ChassisSim
The Winner's Edge

ChassisSim – Creating a model in minutes.

So you have downloaded your demo version of ChassisSim or even better yet bought your copy of ChassisSim and your thinking this is great but what do I do know?

The purpose of this document is to show you how you can create a workable model in a matter of minutes. While the model will not be perfect the purpose of this document is to get you over the beginner hump so you can see yourself just how powerful ChassisSim is.

The only pre-requisite you need is to have your car measured up and access to good data from a lap. Once you have this you can create a workable model in a matter of minutes. The process we will be following is,

- Step – 1 – Measure up the racecar and create an initial model.
- Step – 2 – Create a monster file.
- Step – 3 – Create the aeromap.
- Step – 4 – Run the tyre force estimation feature.
- Step – 5 – Create a track map and refine the results if needed.

That's all we need to do. Using ChassisSim it's actually that simple. So without further adieu let's get started

Step – 1: Measure up your racecar and create an initial model

The first step is to measure up the racecar. While this might sound perfectly obvious this is something you must get right. If you don't you will be forever chasing your own tail. Fortunately I wrote an article in Racecar Engineering about this. The link is,

http://www.chassissim.com/blog/chassissim-news/how-to-measure-up-a-racecar

However the highlights are,
- Measure tracks and wheelbases.
- Measure the suspension geometry.
- Measure the car masses and centre of gravity height.
- Determine the aero map

What you will be focusing on here is everything except the aeromap. We'll cover this in step 3

Once the car is measured up the next step is to choose one of the ChassisSim default models that is closest to your car and modify to it your needs. To do this start ChassisSim and chose one of the car templates. All you need to do is go to the right hand side of the screen and where it says Car. Click on the drop down box where you see the car name. This is the

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currently loaded template. A dialog will come up and choose one of the cars that most closely resemble your car.

When you have selected this save the car file. To do this all you have to do is go File->Save As and then save this as whatever name you wish and place it in a directory of your choosing. As a suggestion I would recommend C:\ChassisSim Technologies\Models\Car Type. For example it's an F3 car I would choose C:\ChassisSim Technologies\Models\F3

The next step is to select the units you want to setup the vehicle model in. This is selected by selecting View->Select units to use. This will form the basis of how spring rates, suspension geometry lengths and other items of apparel are entered.

Once we are at this point you simply enter the vehicle parameters. To do this all you have to do is to drag your mouse over the appropriate car component and click on it. This will bring up the appropriate dialog and you simply fill in the parameters. If you are in any doubt refer to the help menu.

Some quick pointers in your modelling,

- Motion ratios in ChassisSim are entered as Damper/Wheel ratios. Typically most race car manufacturers have this the other way around.
- If you are dealing with a monoshock enter the monoshock motion ratio in both the main spring and third spring entry. This will aid you in using the ChassisSim toolboxes.
- If you are using bump rubbers and have the packer gaps as ground gap click on the ground gap calculator to enter the ground gaps.

Once you have entered the model parameters save the file. This is covered in detail in the document CSim_lite_qstart.pdf for lite users or CSim_std_qstart.pdf for standard users and above.

Step – 2 Create the Monster Import File

One the car model is created we need to create a monster file that is relevant to the car file you have created. This monster import file contains all the information that ChassisSim needs to create a circuit and bump profiles and run the toolboxes. This data is taken from a flying lap of the data at speed exported at 50Hz. The format of the file is an ASCII tab delimited file of the data with no headers and footers. The data that is required is,

lap distance (m)
rpm
ay (g)
ax (g)
damp front left (mm)
damp front right (mm)

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damper rear left (mm)
damper rear right (mm)
steering (deg) – This is the angle of the tyre as opposed to the steering wheel.
throttle pos (%)
Vehicle speed (km/h)

If you have strains,

Strain Front Left (kgf)
Strain Front Right (kgf)
Strain Rear Left (kgf)
Strain Rear Right (kgf)

These are added at the end of the other listed parameters. What it would look like in a file is shown below,

