CHASSISSIM
The Winner's Edge

Creating circuit models in ChassisSim.

The elements that construct a ChassisSim circuit model are the following,

- The curvature file which is a plot of inverse corner radius vs distance.
- The bump profile which is a plot of all 4 road displacements vs distance.
- The altitude road camber file which plots altitude and road camber.
- The bump scale factor which fine tunes the bumps.
- The grip scale factor which tunes in local grip.

Don't be intimidated by this list. This has been listed this in order of importance. So the way you construct a circuit model is that you start at the top of this list and work your way down.

The first order of importance is to generate the curvature and bump profile and the other files refine the model. As we will discuss the curvature and bump profile get you 90-95% there in most cases. The road camber, bump and grip scale factor refine the results.

We are going to break this tutorial into 2 sections. The first section is we will discuss the auto generation features to create a curvature, bump profile, altitude road camber file and grip scale factor file. In the second section we'll discuss what you need to do to refine the results.

Step – 1 – Generate a Monster import file.

The monster import file is ChassisSim primary way of communicating with data. The list of channels to export is shown in the list below. These are listed across the page with a space or tab space. However for ease of illustration I've listed them below,

Lap Distance (m) – Note please make sure this has at least 2 decimal places
RPM
Lateral acceleration (g)
Longitudinal acceleration (g)
Damper Front Left (mm)
Damper Front Right (mm)
Damper Rear Left (mm)
Damper Rear Right (mm)
Steering angle (deg) – Please note this is measured at the tyre as opposed to the steering wheel.
Throttle Position (%)
Car Speed (km/h)

If you have strains then you can also add these to the monster file
Load Front Left (kg)
Load Front Right (kg)
Load Rear Left (kg)
Load Rear Right (kg)

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

Also please note the numeric format for the file is the following

1.234 6500.23 1.2 0.8 ……..

It is not,

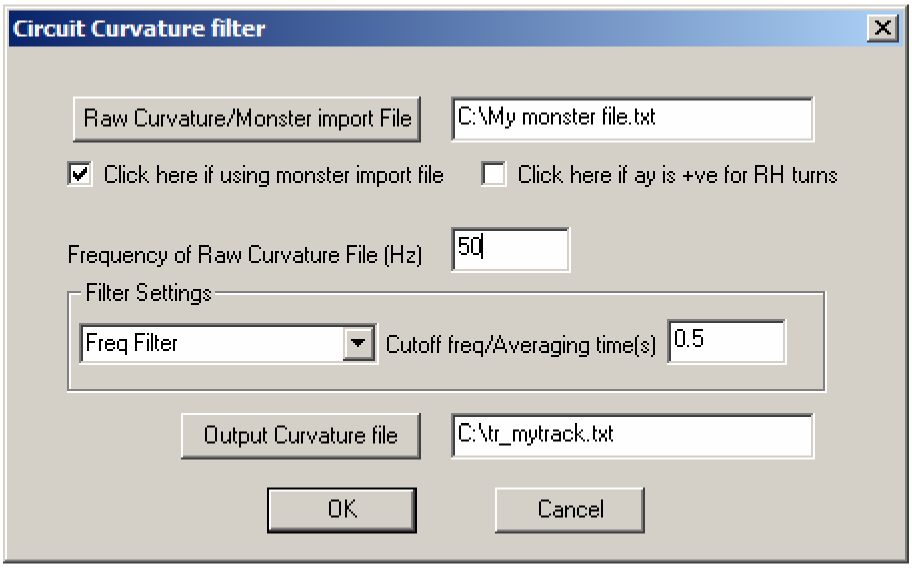
1,234 6500,23 1,2 0,8 ……..

All decimals must use . as opposed to ,

This data must be exported at 50 Hz. Please note this file must be an ascii file.

Step 2 – Generate the curvature file.

Go to Circuit->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 click on Output Curvature to indicate the file you want this written to.

When it comes to track filtering you have two options, frequency filtering or moving average filtering. This is what we have found works best,

- If lateral acceleration is being logged at 50 Hz – use the frequency based filter at a setting of 0.5s.

