



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

School of Engineering

BSC Motorsport Engineering

Race Engineering – Driver Comparison
Through Data Analysis

Jamie Prewett (P149702)

Contents

- 1. – Introduction (Page 4)**
- 2. – Literature Review (Pages 4-5)**
 - 2.1. – MoTeC Software**
 - 2.2. – Brands Hatch GP Circuit**
 - 2.3. – Aston Martin DBR9**
- 3. – Methodology (Page 6)**
- 4. – Analysis (Pages 7-22)**
 - 4.1. – Tim**
 - 4.2. – Joshua**
 - 4.3. – Daniel**
- 5. – Conclusion (Page 23)**
- 6. – Bibliography (Page 23)**

List of Illustrations & Figures

- 1. Image 1 – MoTeC M800 ECU**
- 2. Image 2 – Brands Hatch GP Circuit**
- 3. Image 3 – Aston Martin DBR9**
- 4. Image 4 – Lap 1 (Tim – Session 1)**
- 5. Image 5 – Lap 15 (Tim – Session 1)**
- 6. Image 6 – Lap 19 (Tim – Session 1)**
- 7. Image 7 – Lap (Tim – Session 2)**
- 8. Image 8 – Lap (Tim – Session 2)**
- 9. Image 9 – Lap 5 (Joshua – Session 1)**
- 10. Image 10 – Lap 6 (Joshua – Session 1)**
- 11. Image 11 – Lap 15 (Joshua – Session 1)**
- 12. Image 12 – Lap 16 (Joshua – Session 1)**
- 13. Image 13 – Lap 14 (Joshua – Session 2)**
- 14. Image 14 – Lap 2 (Daniel – Session 1)**
- 15. Image 15 – Lap 7 (Daniel – Session 2)**

- 16. Figure 1 – Tim’s Lap Times (Session 1)**
- 17. Figure 2 – Tim’s Lap Times (Session 2)**
- 18. Figure 3 – Joshua’s Lap Times (Session 1)**
- 19. Figure 4 – Joshua’s Lap Times (Session 2)**
- 20. Figure 5 – Daniel’s Lap Times (Session 1)**
- 21. Figure 6 – Daniel’s Lap Times (Session 2)**

1. Introduction

Along with vehicular tuning setups, the key element to winning motorsport races is a successful race technique. The learning process requires time and patience, but the milliseconds that can be taken off a lap time can be crucial, especially in circumstances such as qualifying.

The objective for this assignment is to use the computer software MoTeC, to analyse data recorded from two test sessions in the driving simulator. The primary aim is to establish the techniques of three different drivers, and produce a list of improvements for each driver to ensure they achieve faster lap times during our second session. With the use of screenshots from MoTeC and graphs from Microsoft Excel, I will be talking in-depth about each driver's performance, and where each instance of inconsistency has increased the lap times. Lastly, I will be comparing each driver to each other to review overall lap times and driver techniques.

2. Literature Review

(2.1.)

MoTeC is computer software that specialises in race data analysis. The software has been widely used in motorsport applications across the world. Racing champions such as V8 Supercars have used MoTeC because of its versatility, providing engineers with data such as; engine management, data acquisition, driver display, power distribution, video capture and accident recording (MoTeC, 2011). MoTeC systems are not just used in motorsport. Systems are also being put to use in passenger automotive, commercial, industrial and military applications (MoTeC, 2018).



Image 1 – MoTeC M800 ECU (Melbourne Performance Centre, 2018)

(2.2.)

Brands Hatch is a racing circuit, situated in Longfield, Kent, UK (Brands Hatch, 2018). The venue hosts racing events with two variations of the track, the Indy circuit and GP circuit. We will be using the GP track for this assignment, where a complete lap is 2.433 miles (Brands Hatch, 2018). The current GP track layout has been in use since 2003 (RacingCircuits.info, 2018). GP track is used for numerous major racing events throughout the year, such as the final race on the British Touring Car Championship calendar (BTCC, 2018).

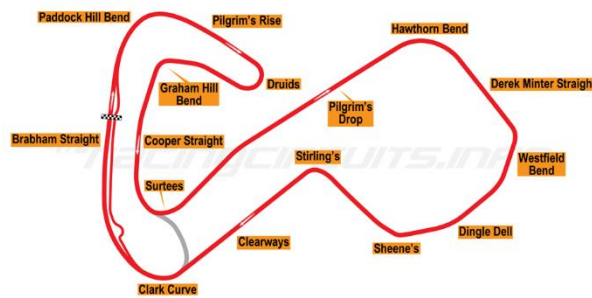


Image 1 – Brands Hatch GP Circuit (RacingCircuits.info, 2018)

(2.3.)

The Aston Martin Vantage DBR9 is a GT1 racing vehicle that took part in international sports car racing until the end of the GT1 category in 2011 (Wikipedia, 2018). The vehicle was produced in November 2005, with the intention of competing in the 2006 GT1 championship (Ultimatecarpage.com, 2005). Sharing the same design as a road-registered DB9, the original 6-litre V12 engine has additional racing modifications which produces around 600bhp and hand-made body panels from carbon-fibre composite helps the vehicle to meet its 1,100kg minimum weight ("Nick D", 2016).



Image 3 – Aston Martin DBR9 (Adolphus, 2013)

3. Methodology

Before test session one began, three drivers were selected to use the driving simulator. These three drivers were picked because of their similarity in height. Our group was given 90 minutes to complete the first session, so we constructed a test plan to ensure we completed the test on time. Our test plan consisted of each driver having:

- **4-minute warm-up period**

This time is allocated so that the driver can learn the characteristics of the vehicle and warm-up the tyres to provide maximum levels of grip. This would also give the driver a chance to quickly adapt to the track environment, which will benefit lap times as the driver will be able to remember to slow down for specific portions of the track such as cambers and turns.

- **25-minute drive period**

During this time, we are able to closely monitor the incoming data to be able to fully understand the positive and negative aspects of the driver's technique. Each driver was expected to fully commit to providing their fastest laps, although we were allowed to instruct the driver to change their technique at specific turns. These instructions are displayed in my 'Analysis' section.

During the session, I closely monitored and recorded the lap times and inconsistencies of each driver to help me with my analysis. When a driver incorreced the steering and spun the vehicle, I was able to note exactly where the vehicle is on the track in relation to the track sector and turn.

Once session one was complete, we reviewed the recorded data as a group and came up with a small list of improvements for each driver. For example, I recorded 5 instances where the three drivers lost control of the vehicle at sector 1, turn 2 of the track. I recommended each driver to lift off the throttle and brake into the corner earlier to prevent the vehicle from losing control.

With a set list of improvements for each driver, we commenced test session two. We had 90 minutes to complete the test, so we adapted the same structured test plan that was used for test session one. Having completed the session, I had acquired two sets of data to analyse and compare.

4. Analysis

With the data recorded from the two sessions, I have been able to carefully examine where each driver had lost speed and gained time to their laps. Within MoTeC, I have used these 'groups' to compare between each driver:

- **Engine RPM**
- **Corrected Speed**
- **Throttle Position**
- **G-Force Latitudinal/Longitudinal**
- **Braking Position**
- **Steering Position**
- **Gear**

(4.1.)

We chose Tim as our 'Baseline Driver' as we knew he would have experience in using the driving simulator. We expected little to no driver error, due to the experience he has on the track.

