THE IMPACT OF THE HALO ON DRIVER SAFETY AND PERFORMANCE

Submitted
to
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by

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The report examines the impacts of the Halo's enforcement on Formula 1 cars, focusing on its effects on driver safety and performance. Specifically, it evaluates the Halo's role in aerodynamic drag, visibility, potential obstruction issues, and safety outcomes in post-Halo crashes.

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EXECUTIVE SUMMARY

This evaluation report examines the impact of the Halo on driver safety and performance in Formula 1 since its implementation in 2018. The evaluation found that the Halo does work effectively in protecting drivers without impacting their ability to perform.

An issue brought up against the implementation of the Halo was the additional weight and the impact it has on the aerodynamics of the Formula 1 car itself. Since its implementation, the minimum weight of the cars has increased from 640 kg in 2012 to 798 kg in 2024, to adjust for additional material, the weight and height of different drivers, etc. Given that the Halo is made from titanium and weighs 7 kg, and the minimum weight has been increased, the Halo does not impact the performance of the car aerodynamically.

Another main issue brought up in respect to the Halo was the obstruction of the driver's vision. Overall, since the addition of the Halo, it has caused some additional obstruction to the driver in comparison to earlier years when the Halo was not implemented, causing a 10% increase in the Percent Area Visual Obstruction from 34.5% pre-Halo to 45.5% post-Halo.

Since the Halo's implementation, there have been many drivers who have been saved from extreme injuries and death, with examples like Charles Leclerc in Belgium 2018, Zhou Guanyu in Silverstone 2022, and Romain Grosjean in Bahrain 2020.

While the Halo does cause some vision obstruction to drivers, the benefits of the Halo's implementation outweigh the cons. Some vision obstruction is better than being permanently paralyzed or killed. Therefore, my recommendation is to keep the Halo and ensure that it remains a mandatory aspect of all Formula 1 cars.

1.0 INTRODUCTION

Formula 1 could probably be considered the most popular racing series in the entire world. With such a massive platform and millions of people tuning in to watch almost every Sunday, the importance of ensuring that each race is filled with high-intensity racing is very important. While extreme racing is why people enjoy Formula 1, people also love the drivers that support each of their favourite teams, meaning the safety of the drivers is just as important as the race itself. After the accident that occurred at the Japanese Grand Prix in October 2014, the importance of driver safety was more focused on, bringing in the development of the Halo and, soon after, the forced implementation of the Halo in every single Formula 1 car to ensure the safety of the drivers.

The purpose of this report is to analyze and assess the effectiveness of the Formula 1 Halo and whether the concerns surrounding the loss of aerodynamics and how the Halo causes vision obstruction are plausible concerns. The goal is to provide this information to the International Automobile Federation (FIA) and Formula 1 team principals such that all the information surrounding the Halo has been taken into account. This evaluation report will hopefully help conclude the long discussion: is the Halo needed?

This report is split up into six main sections. The first is a summary of the findings regarding the issues involving the cars' aerodynamics, vision obstruction, and the Halo's effectiveness in driver safety. Afterwards, background information about the development of the Halo and its implementation will follow. A description of the evaluation approach used will come next. Then, there will be a discussion of findings, which will be divided into three separate subsections discussing aerodynamics, vision obstruction, and post-Halo crashes. The final section will give a formal conclusion on the Formula 1 Halo and any recommendations regarding the Halo.

2.0 SUMMARY

The development of the Halo caused discourse about its potential impact on the car’s aerodynamics. However, the titanium Halo, combined with adjustments to the minimum vehicle weight, ensures it does not negatively affect a driver's ability to perform or the car's overall aerodynamics. Another concern was the obstruction of the driver's vision, as the Halo causes some additional obstruction compared to post-Halo designs. Despite these issues, the Halo has proven to save drivers from severe injuries and death in high-intensity crashes, with an example being Charles Leclerc’s crash in Belgium 2018.

