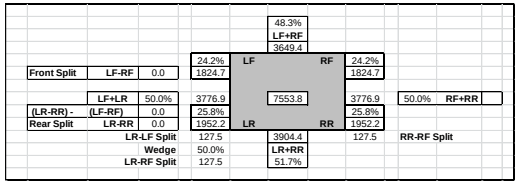
How Wheel Load Distribution Affects Car Handling Balance

Finding the Front and Rear load splits

Add the wheel loads calculated last week to a simple load split calculator



					48.3%				
					LF+RF				
					3649.4				
			24.2%	LF		RF	24.2%		
Front Split	LF-RF	0.0	1824.7				1824.7		
	LF+LR	50.0%	3776.9		7553.8		3776.9	50.0%	RF+RR
(LR-RR) -	(LF-RF)	0.0	25.8%				25.8%		
Rear Split	LR-RR	0.0	1952.2	LR		RR	1952.2		
	LR-LF Split		127.5		3904.4		127.5	RR-RF Split	
	Wedge		50.0%		LR+RR				
	LR-RF Split		127.5		51.7%				

[Rowley Load Split Calculator]

We can now see how this will influence the handling behaviour of the car

A definition of handling

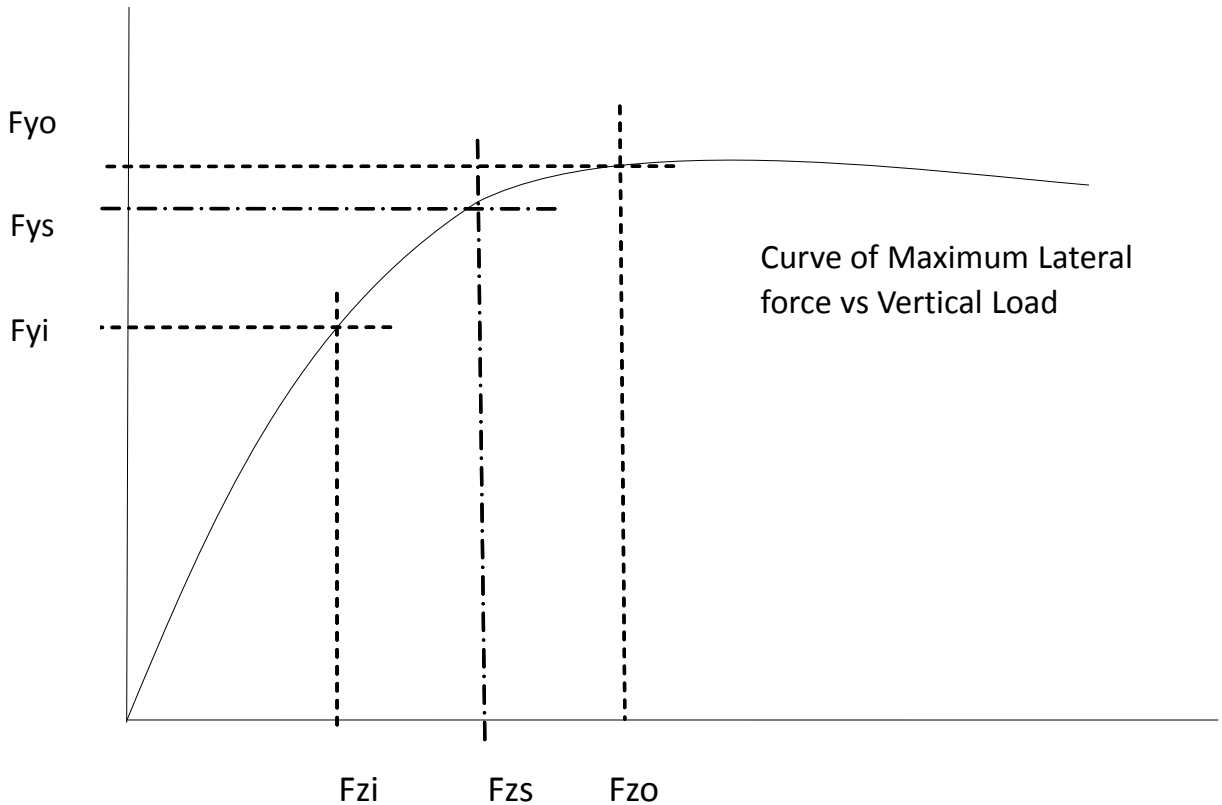
"Handling" is different to maximum steady state lateral acceleration ("grip") Slightly awkward to define

Prodrive's working definition:

> "a quality of a vehicle that allows or even encourages the operator to make use of all the available grip"

The capability of the tyres at each end of the car to provide the required lateral force required to achieve the required lateral acceleration for the vehicle mass will determine the car’s handling balance

