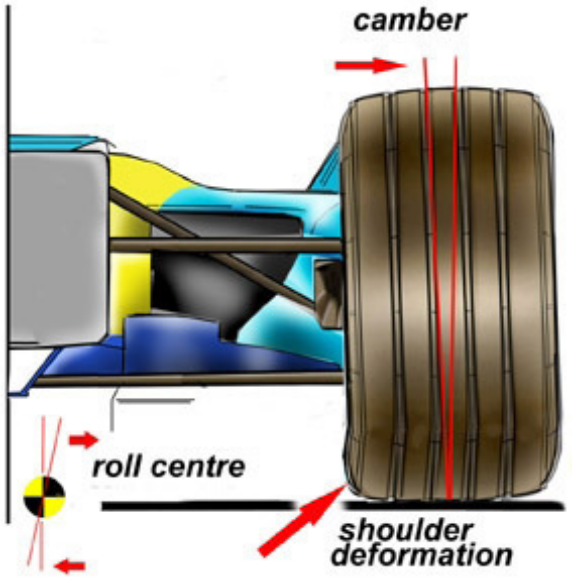
Honda RA106 - exhaust side-cooling vents

A small, but interesting modification for Japan is these small cooling vents placed in the area close to the exhaust pipes on the Honda. These provide better extraction of hot air from the sidepods, caused by the high pressure of the exhaust gases. Furthermore they actually increase the speed of the airflow in this area by adding a portion of hot, high pressure (and hence faster) air. This is useful in increasing the efficiency of the rear diffuser, helping it to better extract the air from the bottom of the car.



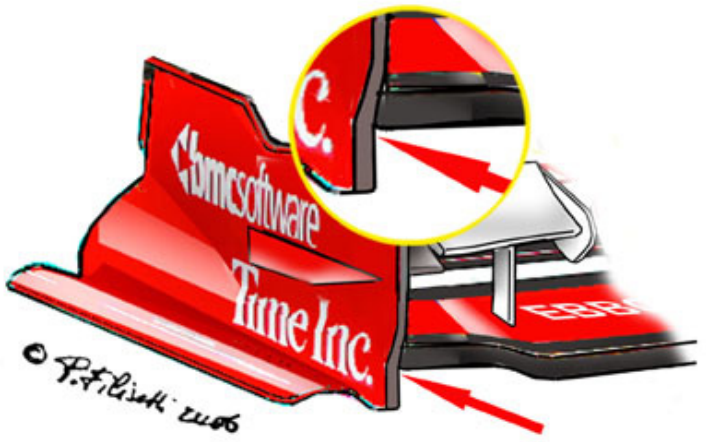
Ferrari 248 F1 - suspension geometry

One of the 248 F1's strong points is its ability to exploit the full potential of its Bridgestone tyres, while maintaining very low wear rates and avoiding disruptive phenomena such as graining and blistering. The car's suspension geometry features a very small camber angle, made possible by what's believed to be a slightly more flexible shoulder on the Bridgestone tyres in comparison to this season's Michelins. This means the tyre slides less in the corners, reducing major heat fluctuations in the tyre's surface. This in turn reduces graining in the early laps and lessens the likelihood of blistering towards the end of a stint.