Session One

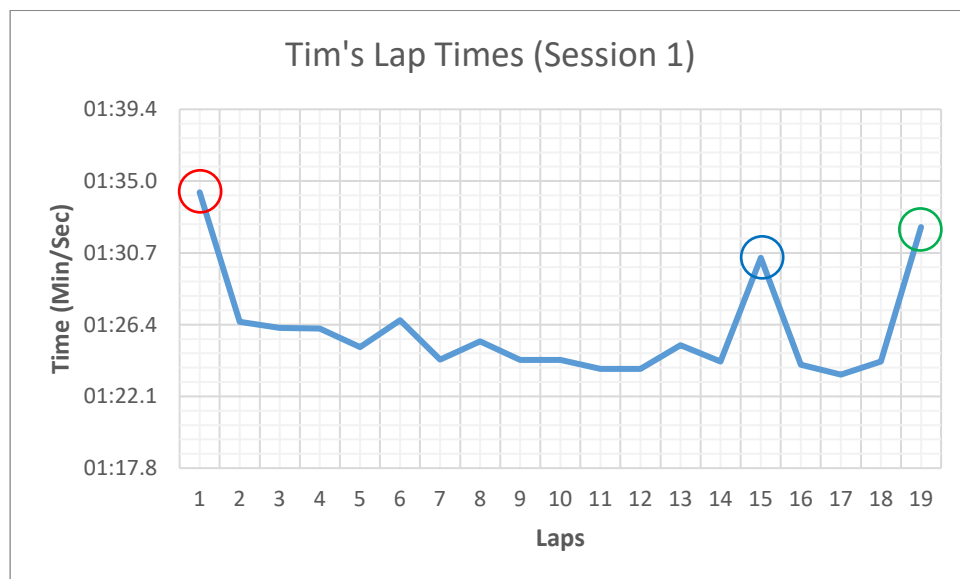


Figure 1 – Tim's Lap Times (Session 1)

For the first session, Tim's lap times were quite consistent from lap 2-14, with a visible decrease in lap times. However, there are a few laps that have a significant increase in time due to driver error. I have circled where these errors occurred:

Red

Although this lap is considered as part of the 'warm-up' period, Tim encountered an error while entering turn 2. MoTeC shows that Tim applied too much throttle while trying to complete turn 2, which resulted in him losing control of the vehicle. He tried to apply the brake to maintain control of the vehicle, but this failed to do so. This could be due to the heat of the tyres, as they would not be warm enough to produce the sufficient grip that is needed. If compared with Joshua's fastest lap of the session, it is clear that Tim had also applied full throttle for too long and started braking too late into the braking zone, meaning he carried too much speed into the turn. Tim's data is labelled in red and Joshua's data is labelled in black.

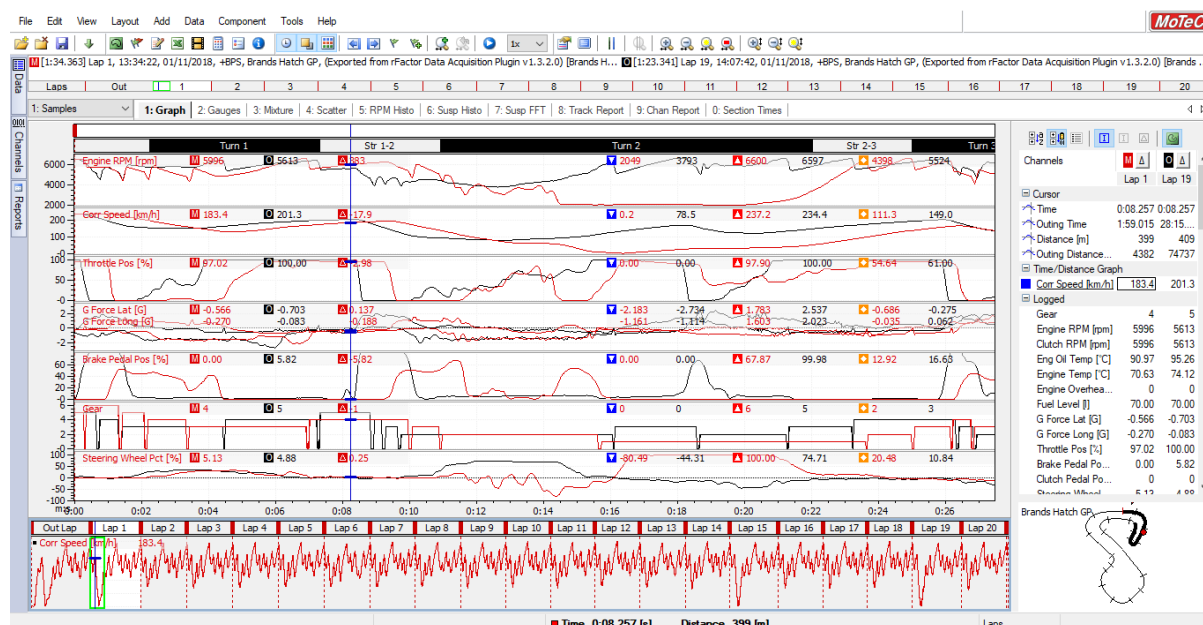


Image 4 – Lap 1 (Tim – Session 1)

Blue

As displayed on the graph, Tim produced a lap time of 1:30.419 due to losing control of the vehicle at turn 2. The error is clearly displayed on MoTeC, which shows that he was carrying too much speed into the corner. Tim entered the braking zone at 199.3km/h. When doing so, he displayed a brake position of 66.6% in an attempt to slow the vehicle down. He managed to reduce the speed of the vehicle to 106.8km/h before attempting to steer into the corner. As you can see in the screenshot, Tim applied 80% throttle position while in first gear, which severely affected the stability of the vehicle. Tim attempted to counter-steer to try and maintain control of the vehicle, which failed to do so.

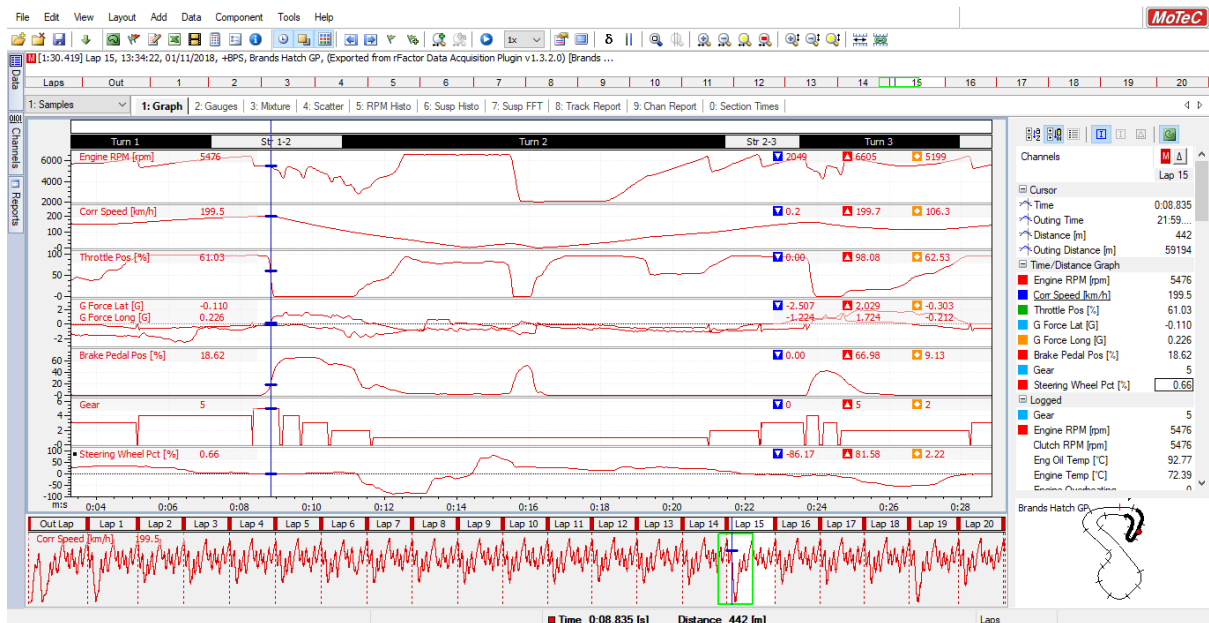


Image 5 – Lap 15 (Tim – Session 1)

Green

Although this was classed as Tim's last lap, he lost control of the vehicle at turn 2. According to the data on MoTeC, Tim entered the braking zone at 200.0km/h and displayed a brake position of 65.21% while entering the corner. He reduced the speed of the vehicle to 89.1km/h before turning the steering wheel. Alike the error on the first lap, Tim had carried too much speed into the turn and attempted to counter-steer to try and maintain control of the vehicle, which failed to do so.

