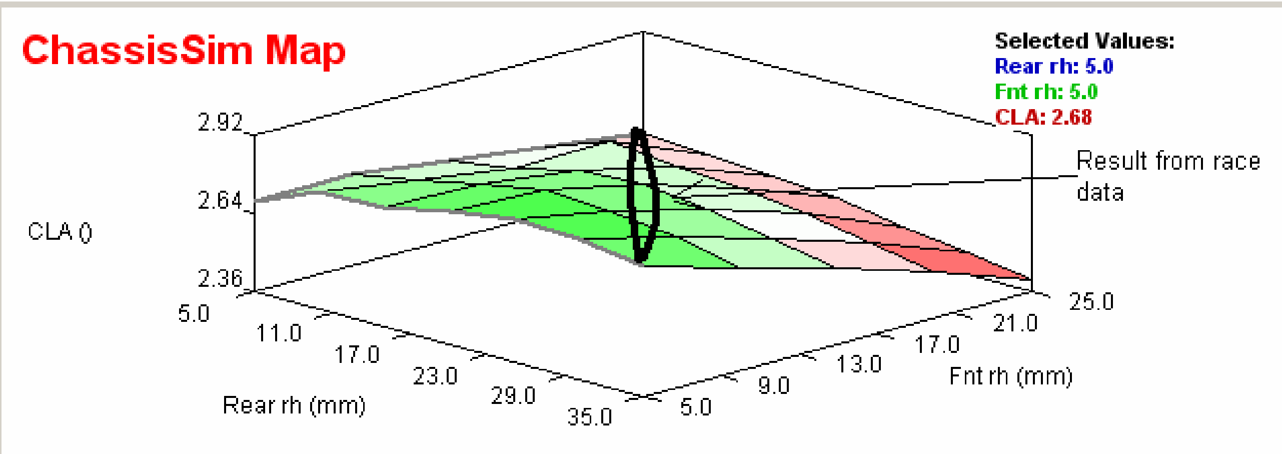
ChassisSim – Refining the model.

The purpose of this document is to show you how to use the ChassisSim toolboxes to refine the vehicle model and produce a battle ready vehicle model. To get the most out of this document please read the ChassisSim getting started guide, how to create a monster file, modelling in minutes and track creation guide. This will get the model to the point where we can refine the vehicle model.

This document will focus on how to use the ChassisSim aero toolbox and tyre force modelling toolboxes. These will become indispensible tools as you refine a vehicle model that can be used in practice.

