

Driver Comparison Through Data Analysis

by Samuel Fripp

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Race Engineering

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1-Introduction

This assignment will focus on collecting data from 3 different drivers driving around the same track using the same car in a simulator. The data will then be analyzed looking at driver inputs such as gear, throttle position and brake position and each driver will be compared to each other and themselves to see if it is possible to improve the drivers performance using the data collected. The choice of cars was between a GT1 car and a GP2 car. The track selection was any track that was available on the simulator.

2-Methodology

2.1-Driver in the Loop

The testing procedure will be done on a simulator using a method of testing known as driver in the loop. Driver in the loop is basically when a driver tests a vehicle virtually. In the case of this experiment it involves a driver using a simulator to test the car but can also be used as a means of improving the driver.

One of the advantages of this are that some variable e.g. track temperature can be controlled that otherwise wouldn't be able to. This is backed up by a report by J.C.F. de Winter which states that it improves not only controllability but reproducibility and standardization of test conditions. The report also states that it is easier to collect data, allow more extreme conditions to be tested whilst removing potential physical risks and a good opportunity for feedback and instruction. The ease of collecting data in testing is immediately noticeable and very useful for collecting more data in a shorter space of time. The extreme conditions is another obvious advantage as the extreme conditions could be potentially dangerous or even fatal in real life but in a simulator the risks are significantly reduced. The improved feedback ties into the ease of collecting as it allows easier, quicker and more efficient and potentially accurate data analysis which allows the testers to give more informed information to the driver.

There are however also downsides to using this method of testing. De Winter states a lack of fidelity on a simulator. This can be a problem as it may affect the results as well as demoralize the driver as they may not be satisfied with the lack of feel with the simulator.

Another downside is that the simulator will not be 100% accurate when compared to real life conditions, it is very close in accuracy, therefore the differences will be small but may be enough to create a large effect on the results. De Winter also suggests that there is a “lack of research demonstrating validity of using simulators” However this report was made in 2012 and simulators have improved since then and more research has been done into the validity of simulators.

2.2-Equipment

2.2.1-Motec

“The software that is being used to analyze the data is called Motec i2 Pro. The software was made by Motec and is designed with a simple user interface to show the data as clearly as possible and provide the user with a wide range of possibilities of graphs, gauges and reports.

The simulator itself is based on a f1 chassis tub with motors for force feedback and pedal adjustment inside the nose. The screen is curved to provide the driver with a more realistic view of the track. And monitors are used to show a live feed along with other live data which is then stored in a data log folder to be saved and then used on Motec.

2.2.2-R Factor

The simulator runs on a professional version of R factor which was first released back in 2004 which provides very realistic handling physics along with low latency and ease of use. It is also compatible with Motec meaning the data can be logged and transferred very quickly Motec allowing for more time for analysis. F1 teams like Ferrari, Alfa Romeo Sauber and Mercedes use R factor and there is even a quote from the head of simulation at Ferrari on the R factor pro website praising the simulator saying “The way in which TerrainServer captures every LiDAR scanned data-point within the tyre contact patch, and integrates them all to provide our vehicle model with accurate road input, improves correlation with our measured data and also feels more realistic for the driver”. (Giacomo Tortora, 2018)

2.2.3-Car

The car being used for the test is the GP2 car. The GP2 car in question was introduced in 2011 and it's chassis is made by Dallara which is 5065mm long, 1800mm wide and has a height of 1072mm. The naturally aspirated V8 produces 612bhp and can rev up to 10,000RPM. This power lets the GP2 car accelerate from 0-60mph in just 2.9 seconds and reach a top speed of 209mph. The power is delivered through a longitudinal 6 speed sequential box and paddles are used to change gear. (Jack Leslie, 2015)

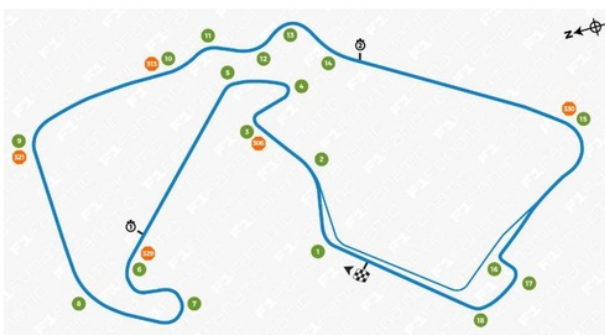


Callum Rowes (2011)