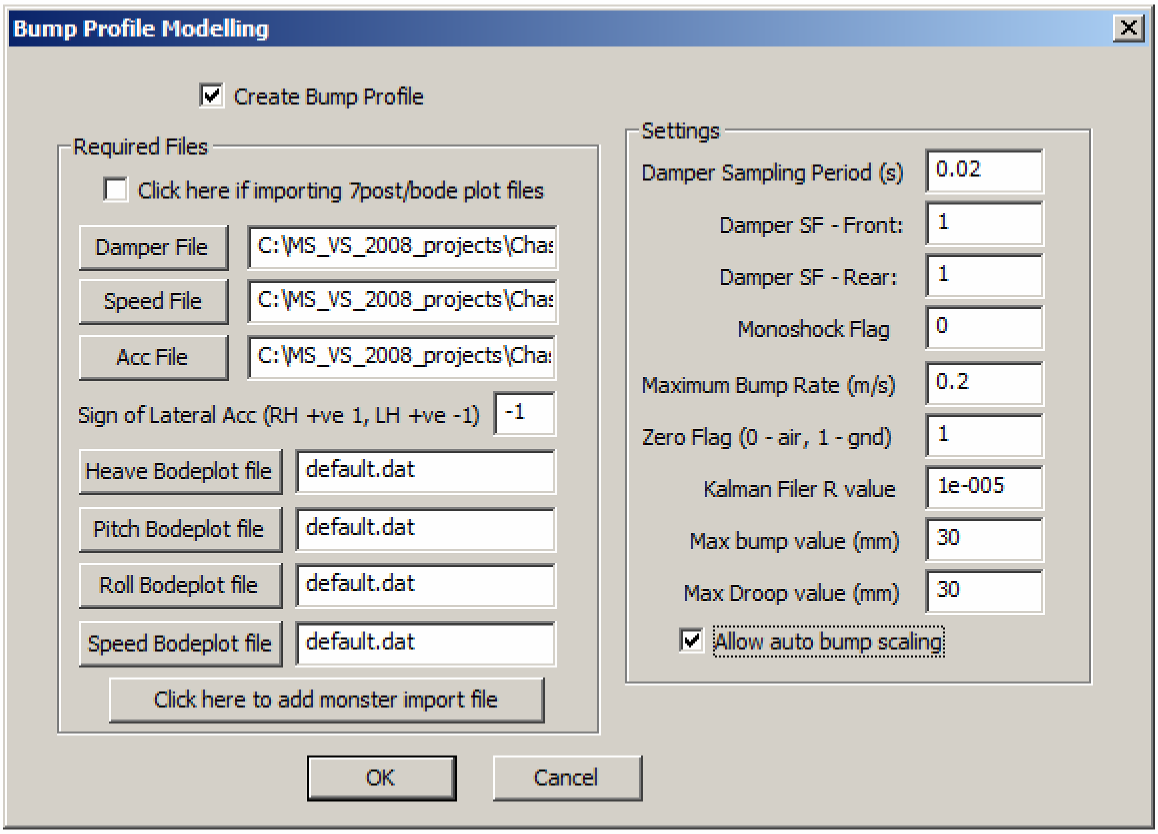
ABN 3517 202 936 9
ChassisSimTechnologies™
9 Harriet Street Marrickville
NSW 2204 Australia
Danny Nowlan, Director mobile: +61 425 219 375

- If the lateral acceleration signal is being logged at 10Hz or less use the moving average filter set to 0.4s.

Just a note on track naming. My personal convention for curvature files is tr_trackname.txt. You can use any convention you wish just be consistent!

Step 3 – Generating the bump profile

To generate the bump profile, Load in your setup and go to Simulate->Generate Bump Profile. This will bring up the following dialog,



Click on the Monster import file tab. Also enter the sign if the lateral acceleration. In this case -1 indicates left hand turns as positive. This will automatically populate the Damper and Speed file as shown. Click on the Create bump profile tab. I've also shown the typical baseline settings you need to create a bump profile with.