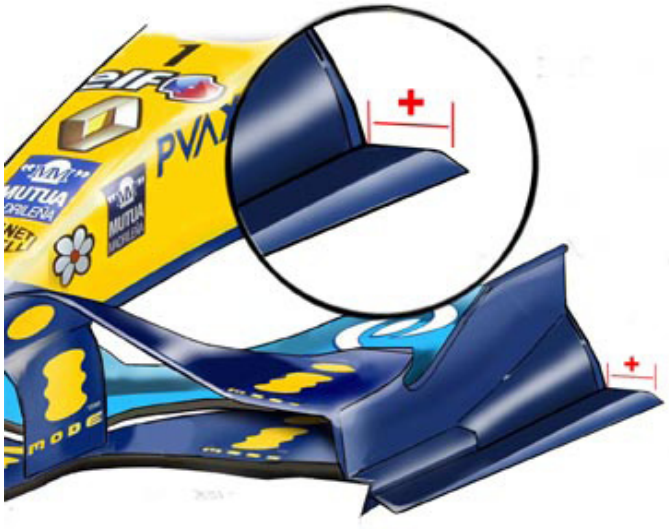
Renault R26 - suspension geometry

On the surface the R26's geometry looks little different to that of its Ferrari rival, at least in terms of its centre of roll position, due to similar positioning of the suspension's pick-up points. What differs is the respective lengths of the upper and lower wishbones and the average camber angle used. That angle is clearly higher than that on the Ferrari, due to the fact that the shoulders of the Renault's Michelin tyres are reportedly less flexible than the Italian car's Bridgestones. This in theory means more lateral sliding in the corners, quickly increasing the temperature in the tyre's contact patch. This means the Renault could be more susceptible to graining in the early laps on fresh tyres and blistering towards the end of a stint.



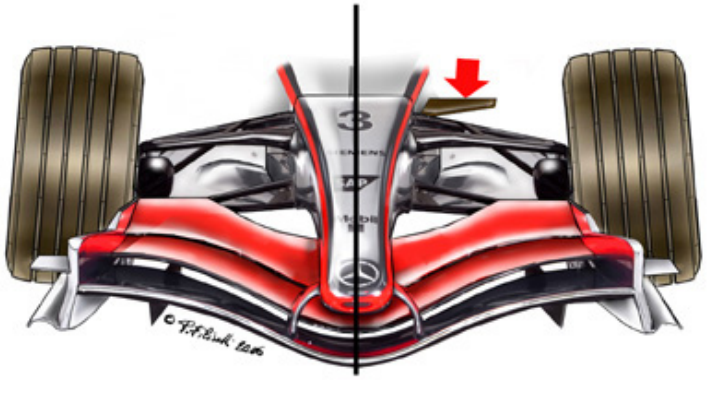
Toyota TF106B - front-wing development

In Brazil, a small but interesting change to the endplate, which now features a curving - rather than straight - vertical profile. This increases the width of the 'channel' under the wing profile, in turn raising the quantity of air passing under the wing. This improves the efficiency of the bottom of the car by directing more air underneath it, therefore generating more downforce.



Renault R26 - front-wing development

Not surprisingly, the last race of the season sees relatively few changes. This one was introduced at the last round and remains for Brazil. The knife-edge profile on the front wing's endplate has been widened, in turn reducing the overall section of the wing elements. This is to reduce airflow disruption caused by the front wheels close to the extremities of the wing. With the airflow hitting the front wing finding less turbulence, this cuts drag and improves overall aerodynamic efficiency.



McLaren MP4-21 - front chassis winglets

McLaren continue their aero development into the final round in Brazil with two horizontal, pointy winglets (red arrow), one either side of the chassis' foremost section. These slightly odd-looking elements serve a similar function to the similarly-located devices seen on the Renault this season. They improve the car's front-end balance, by improving airflow quality in this area and adding a small amount of downforce. As on the R26, the elements help in stabilising the front of the car over the frequent bumps found around the Interlagos circuit.