Typical Tyre Behaviour



Increasing Weight transfer

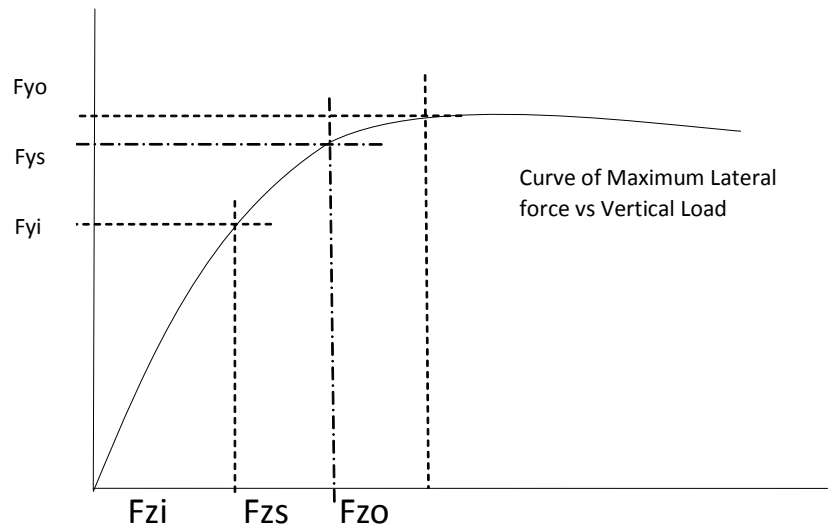
The greater the weight transfer the greater the difference in vertical loads between inner and outer wheels or load split.

The greater the split

the greater the loss

of lateral force from the

axle as a whole.



Effect of different load splits

The greater the load split the greater will be the loss of grip.

So:

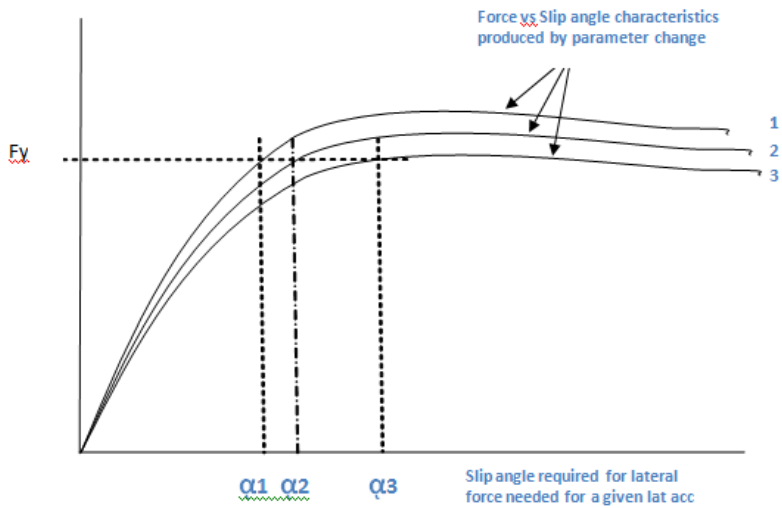
If the load split is greater at the front of an otherwise symmetrical car it will understeer

If the loss of grip is greater at the rear of an otherwise symmetrical car it will oversteer

This handling balance will show itself to the driver through the steering behaviour of the car

