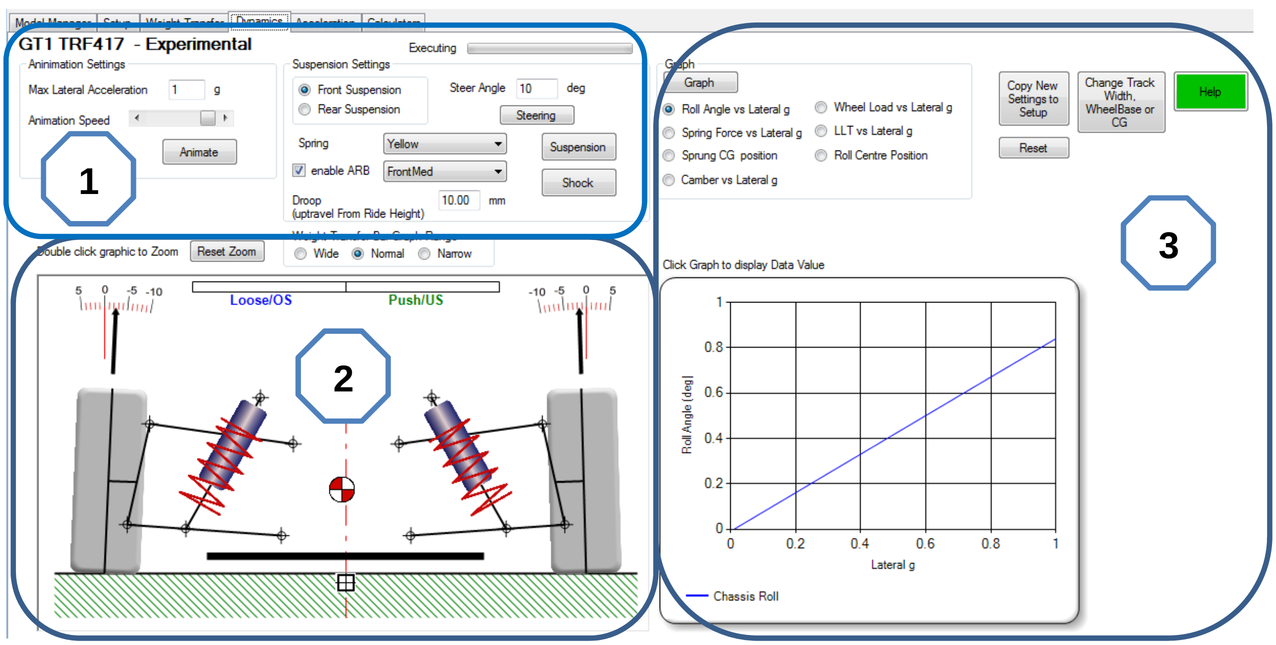
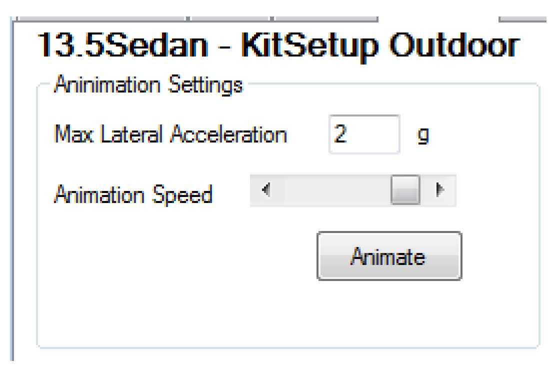
Dynamic Tab

A dynamic simulation and animation of the front/rear suspension in roll is provided in this section. The model calculates suspension geometry, forces and lateral acceleration based on rolling the chassis around the kinematic roll centre axis. At each roll increment shock spring forces, wheel loads, sprung mass CG, dynamic roll centre position, Lateral Load Transfer (LLT) and camber are calculated and saved for graphing.