Ferrari 248 F1 - fuel system

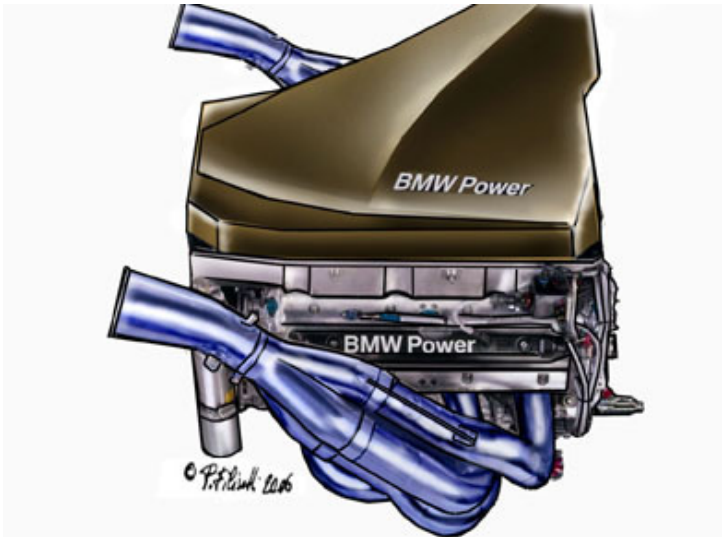
According to Ferrari, the failure that stopped Michael Schumacher running in the third qualifying session in Brazil was related to the fuel pump. The failure prevented fuel being correctly transferred from the tank to the engine's injection system. A Formula One car's fuel system can be summarised in four main elements: the pump (1) aspirates the fuel from the tank by means of a small suction duct (2), which can catch fuel even when the level in the tank is very low. The fuel is then transferred to a central main duct (3). This is connected to a final duct (4), which is in turn linked to the engine's injection system.

General - experimental cockpit GPS system

Trialled in Brazil, this safety feature is due to become mandatory next season. The system comprises three LEDs in the cockpit, representing the yellow, red and blue warning flags used by marshals. The aim is to avoid the risk of drivers not spotting flags being waved by marshals. The marshals will be able to signal race control when an incident occurs, allowing the race director to switch on the appropriate LED in cars as they pass through the affected area of track. In the case of a red flag, the red LED in all cars will come on simultaneously.

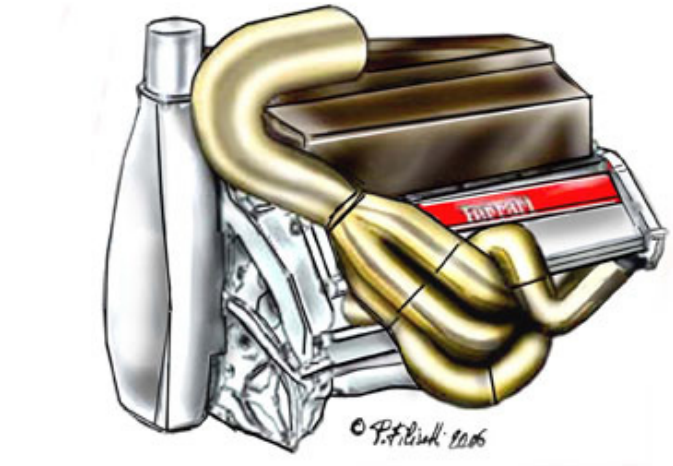
Ferrari 248 F1 - cooling vents

Ferrari knew reliability would be paramount in Brazil if they were to have any chance of beating Renault to the title. To avoid any risk of overheating, they adopted an asymmetrical cooling configuration, with five separate vents on the top of the left sidepod, plus a triangular one under the winglet, but only two vents on the right sidepod. This helped the team to fully exploit the increased power and higher revs of their single-race engine, taking Felipe Massa to a comfortable win at his home event.



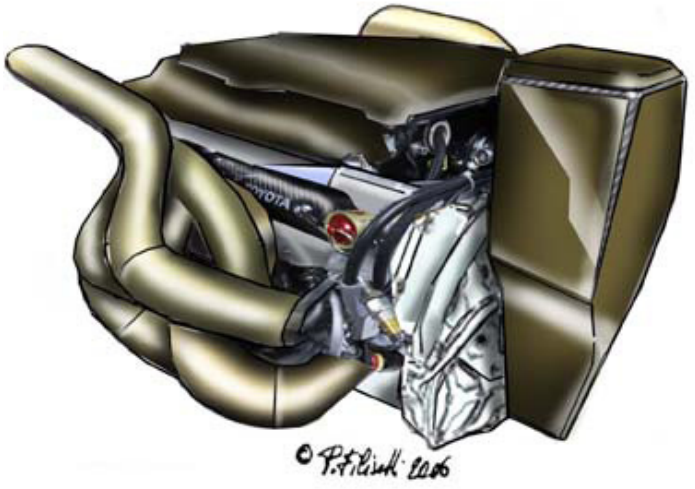
Engine analysis - **BMW P86** (20 Nov.)