Step 1 - Using the Aero toolbox

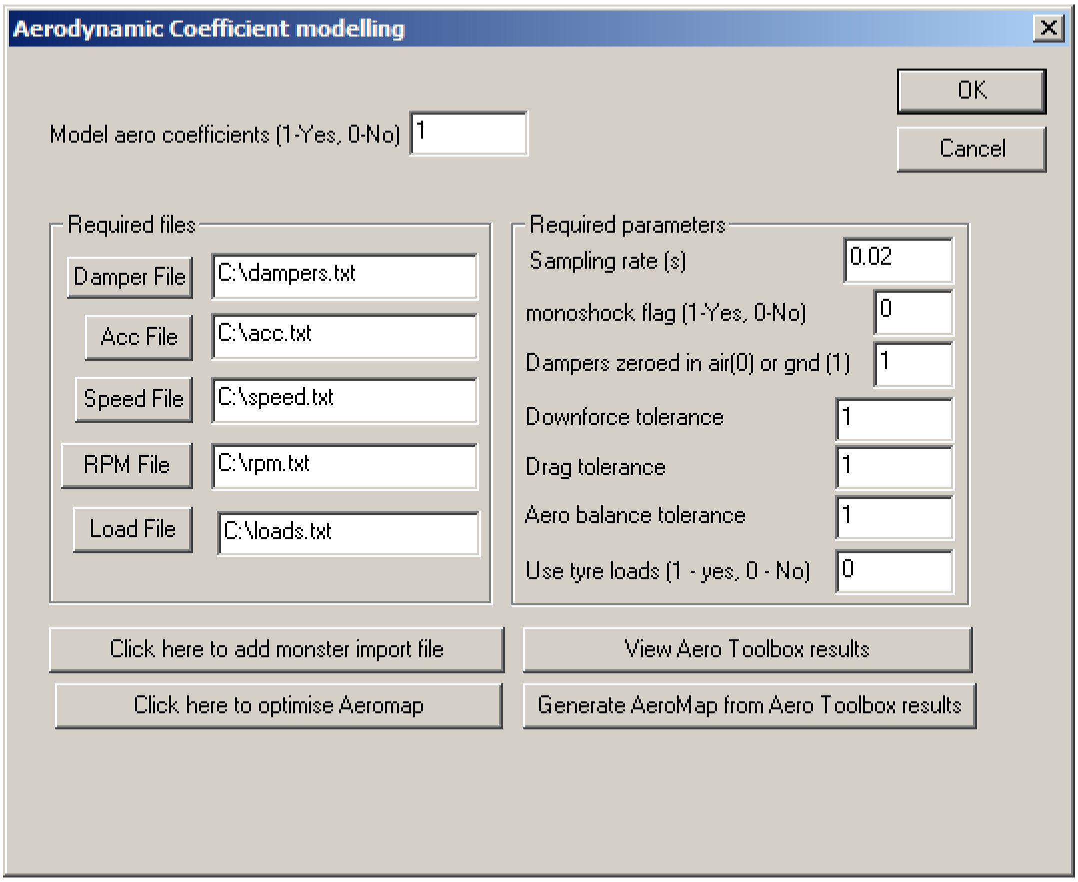
The Aero toolbox will help you reverse engineer the aeromap of the car. As the car is driven around the circuit it will return a thin sliver of the aeromap. This is illustrated below,



Unfortunately it is very difficult to determine the whole aeromap from this thin sliver. Mathematically it is very difficult. However if you put enough of these thin slivers together an aeromap can be generated. Fortunately with the ChassisSim aero toolbox you can do both.

The first step is to generate a thin sliver of the aeromap. To do this you need the monster file and you need to load the car file that represents the setup that the monster file came from. To access this what you need to do is Select Simulate->AeroModelling. This will bring up the following dialog.

ABN 3517 202 936 9
ChassisSim Technologies™
9 Harriet Street Marrickville
NSW 2204 Australia
Danny Nowlan, Director mobile: +61 425 219 375



Click on the tab that says import the monster import file. If it has loads click on the checkbox first and then import the monster file. Indicate if you want to use loads, indicate if the loads and dampers are zeroed on the ground, and click to 1 to model the aero coefficients.. Also if the car is a monoshock – but you are importing the monster file – ensure the monoshock flag is set to 0. Then click OK

This will return you to the ChassisSim main window. Click on the Start button and click on the start simulation tab. This will generate a file called aero_analysis_results.dat . This will be in the same directory as the car file. Its format will be,

Front ride height (m), Rear ride height (m) C_LA, C_DA, aero balance/100

This is an ascii file.

If you do this over a number of setups with the same wing configuration your now in a position to generate an aeromap. What you do is you get all the different aero_analysis_results.dat and combine them in a single file. You are now ready to generate an aeromap. The more of a spread of the ride height envelope you have the better the aeromap will be. To do this you have two options.

