

# How Did the 2022 F1 Regulations Affect the Speed of the Cars?

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This research paper explores the effects of the 2022 Formula 1 aerodynamic regulation changes on car speed. The study focuses on three key areas: straight-line speed, high-speed corners, and low-speed corners, comparing the performance of 2022 cars with their 2021 counterparts. The investigation includes a detailed analysis of three top teams—Red Bull, Mercedes, and Ferrari. The results reveal that while the 2022 cars demonstrated increased top speeds in straight-line races, they exhibited significant reductions in cornering speed, resulting in an overall decrease in lap times compared to the 2021 season.

**Keywords:** Aerodynamics, 6G, Downforce, Ground effect, Mechanical Grip

## Introduction

Formula One, as a premier global spectator sport, has long enthralled audiences by bringing together the finest drivers, engineers, and scientists. However, the sport's escalating budgets, reaching hundreds of millions of U.S. dollars per season, have led to a dominance of technological development, particularly in aerodynamics. The excessive aerodynamic downforce generated by wings and ground effects has posed a significant challenge, creating turbulence that hampers the performance of following cars, hindering passing and competitive racing. This issue has raised concerns among drivers seeking a level playing field and spectators desiring races filled with excitement and unpredictability. The most recent Formula One regulation overhaul occurred in 2022, focusing on three key areas to enhance racing dynamics. Firstly, both front and rear wings underwent simplification to mitigate the production of turbulent air, commonly known as "dirty air"<sup>1</sup>. Secondly, the introduction of 18-inch tires, accompanied by winglets, aimed to redirect airflow away from the rear wing<sup>2</sup>. Lastly, ground effect, a feature absent since its ban in 1982, was reinstated to compensate for the reduced downforce resulting from streamlined front and rear wing. While the FIA expresses confidence in the positive impact of these changes, their actual effectiveness remains unexplored. The research aims to investigate the performance of Formula One cars after the 2022 regulations with the 2021 cars, assessing the efficacy of these rule changes in enhancing the racing spectacle.

I hypothesise that the 2022 cars are slower than the 2021 cars due to two reasons: firstly, the cars are now roughly 40 kilos heavier due to safety features and new tyre size. Secondly, the 2022 cars have significantly less downforce compared to the 2021 cars due to a simplification of the aerodynamic surfaces of the cars.

## Method of Analysis

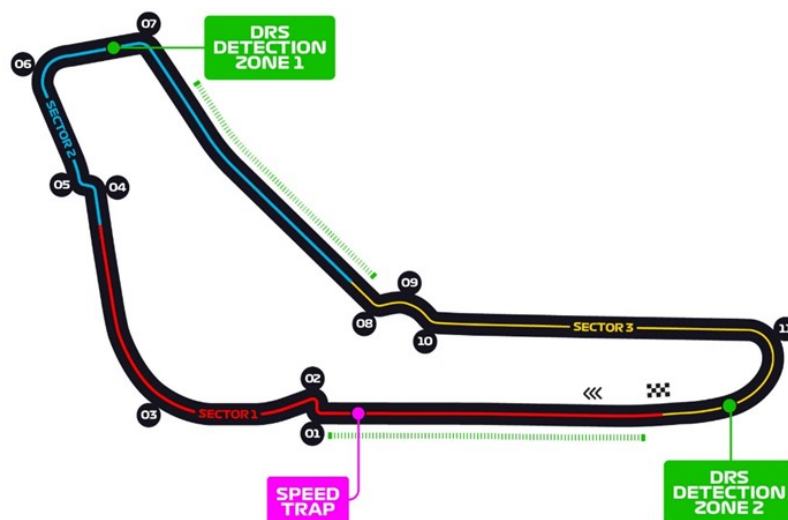
I have selected three teams for the analysis: Red bull (Verstappen, Perez), Ferrari (Leclerc, Sainz), Mercedes (Hamilton). I selected these three teams because their standings in the championship varied the least between 2021 and 2022 as they occupied the top three spots in both years<sup>3</sup>. I also use data from other teams to give an average measure of Top speed and Cornering speed in high and low-speed corners<sup>4</sup>. Most of the data in use is from qualifying sessions (because teams run the cars the fastest during qualifying).

In order to assess the impacts of the 2022 regulations on the speed of the car, I have divided the 'speed' of the cars into 3 categories. I will use three separate racetracks to measure each of these metrics: straight line speed, speed on high-speed corners, and speed on low-speed corners.

The top speed will be measured by the speed trap at the end of the start finish straight on the track. I have selected Monza as this track is comprised mainly of long straights. So, teams run the least amount of downforce here, which should give them the highest top speeds<sup>5</sup>. A layout of the track is presented below<sup>6</sup>.

## High-speed Corners

In order to measure the impacts on high-speed corners I will compare the overall lap time between 2021 and 2022 in a track dominated by high-speed corners. I have selected Silverstone in England because teams run very high downforce (A force, produced by a combination of air resistance and gravity, that acts on a moving vehicle, having the effect of pressing it into the ground and giving it increased stability) on this track. I will also analyse the peak speed achieved on the infamous 'copse' corner (turn 9). This is the fastest corner on the Formula one calendar and requires a large amount of downforce. I have used data from



**Fig. 1** Layout of Monza Race Track in Italy

the race as it rained during qualifying. I also use Perez’s data instead of Verstappen for red bull as the latter crashed. A layout of the track is presented below<sup>7</sup>.

### Low-speed Corners

Similarly, for slow-speed corners I will directly compare the lap times around a track that is dominated by slow-speed corners. I have selected Monaco as it is the slowest circuit on the calendar. Generally, the aerodynamics of the car are not that important on the low-speed corners; Mechanical grip of the cars play a larger role. Accordingly, I will also analyse the peak speed through the Monaco hairpin in order to assess the difference in mechanical grip between the two years. A layout of the track is presented below<sup>8</sup>.