Without loads,

0	7392.94	-0.03	0.1	4.65	4.87	5.51	5.57	0	100	207.92
1.174	7395.56	-0.03	0.11	5.01	4.58	5.16	4.72	0.03	100	207.99
2.346	7398.33	-0.02	0.11	5.08	4.85	5.98	6.57	0.06	100	208.07
3.52	7401.26	-0.02	0.12	4.83	4.81	10.52	11.16	0.08	100	208.15
4.693	7404.28	-0.02	0.12	3.93	3.96	13.22	13.3	0.09	100	208.24
5.867	7407.27	-0.02	0.12	4.07	3.72	12.74	12.42	0.1	100	208.32
7.042	7410.23	-0.02	0.12	6.22	5.88	13.07	12.63	0.06	100	208.4
8.217	7413.14	-0.03	0.12	5.77	5.69	11.26	11.23	0.02	100	208.49
9.392	7416.04	-0.03	0.12	5.52	5.44	10.26	10.61	-0.01	100	208.57
10.568	7418.92	-0.03	0.11	7.27	6.85	11.73	11.65	-0.03	100	208.65
11.744	7421.78	-0.04	0.11	7.36	6.88	12.43	11.88	-0.03	100	208.73
12.921	7424.61	-0.05	0.11	5.72	5.62	10.39	10.2	-0.01	100	208.81
14.098	7427.42	-0.05	0.11	5	5.05	8.36	8.39	0.01	100	208.89
15.276	7430.27	-0.05	0.11	6.46	6.37	8.75	8.48	0.03	100	208.97
5865.339	7392.94	-0.03	0.1	4.65	4.87	5.51	5.57	0	100	207.92

With loads the file looks like

```
0      7392.94  -0.03 0.1      4.65  4.87 5.51 5.57   0 100   207.92  166.98  157.86  216.53
       202.85
1.22   7392.94  -0.03 0.1      4.65  4.87 5.51 5.57   0 100   207.92  166.98  157.86  216.53
       202.85
4.55   7392.94  -0.03 0.1      4.65  4.87 5.51 5.57   0 100   207.92  166.98  157.86  216.53
       202.85
```

Please note the distance vector needs to have at least 2 decimal places. This is very important. Also dampers and loads must be positive in bump.

It is also highly recommended that the dampers and loads are zeroed on the ground. In my experience the best place to zero is when the car is leaving the pits going down pitlane.

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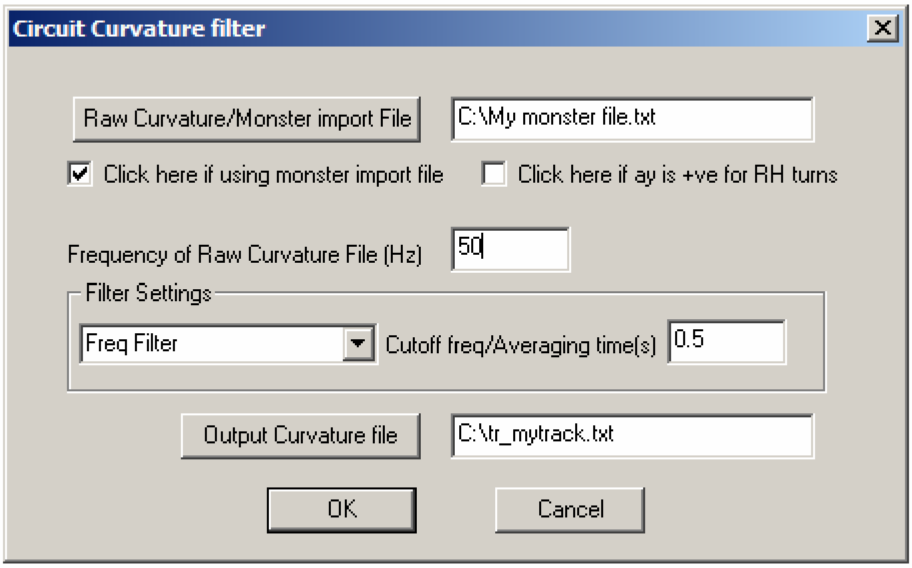
Step – 3 - run a sanity check

The one touch modelling procedures are designed to take you from a blank sheet of paper to a model that is up and breathing.

It is advised to run a sanity check. You might be adjusting a template that is very well sorted. If this is the case you can actually omit the one touch modelling. Alternatively there might be some inaccurate information from the race car manual or say motion ratios that might through the one touch modelling out.