What has been shown here is baseline settings to get you going. A very useful tuning feature to play with is the maximum bump rate. Some rough rules of we have found that have worked well are shown below,

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

Car Type	Max bump rate (m/s)
Open Wheeler/Sportscar	0.2
Touring car/Saloon car	0.4

This will vary from car to car but these are some good rules of thumb to get you going.

Also you will note the tab that says click here to allow bump scaling. This will allow further bump refinement. If you have good quality damper data leave this check box on, however if the bump results look a little suspect you can turn this off. Our recommendation is to leave this on.

Once you are ready click on OK. This will generate a file called bump_profile.dat in the same directory as the car file is saved in. Rename this to bump_profile_mytrack.dat and you are good to go.

Step – 4: Running the Altitude road camber generation feature

This step is necessary is when you have circuits that have significant altitude and road camber and you don't have GPS data. Examples of circuits you would use this for is Bathurst in Australia, Mosport in Canada and Road Atlanta in the U.S and Spa-Francochamps in Belgium. If your circuit doesn't have significant road camber and elevation this step can be omitted.

To access this feature you select Circuit->Edit Road camber and altitude->Generate Circuit Altitude and Road camber data. This will display the dialog shown overleaf.

As can be seen you load in your curvature file, bump profile and what you want to call your road camber/altitude file. Load in your monster file and indicate if your dampers are zeroed. At this point all you need to do is click on OK and the altitude road camber file will be generated.

At this point it would be prudent to add a number of observations.

Firstly you will notice there is a tab that says click here to generate elevation damper data from damper data. If you are confident in your aero model by all means play with this because it will match the undulation data very well. However it is not recommended to use this model when the aero model still needs refinement.

Also it should be stated that because we have to rely on race data, the altitude and road camber will not be perfect. The elevation data is deduced by changing the road angle to match speed, and the difference in normal loads in the corners is adjusted by changing road camber. However what it will do is match the speeds very well and the tyre loads which is 95% of the battle. It is also a good back up if you don't have GPS data.