3.0 BACKGROUND INFORMATION

This section will discuss the history of the Halo, starting from what caused different Formula 1 teams to explore the possibility, to its development, and finally to its implementation.

3.1 THE DEVELOPMENT OF THE HALO

During the October 5th weekend of 2014, the Japanese Grand Prix took place on the Suzuka Circuit. During that race, a terrible tragedy occurred: Marussia Formula 1 driver Jules Bianchi spun off the track and crashed into a recovery vehicle because of the rainy conditions on the track.

After the tragedy that shocked the entire motorsport world, many teams began looking into different types of safety features to add to their cars to ensure that what happened to Jules Bianchi does not happen to any other driver. In 2015, the Mercedes AMG Petronas F1 Team presented the idea of the "Halo," which is a three-way titanium rod in the form of a wishbone, having a similar shape to that of a fighter jet cockpit (Formula 1, 2021, "The Original Idea" section).

3.2 THE IMPLEMENTATION OF THE HALO

After vigorous impact testing done by Mercedes, in 2018 the Mercedes design of the Halo was chosen by the FIA to be implemented in all Formula 1 cars to improve driver safety. With this forced implementation came a lot of backlash to the FIA, with people saying it removed from the aesthetic of the car, what Formula 1 represents, and that the Halo would impede the driver's ability (Formula 1, 2021, "The Original Idea" section).

4.0 THE EVALUATION APPROACH

The method used to properly evaluate the effectiveness and usefulness of the Halo will involve analyzing data from simulations that replicate the conditions faced by Formula 1 cars, reviewing real-life visuals to observe the different aspects of the Halo, and examining real-life crash scenarios where the Halo was utilized. This evaluation will consider the main issues arising from its mandatory implementation and assess whether they truly have a significant impact.

5.0 DESCRIPTION OF PROPOSED TECHNOLOGY

As mentioned previously, the Halo is a three-pronged titanium rod shaped like a wishbone. Titanium is used because it is a relatively strong metal and not excessively heavy. The Halo's shape is designed to withstand extreme forces from all directions, ensuring the driver's protection in various types of accidents. The maximum force that the Halo can endure from multiple directions was determined during the 2018 crash tests conducted just before its implementation. The following is an image representing the forces determined from the crash tests:

