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## Conclusions

- McLaren increased their performance relative to other through step-by-step development of a whole car concept.
- Aston Martin performance relative to competitors has declined, through taking wrong development route.
- Crucial McLaren upgrades were brought to Spain, Canada and Austria, which were instrumental in their performance gains. These upgrades addressed the core issues and resulted in consistent performance improvement over Aston Martin.
- Crucial Aston Martin upgrades were brought to Spain and Canada, although these did not yield the expected improvements. The upgrades failed to address the fundamental issues, resulting in continued underperformance compared to McLaren.
- McLaren has gained a noticeable edge in cornering performance relative to Aston Martin. This advantage is particularly evident in tracks with a high number of technical corners, where McLaren's high downforce setup provides superior grip and stability.
- Despite McLaren's overall performance gains, Aston Martin has managed to remain competitive on straights. This suggests that their car still maintains strong straight-line speed, likely due to a lower drag setup that favours high-speed sections of the track.

- McLaren was more consistent than Aston Martin in scope of the season. McLaren was 4<sup>th</sup> in F1 constructors championship standings while Aston Martin ended up 5<sup>th</sup> in F1 constructors championship standings.

## Introduction

This report's goal is to analyse rivalry of Aston Martin and McLaren F1 teams in 2023 season. Performed analysis puts heavy emphasis on pure pace performed in qualifying sessions of Formula 1 World Championship. There are 10 teams competing in the championship. Every team consist of pair of drivers. Qualifying sessions happen a day before a race and decide about its pecking order. Formula 1 qualifying session is divided into three segments. In each of first two segments (Q1, Q2), five cars with slowest lap times get knocked out and secure spots on race starting grid in order from fastest to slowest. In Q3 10 cars compete for best spots on the grid.

Analysis is limited to fastest lap of a given driver from every qualifying segment. This means that if driver A performed personal best lap of a session in Q2 and driver B performed it in Q3, then those laps are compared to each other. Issue coming from this is that if driver A made a better lap in Q3 than driver B, then starting grid on the race would differ from what is presented on lap telemetry plot. This problem is multidimensional as lap times in different segments can be influenced by tire degradation, weather and track conditions. This is why performance in single session needs to be analysed as a part of a trend in scope of a season. It's also worth noting that racing car can have a strong qualifying pace and poor race pace. Reversed situation is also possible. Important information is that FastF1 library an API which provides data for this analysis can contain mistakes in lap times and other data. Data provided by library was checked with official data in F1 resources. If the data on a plot does not match it won't be included in analysis.

Teams build new cars every season. Engineers are constantly trying to make their cars faster. Changes in pace trend of Formula 1 teams across the season is heavily influenced by car upgrades introduced in between races. Upgrades are a risk as their implementation can make a car faster or slower relative to opponents. This is the reason why this analysis heavily relies on upgrades brought by teams during 2023 season.

This paper shows key moments in a story of McLaren and Aston Martin F1 championship development. Comparison of fastest qualifying laps is a tool that is meant to present their one lap pace in relation to each other. Analysis of multiple qualifying laps and race performance in a scope of a season is helpful in identifying pace trend. Upgrades analysis is meant to show how, why and when those changes in trend happened.

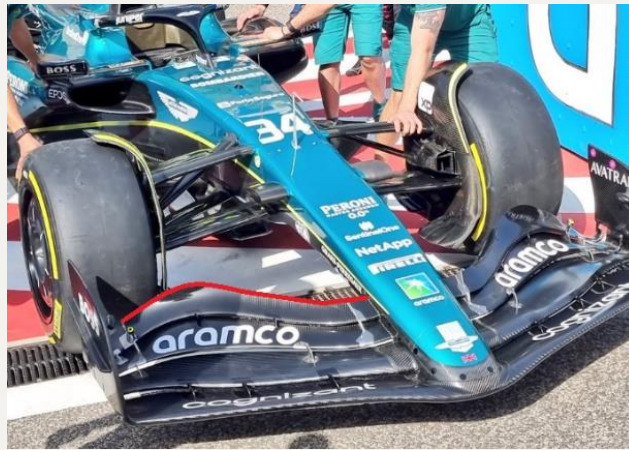
## Car concepts

McLaren's concept was not much different to car at the end of 2022 season. The 2023 MCL60 car freed space at the lower front of the sidepod in order to prepare it for vaned inlets for the underfloor tunnels. Upper surface of the sidepods was changed in order to fit revised radiator layouts. In theory, this should improve the ground-effect underfloor performance and result in a faster car. The air flow was to be improved with new, wider nose. The floor and rear were not improved relative to 2022. Car did not behave as expected. The main problems of evolved 2022 concept was that it didn't have a good balance between downforce and drag. Downforce and drag are forces that affect cars speed. In theory a fast car concept should aim to reduce drag and increase downforce. Characteristics of McLaren's concept made the car slow and ineffective.

Aston Martin's for AMR23 car concept was to place sidepods as outside component of a body in order to gain aerodynamic flow. This solution reduces weight of the car and improves balance. Compared to AMR22 cooling system was changed from air – air system to more efficient water – air system. Slim rear and new front suspension allowed for high downforce creation. As for air flow, new nose was introduced which affects floor in order to create solid ground effect. Body of the car was arranged in smooth shapes which further improves clean air flow. This concept proved to be fast resulting in second fastest team on the start of 2023 season. There are claims that Aston Martin copied concept of 2022 Red Bull car - RB18.



