

University of Wales Trinity Saint David

Wales Institute of Science & Art



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

***Vehicle Performance Optimisation
using Simulation Software***

***Introduction to Automotive Engineering
(ACHA4035)***

Owen Hooper
2517449

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1. Introduction

Throughout this report, I will be examining ways to improve vehicle lap times around a circuit, based on pre-set lap-times. I can change certain variables on the car such as power output, aerodynamics, tyres, engine efficiency and so-on. These changes are based on a point system.

I am capped at 150 points, so my requirement is to try and produce the fastest lap-times with said budget of 150 points.

Within the report, I will be going over the variables changed, what the cost was, and what combinations of variables gave the fastest lap times out of 3 setups made. The idea is to create a setup that can be ran throughout a season, with consistent lap-times, regardless of whether the circuit at hand is better suited for a cornering-optimised setup, or a setup based on achieving straight-line speed.

The base lap-times and the setups made are for a prototype vehicle and are all specific to that vehicle, there are no other vehicles for this test.

I have chosen 3 circuits to assess at, which are as follows: Silverstone, Monaco, and Spa-Francorchamps.

Said circuits have varying layouts, with varying technicalities. Some, such as Spa-Francorchamps, favour long sweeping corners/straights, where optimised gearing/top-speed is favoured, yet Monaco heavily favours technical corners and would benefit more from aerodynamics and tyres rather than direct power.

2. Main Body

To start the test, I required some base lap-times, without any set-up changes, only what was given out the gate. 0 points spent, and some lap-times tested on my chosen circuits, and the results were as follows (in seconds).

