Semester Championship Documentation

Vehicle Mechanics Fundamentals

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1. General

1.1. My goal

First, let me explain the strategy chosen. I have decided that I don't want to tune the car for a specific type of track and win those races, but I want to achieve an average best setting for all tracks. Thus, when optimizing the car, I always aimed to minimize the total lap time for all tracks.

1.2. Tools

I have recorded the actual parameters and costs in tabular form to keep track of the results. Including simulated lap times, improvement rates, total lap times, total improvement, and deviation of improvements for each track. The table contains brief information on changes, conclusions, and decisions for the current setting. In the first phase of setting up the car, I used only this to narrow down the range of settings to those that were probably optimal.

1.3. Development stages

In the first phase, I wanted to find an initial setup where all costs are used for one component. From this setting, I can think backwards to develop the setting further. In the next phase, I have logically combined the parameters in proportion to the improvements in the initial settings, further narrowing the range of possible good settings. Once I had narrowed down the possible settings and got an idea of the impact of the parameters, in the third phase I used the corresponding Optimum Lap diagrams to investigate the effects of the changes, make decisions and find the best setting.

1.4. Development cost table

Development cost table		Step		Cost	Default
		step unit	dimension	$/step	value
Tire Data					
	Longitudinal Friction	0.005	-	10.00 M	2.100
	Lateral Friction	0.005	-	20.00 M	1.950
Aero Data					
	Aero Efficiency	0.010	-	5.00 M	2.000
Scaling factors					
	Power factor	0.100	%	1.18 M	100.000
General					
	Weight	0.500	kg	1.20 M	743.000
The available budget for the team is			100.00 M		

2. First development stage

0	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.0000	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
0.00 s	Power factor	0	100.000	0.00 M	87.48 s	91.39 s	76.59 s	71.37 s	68.18 s	69.39 s	83.59 s	81.02 s	72.85 s	101.38 s	64.16 s	86.09 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
953.49 s			**sum**	**0.00 M**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**update**
			remaining	**100.00 M**													
	This is the base car.				All of the budget is remaining to be spent.						Spending the whole budget on one factor, and then working backwards from there. Have to find which aspect to max out.						**comment**

1	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.4167	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-11.10 s	**Power factor**	84	**108.400**	99.12 M	86.48 s	90.46 s	75.87 s	71.38 s	67.21 s	68.55 s	82.22 s	80.09 s	72.25 s	99.68 s	63.30 s	84.90 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
942.39 s			**sum**	**99.12 M**	-1.00 s	-0.93 s	-0.72 s	0.01 s	-0.97 s	-0.84 s	-1.37 s	-0.93 s	-0.60 s	-1.70 s	-0.86 s	-1.19 s	**update**
			remaining	**0.88 M**													
	Increasing the engine power to the maximum to get initial setup.				Performs better on almost every track.						For now, this is the best initial setup to work backwards from.						**comment**

2	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.2353	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-10.35 s	Power factor	0	**100.000**	0.00 M	86.53 s	90.33 s	75.71 s	71.07 s	67.55 s	68.72 s	82.74 s	79.99 s	71.84 s	100.42 s	63.32 s	84.92 s	**laptime**
Σ laptime	**Weight**	83	**701.500**	99.60 M													
943.14 s			**sum**	**99.60 M**	-0.95 s	-1.06 s	-0.88 s	-0.30 s	-0.63 s	-0.67 s	-0.85 s	-1.03 s	-1.01 s	-0.96 s	-0.84 s	-1.17 s	**update**
			remaining	**0.40 M**													
	Decreasing the weight to the minimum to get initial setup.				Maximizing engine power performs better overall.						Not changing the initial setup to this.						**comment**

3	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.4165	Lateral Friction	0	1.950	0.00 M													
Aero Efficiency	**Aero Efficiency**	20	**2.200**	100.00 M													
Σ update	Power factor	0	100.000	0.00 M	86.51 s	90.44 s	75.79 s	71.35 s	67.23 s	68.60 s	82.17 s	80.13 s	72.21 s	99.65 s	63.38 s	84.93 s	**laptime**
-11.10 s	Weight	0	**743.000**	0.00 M													
Σ laptime			sum	100.00 M	-0.97 s	-0.95 s	-0.80 s	-0.02 s	-0.95 s	-0.79 s	-1.42 s	-0.89 s	-0.64 s	-1.73 s	-0.78 s	-1.16 s	**update**
942.39 s			remaining	0.00 M													
	Increasing the aero efficiency to the maximum to get initial setup.				Overall it performs the same as maximizing the engine power, but the devation of the updates per track is smaller.						Even though the deviation is smaller not changing the initial setup to this, as engine power is more understandable from the get go.						**comment**