Area 1 – Animation Settings



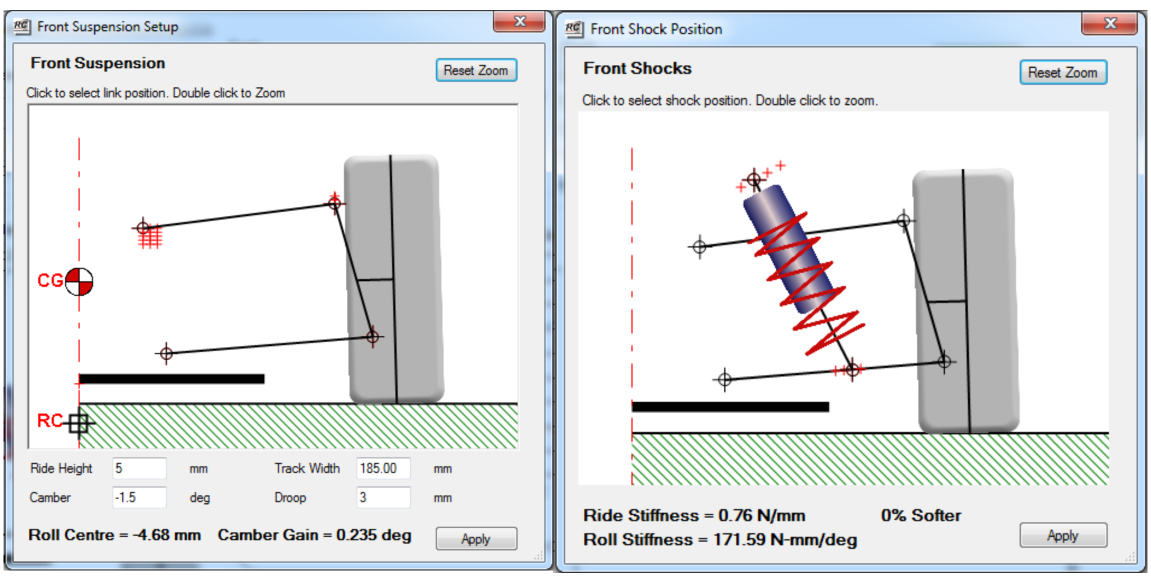
Enter the Maximum Lateral Acceleration for the simulation. Calculations will proceed until the entered g value is reached or the chassis contacts the ground. Note that the entered g value does not necessarily mean the car will be able to reach that g level. Therefore the value entered should be representative of the vehicle. Suggested are 2-3g for on-road and 1-1.5g for off road. If the entered g value is positive the chassis will roll CCW (left) if the value is negative the chassis will roll CW (right).

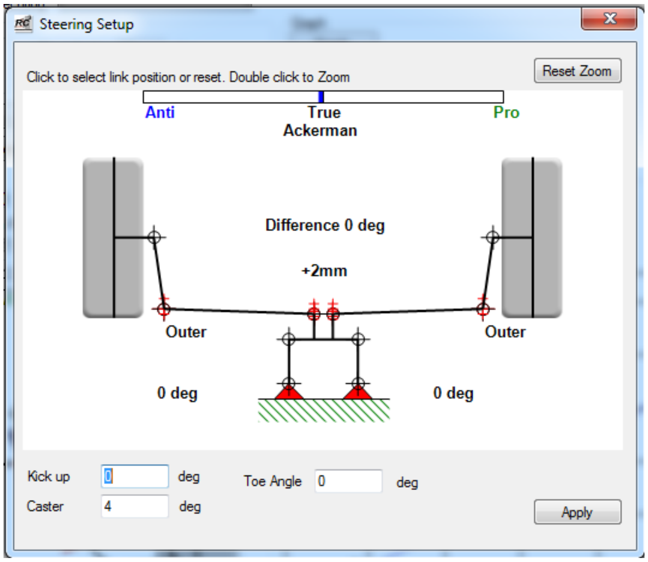
Use the slider control to set the animation speed. Click the Animate button to initiate the Animation.

Select the Front or Rear Suspension radio buttons to manipulate the settings on that end of the car.

The Front Suspension allows the Outside Wheel Steer Angle to be set to simulate the effects of steering angle on tire camber. The resultant Steer Angle of the inside wheel is calculated based on the steering model. If no steering model is entered this function is disabled.