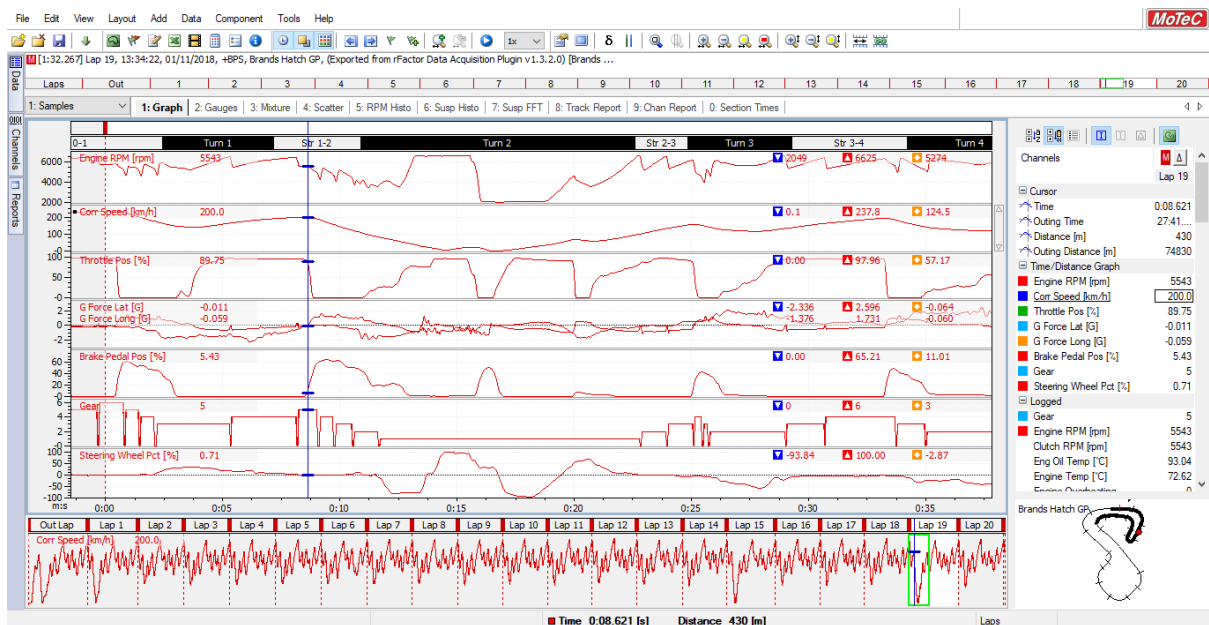


Image 6 – Lap 19 (Tim – Session 1)

Other recorded notes include:

- No recorded instances where Tim reached 100% throttle application. He averaged around 96.5-97.5%. Once his test run was complete, he mentioned that his shoes “touch the back of the cockpit”, thus reducing throttle application.
- He made full use of the vehicle’s rev range, reaching 6500-6600rpm per gear change. This is a key element for producing fast lap times, as the vehicle can be able to produce as much power as possible.
- During his test run, I noticed that Tim would not use the full application of the brakes, averaging 50-60% per application. This is a good technique to use, as he is able to maintain full control of the vehicle under braking. If 100% was to be applied, the brakes will lock up and the vehicle could lose control.
- Tim’s fastest lap was 1:23.390, which was achieved on lap 17.

Upon assessing the data, I had drawn up a list of potential improvements for Tim to achieve faster lap times. These improvements are:

- Achieve 100% throttle position to maximise the vehicle’s potential.
- Reduce the throttle earlier at the bottom of the decent, entering the braking zone of turn 2.

Session 2

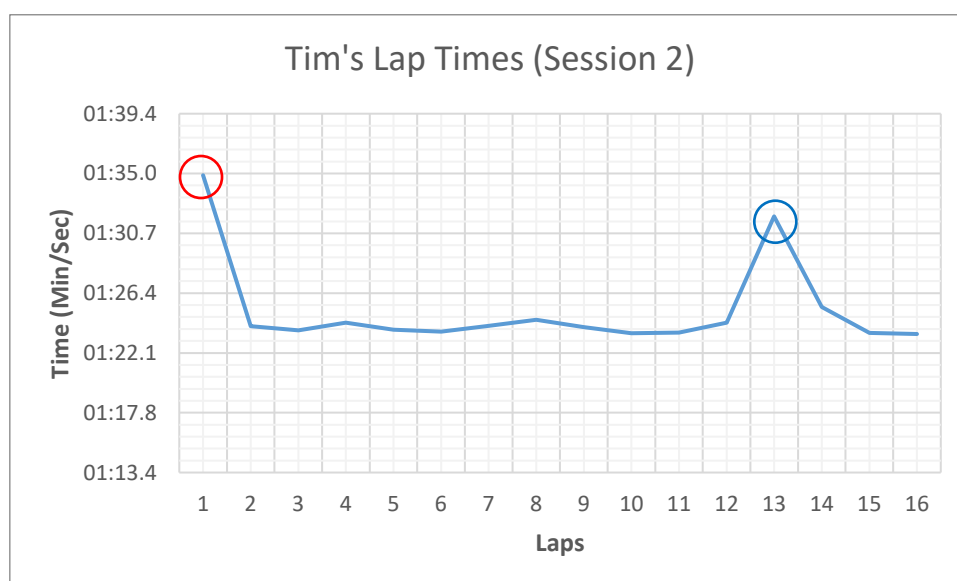


Figure 2 – Tim's Lap Times (Session 2)

In comparison to the first session, Tim's lap times were visibly more consistent. All but two laps were recorded within 1.948 seconds of each other. However, laps 1 and 13 were recorded with significant differences in time due to driver error on both accounts. I have circled where these errors occurred:

Red

Although this lap is considered as part of the 'warm-up' period, Tim encountered an error while braking for turn 2. Alike the first session, this could be due to the heat of the tyres, as they would not be warm enough to produce the sufficient grip that is needed. However, when compared to Joshua's fastest lap of the session, Tim applied the throttle for too long and applied the brakes too late into the braking zone. This is clearly displayed to the right side of the blue marker, where Tim's data is labelled in red and Joshua's data is labelled in black.

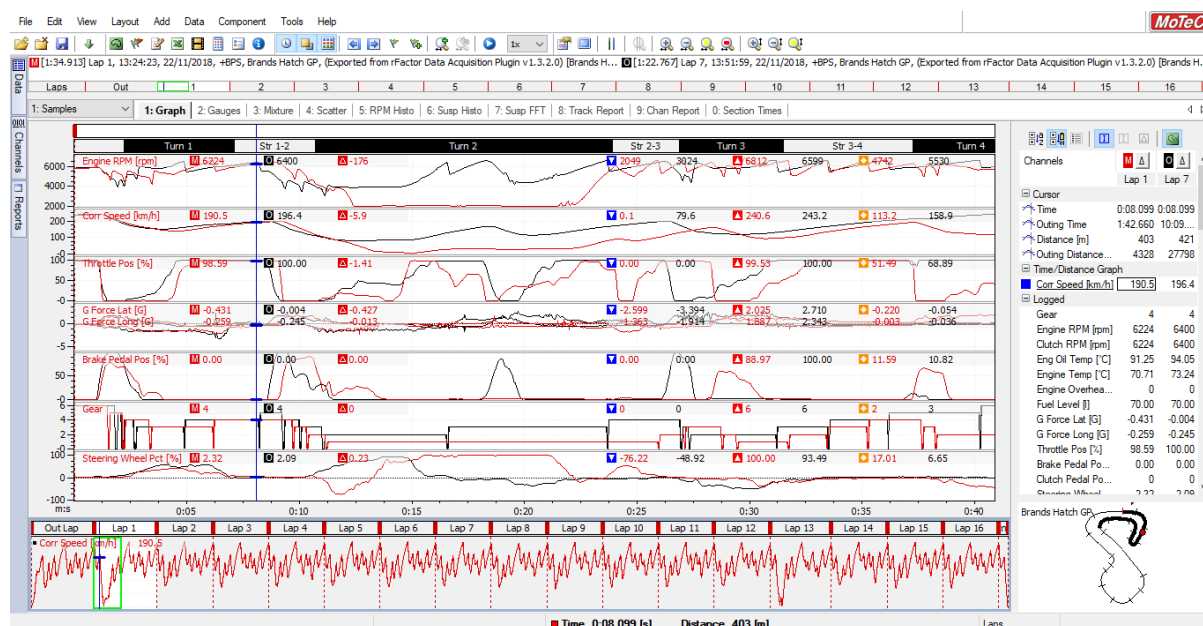


Image 7 – Lap 1 (Tim – Session 2)

Blue

On lap 13, Tim encountered an error while completing turn 2. MoTeC shows that Tim was travelling into the braking zone at 200.6km/h and applied 72% brake position. While turning the corner, Tim applied 100% throttle position too early, which caused the vehicle to oversteer. To regain control, he tried to counter-steer the vehicle, but failed to do so.