4	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.1355	**Lateral Friction**	5	**1.975**	100.00 M													
Σ update	Aero Efficiency	0	**2.000**	0.00 M													
-4.59 s	Power factor	0	100.000	0.00 M	87.13 s	90.85 s	76.14 s	71.32 s	67.91 s	69.09 s	83.21 s	80.54 s	72.36 s	100.95 s	63.82 s	85.58 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
948.90 s			sum	100.00 M	-0.35 s	-0.54 s	-0.45 s	-0.05 s	-0.27 s	-0.30 s	-0.38 s	-0.48 s	-0.49 s	-0.43 s	-0.34 s	-0.51 s	**update**
			remaining	0.00 M													
	Increasing the lateral friction to the maximum to get initial setup.				Performs worse than the above 3 factors.						Not changing the initial setup to this.						**comment**

5	Development	Step	Value	Cost	Track												
deviation	**Longitudinal Friction**	10	**2.150**	100.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.0779	Lateral Friction	0	**1.950**	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-2.22 s	Power factor	0	100.000	0.00 M	87.23 s	91.12 s	76.34 s	71.40 s	67.98 s	69.19 s	83.43 s	80.82 s	72.63 s	101.19 s	64.02 s	85.92 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
951.27 s			sum	100.00 M	-0.25 s	-0.27 s	-0.25 s	0.03 s	-0.20 s	-0.20 s	-0.16 s	-0.20 s	-0.22 s	-0.19 s	-0.14 s	-0.17 s	**update**
			remaining	0.00 M													
	Increasing the longitudinal friction to the maximum to get initial setup.				Performs way worse than the every other factor.						Not changing the initial setup to this.						**comment**

3. Second development stage

0	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.0000	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
0.00 s	Power factor	0	100.000	0.00 M	87.48 s	91.39 s	76.59 s	71.37 s	68.18 s	69.39 s	83.59 s	81.02 s	72.85 s	101.38 s	64.16 s	86.09 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
953.49 s			**sum**	**0.00 M**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**update**
			remaining	**100.00 M**													
	This is the base car.				All of the budget is remaining to be spent.						Spending the whole budget on one factor, and then working backwards from there. Have to find which aspect to max out.						**comment**

1	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.4167	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-11.10 s	Power factor	84	**108.400**	99.12 M	86.48 s	90.46 s	75.87 s	71.38 s	67.21 s	68.55 s	82.22 s	80.09 s	72.25 s	99.68 s	63.30 s	84.90 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
942.39 s			**sum**	**99.12 M**	-1.00 s	-0.93 s	-0.72 s	0.01 s	-0.97 s	-0.84 s	-1.37 s	-0.93 s	-0.60 s	-1.70 s	-0.86 s	-1.19 s	**update**
			remaining	**0.88 M**													
	Increasing the engine power to the maximum to get initial setup.				Performs better on almost every track.						This will be the initial setup.						**comment**

2	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.0259	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	10	**2.100**	50.00 M													
-0.36 s	Power factor	42	**104.200**	49.56 M	86.47 s	90.42 s	75.80 s	71.35 s	67.19 s	68.55 s	82.16 s	80.08 s	72.20 s	99.62 s	63.31 s	84.88 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
942.03 s			**sum**	**99.56 M**	-0.01 s	-0.04 s	-0.07 s	-0.03 s	-0.02 s	0.00 s	-0.06 s	-0.01 s	-0.05 s	-0.06 s	0.01 s	-0.02 s	**update**
			remaining	**0.44 M**													
	When choosing the initial setup, the Aero Efficiency and Power Factor had a very similar performance increase. Spending half of the budget on one and the other.				Performs slightly better almost on every track.						This is a better result, keeping this iteration.						**comment**

3	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.1026	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	7	**2.070**	35.00 M													
0.21 s	Power factor	28	**102.800**	33.04 M	86.46 s	90.38 s	75.73 s	71.26 s	67.30 s	68.60 s	82.32 s	80.05 s	72.09 s	99.85 s	63.31 s	84.89 s	**laptime**
Σ laptime	Weight	26	**730.000**	31.20 M													
942.24 s			**sum**	**99.24 M**	-0.02 s	-0.08 s	-0.14 s	-0.12 s	0.09 s	0.05 s	0.10 s	-0.04 s	-0.16 s	0.17 s	0.01 s	-0.01 s	**update**
			remaining	**0.76 M**													
	Combining the three top performers of the initial setup change based on their performance increase.				Performs worse overall.						Not keeping this iteration.						**comment**