Silverstone: 100.14 seconds

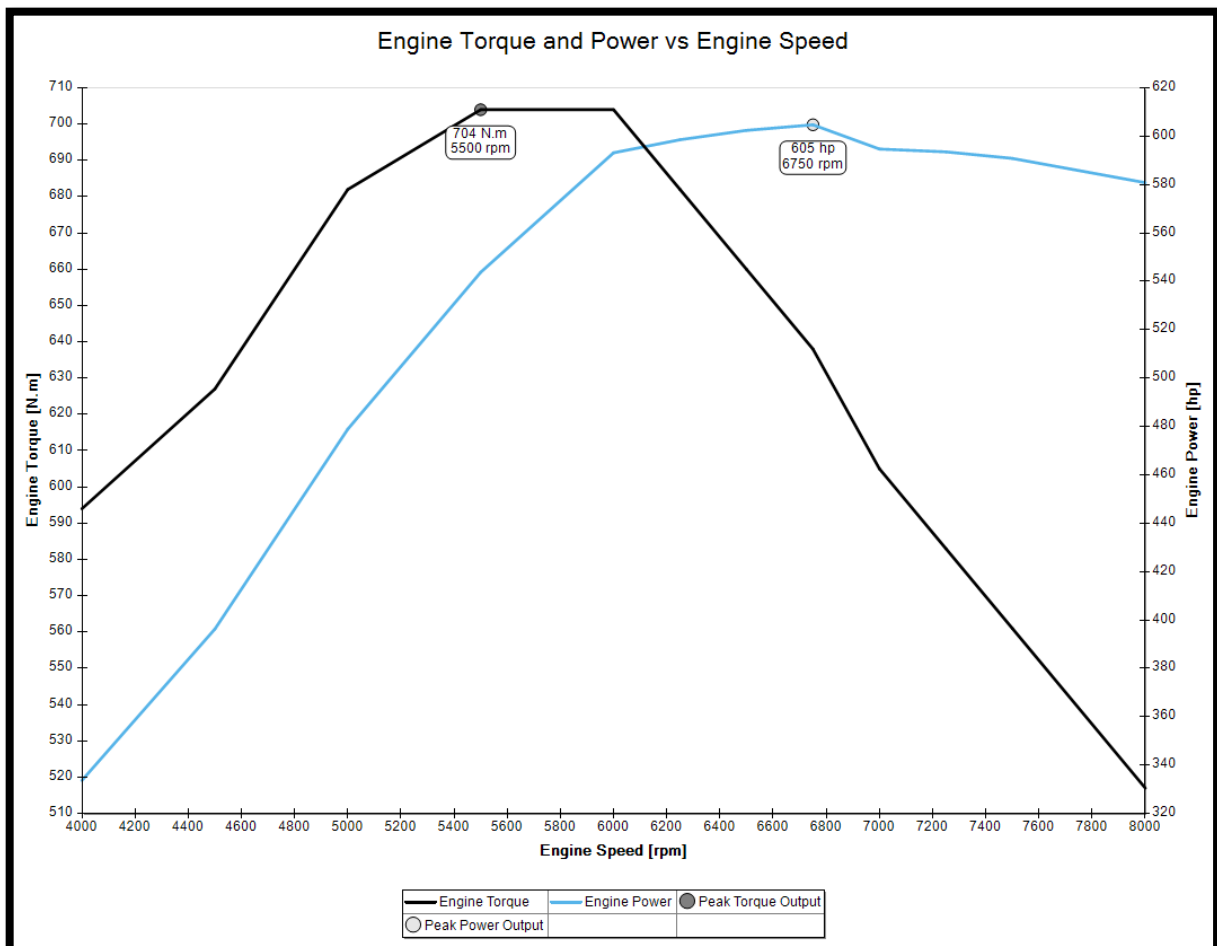
Spa-Francorchamps: 121.27 seconds

Monaco: 83.25 seconds

The car at this stage was as mentioned, completely standard.

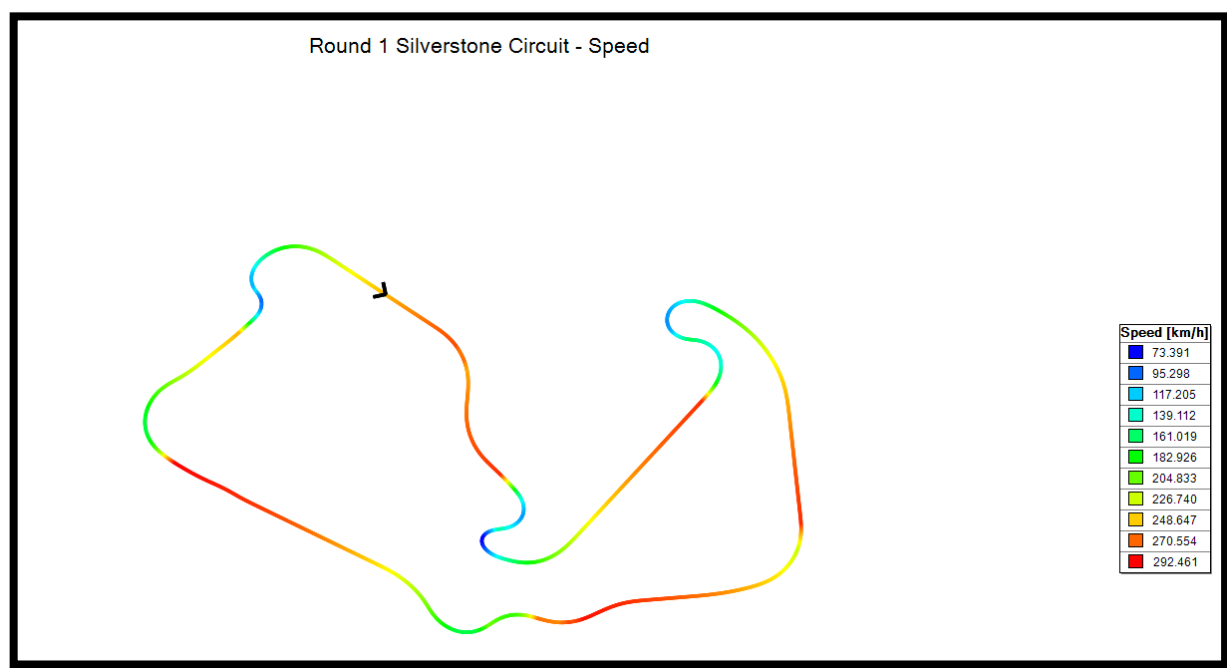
It came in at 975kg (kilograms), with a peak power output of 605hp (horsepower) @ 6750rpm (revolutions per minute), and a peak torque output of 704Nm (Newton-meters) @ 5500rpm.