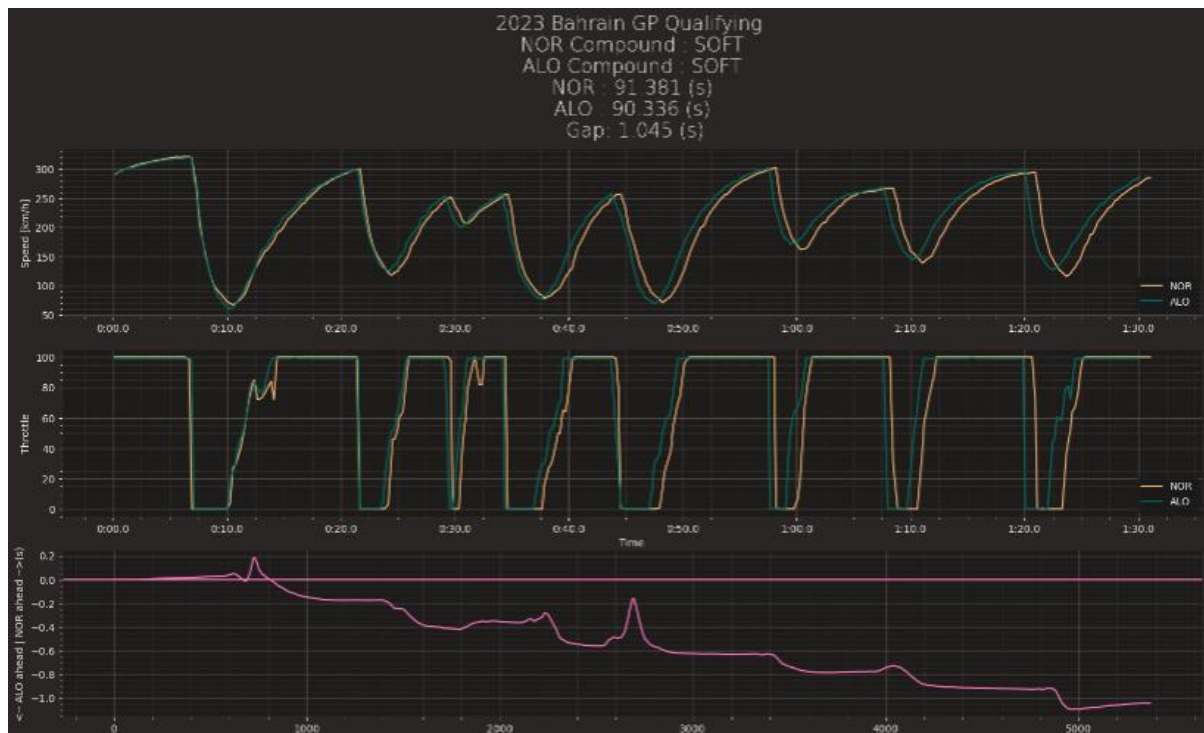
AMR23 have a very similar sidepods airflow to old Red Bull concept. Bodies of these cars are resembling downwash ramp that smoothly moves the air starting from area around cockpit to rear suspension. Noses of both cars look quite identical too. Their lines are very similar and align with core aerodynamic concept.



Although bodies are quite similar, wings and suspensions are non-identical. Aston Martin endplate has a smooth airflow while Red Bull's has a curvy indentation. Front wings have a completely different line. AMR23 line is skewed right while RB18 is elevated in a middle of a main plate. 2022 Red Bull's constructions is supported by pull-rod suspension at the front and pull-rod at the back which is inverse compared to Aston Martin. Top Aston's rear wing is flat and does not have an indentation like RB18. Rear wing endplates share core design with similar shapes. Air flowing through diffuser moves a bit differently.

Thesis that AMR23 is a copy of RB18 may be considered false. Although these cars share similar aerodynamic concept, they differ in details found in wings and suspension. These cars can't be identical because of different than Red Bull's manufacturing parts provided to Aston by Mercedes. These parts require application of slightly different concepts for them to work.

Season start

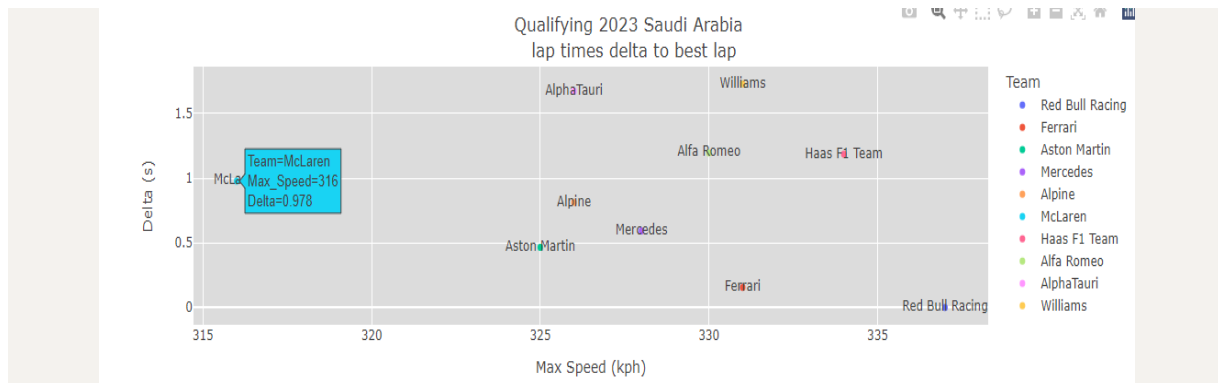


At the start of the season McLaren had a huge pace gap compared to Aston Martin. During Bahrain Grand Prix qualifying, Fernando Alonso was 1.045s faster than Lando Norris. McLaren was dominated by Aston in every sector but they've managed to gain a little time in corners.

After second race of the season in Saudi Arabia Norris said:

*I definitely think we are worst today. Our strengths and weaknesses clearly just aren't in the right places. I don't even say we're good in the corners, but we're way too slow in the straights. We can't use what we have in the corners at high speed so I can get close but we just can't do anything more than that.*



