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RESEARCH ARTICLE

CFD Aerodynamic Analysis of Design and Force Coefficients of 2022 and 2026 Formula One Cars

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ABSTRACT: The 2026 Formula One car is different from any other car that Formula One (F1) has introduced in previous eras; it is, in fact, the entire car that is visually unique. In this investigation, the aerodynamics of the 2026 and 2022 F1 cars are compared to analyze aerodynamics by using a CFD, incompressible flow simulation provided by SimScale, with 3D car models available online (both are unofficial models). This research aims to compare aerodynamic characteristics of the 2022 and 2026 Formula One regulation cars and examine possible effects on racing performance. Results show that the 2026 model has eliminated the ground effect, indicating a major loss of a source of downforce. Simultaneously, the upward diversion of wake behind the rear wing is reduced, potentially compromising overtaking opportunities for the car behind. CFD analysis concludes that the 2026 regulation reduces both the lift coefficient and the drag coefficient by approximately 75% compared to the 2022 model. These findings demonstrate the substantial reduction in downforce and altered aerodynamic characteristics of the 2026 Formula One car, indicating that the car compromises cornering performance and race competitiveness.

KEYWORDS: Engineering Mechanics, Aerospace and Aeronautical Engineering, Computational Mechanics, Racing Car, F1.

Introduction

Formula One began its journey on May 13, 1950, at the Silverstone circuit in England.[1] Ever since the first grand prix, Formula One cars have been evolving as a pinnacle of motorsports with their engine development, energy efficiency, and safety to pursue speed. One of the remarkable and perhaps revolutionary developments of F1 is the aerodynamics. In the late 1970s, 20 years after the inception of F1, the concept of innovative aerodynamics, with inverted wings, was introduced by the Lotus 49. In 1977, another aerodynamic concept of ground effect was introduced by the Lotus 78.[2] The principal purpose of aerodynamics in F1 is to minimize drag and increase downforce of the car, achieving incredible speed not just in the straight but also in corners.

Once every few years, the FIA (Federation Internationale de l'Automobile) introduced new concept cars, which became the basis for other teams' foundations for the forthcoming seasons. Recent developments include major aerodynamic regulation changes in 2009, the introduction of new hybrid-turbo engines in 2014, and the complete resurrection of ground-effect cars in 2022. In 2026, the FIA launched an overhaul of the F1 car, featuring a futuristic design and an utterly and fundamentally new concept. The 2026 car is a completely unexplored character; even the teams have no solid certainty of what to expect from it. There is every reason to be excited about what the 2026 car holds and how it will redefine the competition in the car market.

In this research, the aerodynamic performance of the 2026 car is investigated using computational fluid dynamics (CFD), with a comparison to the 2022 model to evaluate the effects of the new regulations on airflow behavior, downforce generation, and ground effect in particular.

Background information

General Aerodynamic Performance of a Formula One Car:

The average maximum speed of a Formula One car is between 210 and 220 mph.[3] At this speed, without adequate downforce, the Formula One car would be flying everywhere. Downforce is mainly generated by the 2 wings, the front wing and the rear wing. Essentially, these wings function as inverted wings.

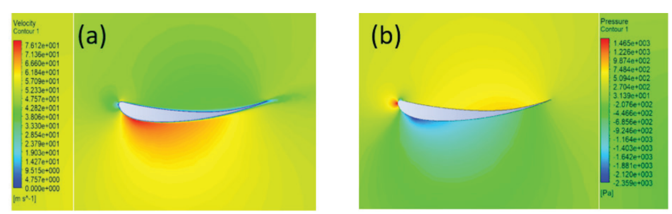

Figure 1: This shows the aerodynamics of an inverted airfoil.[4] Velocity (a) and pressure (b) contours around an inverted airfoil are shown. The red region indicates high velocity underneath the airfoil, which corresponds to lower air pressure shown in (b).

The generation of downforce can be explained by Bernoulli's principle, which states that as the velocity of airflow increases, the pressure decreases for a single, steady incompressible flow. Essentially, the airfoil would have two independent streams of air: one across the top surface and the other across the bottom surface. Furthermore, the inverted airfoil has more curvature at the bottom surface, whereas the curvature is milder across the top surface.[5] This airstream moves down along the curvature; to prevent a void, the airstream is pulled towards the trailing edge of the airfoil, accelerating the airstream upwards.[5] As a result, according to Bernoulli's principle and greater curvature, the airstream at the bottom surface has relatively higher velocity, hence, lower air pressure. This is illustrated in Figure

