Front Wing Aerodynamics

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Formula One is a high-speed sport with top-of-the-line cars often considered at the forefront of automotive engineering. During a Formula One season, these cars are raced around the world in a series of 24 races. These races are called Grand Prix and are raced on special tracks that all require a different driving technique. Red Bull is a particularly exceptional team in this sport. Red Bull has had 8 world championship titles since 2010 (StatsF1). This is due to a combination of things: great drivers, great pit crew, great engineers, and great cars. In recent years, teams like McLaren have made changes to their car that seem like night and day, putting Red Bull one step behind.

The front wing and nose cone are an example. Red Bull has made significant changes to the RB20 front wing almost every race due to them desperately trying to regain control of the 2024 season (Autosport). The 2025 season is not looking much better with Max Verstappen making these comments: “Then in qualifying, everything felt bad. Every corner was a struggle; I just didn’t have the balance. It was either understeer or oversteer. Even every single lap that I did, I had a bit of a different behaviour from the car, so that’s not ideal” (Verstappen).
With the FIA redefining how cars will be manufactured in 2026, Red Bull is overdue for a change. The cars will be 30 kg lighter, feature a dynamic rear wing, removal of DRS (drag reduction system), and a 100mm decrease in the width of the car (Formula1). This should allow for more agility, overtaking possibilities, and closer racing. More importantly, to the front wing, the new 2026 regulations say it should have a dual airfoil system as opposed to the multiple sections used prior, as well as a 100 millimeter decrease in width. Due to this, I decided to take my best shot at modeling a new front wing setup following the new 2026 guidelines, which would perform better than the current RB21 setup.

I started by looking at the race highlights of 2024 and some 2025 races that were complete. During these highlights, McLaren was particularly notable. Their car, called the MCL38, seemed to cut through the air on a level unmatched by the other cars. This warranted a closer look at their car. Upon further inspection of their front wing, I noticed a difference in geometric structure and, more importantly, flow.

The RB21 seemed to adopt a more rigid, aggressive design. It featured three airfoils on the front wing with a sudden geometric change when tapering down toward the middle. MCL38's front wing has four airfoils as opposed to three, but has a gradual flow, which the RB21 lacks. There are no sudden geometric changes. The RB21 had a sudden decrease in the sizes of its airfoils as you moved up the car, as opposed to the MCL38's gradual decrease and overall skinnier airfoils. The endplates were also to be noted. The endplates on the MCL38 had a trapezoid shape to them, with a slope that was also different from the rectangle that Red Bull possessed. This caused me to look at the other cars like the Mercedes W16 and the SF-25. There was a strong resemblance between all these cars, most notably in the flow (gradual changes in geometry typically from big to small), size of airfoils (on the skinnier side), and number of airfoils (four).

Although, as the 2025 season is progressing, Red Bull is actively changing many aspects of their car, especially the front wing. There has been an evolution of the front wing that is starting to resemble a mix of the Mercedes W16 and SF-25. The technical director for Mercedes, James Allison, evaluated Red Bull's Imola upgrade, which included a revised floor and front wing, and said, "It does look as if their upgrade was a downgrade." Allison remarked. "That makes life hard because the moment you stop trusting your tools, you backtrack and you start losing time" (Mitchell, Autoracing1). This seems to be true because, despite a significantly improved front wing, they are still in fourth overall for the constructors' championship by a large margin. Max Verstappen said, "I've said a lot and now it's up to the team to come with a lot of changes with the car, because we went from a very dominant car to an undriveable car in the space of six to eight months," and "That is very weird for me and we need to turn the car upside down" (The Makings of a Monster). The 2026 season could turn this around.

I used the software FreeCAD to model a front wing and nose cone for Red Bull that adheres to the 2026 FIA regulation changes. This design assumes other aspects, such as the monocoque, ground effects, and rear wing, are altered according to the new changes as well.

The front wing is 1900mm long and features a dual front wing design. The bottom airfoil is 950mm long by 150mm wide, and the top airfoil is 950mm long by 95mm wide (Figure 1). Both airfoils start at a thickness of 30mm and taper down to 10mm. The bottom airfoil has an angle of attack of 8 degrees to the ground, while the top has an angle of attack of 10 degrees to the ground. This is mirrored on both sides. The nose cone sits 52.71mm behind the tip of the first airfoil (Figure 7), with the length being 1800mm long and 150mm wide, and a thickness of 30mm at the tip, fanning out to 113mm at 37

7mm in length before narrowing out to 125mm (Figure 2). This incorporates something similar to the bubble design from the Ferrari SF-25 (Figure 6). The angle relative to the ground is 12 degrees (Figure 2). The bottom of the nose cone, as well as the front wing, should both sit 70mm above the ground. The space between the two airfoils is 21.5mm to accommodate the active aerodynamics (Figure 5). The endplates incorporate a curved trapezoid-type design featuring a 15mm extended end plate winglet for added aerodynamics (Figures 4 and 5).