ABN 3517 202 936 9
ChassisSim Technologies™
9 Harriet Street Marrickville
NSW 2204 Australia
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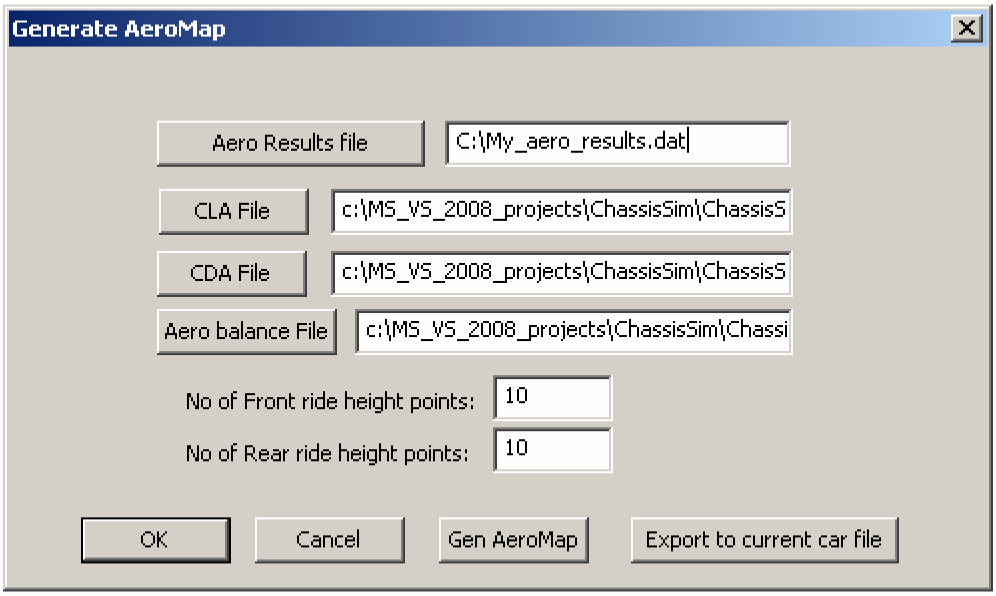
The first option is to click on the tab that says Generate AeroMap from Aero Toolbox results. This will bring up the following dialog,



You have the option to generate separate C_LA, C_DA and aero balance files for your inspection. This will show you the ride heights and the results. However you can't import these straight into the aeromaping dialog when you edit the aeromaps. These have been supplied for sanity checking. However you can export this straight to the current car file by clicking on the tab that says Export to current car. When you click on this will update the car file with all aspects of the generated aeromap.

The other option is to use the Aero surface optimisation feature. To activate click on the tab that says Click here to optimise Aeromap. This will display the following dialog overleaf.