With the 2006 introduction of the 2.4 litre V8 rule, this engine was built from scratch, with its development then phased into three steps over the season. The aim was to start with a solid foundation and then gradually raise the revs. Specific figures for peak power and revs were not revealed, but the P86 was certainly very capable of high rpm. By the end of the year was generally considered the third most powerful engine, just behind Renault and Ferrari. The 20,000 rpm barrier was certainly broken, the optimum probably closer to 21,000.



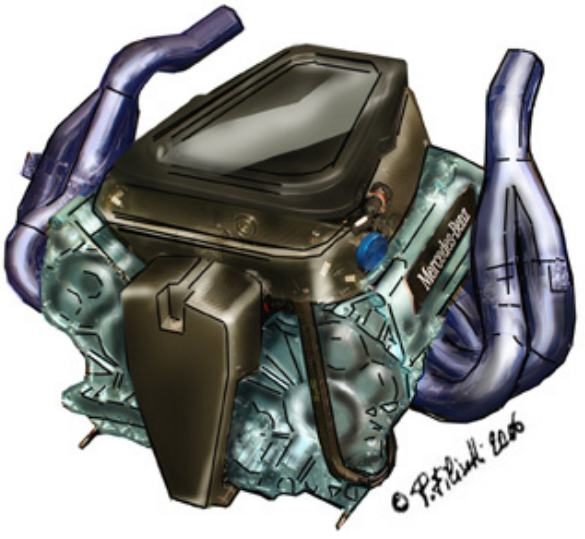
Engine analysis - **Ferrari Type 056** (20 Nov.)

Designed by Gilles Simon under the supervision of Paolo Martinelli, this engine was conceived as a reliable starting point not just for the 2006 season, but also for 2007. It may have lost two cylinders, but the new V8 was no lighter than its V10 predecessor, as Ferrari focussed on strengthening the inner mass of the engine to reduce the risk of possible weaknesses - even though in many ways the vibrations generated by a V8 are less disruptive than those of a V10. It represented a cautious start to the season, as Ferrari concentrated on issues with other parts of the car. However, they pushed hard on engine development later in the year, clearly increasing the revs, as well as paring away some of the weight. It didn't go entirely to plan, with Schumacher's engine failure at Suzuka costing him the race - and arguably the title.



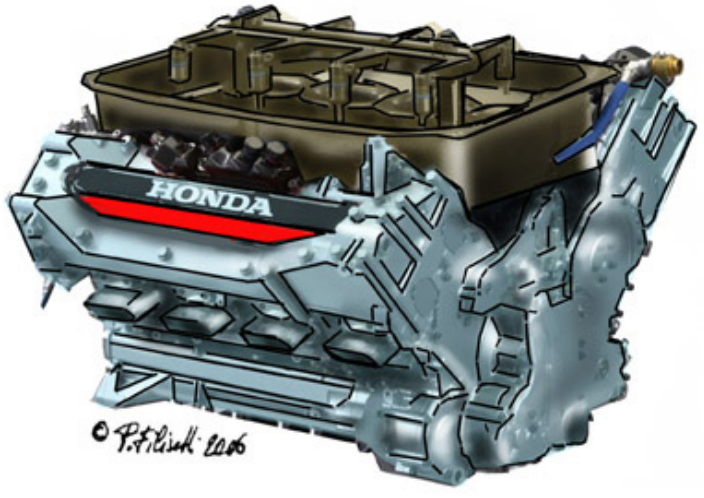
Engine analysis - **Toyota RVX-06** (20 Nov.)