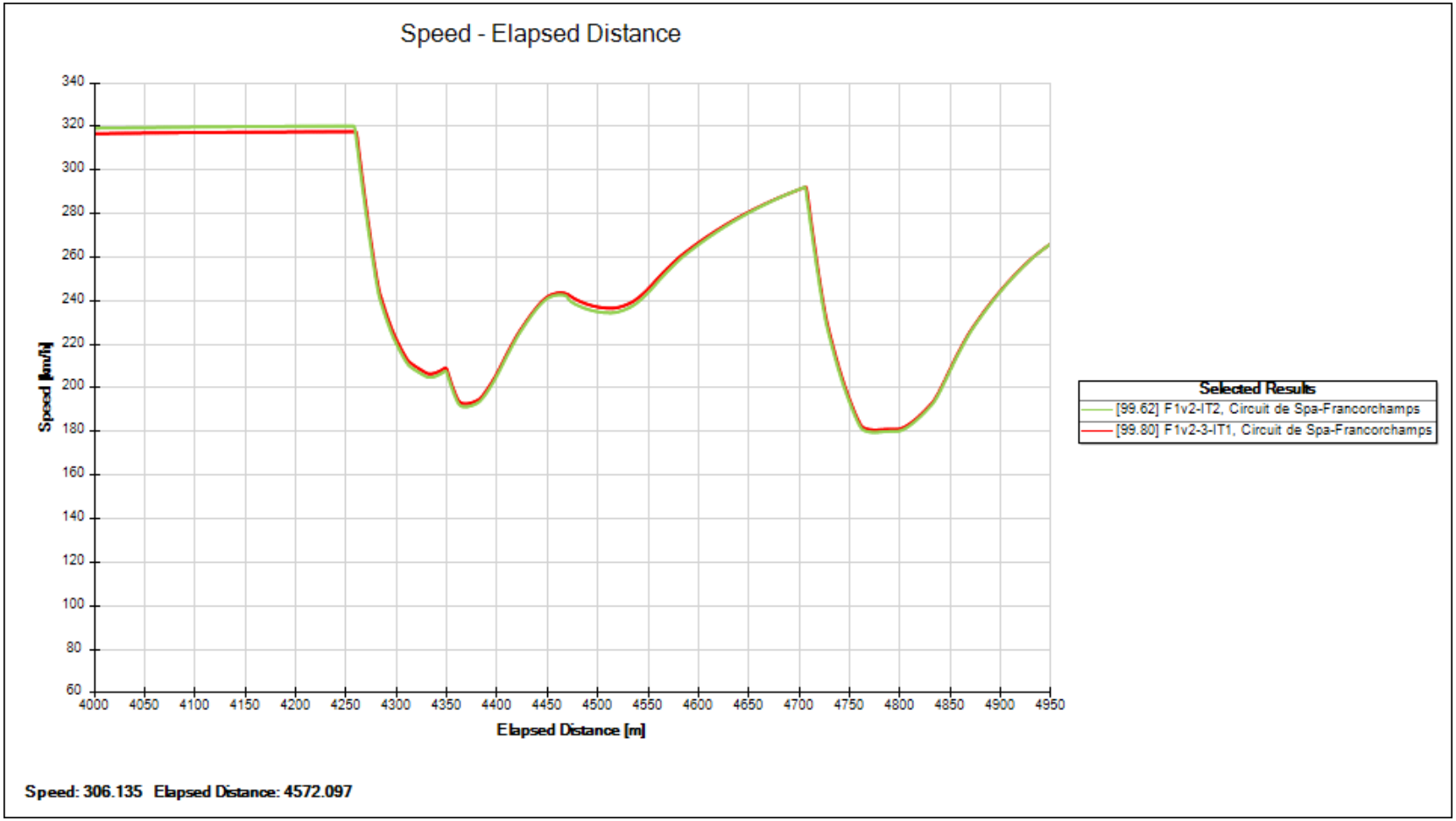
4	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	1	**2.105**	10.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.1868	Lateral Friction	1	**1.955**	20.00 M													
Σ update	Aero Efficiency	4	**2.040**	20.00 M													
2.31 s	Power factor	20	**102.000**	23.60 M	86.66 s	90.55 s	75.87 s	71.29 s	67.50 s	68.76 s	82.64 s	80.23 s	72.19 s	100.23 s	63.49 s	85.14 s	**laptime**
Σ laptime	Weight	22	**732.000**	26.40 M													
944.55 s			**sum**	**100.00 M**	0.18 s	0.09 s	0.00 s	-0.09 s	0.29 s	0.21 s	0.42 s	0.14 s	-0.06 s	0.55 s	0.19 s	0.24 s	**update**
			remaining	**0.00 M**													
	Combining all of the parameters of the initial setup change based on their performance increase.				Performs even worse then the previous iteration.						Changing the friction coefficients might not be a viable option. Very high cost, very low impact.						**comment**