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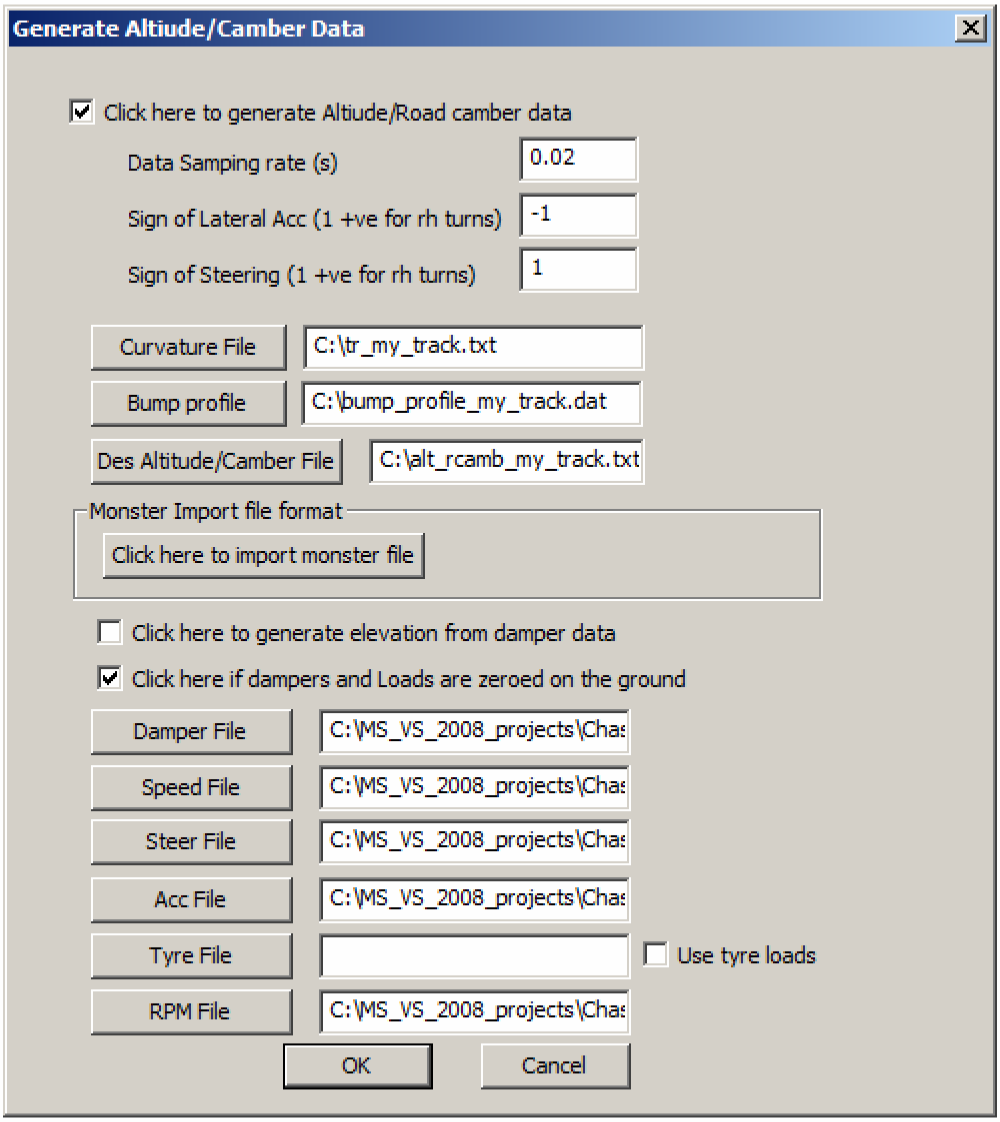
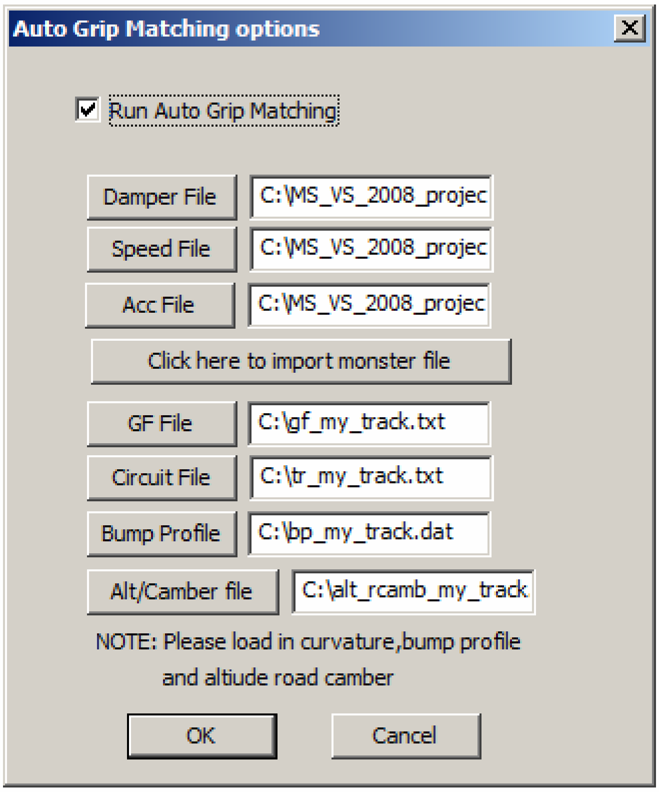


Step – 5 – Running the Auto Grip feature.

The last step in this process is to run the auto grip feature. First things first is to go into Circuit->Circuit Data and load in the curvature, bump profile and altitude road camber files. To access this feature select Circuit->Auto Grip Determination. This will display the following dialog,



You simply select the desired name for the grip factor file, import the monster file, click on the tab that says Run Auto Grip Matching and click on OK. This will generate the grip factor file.

Step – 6: Running your circuit model

To run your curvature and bump profile go to Circuit->Circuit Data. This will bring up the following dialog shown overleaf.

Click on the Curvature file tab to navigate and load in your desired curvature file. The same process is applied for the bump profile, grip factor file and Altitude road camber file. Note however in the file dialog for the bump profile to change the file filter to *.dat. Also as a rough rule of thumb if the elevation data is very poor it is advised to click on the tab that says Click here to disable damper movement under elevation changes. However in 99% of cases this won't be necessary. The files you'll load in are illustrated in the dialog overleaf.