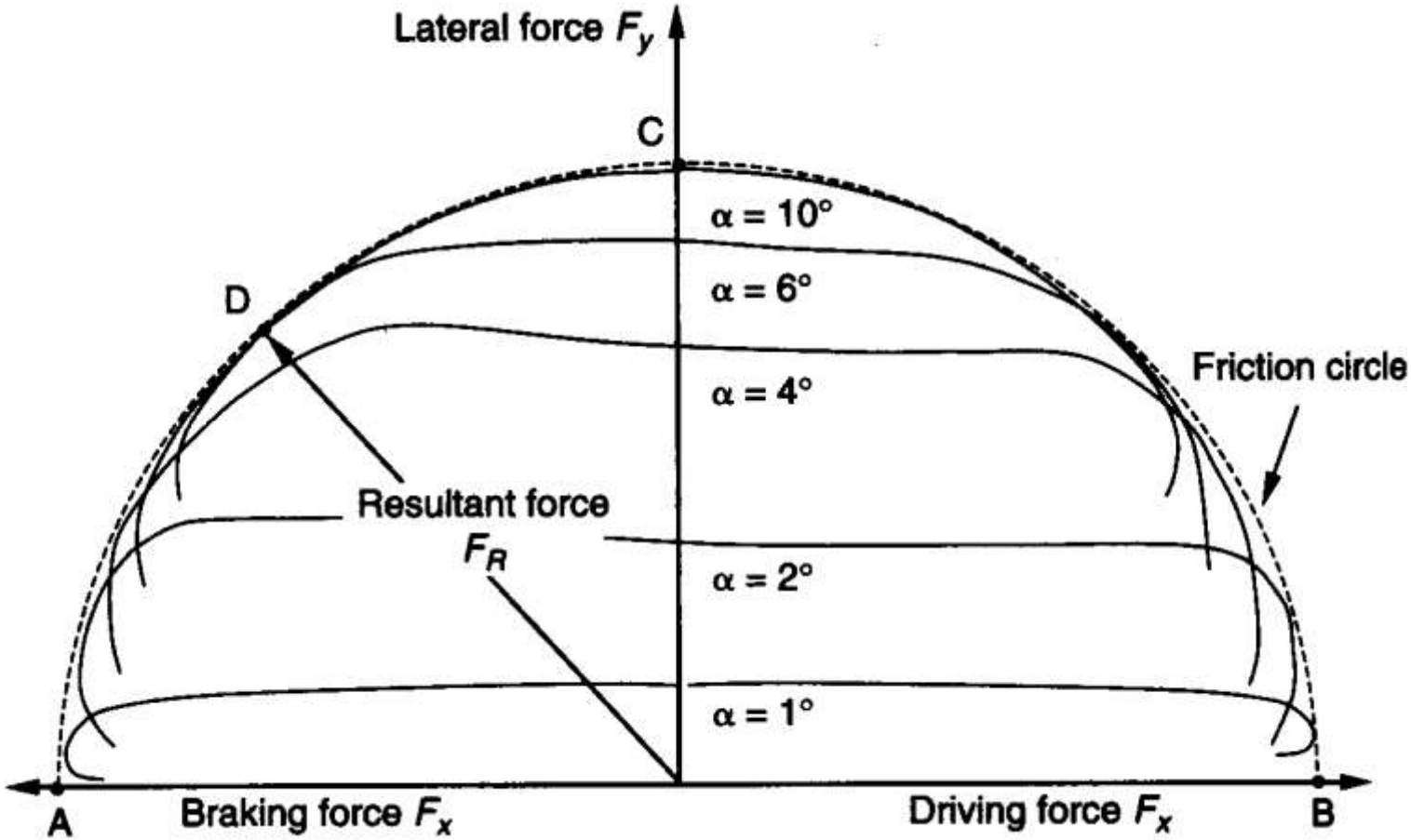
Steering behaviour indicating handling balance

If something is done to the front axle of a car that increases the grip characteristic from Level 3 to Level 1 the slip angle required to produce the force required for specific lateral acceleration will change from α_3 to α_2

