

Driver comparison through data analysis

by Ehab Aziz Barsoum

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Bsc Automotive Engineering

Race Engineering

Driver Comparison through Data Analysis

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P149568

2. Abstract

Sports discipline is a good way for car racers to be successful which involves recording their analysis and performance, including drawing graphs and writing a conclusion to show exactly what factors influenced that performance,

For example, the people who running marathon they log their running distance, speed and heart rate to optimize training table.

In the race car, the methods are huge recording devices. They have been used in the track with a lot of sensors in conjunction to log what the driver and car are doing in the track. In addition, motor race companies employ special engineers full time and their main job is to draw correct summary, by analysing the data and monitoring the system.

Nowadays the data acquisition systems are much more affordable and the computer now makes it very accessible to every single person.

This assignment is for the people who are interested in race engineering investigation. It is designed to show the different performance and techniques for three drivers in the same race car circuit. A simulator for one chosen vehicle has been used by each driver. Moreover, the most important thing here is making a comparison with rational critical analysis and evaluation of driving action of the drivers. This includes areas such as gear selection, throttle application, braking, and steering technique.

(Segers, 2008)

3. Acknowledgement

I would like to thank pro/T Tudor for guiding this assignment in the appropriate direction and helping me to finish it with great style, I am very thankful for his support which led to my interest in research.

4. Contents

1. Title page.....	1
2. Abstract	2
3.Aknowldgments.....	3
4. Contents	4
5. Introduction	5
6. Literature review.....	6
6.1 Throttle application.....	6
7. Methodology	10
7.1 First session	10
7.4 Total Group channels.....	16
7.5 Session1.Three Driver Comparison.....	22
8. General Drivers Mistakes	23
9. Second Session Analysis for three Drivers.....	24
10. Total Math channels for three drivers.....	31
11. Conclusion	38
12. Bibliography.....	39

5. Introduction

The aims and objectives of this study include firstly assessing how the drivers' performance impacts the response of the vehicle during race time. This involves looking at the sectors time and overall lap and examining the relationships between the drivers' performance by using a driving simulator. This machine is used to look at the drivers' consistency and their performance at turns and curves.

The second point is to create an efficient plan to drive the race car, which means developing a style to maintain a good level each time. The track data is vitally important and that is why it is important to record data accurately. Creating opportunities for discussions and suggestions are important before, during and after the drivers driving track test. Live data will guide the drivers for self-improvement via discussion and identification of the strengths and weaknesses.

The job here is to analyse the data properly, which means that choosing, and installing the data acquisition system and interpreting exactly what the data shows. Also knowing how to interpret and work this data, how to find a solution for each problem and modifying what may be needed for the future. For example, as stated by Templeman, 2008, to identify the understeering or oversteering faults during steering car wheels in turns, to deal with facts and different theories for better solutions needed for different situations.

(TEMPLEMAN, 2008)

6. Literature review

6.1 Throttle application

Temple man explains in his book the way to control throttling and managing to feed the engine with chosen limits of fuel by pressing or mashing the pedal up and down to increase or decrease the engine RPM and speed. Exactly how much the driver applied to feed the vehicle's power, depends on whether it is opened fully or less. It also shows performance under braking, the percent from zero to 100% measurement, which is located in y axis and distance in x axis in simulator graphs.

(TEMPLEMAN, 2008)

6.2 Braking Aggressiveness

It's necessary to assert brake application at the beginning of the braking stage while the car is in high downforce. It is important for the driver and his role is to build up brake pressure as soon as possible and with quick reactions. The peaks will show how aggressively the driver is braking.

(Segers, 2014)

6.3 Steering Techniques

This is the correct way to steer the vehicle and learning about bad habits of steering techniques. The first method is how to place your hands on the steering wheel and choose an appropriate position for different situations to drive smoothly.

When this is achieved the driver will automatically know different styles and steering methods, like hand over hand steering technique, pull-push steering technique, hand to hand steering technique, all these techniques can be used in appropriate situations in the race circuit.

(epermittest.com, 2018)

6.4 Steering wheel positions

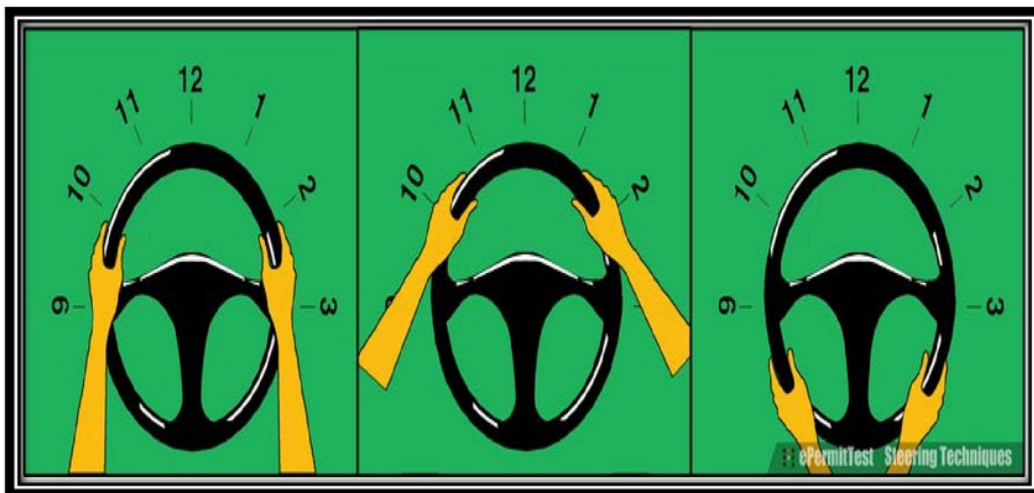


Figure (1)

(epermittest.com, 2018)

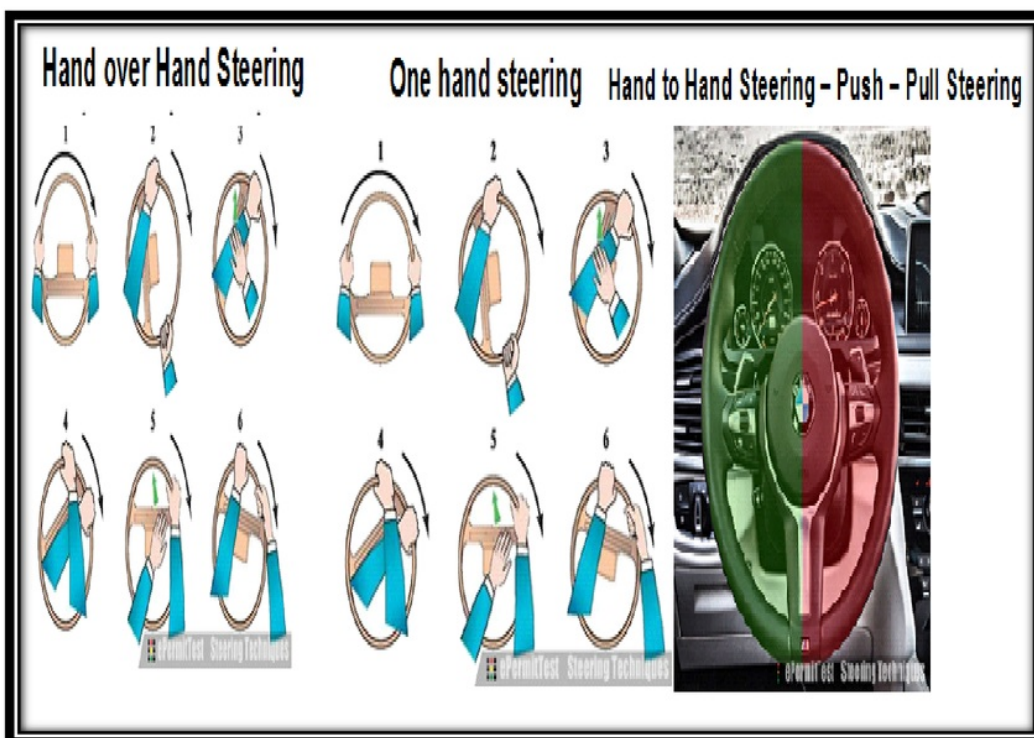


Figure (2)

(epermittest.com, 2018)

6.5 Braking Techniques

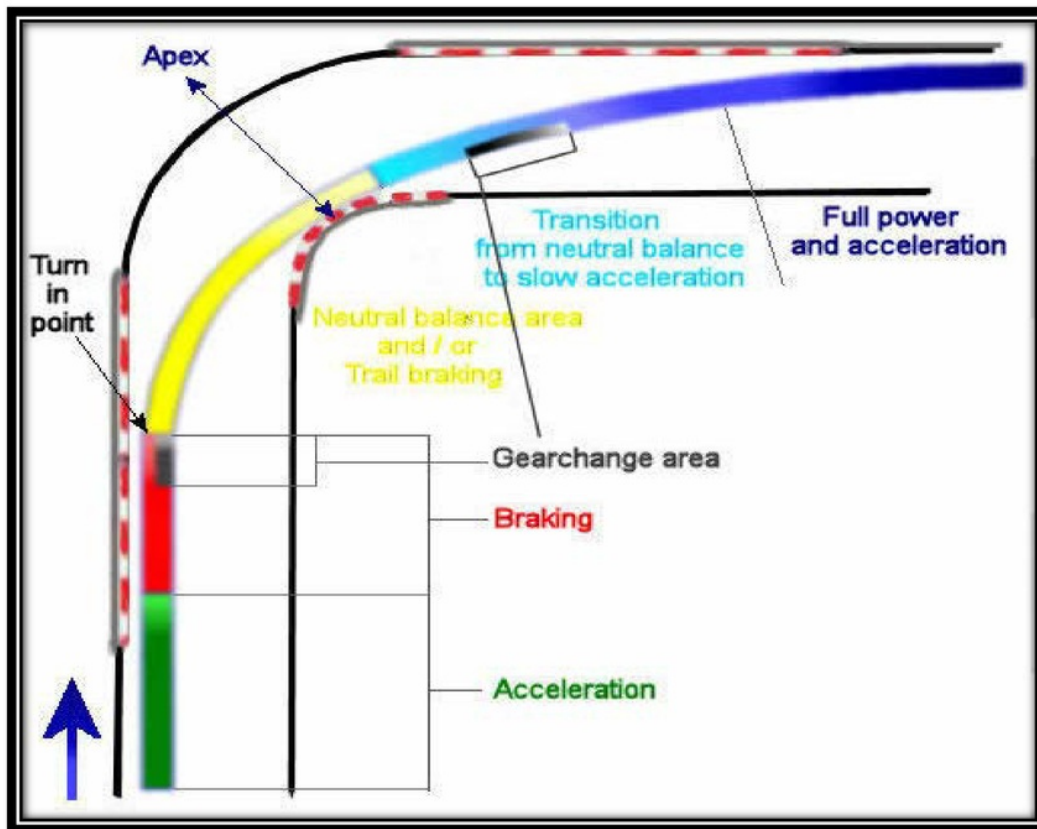


Figure (3)

(formula1-dictionary.net, 2018)

Braking techniques are essential mechanism to change different types of energy. For example during driving at specific speed limit, the car's own kinetic energy, shoes or pads that push the pedal against the brake rotor or drum deliver kinetic energy into thermal energy due to friction. Heat dissipation by cooling the brakes pads makes the vehicle slow down.

In the race track the vehicle deals with repetitive heavy orders at high speed, the brake component temperature will be sensitize gradually so this requires different materials to overcome these excesses.

(formula1-dictionary.net, 2018)

The Techniques of braking are:

Cadence braking ,threshold braking, locked wheels in the dry and anti-lock braking system(ABS) .

(formula1-dictionary.net, 2018)

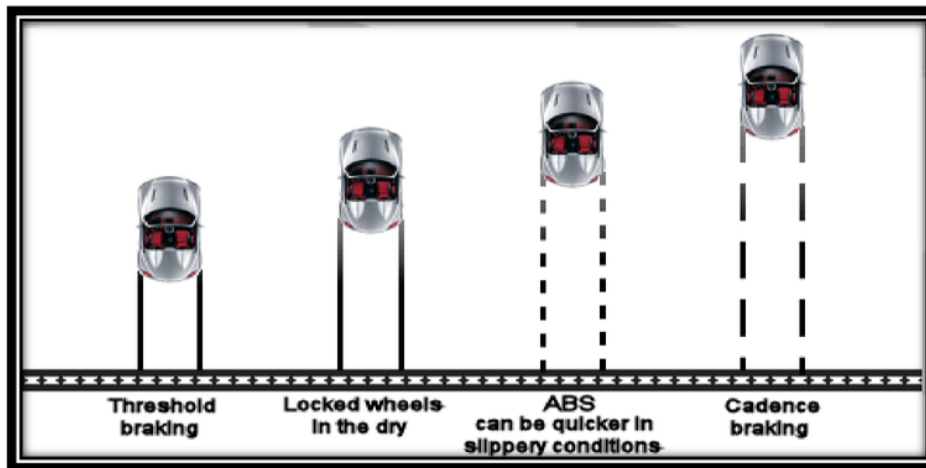


Figure (4)

(formula1-dictionary.net, 2018)

6.6 Gear Selection

Selecting the appropriate gear at the correct time for the speed is the easy method for optimizing fuel consumption, safety and to provide extra power in the race track. This can also maximize time efficiency in order to be able to win the race.