Consequently it is advised to run a baseline simulation with just a curvature file to see where the model is at. To create a curvature file Go to Circuit->Create/Filter Curvature file. This will bring up the following dialog,



To import the monster import file, click on the Raw Curvature/Monster Import File and navigate to your monster import file. Click on the monster import file check box. Input the frequency of the Monster import file and if RH turns are positive for right hand turns click on this box, and click on Output Curvature to indicate the file you want this written to. Given we are doing a quick sanity the Filter settings to moving average with an averaging time of 0.5s. Also save the curvature file in the same directory as the monster and car file.

You are know ready to do your initial simulation check. To load this curvature file in go to Circuit->Circuit Data and click on the curvature file tab and load in the curvature file. Then

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setup a data log as we discussed in the quick start guide. Then compare the data to your actual data.

You know you don't need to run the one touch aero modelling and tyre force estimation when you have relatively close correlation. If you don't need to run these features you'll have something that looks like this,

As we can see while the corner speeds in the main are over optimistic we can see some common trends,

- Down the straights the dampers are very close.
- The accelerations are relatively close
- So is the steering.

If you see something like this you can actually skip the one touch aero modelling and tyre force estimation. Some rough rules of thumb if the damper displacements are within +/- 1mm then you can go straight to circuit modelling. If the lateral accelerations are off by 0.2 – 0.4g then run the tyre force estimation.

From time to time when you compare some initial data there will be a large discrepancy. In the plot overleaf you'll see the front dampers are off by 30% and the rear dampers are off by 50%! If you see something that looks the plot overleaf this is your queue to check the following,

- Double check all motion ratios.
- Double check all spring rates and bump rubber gaps

In this situation your best defence is to do a hand calculation of the downforce of the data. This will tell you very quickly what you are dealing with.

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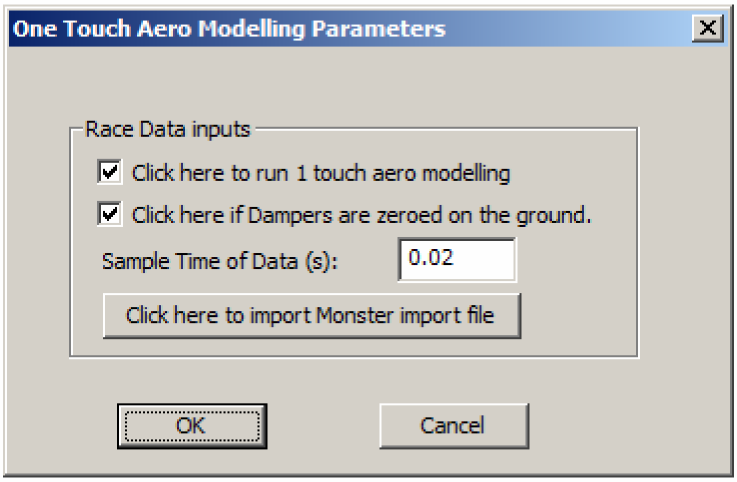
Step – 4 Create the aero model

To create the aero model the user takes the monster file they created in Step – 2 and then goes to Simulate-> One Touch Aero Modelling. This will display the following dialog,



The user puts in the sampling period of the monster file. This is 1/sampling frequency which in this case is 0.02s (50 Hz). The user indicates they want to run one touch modelling, by clicking on the checkbox as illustrated. If the dampers are zeroed on the ground click on the checkbox as illustrated. The user then presses on OK.

When the user returns to the main screen, the user clicks on the Start button, or the user can select Simulate->Simulate. This will bring up the simulation window. The user then presses