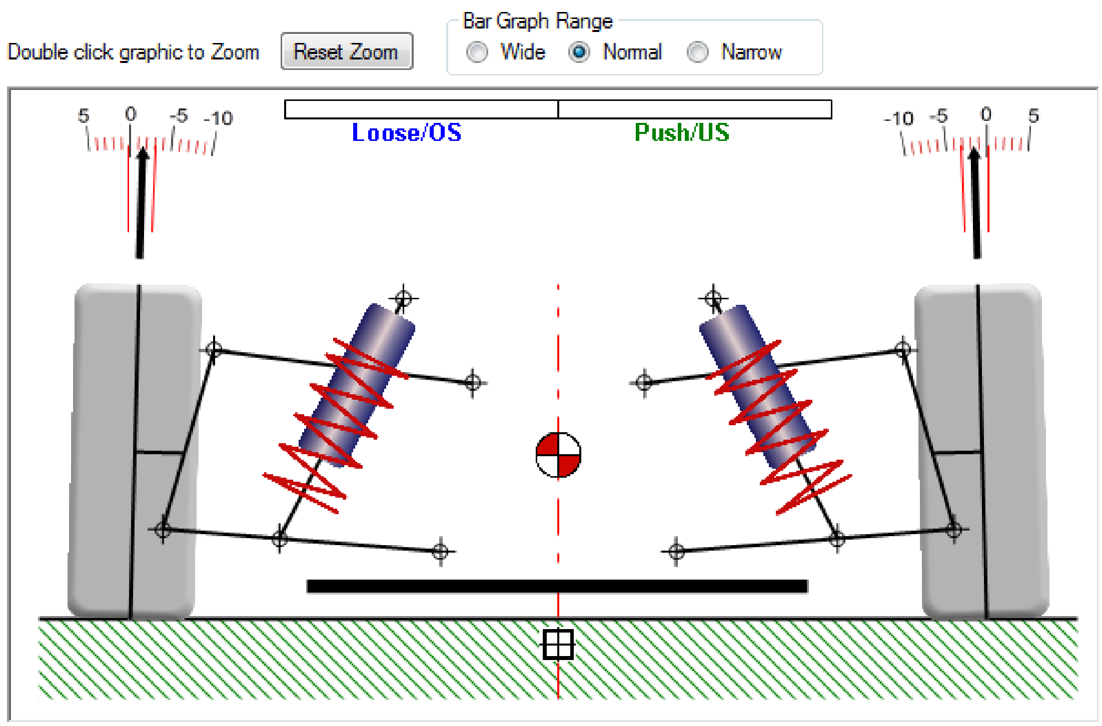
As suspension settings are altered the simulation will automatically execute and the graphing data will update. Simply select different Steer Angle, spring, ARB, Droop or click the Suspension, Shock or Steering buttons to change the setup and see the effects.





Area 2 - Animation Graphic

Clicking the Animate button initiates the animation sequence. As the chassis rolls the arrow pointer indicating the tire camber angle will move to show the range of camber change. When the animation ends two lines that represent the total