### Source of Data on F1 Cars

I gathered most of the data from the FastF1 python library<sup>9,10</sup>. It is an opensource library which provides access to Formula one car telemetry. The library gets the data from the Ergast website.

A Formula one car generates an enormous amount of data over a race weekend. The cars each generate roughly 30 MB of data per lap<sup>11</sup>. Every car has a small computer onboard called the ECU (electronic control unit). This communicates with the various sensors on board to generate and transmit the data back to the teams. The sensors on a Formula one car can be broadly classified into three categories: Instrument sensors (For example, tire pressure and fuel flow sensors), Control sensors (These send the drivers inputs such as acceleration and steering back to the teams), Monitoring sensors (These measure the condition of the car)<sup>12</sup>.

## Results

### Straight Line Speed

As shown in the track layout, the speed trap is placed at the end of the longest straight on the track, just before the first braking zone. So, the enlarged graph will likely show a sharp decline since the speed will drastically reduce.

**Red Bull:** Given below is the speed vs distance graph of the 2022 and 2021 red bull F1 cars. Below the enlarged graph of turn 1 is the top speed and lap times of both.

Evidently, the 2022 car reached a higher top speed than the 2021 car. This point can be further strengthened by zooming into the speed trap just before the first braking zone. However, the lap times state that despite the increased top speed, the 2022 car was roughly 0.4 seconds slower.

**Mercedes:** Given below is the speed vs distance graph of the 2022 and 2021 Mercedes F1 cars. Below the enlarged graphs I have also added the top speed and lap times of both.

It appears that on average the 2021 car was faster than the 2022 car. However, the top speed seems identical.

After zooming into the speed trap, it is evident that the top speed was indeed almost identical. However, in F1 even the slightest margins matter (1km/h in this case). This is not as big of a difference as the red bull. This may be because of 2 reasons: Firstly, Mercedes may have gotten the concept of the car wrong. This means they did not fully exploit the regulations. Secondly, Mercedes and a few other teams suffered from porpoising (violent up and down motion of the car at high-speeds). This meant they had to run their car higher than the optimum amount to prevent it from hitting the ground and damaging the floor<sup>13</sup>. Since they were slower in the corners and could not