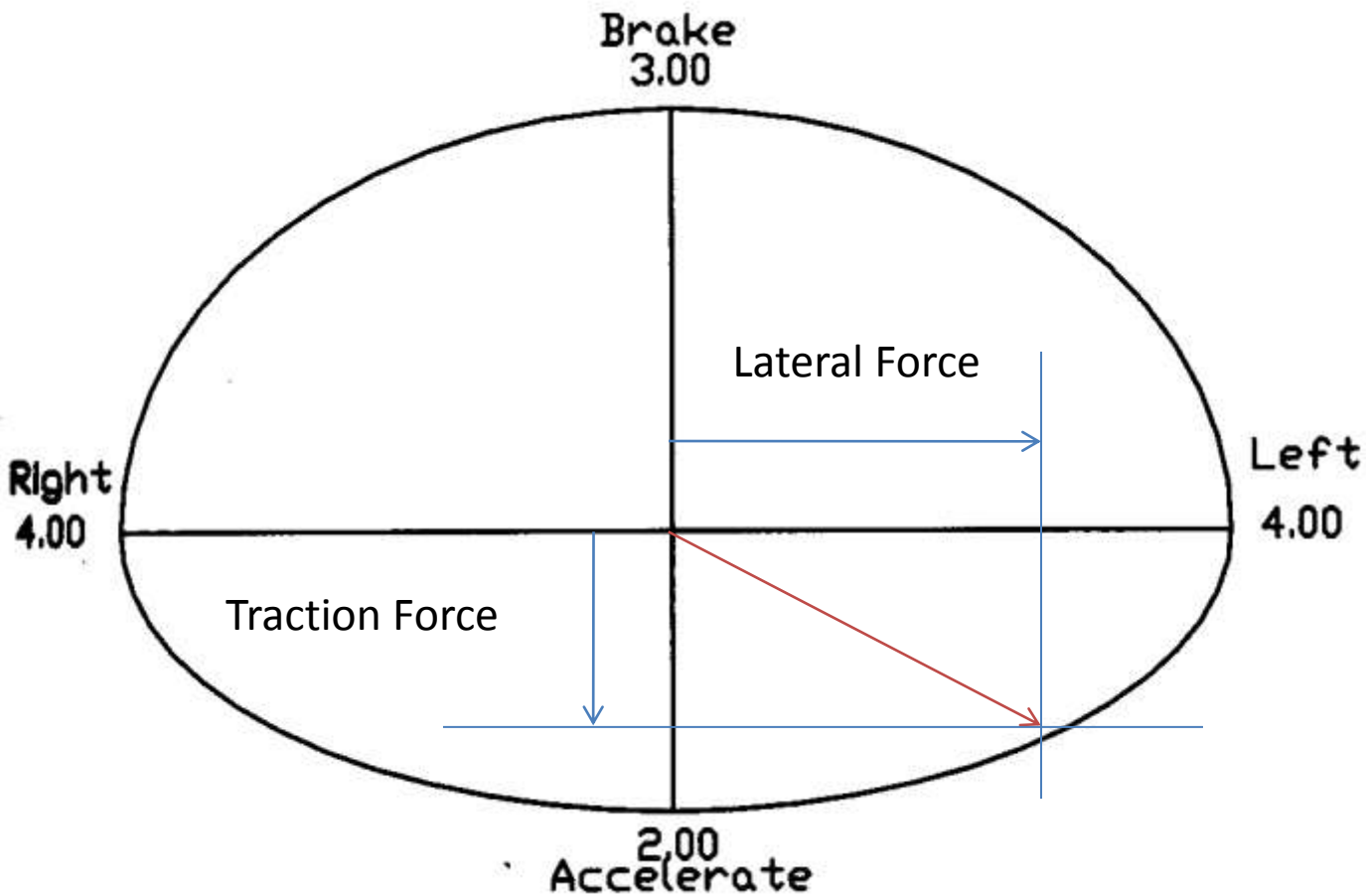


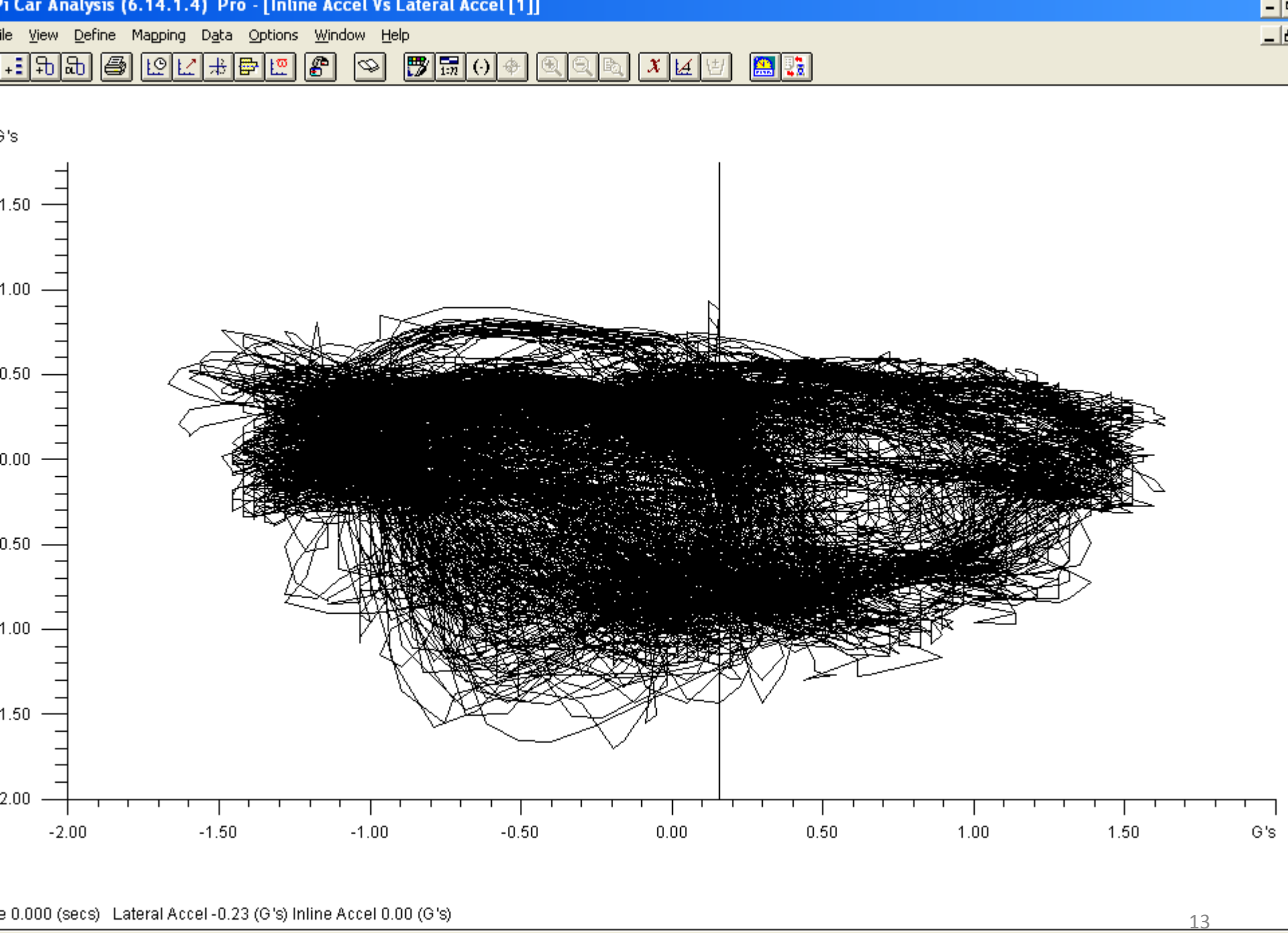
Traction and braking forces will further reduce the lateral force available for cornering and influence the handling balance.