The power graph is as shows here:



After taking my set of base-laps, I went and examined the speed in which was achieved on-track. Using Silverstone as a baseline for all laps felt appropriate, as I found it to be the happy-medium between technical cornering and straight-line speed.

The heatmap for speed achieved in different sections of the track can be seen here:



As the track shows, the red is where speed is maxed out, mainly towards the start of Sector 3, if I'm referring to Formula 1's sectoring system (formula1.com). This could mean I have more room to give in terms of top speed, so on my newfound setup, I went for the fastest possible map, Map E, which gives a 20% Power Factor percentage increase.

In addition to the fastest possible map for the engine, I also changed the aerodynamics, despite having further tiers, to hold points back for other upgrades, I found the Aerodynamic Map D was the appropriate choice, based on it being a happy medium of the two values to be changed.

Aerodynamic Map A consists of a drag coefficient of 0.51 and a downforce coefficient of 1.6, whereas Map F, the maximum, consists of a drag coefficient of 0.52 and a downforce coefficient of 2.05, at a cost of 50pts.

I felt that Map D was the medium, with a drag coefficient of 0.58, and a downforce coefficient 2.2, hence my selection.

I also needed to adjust the tyre setup, to which again, I went with the best possible tyres I could choose, which was Map E, which takes the longitudinal friction multiplier from 1.8 to 1.85, and the latitudinal friction multiplier from 1.8 to 1.85.

At this stage, I wasn't aware that this was already close to being the fastest setup I could've had.

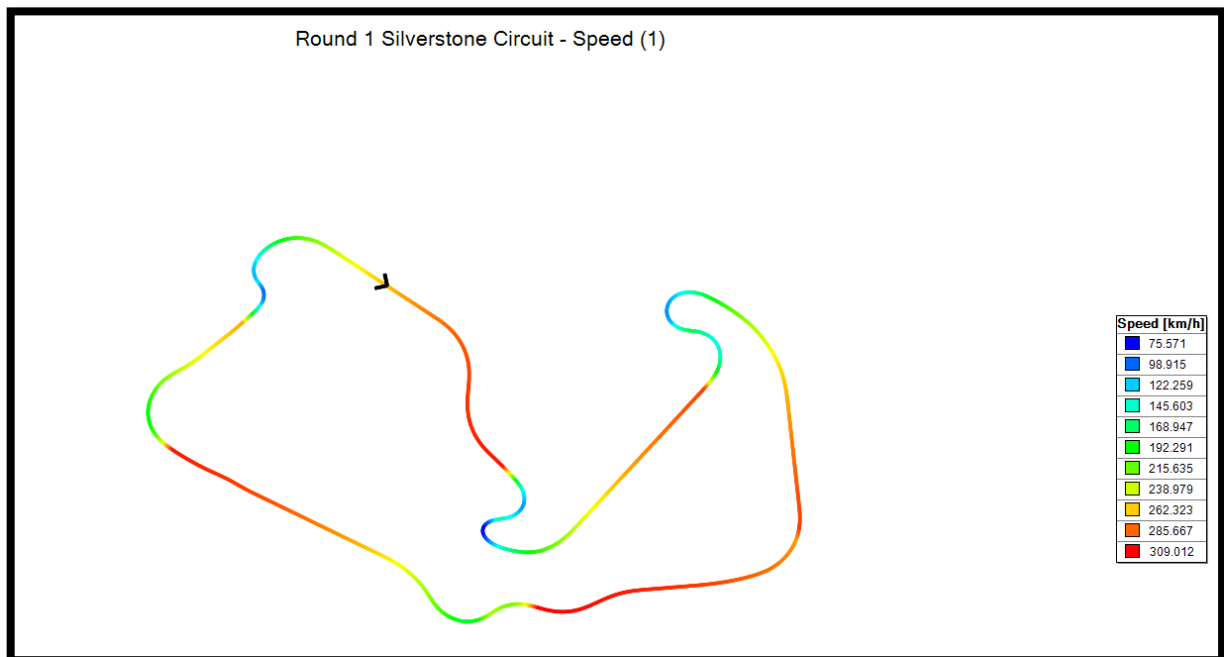
With this setup, I achieved the following lap-times:

Silverstone: 93.61 seconds

Spa-Francorchamps: 113.64 seconds

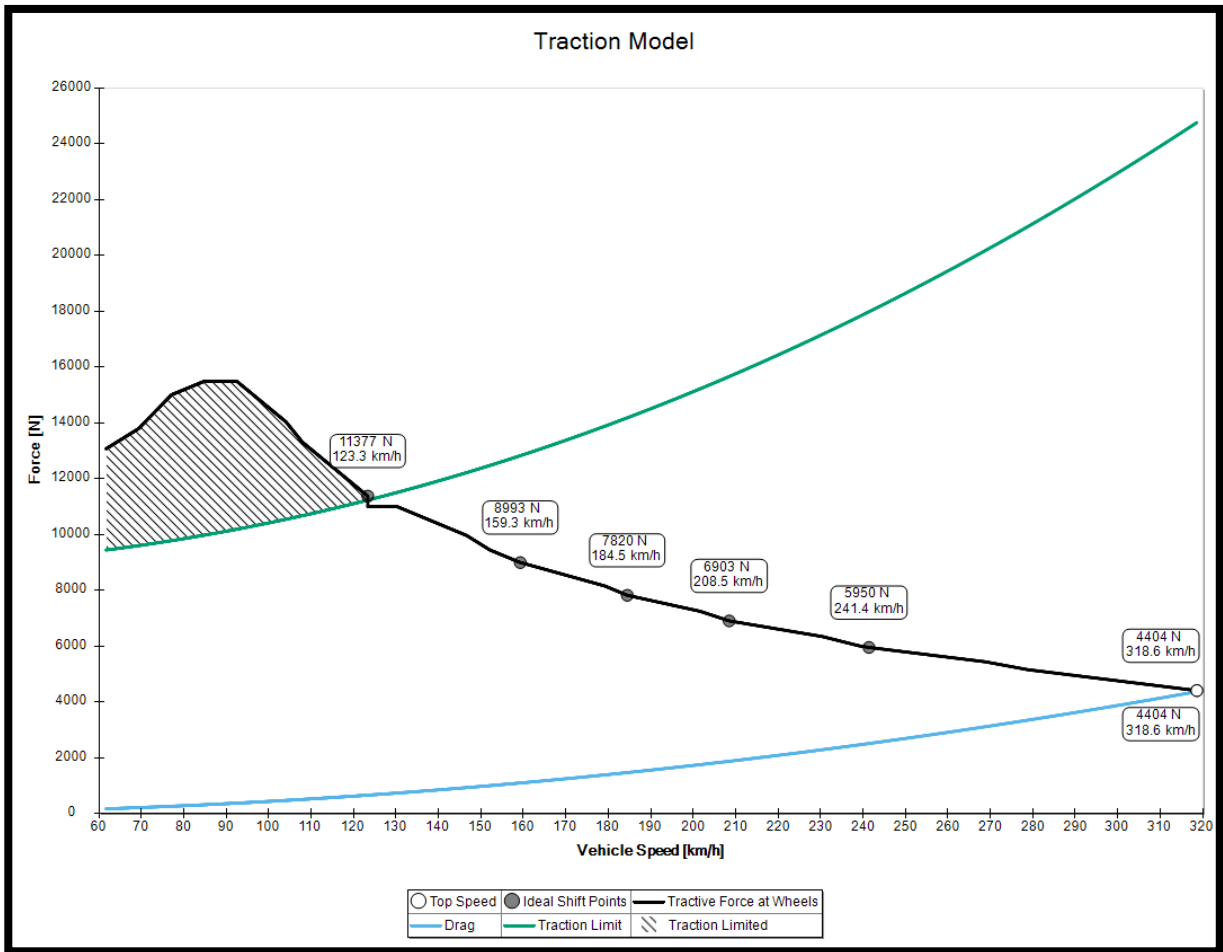
Monaco: 79.59 seconds

Going back to Silverstone's speed heatmap, I went to see where differences were made and to examine in further detail what changes I could've made to the car.



Looking at the graph with all previous changes made, I could see the top speed has made an increase (refer to graph's key off to the right hand side, where the max now is 309.012kmh, whereas before was 292.461kmh.)