2.2.4-Track

The track used for the test is the Silverstone GP circuit. Silverstone was first created in 1943 out of an old WW2 bomber station. Over the years it has hosted many major motorsport events including Moto GP and Formula 1. The current iteration of the circuit has been in use since 2010 and consists of 18 corners over 3.7 miles. The track was chosen for this experiment because it is a technical circuit good mixture of high and low speed corners which will allow the testers to see how each driver performs over a wide range of corners as well as producing high tyre wear which will allow the differences in degradation of the tyre to become more noticeable more quickly.” (Samuel Fripp, 2018)

Race fans (2016)



2.3-Test procedure

The testing in the simulator with each of the 3 drivers was split into 2 1 hour 30mins sessions. In each session the drivers were given 2 5laps stints to try and get the fastest lap and most consistent set of laps possible. Each driver took it in turns to do their stint. Driver A (Racing driver) went first then driver B (Sim racer) then Driver C (little experience in either). Once each driver had completed their first stint they then did their second stints in the same order. The reason for the break in between was to minimize driver fatigue which would affect their performance on track. The first session was mainly used to get the data needed for the initial analysis. The 3 drivers that were chosen were selected because they should provide an interesting comparison in the results as one of them is a professional racing driver, one is a sim racer and one of them does not have any experience with either.

The analysis of the first set of data is to see what errors and habits each of the drivers had and how it is affecting their lap time. This is done by comparing drivers first stint to their second along with comparing each driver to each other to see where most of the time is being lost and what they are doing that is causing this loss in time. Then each driver was given 2 or 3 instructions to implement on their second session although they were not told these instructions until during the second session.

The second session took place 2 weeks after the first session. During this session the first stint was basically treated as a warm up stint to make sure the drivers were driving at the same level as before. After the first stint, the data from that first stint was compared to the data in the first session to make sure that they were driving as quickly as they were before to see if there anything else that the driver could implement in their second stint that could improve their lap further. The drivers then commence their second stint. During this stint the instructions given to them were told to them while they were driving to make sure they were implementing the instructions.

3-Analysis

The relevant screenshot in the appendix is written in the title of each section. For each section the fastest time is in red and the slowest time is in black for the same driver and for when comparing multiple drivers, Driver A is red, Driver B is black and Driver C is green.

3.1-Session 1 Data

3.1.1-Driver A first stint compared to second stint (Ap1)

During the first session Driver A was faster in the first stint than in the second stint producing a time of 1:37.994 and 1:38.254 respectively. Using the data on Ap1 we can see that the second stint lap starts to edge away in turns 1 and 2. This could be partially down to the fact that he was not using full throttle into turn 1 on the second stint although the difference is only about 5-6% which is not worth a tenth of a second. The steering wheel percentage and yaw seem to be very similar however in the second stint they are both very slightly smoother especially through turn 2 which could help reduce the amount of speed lost in the corner as the smoother line would cause less resistance through the tyres. This is

backed up by the speed of the car reducing from 270 to 254km/h (16km/h lost) in the first stint lap while during the best lap of the second stint the speed dropped from 273 to 258km/h (15km/h lost) which may sound very small but the car was already 3km/h slower into turn 1 which will definitely help build a small gap over the other car.

However, when heading towards turn 3 he brakes slightly earlier on his second stint and does not carry as much speed into the corner as in the first stint yet is only able to match the corner speed at the apex which allows his first stint lap to gain some time back. It is a similar story in turn 4 only this time the first stint lap gains a larger amount of time. This could be due to the small increase in steering wheel percentage compared to the second stint lap as the difference in time is smaller in turn 3 where the steering is virtually identical on both laps.

The next big difference is through turns 6 and 7 where on the first stint lap he brakes later and bleeds off the brakes for longer while also maintaining a smoother steering angle throughout turn 6 gaining 2 tenths in the process by carrying more speed. However through turn 7 he brakes a lot harder on his second stint and takes a wider line which is very noticeable in the steering wheel percentage where it peaks much higher but does not steer for as long which initially loses him time on the second stint but gains it back through 8 and the old start/finish straight due to being able to apply full throttle sooner. Driver A uses more throttle between turns 6 and 7 but overall due to braking more into turn 7 loses the time.