Traction Circle



Traction Circle (another version)




i Car Analysis (6.14.1.4) Pro - [Inline Accel Vs Lateral Accel [1]]
ile View Define Mapping Data Options Window Help
G's
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-0.50
0.00
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G's
e 0.000 (secs) Lateral Accel -0.23 (G's) Inline Accel 0.00 (G's)
042:002:001 - 034 59:45.76 MATT GT 2
Inline Accel (G's)
Brands Indy

Having determined the relative grip available at each end of the car we now need to define how the handling of the car can be described

Basic Definitions

$$\text{Overall Steering Ratio} = \frac{\text{Steering Wheel Angle}}{\text{Road Wheel Angle}}$$

So

$$\text{Road Wheel Angle} = \frac{\text{Steering Wheel Angle}}{\text{Overall Steering Ratio}}$$

Neutral Steer

The SAE defines neutral steer as :

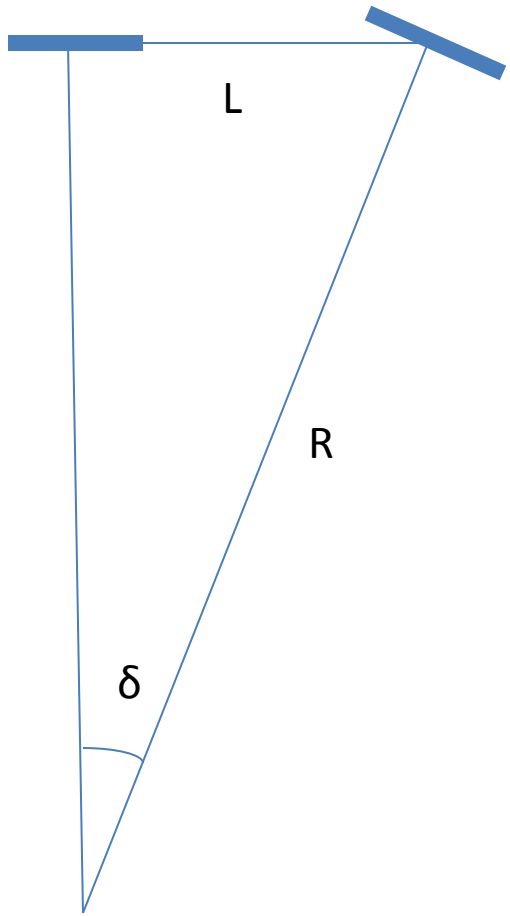
A vehicle is neutral steer at a given trim if the ratio of the steering wheel angle to the overall steering ratio [ie the actual steered wheel angle] equates to the Ackerman steering angle for a given radius of turn.

Ackerman Steering

Ackerman steering angle δ is the geometric steered wheel angle required for a car of wheelbase L to track round a turn of radius R at low speeds where the external forces due to accelerations are negligible so

$$\delta = L / R \text{ for small angles.}$$

Ackerman Steering Angle



Which means …

If the amount you have to turn the steering wheel to go round a particular corner at speed is the same as when travelling at very low speed then that is neutral steer

Understeer

A vehicle is understeer at a given trim if the ratio of the steering wheel angle to the overall steering ratio is greater than the Ackerman steering angle for a given radius of turn

Which means....

If the amount you have to turn the steering wheel to go round a particular corner at speed is greater than when travelling at very low speed then the car is understeering

Oversteer

A vehicle is oversteer at a given trim if the ratio of the steering wheel angle to the overall steering ratio is less than the Ackerman steering angle for a given radius of turn

Which means…

If the amount you have to turn the steering wheel to go round a particular corner at speed is less than when travelling at very low speed then that is neutral steer

Finding the Ackerman Steering Angle from track data

To create a radius of turn R channel in a data acquisition system then

$$a = v^2 / r \quad .$$

V and a will be known channels giving :

Rad =Pow([Speed], 2) /[Lat acc]

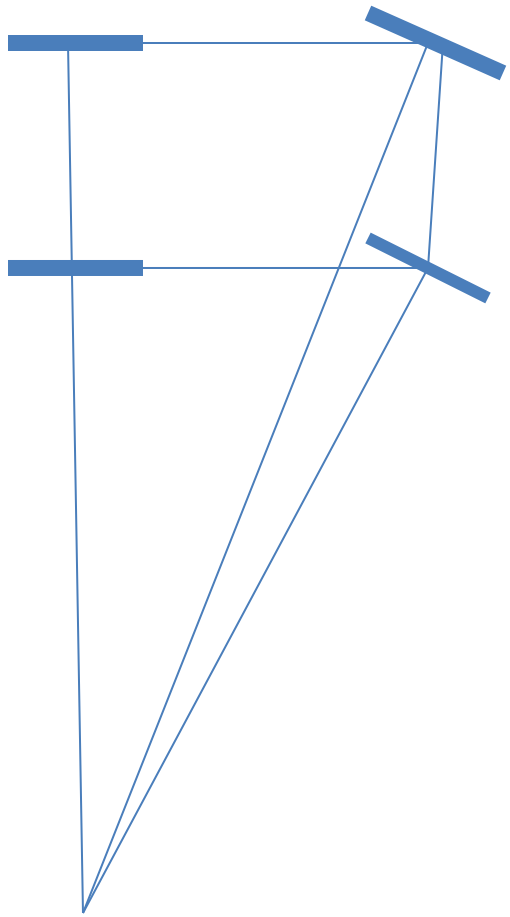
This can be compared with actual road wheel angle to determine whether the car is oversteer or understeer