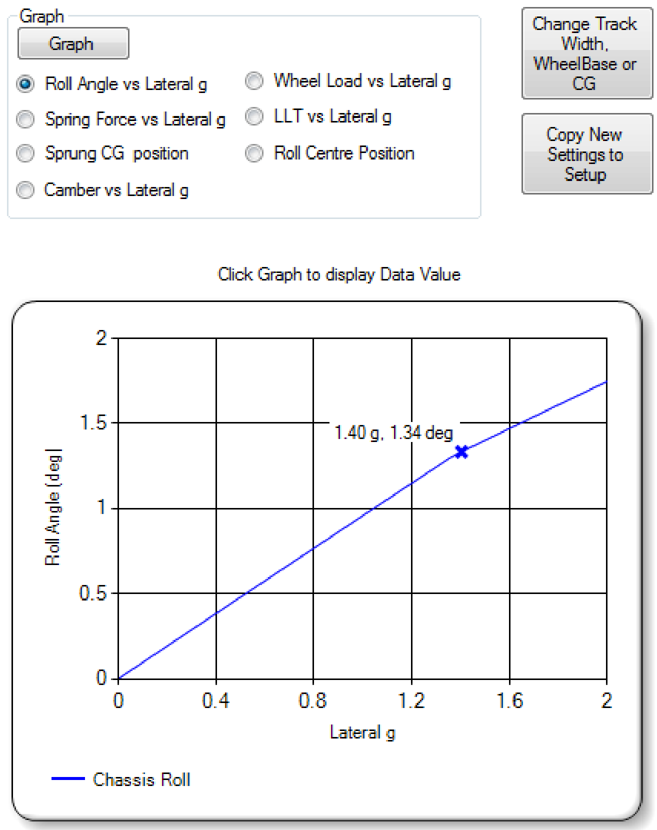


range in camber angle change will appear. Another feature of the animation graphic is the push-loose bar graph. This graph displays the predicted handling tendency based on the weight transfer balance between the front and rear suspension. It is also helpful to showing the effects droop settings have on handling. If required the bar graph display range can be changed to suit the animation by selecting the Narrow-Normal-Wide radio buttons.

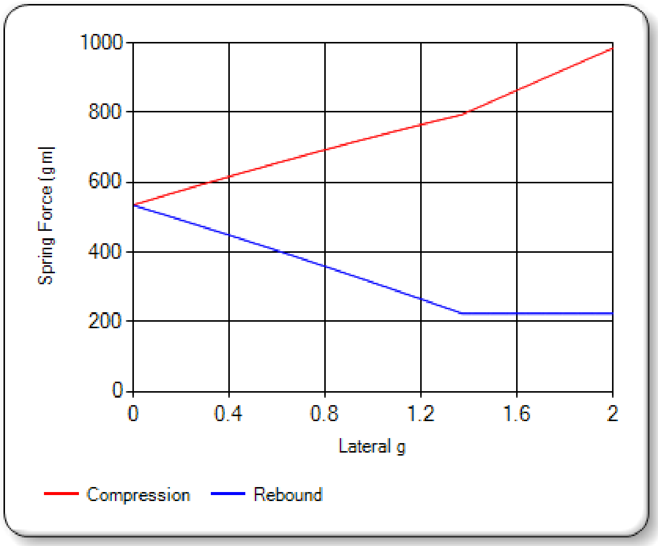
To zoom in to an area of interest double click on the image. Click the Reset button to return to the full size image. Zoomed image will not display the camber gauge or bar graph,

Area 3 – Graphical Results

In addition to the animation image, results can be displayed in graphical format. The following outputs are provided.

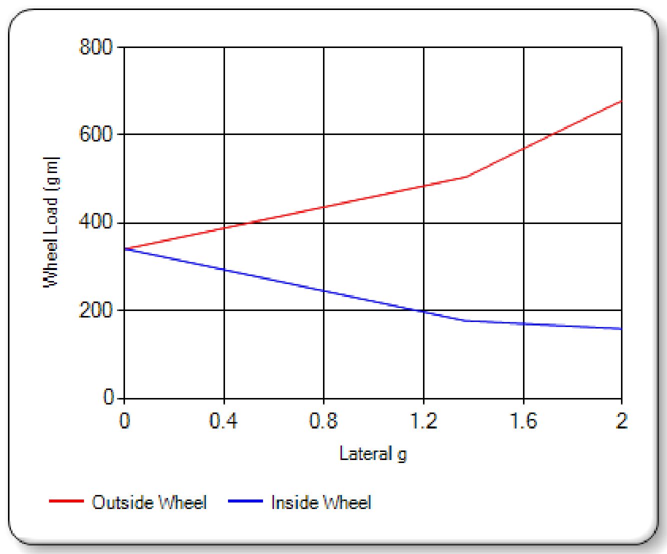


Roll Angle versus Lateral g – Graphs the chassis roll angle up to the maximum lateral g entered in the Animation Settings. The slope of the line is the Chassis Roll Sensitivity which was discussed in the setup section. The shallower (lower) the slope the higher the roll stiffness and more responsive the car will be. The change in slope in the upper region of the adjacent graph is the point where the inside suspension arm has reached the droop limit. Once this limit is reached the inside shock no longer extends. As the roll angle increases with increasing g the outside spring continues to compress but the inside shock remains fixed and does not release any of the remaining stored spring force. This causes the roll stiffness to increase which is indicated by the reduced slope of the curve in the upper g range. Clicking on the line will display the data value at the selected point.