4. Third development stage

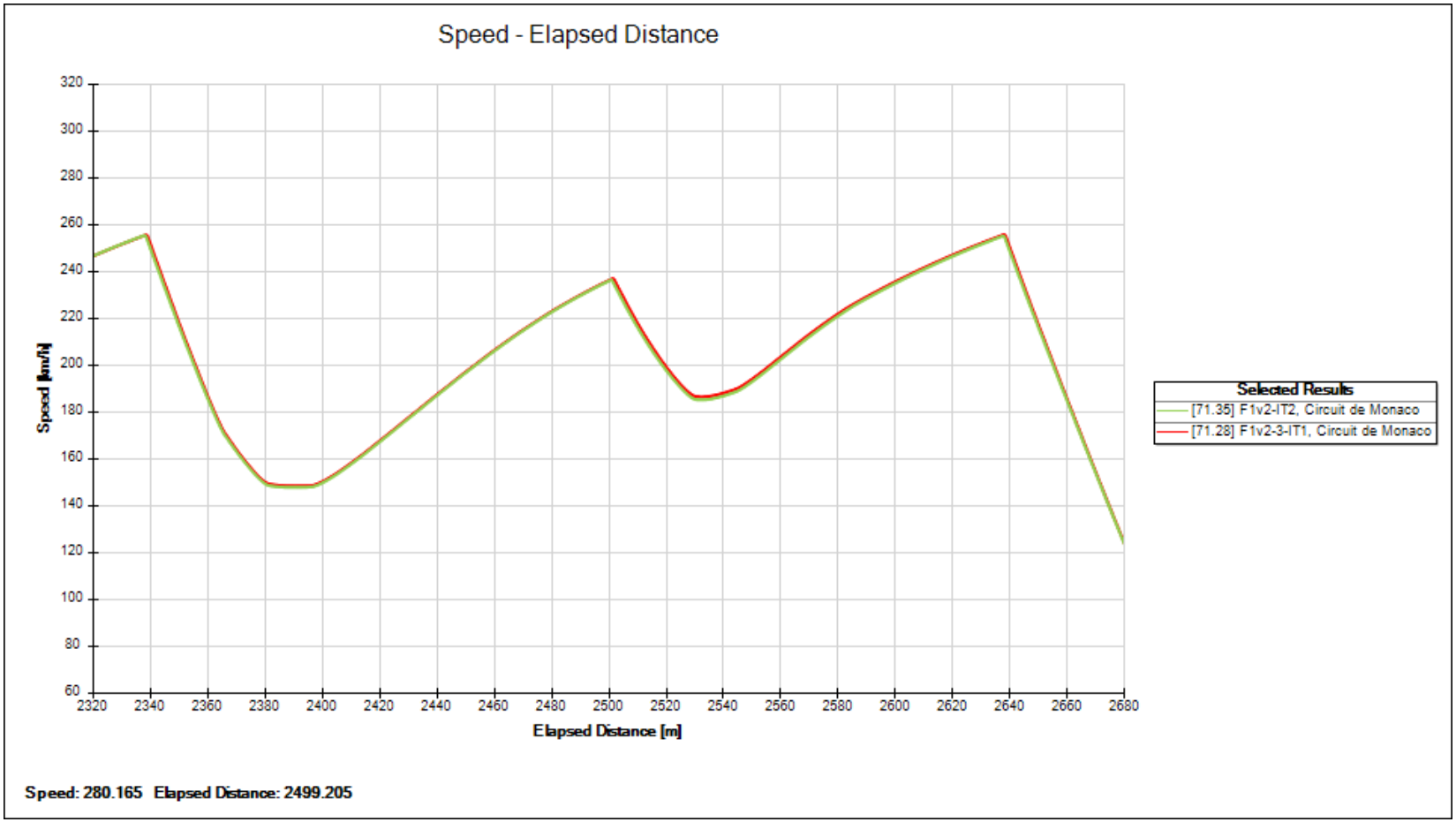
For this stage I choose two tracks to perform my analysis (Spa and Monaco). These two tracks were chosen based on the improvement percentage in lap times with the second stage setup. I choose the tracks with the biggest and the smallest improvements to carry out my analysis and to save time. These tracks have significantly different characteristics as well, so they will be perfect candidates to evaluate the setups. This means that in this stage of my development I will make decisions and visualize diagrams from these two tracks.

4.1. Iteration 1

This setup change caused the following behavior on Spa: the top speed of the car was slower, but the reduced weight allowed higher cornering speed in the simultaneous corners where top speed was not the limiting factor. The following snippet from the track demonstrates this effect.



In Monaco this is a favorable setup as it is a street circuit where corners dominate not top speed. The following shows us that the newer setup could achieve higher speeds in consecutive turns than the previous. Although this setup works for Monaco, overall, there are more tracks where the previous setup works better. It might be beneficial to reduce the top speed slightly and increase cornering speed, but with a less aggressive change in aero efficiency.



1	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing*	
0.0816	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	5	**2.050**	25.00 M													
0.12 s	Power factor	42	104.200	49.56 M	86.45 s	90.39 s	75.75 s	71.28 s	67.27 s	68.58 s	82.29 s	80.05 s	72.11 s	99.80 s	63.30 s	84.88 s	**laptime**
Σ laptime	Weight	21	**732.500**	25.20 M													
			sum	**99.76 M**	-0.02 s	-0.03 s	-0.05 s	-0.07 s	0.08 s	0.03 s	0.13 s	-0.03 s	-0.09 s	0.18 s	-0.01 s	0.00 s	**update**
942.15 s			**remaining**	**0.24 M**													
	For this iteration not changing the power factor, but halving the aero efficiency and spending the rest on weight.				Performs slightly worse than the previous setup.						Drawing conclusions, it might be a great comprimise but a bit too agressive change.						**comment**