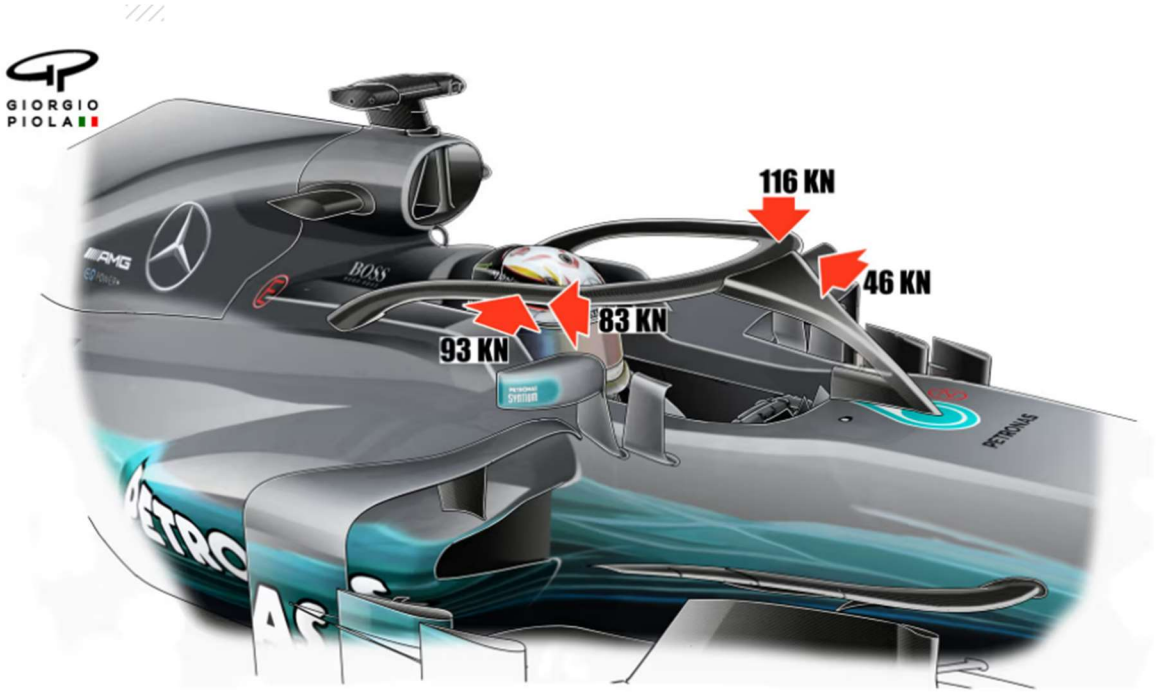

Figure 1. Forces applied to the Formula 1 Halo Source: (Formula 1, 2021, “The regulations behind Hamilton’s protection” section)

Figure 1 illustrates the Halo's ability to withstand significant forces from various angles during a crash. For example, if a car flips and lands on another vehicle, specifically impacting the Halo, it can endure forces up to 116 kilonewtons, effectively protecting the driver from being crushed.

6.0 DISCUSSIONS OF FINDINGS / DATA ANALYSIS

This section will discuss the two separate issues that the Halo is said to have: the first being the impact of the Halo on aerodynamic drag, and the second being visibility and potential obstruction caused by the Halo. Lastly, it will analyze the safety outcomes of post-Halo implementation crashes.

6.1 IMPACT OF THE HALO ON AERODYNAMIC DRAG

The entire engineering concept behind Formula 1 is centered on building the fastest car on the grid without breaking regulations. When the Halo was introduced, many believed it would cause additional drag and slow the car down. In a sport like Formula 1, even a fraction of a second can mean the difference between winning the World Championship or finishing in second place.

Before the implementation of the Halo, the minimum weight of a Formula 1 car in 2012 could be no less than 640 kg (Toet, 2013, p. 5). In 2024, the minimum weight has

increased to 798 kg (GPFans, n.d.). This significant increase is primarily due to safety improvements and ensuring a level playing field for all teams. While the Halo does add some negligible drag, regulations have adjusted over the years to accommodate these weight increases. As a result, all teams face the same disadvantage, meaning the additional 7 kg from the Halo (Racecar Engineering, n.d.) does not impact overall driver performance.

Regarding the negligible drag, a study was conducted by a university student at the University of Washington titled “CFD Analysis of a Formula One Car to Determine the Halo’s Effect on the Car’s Performance” (D'Alessandro & Nolan, n.d., "Introduction" section). CFD, or computational fluid dynamics, is a simulation method used to study factors like drag and lift that could impede the car’s performance (D'Alessandro & Nolan, n.d., "Introduction" section). This study compared different coefficients, such as drag and lift, to determine the impact of the Halo. Figure 2 presents the data collected for a Formula 1 car without a Halo, while Figure 3 shows the data for a car with a Halo.