Some drivers maintain at low gear ratio to keep stability and speed and also to reduce workload on the motor vehicle performance and maintain speed at specific limits on the track.

A group of racers favour a manual gearbox and it is an easy way to choose proper gears for speed, helping to overcome track variation circumstances. An engine performing at high speed consumes a lot of fuel but if the car has a different sort of economic engine injection sensors it will save fuel.

If track conditions are muddy, icy or stony choosing an appropriate gear to match the speed at different corners and turns for each lap is essential.

(citroen.co.uk, 2018)

7. Methodology

The competition car must be ready to run on the track where everything is adapted such as tyre pressure, oil limit and engine function perfect. This project consists of three drivers A, B, and C

A is Tim Tudor

B is Sam

C is Jack.

The first stage is comprised of two runs for each driver, one to warm up the engine and one for data logging and recording.

The second stage consists of again warming up the engine and the driver will focus on:

1. Driving at speed
2. Cornering speed
3. Throttle percentage
4. Brake pedal %
5. Engine RPM increase or decrease

All of this is dependent on the driver's style and experience.

7.1 First session

Warm up for the drivers before starting to run on the track which consists of three sectors, first sector is red, second sector is yellow and third sector is green for each total lap.

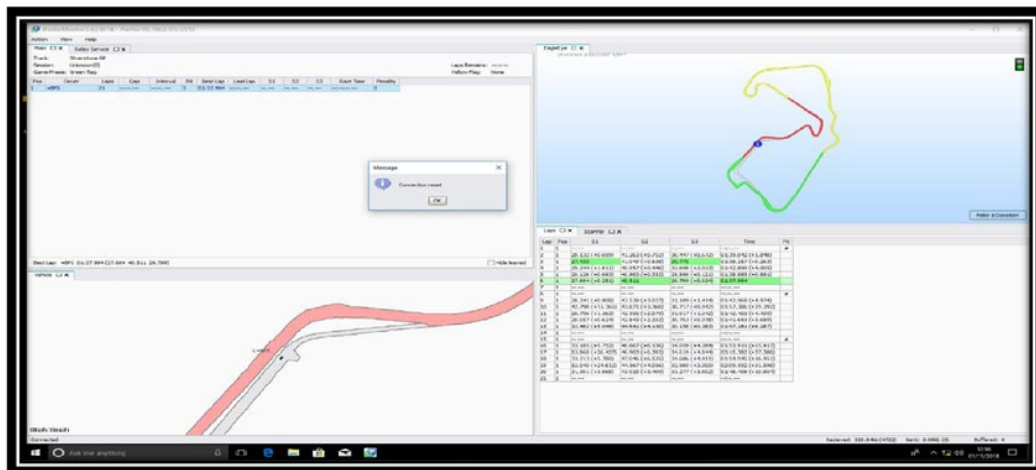


Figure (5)
the green colour is showing which driver is fastest and not wasting time in each lap, the first driver is the best on the five lap's driver A.

7.2 Analysis First practical session

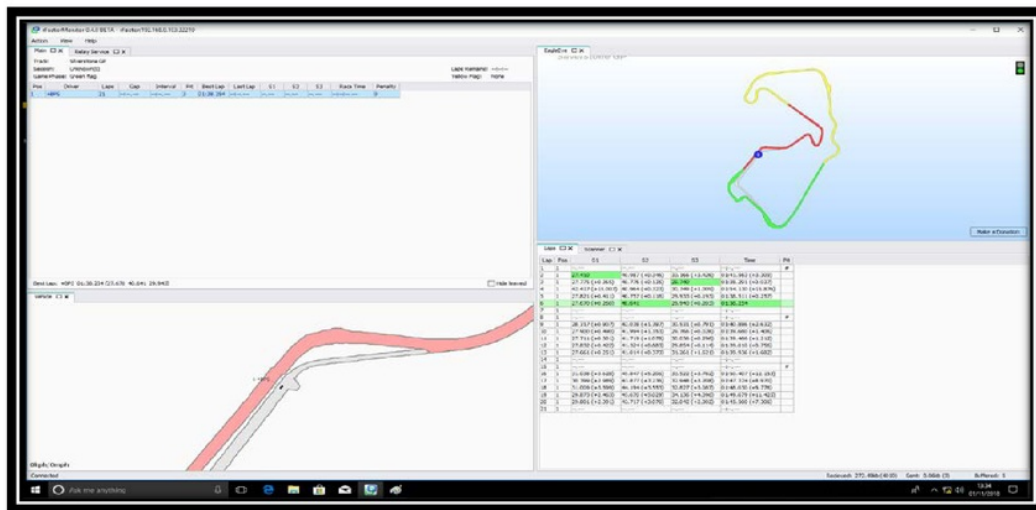


Figure (6)

this figure shows the first run for three drivers on the track, luckily the weather is wonderful to run there is no rain at all.

Driver A performance

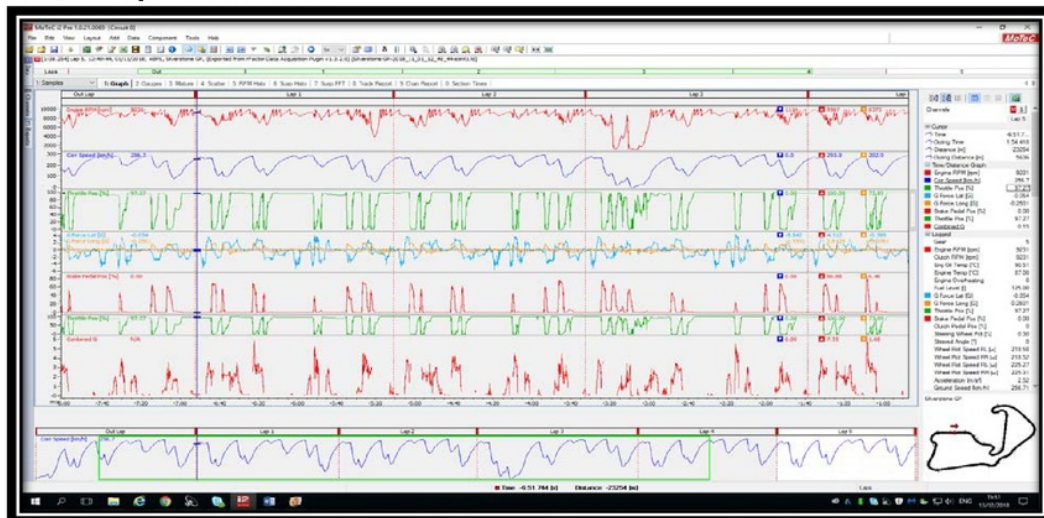


Figure (7)

Drive A is very talented the reason is laps from 1 to 5 it show how his confident performance is fast without wasting time. He uses less brakes and gearing is perfect, timing to upshift and downshift is perfect, lateral and longitudinal and without passing limits of oversteer or understeer.

Driver A Engine RPM turn1

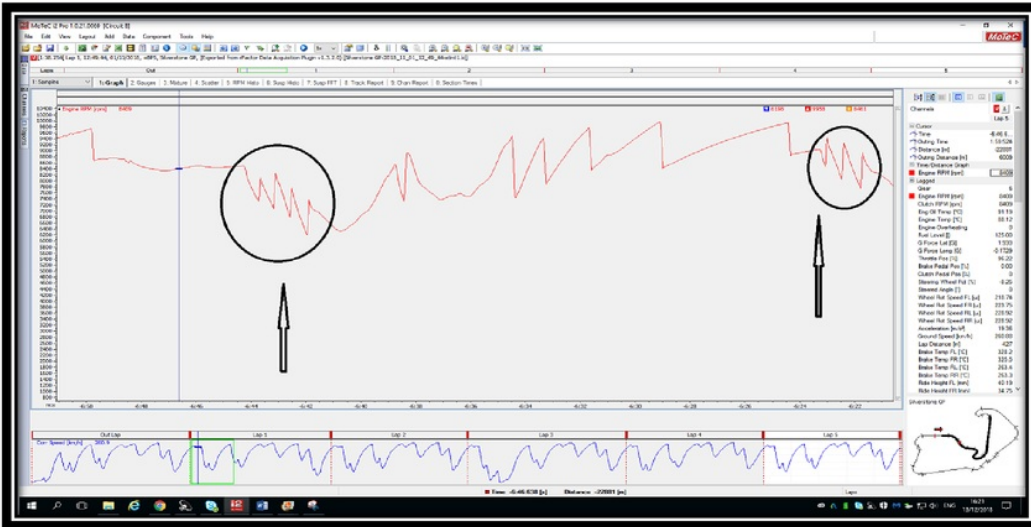


Figure (8)

This shows the upshifts traces of driver performance around the turn. The RPM is up and fairly stable keeping the engine revs in good range and allowing the car to increase power to pass from the turn to the straight line. The next stage will show what the throttle position at the same turn will look like.

Throttle Position

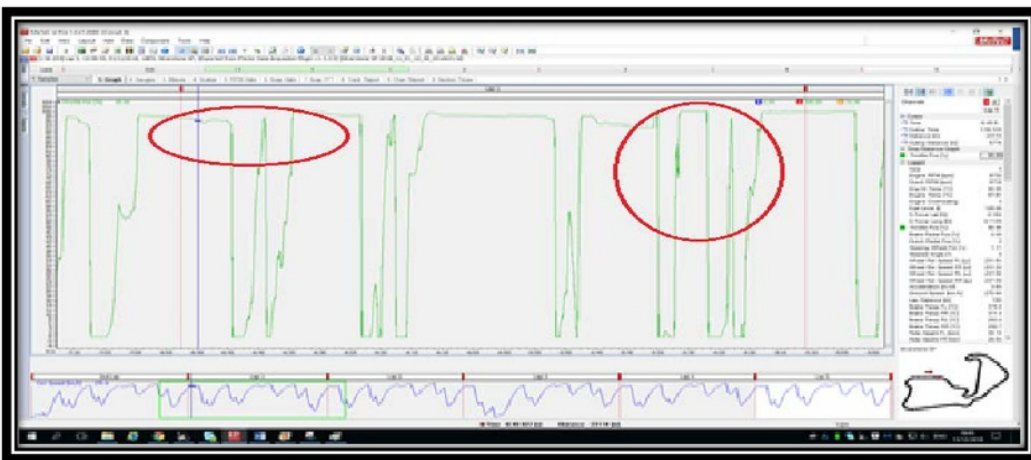
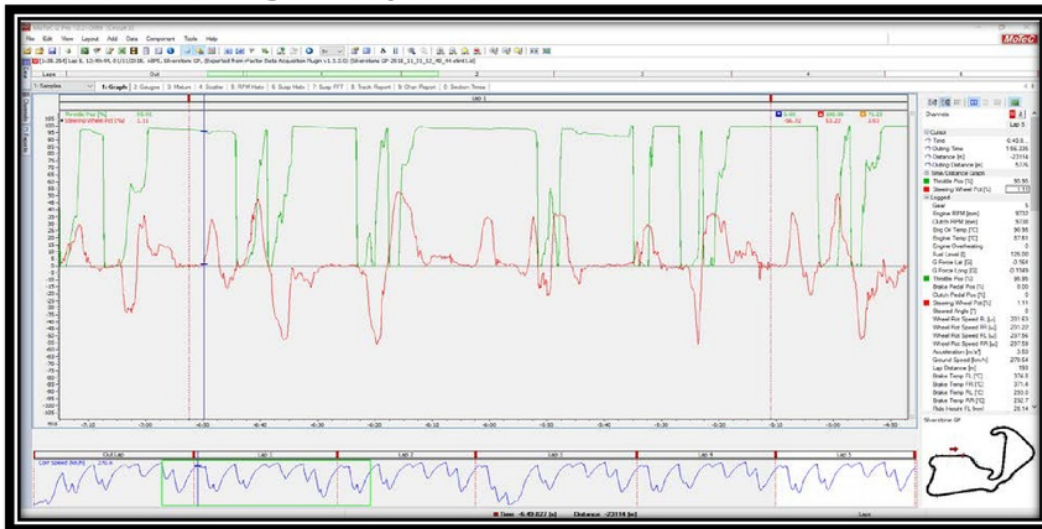


Figure (9)

Throttle position is one of important elements and reflects the RPM in the previous figure. Graham Templeman says it nice to know the car and drive the car smoothly, what the contact patches average, how you feed the power perfectly, how to hit the throttle position what acceptable percentage averages between up and down as the graphs show 0 and 98 which the throttle average rate is 95.95%.

(TEMPLEMAN, 2008)

Throttle & steering wheel position



Figure(10) is showing the throttle position while driver A steers right and left, as turn 1 shows this as preparing to three turns after that will be very encouraging if the driver passes it with good steering without hitting the curves, nice contact patch, and grip which increase the car stability.