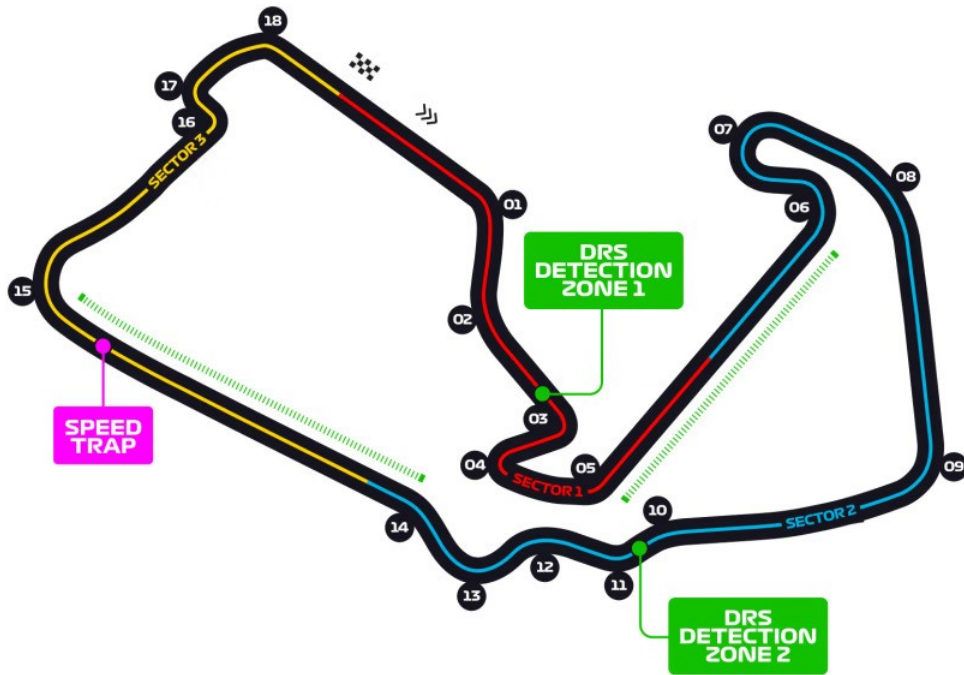


Fig. 2 Layout of Silverstone Race Track in England

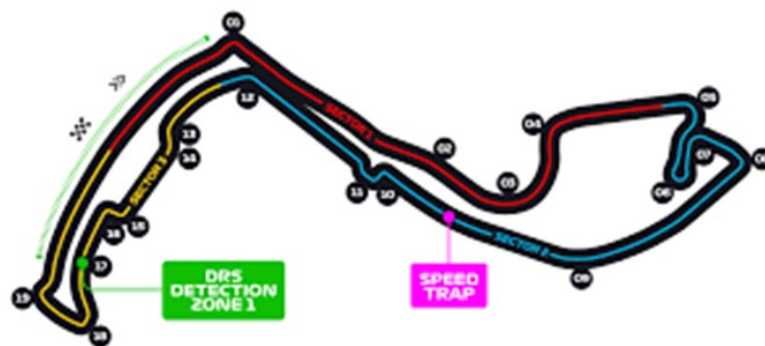


Fig. 3 Layout of Monaco Race Track

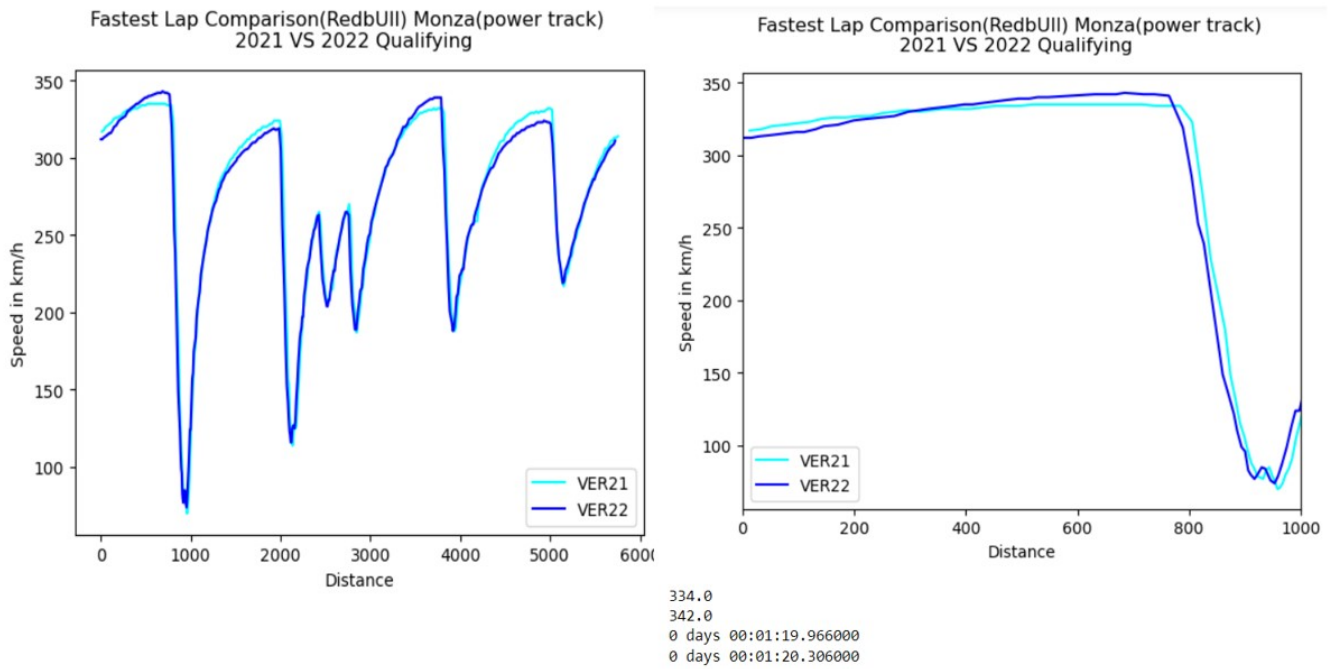


Fig. 4 Red Bull Speed Vs Distance (Straight Line Speed)

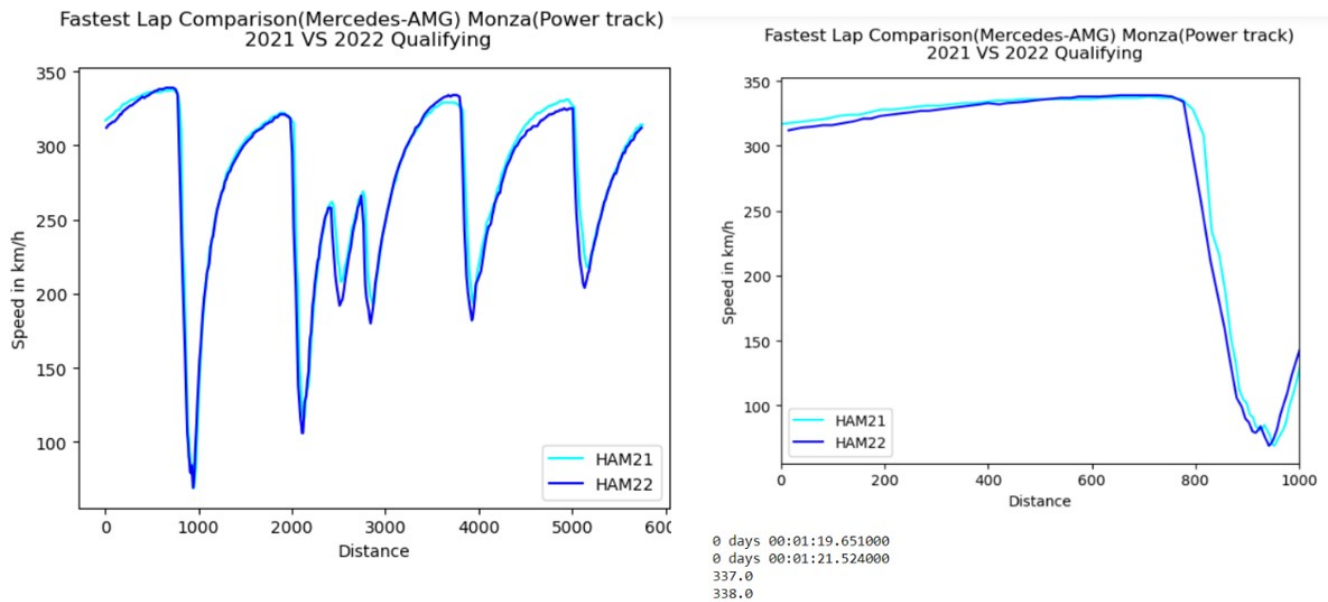


Fig. 5 Mercedes Speed Vs Distance (Straight Line Speed)

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make up for it on the straights, the 2022 Mercedes F1 car was roughly 2.5 seconds slower than its predecessor.

**Ferrari:** Given below is the speed vs distance graph of the 2022 and 2021 Ferrari F1 cars. Below the enlarged graphs I have also added the top speed and lap times of both.

This graph shows a clear result. The 2022 Ferrari seems to consistently have a higher top speed on the graph. In contrast to the red bull and Mercedes graphs, the 2022 Ferrari does not seem much slower than the 2021 Ferrari.