Once you have done this click on OK.

You are now ready to run the simulation. To do this go to Simulate->Simulate or click the Start button. This brings up the simulation dialog. To start the simulation click on Start simulation tab. The simulation will now run.

ABN 3517 202 936 9
ChassisSim Technologies™
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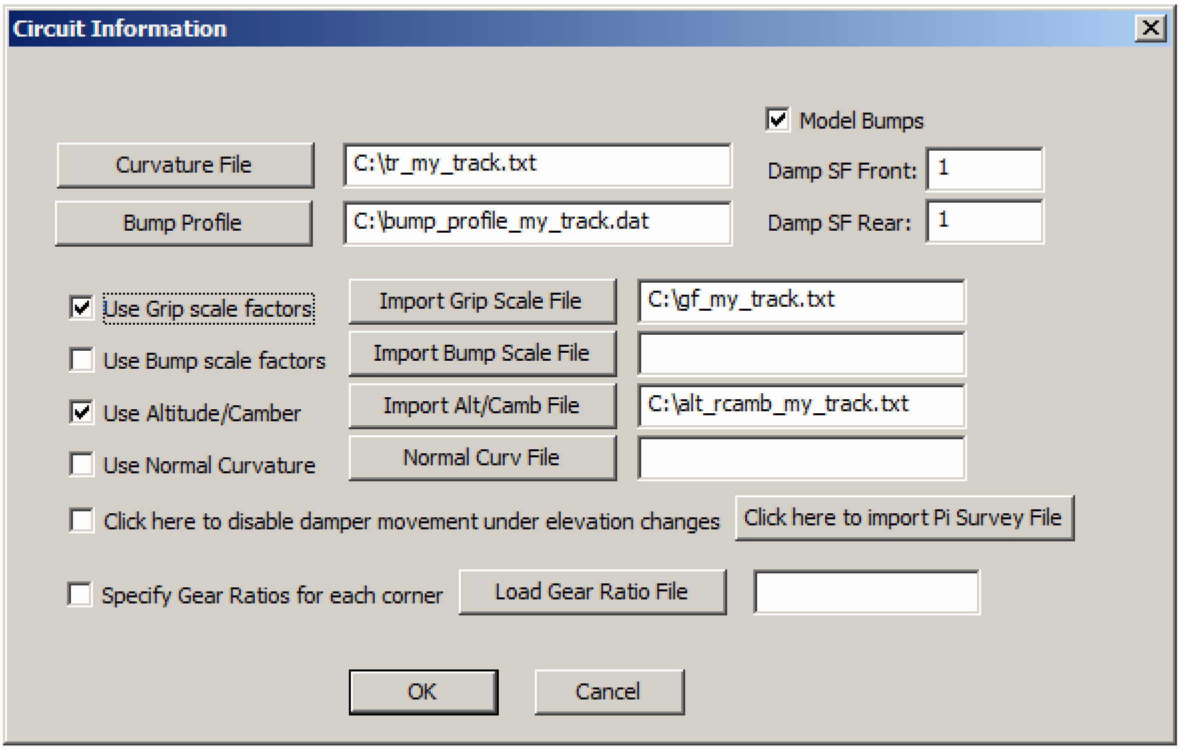


Step – 7: Refining the results

In most cases what we have described in steps 2 – 6 will get you 95% there. You will find that as your tyre model improves the curvature and bump profile on it's own will get you 90 – 95% of the way there.

Before you go tuning the extra's there are some steps you can take to ensure you are within the ball park. As a rough rule of thumb if the speeds are down everywhere or the opposite is the case, this is your cue to adjust the tyre force scaling factors in the tyre model. A dead give away of this situation is when the predicted lap time is say 3s too fast but the shape of the speed trace looks OK. This is particular apparent if the top speeds are comparable. If this is the case then reduce tyre scaling force factor. Strictly speaking this should be done before using auto grip matching, but I included it as Step 5 to help get you going.