Ackerman Steering Geometry is <u>not</u> Ackerman Steering Angle!

The **Ackerman Steering Geometry** is the design of the steering mechanism that enables both inner and outer steered wheels to have the correct steered angle so that they both drive round the same turn centre. In line with the rear axle with no slip angle.

The SAE effectively defines **Ackerman Steering Angle** as the angle of the road wheels that is required with zero front and rear slip angles for both front and rear wheels to track around the same centre.

Ackerman Steering Geometry



Describing handling balance in terms of front and rear slip angles

(A commonly used description but not easily measureable on track)

Neutral steer :

If front and rear slip angles are the same

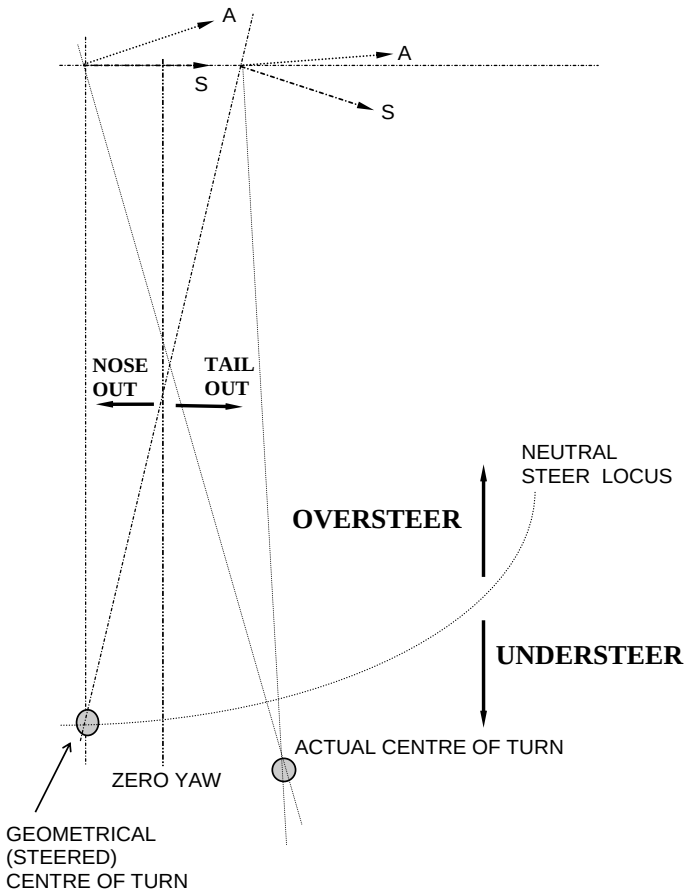
Over steer :

If front slip angle is less than rear

Understeer:

If front slip angle is greater than rear

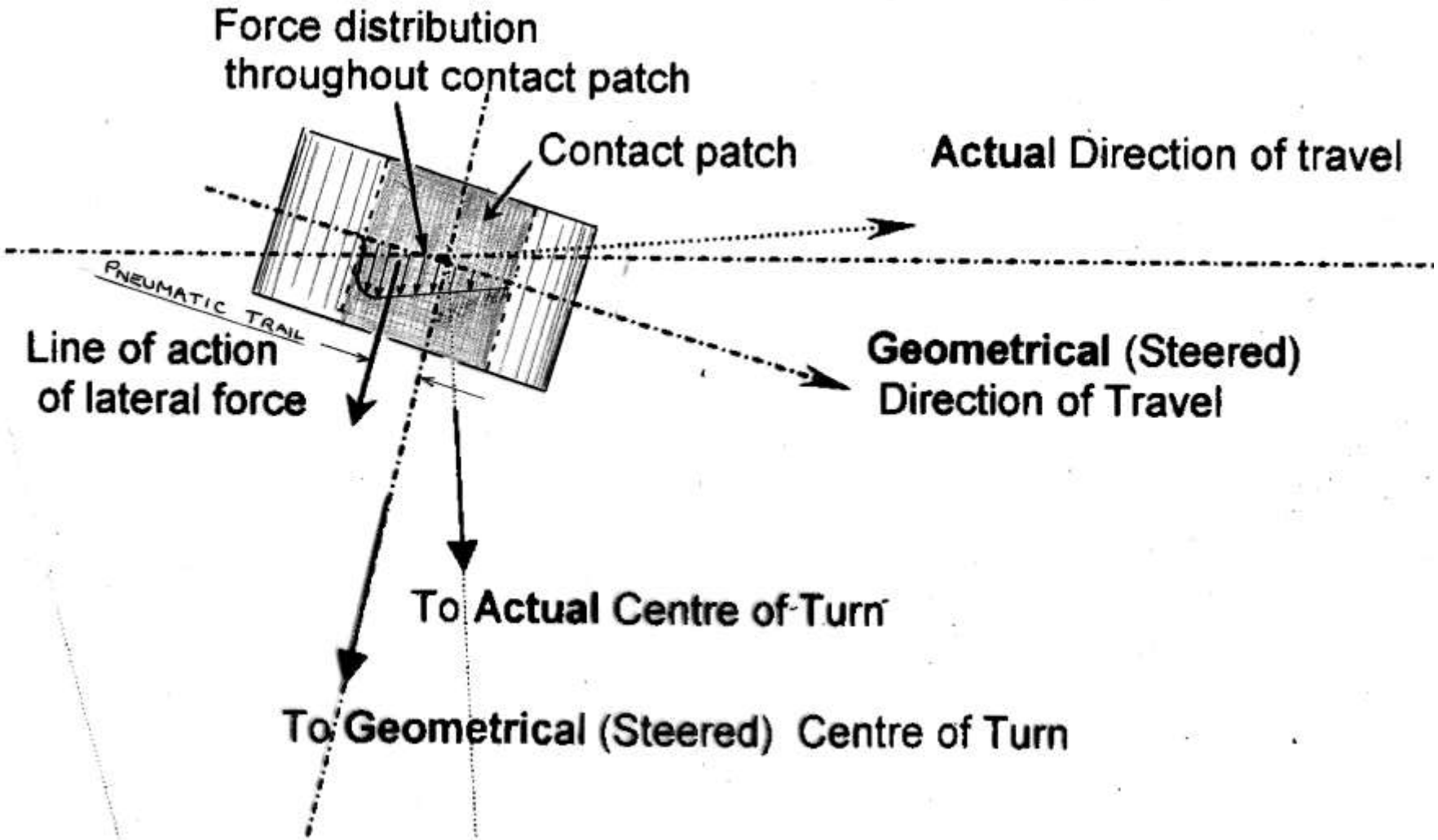
Geometrical method of demonstrating oversteer and understeer based on slip angle