The enlarged portion of the speed trap reveals that Ferrari had similar gains in top speed as the Red bull (7 km/h). Unlike Red bull and Mercedes, Ferrari had a faster car in 2022 than in 2021 (The 2022 car was faster by 0.4 seconds). As mentioned earlier, Ferrari were not as fast as Mercedes and Red Bull in 2021 (They were recovering to the front of the grid after finishing 6th in 2020). This is probably why their 2022 car was faster over a whole lap.

We can infer from these examples that most teams had an increased top speed after the rule changes. The point made by these graphs can be further strengthened by taking the average gain on top speed of all ten teams. It is important to point out that I have only considered the cars of drivers who form the same team in 2021 and 2022 to limit the factors affecting the performance of the cars.

The box plot above shows the average difference in top speed between 2021 and 2022 for 18 drivers. It is evident from the line graphs and the box plot that the 2022 cars had a higher top speed than the 2021 cars. To be specific, cars gained an average increase in top speed of 3 km/h according to the box plot. The only outlier in the data is the Haas F1 car which was 10km/h slower in 2022 than in 2021.

## 0.1 High-Speed Corners

**Red Bull:** Given below is the speed vs distance graph of the 2022 and 2021 Red bull F1 cars. Below the enlarged graphs I have also added the top speed and lap times of both.

This graph gives us a clear insight into the performance difference between the 2021 and 2022 cars. The 2021 car is consistently faster than the 2022 car. This is critical because the track is dominated by high-speed corners and this therefore shows that the Red bull's 2022 car was slower in high-speed corners compared to its predecessor.

The second graph is a zoomed in section of turn 9, better known as cospice corner (considered by many as the fastest corner in Formula one). This corner requires a large amount of downforce. We can see from the enlarged graph that the 2021 car was able to enter and exit with a higher speed. The reason for this is undoubtedly the reduced downforce on the 2022 cars. Although the difference is not huge, over the course of a lap these small differences add up resulting in the 2022 car being roughly 2.3 seconds slower than the 2021 car.

**Mercedes:** Given below is the speed vs distance graph of the 2022 and 2021 Mercedes F1 cars. Below the enlarged graphs I have also added the top speed and lap times of both.

This graph shows similar result to the red bull graph. We can see that the 2021 car is clearly faster than the 2022 car. As a side note there does not seem to be a significant difference in top speed or low-speed corners. So, the difference in lap time can be mainly attributed to the high-speed corners.

The enlarged section of cospice corner is also consistent with our previous findings. It is clearly visible that the 2021 car was able to maintain a higher speed throughout the corner than the 2022 car. This result could be because the 2022 Mercedes was heavier compared to the other cars<sup>14</sup>. The lack of downforce is especially visible in a track like Silverstone as the 2022 car was roughly 0.7 seconds slower than the 2021 car.

**Ferrari:** Given below is the speed vs distance graph of the 2022 and 2021 Ferrari F1 cars. Below the enlarged graphs, I have also added the top speed and lap times of both.

The graph for Ferrari is quite interesting. There does not seem to be a clear visual highlighting that the 2022 car was slower. The 2021 Ferrari was a bit slower when compared to the 2021 Mercedes and Red bull. This may be the reason why the 2022 Ferrari does not appear slower than the 2021 car.

On enlarging this graph, that the 2022 Ferrari was faster through cospice corner than the 2021 Ferrari. This is completely opposite to the results we obtained by analysing the Mercedes and the Red bull. This anomaly can once again be attributed to the fact that Ferrari did not build a very competitive car in 2021.

The box plot shown below indicates the average gain in lap time between 2022 and 2021 of 18 drivers. From the analysis we conducted on the top three teams, it is reasonable to infer that most teams were affected negatively by the rule change (They were slower). Some teams managed to make a faster car in 2022 than in 2021 especially in terms of high-speed corners. This reasoning is strengthened by the box plot showing the average change in lap times for each team from 2021 to 2022.

From the analysis conducted on the line graphs and box plot we can conclude that the 2022 F1 cars were slower in the high-speed corners compared to the 2021 cars. As mentioned earlier, this is because of their simplified aerodynamics that result in lower downforce and their increased weight.

## Low-Speed Corners

Examining the speed of cars through low-speed corners has the same issue that was faced in the analysis of high-speed corners. However, it is possible to get a rough idea about the performance of the cars in low-speed corners by comparing lap times on a track that is dominated by low-speed corners. For this reason, I have selected Monaco. Monaco is the slowest track on the F1 calendar and has the slowest corners of any F1 track (especially the hairpin)<sup>15</sup>. I also zoom into the slowest corner on Monaco

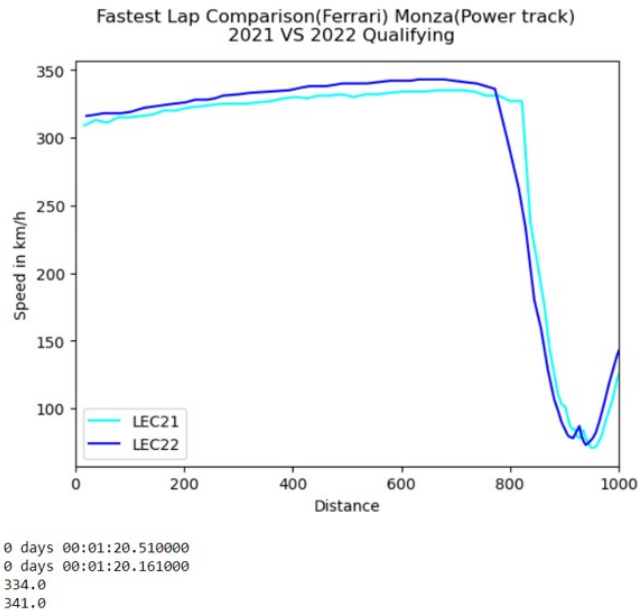
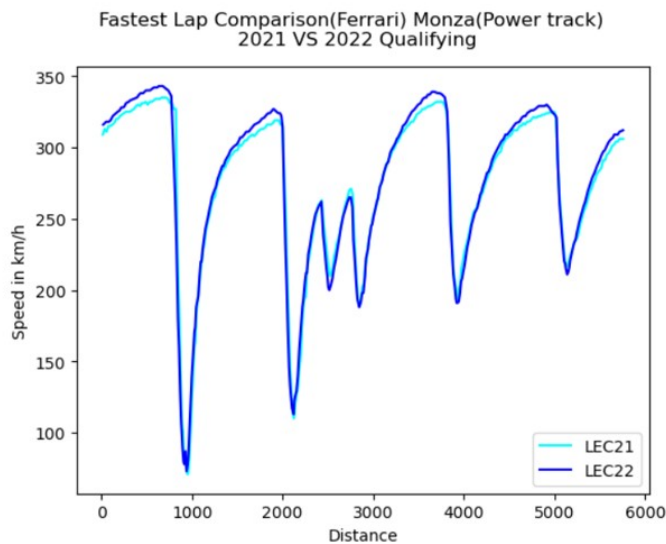