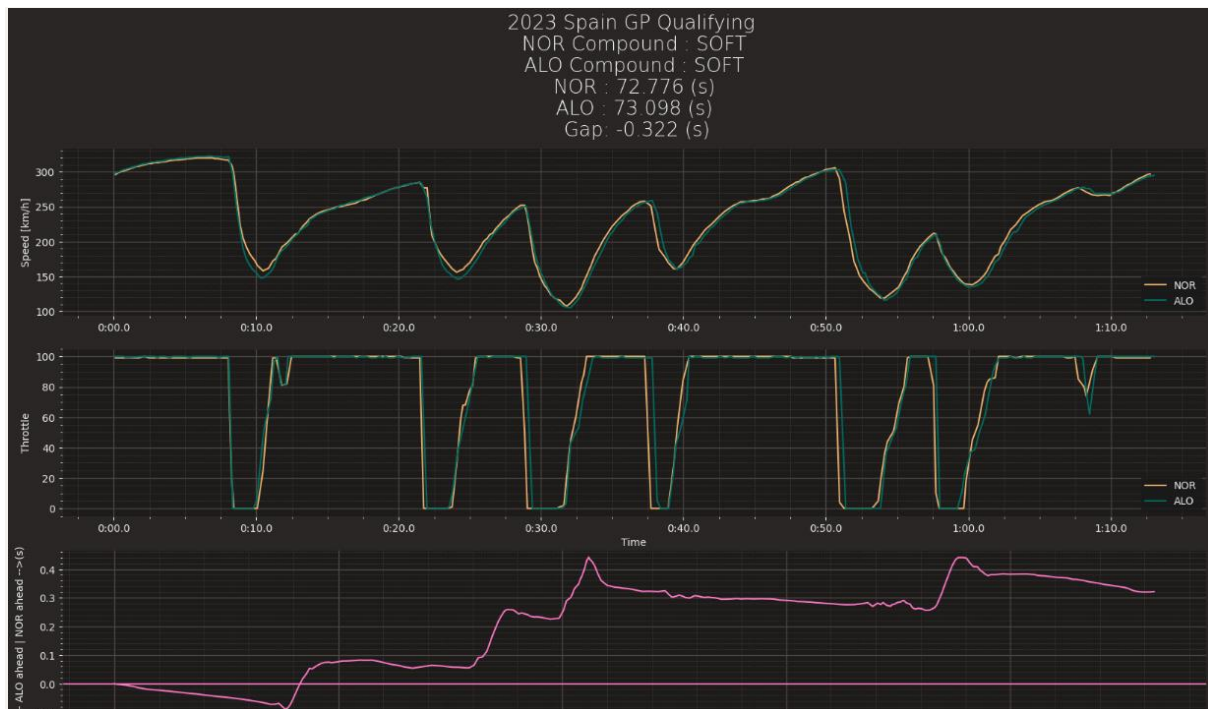


McLaren did not have a good start. In Bahrain Lando Norris, fastest driver of the team was 11th in qualifying, his partner, Oscar Piastri ended 18th. In the race they did not show much finishing outside of points. In Saudi Arabia they had lowest top speed on straights compared to other teams. This statistic is very important in context of Saudi Arabia track as it consist of long straights. In qualifying Piastri was 9<sup>th</sup> and Norris 19<sup>th</sup>. They have finished the race on 15<sup>th</sup> and 17<sup>th</sup> position. The car had no pace at all, the concept was not performing well.

Aston Martin started a season above everyone's expectations. After weak 2022, they developed a fast, competitive car. First sessions of the season in Bahrain were exceptional for the team. Fernando Alonso, new Aston Martin driver who won F1 Championship twice, were in the top three in every practice session. Qualifying was a bit worse as he ended up 5th. Nonetheless Alonso finished the race 3rd after fabulous driving. Lance Stroll, second driver of Aston Martin finished 9<sup>th</sup>. In Saudi Arabia Alonso was 3<sup>rd</sup> in qualifying and in the race. Stroll was 6<sup>th</sup> in qualifying and did not finish the race.

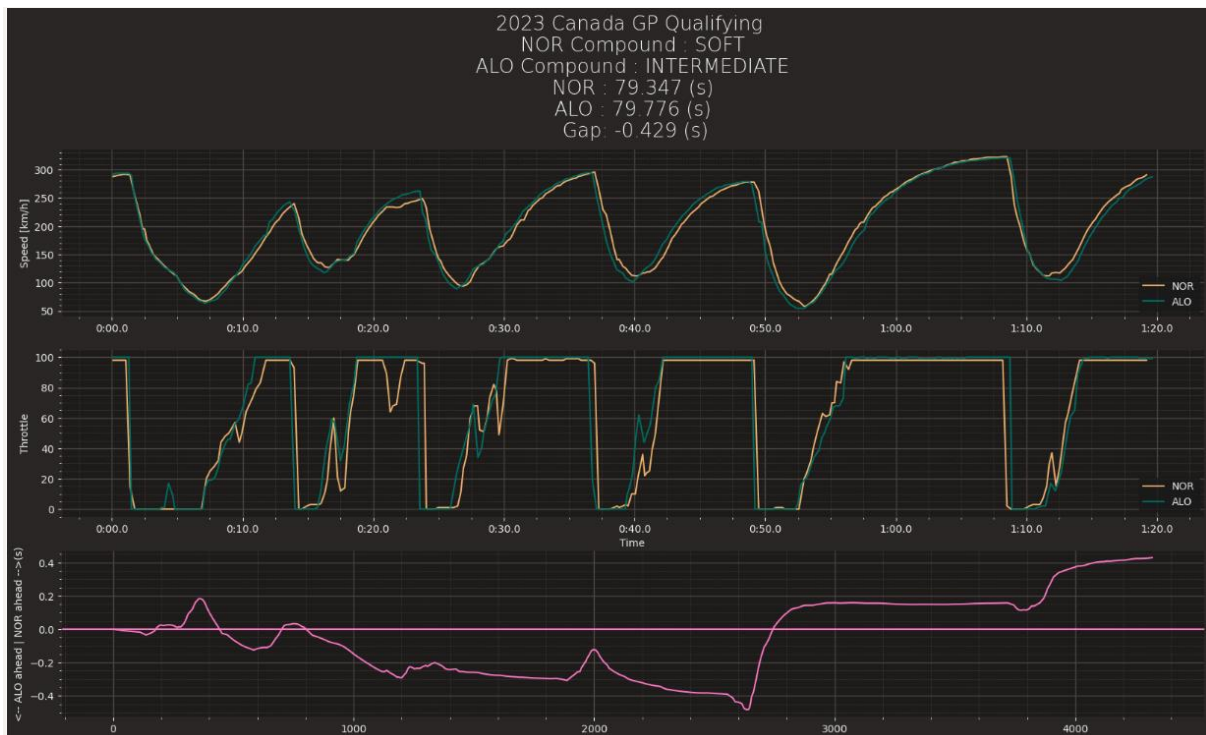
## Upgrades

Ninth round of championship, Spanish Grand Prix was a start to McLaren bettering themselves through upgrades. Pictures taken in paddock before the weekend show that the team *revised the design of the lower section of the endplate [1]*. Aston Martin upgraded wings and nose. This was the first event when McLaren ended qualifying session in top place. Norris ended up 3rd meanwhile best driver of Aston Martin – Alonso found himself on 9th place. Despite great qualifying result from Norris and 10th place from Piastri, McLaren ended the race outside of points because they have lacked consistent race pace.



Norris's best lap in qualifying was much faster than Alonso's lap. McLaren's driver was faster by 0.3s. Norris had faster speed through corners than Alonso which implies greater downforce produced by McLaren's car. In the 3rd sector (corners 10 - 14) Norris was significantly faster through corners exits, lowering his speed in entries. Alonso was slower than Norris despite him braking later most of the lap. Qualifying pace was on top but McLaren lacked a solid race pace yet.

McLaren brought *a new rear wing and beam wing assembly [2]* to Canada. Qualifying sessions went slightly worse than in Spain. Norris ended up 7th and Piastri 9th. Aston Martin did much more complex set of upgrades. The set consisted of new wider sidepods in shape of a water channel in order to move air through the top of bodywork and then to the floor. The floor was modified to suit sidepod changes. Aston's Alonso did much better than last time taking 3<sup>rd</sup> place on the grid while Stroll ended up 13th. Despite that McLaren once again ended the race with no points. Fernando Alonso finished 2<sup>nd</sup> while Stroll 9<sup>th</sup>.