Driver A Gearing

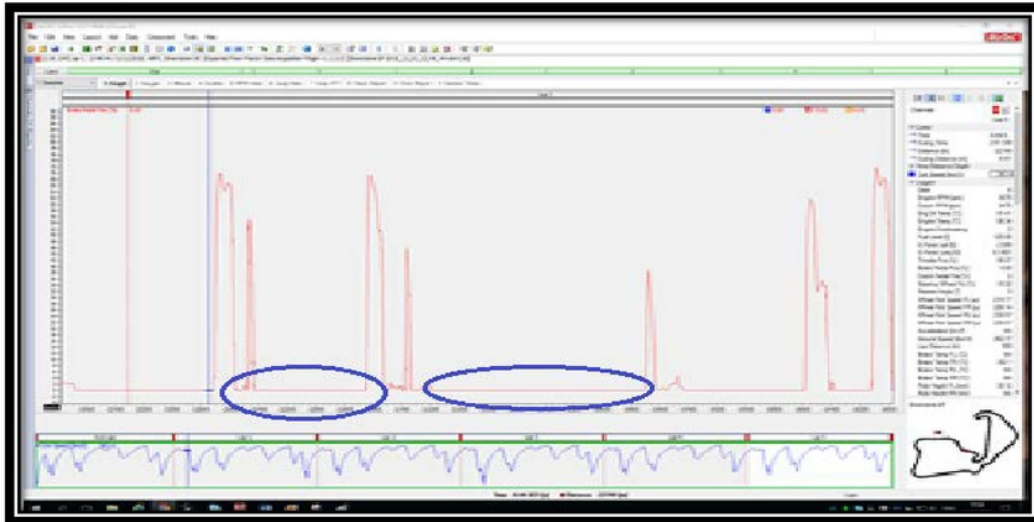


Figure (11)

The figure showing how the driver change gears upshift and downshift, when the driver starts confidence start to change the gear to quickest one as soon as possible to gain extra speed and less time by sometimes change the gears up and down very quickly.

gearing technique around the turns with keeping second and third gears in sharp turns to keep the car speed and time.

A Braking Techniques



Figure(12)

The driver technique is less effective as he brakes too much and does not mash the brake pedals long enough. Also he increases the distances between braking periods it gives good driving experience to not waste the time also.

Brakes are not early must be an optimize limit to the time and not big brakes distance.

7.3 Combined G

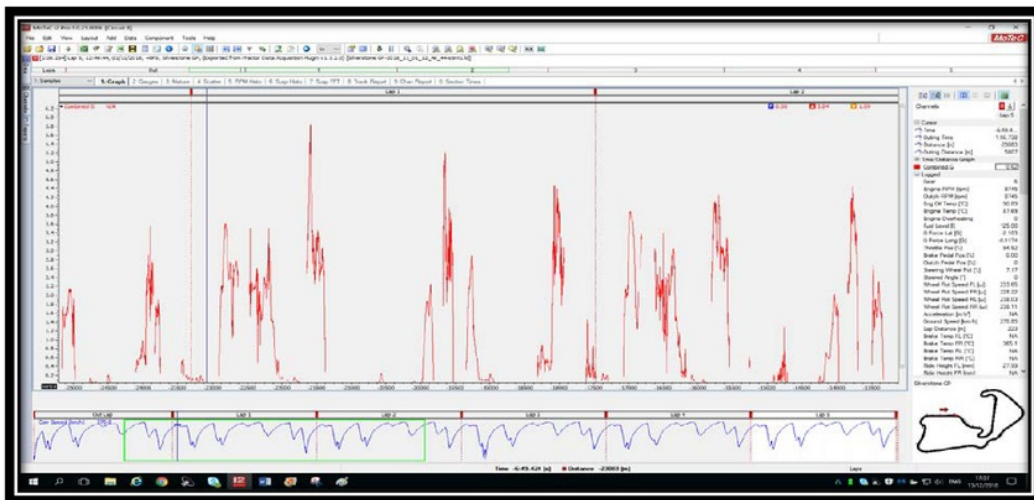


Figure (13)

The graph showing the combined G which is the total calculation consist of the square root of longitudinal G plus Lateral G by using math channel procedures.

$$\text{Combined G} = \sqrt{((\text{G-force Late})^2 + (\text{G-force Long})^2)}$$

$$\text{Braking cornering} = \sqrt{(\text{Combined G})^2 - (\text{G force Late})^2}$$

(TEMPLEMAN, 2008)

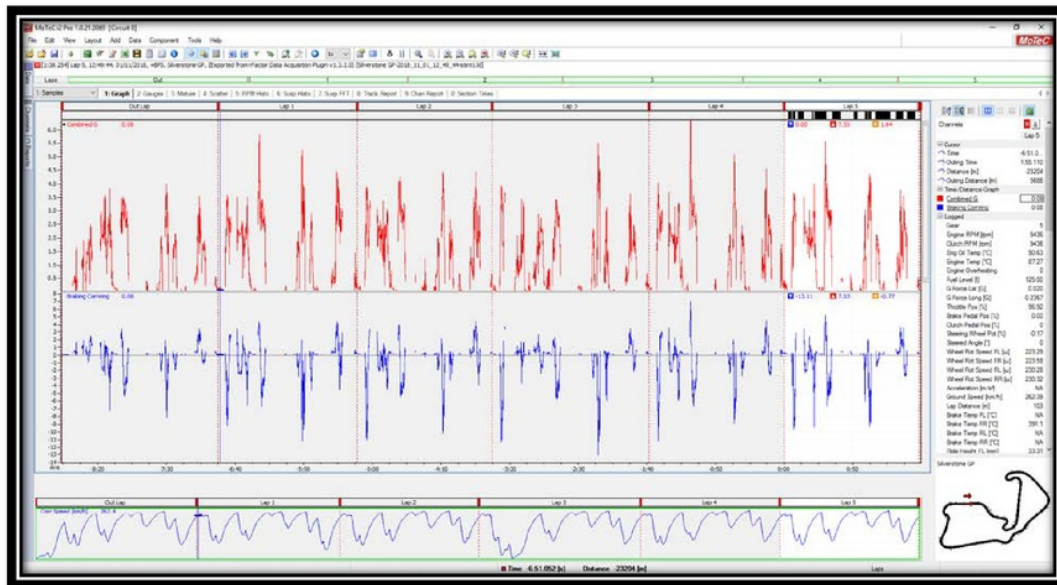


Figure (14)

The graph showing the braking cornering over the distance on both left and right, inconsistency braking between the braking corners is better than stops in specific turns or going outside the track.

7.4 Total Group channels

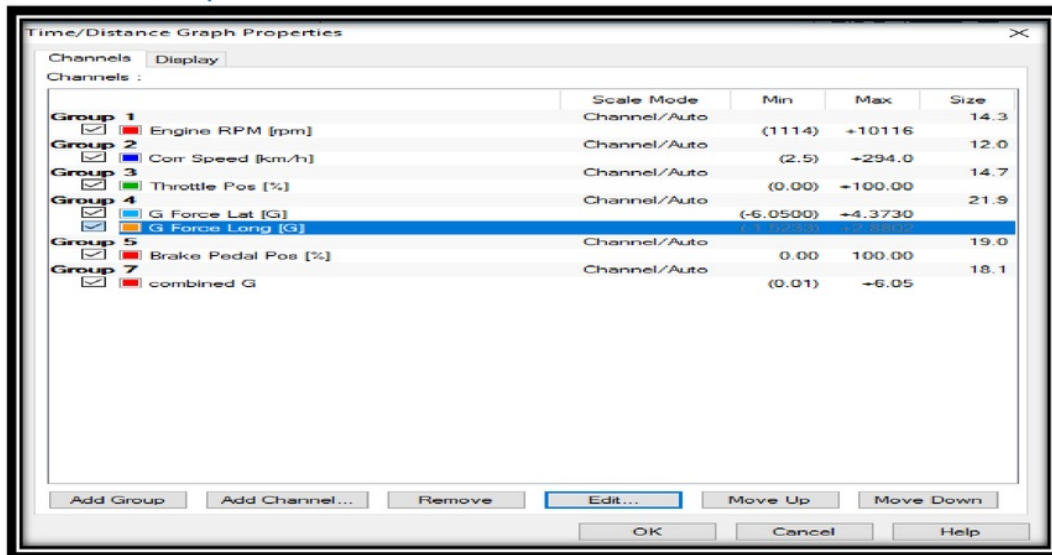


Figure (14)

Driver B Throttle Position

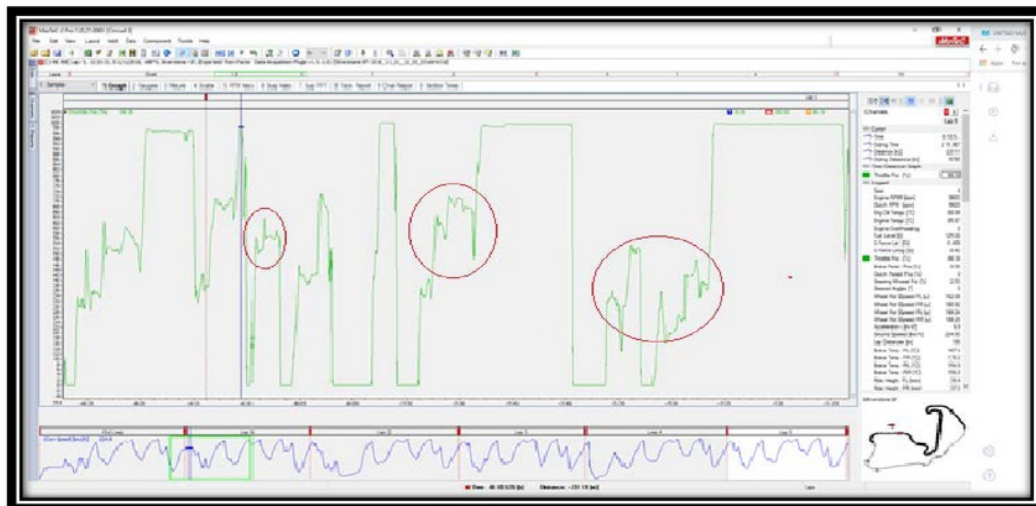


Figure (15)

Driver B his throttle technique is hesitant and mashing too early and not too long at high levels because he is a bit careful about the bend. He jumps to press the gas

too early at the first turn will see next he will increase his cornering radius, also throttle blips decrease brake Gs and for downshift momentarily.

Lateral G vs Throttle position

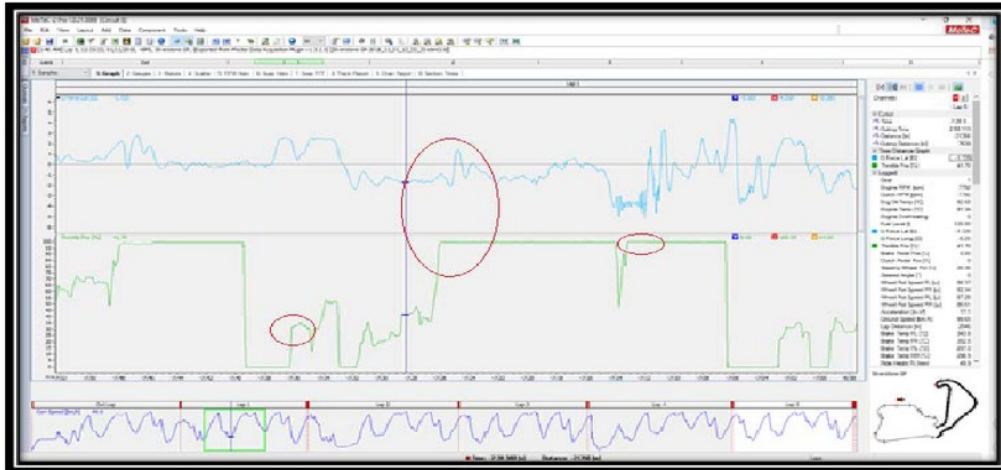


Figure (16)

Driver B is very slow to go to full position throttle which appears in the first left red circle is partial, second big red circle it shows how after the corner is starting to full 100% which is little high peak G Lateral, in third circle is upshift position, bottom is off and top is full throttle.

Driver B Steering Technique

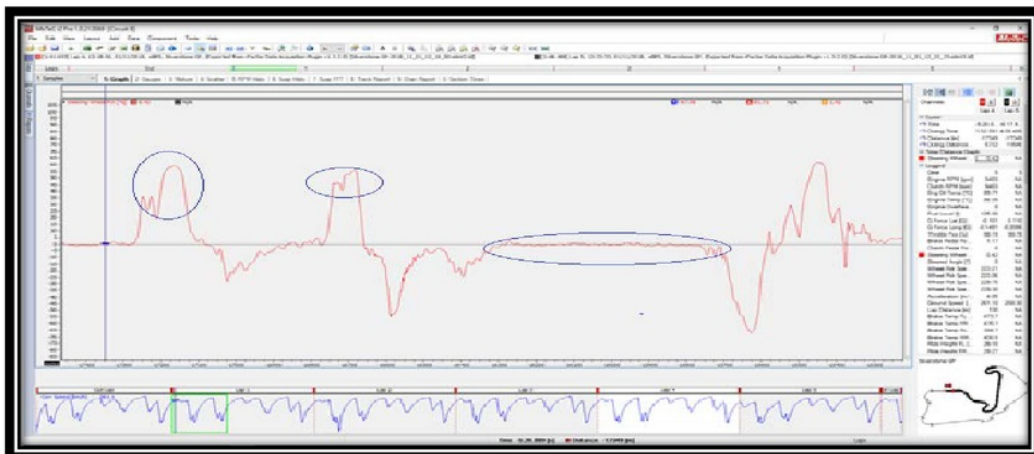


Figure (17)

The first blue circle shows the understeer at first turn in which on the red lap which exactly shows very slow to build up the lateral G. the traces going up means oversteer and down is understeer. The second circle refers how the driver goes oversteer on the red lap which is a sudden spike at the downwards, the third circle shows the lateral G is jagged the reason is it is sampled roughly at 50 Hertz.