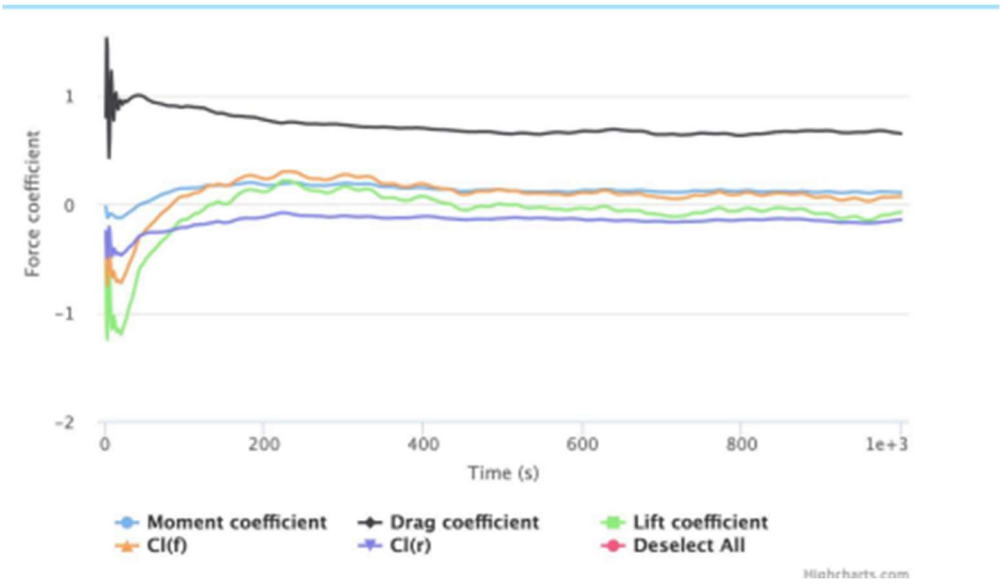

Figure 2. Force coefficients to a Formula 1 car with no Halo Source: (D'Alessandro & Nolan, n.d., "Results" section)

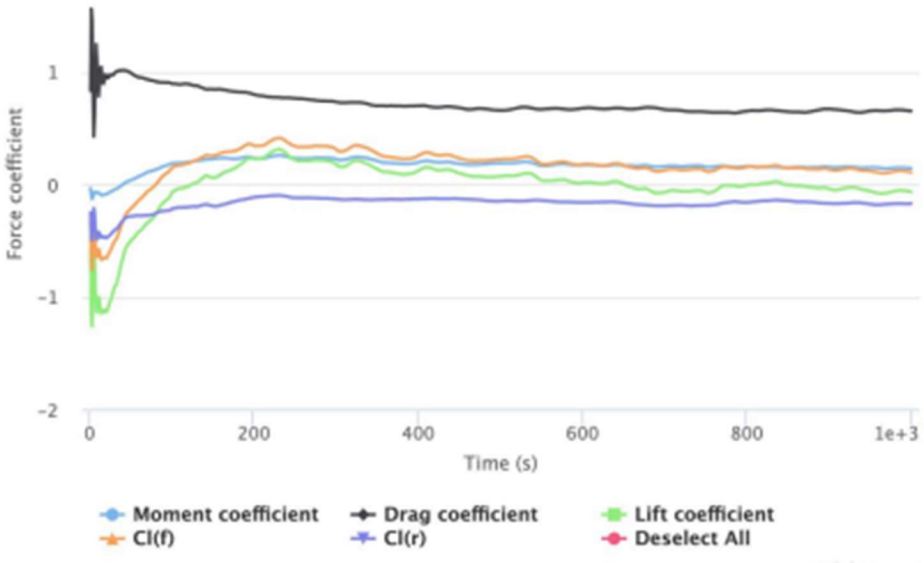

Figure 3. Force coefficients to a Formula 1 car with Halo Source: (D'Alessandro & Nolan, n.d., "Results" section)

As shown in Figures 2 and 3, the differences in factors affecting the car's aerodynamics are negligible. Both versions, with and without the Halo, experience almost identical levels of drag. This demonstrates that the addition of the Halo has a negligible impact on the car's overall aerodynamics.

6.2 VISIBILITY AND POTENTIAL OBSTRUCTION ISSUES

The Halo is positioned and built in such a way that a metal bar runs down the middle in front of the driver's cockpit. With a design like that, some vision obstruction is inevitable. The question is: Does the Halo obstruct too much of the driver's view?