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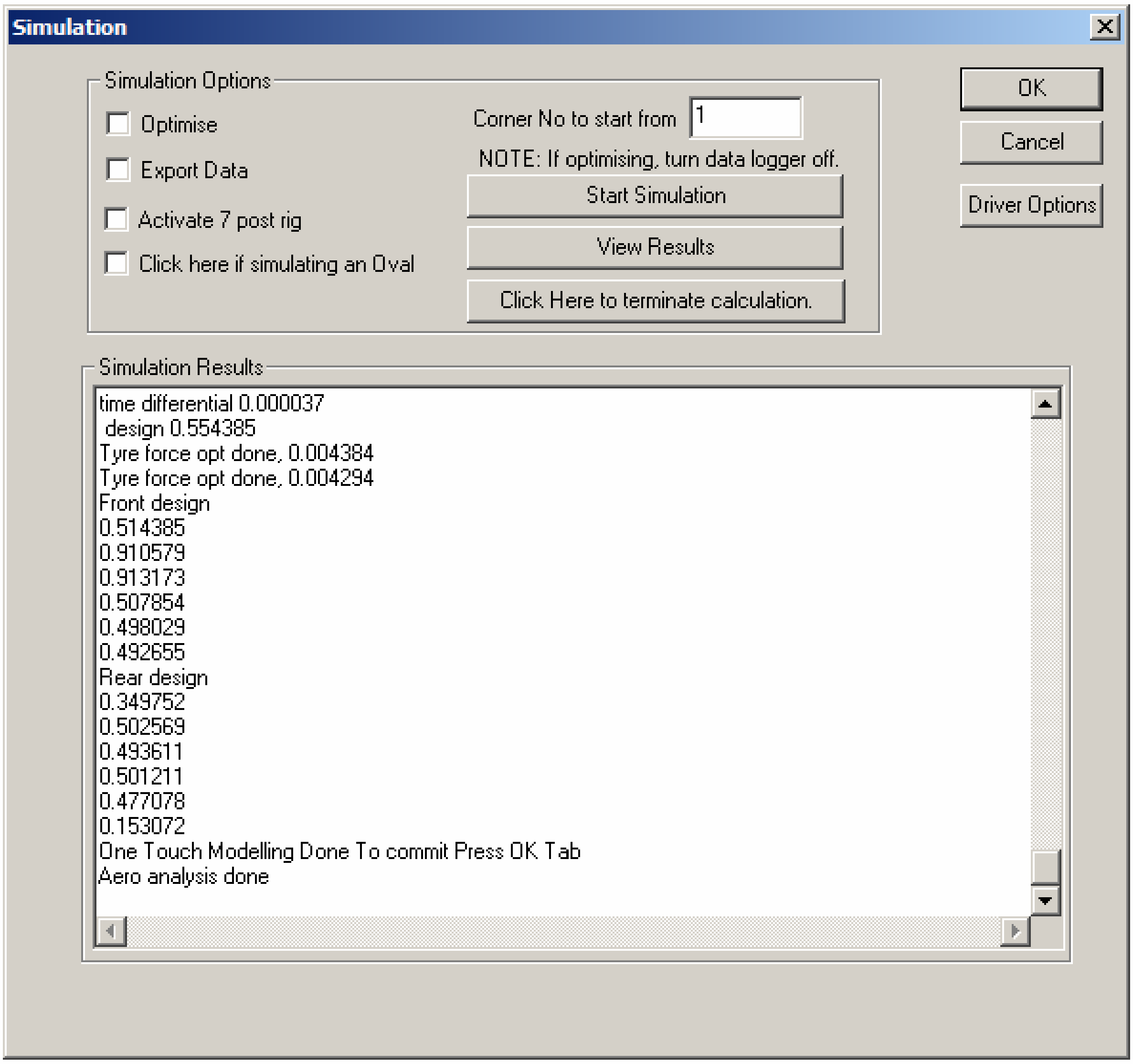
on Start simulation. This will start the aero modelling process. This will take a few minutes so get a coffee or take a stretch. When it is done it will look something like this and to commit the results press OK.

To complete the process when you are done go back to Simulate-> One Touch Aero Modelling and ensure the run 1 touch aero modelling toolbox is turned off. Then go to File->Save to save your changes.



In 90% of the cases this will get you there however from time to time the results may need some tweaking. If you overlay actual to simulated data the following guide should help,