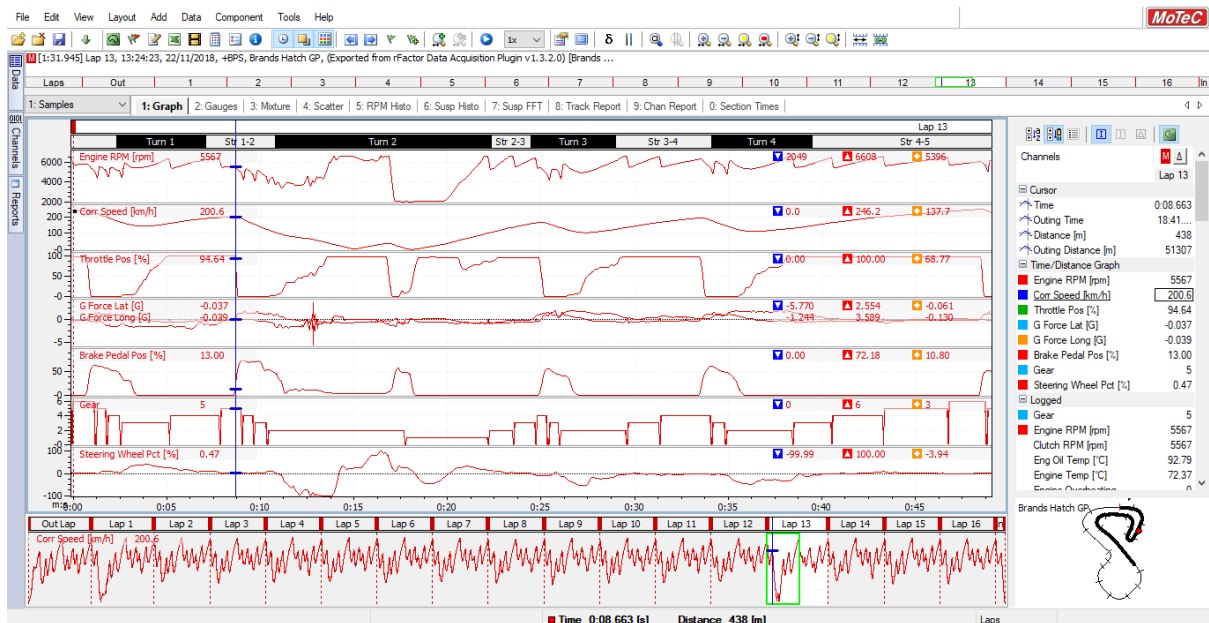


Image 8 – Lap 13 (Tim – Session 2)

Other recorded notes include:

- Heeding the advice given to him, Tim was able to successfully use full 100% throttle application.
- Alike session one, he made full use of the vehicle's rev range, reaching 6500-6600rpm per gear change.
- Using the same technique as session one, I noticed that Tim would not use the full application of the brakes, averaging 50-60% per application. As previously mentioned, this is a good technique to use, as he is able to maintain full control of the vehicle under braking. If 100% was to be applied, the brakes will lock up and the vehicle could lose control.
- Tim's fastest lap for session two was 1:23.448, which was achieved on lap 16. Unfortunately, his fastest lap was 0.448 seconds slower than his fastest lap for the first session.
- On lap 4, I advised Tim to apply more throttle while exiting turn 5. I believed he was not using the vehicle's maximum potential.
- On lap 14, I advised Tim to brake for turn 8 slightly harder.

(4.2.)

We chose Joshua as our 'Driver A' due to his previous experience on the driving simulator. Since he had not recently used the simulator, we expected his lap times to be inconsistent.

Session One

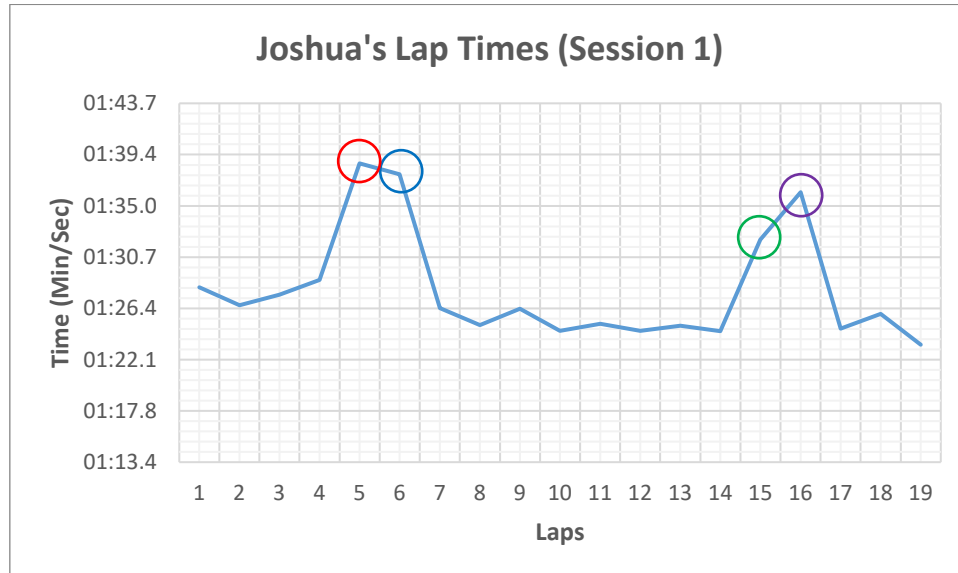


Figure 3 – Joshua's Lap Times (Session 1)

As you can see from the graph, Joshua's lap times were quite consistent from laps 7-14. However, there are a few laps that have a significant increase in time due to driver error. I have circled where these errors occurred:

Red

Lap 5 is recorded at 1:38.619 as Joshua lost control of the vehicle at sector 3, turn 7. The MoTeC data shows me that he entered the braking zone at 201.4km/h, before displaying 71% brake position going into the corner. Joshua was carrying too much speed into the corner, which caused the vehicle to lose control. MoTeC also shows Joshua's attempt to counter-steer the vehicle, which failed to regain control.

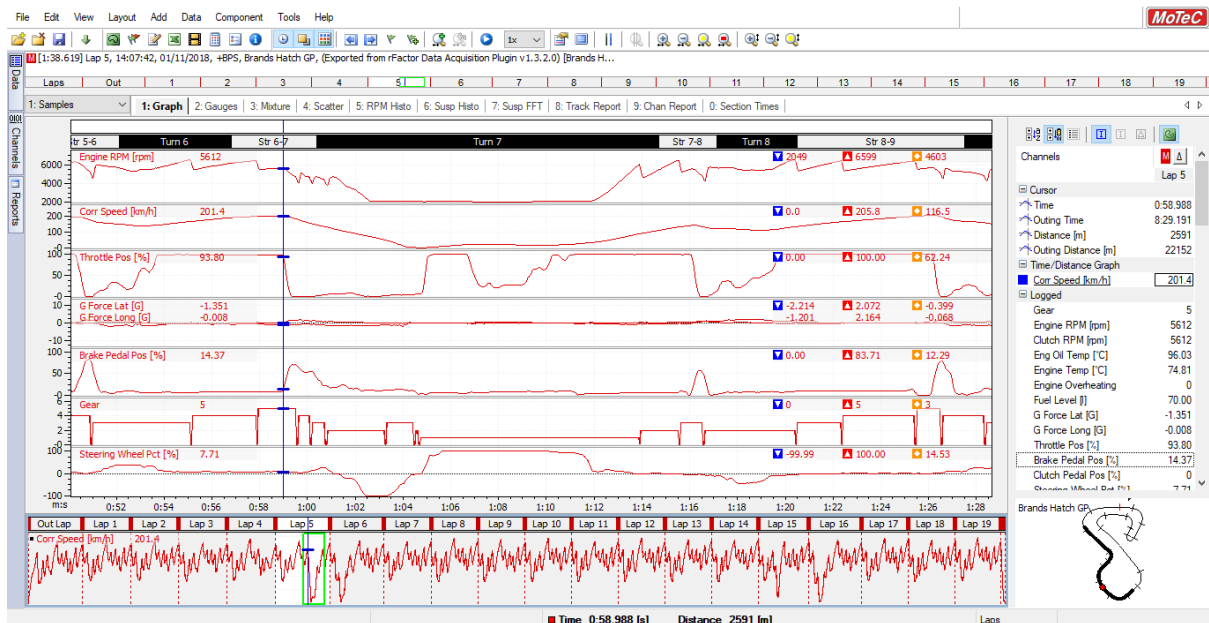


Image 9 – Lap 5 (Joshua – Session 1)

Blue

Lap 6 is recorded at 1:37.702 as Joshua lost control of the vehicle while applying the throttle to exit turn 2. According to MoTeC, Joshua had entered the corner correctly, but applied 100% throttle position too early while steering out of the corner. This meant the vehicle generated oversteer, thus losing control. As you can see, his attempt to counter-steer the vehicle failed to regain control.