Research shows that the introduction of the Halo design for Formula 1 cars increased the Percent Area Visual Obscuration (percent AVO), which is the area in the driver's perspective covered by obstructions, measured in pixels, from 34.5% to 45.5% (Demirel et al., n.d., pp. 40-41). This 10% difference can be illustrated through the following series of images:

See Figure 4 on the next page:

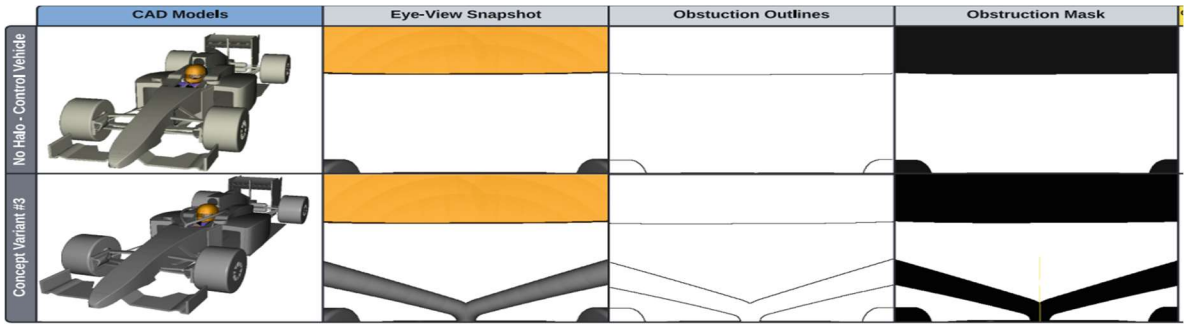

Figure 4. The point of view of the driver within a Formula 1 car with the Halo and without the Halo Source: (Demirel et al., n.d., pp. 40-41)

Figure 4 compares the view from a Formula 1 car without and with the Halo. It is evident that the addition of the Halo does cause additional obstruction to the driver's view. The Halo design blocks nearly half of the driver's perspective, which, in a high-speed sport like Formula 1, could mean the difference between a head-on collision and a safe overtaking maneuver.

6.3 SAFETY OUTCOMES IN POST HALO CRASHES

In a sport like Formula 1, with drivers competing on tracks ranging from extremely hot and dry to cold and wet, combined with the intensity of a Championship fight, almost anything can happen. Following the Halo's implementation in 2018, the first notable incident where the Halo saved a driver occurred during the 2018 Belgian Grand Prix. Fernando Alonso's McLaren landed directly on top of Charles Leclerc's Sauber cockpit, as shown in the following image:

Figure 5. Fernando Alonso's McLaren landed on the Halo of Charles Leclerc's Sauber at the Belgium Grand Prix in 2018 Source: (Racecar Engineering, n.d.)

Formula 1 cars are not like regular cars. While regular cars are essentially secure boxes, Formula 1 cars leave the driver slightly more exposed. As shown in Figure 5, Alonso's McLaren completely landed on top of Leclerc's Sauber. Without the Halo, the McLaren would have struck Charles Leclerc directly instead of being deflected by the Halo. Demonstrating that the Halo saved Charles Leclerc's life that day. The first driver to be saved by the Halo, since Charles Leclerc's Godfather Jules Bianchi died in 2014.

Other drivers who have also been saved by the Halo include Zhou Guanyu at the 2022 Silverstone Grand Prix and Romain Grosjean at the 2020 Bahrain Grand Prix. Grosjean's crash earned him the nickname "The Phoenix" after he emerged from a fiery wreck. These incidents, along with many others, prove that without the Halo, many drivers could have been seriously injured or killed.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this report was to determine the effectiveness of the Halo in protecting drivers, and if the concerns about aerodynamics and vision obstruction were plausible While the obstruction from the Halo is not ideal, there have been no Halo-related crashes. In contrast, the Halo has saved many lives since its mandatory implementation in 2018. Regarding the aerodynamics of the car, the additional weight of the Halo has been adjusted for and does not cause any noticeable drag to the car itself.

Therefore, the recommendation is to keep the mandatory implementation of the Halo since it saves lives. If there are any complaints or crashes caused by the obstruction, the next move would be to slightly change the Halo's design to reduce obstruction, but not in a way that its effectiveness is reduced.

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