Driver B braking Technique

As Walter R.Fey says the brakes are like lawyers - they want charge you everytime when you use them. Optimizing and limiting the braking functioning reduces the cost in lost straightline speed. (R.Fey, 1993)

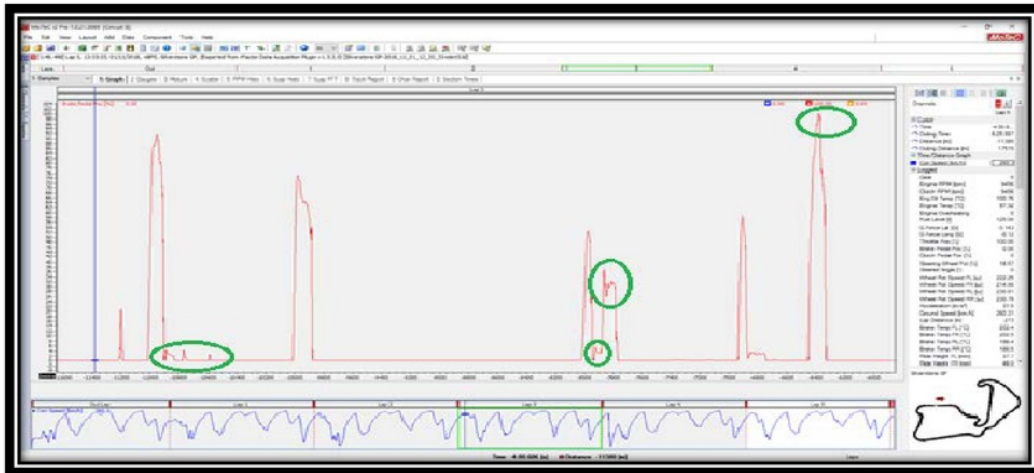


Figure (18) showing that the driver B spike brake trace pedal, the brake traces is tentative and waste times in short distance, also in full pedal percentage 95%, sometimes but not quicker.

Driver B Gear Selection

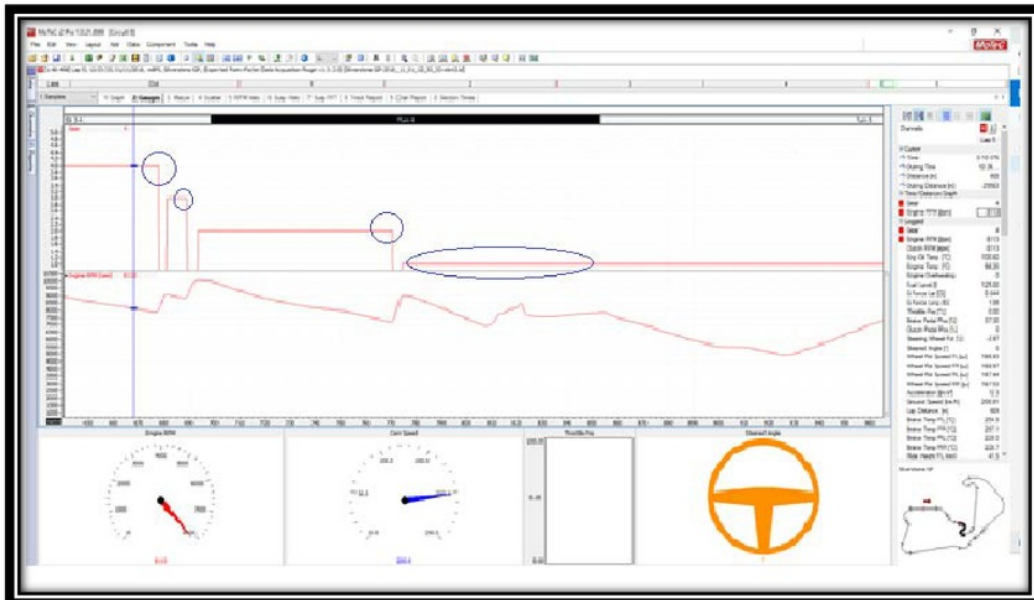


Figure (19) is showing how the driver B is using downshift gears from 4, 3, 2, finally

driving around the corners in the first gear, is not good choice gear, how is that happened in the track and drive long distance in the first gear, minimum allowances to the gears around turn must be second or third gear to keep your speed and earning time.

Driver C throttle application

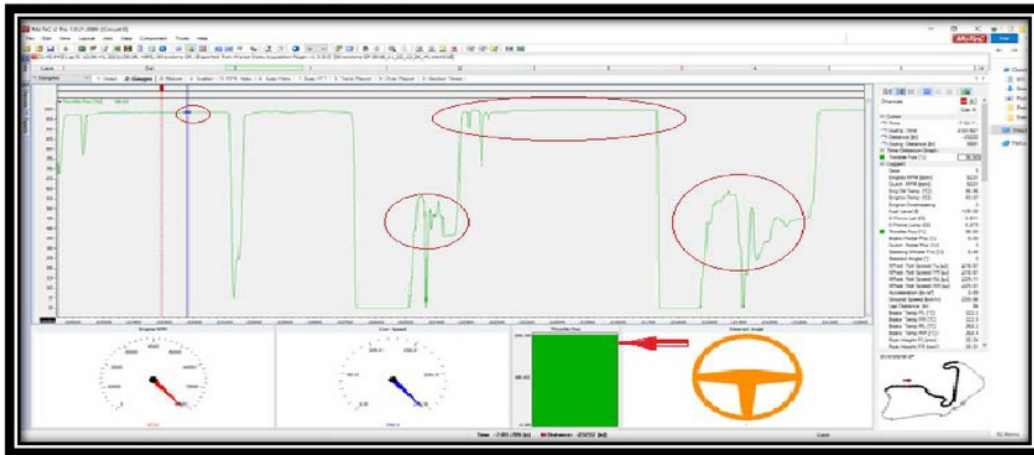


Figure (20)

Driver C is not as experienced as the first and second driver, some point are good and some need improvement.

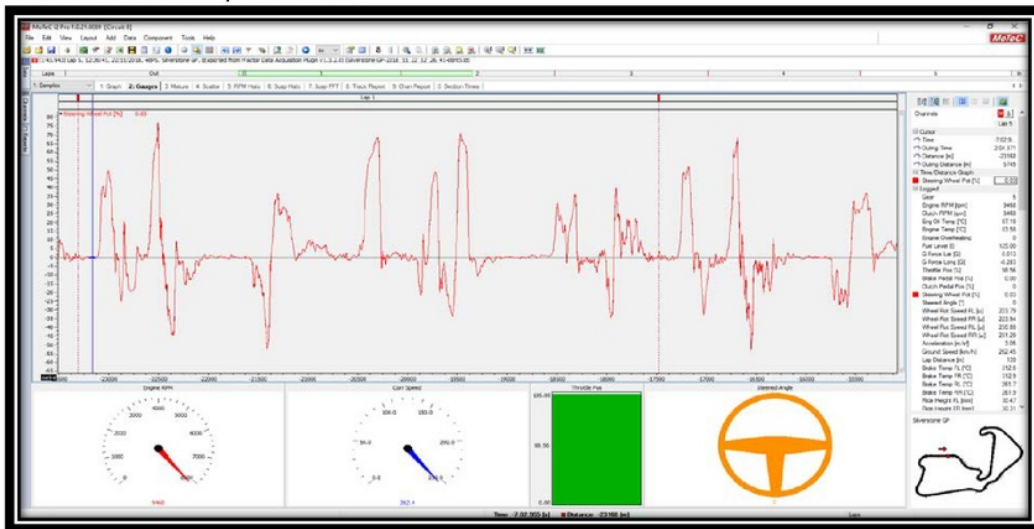


Figure (21)

such as inconsistent throttling correctly around this corner as is come his down but he tried to progress but not too hasty. He made full throttle many times but need to improve his performance in the second session.

Driver C Steering position

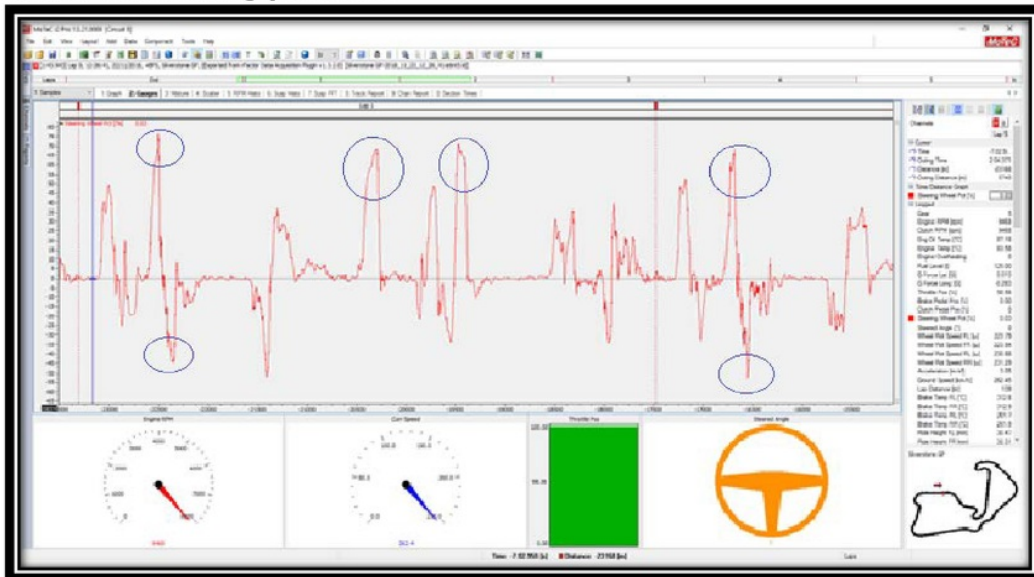


Figure (22)

Driver C

He did a lot of oversteer and understeer that appears in the previous figure clearly. He needs a lot of practice on the track to keep steering position correct and with the appropriate steering angle.

Driver C braking Technique

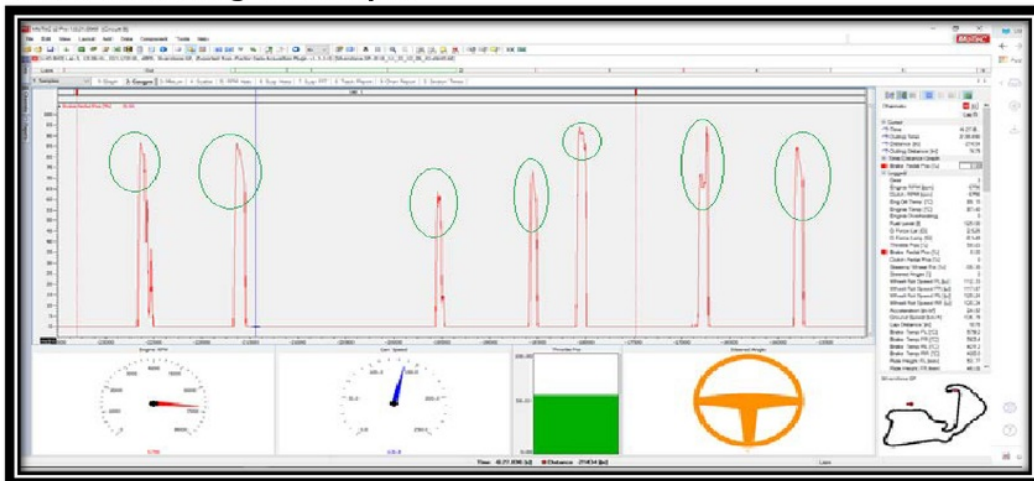


Figure (23)

Driver c is using brakes too much in turn number 6, showing that he is very stressed. He again needs to correct and develop his performance.

Driver C Gear Selection

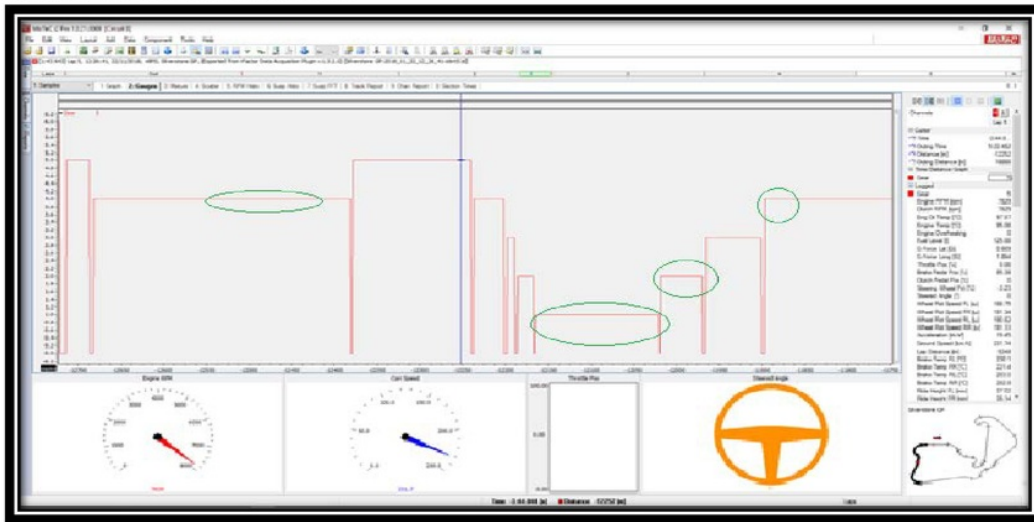


Figure (24)

Driver C

The last figure shows many mistakes - using first gear on turn 17, changing gears too frequently which prevents the car's velocity thereby losing time and ability to drive smoothly.