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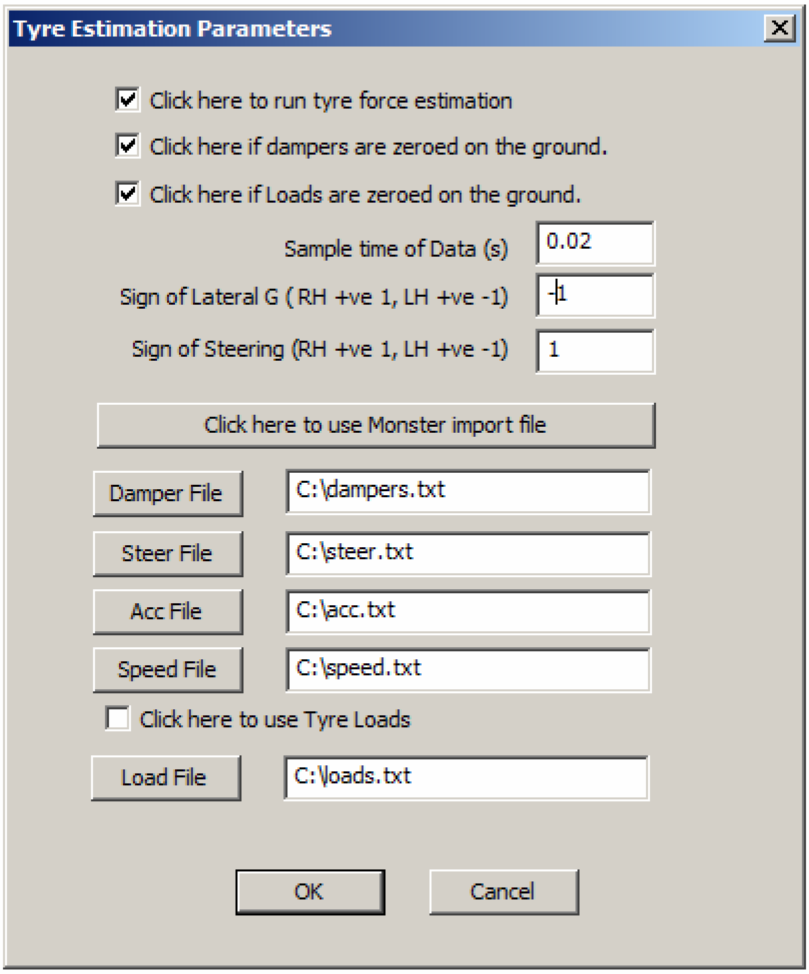
Case	Action
Simulated Damper Displacement to low	Click on rear wing and raise C_LA_{MAX}
Simulated Damper Displacement to high	Click on rear wing and decrease C_LA_{MAX}
Simulated Speed too low	Click on rear wing and decrease C_DA_{MAX}
Simulated Speed too high	Click on rear wing and increase C_DA_{MAX}
Sim Front dampers too much	Click on rear wing and decrease Aero Bal offset

Step 5 – Creating the tyre model

Creating the tyre model is a very straightforward process. To do this you simply select Simulate -> Tyre force Estimation. This will bring up the following dialog,



Click on the tab that says click here to use monster import file. Import the monster file we generated in Step – 1. Indicate where the dampers are zeroed, leave the sample time at 0.02s, and indicate the signs of the steering and acceleration. When you are done click on the checkbox that says Click here to run tyre force estimation. Then click on OK. Select

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Simulate->Simulate or click on the Start button and click on Start simulation. This will start the tyre force estimation process.

When this is completed the results will be stored in the ChassisSim v3 approximation format. The files will be,

Front - Opt_fnt_tyre_file.txt
Rear - Opt_rear_tyre_file.txt

This will be stored in the same directory as the currently loaded car file.

To load these results the user simply click on the front tyre. Selects the tab that says Import CSim v3 approximation/opt results navigates to where the currently loaded car file is and selects Opt_fnt_tf_results.txt. The user then click on the OK button. The user repeats the process for the rear tyre but selects Opt_rear_tf_results.txt. Select File->Save.

Congratulations! You have just completed the first cut of your vehicle model.

Step – 5 – Refine the results.

To refine the results this is what you need to do,

- Create a Circuit and bump profile. This is outlined in the document CSim_track_creation.pdf or CSim_track_creation_lite.pdf
- Log this to data - This is outlined in the document CSim_cookbook.pdf in Step – 5 or ChassisSim getting started guides.
- Adjust the Tyre Force Grip factor parameters in the front and rear tyres until the lap times are approximately equal. Remember more grip factor makes the car quicker, less makes it slower.

In reality you should fine you only need to make very fine adjustments. It is also not advised to go overboard at this stage. Remember the goal here is to lay a platform that you can use to make intelligent decisions later.