Fig. 6 Ferrari Speed Vs Distance (Straight Line Speed)

to compare the 2022 and 2021 F1 cars.

**Red Bull:** Given below is the speed versus distance graph of the 2022 and 2021 Red bull F1 cars. Below the enlarged graphs I have also added the top speed and lap times of both.

We can infer from the graph that the overall lap times look identical. The turquoise and blue lines are constantly coinciding with each other. On the other hand, the 2021 car seems to be faster in the high-speed corners (there are very few).

The above graph shows an enlarged section of turn 6 (“The grand hotel hairpin”). It is the slowest corner in F1<sup>15</sup>. We can see that the driver took a slightly earlier apex in 2022 (reached minimum speed earlier). Also, the 2022 car had higher corner exit speed but a substantially lower corner entry speed. The overall speed through the corner looks similar. On the other hand, the 2022 car was roughly 1.4 seconds slower. This can be accounted for by the few high-speed corners in the final sector of the track.

**Mercedes:** Given below is the speed vs distance graph of the 2022 and 2021 Mercedes F1 cars. Below the enlarged graphs I have also added the top speed and lap times of both.

This graph of the Mercedes gives us a slightly different insight than the Red bull graph. The 2021 car seems to be consistently faster than the 2022 car. This difference in performance is especially evident in the high-speed corners in sector 3.

The enlarged portion from turn 6 shows a similar slope to the red Bull. The 2021 Mercedes had higher corner entry speed but lower corner exit speed. They both had similar speeds at the apex. However, over the course of a lap the 2022 car was slower by roughly 1.5 seconds.

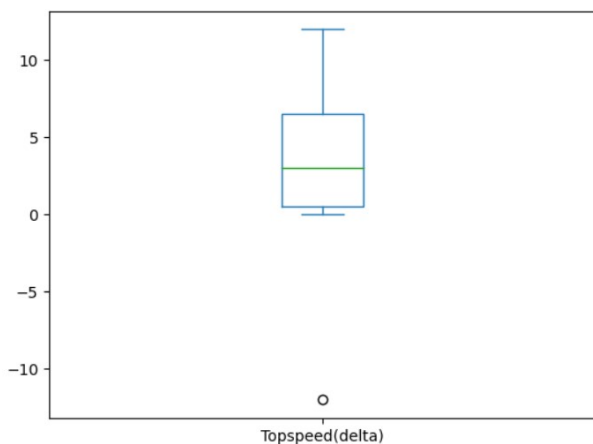
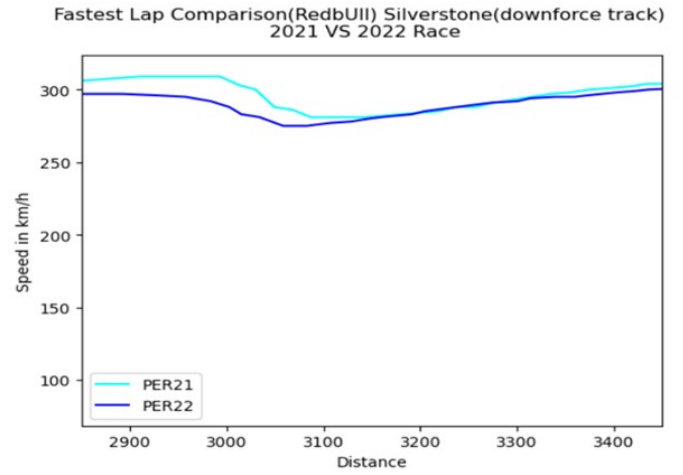
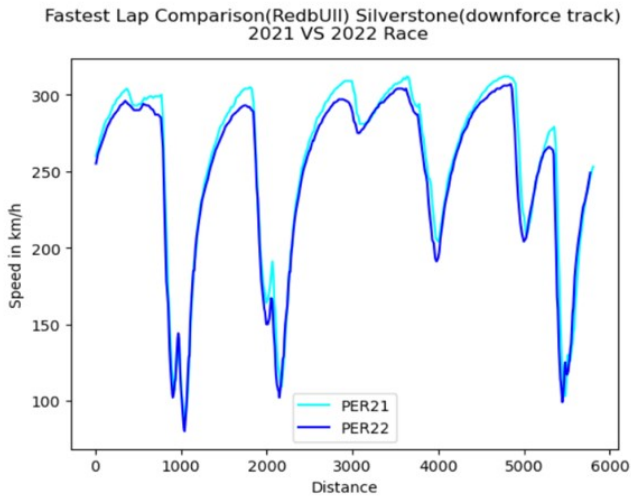
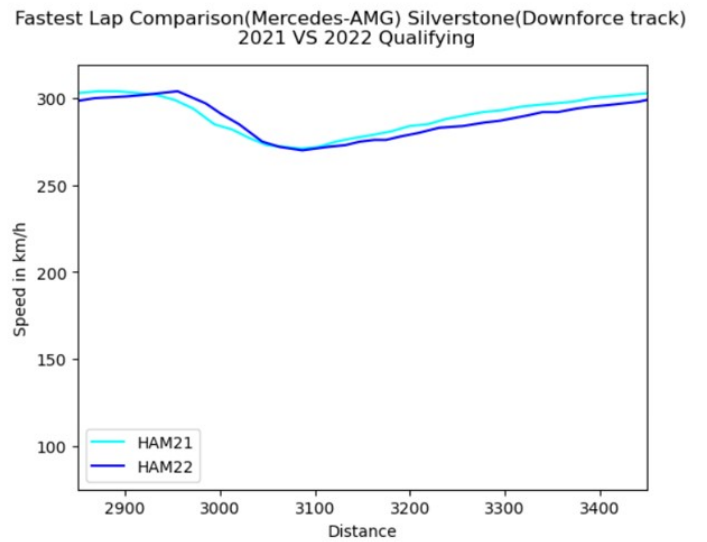
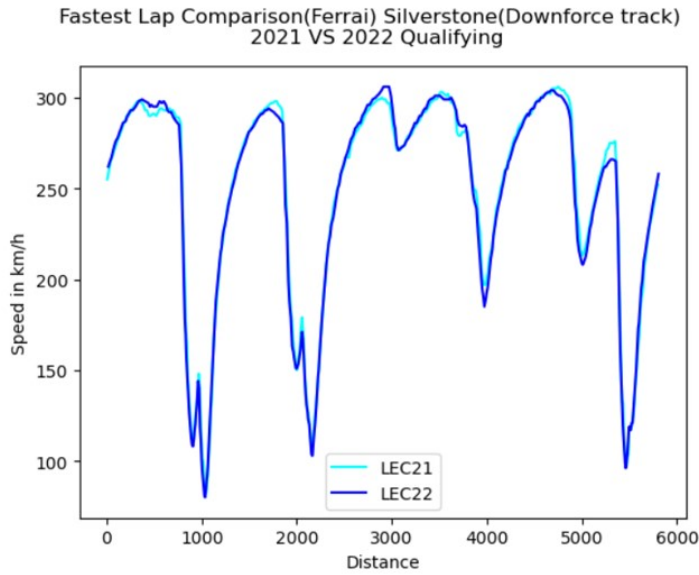