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1, where the region of higher air velocity (near the bottom surface) has lower air pressure, and vice versa. In contrast, the airstream at the top surface has relatively lower velocity, hence, higher air pressure. This results in a pressure gradient between the surfaces, creating a down force, effectively "pushing down" the airfoil. Bernoulli's equation is explained in terms of the conservation of energy. The sum of pressure energy, potential energy per unit volume, and kinetic energy per unit volume is always constant in a single streamline. This can be used to define downforce. For the top airstream:

$$P_{Top} + pgh_{Top} + \frac{1}{2}\rho\left(V_{Top}\right)^2 = P_{\infty} + \rho gh_{\infty} + \frac{1}{2}\rho\left(V_{\infty}\right)^2$$

where the subscript ∞ represents the free stream condition. However, because both the freestream and the airstreams around the airfoil are almost at the same altitude, this allows it to cancel both "ρgh"s. Therefore, the pressure difference between the airstreams is

$$P_{Top} - P_{Bottom} = \frac{1}{2}\rho\left(V_{Top}\right)^2 - \frac{1}{2}\rho\left(V_{Bottom}\right)^2$$

$$\Delta P = \frac{1}{2}\rho\left(V^2_{Top} - V^2_{Bower}\right)$$

Since this pressure difference generates the downforce,

$$L = \frac{1}{2}\rho A\left(V^2_{Top} - V^2_{Bottom}\right)$$

In addition, downforce is dependent on the lift coefficient, a dimensionless constant that indicates the airfoil's capability to generate lift. However, in this case, the constant has a negative value, indicating that it is downforce rather than lift.

$$L = C_L \cdot \frac{1}{2}\rho A\left(V^2_{Top} - V^2_{Bottom}\right)$$

$$C_L = \frac{2L}{\rho V^2 A}$$

where:
L: downforce in N,
ρ: density in kgm^{-3}
V: velocity of freestream in ms^{-1}
A: the wing area in m^2.

DRS

However, the rear wing of Formula One is not just a rear wing; it can also deploy a DRS (drag reduction system). The DRS was introduced to F1 cars in 2011 to promote wheel-to-wheel racing by decreasing downforce and drag force, thereby enhancing the car's speed. DRS contributes to a 53% reduction in the lift coefficient of the car, as well as a 78% decrease in the drag coefficient of the car.[8]

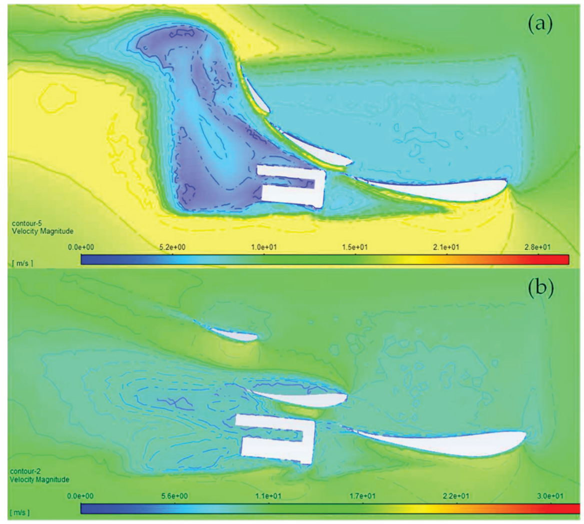
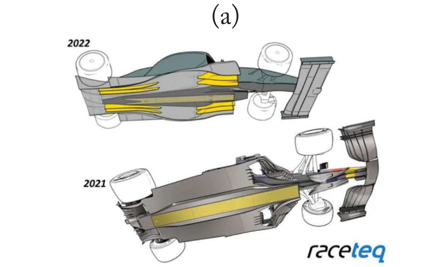


Figure 2: Aerodynamic effect of DRS.[8] Velocity contours of airflow around the rear wing with DRS closed (a) and open (b) are shown. In (a), the large blue region indicates low velocity behind, and when DRS is opened, high velocity is shown just behind the airfoil.

Upon activation of DRS, the multi-element rear wing opens until it reaches the angle of attack of 0 degrees.[8] The Figure 2(a) consists of a large region of low velocity (meaning high air pressure) behind the rear wing. This ultimately contributes to pressure gradients that generate downforce. In contrast, by allowing the airstream to pass between the airfoil, the air velocity in Figure 2(b) has not changed significantly, and the low and high air pressure regions that promote downforce have disappeared; lower downforce results in lower induced drag. Moreover, since the surface area that was getting "pushed" by the receiving air velocity is reduced, the drag force is reduced. Lower drag and downforce allow the car to maximize its pure speed. DRS is mostly applied on long straight lines in the race circuit.[9]

2022 Car:

(a)



(b)

Figure 3: Car floor design difference between the 2022 car and the 2021 car (Giuliana).[11] The images show a comparison between the side and the underside of the car. The 2021 car has an angular body with a simpler chassis. On the other hand, the 2022 car has a smoother body and introduced venturi tunnels in the chassis.