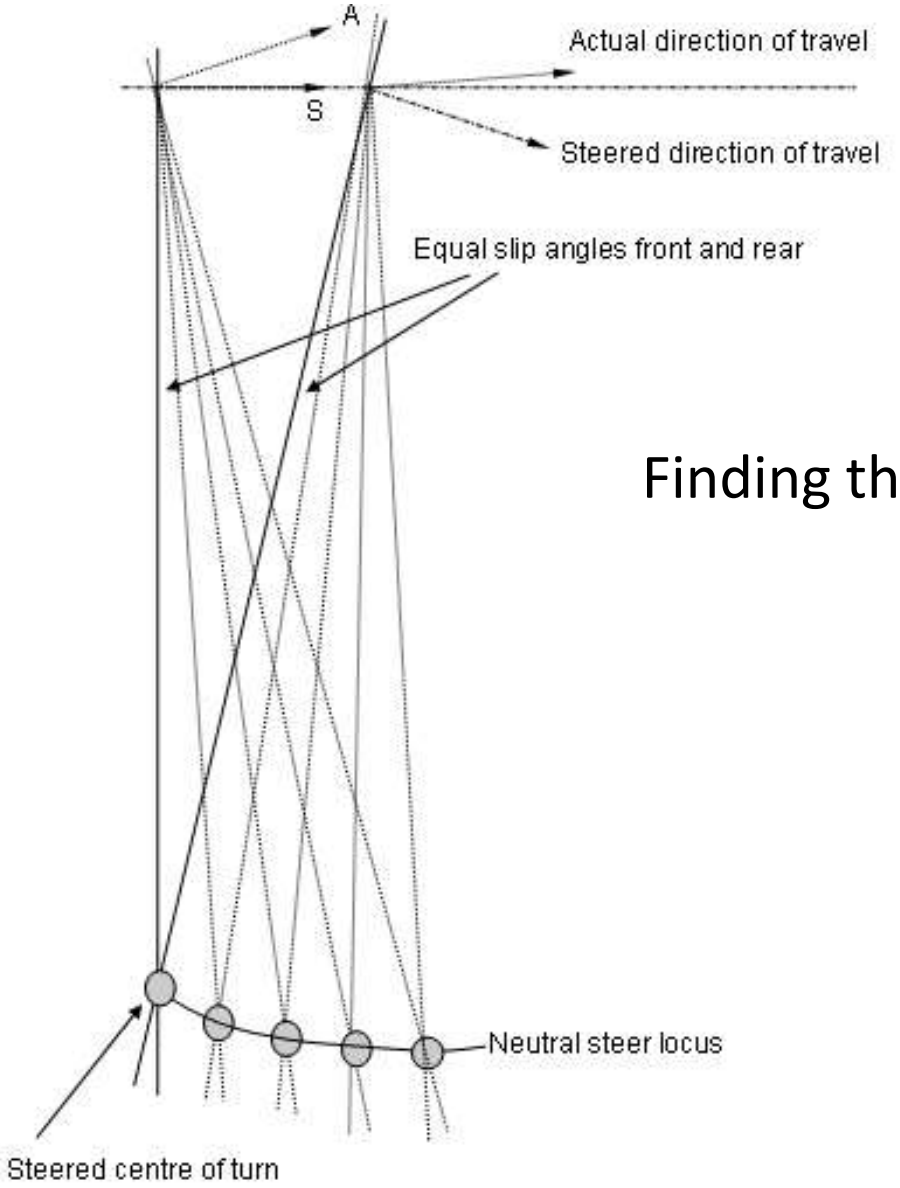


If the centre of turn is closer to the car than the neutral steer locus the car will be oversteer and if it is beyond the locus it is understeer .

So the car shown is understeer with tail out attitude.

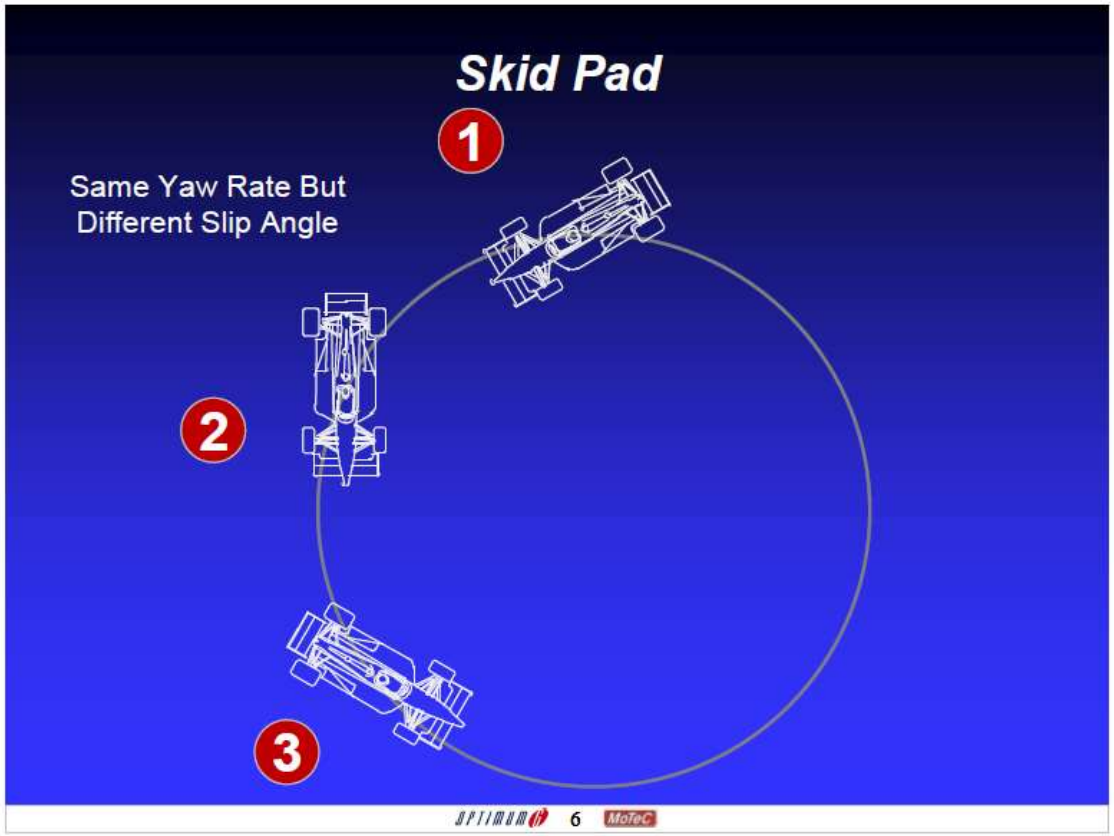
All cars go from a nose out to tail out attitude as speed increases


Force distribution
throughout contact patch
Contact patch
Actual Direction of travel
PNEUMATIC TRAIL
Line of action
of lateral force
Geometrical (Steered)
Direction of Travel
To Actual Centre of Turn
To Geometrical (Steered) Centre of Turn



Finding the neutral steer locus

Tail out cornering on the skid pad



Although this car is obviously ‘ tail out’ with the rear wheels following a larger radius than the front it could still be neutral steer.

Finally…..

Now consider how the load splits you found originally are likely to influence the handling behaviour of the car