Spring Force versus Lateral g - provides two shock curves, one for compression side, and one for rebound side. The effect described above for the inside wheel (rebound shock) when the droop limit is reached can be seen at approximately 1.5 g. At this point the shock spring force will remain constant at around 2.5N as both lateral g and roll angle increase.

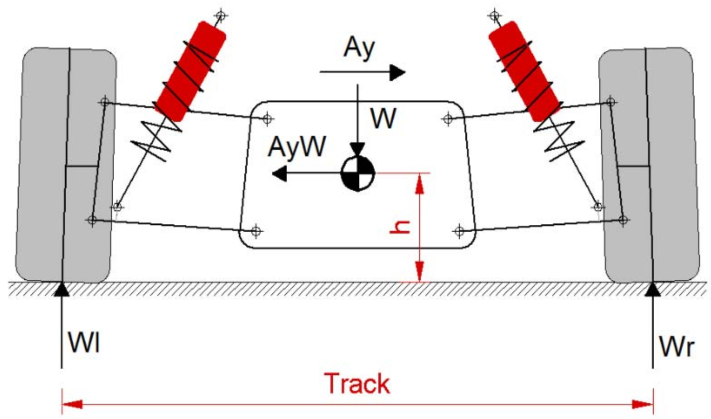
Wheel Load versus Lateral g – Similar to the Spring Force Graphs are the Wheel Loads vs Lateral g for each wheel.



Again the point where the droop limit is reached can be identified by the change in slope of the graphs at around 1.5g. Once the droop limit is reached all the force transfer from the sprung mass is absorbed by the outside wheel, the red line. From that point on the inside wheel, blue line, only transfers the force due to the un-sprung mass. This affect provides some very interesting tuning possibilities. In some cases you may not want to reach the roll droop limit as you can see this introduces an abrupt change in the roll stiffness which can induce unstable or twitchy handling. However used wisely it can and is a very effective tool to induce US or OS at the higher end of the g range. Which result you get will depend on which end of the car reaches the droop limit first. Normally you will set the front droop less than the rear so you will have a tendency to US at high g. Setting the rear less than the front will have a tendency to OS which can help get the car to rotate but may be more difficult to drive.

Lateral Load Transfer (LLT) versus Lateral g – LLT is the amount of load that is transferred from the inside wheels to the outside wheels during cornering. The equation to calculate the total vehicle LLT from the inside tires to the outside tires is quite simple:

$$Wl - Wr = LLT = \frac{Ay * W * h}{Track}$$



$Where$

$Wr = Total\ Load\ on\ Right\ Side\ Tires$

$Wl = Total\ Load\ on\ Left\ Side\ Tires$

$W = Total\ Vehicle\ Weight$

$Ay = lateral\ acceleration\ in\ g\ units$

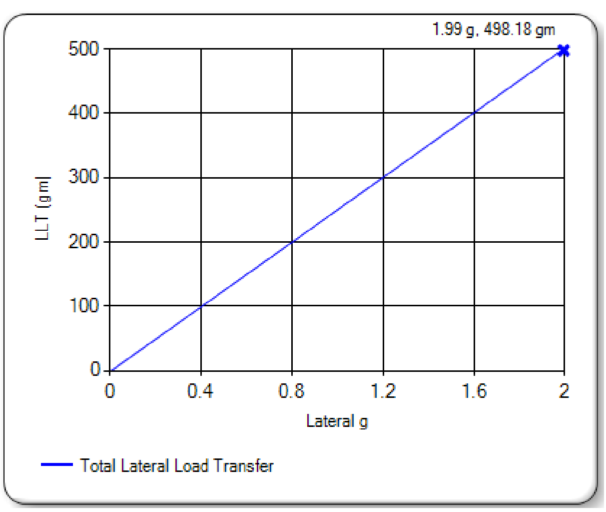
$h = Height\ of\ car\ CG\ aboveground$

$Track = Car\ track\ width\ measured\ between\ tire\ centrelines$

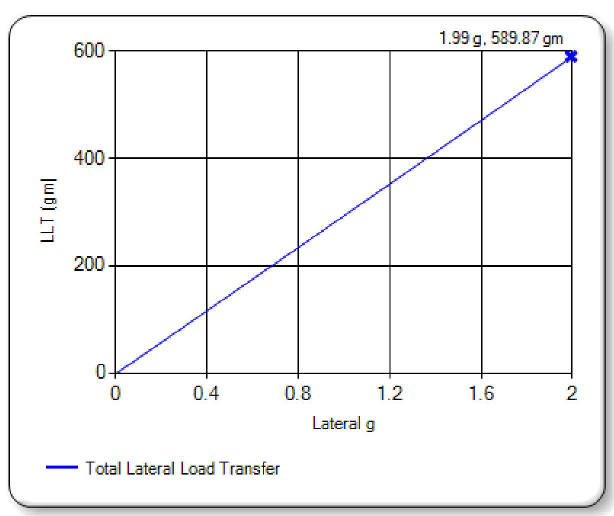
The goal in weight transfer is to minimize the total LLT and then proportion it between the front and rear tires to achieve the desired handling characteristics.

To minimize the vehicle LLT you want to reduce the car weight, lower the CG or increase the track width. Ok so why would you want to reduce the LLT. The reason is tires. Consider two load cases with tire pairs both carrying the same total loads. In the first case the tires carry close to the same load (low LLT) and in the second case the tires carry significantly different loads (high LLT). Because of the way tires convert vertical load into lateral grip the tires with low LLT will produce more grip than the Tires with high LLT.

Once the vehicle LLT has been minimized as much as possible the next step is to proportion it between the front and rear tires. Selecting the **LLT vs Lateral g** graph



Front Suspension

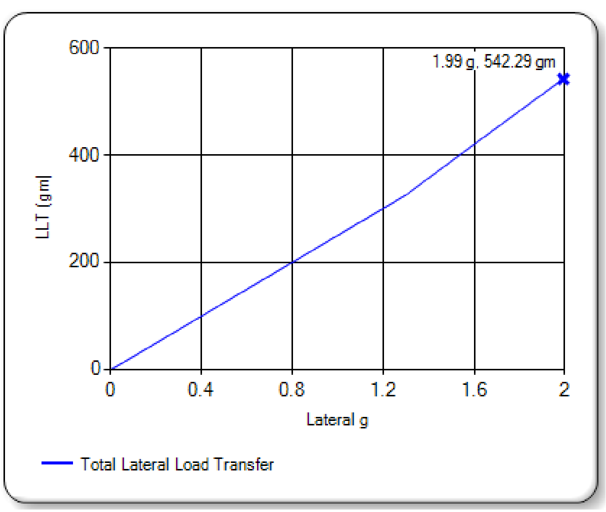


Rear Suspension

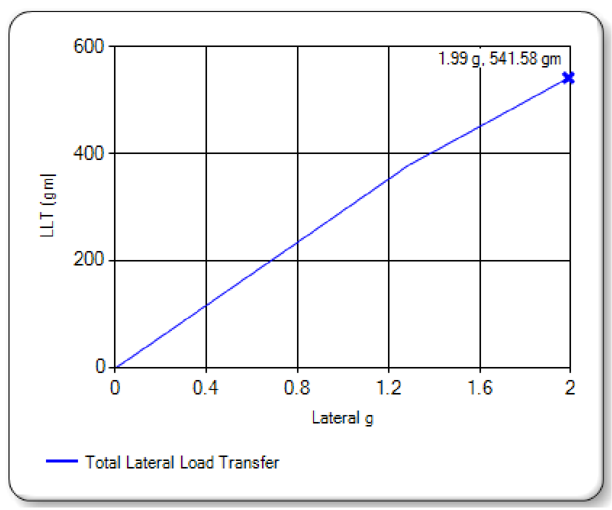
displays the weight transfer for the selected suspension. The sample graphs below display the LLT for the front and rear suspension. Observe the difference in the graphs.

