



Aerodynamics in Formula 1

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Introduction

In modern Formula 1, aerodynamics is a crucial, fundamental and a continually developing principal in the sport; promoting and revolutionizing the fiercely competitive racing the sport has constantly strived for. The development of aerodynamic features on Formula 1 cars has led to improvements in safety, performance, efficiency and closer competition.

Fundamentals of Aerodynamics

- Aerodynamics is the study of how air flows around a body and applies force on it through pressure.[2]
- Air pressure(N/m²) is exerted on all surfaces of a car, and has no direction, but the force(N) created by air pressure on to a surface does have a direction. Pressure can be changed by the velocity(m/s) of the air, air flowing at a high velocity creates a low-pressure environment and a low velocity will create a high-pressure environment. The ability to manipulate the air around a car means we can change the forces acting on it.
- Air pressure around a vehicle results in aerodynamic lift(vertical thrust) and drag(opposing aerodynamic force to the vehicle).
- Lift occurs when the pressure above is greater than the pressure below, and negative lift(downforce) happens when the pressure above is lower than the pressure below.
- Drag is the resistive force that opposes motion and increases with speed. There are different types of drag. Pressure drag is created from differing pressures at the front and rear of the car; frictional drag is created from air moving against car surfaces and rolling resistance from the tyres on the road. Induced drag is created by vortices made by bodywork like wings.



Max Verstappen in the 2023 Formula 1 championship winning RB19[1] Courtesy of, Goodwood.com

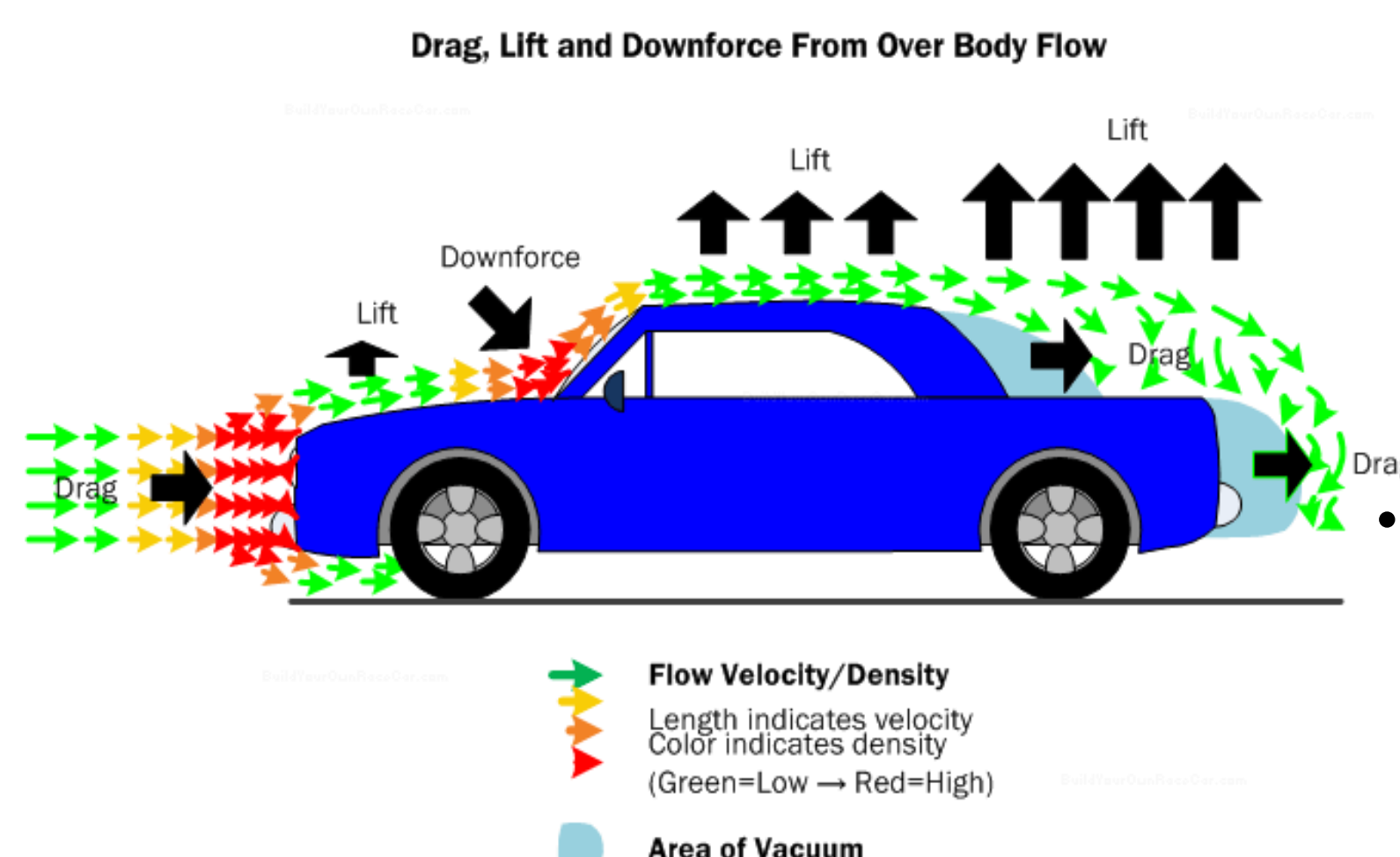


Diagram showing airflow over a vehicle[2] Courtesy of, www.buildyourownracecar.com

Notable Formulae

- Drag force

$$F_D = \frac{1}{2} \cdot \rho \cdot v^2 \cdot C_D \cdot A$$

- Lift Force

$$F_L = \frac{1}{2} \cdot \rho \cdot v^2 \cdot C_L \cdot A$$

- Dynamic Pressure Equation (Bernoulli's Principle)

$$q = \frac{1}{2} \cdot \rho \cdot v^2$$

Major Aerodynamic Breakthroughs in Formula 1

- Advancements in aerodynamics have led to vast improvements in safety.
- The 60's Lotus 49B gave us front and rear wings generating downforce and improving cornering grip, revolutionising how teams thought about airflow.
- The highlight of the 70's was ground effect. The Lotus 78 & 79 sported specially shaped underbodies and skirts creating a venturi effect. The improvement in grip, relative to the other cars, affectively glued the car to the track.
- In the 80's rear diffusers were exploited to accelerate airflow lowering air pressure in the rear underbody and increasing downforce. It continues to play a vital aspect of a Formula 1 cars aerodynamics.
- The Drag Reduction System (DRS) was introduced in 2011, bringing a rear wing with an adjustable rear wing flap reducing drag on straights



Zhou Guanyu's incident at the 2022 British Grand Prix, the halo saving his life despite it facing resistance to being introduced years prior; because of concerns over aerodynamics.[3] Courtesy of, The Sunday Times Driving

Conclusion

Advancements in aerodynamics will continue to surprise fans and stun engineers, here are a few key points to take away.

- Introduction of these innovative concepts reshaped how engineers view Formula 1 over time.
- It has also led to many advances outside of Formula 1, in racing and other areas.
- The driver's safety has witnessed major improvement.