ABN 3517 202 936 9
ChassisSimTechnologies™
9 Harriet Street Marrickville
NSW 2204 Australia
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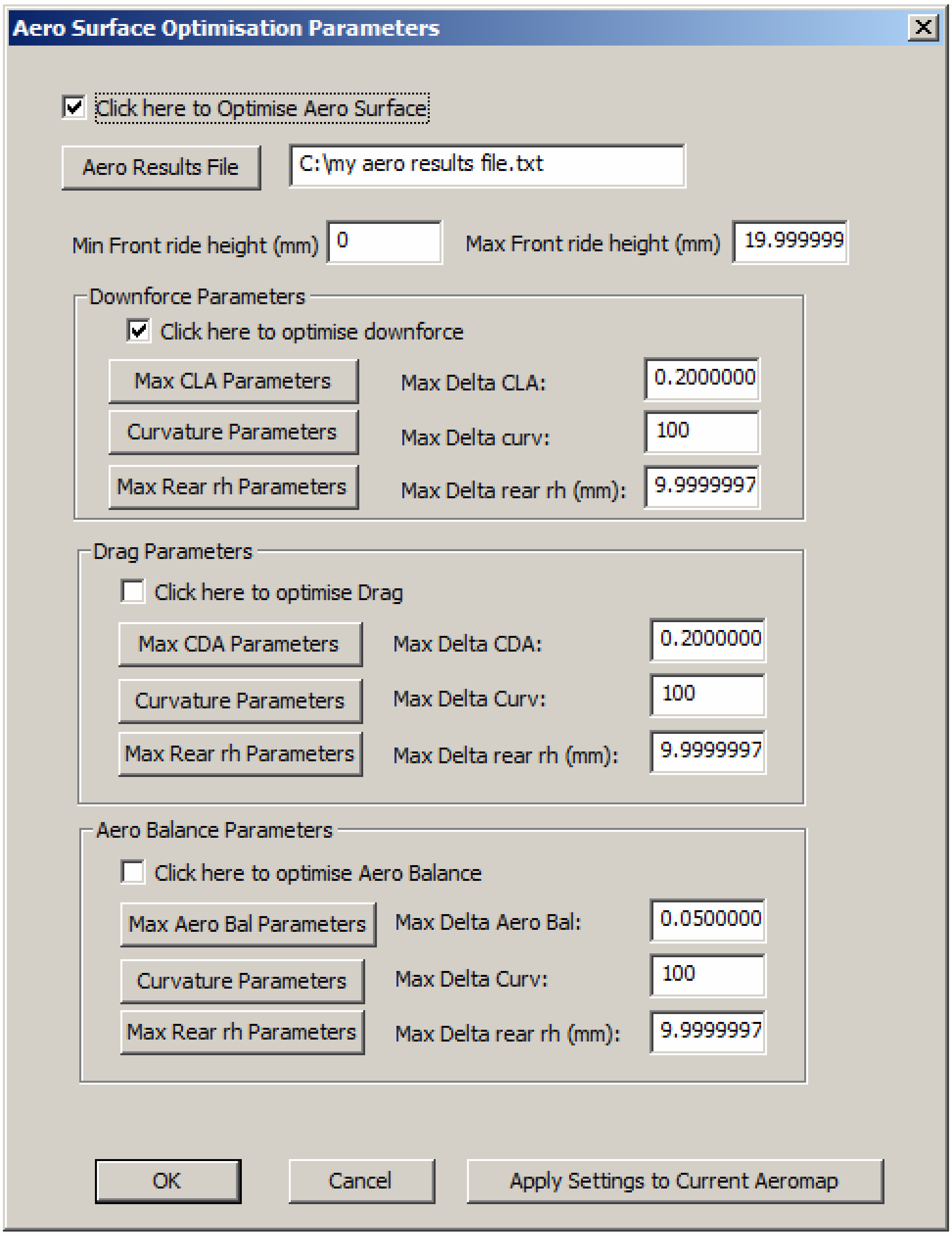

The way this works is it treats the aeromap by splitting it up into front ride height slices. For each slice it is optimising the following equation,

The crux of this technique is illustrated in the figure below,

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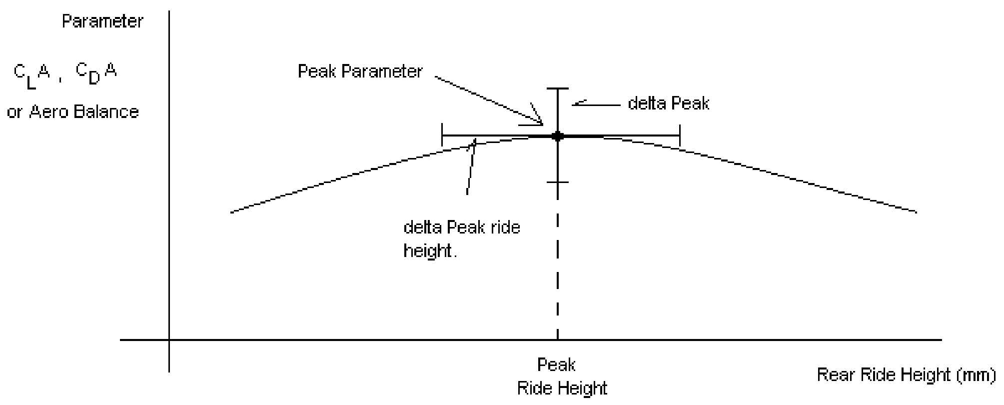

Parameter = Peak Parameter - a_curv*(y - rear ride height)^2

As can be seen what we are doing is breaking up the aeromap into front ride height sections. For each of these front ride height sections the following Parameter curve applies. What it says is at any given front ride height, the parameter whether it be drag, downforce or drag is given by whatever the peak value is at that front ride height minus the curvature value multiplied by the difference between the current rear ride height and the ride height at which the peak occurs. The bigger the curvature value is the more it drops off and vice versa.