7.5 Session1.Three Driver Comparison

Famous mistakes and what must drivers make it in the next session

Area of type compare	Driver A	Driver B	Driver C
Throttle Application	Deal with pedal experience and most his position is full	Medium average on throttle position but needs practice is still hesitant when getting off the throttle around the turns	Hit the throttle without accounted, need practice and feeling the throttle pedal
Steering Technique	Not oversteer or under steer, managing and keep balancing his vehicle	Needs adapting how use wheel steer correctly, not manage steer angle and lose his driving in straight-line of the track, need look at steer angle properly	A lot of mistakes understeer and oversteer is lot because is too fast and not adapt angle steer in turns and curves.
Braking Technique	Timing is correctly but some areas need not early braking just little bit looking at this mistake	Mashing the brake aggressive and without sort of consideration that might loss the stability on the track, need training	Braking early in turns and sometime late that a lot of times hitting the bends and went outside the track need proper training
Gear Selection	Perfect, keeping always high gears that earn time and speed sometimes using third gear in turns that is perfect	Medium performance, selecting wrong gears and lost speed and waste a lot of time, the reason is using first gear in the turns.	Selecting gears is very bad, because using first gear in turns and sometimes keep the running in second gear for another turn, need choose nice gear in correct area to keep fast and not waste the time

Figure (25)

8. General Drivers Mistakes

1. being too aggressive during the first few laps in order to show off skills is misguided. This makes it hard to finish a race well because if you start with a difficult approach it is hard to concentrate on braking points and other skills needed to set high standards.

Recommendation

Take a step back and relax. Never be aggressive during the first a few laps.

2. Hitting the curve lines and public areas when turning laps can result in accidents to the public.

Recommendation

Familiarisation with all aspects of the track which means learning all the bends, curves and public areas. This in turn gives more confidence to improve performance without worry.

3. Forgetting to adjust specific components necessary for optimum results

Recommendation

Make a checklist of all the car and engine components needed for the best outcome. If necessary take the car to a specific area to make any adjustments taking into account weather conditions and the ramifications. Also remembering to warm up the tyres beforehand

4. It is not about how fast the performance is around the track but it is about consistency, efficiency and safety. This requires driver concentration and respect for not over driving the car. It is important to have a clear understanding of how the car performs on the track. The driver must get the right feeling for how the brake pedal affects the performance and how synchronizing gear changes affects timing on bends. Similarly using the fuel pedal to increase or decrease speed and avoiding using the brake too much to maintain speed

5 Seat position is very important as some drivers adjust the seat too far back or too high or low in relation to the steering wheel. This makes the driver lose sight and visibility on the track. The driver must be able to see the car in front, the dash and all mirrors easily.

(DiMaggio, 2018)

Recommendation

Drivers must take time to make sure that the seat positions are optimised.

9. Second Session Analysis for three Drivers

Focus on determining faults and mistakes in the first stage with guidance for avoiding mistakes and developing performance.

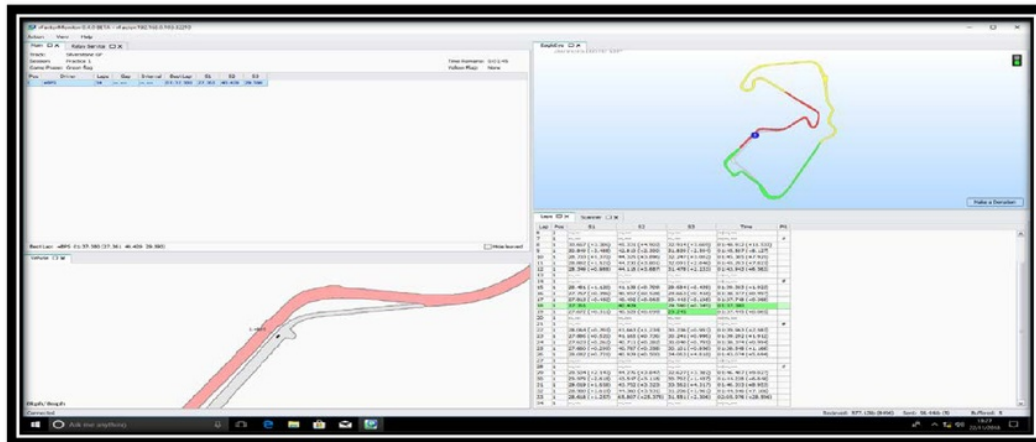


Figure (26) showing the table results of three drivers on the track

Driver A Throttle applications

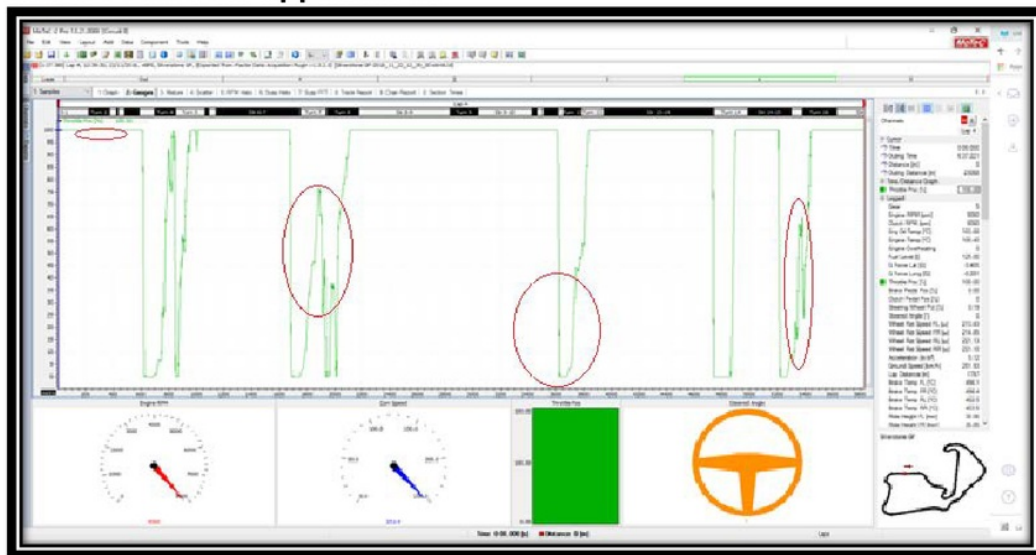


Figure (27)

Driver A

Perfect performance in using full throttle to keep high-speed limit around the sharp turn, for example turn 7 is going with full throttle and progress after each throttle position from zero % into 100% quickly that good sign to earning his keep fast.

Driver A Steering Technique

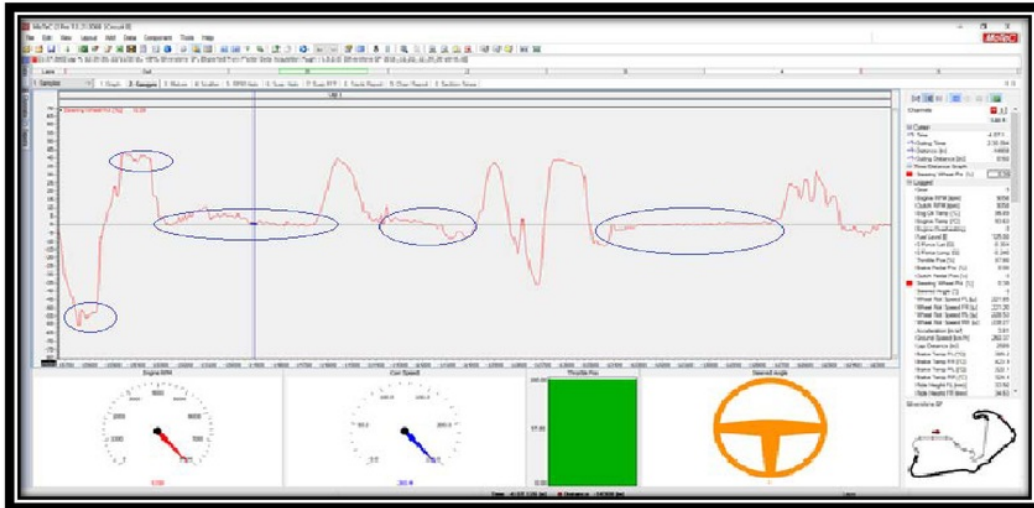


Figure (28)

Driver A handling the wheel steering here is typical and optimizing in this track condition, his keep the car in the track very low oversteer or understeer that mean he manage the car, not the car managed him.

Driver A Brake technique

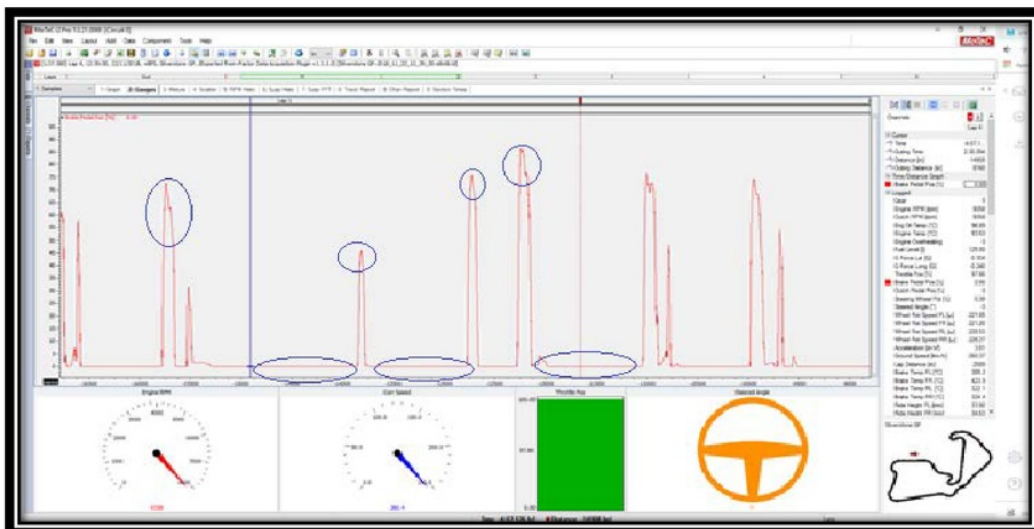


Figure (29)

Driver A is playing nice Symphony because is using the brakes like wheel steering around the corners and turns, you can see his performance is not braking many times, 100% full and long distance without brake pedal functioning.

Driver A Gear Selection

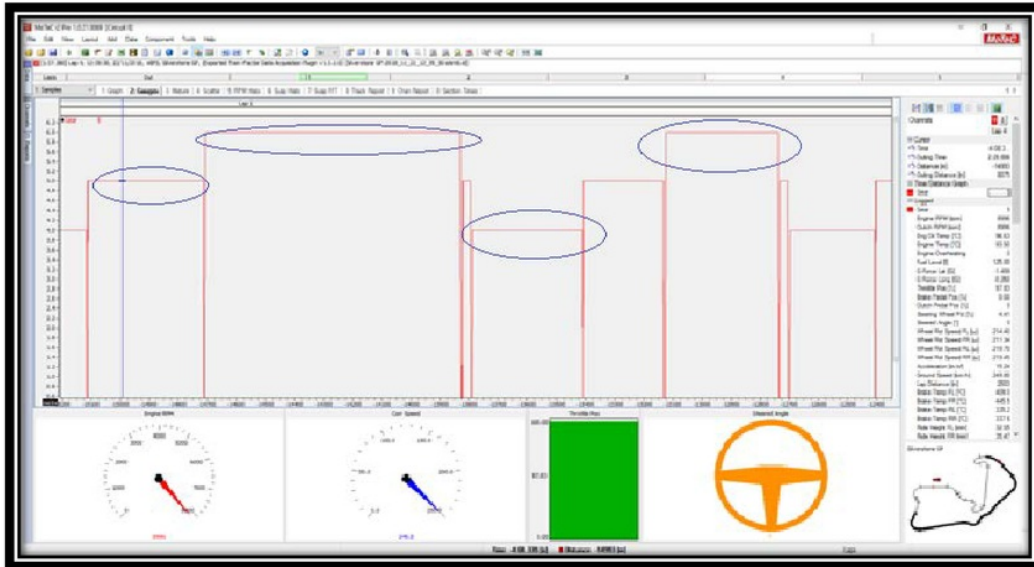


Figure (30)

Driver A

As the last figure shows the driver performance is very good because is keeping and selecting appropriate gear in the turns maintaining fast speed. For example in turn 9 in fifth gear - lots of drivers would be in second or maximum third gears here. Perfect performance!

Driver B throttle position.