Now, the objective was to see where I could've squeezed time out of the car. I already had the best tyre and engine setup, alongside a solid aerodynamic setup, so I went over to check the traction model graph.



Upon inspecting the Traction Model graph, I could see that I am at the limit as far as top speed goes, however I wasn't achieving it at Silverstone, could I have been achieving it elsewhere?

With that question now being asked, I checked the Speed heatmaps of the other 2 circuits, as, if I could now reduce the unused top-speed of 6th, and lower the aero ever so slightly, I could be in means of saving some time.

I started off by reviewing Monaco's heatmap.

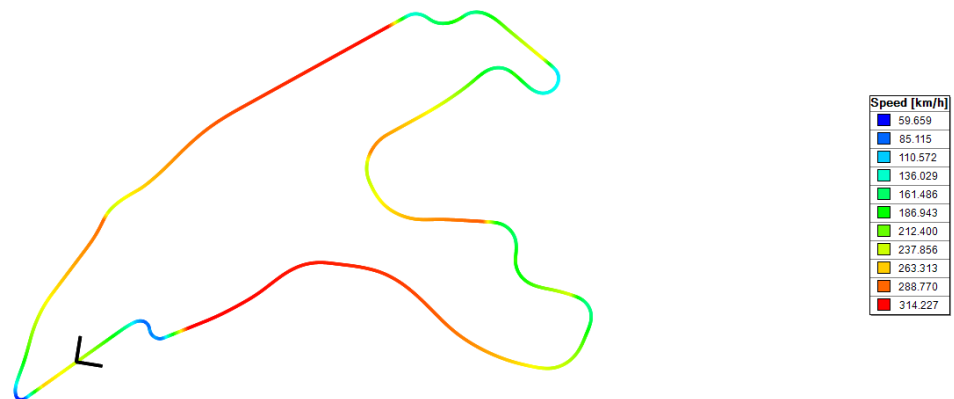
Round 2 Monaco - Speed (1)



When examining the heatmap for Monaco, I can see that the top speed achieved is a hair over 278kmh.

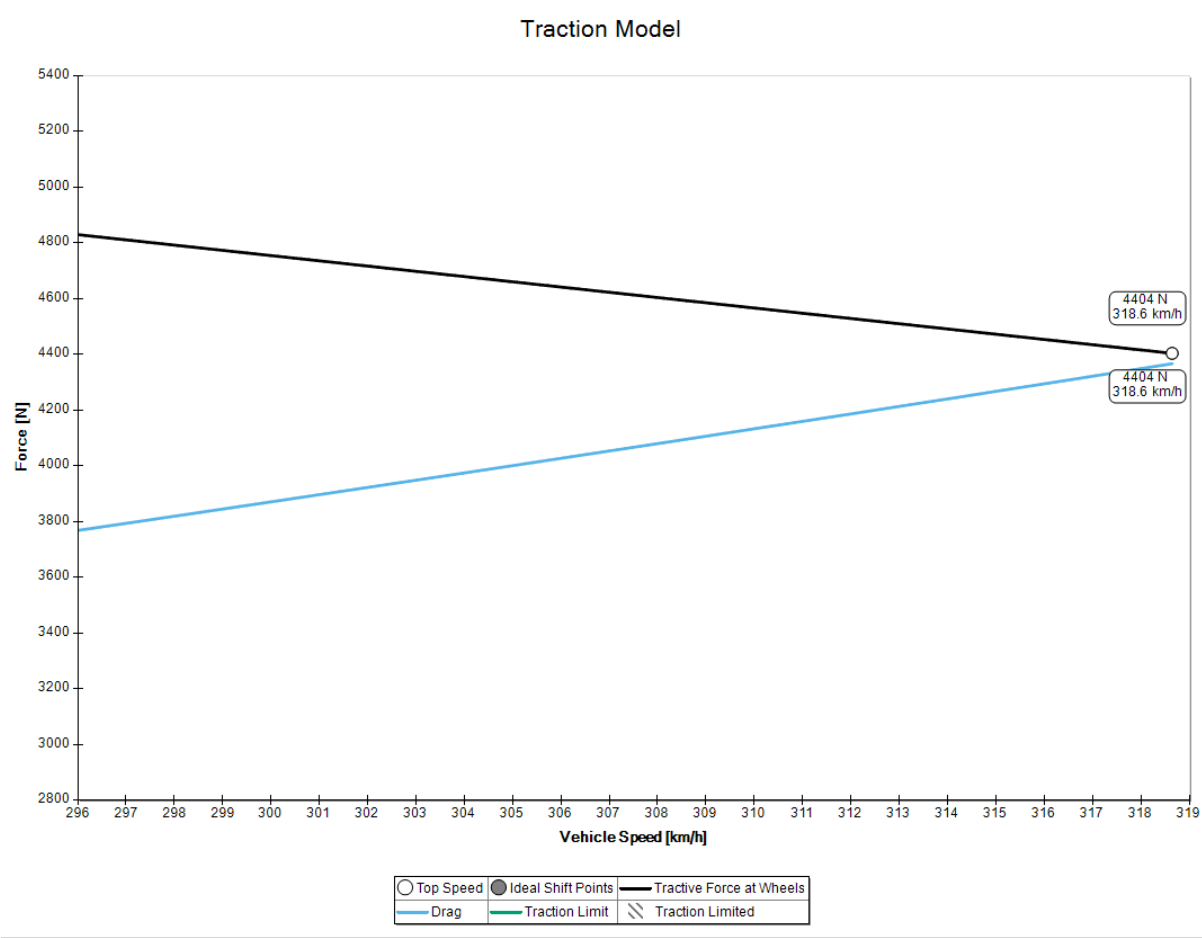
Onto Spa's heatmap...