Conclusion

While these steps may seem intricate, once you are used to them these will take you minutes to execute. Remember the process is,

- Measure up your car.
- Select a ChassisSim that is closest to your car, enter the parameters and save the car file.
- Create a monster file from the appropriate data.
- Create the aeromap.
- Run the Tyre force estimation.
- Create the track map and load this into ChassisSim.

- Run the simulations and adjust the tyre force grip factors in the tyre dialogs as necessary.

The power of what we have just discussed is that in minutes you can create a useable car model. This is something you can use almost immediately. While this is not perfect what it does do is it lays the basis for you to refine the results using the ChassisSim modelling toolboxes such as Tyre Force and Aero Modelling. This is invaluable information for your race car.

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Appendix – Downforce calculation.

Even though this step is not necessary due to One touch aero modelling I have enclosed this for completeness. Besides it's a good skill to develop which is why I have enclosed it. To calculate downforce you always take the damper readings at the end of the fastest straight. It gives your best indication of what to expect with a minimum of error. Smooth the results either using a frequency band pass filter or moving average filter.

Let's walk through an F3 example about how to calculate the relevant aerodynamic parameters. The numbers we'll be working with are shown in in Table-1.

Item	Quantity
Front Motion Ratio	0.9
Rear Motion Ratio	0.8
FL Damper/FR Damper	10mm/10mm
RL Damper/RR Damper	15mm/15mm
Front spring	140.1 N/mm (800 lbf/in)
Rear spring	140.1 N/mm (800 lbf/in)
Front tyre Spring rate	200 N/mm
Rear tyre Spring rate	220 N/mm
Front rh @setup	25 mm
Rear rh @setup	35 mm
Torque at RPM	200 Nm
Rolling tyre radius	0.28m
a_x	0g
Vx	220km/h
Gear ratio value	3
m_t	500kg
h	0.3m
wb	2.6m

Table-1 – Sample values for an aero hand calculation.

Here all motion ratios are Damper on wheel, and the gear ratio is Engine/Wheel velocity and for simplicity I've omitted bump rubbers. Crunching the numbers we see,

$$
\begin{aligned}
FtDownforce &= MR_f \cdot k_f \cdot (FL\_Damp + FR\_Damp) \\
&= 0.9 * 140.1 * (10 + 10) \\
&= 2521.8N \\
\mathrm{Re}\,arDownforce &= MR_r \cdot k_r \cdot (RL\_Damp + RR\_Damp) \\
&= 0.8 * 140.1 * (15 + 15) \\
&= 3362.4N \\
C_L A &= \frac{FtDownforce + \mathrm{Re}\,arDownforce}{0.5 * 1.225 * (220/3.6)^2} \\
&= 2.57 \\
AeroBal &= 100 \cdot \left(\frac{FtDownforce + \dfrac{mt \cdot g \cdot a_x \cdot h}{wb}}{FtDownforce + \mathrm{Re}\,arDownforce} \right) \\
&= 100 \cdot \left(\frac{2521.8 + \dfrac{500 \cdot 9.8 \cdot 0 \cdot 0.3}{2.6}}{2521.8 + 3362.4} \right) \\
&= 42.9\% \\
C_D A &= \frac{gr * T / r_t - m_t \cdot g \cdot a_x}{0.5 * 1.225 * (220/3.6)^2} \\
&= \frac{3 * 200 / 0.28 - 550 \cdot 9.8 \cdot 0}{0.5 * 1.225 * (220/3.6)^2} \\
&= 0.937 \\
frh &= frh_0 - \frac{0.5 \times (FL\_Damp + FR\_Damp)}{MR_f} - \frac{0.5 \times FtDownforce}{ktf} \\
&= 25 - \frac{0.5 \times (10 + 10)}{0.9} - \frac{0.5 \times 2521.8}{200} \\
&= 7.58mm \\
rrh &= rrh_0 - \frac{0.5 \times (RL\_Damp + RR\_Damp)}{MR_r} - \frac{0.5 \times \mathrm{Re}\,arDownforce}{ktf} \\
&= 35 - \frac{0.5 \times (15 + 15)}{0.8} - \frac{0.5 \times 3362.4}{220} \\
&= 8.6mm
\end{aligned}
$$

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