A controversial engine in many ways. In previous seasons the engine has always been a strong point of the Toyota package, but this year it wasn't always so. The TF106 had weaknesses in several areas and the engine was certainly among them. It reportedly lacked top-end power, usually running lower revs than its rivals. The engine block, on the other hand, was one of the lightest - a potential advantage in terms of performance, but a potential risk in terms of reliability. This should not be considered a mistake on the part of engine designer Luca Marmorini, rather a reflection of his compliance with requests from Mike Gascoyne's chassis department to give them more freedom with weight distribution.



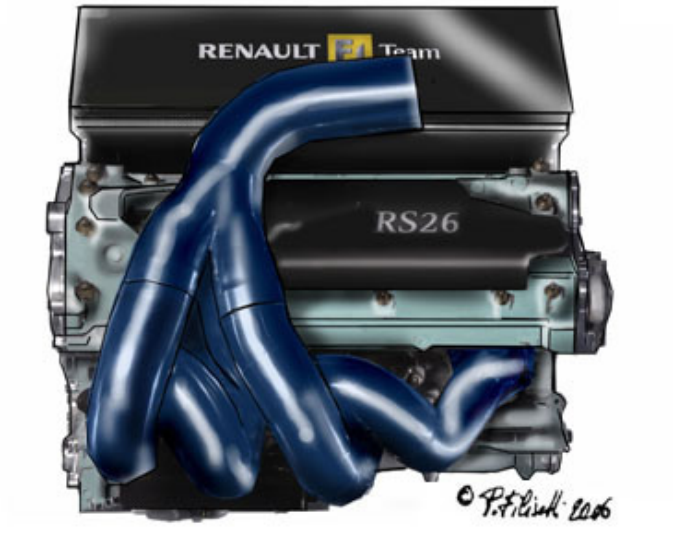
Engine analysis - Mercedes FO 108S (20 Nov.)

This engine displayed some worrying reliability problems right from the very start of last winter's early testing sessions. In fact, for much of January McLaren were obliged to run the MP4-21 in a hybrid configuration, using a modified version of the older V10. By the first race in Bahrain, the inner weaknesses of the V8 had seemingly been solved, but over the course of the season this proved not to be the case. As with the Toyota, the McLaren's problems weren't only engine related, but the need for several pre-race engine changes combined with a string of retirements helped prevent the team scoring a victory in 2006.



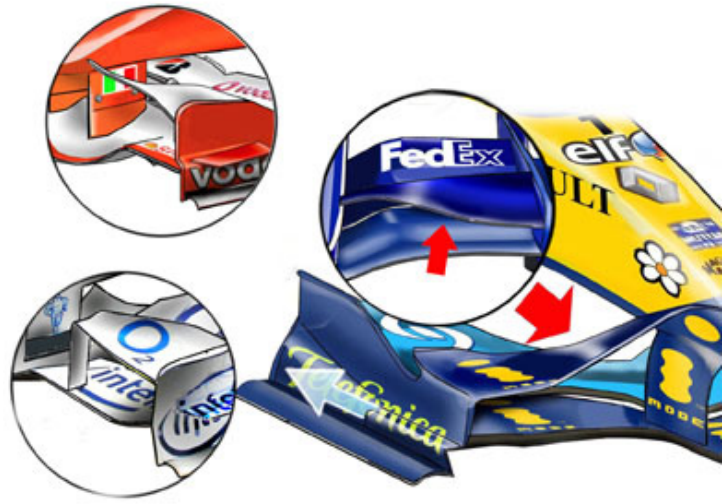
Engine analysis - Honda RA806E (20 Nov.)