Round 3 Spa-Francorchamps - Speed (2)



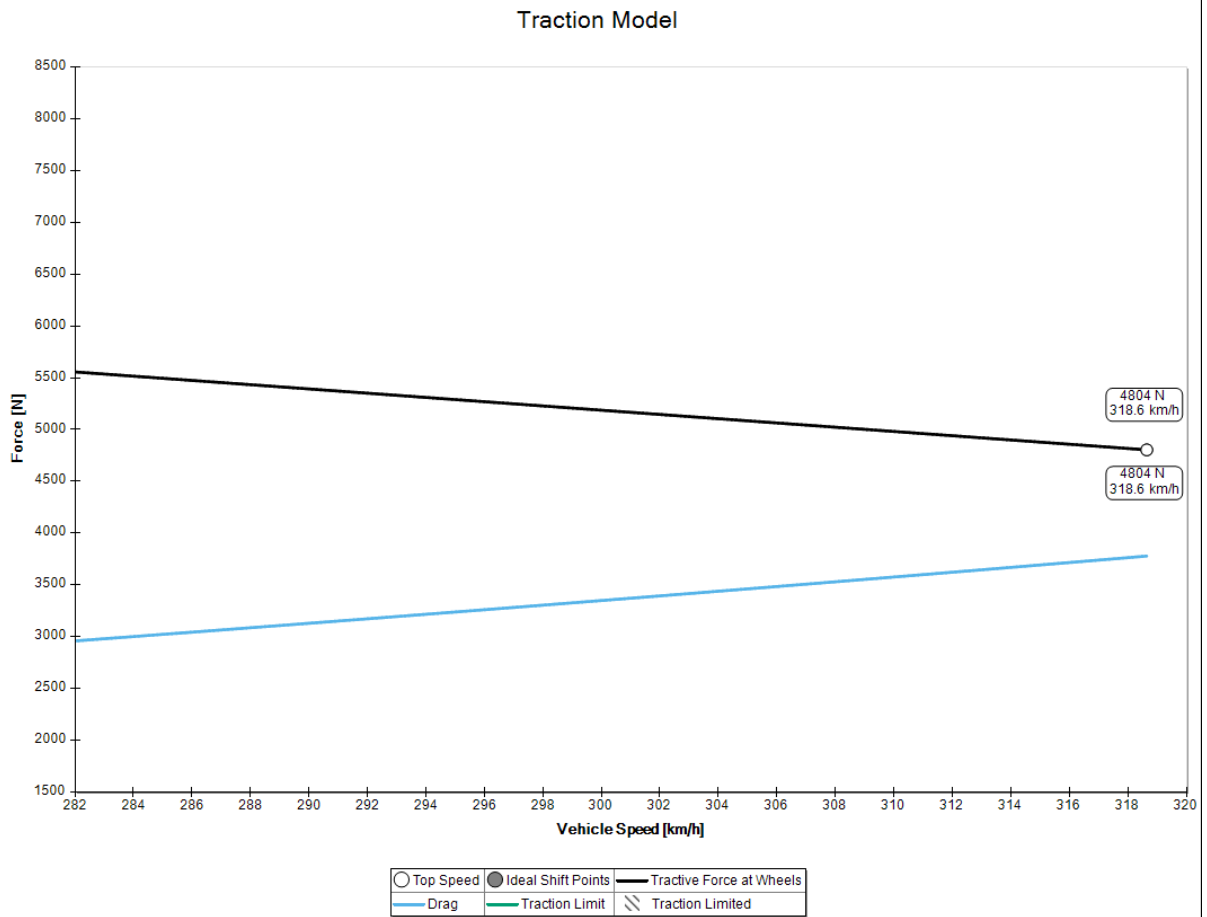
It seems as if at Spa, I'm maxing out at a smidge above 314kmh, which now comparing our top speeds seen, I've only really got about 2kmh of wiggle room between our highest speed achieved on track, and what the maximum our gearing will give.