Fig. 7 Average difference in top speed between 2021 and 2022



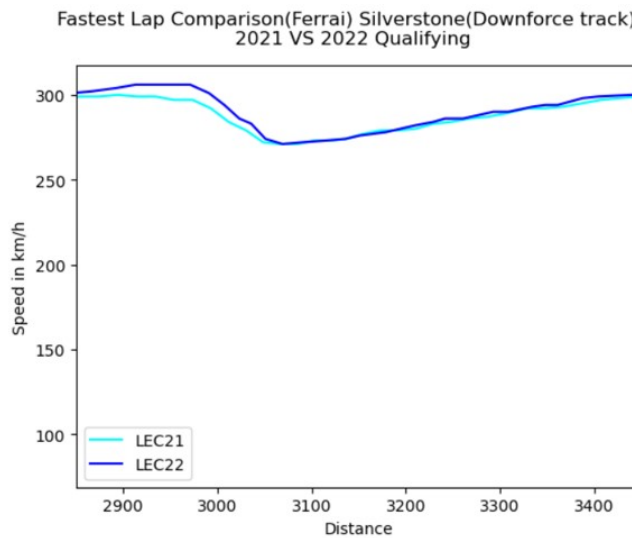
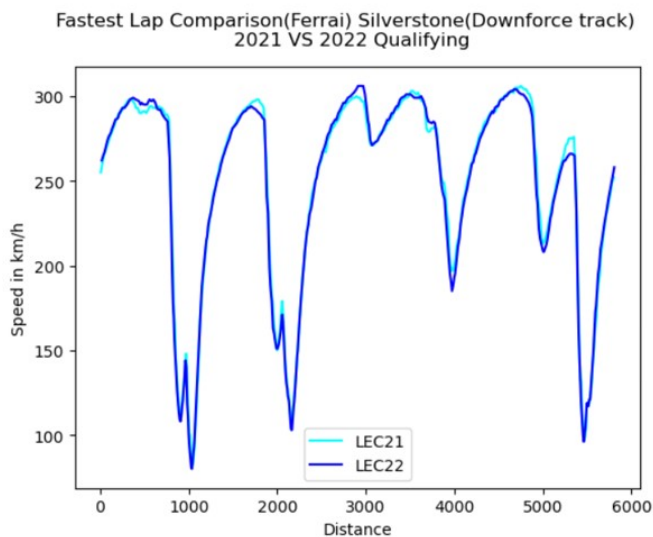
0 days 00:01:28.617000  
 0 days 00:01:30.937000

**Fig. 8** Red Bull Speed Vs Distance (High-Speed Corners)



0 days 00:01:29.699000  
 0 days 00:01:30.510000

**Fig. 9** Mercedes Speed Vs Distance (High-Speed Corners)



0 days 00:01:30.569000  
 0 days 00:01:31.282000

**Fig. 10** Ferrari Speed Vs Distance (High-Speed Corners)

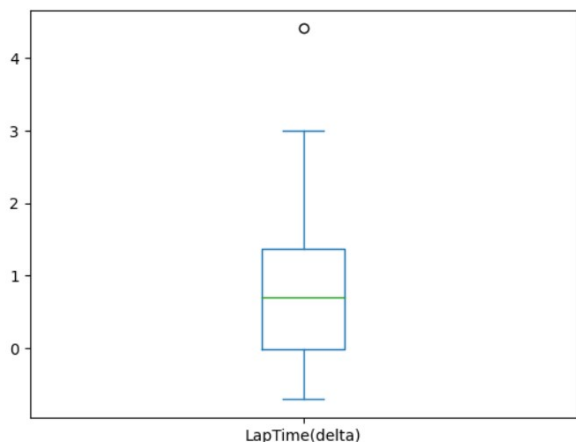
**Ferrari:** Given below is the speed vs distance graph of the 2022 and 2021 Ferrari F1 cars. Below the enlarged graphs I have also added the top speed and lap times of both.