Honda's 2005 engine was one of the most powerful on the grid. That looked to have changed with their 2006 V8, which early in the season displayed lacklustre performance, with a definite lack of torque and acceleration. However, as is tradition with the Japanese maker, the engine was developed at each race, increasing maximum revs in search of top-end power while maintaining a wide rev range. It may not have been as light as the Toyota block, but the RA806E was still believed to weigh in at under 94 kilogrammes with its ancillaries. In the second half of the season, this, combined with a noticeable increase in power and refinements in the RA106's aerodynamics, helped make the Honda far more competitive.



Engine analysis - Renault RS26 (20 Nov.)

The RS26 was the jewel in the Renault's crown. The basis for its design included all the things that were good about its V10 predecessor, the RS25, meaning the team weren't really starting from scratch, even if they were losing two cylinders. The concept was a reliable, fuel efficient engine, that wouldn't need to rev extraordinarily highly in order to be competitive. But Renault did have to modify its intended development path slightly, pushing things on towards the end of the season as Ferrari got closer and closer. They seemingly pushed too far at Monza, where Fernando Alonso's unit failed, and the team reined things in slightly for China and Japan - just by enough to avoid reliability problems and hence beat Ferrari.

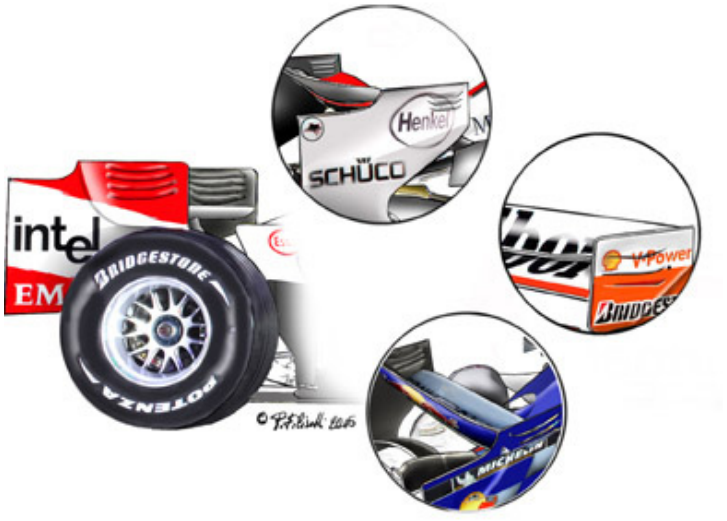


2006 trends - double-profile front wing (13 Dec.)

This concept, which adds significant downforce but minimal drag, was originally introduced the previous season by world champions Renault (right) at the 2005 San Marino Grand Prix. They continued its development into 2006, peaking at the German race. Its design concept was copied by Ferrari (top left) from the start of the season, with other teams then following the trend, BMW Sauber (bottom left) among them. Their latest version, introduced in Turkey, sported double profiles extending just halfway along the main profile.

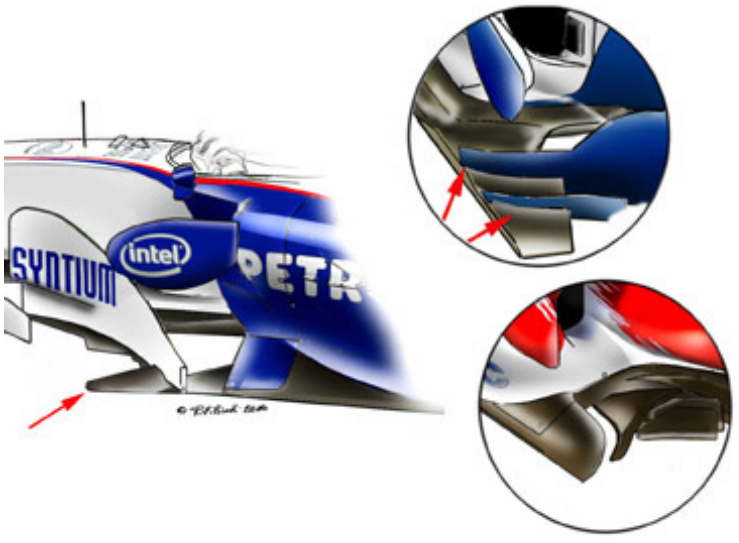
2006 trends - front sidepod shields (13 Dec.)