It is the users job to enter the appropriate values for their race car. The peak is controlled in the Max CLA Paramaters, or CDA Parameters or Aero Balance Parameters Tab depending on what they are editing.. This brings up a 2D graphic where the user clicks on the control and edits the values. The same applies for the curvature values and the peak ride height values. The appropriate delta values are written in the edit controls next to the tab. As can also be seen the user can select which map they want to select.

Then the user specifies the front ride height bounds they wish the map fitted from. To optimise the aeromap click on the appropriate tab. They then select OK. To start the optimisation the user clicks on the Start button on the main window or Simulate->Simulate. Click on Start simulation and go get a coffee. When it is completed the following files will be produced in the same directory as the car file,
CLA_table.txt - Downforce results.
CDA_table.txt - Drag results.
AB_table.txt - Aero balance results.
These can be viewed in Standard mode, by clicking on the front wing and clicking on the relevant map and using the tab Import file on the 3D map viewer.

Here are some general pointers about what technique to use,

- If you have no idea about what the aeromap looks, the aero surface optimisation will give you a good initial picture.

- If you are confident in your experimental results the 2nd order surface fit will give you very good correlation very quickly.

Obviously these results will vary from car to car but these are good pointers to get you going.

Step – 2 Using the Tyre force curve optimisation.

Once you have a good aeromap you are now ready to reverse engineer the tyres. What you need to do to use this toolbox is the following,

- Load in your curvature and bump profile in Circuit->Circuit Data
- If the circuit has significant on camber and altitude variations this also needs to be loaded in Circuit->Circuit Data

You are now ready to perform the tyre force modelling. To do this select Simulate -> Tyre Force modelling. This will bring up the tyre force modelling toolbox, which is shown overleaf. As always we use the monster import file and of course click on the does this file include loads checkbox if the file includes loads. Again if using the monster import file and the car is a monoshock leave the monoshock flag as 0. I should add at this point please ensure the steering angle is calibrated in degrees at the tyre as opposed to the steering wheel. This is very important.