Ground Effect:

The 2022 car was revolutionary, with a futuristic design compared to the previous generation's F1 cars. The car was specifically designed to facilitate further overtakes in racing and is a revival of the ground effect car.[12] Ground effect is an aerodynamic phenomenon that occurs near the ground, resulting in the creation of a low-pressure zone underneath the car, which generates downforce. The current ground effect from F1 cars arises from the Venturi effect, stating that the velocity increases in a constricted area (hence, lower pressure).[13] This ground effect is mostly provided by the chassis of the car, more specifically, the venturi tunnels.[13] This means that the 2022 cars can carry high speed and traction in the corners. Although the incredibly low pressure underneath the car sucks the car down extremely close to the ground, that venturi tunnel becomes a vacuum. This triggers the sudden disappearance of the downforce, as a result, the car springs up only for the venturi tunnel to reopen.[14] This repeated oscillation-like movement due to extreme ground effect is called porpoising and was a major issue to be solved at the beginning of the 2022 season.[14]

Promoting Better Racing:

Another characteristic of the 2022 car is that it has rounded edges on the wings. Previous designs diverted the flow upwards and outwards, meaning the car behind received all the turbulence (or "dirty air"), deteriorating drivability.[15] This new design permits narrower vortices, rotational flow of air to be created, collecting turbulence and wake, and diverting them upwards.[16] Thus, a driver behind experiences less dirty air and overtaking becomes less demanding.

2026:

Figure 4: The 2026 car was announced via FIA.[17] The new regulation introduces new features to the cars, such as X-mode and Z-mode.

The current 2022 generation of F1 is coming to an end in 2025; instead, the 2026 generation will begin. As observed from the preliminary design of the 2026 car, its appearance exhibits a significant difference from that of the 2022 car.

Size:

The 2026 car will be scaled down, with reduced wheel size and a lower car floor. Cutting the wheel size significantly reduces overall weight, contributing to a total of 30 kg in car weight reduction.[17] The weight of the car is important in racing; a lighter mass allows the car to accelerate quickly, resulting in higher energy efficiency to generate the force required to move the car. Furthermore, the light weight decreases the moment of inertia, meaning turning the car becomes easier. Improving the agility of the car is one of the primary objectives of the 2026 car, aiming to enhance the car's responsiveness for competitive racing.

Z-mode & X-mode:

The 2026 car features a system similar to DRS, along with new features called Z-mode and X-mode, a 100 *mm* narrower two-element front wing, and a three-element rear wing with the lower beam removed.[17]

Z-mode: This is the standard mode in which elements of the front and rear wings open at an angle to aid cornering speed.[17]

X-mode: Deploys a low drag configuration, opens both front and rear elements to maximize straight line speed.[17] This is an utterly new feature, as only the rear wing element was subject to DRS.

■ Methodology

Using computational fluid dynamics (CFD), the aerodynamics of the 2022 and 2026 model cars are analyzed. The 2022 car, publicly published by ss10suryansh, and the 2026 car, by reesewu2005, will be utilized for this research.

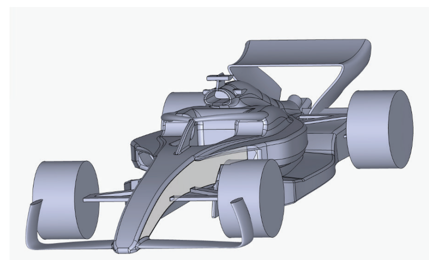


Figure 5: 3D Design of the 2022 model.

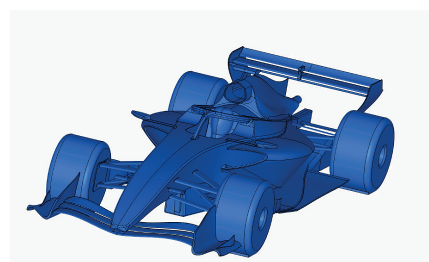


Figure 6: 3D model of the 2026 model. Figures 5 and 6 are the 3D models of the 2022 and 2026 cars used for simulation. The 2026 model also includes the driver's head.

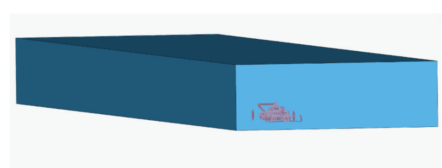


Figure 7: Flow region geometer (model car inside, in red). The flow boundary is defined around the car with the model at the center, where the wind inlet is set on the surface just in front of the model, and force sensors are on the surface of the model.