The next step after we have tuned in the tyre force scaling is to list out the local speed variations. Initially we are looking for discrepancies in the order greater than 5 km/h. What I find very helpful is to list the speed variations out in the following table,

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

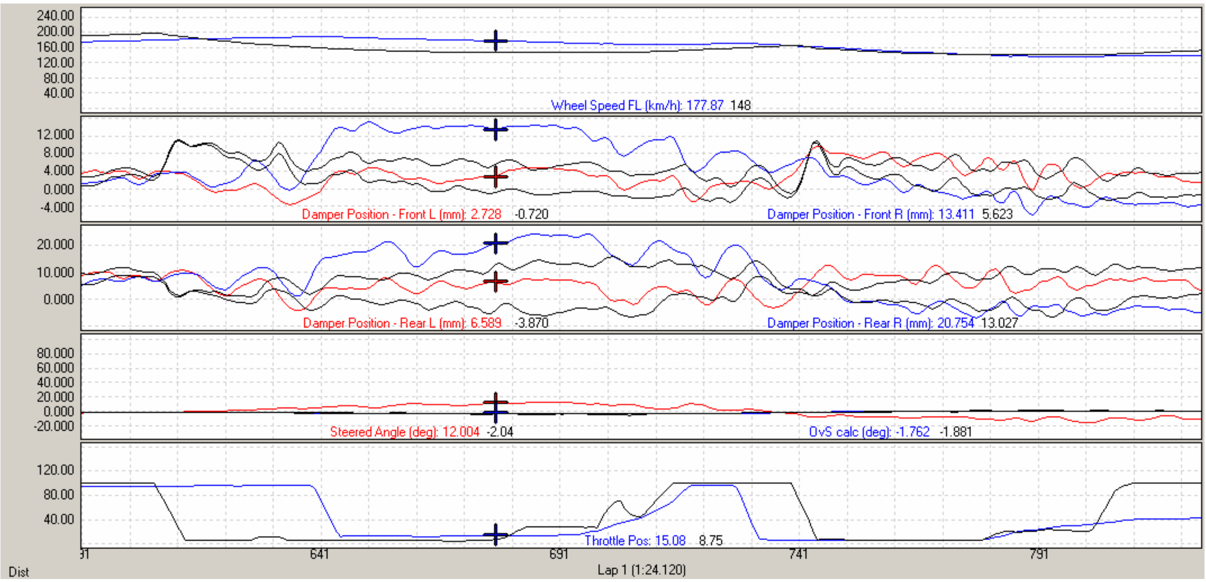
Sector	V_{act}/V_{sim} (km/h)	Road camber	G.S.F	$B.S.F_{fnt}/B.S.F_{rear}$
800 – 1000m	200/190			
1230 – 1260	90/100			

The key to focus on is the mid corner because if you get this right the turn in and exit speeds have a funny habit of looking after themselves. You'll note in this table I've deliberately left the Road camber, Grip scale factor (G.S.F) and Bump scale factor (B.S.F) blank. This is because it's going to be your job to fill in the blanks. The process you work through is quite simple and the order is,

- Is there road camber we need to take into account
- Bump scaling
- Local grip scale factors

You will note these have been listed in order of importance.

There are two ways of determining if there is road camber. The first one is to watch in car camera footage. If you don't have that logged, You Tube is your best friend. The second way of detecting this is when the simulated damper traces are well down on the actual damper traces. This is illustrated below,



The actual damper traces are coloured, the simulated traces are black. As can be seen there is a significant difference here and this is where you need to add road camber. In reality you'll be looking at both, but you'll still be surprised the effect that 4 deg of on and off camber can have so keep an open mind.