In Q2 Norris did a faster lap than Alonso by around 0.4s. Most of the lap Alonso was 0.2/0.3s faster than McLaren. Norris was better than Alonso in first corner and later in the 3rd sector (corners 10 - 14) which implies that McLaren gained its performance on straights. Difference in tire choice of both drivers is due to light rain conditions during qualifying. Q3 laps were made on intermediate compounds and ended prematurely due to Ferrari driver hitting the wall causing a red flag. Maybe if the session ended in time Norris would do a better lap than Alonso.

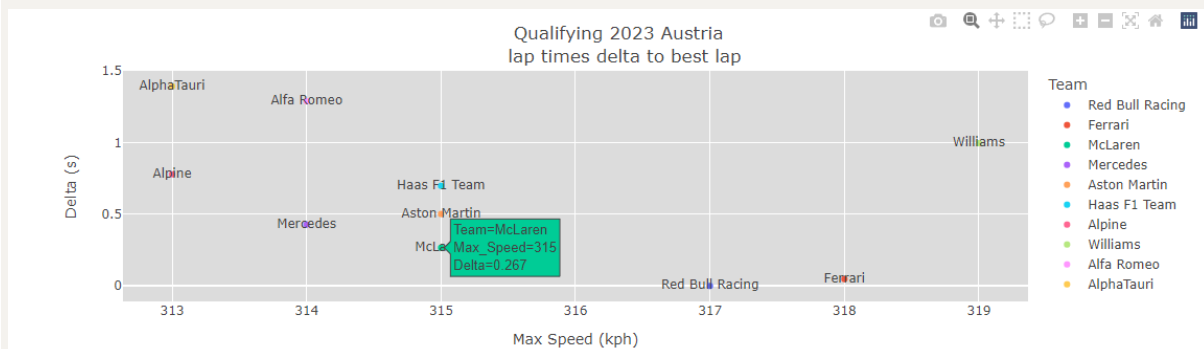
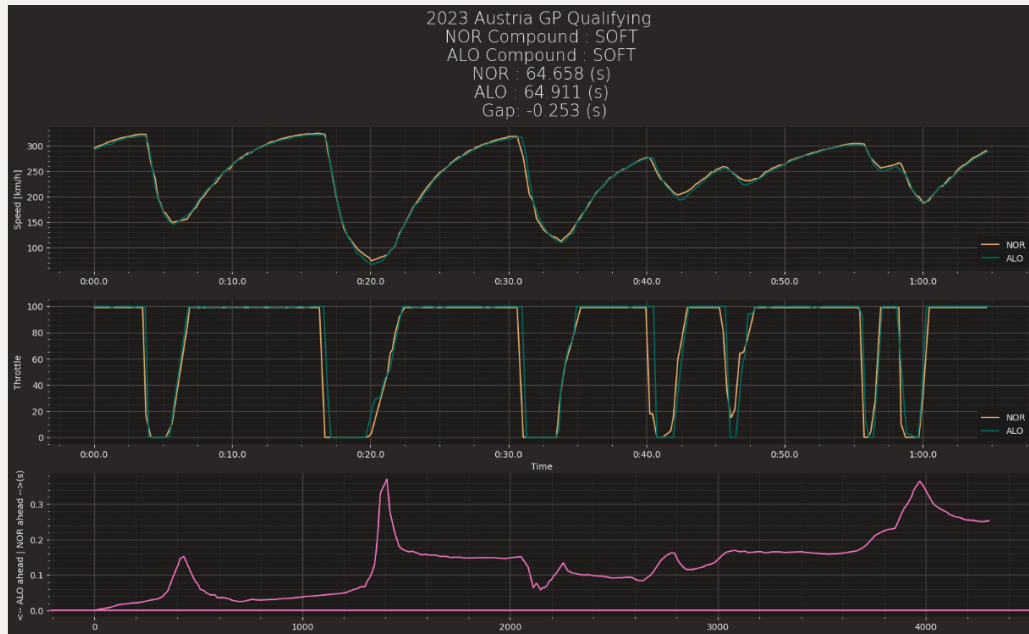


#### McLaren F1 Team

	Updated component	Primary reason for update	Geometric differences compared to previous version	Brief description on how the update works
1	Sidepod Inlet	Performance - Flow Conditioning	New Sidepod Inlet Shape	In conjunction with the new Bodywork Shape, the Sidepod Inlet and Mirror Geometry has been heavily revised, to aid flow conditioning on Bodywork and Floor.
2	Halo	Performance - Flow Conditioning	New Halo Fairing and Furniture	In conjunction with the new Bodywork Shape, both Halo Fairing and Furniture have been updated to aid flow conditioning over the top of the Bodywork.
3	Floor Body	Performance - Local Load	Fully revised Floor	The new floor features updated Fences, Floor Edge as well as Diffuser shape, which in conjunction with the revised Bodywork Shape results in an increase in aerodynamic load.
4	Coke/Engine Cover	Performance - Flow Conditioning	Reshaped Sidepod and Engine Cover	The Engine Cover and Sidepod/Coke has been reshaped to improve flow conditioning to the floor, resulting in the aforementioned increase in load.
5	Cooling Louvres	Performance - Flow Conditioning	Updated Louvre Geometry	The new Bodywork shape requires a revised Shoulder Louvre Geometry featuring various steps, to enable adequate cooling for various ambient conditions.



Upgrades brought to Austria were crucial for McLaren's speed. Team revised every area of the car to gain aerodynamic performance. Changes were made to chassis, body, rear and front of the car. Flow conditioning and aerodynamic load was improved by changing geometry of sidepods, engine cover, mirrors, halo fairing and furniture. Floor of the car was reshaped as well. New cooling system was needed for introduced elements to work properly. Race pace of McLaren was better. Norris to whose car upgrades were brought finished 4th closing a gap to podium. Alonso ended this race just behind Norris. Piastri with no upgrades crossed the finish line 16th. Stroll was 9th.