Honda (right), or rather BAR, were the first team to introduce their distinctive 'shields' back in 2005. Designed to raise downforce and improve airflow to the rear of the car, they were developed significantly by the Japanese team in 2006, peaking in size at the Canadian Grand Prix. Renault (bottom left) introduced their version at the same race, while Ferrari (top left) followed the trend closely towards the end of the season. After continuous development of this area of the car, with multiple barge-board configurations, the Italian team adopted a very similar device in China.



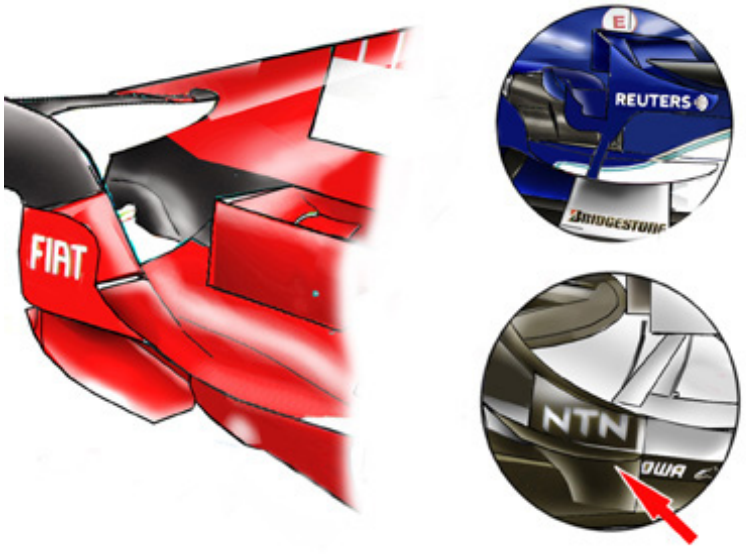
2006 trends - rear wing slits (13 Dec.)

They may not have been as noticeable as the front wing revisions, but there were significant changes at the rear. At the start of the season Toyota's TF106 (left) featured multiple horizontal slits in the top edge of the endplates. The slits help reduce turbulence generated by the endplate profile and cut drag in the boundary area between the endplates and the flap. McLaren (middle top) soon adopted the solution and indeed, as with the double-profile front wings, most teams followed suit, including Ferrari (right) on the 248 F1 and Red Bull (middle bottom) on the RB2.



2006 trends - turning vanes (13 Dec.)

The area immediately in front of the sidepods was one of the most keenly-developed of the season, with the eponymous shields at the top, and a variety of turning-vane solutions at the bottom. Honda were arguably the pioneers here, but the design introduced by BMW Sauber (left) in Germany was among the cleanest. It featured few additional elements, helping to retain much of the original design profile, and yet dramatically increased the efficiency of the underbody of the car. In contrast, Williams (top right) and Toyota (bottom right) added multiple fins and profiles in a bid to make up for the downforce and stability apparently lacking in their cars' original design concepts.



2006 trends - double rear winglets (13 Dec.)

These were orginally introduced by Renault in 2005 and retained on the R26. However, it was arguably Ferrari (left) who best interpreted the function of these additional wings, adding them in the latter part of the season, with notable modifications at Hockenheim, to improve the airflow management in front of the rear wheels. The result was reduced drag and better extraction of air from the rear diffuser's side sections. Many teams adopted the same concept, but not quite as neatly. Williams (top right) improved their aerodynamic performance with a very complex solution, featuring a wide vertical pillar below the winglet to divert airflow towards the centre of the car's rear end. A similar solution was featured on the Honda (bottom right), with Super Aguri and Spyker also on the same wave length.