The trend of the 2021 cars being consistently faster on the Red bull and the Mercedes graphs is less evident on the Ferraris. However, there is a similarity between the graph of the Ferrari and the previous graphs: The 2021 car appears to be significantly faster in the high-speed corners. The low-speed corners look identical.

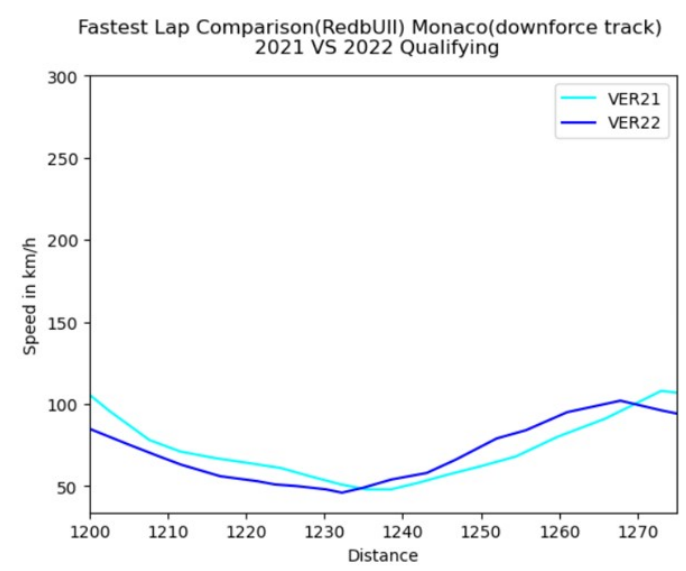
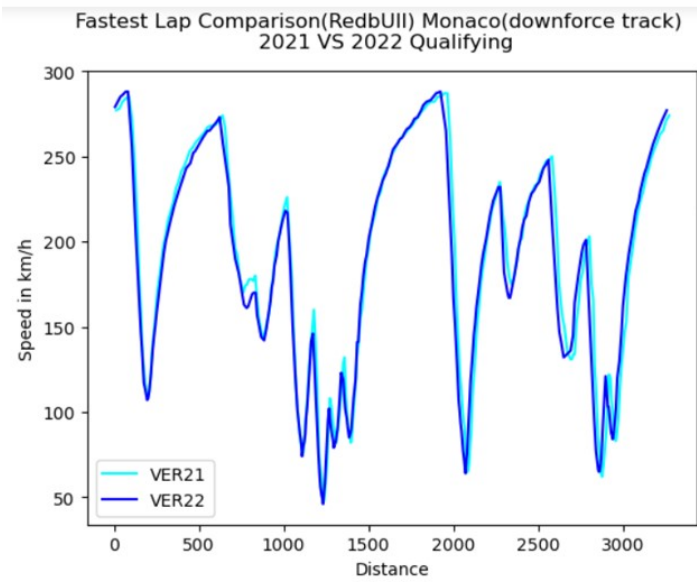
The enlarged graph also shows a similar trend to the graphs of the previous teams: The 2021 cars have a higher corner entry speed, but have a slower corner exit speed. The lower corner entry speed leads to the 2022 Ferrari being roughly 1.8 seconds slower than its predecessor.

Given below is a box showing the average gain in lap time from 2021 to 2022 for 18 drivers. Clearly, most teams were over a second slower in 2022 than in 2021. More surprising, there was not a single outlier in the data. This therefore shows that the 2022 F1 cars were also slower in slow-speed corners than their predecessors.

The box plot and the graphs of the top three teams show the same conclusion. The 2022 cars were slower overall in a track dominated by low-speed corners. The reason for this may be the increased weight on the 2022 cars. It is important to point out that aerodynamics do not have a big impact in performance in low-speed corners (Because the cars are not going fast enough for the aerodynamic devices to work to their fullest)

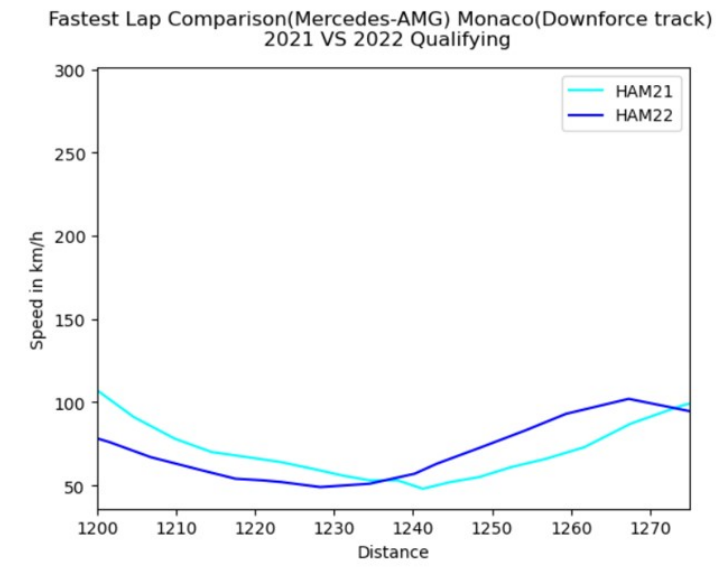
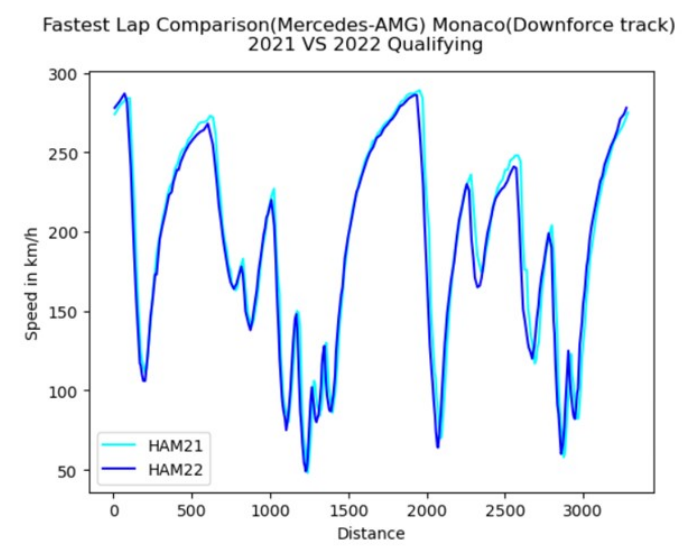