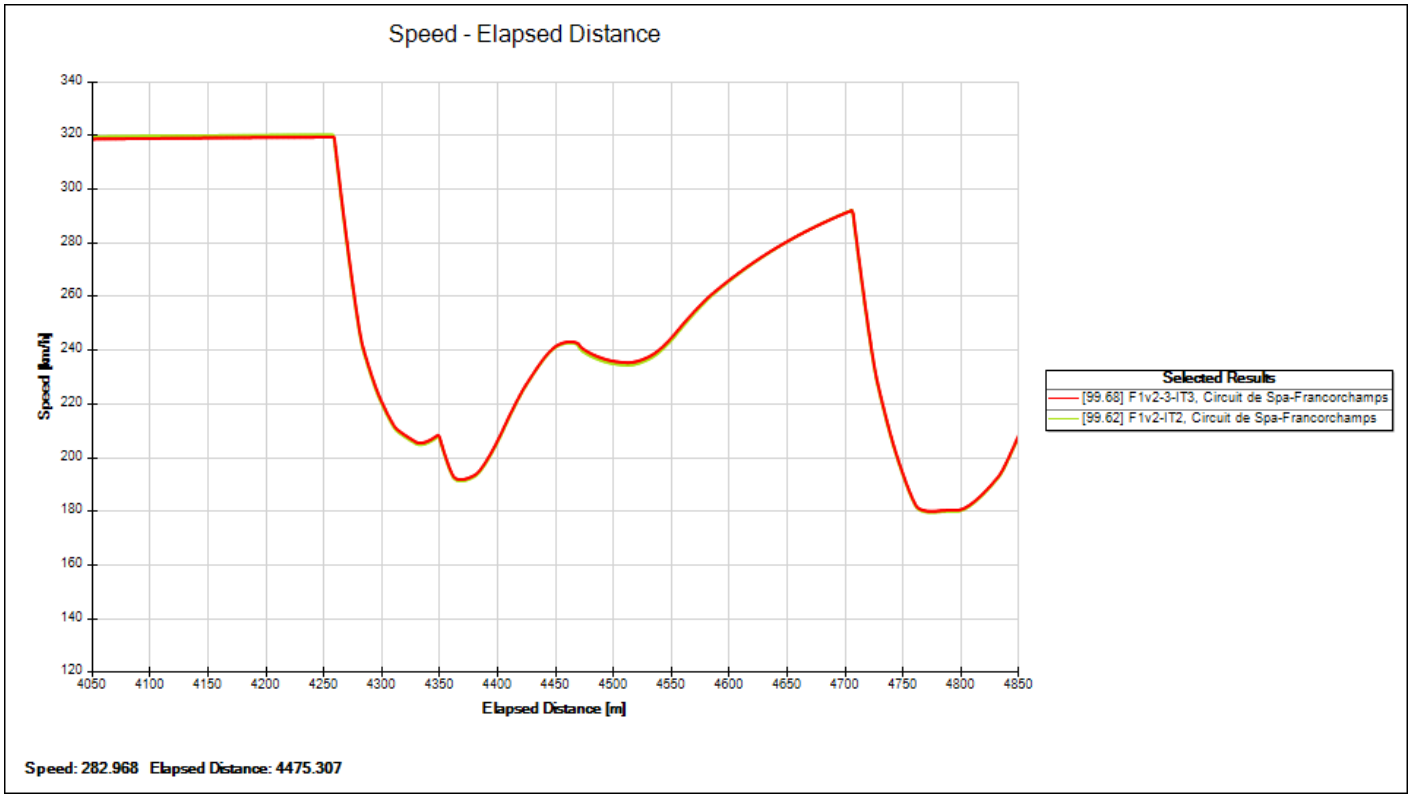
4.2. Iteration 2

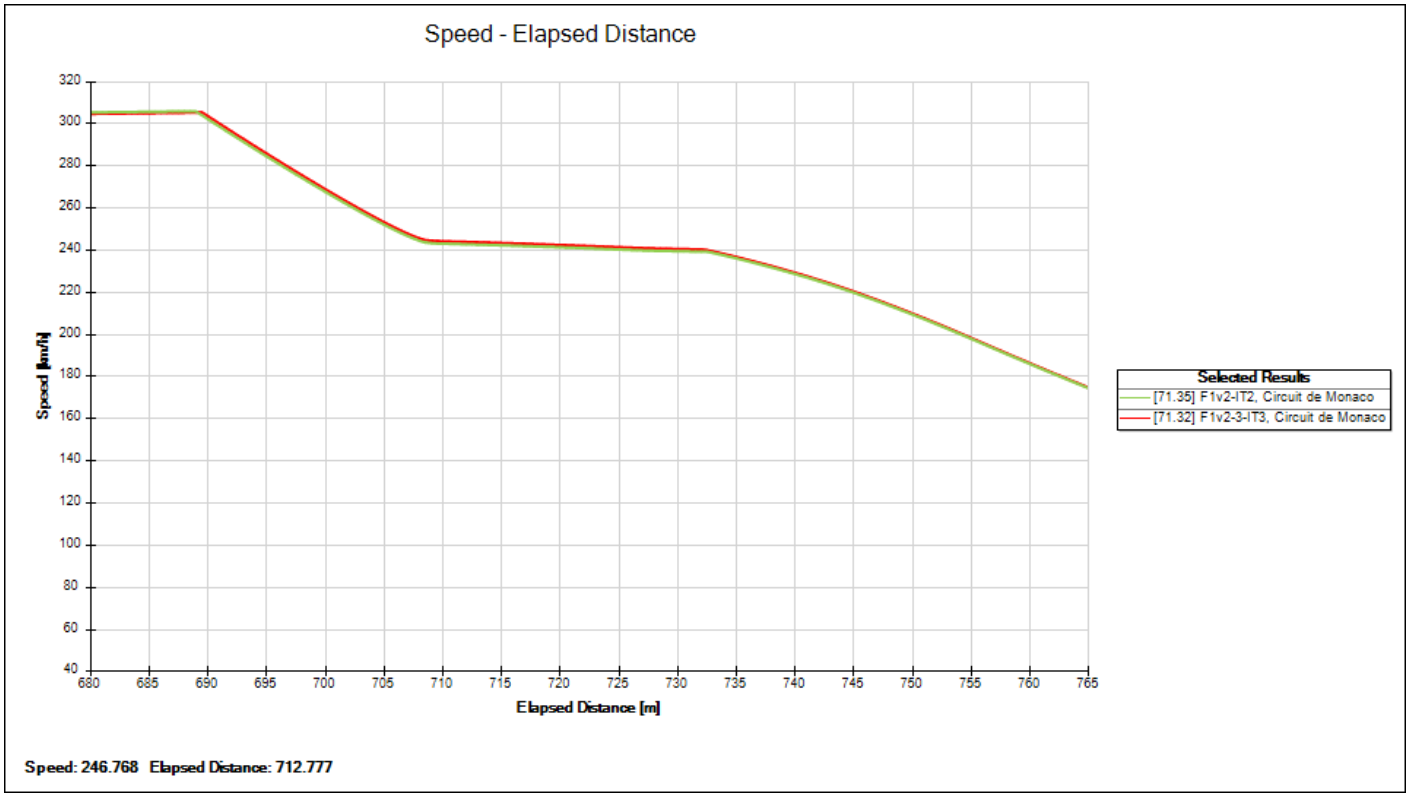
The above-mentioned change turned out to be not beneficial considering all tracks, it had less of a bad effect on the overall lap time, but it did not improve. The negative effect was halved compared to the previous iteration. The diagrams show the same behavior as the previous iteration, but the change is less visible as it is a less aggressive jump in parameters.

2	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	**2.100**	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing*	
0.0309	Lateral Friction	0	**1.950**	0.00 M													
Σ update	Aero Efficiency	8	**2.080**	40.00 M													
0.06 s	Power factor	42	**104.200**	49.56 M	86.46 s	90.41 s	75.78 s	71.32 s	67.22 s	68.56 s	82.21 s	80.08 s	72.17 s	99.69 s	63.31 s	84.88 s	**laptime**
Σ laptime	Weight	8	**739.000**	9.60 M													
			sum	**99.16 M**	-0.01 s	-0.01 s	-0.02 s	-0.03 s	0.03 s	0.01 s	0.05 s	0.00 s	-0.03 s	0.07 s	0.00 s	0.00 s	**update**
942.09 s			**remaining**	**0.84 M**													
	From previous setups I suspect that slightly reducing top speed and increasing cornering speed might be benefitial, changing according to this.				overall it is a slightly better setup as there are only 4 trakcs that require very high top speed						This turned out not to be beneficial even with a less agressive change. Not keeping this setup.						**comment**

4.3. Iteration 3

In the third iteration I reverted the aero efficiency to its second stage value and reduced the weight at the cost of the power factor. This resulted in the same overall lap time as the stage two setup, but it separated the performance on different tracks more. It might be beneficial to have a setup that works better on most of the tracks and performs slightly worse on the rest but overall, it stays relatively the same. This could mean that there is a higher probability to win races and fall behind on other only slightly. This resulted in improved lower speed performance while staying relatively at par on high-speed tracks like Spa, but in Monaco where top speed is less important it proves to be more consistent in low-speed areas thus performing better.