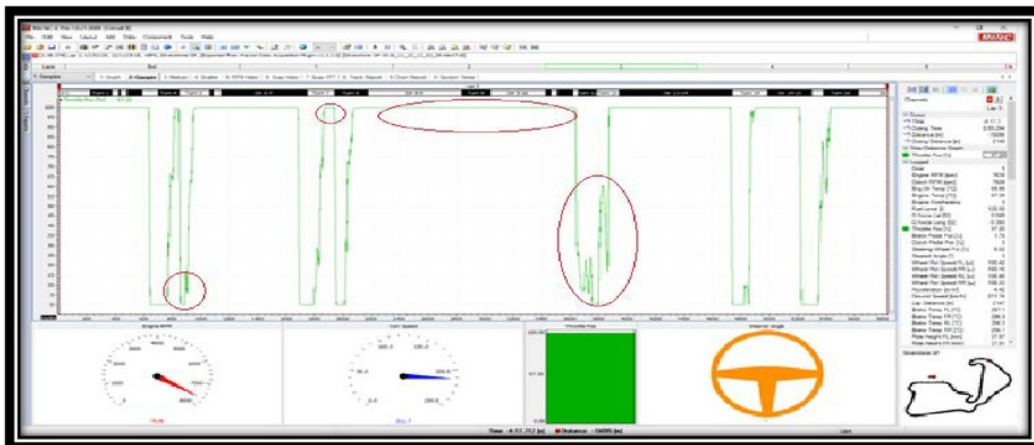


Figure (31)

Driver B improved the driving performance using the throttle position fully most of the time including around corners and long distance with full throttle. He is more confident and has learnt from his previous mistakes.

Driver B steering Technique

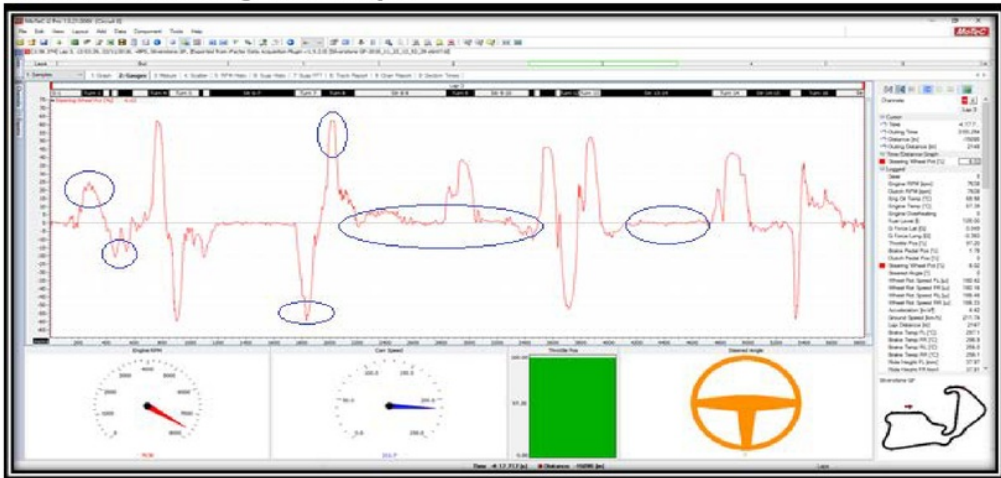


Figure (32)

Driver B

There is a sort of improvement in his steering wheel position. There are some instances of oversteer and understeer but not a high percentage like before.

Driver B braking technique

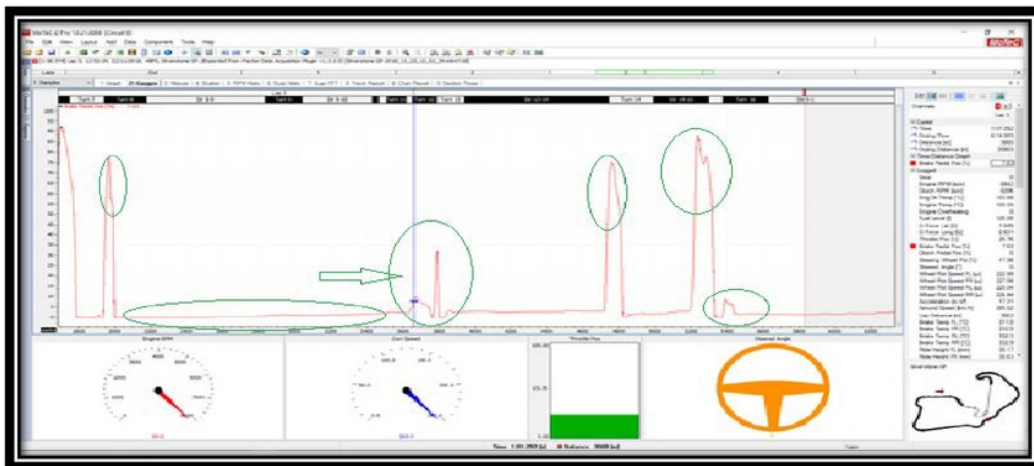


Figure (33)

The green arrow showing the driver performance around turn 13 which is after a long straight distance, the braking traces here is less time, distance and low brake pedal position percentage.

Driver B Gear Selection

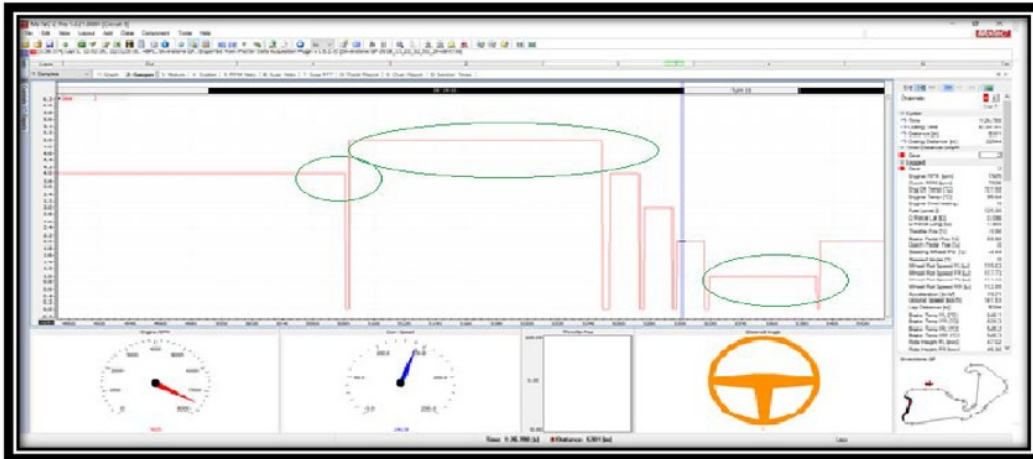


Figure (34)

Driver B

Turn 15 is not easy for the normal driver so the driver here improved but still selected first gear in this corner so he wasted time.

Driver C throttle application

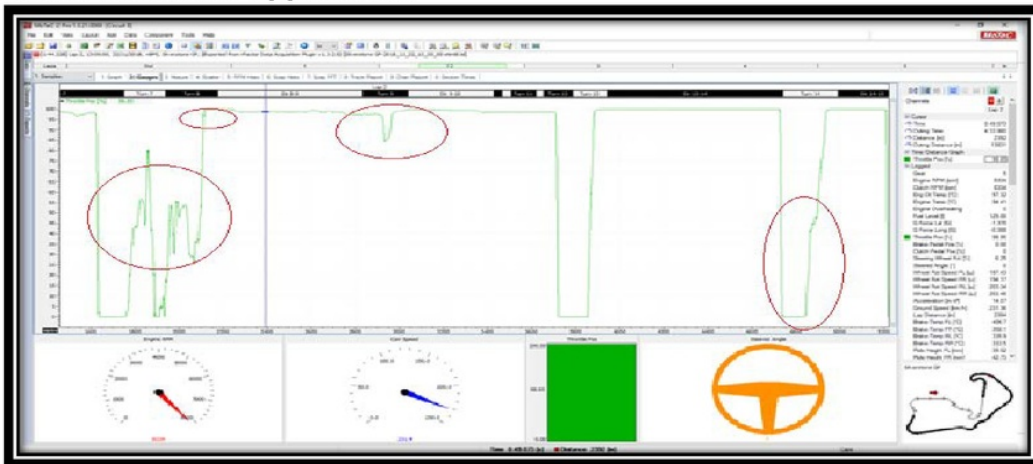


Figure (35)

Driver C is trying to improve but there is a rush with balancing in turns 7&8 but improved at the end of 8 until 14.

Driver C Steering Position

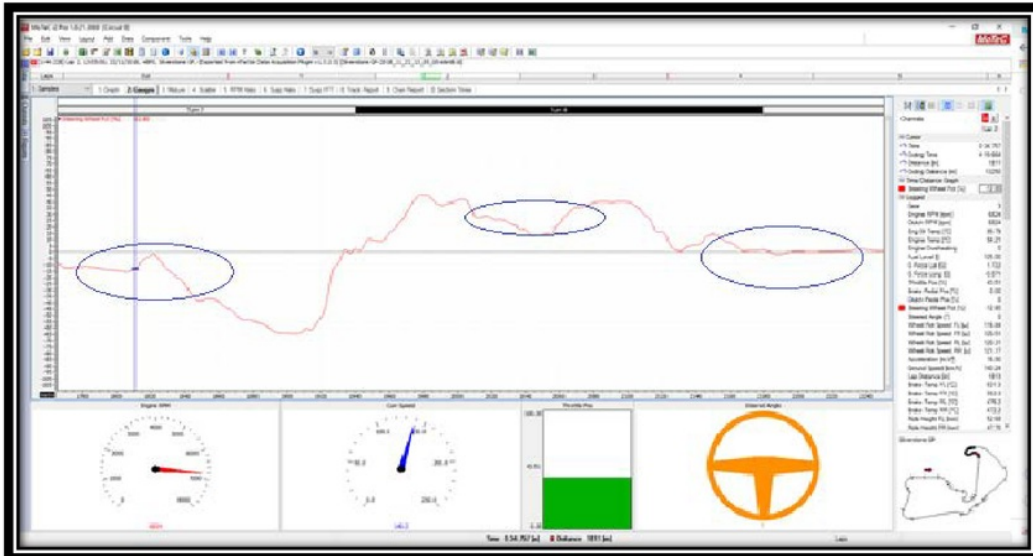


Figure (36)

As the blue circle showing in turn 7 and 8 is typical steering wheel position there is not oversteer or understeer like previous performance.

Driver C Braking Technique

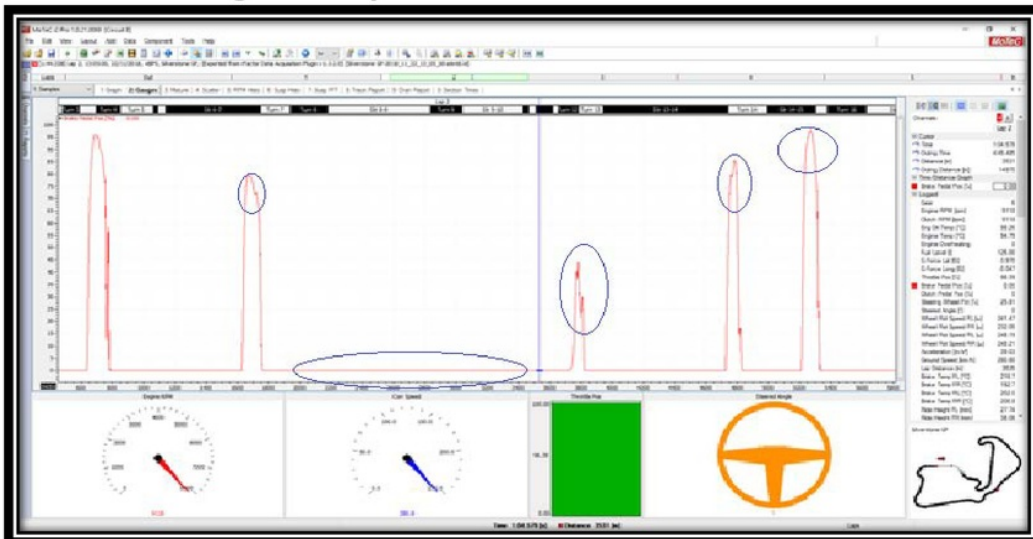


Figure (37) shows the braking performance is changed totally, long distance from 1800meter into 3600 meters with no braking which is a good sign for improved driver performance.

Driver C Gear selection

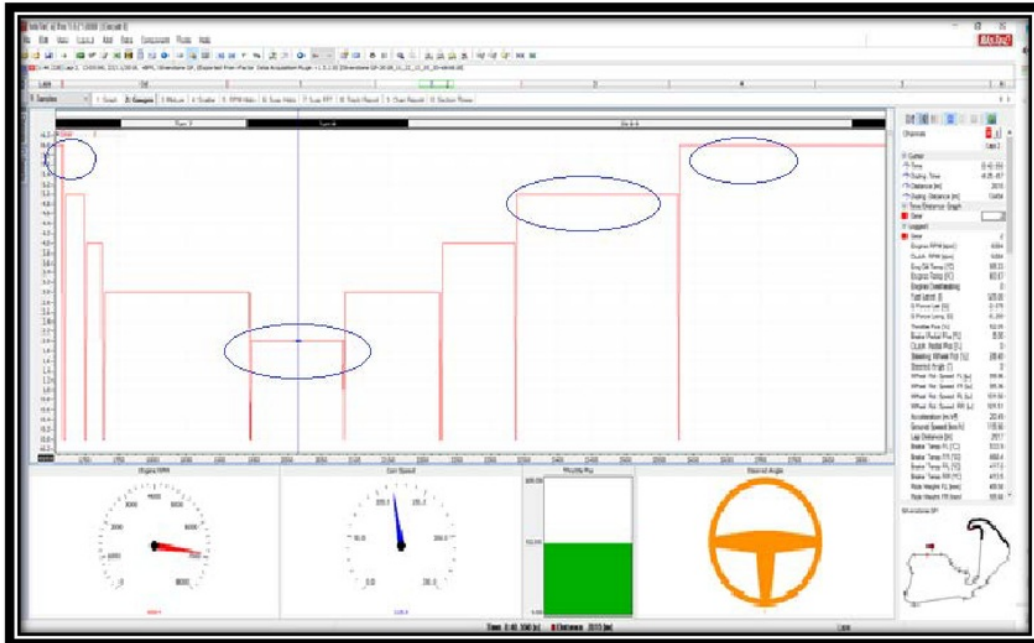


Figure (38)

Driver C is selecting second gear at turn 7 and 6 to keep his fast speed and keep earning time.