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NSW 2204 Australia
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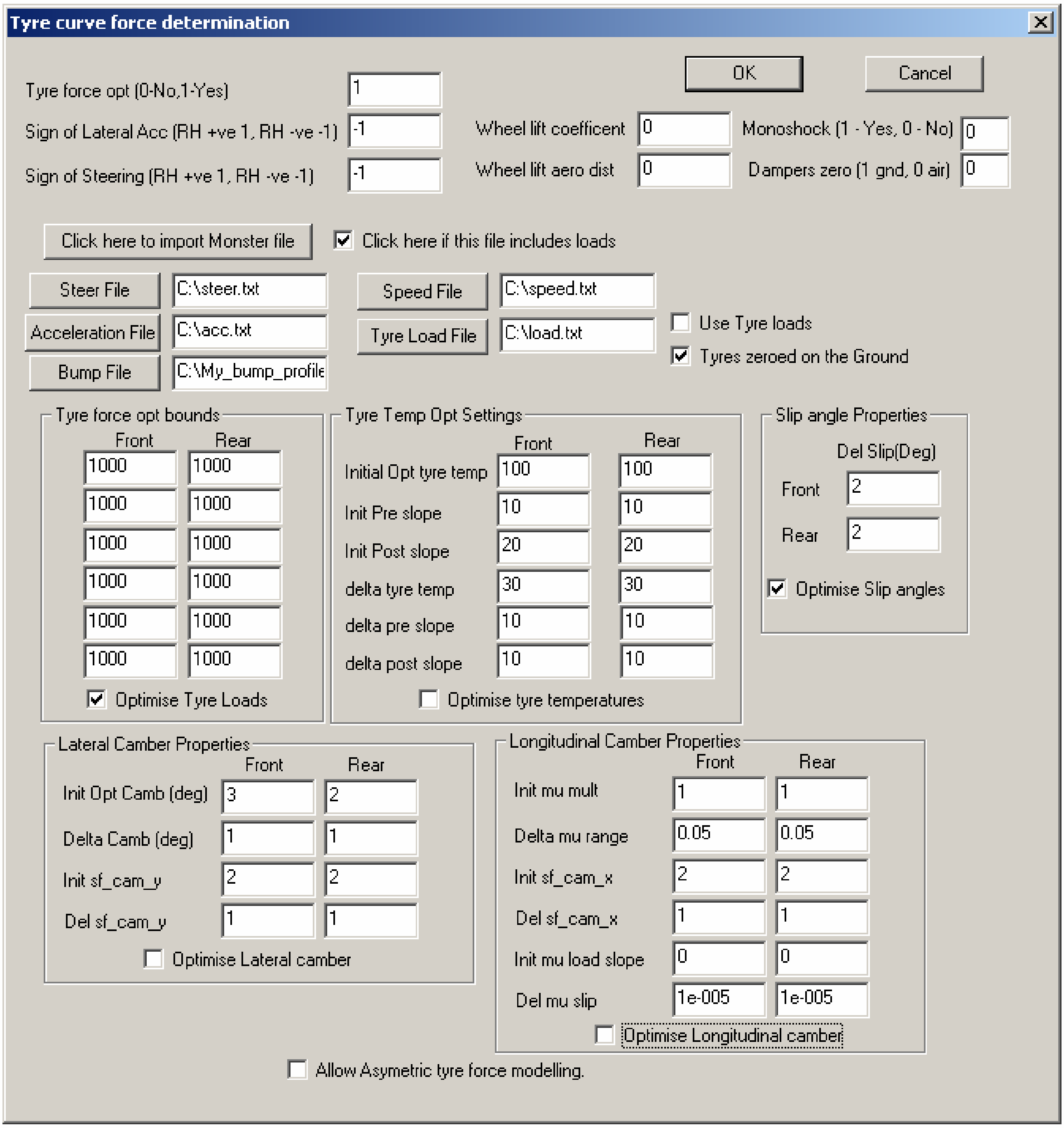

The next option we need to configure is the sign of the lateral acceleration and steered angle from the data. If the lateral acceleration and steering angle is positive for a right hand turn then both these flags are entered as 1. In the example both these signs are set to –1 which means that this data has positive steer and lateral acceleration for a left hand turn.

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9 Harriet Street Marrickville
NSW 2204 Australia
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Once we have this configured we need to indicate what we want to optimise. It depends on what you want to do. If you want a rough ball park, simply select Loads and slip angles and leave the other options blank. If your logged tyre temperatures are reasonable then this can be optimised as well. For your first tyre optimisation leave the lateral and longitudinal cambers unchecked. You can recheck this once you are more familiar with the ChassisSim v3 tyre model.

The optimisation setting shown here are taken from the ChassisSim v3 tyre model. This is documented at length in the document CSim_v3_tyre_model_documentation.pdf. It is highly recommended you read this document to fully understand who to exploit this toolbox.

Once you are ready click 1 to optimise the tyres and press OK. Then click on the Start simulation button to bring up the simulation window and click start simulation. This will start the tyre force optimisation. Be warned this will take at least a couple of hours so this is an over night job.

When the tyre force optimisation is done it will output the results in a series of files in the same directory as the car directory. The front tyre force output file is called Opt_fnt_tyre_file.txt and the rear tyre force output file is called Opt_rear_tyre_file.txt. Once again the user is advised to rename these files once the optimisation routine is completed. To import these into ChassisSim, click on the relevant tyre and click on the tab that says click here to import optimised tyres/v3 approximation.

Conclusion

The aero modelling toolbox and tyre force modelling toolbox are invaluable tools as you seek to understand what makes your car work. Also this is something that will take a couple of runs to refine. This is OK because it will take you a number of applications to truly appreciate what you have in your hands.

However as you become more proficient using these tools it will answer many questions on how your car works.