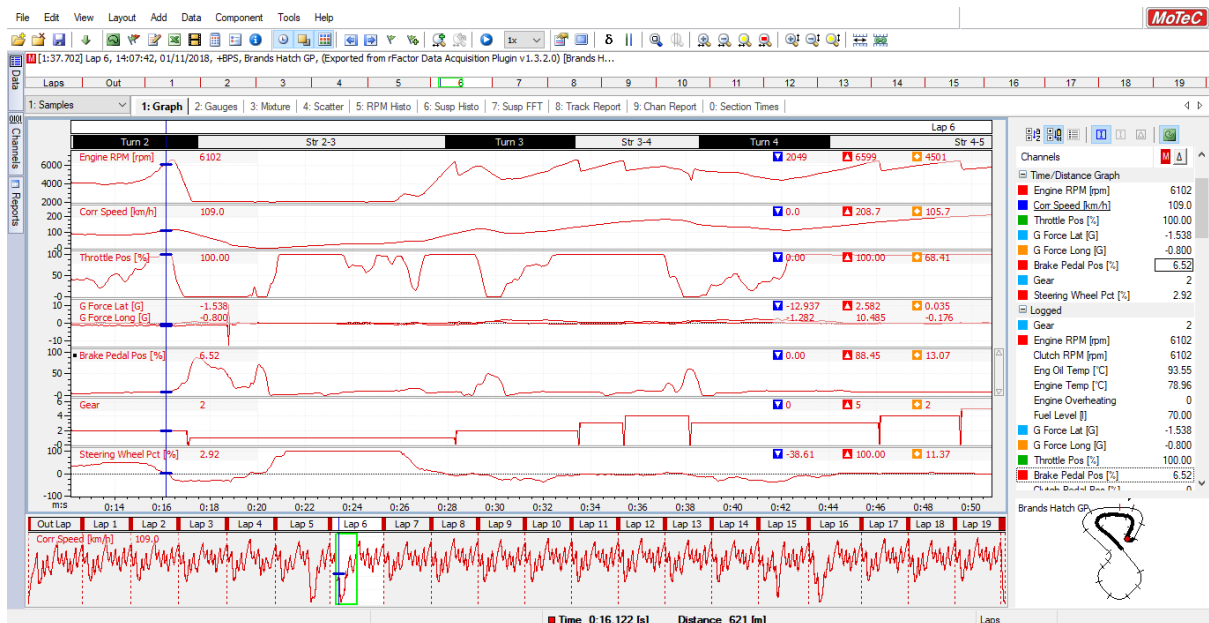


Image 10 – Lap 6 (Joshua – Session 1)

Green

As displayed on the graph, Joshua's lap times were consistent until lap 15 where he lost control of the vehicle at turn 4. This lap time was recorded at 1:32.193. According to the MoTeC data, Joshua made the same error as lap 6. He had entered the corner correctly, but applied 100% throttle position too early while steering out of the corner. This meant the vehicle generated oversteer, thus losing control.

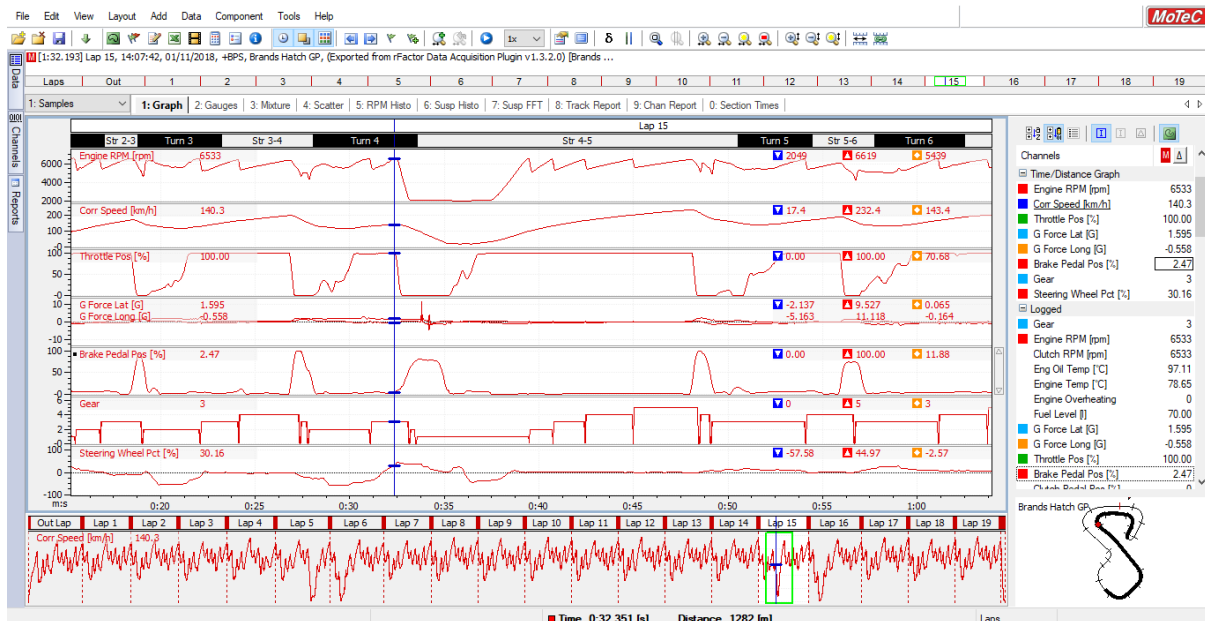


Image 11 – Lap 15 (Joshua – Session 1)

Purple

Joshua lost control of the vehicle at turn 2, sector 1 for second time of his test run. This occurred on lap 16, recording at 1:36.193. According to MoTeC, Joshua had entered the corner correctly, but applied 100% throttle position too early while steering out of the corner. This meant the vehicle generated oversteer, thus losing control. This is the third error this session where Joshua had applied the throttle too early. His attempt to counter-steer the vehicle failed to regain control.