**Fig. 11** Average difference in lap time between 2021 and 2022 (High-speed)



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 0 days 00:01:11.666000

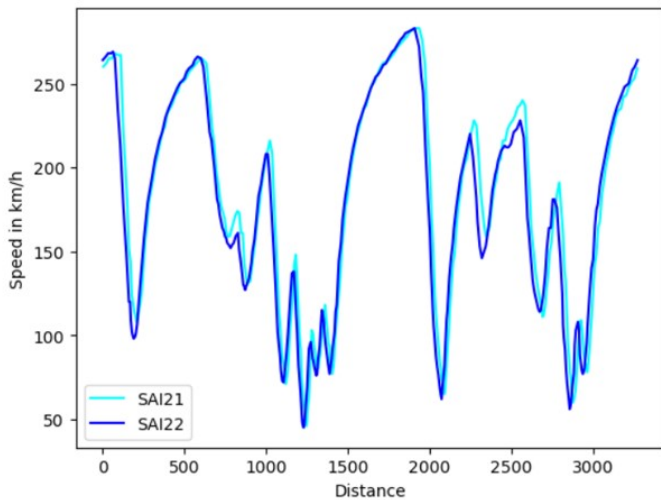
**Fig. 12** Red Bull Speed Vs Distance (Low-Speed Corners)



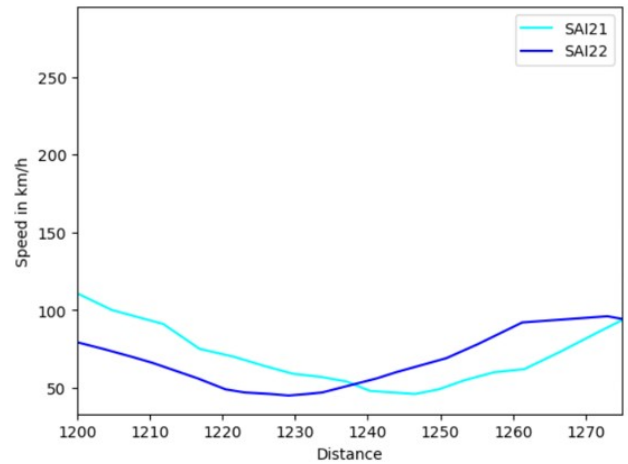
0 days 00:01:11.095000  
 0 days 00:01:12.560000

**Fig. 13** Mercedes Speed Vs Distance (Low-Speed Corners)

Fastest Lap Comparison(Scuderia\_Ferrari) Monaco(downforce track)  
2021 VS 2022 Qualifying



Fastest Lap Comparison(Scuderia\_Ferrari) Monaco(downforce track)  
2021 VS 2022 Qualifying



0 days 00:01:14.621000  
0 days 00:01:16.421000

Fig. 14 Ferrari Speed Vs Distance (Low-Speed Corners)

## Conclusion

My original hypothesis was that the 2022 cars are faster in a straight line due to the reduced drag but much slower in the corners due to the reduced downforce. By comparing the top speed of teams by plotting their peak speeds on a graph and by finding out the average gain in top speed through a box plot, I found out that almost all the teams showed an increase in top speed between 2021 and 2022. However, tracks dominated by high-speed and low-speed corners, both showed an increase in lap time. This conclusion was achieved by looking at the box plot representing the average gain in lap time in high-speed and low-speed corners. Therefore, the 2022 F1 cars may be faster in straight line, but they are significantly slower in the corners. This results in them being substantially slower over the course of a lap. The next steps are to conduct a similar analysis on the upcoming 2026 regulations, which bring with them a new engine, aerodynamics, and fully sustainable fuels.

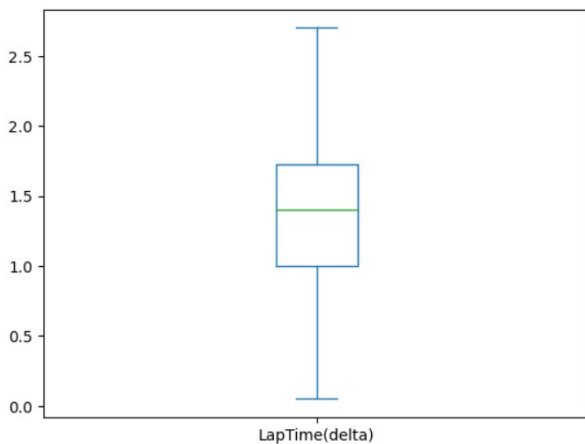


Fig. 15 Average difference in lap time between 2021 and 2022 (Low-Speed)

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