Before the CFD simulation, it is essential to establish the correct setup conditions for accurate and reliable results. The setup process involves defining the flow region, specifying boundary conditions, and setting appropriate parameters to replicate real-world scenarios. There is a slight difference in

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the setup of the two cars: for the 2026 car, the car model and airflow region are independent of each other, while for the 2022 car, the car model is embedded within the airflow region itself. A mesh is a network of cells and nodes that allows analysis of a simulation with complex geometry. The 2026 model consists of 25.8 million cells and 7.8 million nodes, with a gap refinement factor of 0.05 and a runtime of 1.8e+4 seconds. The 2022 model consists of 3.1 million cells and 3.8 million nodes in the internal meshing model, which is run by the Hex dominant algorithm, with a runtime of 1.8e+4 seconds.[18] The observed discrepancy in mesh structure arises from the original author employing different meshing parameters across the models.

A. Creating an enclosure that represents the flow region. The flow region simulates a controlled region, akin to a wind tunnel, where the interaction between airflow and an object inside can be analyzed. Within this enclosure, various boundary conditions and surface sensors are assigned.

B. The wall in front of the model car is where the velocity inlet is assigned. This is also where air is introduced into the flow region, with a density of 1.196 kgms^{-3}, corresponding to the air density at 20 °C. The airflow has a velocity of 50 ms^{-1}.

C. The opposite wall to the velocity inlet is defined as the pressure outlet. This boundary condition permits the airflow to exit the domain, maintaining a realistic pressure gradient within the domain. The ground wall, which simulates a road or racetrack, is set to move at a velocity of 100 ms^{-1} along the x-axis. Furthermore, wheel rotation is an essential factor in analyzing aerodynamic effects around the tires. Both front and rear wheels have a rotational velocity of 166 radians per second.

Results

Qualitative Analysis – 2022:

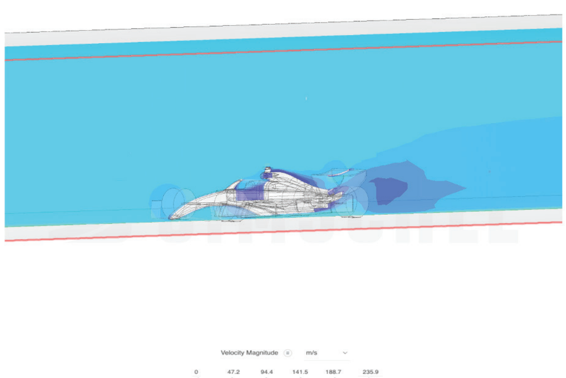

Figure 8: The velocity magnitude of the air around the 2022 model-1. The results show a smooth, continuous, and upcurved lower velocity region behind the 2022 car. Slightly darker blue indicates a slower velocity compared to the light-blue free stream of air.

Further evidence that the 2022 F1 car's effectiveness in preventing dirty air is shown in the velocity magnitude of the free stream air. As shown in the scale below, the closer the color is to dark blue, the slower the velocity of the free stream. The region near the halo or cockpit of the car has the darkest area as air particles collide with the wall, thereby slowing down. The area directly behind the car also has a region of slower air particles, as less air is diverted into the area. The importance of this solution field compared with the vorticity solution field is that the air stream is diverted upward after the particles pass through the car. This is one of the unique characteristics of the 2022 F1 car, which directs the air upwards immediately after the rear wing to create a region that prevents dirty air.

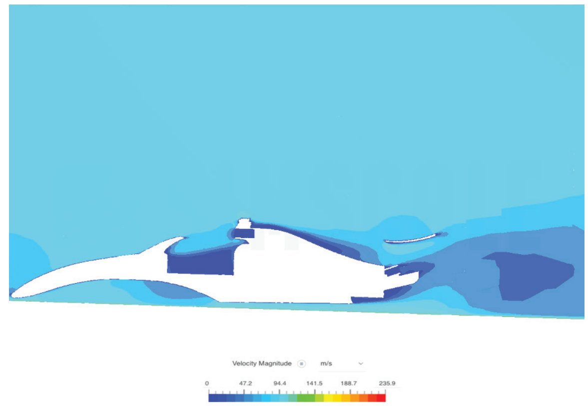

Figure 9: Velocity magnitude around the 2022 model-2. The region between the chassis of the car and the floor has a sky-blue color, indicating that the velocity of the air stream is as high as that of free stream air.

From the earlier Bernoulli's equation states that

$$P_{top} - P_{bottom} = \frac{1}{2}\rho\left(V_{top}\right)^2 - \frac{1}{2}\rho\left(V_{bottom}\right)^2$$

This equation indicates that an increase in velocity results in a decrease in pressure. Applying Bernoulli's principle in this context, the higher velocity near the ground causes lower pressure in this region compared to the region above the F1 car. This pressure gradient between the top surface of the car and the bottom surface of the car creates a net downward force. In other words, this represents the ground effect of the 2022 F1 car.