Finally the first stint lap gains more time by braking and steering earlier which although reducing corner speed allows for greater speed on exit which help gain more time before turns 16-18. This is evident during stint 1 driver A was able to achieve full throttle much sooner than during the second stint.

3.1.2-Driver B first stint compared to second stint (Ap2)

Compared to Driver A there are comparatively less large differences in terms of where time was gained between the first and second stint but there still are a few places where this occurs. Overall though Driver B seems to be consistently faster on the second stint than the first stint with lap times of 1:39.010 and 1:41.653 respectively.

The only time that the first stint is faster is through turns 1 and 2. This could be partially down to changing into 6th gear sooner which may allow the car to accelerate more in the corner. However, on further study it Driver B loses more speed in stint 1 than at stint 2 dropping from 272 to 254km/h (18km/h lost) and 263 to 250km/h (13km/h lost) respectively. This could be due to changing gear sooner but could also be due to some understeer with stint 1 as the steering angle is greater but the yaw of the car remains the same indicating that there is some understeer present.

However, the second stint gains an advantage through 2 different parts of the track. The first part is through turn 6 where during the second stint, Driver B was able to carry significantly more speed than during the first stint. The biggest reason for this is that he had to apply the brakes again on the first stint in the middle of turn 6 while he did not during the second stint. As a result, Driver B on the first stint is almost 40km/h slower through the

corner which is definitely large enough to lose a significant amount of time. There is not much difference through turn 7 as Driver B is able to carry a similar speed through there on both laps.

The second significant time gain for the second stint is through turn 16. This time, not only is Driver B carrying less speed during the first stint into the corner (about 14km/h difference), which will cost Driver B a significant portion of time in the first stint, but there also appears to be some evidence of some oversteer as both the g-force graph and the yaw graph have a sudden spike while the steering wheel percentage is less on stint 1 than it is on stint 2 which would cost even more time on stint 2.

3.1.3-Driver C first stint compared to second stint (Ap3)

Like driver B, Driver C was able to achieve a better lap time during stint 2. Achieving a 1:45.560 while only achieving a lap time of 1:48.498 during stint 1. Overall, the lap he produced in stint 1 was only significantly faster through turn 9. The reason for this is because he doesn't lift into the corner on the first stint which he does in stint 2. Plus, he is able to make the corner with a reduced steering angle but for slightly longer. This suggests a tighter line through the corner but also Driver C may have missed the apex on the second stint which could cause him to have to lift. The reduced steering angle also reduced the resistance exerted on the tyres which also helps reduce the speed lost through the corner. As a result, the speed only drops from 282 to 258km/h (24km/h lost) in stint 1 while in stint 2 the speed drops from 278 to 202km/h (76km/h lost). This difference is colossal which costs Driver C about 1 second which is a very large chunk of time.

Driver C gains most of the time in stint 2 through other areas most notably through turns 3-5 where the net gain of time is about 1.5seconds. Initially Driver C loses time on his second stint through turn 3 as he brakes harder and carries less speed through the corner. However, he uses more throttle between turns 3 and 4 on the second stint allowing the car to accelerate more and gain a few tenths but through turn 4 carries a similar speed in both stints through the corner. However, Driver C gets on the throttle significantly earlier on the second stint which allows him to gain 1.5 seconds over his lap on the first stint hinting at an increased confidence in the car.

3.1.4-Fastest lap time of each driver comparison stint (Ap4)

Driver A was the fastest driver in the first session with a time of 1:37.994, Driver B could only manage a time of 1:39.010 (1.016 seconds slower) and Driver C was only able to achieve a time of 1:45.560 (7.566 seconds slower)