This design incorporates a steady flow of wing geometry near the airfoils similar to that of Mercedes W16 and Ferrari SF-25. The nose cone is inspired by Ferrari. Due to the nature of active aerodynamics, the airfoils had to be placed farther apart than usual in order to have enough clearance to move freely while active aero is working. This is why the bubble design to cover all the airfoils, then taper down again, was so effective. The endplates are inspired by McLaren. The endplates complemented their front wing geometry very well due to the similar sculpting of the airfoils and endplates. The endplates pick up where the airfoils left off by guiding air to the tires, which provides cooling, as well as helps generate downforce in tandem with the airfoils. Since this design had a similar geometry to McLaren, the curved trapezoid endplates would highly benefit the overall front wing. To gather the measurements used in this model, I relied mainly on analysis of the 2024 - 2025 F1 season, known measurement changes stated in the 2026 FIA regulations, and FreeCAD's proportional scaling with high-quality close-up images.

To estimate whether my model would yield better performance than Red Bull, I applied basic concepts of aerodynamics and known formulas for lift and drag. First, I found the surface area of each airfoil in my wing, which totaled $0.3m^2$. I then calculated the downforce in each airfoil by using the lift formula, because in motorsports, downforce is negative lift, resulting in a lift coefficient of 1.0 for the bottom airfoil and 1.1 for the top airfoil. Next, I employed the downforce equation to calculate the downforce of the whole wing and got 729N. I then calculated drag using the drag equation and got 46.9N. This results in a L/D (lift to drag ratio) of 15.5. Red Bull's estimated L/D that I calculated using approximations resulted in 7.8. The number 7.8 was obtained by using a lift of 700 and a drag of 90.1. The reason the L/D number is important is that it tells us how much lift, in this case downforce, is being produced for every unit of drag. So the higher the number is, the more efficiently downforce is being produced for every unit of drag, and vice versa for a lower number. The reason 7.8 was the result of Red Bull's L/D is because of the 2024 regulations allowing multiple airfoils as well as a larger overall length of the front wing, which affects the lift, drag, and surface area numbers. My calculations concluded a higher lift-to-drag efficiency in the concept design as opposed to Red Bull's current design.

Overall, in the 2026 season, the forefront of automotive engineering is shifting back towards small and agile, away from big and powerful, while creating possibilities for innovation. This model reflects those theme changes. Although this is by no means a professional model, it was created with the resources available to me at the time, and I would be honored to receive feedback and suggestions regarding the model, thought process, or even researching techniques. After all, the art of engineering lies not only in the final product but in the journey and path taken to arrive there. grade this

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Figure 1 - Top View of Front Wing and Nose Cone