Quantitative Analysis – 2022:

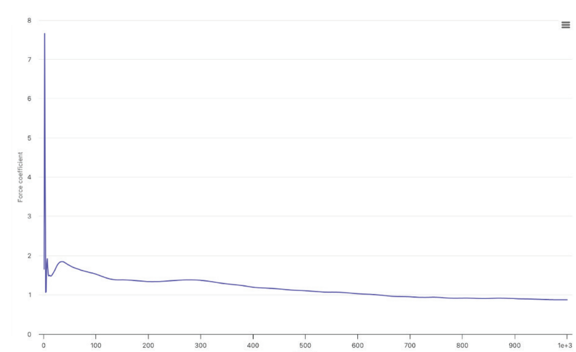

Figure 10: Graph of the drag coefficient of the 2022 model. This graph shows the drag coefficient rapidly decreasing from an initial fluctuation and then gradually stabilizing to a value closer to 1.0.

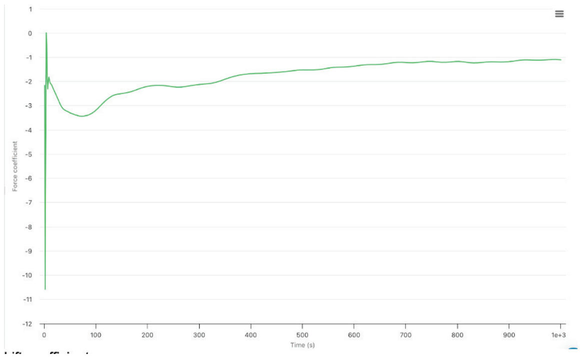

Figure 11: Graph of the lift coefficient of the 2022 model. The value of the lift coefficient gradually stabilized around -1.0. This indicates that the 2022 car constantly generates downforce once the airflow reaches equilibrium.

Both Figure 10 and Figure 11 are collected from the simulation run of the 2022 model on SimScale. The x-axis shows the times, whereas the y-axis shows the force coefficient, presenting the car's coefficient at each second after the simulation began. There are fluctuations in the data at the early part of the graph, but these are mostly due to high unsettled air passing through the car, which gives momentarily high or low coefficients and is not reliable. However, towards the end, there is a tendency for the values to stabilize (in other words, the gradient of the graph approaches zero). This is a more reliable value of the coefficient, as this indicates that the airflow around the car has reached a relatively stable state. Hence, the last value observed (terminal value) on the graph will be used to calculate lift and drag forces.

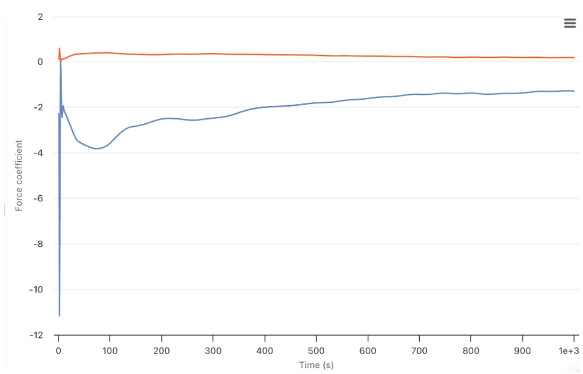

Figure 12: The graph shows the lift coefficient of the front of the model, C(f), and the rear end of the model, C(r). Both values of Cl(f) and Cl(r) seemed to settle around a constant value.

Table 1: This Table shows the terminal values of Cl(f) and Cl(r) of the 2022 model obtained from Figure 12. Positive value indicates that it is contributing to lift, while a negative value indicates it is contributing to downforce.

Cl(f)	Cl(r)
0.1872	-1.2864

Cl(f) and Cl(r) are the measures of the lift coefficient generated from the front or rear section of the car, respectively. From Table 1, the positive value of the lift coefficient for the front area indicates that this area contributes to generating lift rather than downforce. This suggests that the aerodynamic profile of the front end contributes minimally or even detrimentally to vertical load generation, potentially damaging the front tire grip at corner entries. On the other hand, Cl(r) has a significantly larger negative value. Hence, this suggests that the downforce of the 2022 model is mostly provided by the rear end of the car.

Table 2: This table presents the terminal values of the Drag coefficient and Lift coefficient of the 2022 model obtained from Figure 10 and Figure 11, respectively.

Force coefficient	Terminal value
Drag coefficient	0.8749
Lift coefficient	-1.099

Using the force coefficients values, both the Drag and Lift forces can be calculated using the formulas:

$$C_L = \frac{2L}{\rho V^2 A}$$

$$C_D = \frac{2F_D}{\rho V^2 A}$$

Where:
L: force
F_D: Drag force
C_L: Lift coefficient
C_D: Drag coefficient
ρ: Air density (1.195 kgms^{-3})
V: Velocity of free stream air (50 ms^{-1})
A: Surface area

Table 3: This table shows forces on the 2022 model calculated using the force coefficients listed in Table 2.