Driver A gains the most time on Driver B through turns 6 and 7. The braking point is identical for both drivers although Driver B brakes for a shorter amount of time indicating that Driver A could brake later into turn 6. Driver C brakes much earlier than the other 2 drivers and as a result carries much less speed into the corner. There seems to be some understeer for Driver B as the steering input is greater for turn 6 yet the yaw and g-forces are similar to Driver A. On the exit of turn 6 Driver B applies full throttle while Driver B and Driver C apply similar amounts of throttle throughout the whole corner. This seems to give Driver B a small advantage, but the advantage is then lost in turn 7 where Driver B despite taking a tighter

line is able to carry more acceleration out the corner by being able to apply the throttle earlier. The wider line taken by driver B is evident in the initial increased steering angle which should allow for more speed on the exit, but Driver B does not apply the throttle as quickly indicating a lack of confidence in the car. Driver C follows a similar line and throttle application as Driver A however does not carry as much speed into the corner so loses out the most overall. An interesting thing to note is that through turn 7 Driver B actually gains a net 1 tenth of time which indicates that taking a wider line through turn 7 might actually help Driver A and C improve.

Another part where driver B gains a small amount of time is through turn 16 which is also the only point where Driver C gains some time over Driver A. This is because Driver A brakes earlier and not as hard indicating that he is not using the full potential of the brakes. However, through turn 17 and 18 Driver A gains the time back. In the case of driver B it is because of gear selection as he chooses to use 2nd gear while Driver A uses first gear which allows the car to accelerate more which means that he gains more time. Driver C actually has an oversteer moment through turns 16 and 17 which is shown by a sharp peak on the yaw angle and the steering angle suddenly dropping.

3.2-Session 2 Data

For session 2 each driver was given instructions on how to improve their performance on track. The following instructions were given to each driver as follows

Driver A

- Brake later in general
- Turn earlier into Turn 15

Driver B

- Tighter lines from turn 8 onwards
- 1st gear into turn 16
- Keep on throttle through chicane
- Later on brakes into turn 7 and 16

Driver C

- Shift when all lights on steering wheel are on
- Full throttle turns 1 and 9
- 1st gear turn 16

The first stint was basically a warm up for the drivers before they were given their instructions, so it won't be looked at much. The exception of this will be For Driver C who was quicker in the first session. This was mainly due to a communication breakdown during the second session which caused the driver to be distracted hampering his performance.

3.2.1-Driver A Compared to Previous Session (Ap5)

Driver A was able to achieve a time of 1:37.380 which is a sizeable improvement to the 1:37.994 achieved in the previous session.

Generally Driver A has taken on the instruction of braking harder and later which has helped improved the lap time for example into turn 3 where braking later and harder has gained him 2 tenths over his previous session's best. However braking harder and later seems to lose him time through turn 4 despite being able to get on the throttle sooner reducing the amount of time lost in this corner. This indicates that braking harder in this corner will actually make Driver A slower, so he should brake less hard into turn 4 to carry more speed into the corner.

Driver A did not turn earlier into turn 15, in fact his steering inputs were very similar throughout the lap, but did brake later into the corner which initially gave him an advantage, he then loses time though on the exit balances out the time he gained. This is because he gets off the brakes later and does not get on the throttle as quickly meaning that he carries more speed on the exit of turn 15 in the first session which cancels out the time gained on entry.

Driver A also gains a significant time into turn 16 by braking much later. However, like with turn 15 he doesn't get on the throttle as quickly through turns 17 and 18 compared to his first session although the difference is very small and is small compared to the amount of time he gained on the exit. This indicates that he needs to apply throttle more quickly on exit to maximize the grip of the car

3.2.2-Driver B Compared to Previous Session (Ap6)

Driver B was also able to improve by a similar amount going from a 1:39.010 to a 1:38.374. Driver B seems to have taken on the advice of taking tighter lines through corners which is shown in turn 15 where he also turns later which ends up giving a slightly more speed on exit despite going on the throttle at the same time in both sessions. The difference however is very small.

Driver B also used 1st gear in turn 16 which helped Driver B be able to get on the throttle sooner which allowed Him to gain a tenth over his best lap in the previous session showing that this instruction provided a small improvement to the lap time. Driver B however failed to apply the instruction of braking later into the corner but did brake harder but seemed to lose some time as he did not carry as much speed through turn 16 but this does show that he could brake later into the corner and still carry the same speed as session 1 as the steering inputs, g-forces and yaw are very similar.