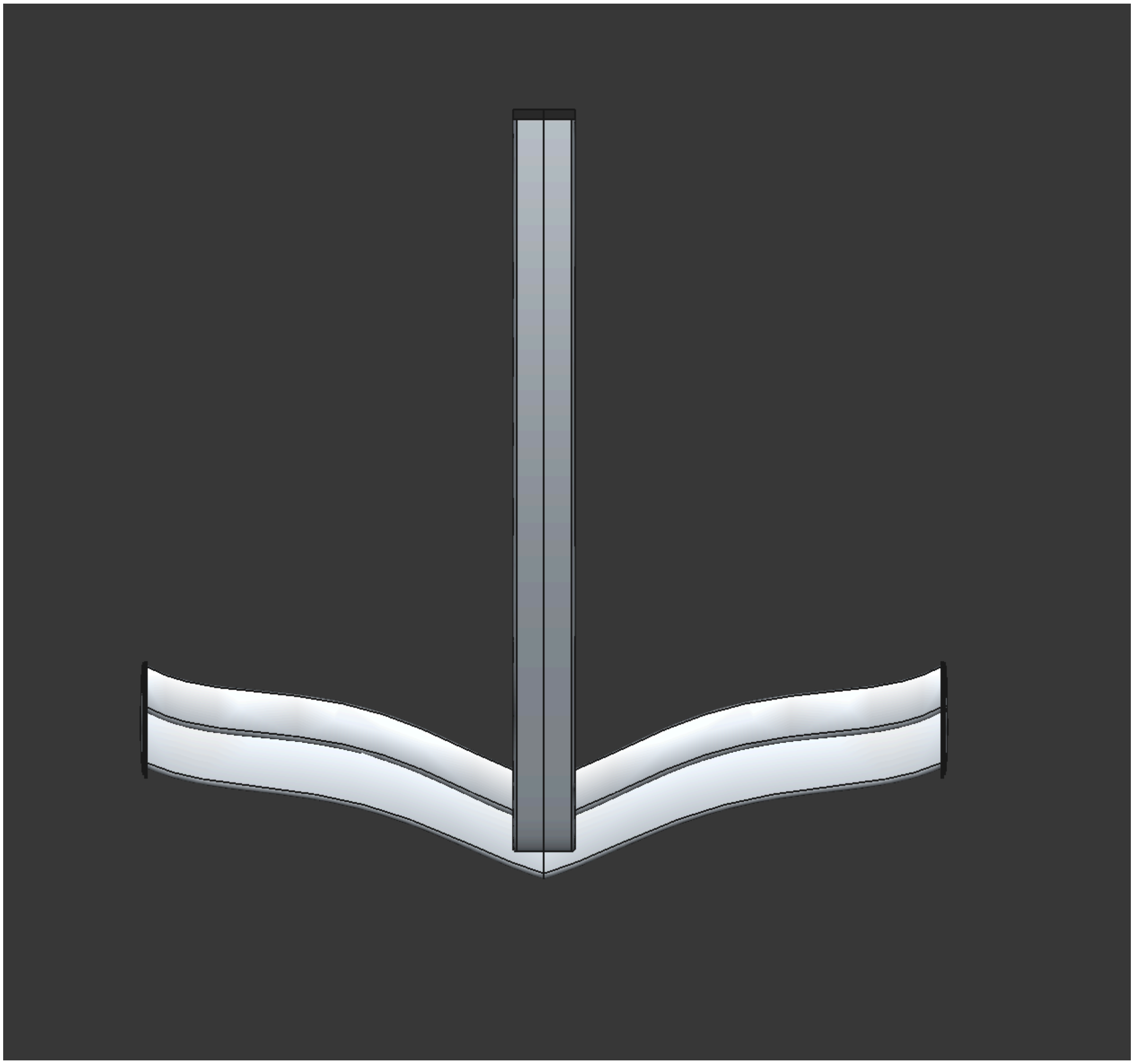

Figure 2 - Side view of Front Wing and Nose Cone

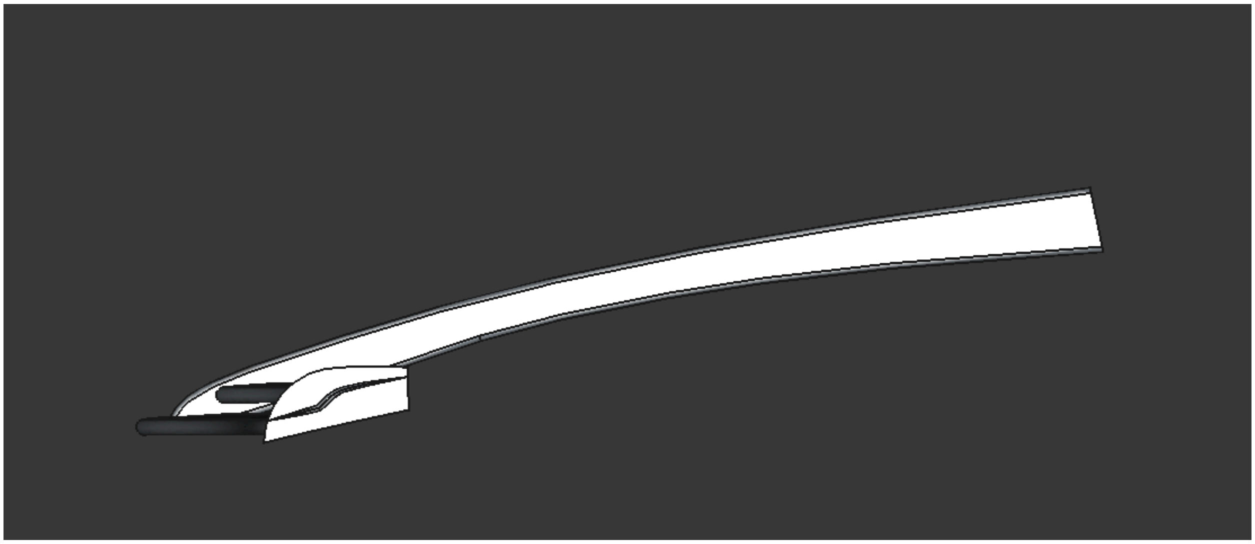

Figure 3 - Front view of Front Wing and Nose Cone