Total math channels Driver A

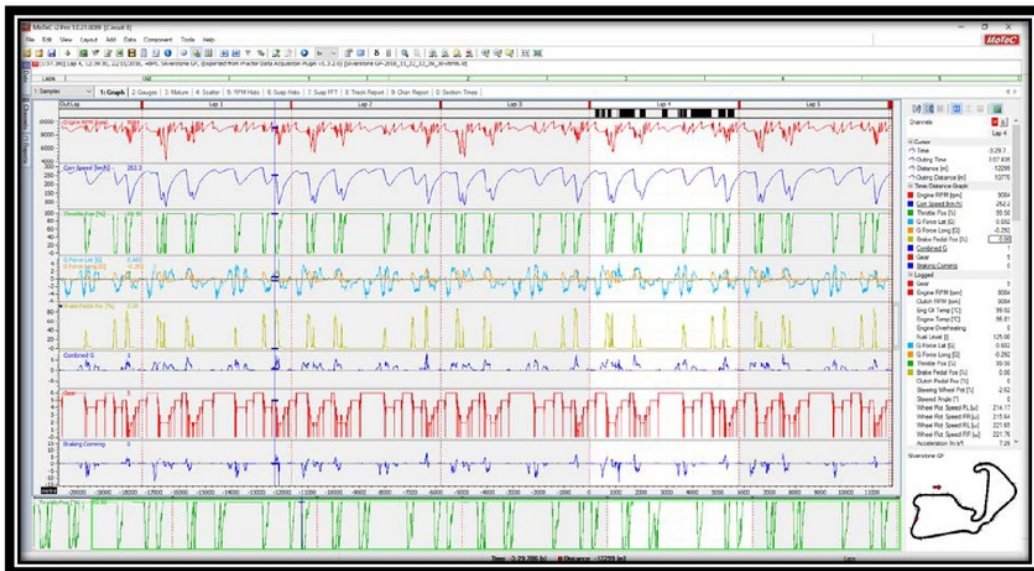


Figure (39) driver A traces on Motec simulator all the dchannels.

10. Total Math channels for three drivers

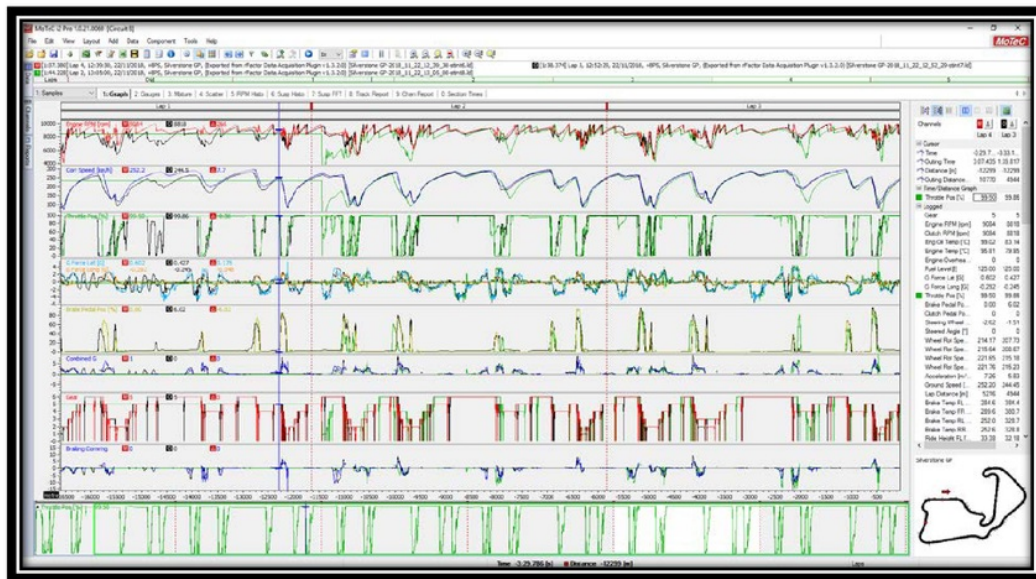


Figure (40) create two math channels combined G and braking corning.

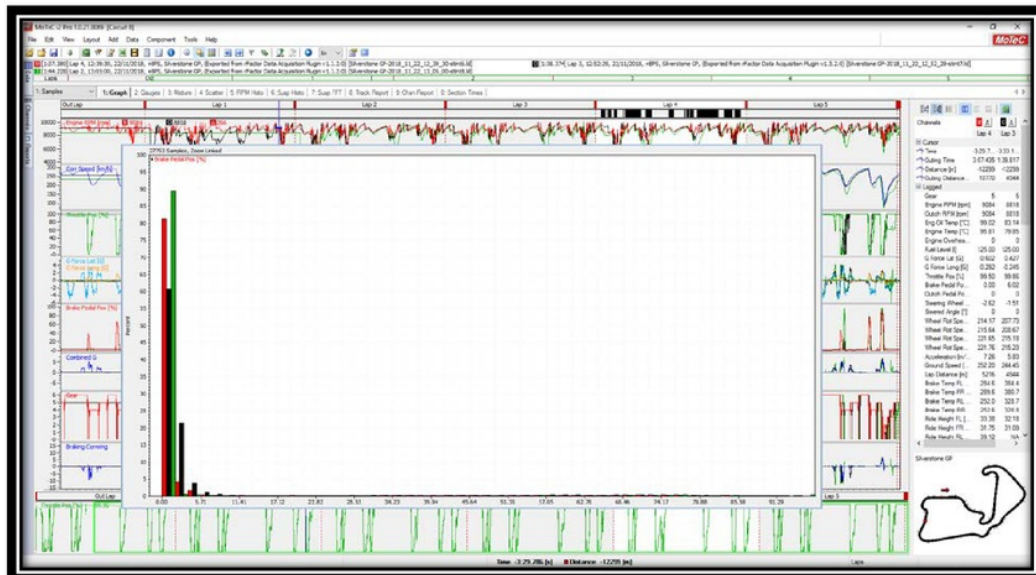


Figure (41) Histogram brake pedal % for three drivers. C is braking too much with wrong timing.

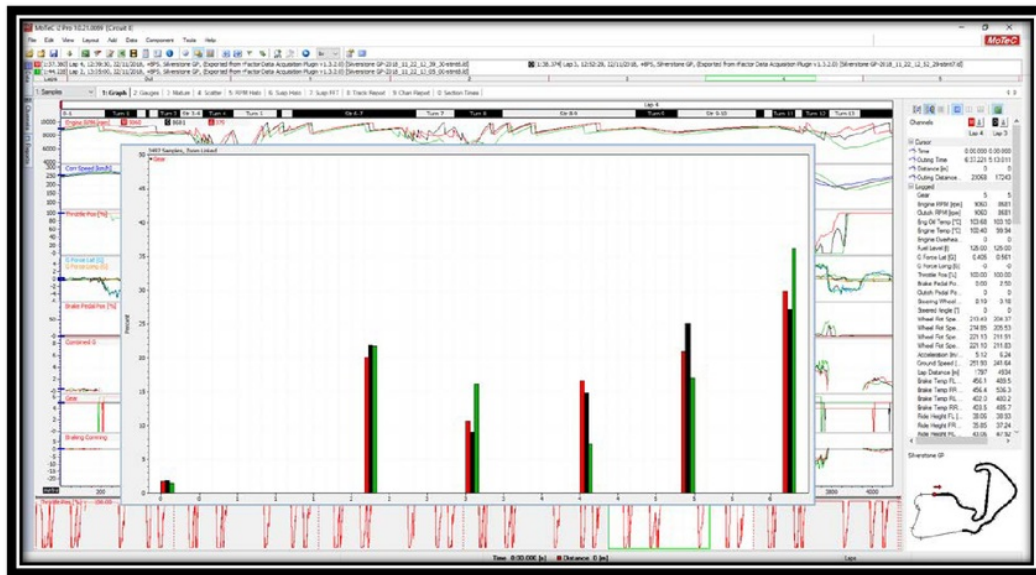


Figure (42) Gear Selection red A driver selecting very good gears in correct time ,faster and less time than others .

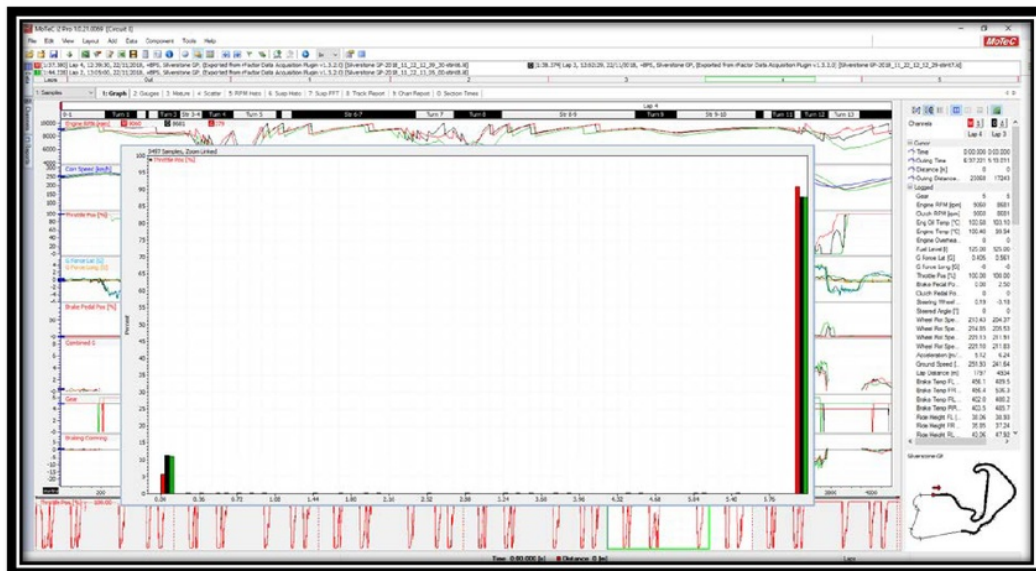


Figure (43) Throttle position%, red driver A full throttle always means he is very confident to win the competition.

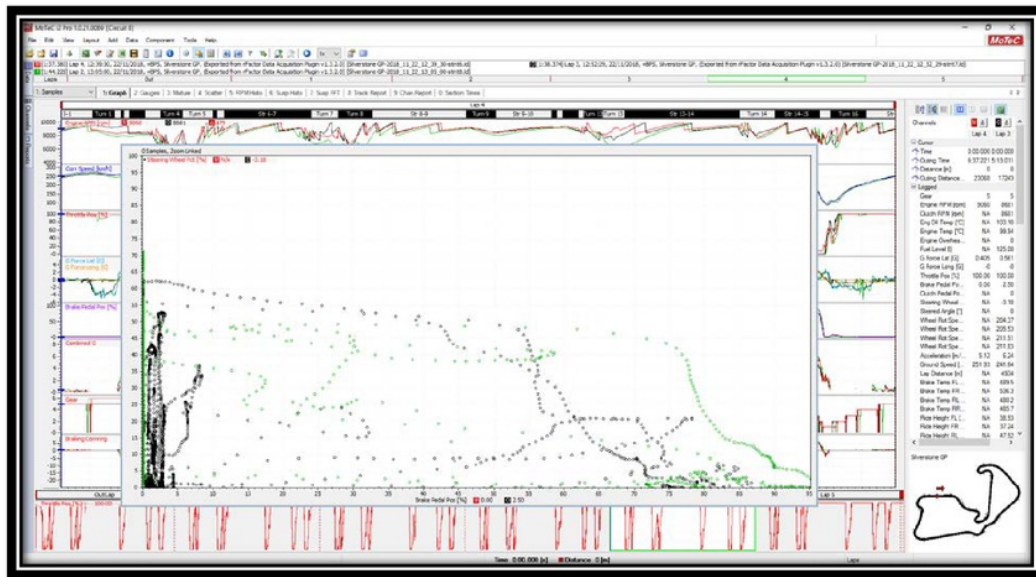


Figure (44) Scatter plot for steering wheel percentage and Brake, green is C ,negative steering angle and with correct timing, black aggressive braking and green is less.