Speed - Elapsed Distance
340
320
300
280
260
240
220
200
180
160
140
120
Speed [km/h]
4050
4100
4150
4200
4250
4300
4350
4400
4450
4500
4550
4600
4650
4700
4750
4800
4850
Elapsed Distance [m]
Selected Results
[99.68] F1v2-3-IT3, Circuit de Spa-Francorchamps
[99.62] F1v2-IT2, Circuit de Spa-Francorchamps
Speed: 282.968 Elapsed Distance: 4475.307



3	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	**2.100**	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing*	
0.0305	Lateral Friction	0	**1.950**	0.00 M													
	Aero Efficiency	10	**2.100**	50.00 M													
Σ update	Power factor	34	**103.400**	40.12 M	86.46 s	90.40 s	75.77 s	71.32 s	67.22 s	68.56 s	82.20 s	80.07 s	72.16 s	99.68 s	63.31 s	84.88 s	**laptime**
0.00 s	Weight	8	**739.000**	9.60 M													
			sum	**99.72 M**	-0.01 s	-0.02 s	-0.03 s	-0.03 s	0.03 s	0.01 s	0.04 s	-0.01 s	-0.04 s	0.06 s	0.00 s	0.00 s	**update**
Σ laptime			**remaining**	**0.28 M**													
942.03 s	Reverting the aero efficiency parameter and reducing weight at the cost of lowering the power factor,				Overall this did not improve the laptime, but it separated the performance of the car on different characteristic trakcs.						It might be a great option to improve performance on a subset of tracks and slightly decrease on the others to win certain races. Keeping this setup.						**comment**

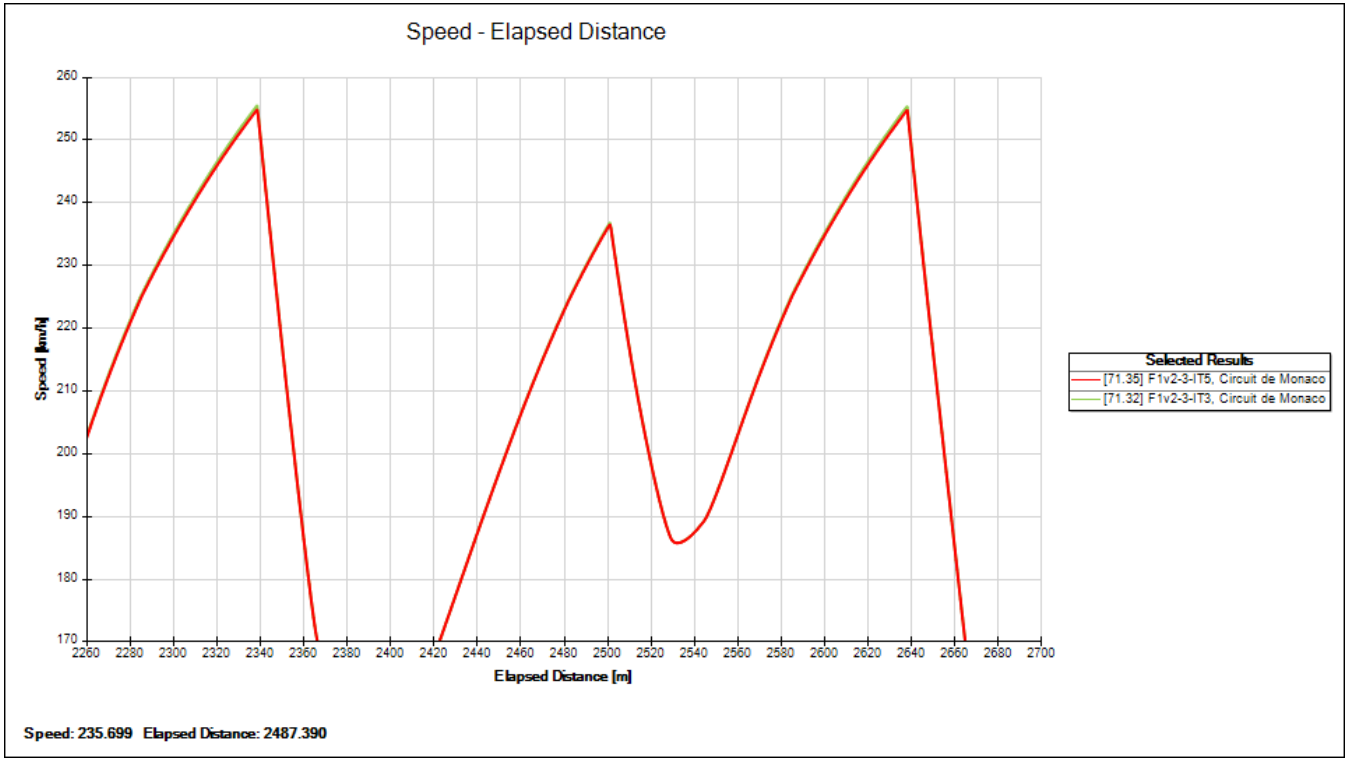
4.4. Iteration 4

I tried reducing the weight a bit more aggressively at the additional cost of losing power, to increase performance on the above selected good performing tracks and widen the gap between different types of tracks. This iteration did not work as I intended it. It did not really improve the performance on the tracks that I wanted it to, but also increased lap time on the other tracks.