Figure 4 - Close up view of the Winglet on the Endplate

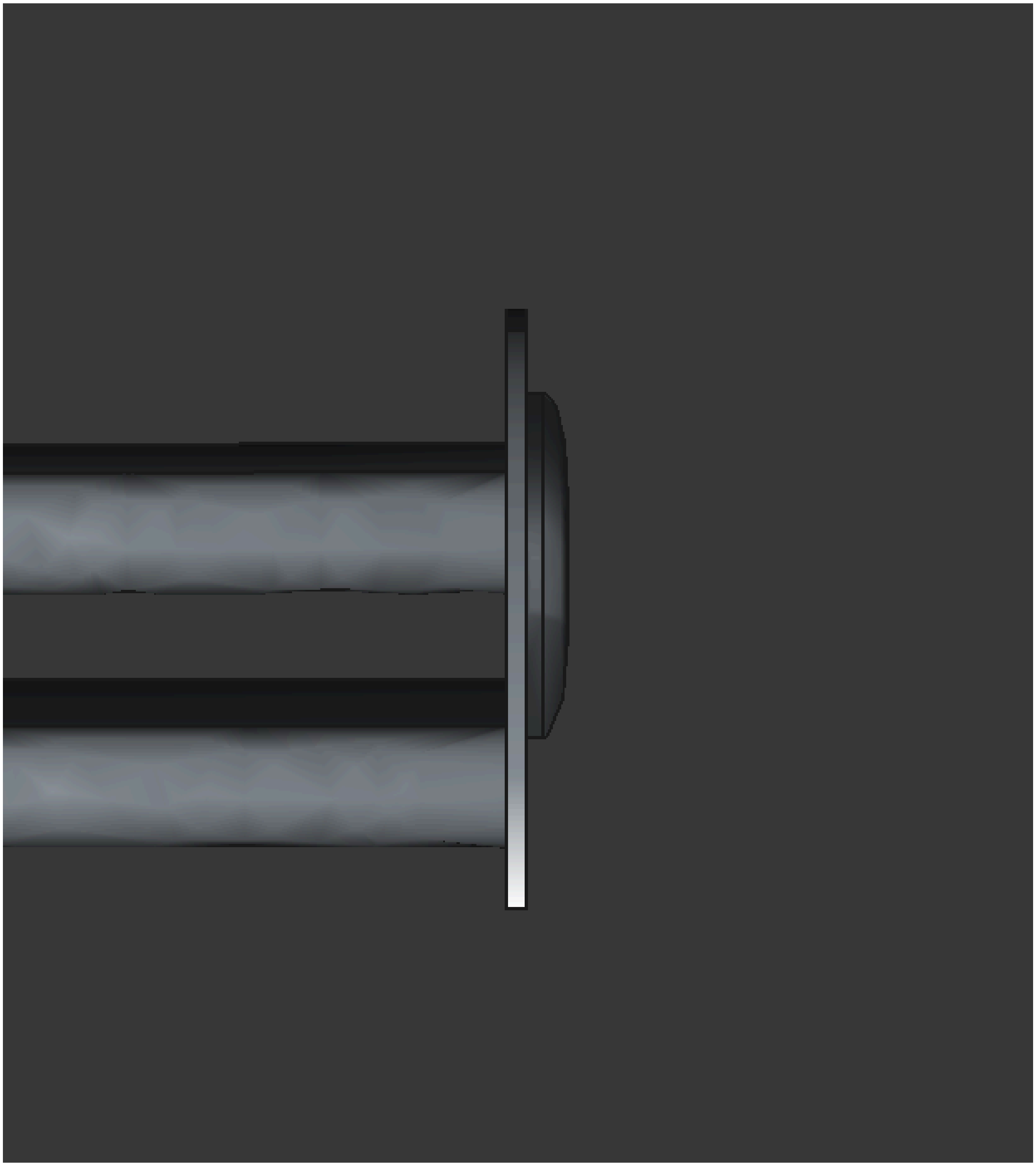

Figure 5 - Close up view of distance between airfoils and endplate

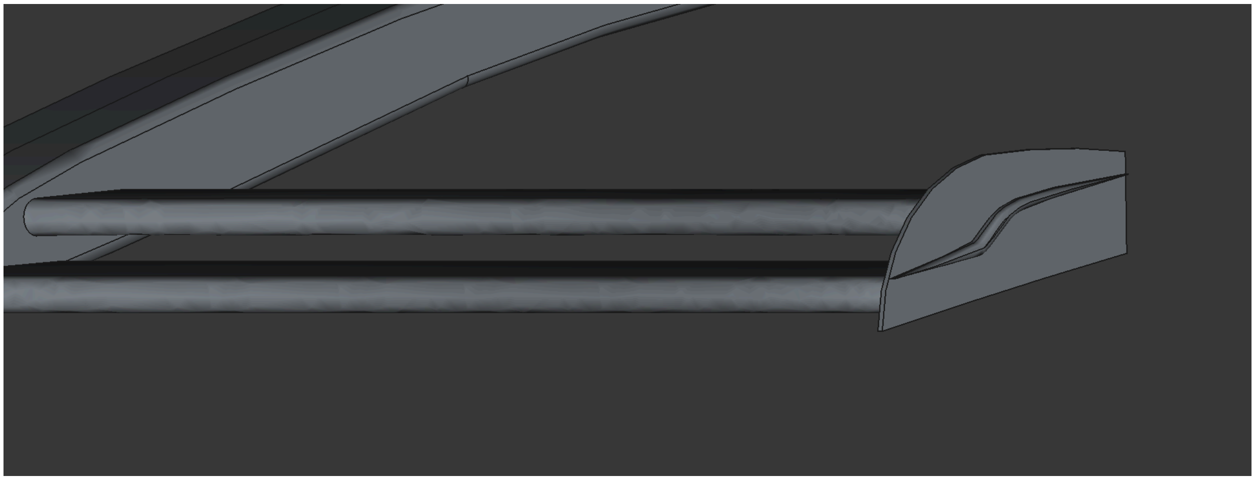