Driver B was also told to stay on throttle through turns 10 and 11. He did stay on throttle for a fraction longer but did not stay on full throttle through each of the corners. He also applies less throttle through turn 12 and brakes less into the corner as well. This however seems to lose him time through this section. This is because the small squirt of full throttle allows Driver B to carry more speed on the exit of turn 12 and into turns 13 and 14. This means that he needs to carry more speed into these corners which could be solved by applying full

throttle for longer indicating that the instruction to stay on full throttle for longer could help improve the lap time further.

Driver B was also instructed to brake later into turn 7 however he ended up braking slightly earlier losing a bit of time entering turn 7. Driver B was able to apply throttle more quickly on exit in the second session whilst using slightly less steering input allowing the car to accelerate faster and gain about 3 tenths compared to the previous session.

3.2.3-Driver C Compared to Previous Session (Ap7)

Driver C made the largest improvement in the second session improving from a 1:45.560 to a 1:43.943. Looking at the RPM throughout the lap he seems to be shifting earlier in the second session. This seems to be losing him speed on the straight which is evident through turn 8 and the old start finish straight where he loses about a tenth of a second before turn 9.

Driver C fails to stay on full throttle through turn 9 however there is an improvement as he does not lift for as long and does not completely go off throttle through turn 9 which means he still improves over his previous session best by about 0.25 seconds. Driver C does end up applying full throttle through turn 1 which shows how much time could have potentially been gained in turn 9 if he stays on full throttle through the whole corner as he ends up being over half a second (6 tenths quicker) through the corner which is a large chunk of time showing that this instruction worked really well and has improved the lap time massively.

Like Driver B, Driver C was also recommended to use first gear into turn 16. However in this case he seems to lose some time initially as he slows down too much for the corner dropping down to 79km/h as opposed to only dropping down to 93km/h. Interestingly he is able to get on the throttle sooner though. Another thing to note is that there is a sudden spike in the g-force and yaw graphs indicating that he had some oversteer in the first session which was not present in the second session which also could have had a large reason why he able to accelerate better out of the corner and therefore gained time. This is also backed up by the fact that he starts gaining time on his previous sessions best straight after the spike on the yaw and g-force graphs.

3.2.4- Fastest lap time of each driver comparison stint (Ap8)

Driver A and Driver B kept a similar gap to the previous session with Driver A still faster achieving a lap time of 1:37.380 and 1:38.374 (0.994 seconds slower). Driver C however was able to close the gap from 7.566 seconds to 6.564 seconds achieving a lap time of 1:43.943.

Driver B loses by far the largest chunk of time through turns 13 and 14. Through the previous corners Driver B is actually able to gain some time over Driver A. However the extra speed might be unsettling the car as there seems to be evidence of large amounts of understeer through turn 13 as the steering angle is much greater for Driver B than for drivers A and C yet the yaw does not seem to be much different. This indicates that Driver B may need to carry less speed into the corner. Another possibility is that the extra braking into turn 13 could be the cause of the understeer in which case the driver would either need to carry less speed or brake earlier and less hard to unsettle the car less.

Driver B gains time over Driver A through turns 6 and 7 which is where, like in the previous session, Driver C loses most of his time through the same corners. Initially Driver C brakes much earlier into turn 6 than the other 2 drivers which costs him about a second by the time they reach turn 7. Drivers A and B however brake at the exact same time although Driver B brakes harder which causes him to lose a few tenths into turn 6. However Driver B applies full throttle towards the end of turn 6 which reduces the gap to what it was before braking for turn 6. Like in the previous session, Driver B takes a wider entry into turn 7 and brakes a lot more as well to help get the nose turned in to get a better exit. However unlike the previous session Driver B is able to apply the throttle more quickly than Driver A and therefore get a better exit out of turn 7 and is able to overall gain a bit of time through turn 8 and the old start finish straight.

Driver C does not brake at all for turn 7 unlike the other 2 drivers. He is however not carrying as much speed through turn 6 as the other 2 drivers have and also keeps a steady throttle throughout both corners. He also does not apply full throttle as quickly as Drivers A and B which loses him a lot of time through turn 8 and the old start/finish straight. Driver C also takes third gear through turn 7 while the other 2 drivers take second gear through the same corner. He does however take more speed through turn 7 which shows that the other 2 drivers could carry more speed through turn 7. Driver C does not gain much time over either driver anywhere else.