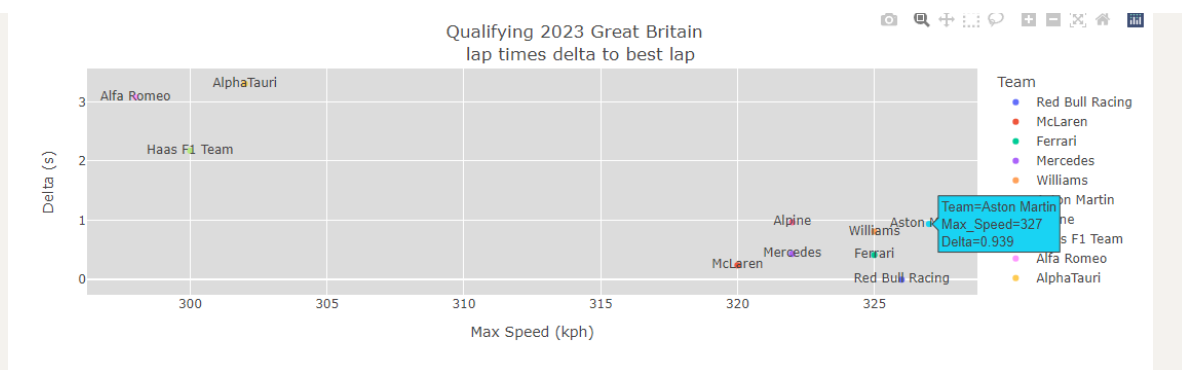


McLaren after aerodynamic upgrades was significantly faster. The car was quicker than Aston Martin with advantage of around 0.2s on a best qualifying lap. McLaren improved on straights and started to gain advantage on Aston. The gap increased consistently at corner exits. Lap times delta to best lap shows that McLaren's speed on straights improved as they were third fastest team and fourth in straight speed aspect in Austria. This was the moment when Aston Martin started to be consistently slower than McLaren. Fernando Alonso's aggressive driving through braking later than Norris wasn't effective.

Aston's further sets of upgrades were brought to Great Britain, Hungary, Belgium, Netherlands. Upgrades did change car's cooling system as well as floor and wing designs. In UK new front wing was introduced in order to gain downforce. Changes in cooling system were made by introducing new rear brake duct inlets. In Hungary further development of cooling system by changing engine cover was made. In Belgium and Netherlands, the team revised floor in order to increase performance. Meanwhile McLaren upgraded its car further. In UK, Hungary, Belgium and Netherlands they have introduced a set of upgrades that developed wings, nose, brake ducts and suspension.

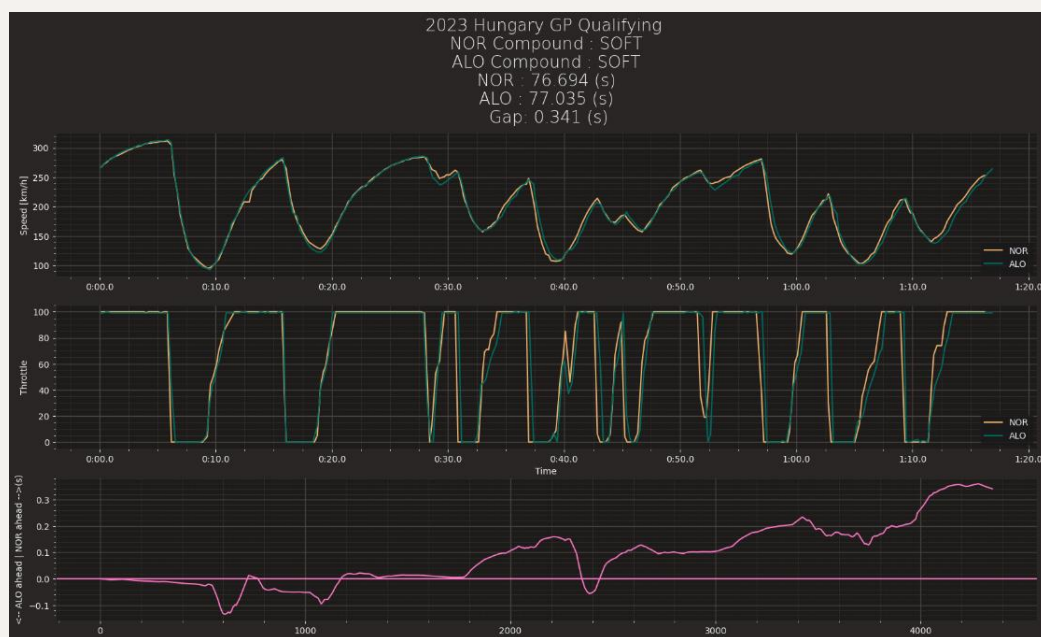
In UK Aston introduced a new front wing in order to gain downforce. Changes in cooling system were made by introducing new rear brake duct inlets. McLaren prepared a new front wing assembly that features new elements as well as end plate geometry, aimed at better flow control and increased load, while a new nose has been designed to work in sympathy with the new wing. Meanwhile, at the rear of the car McLaren have revised the winglets of the brake ducts to produce more load and changes have been made to the rear suspension to achieve the same goal. This is a first race after Astons upgrades which only deepened qualifying pace difference compared to McLaren. Lando Norris finished 2<sup>nd</sup> and Oscar Piastri 4<sup>th</sup> while Fernando Alonso was 7<sup>th</sup> and Lance Stroll 14<sup>th</sup>.





During best qualifying laps McLaren was significantly faster than Aston Martin. Pace qualifying data shows that Alonso max speed on straights was 7 km/h faster than Norris. This characteristic is visible on telemetry lap data. Fernando is gaining a little bit time on Norris only to lose significant amount of it in corners. McLaren finished the lap faster by 0.698s.

In Hungary Aston Martin have altered the engine cover of the AMR22, with a large exit area increasing the volume of cooling flow exited from the bodywork. Norris finished 2<sup>nd</sup> and Piastri finished 5<sup>th</sup>. Alonso and Piastri were 9<sup>th</sup> and 10<sup>th</sup>.



Alonso was slower than Norris by 0.341s being faster in three corners by around 0.1s. Despite that the rest of the lap was dominated by Norris who gained in second part of the lap in corners and on straights as well.

Aston Martin Aramco Cognizant Formula One Team

	Updated component	Primary reason for update	Geometric differences compared to previous version	Brief description on how the update works
1	Floor Edge	Performance - Local Load	Floor edge updated to subtly revise the geometry, conceptually similar.	Small changes to the features generated from the floor edge to improve their interaction and hence local load on the lower surface of the floor.
2	Rear Wing	Circuit specific - Drag Range	New rear wing flap with reduced chord on the low drag rear wing.	Reduced wing loading and hence drag to suit the characteristics of the circuit, may be used but defined by the chosen setup.
3	Beam Wing	Circuit specific - Drag Range	Single element beam wing.	Reduced wing loading and hence drag to suit the characteristics of the circuit, may be used but defined by the chosen setup.

Aston changed its floor in Belgium and altered its wing structure as well to suit circuit characteristics. Floor edge was updated to revise its geometry. New beam wing and new rear wing flap was introduced. McLaren focused on developing its rear and front wings also in order to suit circuit characteristics. For this purpose, beam wing was offloaded, rear wing was updated with new endplate infill and flap trims. This time around Alonso was better than McLaren and finished 5<sup>th</sup>. Stroll was 9<sup>th</sup>. Norris was 7<sup>th</sup> while Piastri did not finish the race.