Figure 6 - Rear view of the Nose Cone to show bubble design and taper

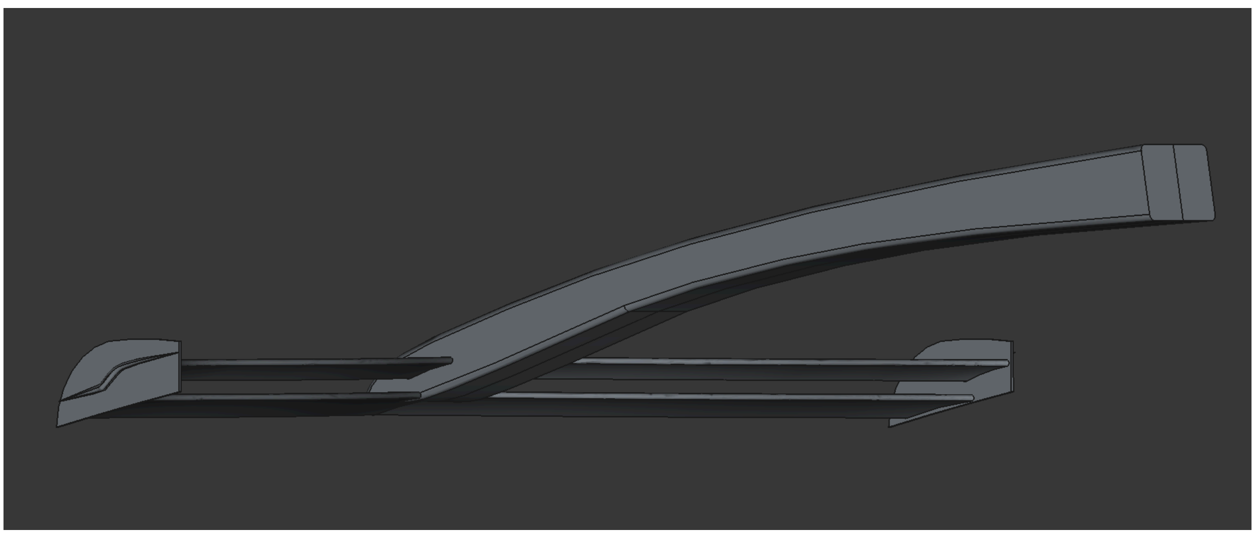

Figure 7 - Close up view of distance between tip of Front Wing and Nose Cone