3.2.5-Driver Instruction Recommendations

The following instructions are for each driver and could be applied if another test session was held:

Driver A

- Carry a bit more speed through turn 7
- Brake later and harder into turn 6
- Apply throttle earlier on exit turn 16/entry turn 17

Driver B

- Carry more speed through turns 6 and 7
- Brake less for turn 13
- Brake later into turn 16

Driver C

- Apply throttle earlier on exit of most corners
- Use 2nd gear for turn 7
- Stay on full throttle through turn 9

4-Conclusion

Overall I conclude that testing with a simulator has been very successful in improving each of the 3 drivers by comparing where each of them gain time to each other and has helped to identify bad driver habits and helped to reduce the impact of them. Although not all of the

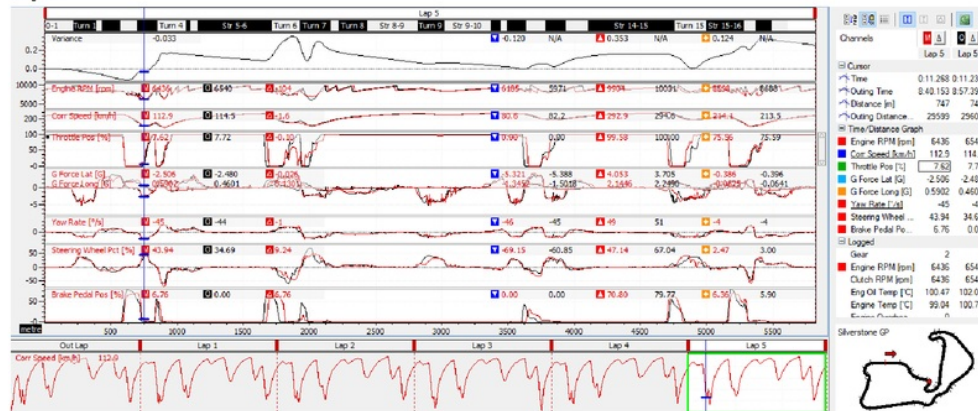
driver inputs were implemented successfully the ones that were implemented were generally very successful. Driver improvement seems to be easier to achieve for less experienced drivers as Driver C was the driver that improved the greatest.

5-Recommendations for further study

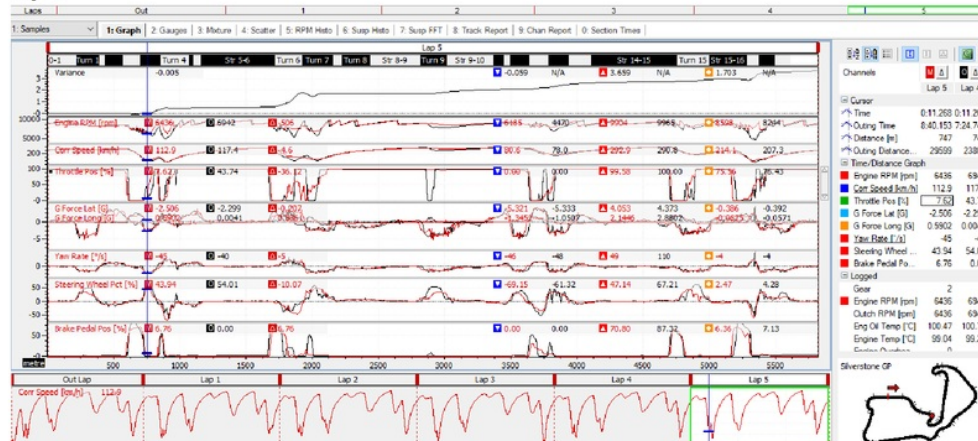
Although there were good points the test was not run 100% smoothly so more planning is required beforehand to make sure it goes more smoothly next time.