To edit road camber you will find the following video tutorial helpful,

ABN 3517 202 936 9
ChassisSim Technologies™
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NSW 2204 Australia
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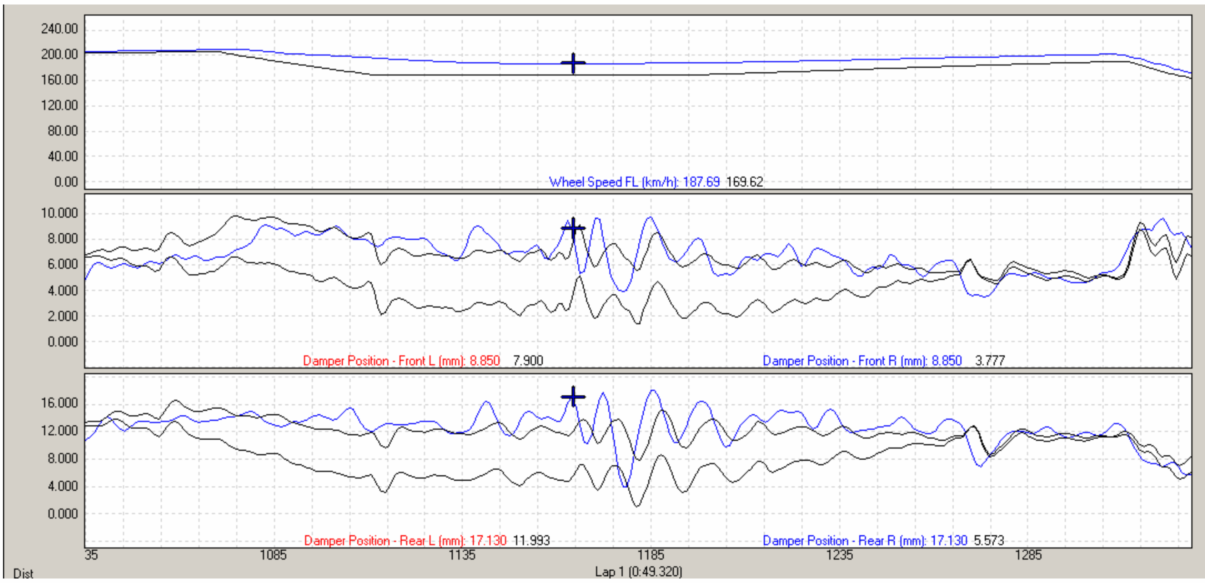
http://www.youtube.com/watch?v=TpNgyCFSpNE&list=UU4W7Lqv3XrQps-RlcR4fEOA&index=4&feature=plcp

Once the road camber has been determined our next point on the list is to look at bump scale factors. The tell tale sign we need to add in bump scale factor is when the simulated and actual bumps are the same, but the simulated speed is down by say 20 km/h. This is illustrated below



Again the actual dampers are coloured the simulated trace is black. As we can see if we are getting the same bump magnitudes with such a large speed difference that's a pretty clear sign we need to reduce the scaling of the bumps. What you are looking for is to get the magnitudes the same with about a 5km/h differential.

The last point on the list is grip scale factor. Once the road camber and bumps have been handled, grip scale should be a minor tweak. In terms of what to apply you should find the following formula very useful,

$$G.F = \left(\frac{V_{ACT}}{V_{SIM}}\right)^2$$

Here, G.F is the grip factor we need to apply, V_{ACT} is the actual speed and V_{SIM} is the actual speed. If the grip factor is a fine tweak you know your model is working well

The mechanics of manipulating bump and grip scale factors are covered in this video tutorial, http://www.youtube.com/watch?v=u-fMPHKMAM4&list=UU4W7Lqv3XrQps-RlcR4fEOA&index=2&feature=plcp

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To conclude this section you don't need to be aiming for accuracy within 0.1km/h. Your objective is to get the cornering speeds within 2-3 km/h for the high speed corners and 1-2km/h for the low speed corners that is good enough. Remember the goal is to establish a representative envirorонment. As your model get's better the correlation has a funny habit of looking after itself.

Conclusion

In closing when constructing a circuit file the components we are putting together are

- Curvature file
- Bump profile
- Road camber file
- Bump scale factor
- Grip scale factor.

In most cases the Curvature and bump profile, and the generated altitude and bump profiles will get you 95% of the way. As your tyre models get more advanced you can actually just concentrate on generating the curvature and bump profiles. To refine the results you generate these first and then compare to real data. You then refine the results by adding in road camber, bump scale and grip scale factor. If you follow this process you'll be generating high fidelity circuit models in no time.

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