I proceeded to take a look at the Traction model graph in further detail, to see where I was limited by drag.

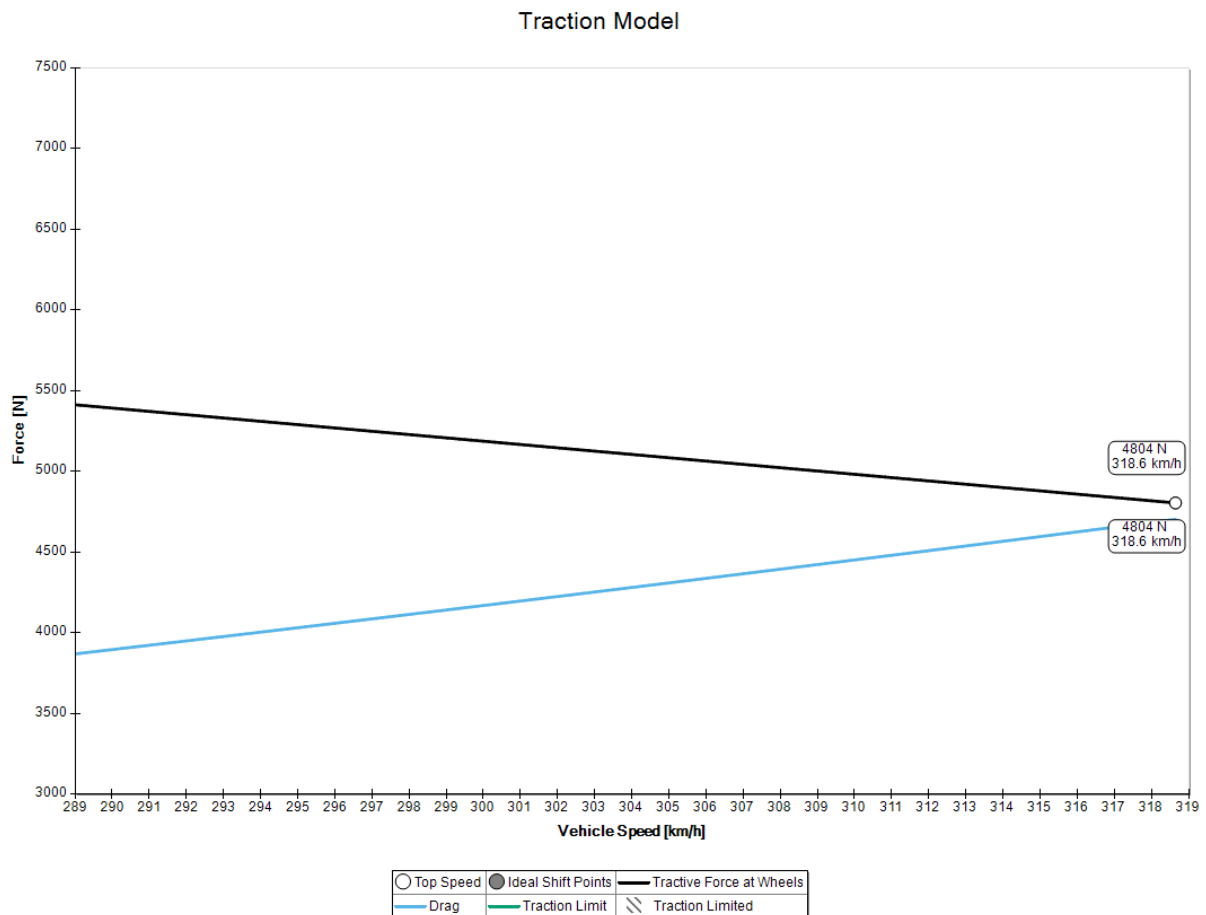


It appears I wasn't yet limited by drag, which means I can run some more tests by knocking the aero map back from Map D, to Map C, in hopes of securing some extra budget, and in hopes that I don't get limited before Spa's 314kmh top-speed.

Just as I had hoped for, I hadn't been limited by drag yet, let's knock it back another map, down to map B.



Now at Map B, here's what I'm looking at in terms of our top speed being limited by drag.



I then had 20 points to play with, in hopes of compensating for the decrease in aerodynamic performance, I spent those points on reducing the weight from 975kg to 955kg, and proceeded to run some laps.

Here is the outcome of such testing:

Silverstone – 94.09 seconds

Spa – 114.49 seconds

Monaco – 80.11 seconds

After testing, I've not made any improvement, instead of spending the 20 points on saving weight, I decided to increase drive efficiency at the cost of 15 points, which took me from 90% efficiency, to 92%.

Here is the outcome of such testing:

Silverstone – 94.17 seconds

Spa – 114.61 seconds

Monaco – 80.19 seconds

Seems as if I've again, not made an improvement, so I'm going to revert back to the original testing, and check the gearing.

After tampering with the gearing, I changed them to as follows:

Gear 1 – 3.1:1 > 2.4:1

Gear 2 – 2.2:1 > 2:1

Gear 3 – 1.8:1 > 1.7:1

Gear 4 – 1.6:1 > 1.5:1

Gear 5 – 1.4:1 > 1.3:1

Gear 6 – 1.2:1 (stays the same)

I then proceeded to run tests, which came out to the following:

Silverstone – 93.60 seconds

Spa – 113.76 seconds

Monaco – 79.83 seconds

These tests show that I am losing time on Monaco and Spa, so I reverted to the selected gearing.