Forces	Terminal value (N)
Drag force	1306.88 x area
Lift force	-16434.005 x area

Qualitative Analysis – 2026:

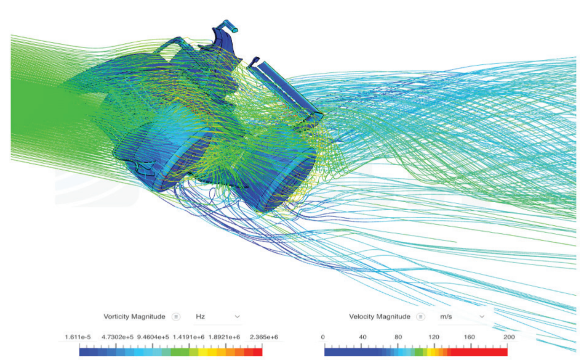

Figure 13: Diagonal view particle trace visualization of the 2026 model. Trace around the vehicle shows an entrance velocity of 100 ms^{-1}, and vorticity is depicted on the surface of the car.

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This solution field represents the magnitude of vorticity of Formula 2026 in a free-stream car at 50 ms^{-1}. The coloring of velocity is on the air particles, and the coloring of vorticity magnitude is on the F1 car. Similar to that of a 2022 car, the velocity of the air stream decreases when a free stream hits the car. However, the difference between the 2022 car is that the intense undulation is observed around the front tires and immediately after the rear wing. The vorticity is higher at the edges of the car component, most obviously shown on the rear wing.

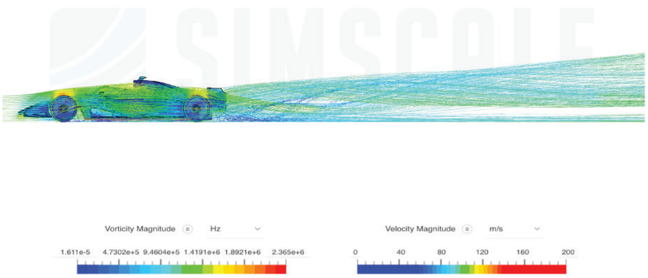

Figure 14: The figure shows a side-view particle trace visualization of the 2026 model. Particle trace shows that the air flows smoothly and gradually above.

From the horizontal view (Figure 14), the effect of dirty air on the car behind is clearer. Unlike the 2022 car, where the air is diverted upwards immediately, the undulating air remains at the ground level. This indicates that the car behind experiences the effect of vortices.

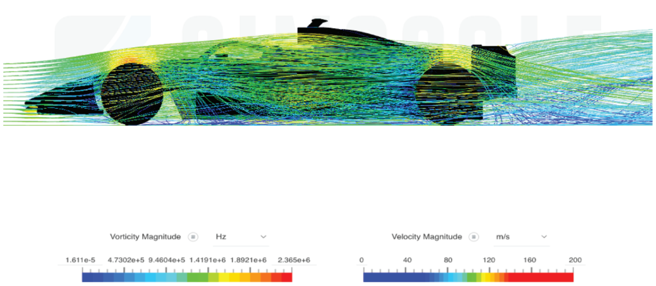

Figure 15: The diagram shows the particle trace around the 2026 model (focused). While higher velocity regions are concentrated above and behind the car, the lower velocity region is observed beneath the car.

The color on the particle represents the velocity magnitude, in which, as the color approaches red, it indicates that the velocity is higher. The air particles below the chassis are blue, indicating a low velocity of air, which means it is a region of high pressure. On the other hand, the color of particles on the top surface is mostly green, suggesting a higher velocity of air and a low-pressure region. Hence, there is a higher-pressure region beneath the car and a lower-pressure region above it. The pressure gradient is set such that there is a net force acting upwards. This indicates that ground effect is undetectable for the 2026 model, resulting in the loss of downforce typically gifted by ground effect in 2022.

Quantitative Analysis – 2026:

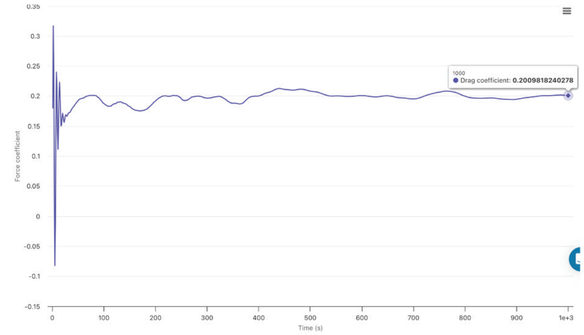

Figure 16: The graph shows the drag coefficient of the 2026 model. The value mostly fluctuates around 0.2.