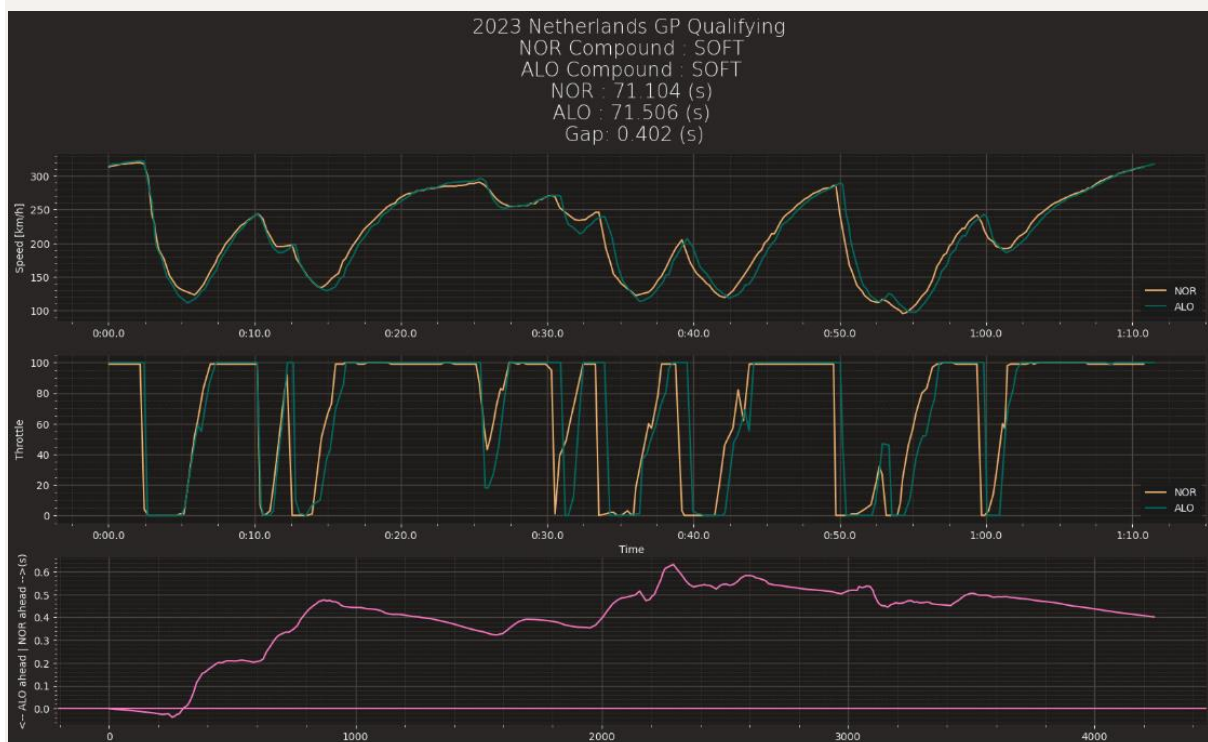


Teams were very close to each other in qualifying pace. Norris was faster than Alonso by 0.174s but Alonso dominated most of the lap. Alonso probably made a mistake in turn in 8th turn as his cornering speed was much lower than Norris'. After that event Norris gained time on Alonso and was faster than him. Probably if no mistake was made, Alonso would be faster than Norris on this occasion.

**Aston Martin Aramco Cognizant Formula One Team**

	Updated component	Primary reason for update	Geometric differences compared to previous version	Brief description on how the update works
1	Floor Body	Performance - Local Load	The lower surface of the floor has been modified to change the volume underneath the floor.	The package of floor modifications work in combination to improve local flow details and increase the load generated by the floor.
2	Floor Fences	Performance - Local Load	The fences have been reshaped slightly in conjunction with the main body changes.	The package of floor modifications work in combination to improve local flow details and increase the load generated by the floor.
3	Floor Edge	Performance - Local Load	The floor edge is the same concept but adjusted to suit the floor body modifications.	The package of floor modifications work in combination to improve local flow details and increase the load generated by the floor.
4	Diffuser	Performance - Local Load	The upper corner of the diffuser is modified to change the volume of the lower surface. A small winglet is also added behind the diffuser.	The package of floor modifications work in combination to improve local flow details and increase the load generated by the floor.

In Netherlands Aston further tried to develop their floor and McLaren focused on wings. Aston updated floors body, fences, edge and diffuser. These modifications were made in order to change volume of the floor and lower surface. McLaren changed rear wing assembly and beam wing assembly to suit circuit needs. In Netherlands Alonso was 2<sup>nd</sup> and Stroll was 11<sup>th</sup>. Norris was 7<sup>th</sup> while Piastri 9<sup>th</sup>.



These changes were unfortunate for Aston as Lando Norris dominated Fernando Alonso on a whole lap ending it with 0.402s advantage. Lando dominated in corners effectively increasing his advantage over Alonso. Netherlands Zandvoort circuit specific is that there is lots of elevated corners which appealed to McLaren strength. Delta plot shows that on straights Alonso gained a little to Norris but it wasn't much to come close to a time of a Brit.