6-Appendix

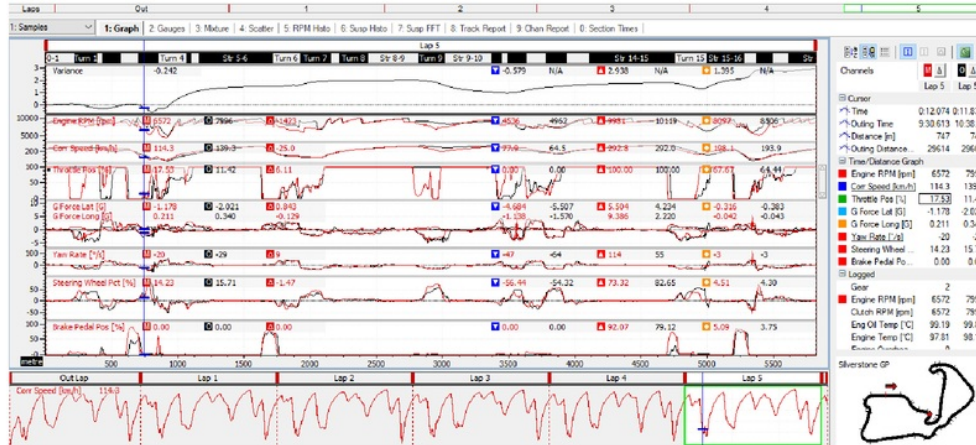
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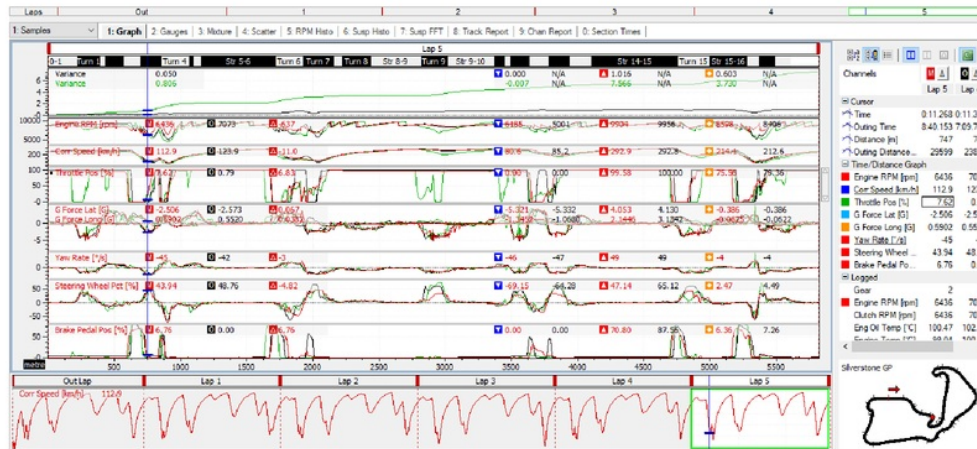
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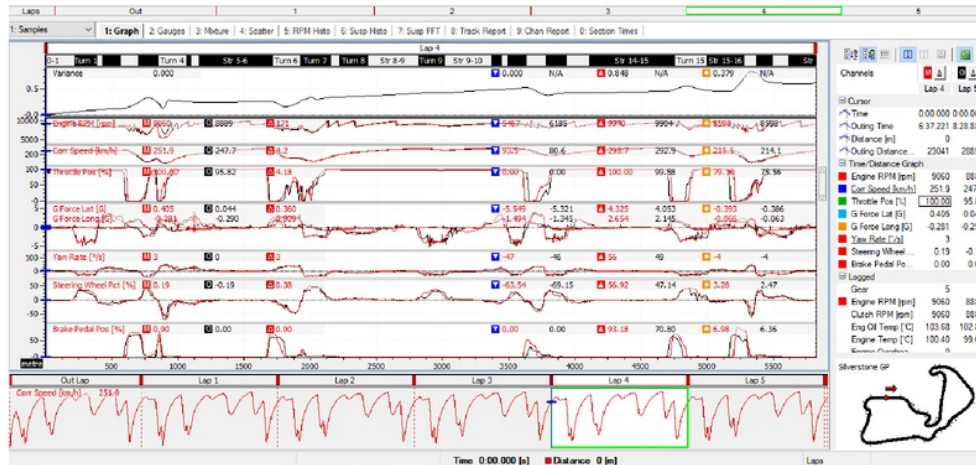
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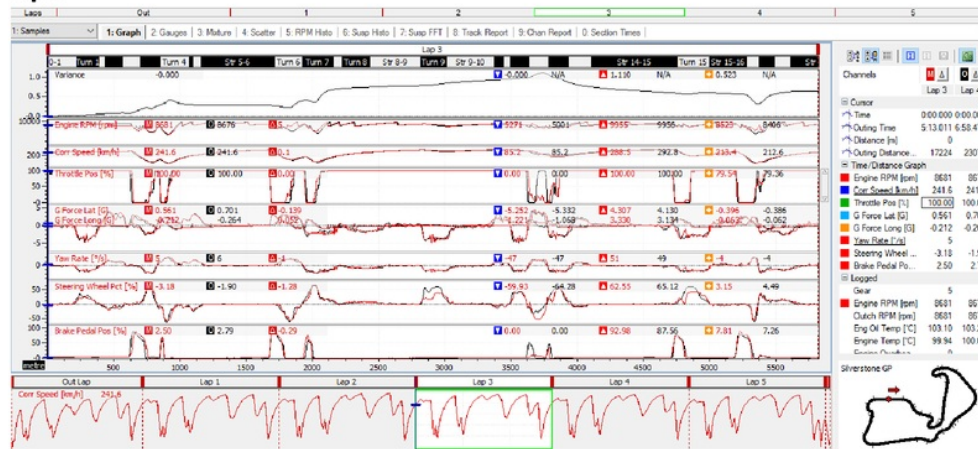
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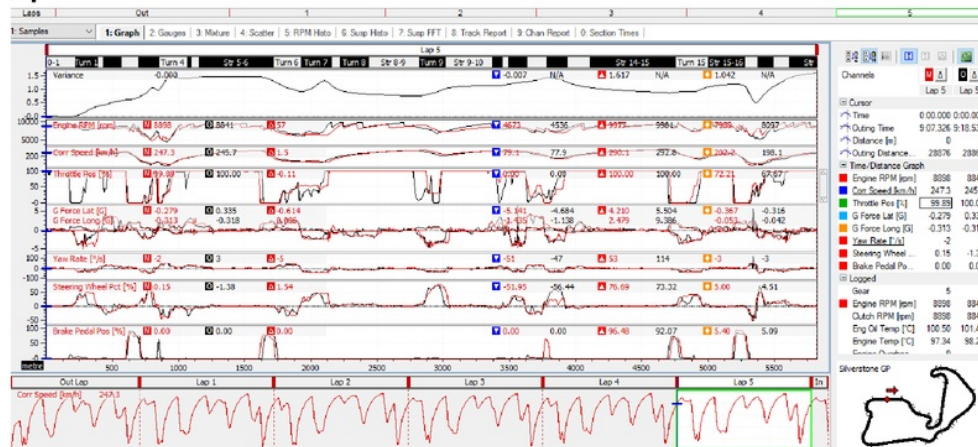
Ap5