Looking at the LLT data values at 2g the front end is transferring 498 gm and the rear is transferring 589 gm. Total LLT for the vehicle is 1187 gm. The reason more load is transferred at the rear than the front is a result of the rear roll stiffness being setup stiffer than the front. This setup based purely on the proportioning of the LLT the handling would be biased slightly to oversteer (loose) because the rear is transferring more weight than the front. General guideline being the end of the car that transfers the greater proportion of the weight will lose grip first.

To illustrate how we can make a simple change and affect the weight transfer the next pair of graphs show the effect of reducing the front droop from 3mm to 1.5mm.The point where the slope of the line changes indicates when the droop limit is reached. This occurs at around 1.3g. Below this point the handling would be the same as the previous example since the suspension stiffness is unchanged. Above 1.3g the front suspension stiffness increases significantly and the LLT proportioning is changed. Now at 2g the front transfers 542 gm and the rear transfers 542 gm. The weight transfer handling tendency should now be neutral as proportion is balanced. So the weight transfer handling tendency of this setup would be slightly loose on low speed corners and neutral at the limit.



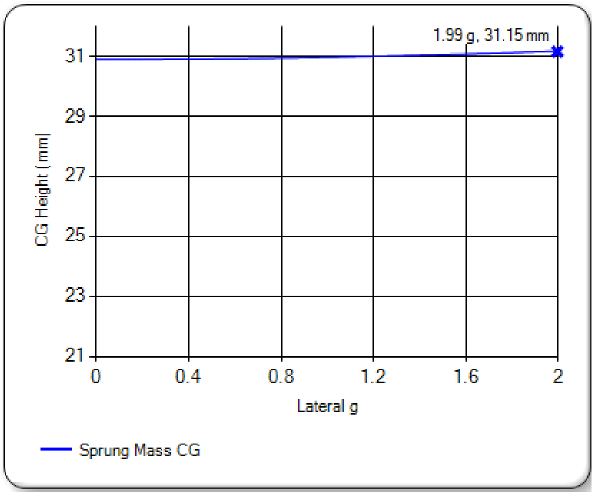
Front Suspension

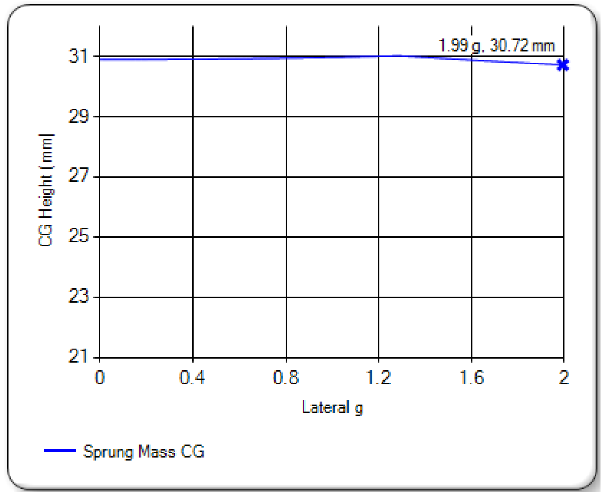


Rear Suspension

Note that the vehicle LLT is now 1184gm which is slightly less than the previous example. This change is a result of changes to the sprung mass CG and roll centre heights which will be discussed next.

The effect on the CG position of reducing front suspension droop can be seen the Graphs below. At the 2 g limit the droop limited suspension lowers the CG by .4mm,