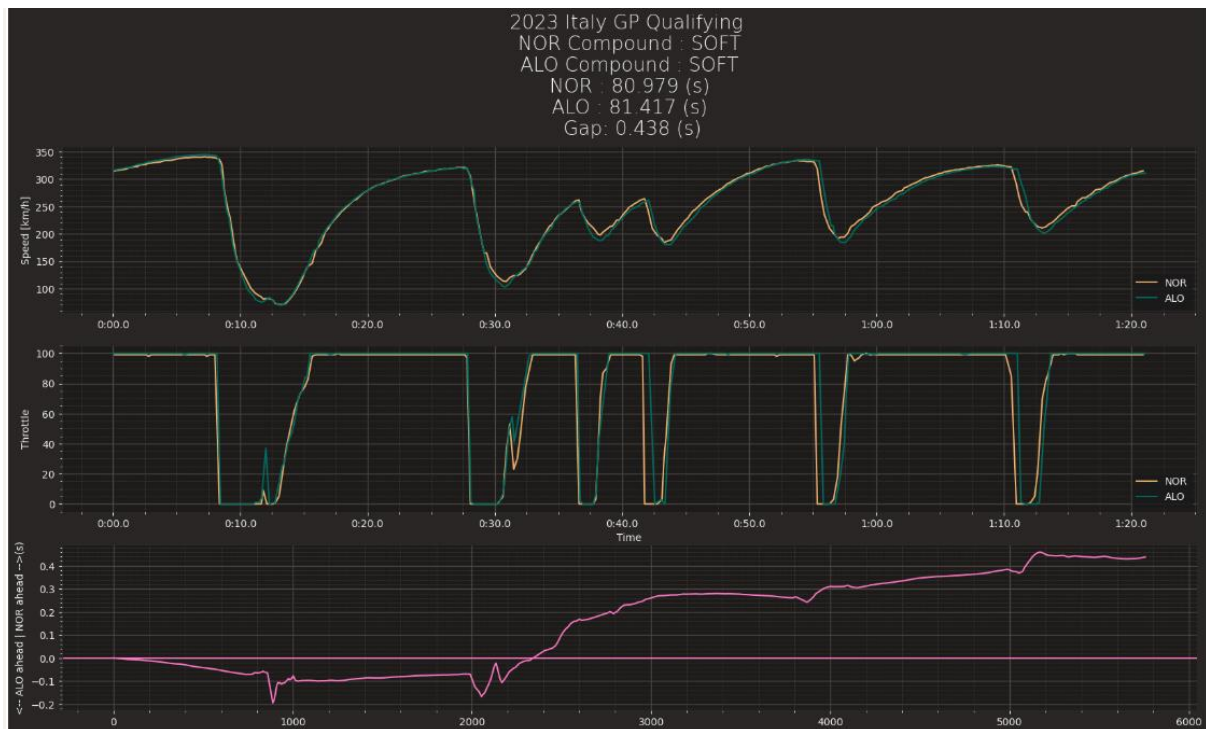
### McLaren F1 Team

	Updated component	Primary reason for update	Geometric differences compared to previous version	Brief description on how the update works
1	Front Wing	Circuit specific - Balance Range	Low Balance Front Wing Flap	Altered Front Wing Flap shape, aiming at efficiently reducing Front Wing loading to balance low downforce Rear Wing options at this track.
2	Front Corner	Performance - Flow Conditioning	New Front Brake Duct Scoop	A new Front Corner Scoop geometry, which results in improved flow conditioning and subsequently an efficient increase in aerodynamic load while maintaining sufficient Brake Cooling Performance.
3	Rear Wing	Circuit specific - Drag Range	New lower Drag Flap Assembly and Trims	New, low drag flap assembly with two trim options, reducing flap loading and resultant Downforce and Drag of the RW Assembly.
4	Rear Wing Endplate	Circuit specific - Drag Range	Rear Wing Endplate Infill	A modified Rear wing endplate featuring a different sideview shape, which reduces Rear Wing Mainplane loading and thus efficiently reduces aerodynamic Drag and Load.
5	Rear Wing	Circuit specific - Drag Range	Lower Drag Rear Wing Assembly	New lower Drag Rear Wing Assembly, with an offloaded Mainplane and Flap, resulting in an efficient reduction of Downforce and Drag.
6	Rear Corner	Circuit specific - Drag Range	Revised Rear Corner Winglet arrangement	New Rear Corner Winglet configuration which results in a reduction of aerodynamic load and drag, suitable specifically for this circuit.

### Aston Martin Aramco Cognizant Formula One Team

	Updated component	Primary reason for update	Geometric differences compared to previous version	Brief description on how the update works
1	Rear Wing	Circuit specific - Drag Range	New rear wing flap with reduced chord on the low drag rear wing.	Reduced wing loading and hence drag to suit the characteristics of the circuit, use depends on the chosen setup.

McLaren got a big upgrade of wings structure in Italy to suit a circuit. They have updated front wing, front corner, rear wing, rear corner and rear wing endplate. Only performance change in McLaren was new front brake duct scoop aimed to further improve flow conditioning. Aston only changed rear wing flap to suit the circuit environment. Norris was 8<sup>th</sup> while Piastri 12<sup>th</sup>. Alonso was 9<sup>th</sup> and Stroll 16<sup>th</sup>.

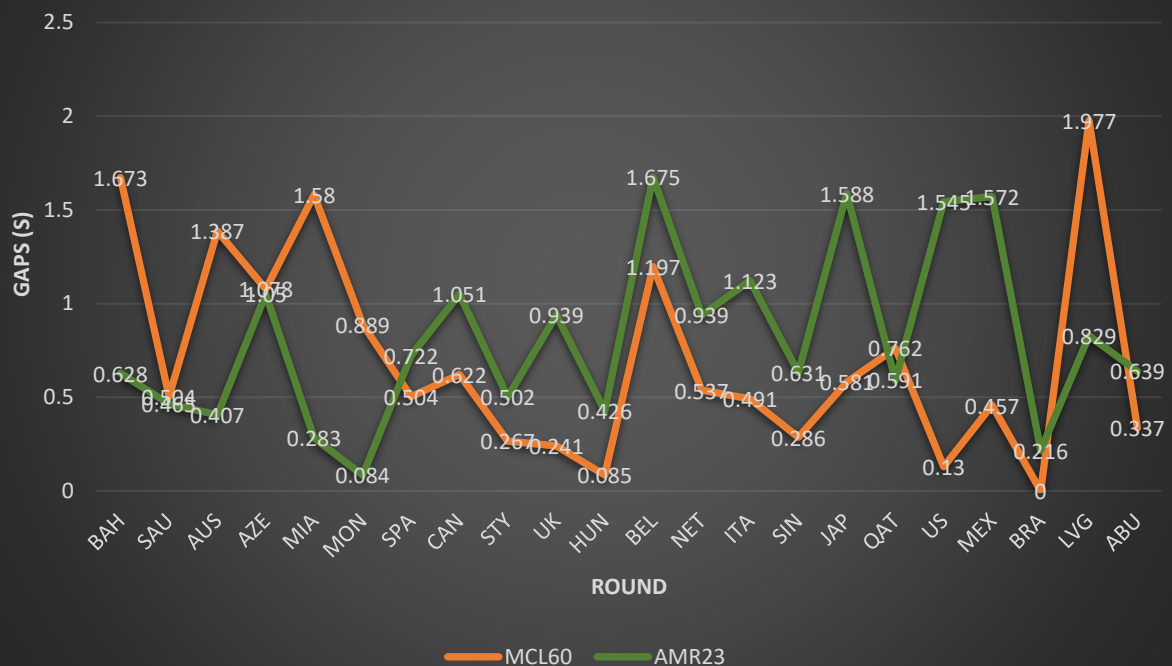


First part of the lap was dominated by Aston Martin but after 3<sup>rd</sup> corner McLaren was faster and dominated the rest of a lap. It seems like Fernando was breaking a little bit harder than Norris which implies lower downforce in turns 3<sup>rd</sup> and 4<sup>th</sup>. Lando Norris was faster than Fernando Alonso on this lap ending it with 0.438s gap.

Aston Martins form started to fell from Spanish and Canadian Grand Prix. This means that these complex upgrades introduced in Canada and Spain affected the team performance most.