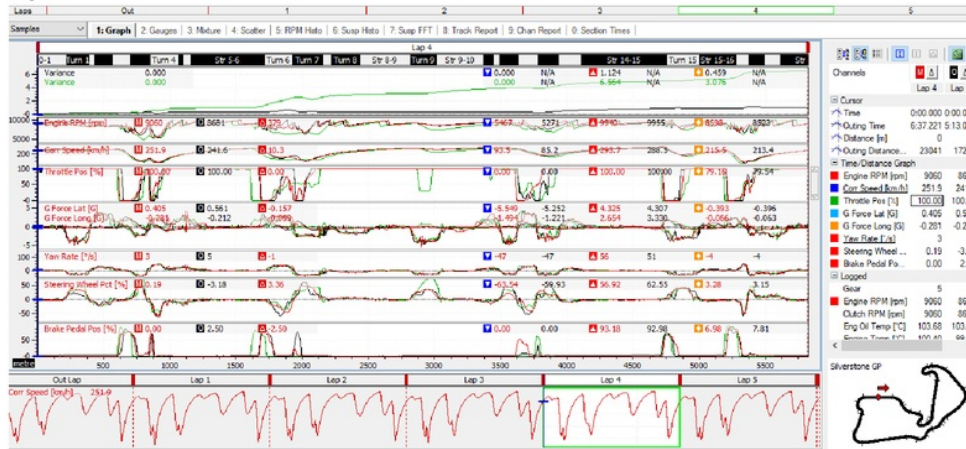
Ap6



Ap7



Ap8



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