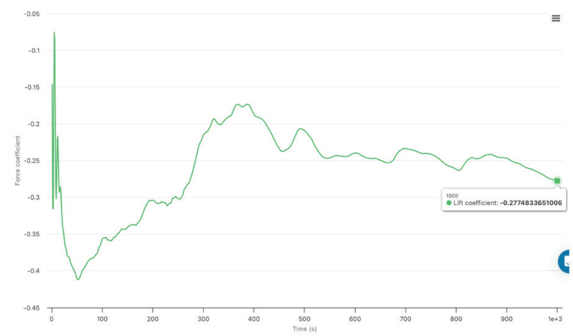

Figure 17: The graph shows the lift coefficient of the 2026 model. The dataset demonstrates the greatest variation in the magnitude of force coefficients, which are noticeably larger than those observed in other graphs.

Figures 16 and 17 show the variation of the lift coefficient over time for the 2026 model. In contrast to the 2022 model, frequent fluctuations in data are observed. Overall, the drag coefficient ranges between 0.15 and 0.2, which is significantly lower than the 2022 model, which ranges from 0.8 to 2. The lift coefficient of 2026 exhibits even more frequent fluctuations in value, ranging from -0.17 to -0.278, which is significantly lower in magnitude compared to the lift coefficient of the 2022 car. In conclusion, both drag coefficient and lift coefficient have a lower magnitude of 2026, which is significantly lower than in 2022.

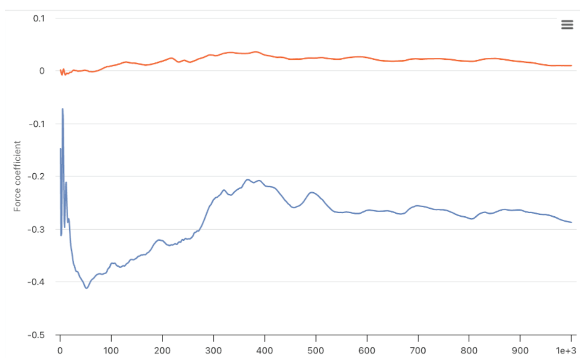

Figure 18: The graph shows Cl(f) (orange) and Cl(r) (blue) of the 2026 model. While the trend line of Cl(f) is relatively stable, the trend line of Cl(r) shows variation, which was not seen in the graph for the 2022 model.

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Table 4: Table showing terminal values of Cl(f) and Cl(r) of the 2026 model from Figure 18.

Cl(f)	Cl(r)
0.0097	-0.2871

According to Table 4, the 2026 model is an aerodynamically rear-end-dominant car in terms of downforce generation. However, in comparison to the 2022 model, the front wing contributes less lift, enhancing downforce on the front section of the car. Nonetheless, downforce generated by the rear end is significantly reduced. Overall, the 2026 car is a more rear-biased vehicle, as shown in Table 4. This imbalance in downforce makes the 2026 model an aerodynamically rear-end dominant car for downforce. However, in comparison to the 2022 car, the front wing contributes less lift, thereby enhancing downforce on the front section of the car. Nonetheless, the downforce generated by the rear end is significantly less. Overall, the 2026 car is more rear-biased, and such an imbalance of downforce may cause extraordinary instability in corners.

Table 5: Table showing terminal values of the Drag coefficient and Lift coefficient of the 2026 model from Figures 16 and 17, respectively. Compared to Table 2, the magnitude of force coefficients is significantly lower for the 2026 model.

Force coefficient	Terminal value
Drag coefficient	0.20098
Lift coefficient	-0.27748

Applying the same formula to calculate the two forces (Table 6),

Table 6: The table shows forces on the 2026 model calculated using the force coefficients listed in Table 5.

Forces	Terminal value (N)
Drag force	300.4561 x area
Lift force	-414.8326 x area

Comparison between the forces of the 2022 and 2026 F1 cars

Table 7: The table presents a comparison of forces on the model between 2022 and 2026. Overall, without accounting for area in the calculation, the 2022 model experiences greater Drag force and Lift force compared to the 2026 model.

Forces / Model of F1 car	2022 (N)	2026 (N)	Reduction
Drag force	1306.63 x area	317.9043 x area	75.66%
Lift force	-1641.6312 x area	-414.8326 x area	74.7%

From Table 7, it is conclusive that 2026 has both a lower drag force and downforce. This reduction is indeed significant, with a 75.66% decrease in drag force and a 74.7% decrease in downforce for the lift force for the 2026 model compared to the 2022 model. This is slightly contradictory to the statistics from the FIA, which claimed a 50% reduction in drag force and only a 30% reduction in downforce.[4] The difference in the statistical analysis is partially due to the unknown surface area. However, because the entire size of the 2026 car is smaller than that of the 2022 car, it is less likely that the surface area of the 2026 car is greater than that of the 2022 car. In other words, the reduction of force compared to 2022 is less likely to decrease (e.g., it cannot be lower than 75.66% since the ratio of surface area will never exceed 1). Although the 2026 model shows a reduction in downforce in percentage terms, the lift coefficients of both models are closer to those of conventional road cars, suggesting potential limitations in the modelling approach or simulation conditions. Nonetheless, it is also unclear how FIA determined that there is a reduction or in what context this reduction occurs.