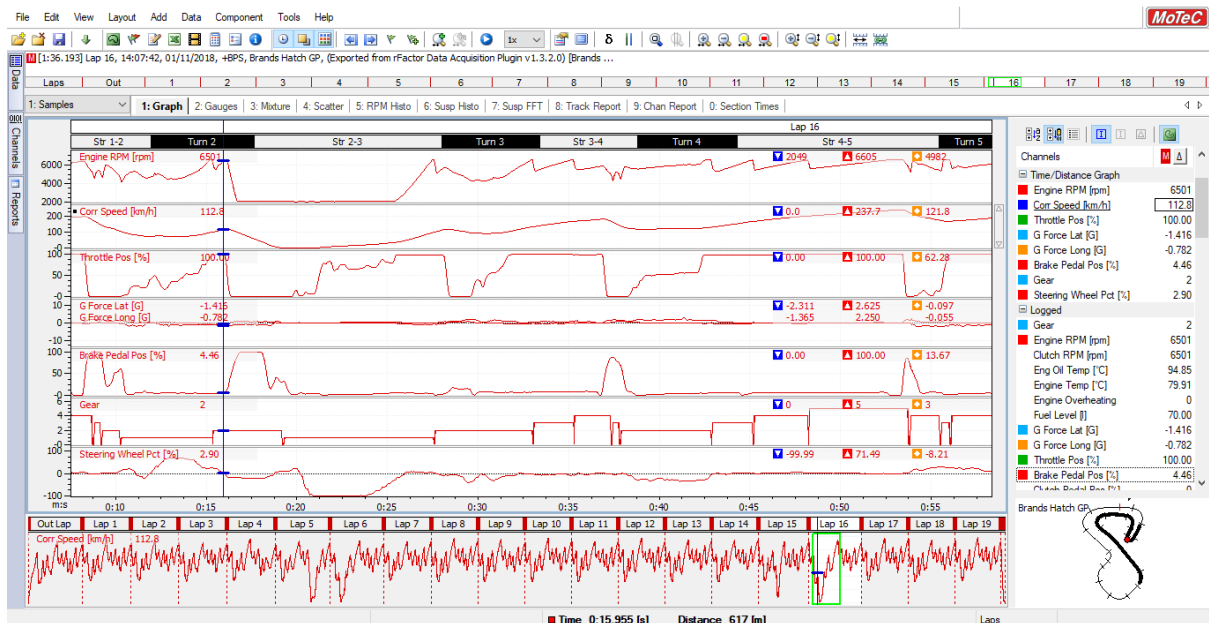


Image 12 – Lap 16 (Joshua – Session 1)

Other recorded notes include:

- Joshua displayed full 100% use of the throttle, which will enable him to use the vehicle's full potential.
- His racing technique is different to Tim's, as he frequently displayed 100% brake position while entering a corner. I believe that this is the wrong technique to use for racing. To maximise his speed while exiting the corner, he should use 50-60% of the brake for longer periods of time. This will prevent the wheels from locking up, and potentially losing control of the vehicle.
- Joshua's fastest lap was 1:23.341, which was achieved on lap 19. This is 0.049 seconds quicker than Tim's fastest lap during the first session.

Upon assessing the data, I had drawn up a list of potential improvements for Joshua to achieve faster lap times. These improvements are:

- Rather than applying 100% use of the brakes while entering a corner, try and use 50-60% for longer periods of time.
- Reduce the throttle earlier at the bottom of the decent, entering the braking zone of turn 2.
- Carefully apply the throttle on the exit of a corner, and increase to 100% throttle position when steered out of the corner.

Session 2

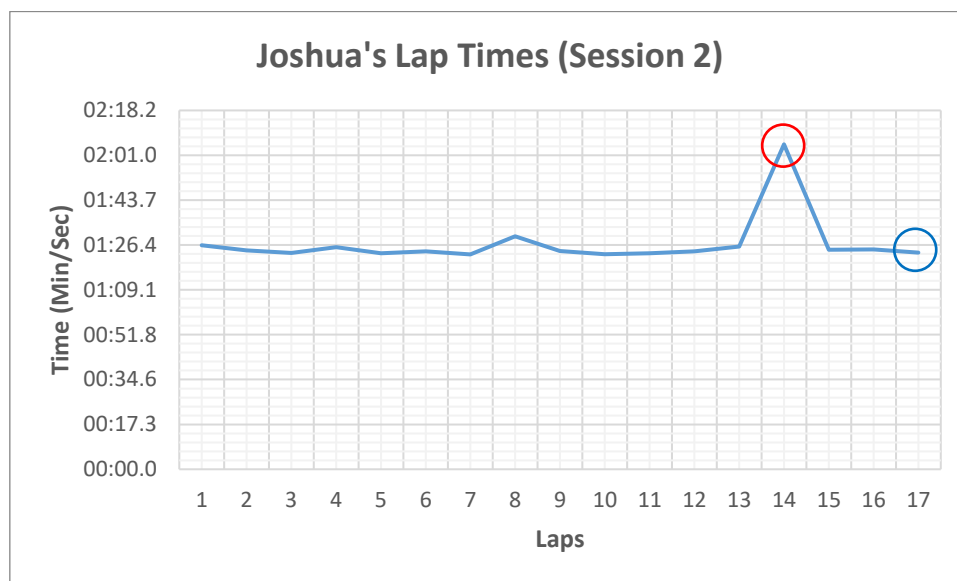


Figure 4 – Joshua's Lap Times (Session 2)

The graph shows that Joshua's lap times were much more consistent during the second session. He showed significant improvements in relation to his racing techniques, and clearly displayed a decrease in lap times as his test run continued. Only lap 14 shows a significant difference in time due to driver error. He also produced the fastest lap time of both sessions on his last lap. I have circled where these instances occurred:

Red

Joshua's only error this session occurred on lap 14, which is recorded as 2:05.179. This is due to an error Joshua made while completing turn 4. As you can see from the MoTeC screenshot, he entered the corner correctly, but applied the throttle as he was approaching the corner. He applied 97.19% throttle position twice in quick succession, which caused the vehicle to oversteer and lose control.

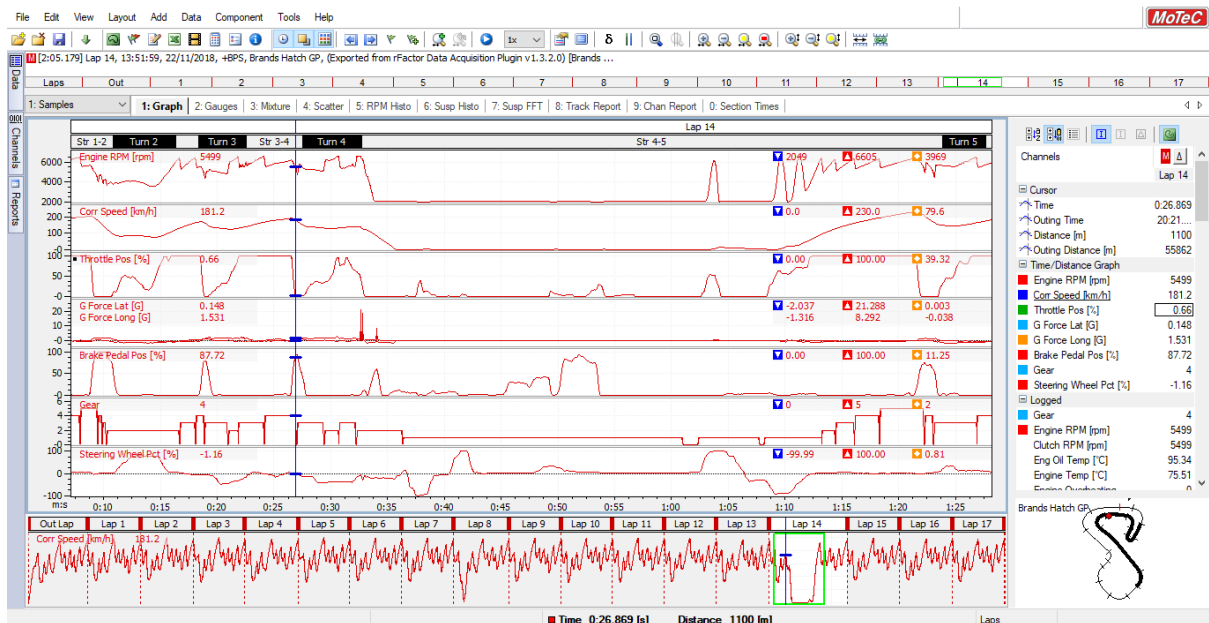


Image 13 – Lap 14 (Joshua – Session 2)

Blue

On lap 17, Joshua put out a stunning lap time of 1:22.767. This is the only instance during the two test sessions where a driver has succeeded a lap time below 1:23.000. This supersedes his fastest lap during session one by 0.574 seconds, which is a big improvement. I believe that the improvements set for Joshua increased his ability to produce a lap time under 1:23.000.

Other recorded notes include:

- On lap 1, I advised Joshua to use the steering less forcefully. I also advised him to stop rest his foot on the brake pedal, as he applied 10% brake position when doing so. After this advice was given, his lap times were very consistent and quick.
- Frequently used 100% of the throttle to maximise the potential of the vehicle.
- On lap 8, I advised him to merge the brake with the throttle while exiting a corner.