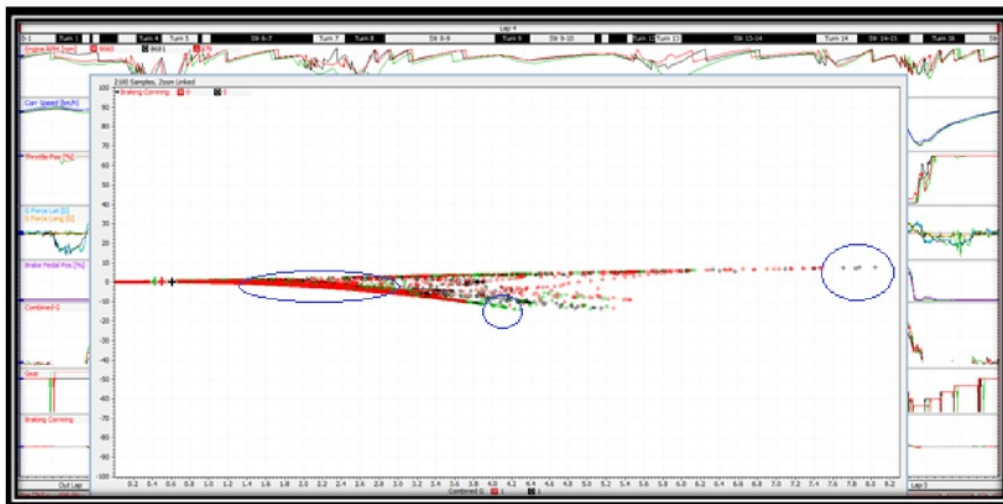


Figure (45) scatter plot for braking cornering vs combined G, drive C is green which you can see lateral and longitudinal force areas ,also braking C is massive not like A in the middle of the track.

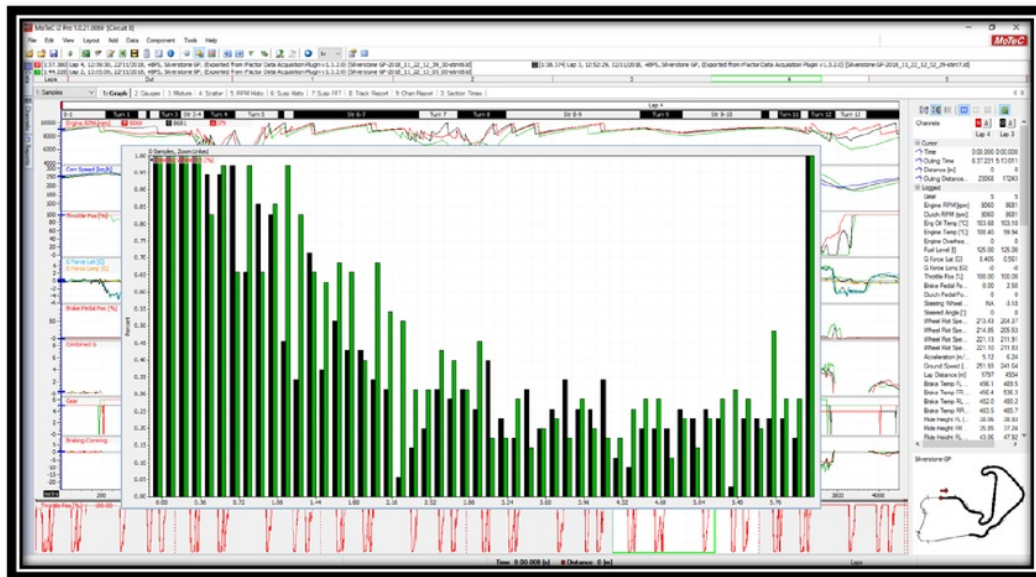
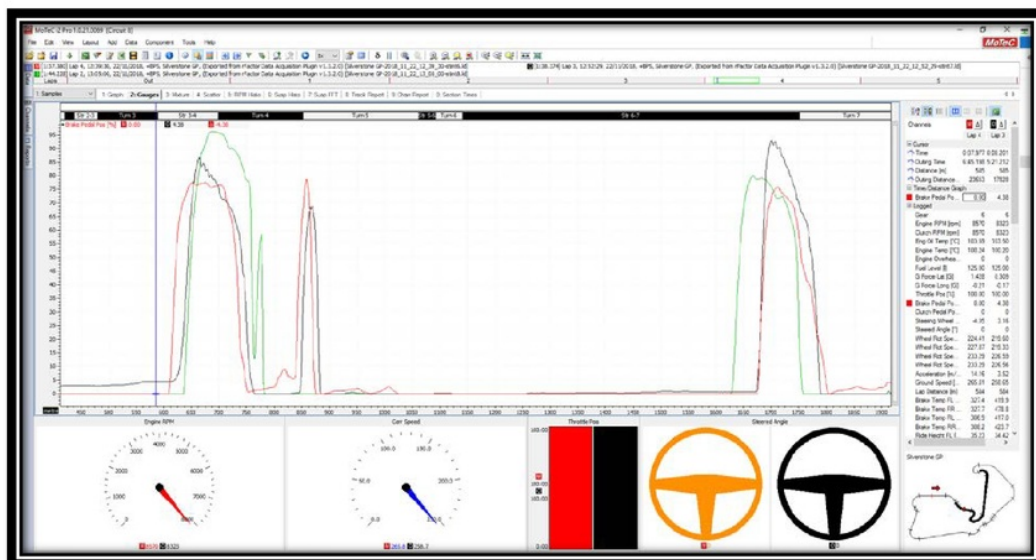
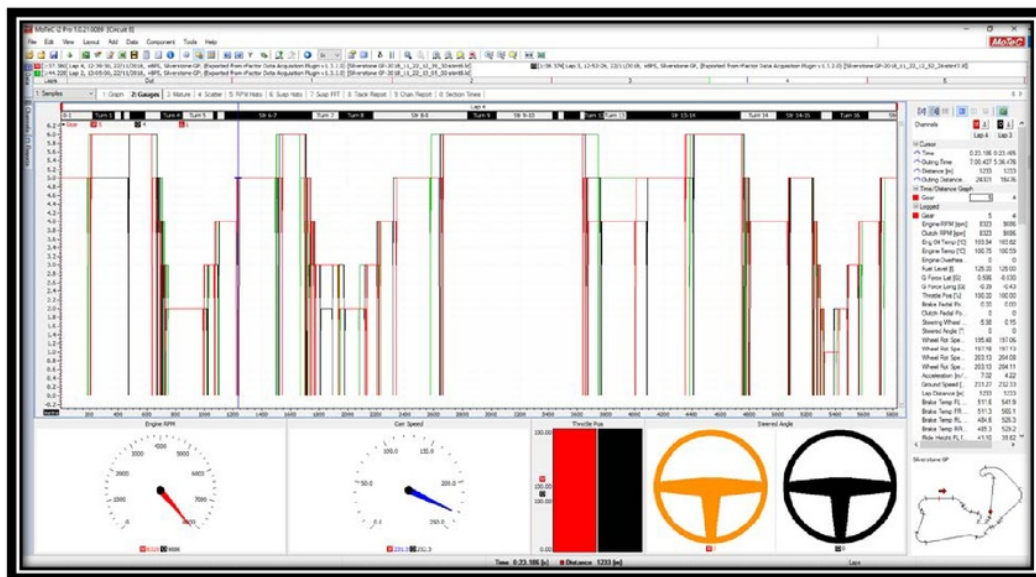


Figure (46) steering wheel percentages for each driver green one is high steering angle and black which will oversteer and understeer.

Section	Driver 1	Driver 2	Driver 3
Str 1	0:00:00.000	0:00:00.000	0:00:00.000
Str 2	0:00:00.000	0:00:00.000	0:00:00.000
Str 3	0:00:00.000	0:00:00.000	0:00:00.000
Str 4	0:00:00.000	0:00:00.000	0:00:00.000
Str 5	0:00:00.000	0:00:00.000	0:00:00.000
Str 6	0:00:00.000	0:00:00.000	0:00:00.000
Str 7	0:00:00.000	0:00:00.000	0:00:00.000
Str 8	0:00:00.000	0:00:00.000	0:00:00.000
Str 9	0:00:00.000	0:00:00.000	0:00:00.000
Str 10	0:00:00.000	0:00:00.000	0:00:00.000

Figure (47) Section time for the three drivers, which showing fastest time and fastest sector Str6-7,also 2% of sector time in the same role numbers.



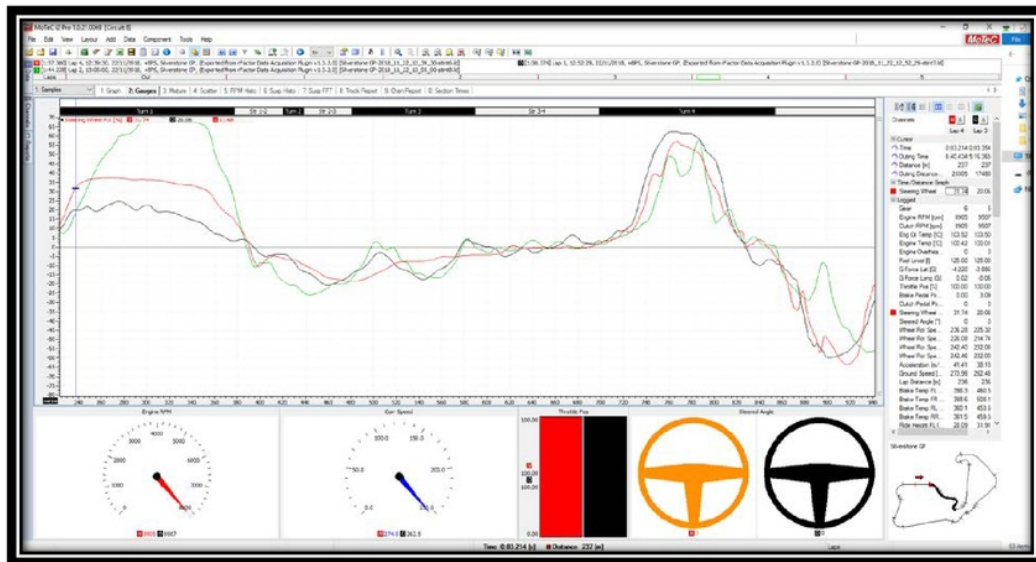


Figure (50) steering wheel % for three drivers, driver green C oversteer and under steer too much ,A & B dealing very good in graph.

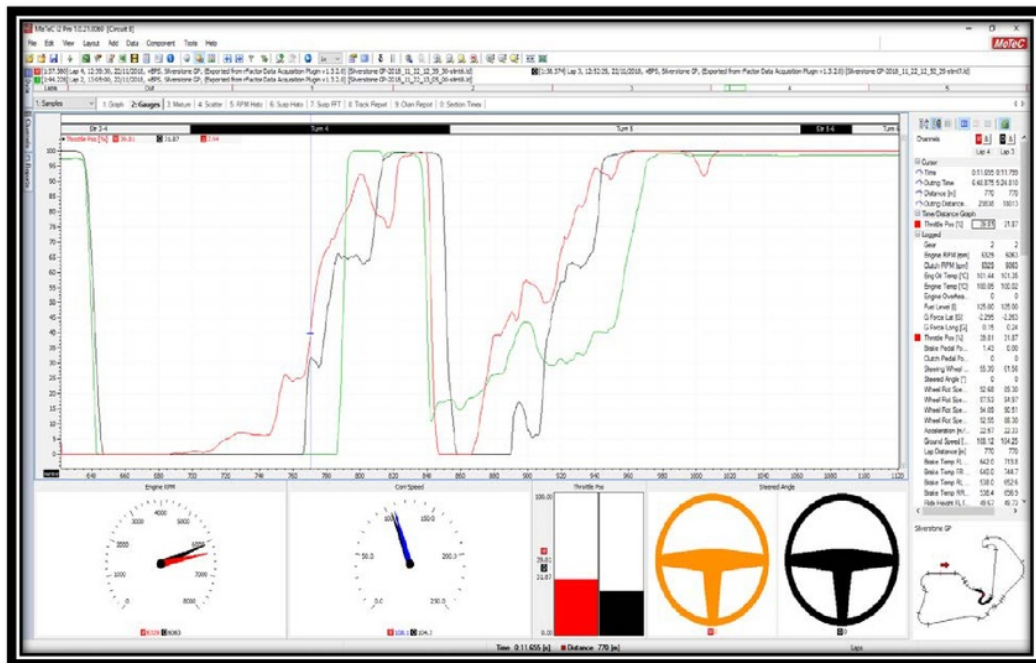


Figure (51) Throttle position % for three drivers, driver A very tidy trace, B is close to deal nice but C is very randomly using throttle.

10.1 Session 2 Comparison between three drivers

Area of type compare	Driver A	Driver B	Driver C
Throttle Application	Perfect, progressive deal with throttle application, very concentrate but not too hasty	Not too bad, performance is change totally better than before using full throttle position nice in turns and progress	His performance developed, keeps full most of time.
Steering Technique	Perfect speed is evidence of good steering angle that appeared in the table session 2	Better than before good steer angle not oversteer and under steer like the past session	Better than before good steer angle not oversteer and under steer like the past session.
Braking Technique	Perfect braking timing and not too much	Less than before not too early and not too late is adapted	Less than before not too early and not too late is adapted
Gear Selection	Good gear selection and there is not wheel spin happened at all.	Better than before but need extra practice to achieving driver A	Better than before but need extra practice to achieving driver A

Figure (52)

11. Conclusion

It is interesting to create analysis and discussion around race engineering science because you will see the impact of the drivers' techniques which appear in Motec simulator traces. It is amazing to see how each driver deals with different sectors of the track and what his reaction is when facing sudden turns and sharp curves. As an engineer you need to have ideas and quick solutions to problems or this can waste time, money and the also the competition so keep the data analysis on your performance , learn from your mistakes and develop yourself each time - as Shakespeare says "to be, or not to be ,that is the question"

(Shakespeare, 1600)

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