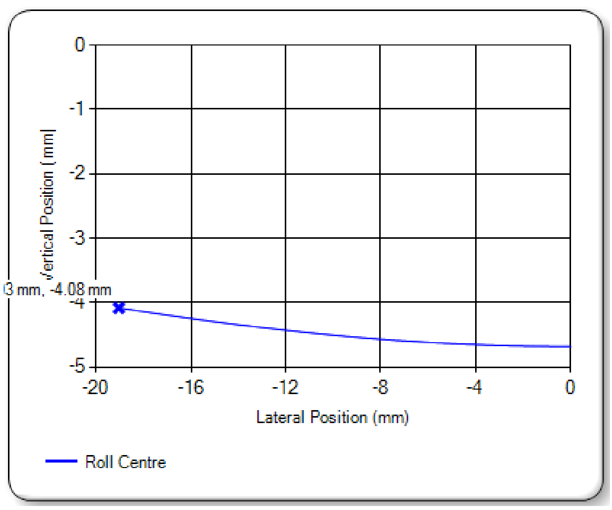


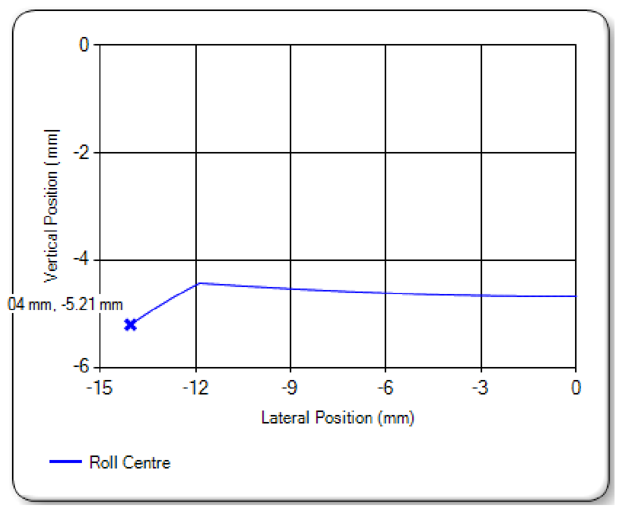


Roll not Droop Limited

Roll Droop Limited

which on its own would reduce the LLT and increase the overall grip. However the droop limited suspension also affects the Roll Centre position as can be seen in the next series of graphs.





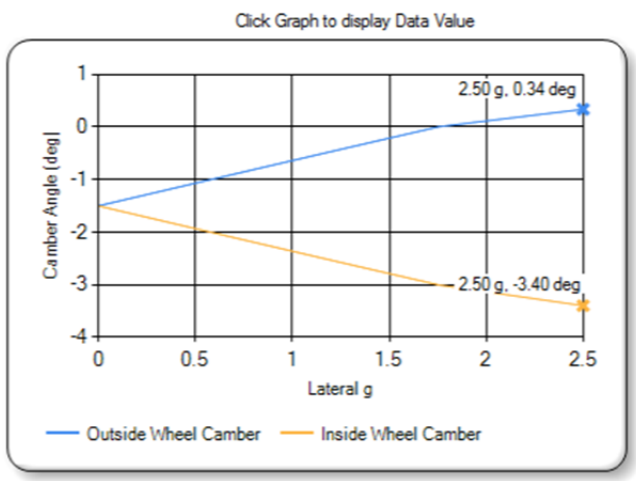
Roll not Droop Limited

Roll Droop Limited

Reducing front suspension droop lowers the Roll Centre 1.1 mm and also reduces the lateral movement by about 5mm. The important point is to remember in this example is that a single change can affect a number of suspension properties. Knowing which property has the most impact is key to making good decisions when making setup changes. In this case the changing the front droop, significantly increases the front roll stiffness in the higher lateral g range. The increased front roll stiffness moves more weight transfer to the front.

A good general rule to follow is the end of carr with the greater roll stiffness will have the greatest LLT and consequently the lowest grip based on weight transfer.

Camber Angle versus Lateral g – The graph displays the tire camber angle relative to the ground for the inside and outside wheel over the simulation g range. This is a very key graph to use in optimizing chassis setup. The camber angle starts at the static value set on the setup tab and then either increases, inside wheel, or decreases, outside wheel. By changing the length and/or angle of the camber link the amount of camber gain change can be adjusted and the effects observed using this graph.



In this example the camber angle goes positive on the outside wheel which is not likely to produce the maximum grip. Either more static camber or more camber gain can be used to improve this situation.

So to summarizes there are three key factors to achieving the best possible setup:

- Tires, tires, tires. Get the right tires. Tires are 90-95% of the handling.
- Maximize the contact patch of the tire with the ground. You do this by adjusting the static camber and camber gain to match the chassis roll.
- Adjust droop, roll stiffness and roll centres to proportion the LLT where you want it.

That`s the beauty of a simulation, now you can quickly try out many possibilities and then pick one to try on the track knowing what to expect. Experiment and you won't be sorry.