(4.3.)

We chose Daniel as our 'Driver B' due to his lack of experience on the driving simulator. We thought it would be interesting to compare the techniques and lap times of Daniel to the other drivers, who have experience in using the simulator.

Session One

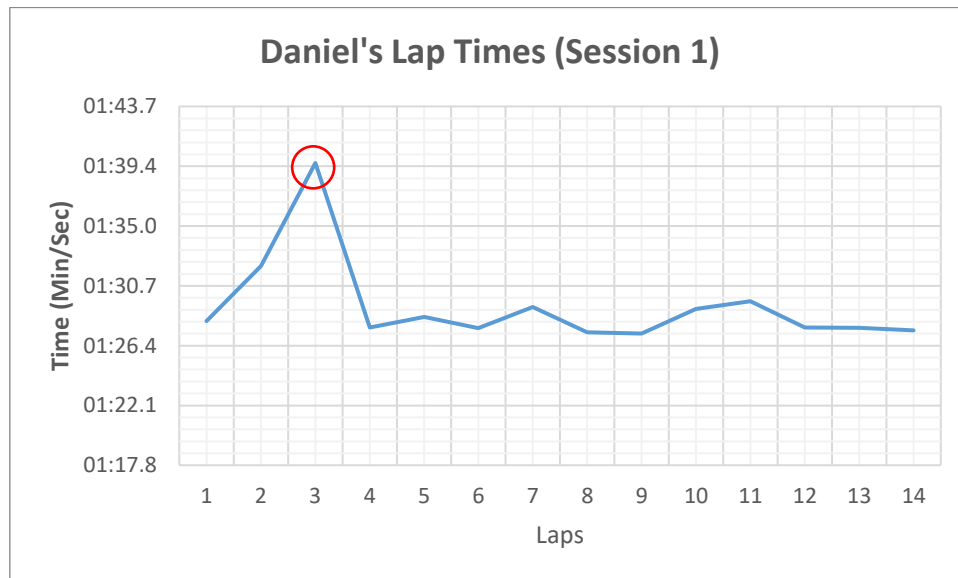


Figure 5 – Daniel's Lap Times (Session 1)

As shown in the graph, Daniel's lap times were quite consistent from lap 4-14, with visible fluctuation. His lap times are generally slower than Tim's and Joshua's, which was to be expected due to his lack of experience. Daniel began his test run and came across as hesitant in relation to his performance, recording a lap time of 1:32.154 for lap 2. However, during his test run, only one lap has a significant increase in time due to driver error. I have circled where this error occurred:

Red

Although this lap is considered as part of the 'warm-up' period, Daniel encountered an error at turn 2. As displayed on MoTeC, Daniel approached the braking zone at 185.3km/h. He applied 80% brake position to try and slow the vehicle down, but failed to make the corner. To display how late Daniel applied the brakes, I have added Joshua's fastest lap time from the session into MoTeC. Daniel's data is labelled in red, and Joshua's data is labelled in black. Displayed each side of the blue marker, it is clear that Daniel had applied the throttle for too long and had applied the brakes too late into the braking zone. The vehicle was not able to turn the corner at such a high rate of speed, thus sending the vehicle off the track and into the gravel trap.

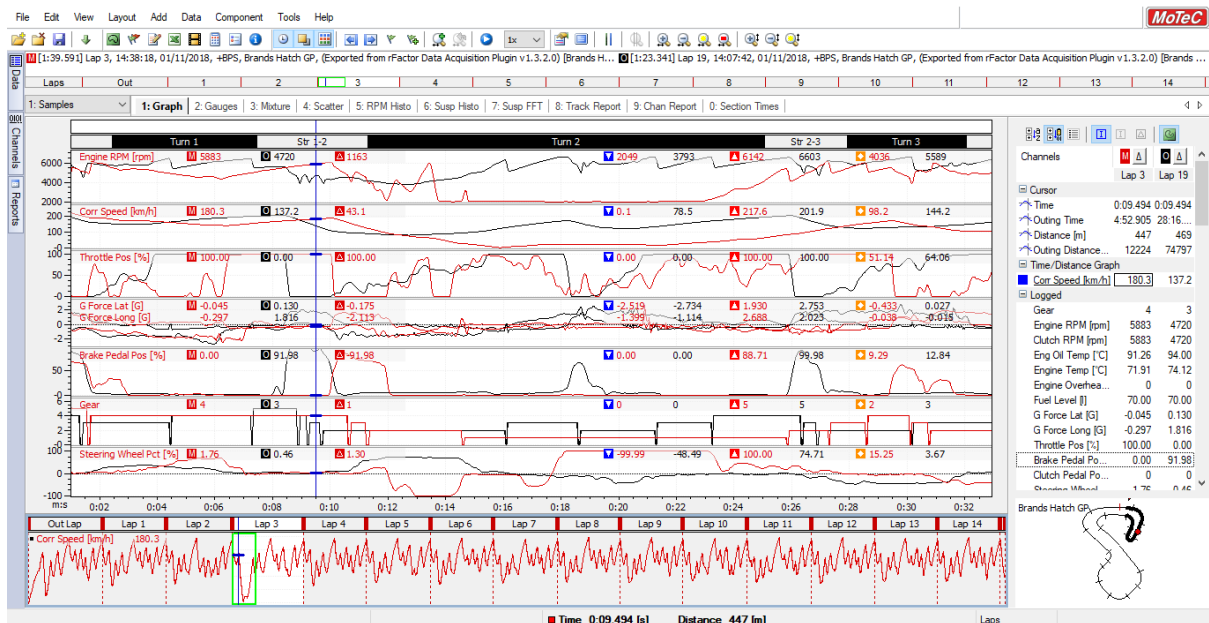


Image 14 - Lap 2 (Daniel – Session 1)

Other recorded notes include:

- Daniel made full use of the throttle, displaying 100% throttle position throughout the session.
- He made full use of the vehicle's rev range, reaching 6500-6600rpm per gear change. As stated previously, this is a key element for producing fast lap times, as the vehicle can be able to produce as much power as possible.
- Daniel reported of having trouble fully applying the brake, describing the brake pedal as feeling "hard". After discussing the issue with him, we concluded that his shoes were not practical for the test. This is because the soles of his shoes were thin, which meant he could feel the pressure of the brake pedal. Daniel averaged around 40-55% brake position during his test run, which is a safe amount of braking force to use as the vehicle will be able to maintain control.
- Daniel's fastest lap this session was 1:27.274, which was achieved on lap 9. This is 3.933 seconds slower than Joshua's fastest lap for session one, which shows Daniel must improve his racing technique.

Since Daniel was producing much slower lap times than Tim and Joshua, his racing technique was definitely in need of improvements. After assessing the data, I had drawn up a list of improvements for Daniel to achieve faster lap times. These improvements are:

- Minimise hesitation, possibly practice at Brands Hatch on another racing simulation game.
- Reduce the throttle earlier at the bottom of the decent, entering the braking zone of turn 2.

Session 2

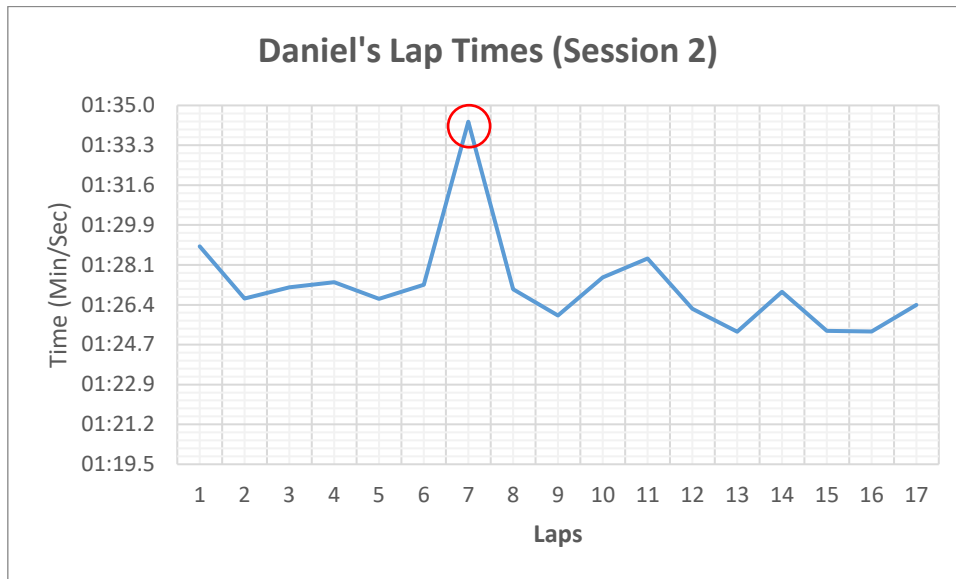


Figure 6 – Daniel's Lap Times (Session 2)