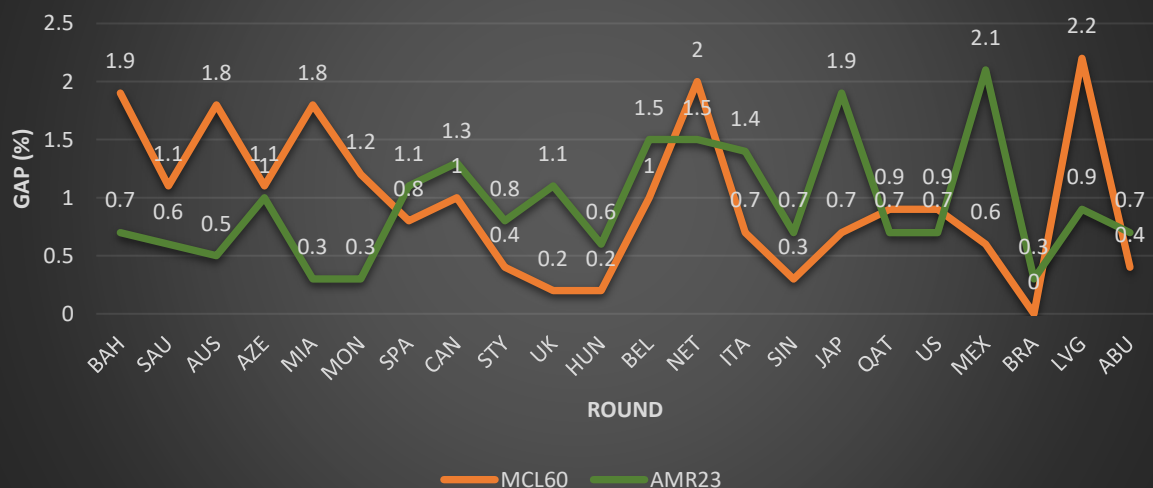
Season summary

## MCL60 vs AMR23 qualifying gap to pole 2023 season



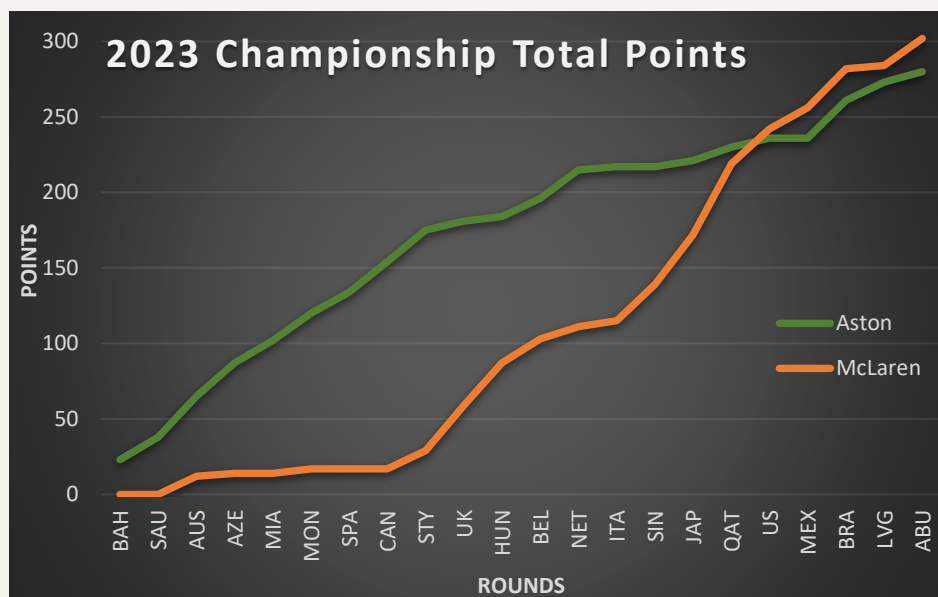
McLaren's form started visibly improving in Spain. Average gap to pole before Spain was 1.18s. After Spain average gap to pole dropped to 0.529s. Before Spain on average, they've scored 2.8 points per race. After Spain on average, they scored 17.8 points per race. Across the season Aston started losing its form after in Canada. Before Canada on average, they've scored 19.1 points per race. After Canada they've scored on average 9.7 points per race. Before Canada average qualifying gap to pole was 0.642s and after it increased to 1.08s.

## % Gap to pole 2023 Aston vs McLaren



Percentage gap to pole plot shows that Spanish and Canadian upgrades were crucial to development of both McLaren and Aston Martin. After Monaco qualifying performance of both teams relative to pole position changed significantly. Before Spain Aston Martin percentage gap to pole position was close to zero in most occasions while McLaren's gap was over 1% in every event. In Spain tables have turned and McLaren's gap started shifting towards zero and Aston Martin started scoring close to 1% mark. This trend was later visible most of the season with few occasional changes.

Both teams on average qualified on similar positions across the season. Best drivers with better qualifying results than their teammates, Norris and Alonso on average finished qualifying on 7<sup>th</sup> position. If other drivers are taken into consideration Aston Martin's average qualifying position was 10<sup>th</sup> while McLaren's 9<sup>th</sup>. Norris average race result is 8<sup>th</sup> and Alonso is 7<sup>th</sup>. Aston Martin finished the race on 9<sup>th</sup> position on average while McLaren 10<sup>th</sup>. McLaren team was slightly better in qualifying results while Aston Martin at race results. Those statistics show that rivalry between Aston Martin and McLaren in 2023 season was tight but development route and single session analysis shows that those two teams were far better from each other in different parts of the season. Aston Martin clearly dominated over McLaren the first part of the year up to British Grand Prix. From this event forward McLaren gained significant advantage over Aston Martin.



Development route is crucial for performance of F1 cars. Engineering solutions applied during the season can significantly change pecking order like in Aston and McLaren rivalry. Aston started as second fastest team on the grid just to start losing in the middle of the season because of development route they have taken in Spain and Canada. Changes to Aston's concept were crucial in slowing the car down and probably lowering downforce and increasing drag relative to their opponents. McLaren did well in identifying and fixing their weaknesses slowly introducing their solution in a few races (Spain – Austria). Incremental changes made to whole car made for great concept that

excelled on track right away. McLaren's thorough upgrades were a key to performance increase. Aston's upgrades were mismatched with the car and did not address its weaknesses. As a result despite a very strong start, Aston Martin was out developed by other teams losing the battle for 4th place in championship to McLaren.

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[1] *Spanish Grand Prix: F1 technical images from the pitlane explained*, Matt Somerfield, Giorgio Piola

[2] *F1 teams reveal upgrades for Canadian GP*, Taylor Powling