Discussion

Overall, the data analysis using SimScale confirmed that the 2026 car generates significantly less downforce than the 2022 model. This reduction is evident both qualitatively and quantitatively. In particular, the distinctive aerodynamic features that contributed to the performance and stability of the 2022 car—such as the utilization of ground effect and the upward diversion of airflow behind the rear wing—are no longer present in the 2026 design.

The 2022 model takes full advantage of ground effect, as shown by the high-velocity airflow between the car's floor and the ground, resulting in low pressure beneath the chassis. According to Bernoulli's principle, this creates a pressure differential that generates significant downforce, keeping the car pressed to the track and enhancing grip during high-speed cornering. This improves lap times and drivability of the car while maintaining higher cornering speeds.

Moreover, the airflow is diverted upward after the rear wing, reducing the intensity of the dirty air experienced by a car following behind, which enables the trailing car to accelerate more quickly. This is a key design principle introduced in 2022 to promote closer racing and overtaking during the race.

In contrast, the 2026 car lacks these aerodynamic mechanisms. As seen in the particle trace, the slow-flowing air beneath the car results in high pressure under the chassis and a net upward force, significantly reducing ground effect. Furthermore, particle traces in the vorticity field reveal significant airflow undulation and turbulent vortices, particularly behind the rear wing and around the front tires. In other words, the front tires are more prone to degradation from air resistance, suggesting that long run might not be an advantage for 2026 cars compared to other generations.

These regions of unsteady flow imply a resurgence of dirty air, which could hinder the ability of cars to follow closely. The car behind could experience a sudden loss or gain of downforce, losing control of the car, especially when braking. Importantly, the car experiences more aerodynamic drag due to this dirty air, which could slow it down in the straights. Nevertheless, the newly introduced X-mode, which can open both the front and the rear wings, may balance out the negative effects caused by dirty air by reducing greater downforce in exchange for boosting straight-line speed. From a race-craft perspective, this suggests that while following performance may marginally im-

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prove on straights with activation of X-mode, the loss of overall downforce could still limit close-corner following, meaning dirty air remains a significant constraint. Overall, there may be fewer overtaking opportunities for 2026 cars, contrary to what the 2022 regulations intended to provide.

In general, the 2026 model has lower drag. As a result, it may benefit straight-line speed and fuel efficiency (since less power is required to overcome aerodynamic drag), but the drastic reduction in downforce compromises performance in terms of cornering speed and braking. Plausibly, the 2026 cars may exhibit understeer behavior in corners, where the impact can be critically pronounced, particularly in higher speed corners like those at Spa (a racing circuit in Belgium). Understeer is a phenomenon in which the car turns less than intended due to loss of grip from the front tires. Since the downforce of the 2026 model is mostly contributed by the rear, a lack of grip from the front tires may cause understeer.

This trade-off could have major implications for driver confidence and racing dynamics. It also raises questions about whether the intended goals of the 2026 regulations—to improve sustainability and maintain racing quality—have been achieved. However, it should be noted that the simulation results, especially the reported percentage reductions in downforce and drag, should be interpreted with caution, as the effective surface area is not accounted for in the calculations and the models likely differ from those used by the FIA.

Conclusion

In this investigation, computational fluid dynamics were utilized to analyze the aerodynamic performance of the 2022 F1 model in comparison to the forthcoming 2026 model. This investigation revealed that, qualitatively, the 2026 model has eliminated the ground effect, indicating a major loss of a source of downforce. Simultaneously, the upward diversion of wake behind the rear wing is curtailed, potentially compromising overtaking opportunities for the car behind.

This is supported by Quantitative analysis, which calculates the results from the values of the Lift coefficient and the Drag coefficient obtained from CFD analysis. The analysis concludes that the new regulation would deliver approximately a 75% reduction in both drag and downforce compared to the 2022 and 2026 models.

Yet several key questions remain open. Will the dramatic downforce reduction truly advance the FIA's goals of sustainability without compromising cornering performance and close-quarters racing? Although a reduced drag force may require less fuel to generate a car's power, the broader sustainability impact of diminished aerodynamic performance remains uncertain. How might teams adapt suspension, ride-height, and wing angle strategies to recover lost grip?"To what extent does the opening of the front wing flap introduced in X-mode reduce drag? This research can be conducted using CFD, particularly for the study of X-mode. A car model with a front wing design featuring an open element can be used to run simulations, allowing for comparison with the closed wing and drag reduction from the rear wing, as measured by the Cl(f) and Cl(r).

For further investigation, wind-tunnel experiments and on-track telemetry (real-time data received from the car on the track) should be used to validate these CFD predictions under real-world conditions, particularly to capture transient effects such as porpoising and wake interaction.

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