In comparison to the first session, Daniel's lap times were unfortunately more inconsistent. His overall performance had improved from the first session, and laps 2-6 were quite consistent, but he failed to maintain this consistency throughout the rest of the session. Daniel occasionally displayed hesitation, particularly on laps 11 and 14. However, only one lap time was recorded with a significant difference in time due to driver error. I have circled where this error occurred:

Red

On Lap 7, Daniel encountered an error while entering turn 2. The lap time is recorded at 1:34.333. MoTeC shows that Daniel approached the braking zone at 192.7km/h. In comparison to Joshua's fastest lap, it is clear that Daniel applied the throttle for too long and applied the brakes too late into the braking zone. Daniel's data is labelled in red, and Joshua's data is labelled in black. He applied 48.52% brake position, which would not be sufficient enough slow the vehicle down to a suitable cornering speed. In an attempt to guide the vehicle around the corner, Daniel began to turn the steering wheel and applied 72.54% throttle position. This caused the vehicle to oversteer, thus sending the vehicle off the track and into the gravel trap.

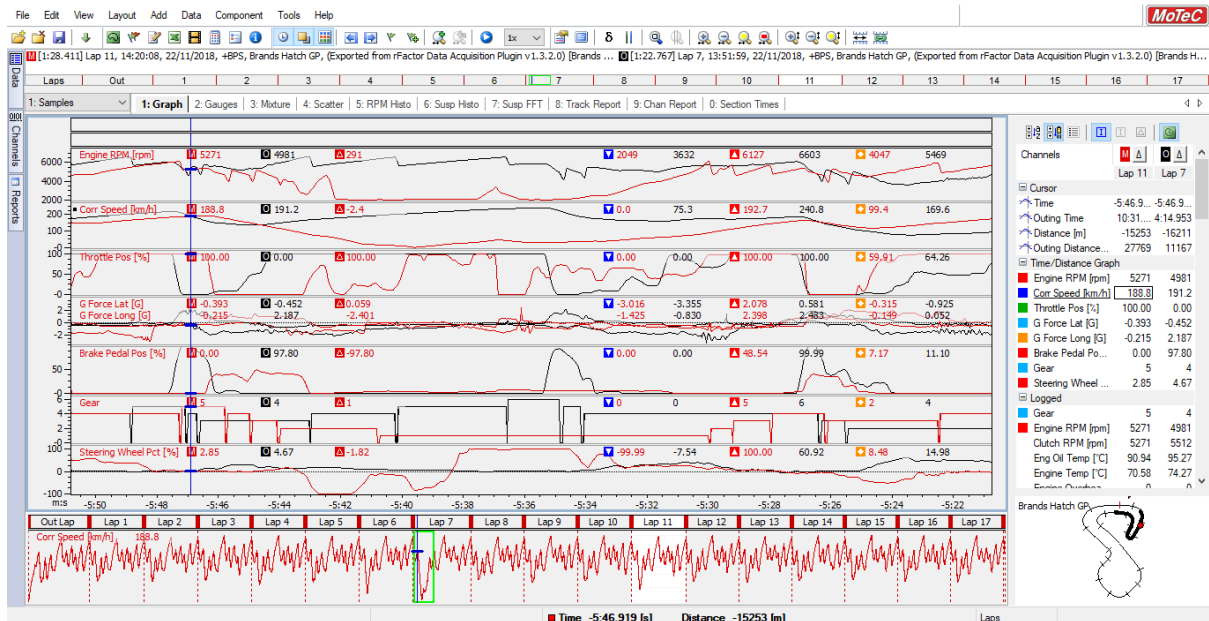


Image 15 – Lap 7 (Daniel – Session 2)

Other recorded notes include:

- Heeding the advice given to him, Daniel was satisfied by the feel of the brake pedal as he had changed his shoes. He averaged around 70% brake position during this session.
- Alike session one, he made full use of the vehicle's rev range, reaching 6500-6600rpm per gear change.
- On lap 8, I advised Daniel to downshift quicker while entering a turn. After discussing the session with him, he found that the stability of the vehicle while under braking was compromised after this advice. This could be due to the tuning setup of the vehicle.
- On lap 11, I advised Daniel to enter turn 2 on the outside on the track and to make full use of the racing line around the turn. After the advice was given, Daniel managed to produce consistent lap times and achieve his fastest lap around the track.
- Daniel's fastest lap this session is recorded at 1:25.233. This supersedes his fastest lap for the first session by 2.041 seconds, which is a significant improvement. However, he failed to beat Joshua's fastest lap by 2.466 seconds.

5. Conclusion

From this investigation into driver comparison through data analysis, I have successfully used MoTeC to analyse the performances and techniques of three individual drivers. I have critically examined each driver during the test sessions, and have created a list of improvements in relation to their individual performances. These improvements have proved to be beneficial for all three drivers, who saw a general decrease in lap times during the second session.

Through the use of Excel graphs and screenshots, I have clearly displayed where and how each driver had made crucial racing errors and have suggested ways to minimise these errors for future testing sessions. I enjoyed working through this assignment, as I find race data analysis personally interesting.

6. References

Adolphus, D. T., 2013. 2005 Aston Martin DBR9 Race Car - Gooding & Co. Auction of Aston DBR9/05 at Pebble Beach 2013. [Online] Available at: <https://www.roadandtrack.com/new-cars/news/a5219/go-news-pebble-beach-2013-2005-aston-martin-dbr9-auction/> [Accessed 6 November 2018].

Brands Hatch, 2018. Brands Hatch - Circuit Information. [Online] Available at: <http://www.brandshatch.co.uk/circuit-information.aspx?alttemplate=MSV-CircuitInfoV2&mapId=21810#circuitMap> [Accessed 5 November 2018].

Brands Hatch, 2018. Brands Hatch - Circuit Information. [Online] Available at: <http://www.brandshatch.co.uk/circuit-information.aspx/CircuitLocation> [Accessed 6 November 2018].

BTCC, 2018. BTCC - Circuits. [Online] Available at: <http://www.btcc.net/calendar/brands-hatch-gp/> [Accessed 6 November 2018].

Melbourne Performance Centre, 2018. Melbourne Performance Centre | Dyno Tuning Centre. [Online] Available at: <http://melbourneperformance.com/products/311/> [Accessed 5 November 2018].

MoTeC, 2011. V8 Supercars choose MoTeC for the "Car of the Future". [Online] Available at: <https://www.motec.com.au/latestnews/newsv8supercarott/> [Accessed 5 November 2018].

MoTeC, 2018. MoTeC > 25 Years of Driving Success. [Online] Available at: <https://www.motec.com.au/Success> [Accessed 5 November 2018].

"Nick D", 2016. 2005 Aston Martin DBR9 | Aston Martin | SuperCars.net. [Online] Available at: <https://www.supercars.net/blog/2005-aston-martin-dbr9/> [Accessed 6 November 2018].

RacingCircuits.info, 2018. Brands Hatch - RacingCircuits.info. [Online] Available at: <http://www.racingcircuits.info/europe/united-kingdom/brands-hatch.html#.XBVyGiz7TIV> [Accessed 5 November 2018].

Ultimatecarpage.com, 2005. 2005 Aston Martin DBR9 - Images, Specifications and Information. [Online] Available at: <https://www.ultimatecarpage.com/car/2039/Aston-Martin-DBR9.html> [Accessed 6 November 2018].

Wikipedia, 2018. Aston Martin DBR9 - Wikipedia. [Online] Available at: https://en.wikipedia.org/wiki/Aston_Martin_DBR9 [Accessed 6 November 2018].