At this stage, my setup was the same as it was off the get-go.

For the engine, I selected Map E, for the tyres, Tyres E, for the Aerodynamics, Map D.

Those selected changes proved to be the fastest over my course of testing.

3. Conclusion

When all is said and done, the data shows that my adjustments have made a substantial difference to on-track performance.

At Silverstone, I had a reduction from a 100.14 second lap-time, down to a 93.61 second lap-time. I saved a total of 6.53 seconds.

At Spa-Francorchamps, I went from a 121.27 second lap-time to a 113.64 second lap-time.

The most substantial decrease, of 7.63 seconds.

At Monaco, I managed to reduce the time from an 83.25 second lap-time, to a 79.59 second lap-time.

The smallest decrease, at 3.66 seconds shaven.

When comparing Spa's decrease, and the likes of Monaco's decrease in lap-time, I simply put that down to the differences of the two. Spa favours straights, yet Monaco favours corners.

Monaco is also a much faster track to complete a lap-time in, so to see the differences in a more comparable format, I calculated the differences in a percentage.

At Monaco, I had a 4.3964% decrease in lap-time. At Spa, I had a 6.29175% decrease. At Silverstone, I had a 6.52087% decrease.

This shows that setting up vehicles in an "across the board" way can be beneficial, however different tracks have different requirements, for example, Monaco favouring cornering over Spa favouring straights but with both having lap-time decreases regardless. It shows that in the end, the car would benefit more with a per-track change, over a general change.

4. References

Formula1.com – British Grand Prix – F1 Race – Silverstone Circuit

Available at: <https://www.formula1.com/en/information/great-britain-silverstone-circuit.2DtFVl1FjkYgLVdGhbAlv0>

(Accessed: 14th November 2025).