4	Development	Step	Value	Cost	Track											
deviation	Longitudinal Friction	0	**2.100**	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing*	
0.0386	Lateral Friction	0	**1.950**	0.00 M													
	Aero Efficiency	10	**2.100**	50.00 M													
Σ update	Power factor	32	**103.200**	37.76 M	86.46 s	90.40 s	75.77 s	71.31 s	67.23 s	68.57 s	82.21 s	80.07 s	72.15 s	99.70 s	63.31 s	84.88 s	**laptime**
0.03 s	Weight	10	**738.000**	12.00 M													
			sum	**99.76 M**													
Σ laptime			**remaining**	**0.24 M**	-0.01 s	-0.02 s	-0.03 s	-0.04 s	0.04 s	0.02 s	0.05 s	-0.01 s	-0.05 s	0.08 s	0.00 s	0.00 s	**update**
942.06 s	Changing the parameters in this direction again, but introducing a bit more weight reduction than before.				Overall it reduced the performance and didn't widen the gap between the different types of tracks.							I will not keep this iteration as it does not achieve the goal I set for this iteration.					**comment**

4.5. Iteration 5

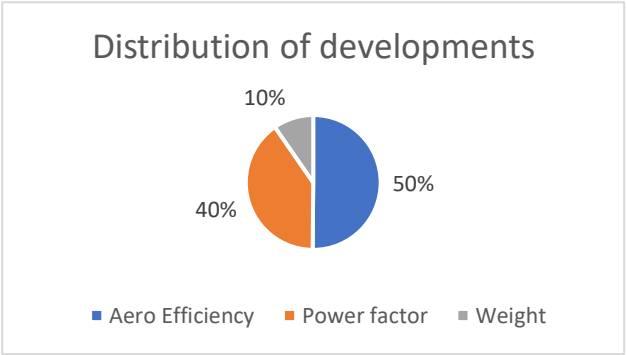
I tried increasing cornering speed by a different measure, with increasing the lateral friction coefficient. This is a very costly parameter, so I had to make a compromise in aero efficiency and power factor as well. This resulted in less top speed and the car did not have enough power even in the low-speed cornering sections of Monaco. As the car became power limited rather than being grip limited in almost all sections of the track.



5	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	**2.100**	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing*	
0.0788	Lateral Friction	1	**1.955**	20.00 M													
Σ update	Aero Efficiency	9	**2.090**	45.00 M													
1.55 s	Power factor	29	**102.900**	34.22 M	86.59 s	90.52 s	75.87 s	71.35 s	67.34 s	68.67 s	82.37 s	80.19 s	72.24 s	99.88 s	63.43 s	85.13 s	**laptime**
	Weight	0	**743.000**	0.00 M													
Σ laptime			**sum**	**99.22 M**													
			remaining	**0.78 M**	0.12 s	0.10 s	0.07 s	0.00 s	0.15 s	0.12 s	0.21 s	0.11 s	0.04 s	0.26 s	0.12 s	0.25 s	**update**
943.58 s	I want to increase cornering speed but keeping the top speed relatively the same, with changing the lateral friction. But its high cost makes the power factor and the aero efficiency a lot lower.				Performs way worse as the power factor had to be changed to a very low value compared to before.						This will not work because even if I lowered aero efficiency more and increased power factor then the top speed would be less as well.						**comment**

6. Decision

From my analysis I concluded that spending a big chunk of the budget on improving the friction coefficients is not beneficial. Coming from this I tried to achieve an optimal setup by only changing the other three parameters. My chosen setup spends 10 steps on Aero Efficiency as it is one of the most important factors in achieving high top speeds, 34 steps on power factor which is the second most important parameter and 8 steps on weight reduction to increase cornering speed, acceleration, and braking performance. There was another setup that had the same overall lap time, but I choose this in the end to have a setup that could potentially win some of the races and only fall behind on the other tracks only a little.



base	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing*	
0.0000	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
0.00 s	Power factor	0	100.000	0.00 M	87.48 s	91.39 s	76.59 s	71.37 s	68.18 s	69.39 s	83.59 s	81.02 s	72.85 s	101.38 s	64.16 s	86.09 s	**laptime**
	Weight	0	743.000	0.00 M													
Σ laptime			**sum**	**0.00 M**													
			remaining	**100.00 M**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**update**
953.49 s	This is the base car.				All of the budget is remaining to be spent.						Comparing my final setup to the base car.						**comment**

final	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing*	
0.3987	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	10	**2.100**	50.00 M													
-11.46 s	Power factor	34	**103.400**	40.12 M	86.46 s	90.40 s	75.77 s	71.32 s	67.22 s	68.56 s	82.20 s	80.07 s	72.16 s	99.68 s	63.31 s	84.88 s	**laptime**
	Weight	8	**739.000**	9.60 M													
Σ laptime			**sum**	**99.72 M**													
			remaining	**0.28 M**	-1.02 s	-0.99 s	-0.82 s	-0.05 s	-0.96 s	-0.83 s	-1.39 s	-0.95 s	-0.69 s	-1.70 s	-0.85 s	-1.21 s	**update**
942.03 s	Reverting the aero efficiency parameter and reducing weight at the cost of lowering the power factor.				Improves laptimes on all tracks, performs the best on high speed tracks like Spa.						This setup resulted in the overall lowest cumulated laptime and the highest deviation in improvements, while making improvements on all tracks.						**comment**