Hochschule Kempten
University of Applied Sciences

drive livinglab

ADAS Master WS 20/21
Lecture 8

Vehicle Dynamics in context of Advanced Driver Assistance Systems and Automated Driving.

Lecture program

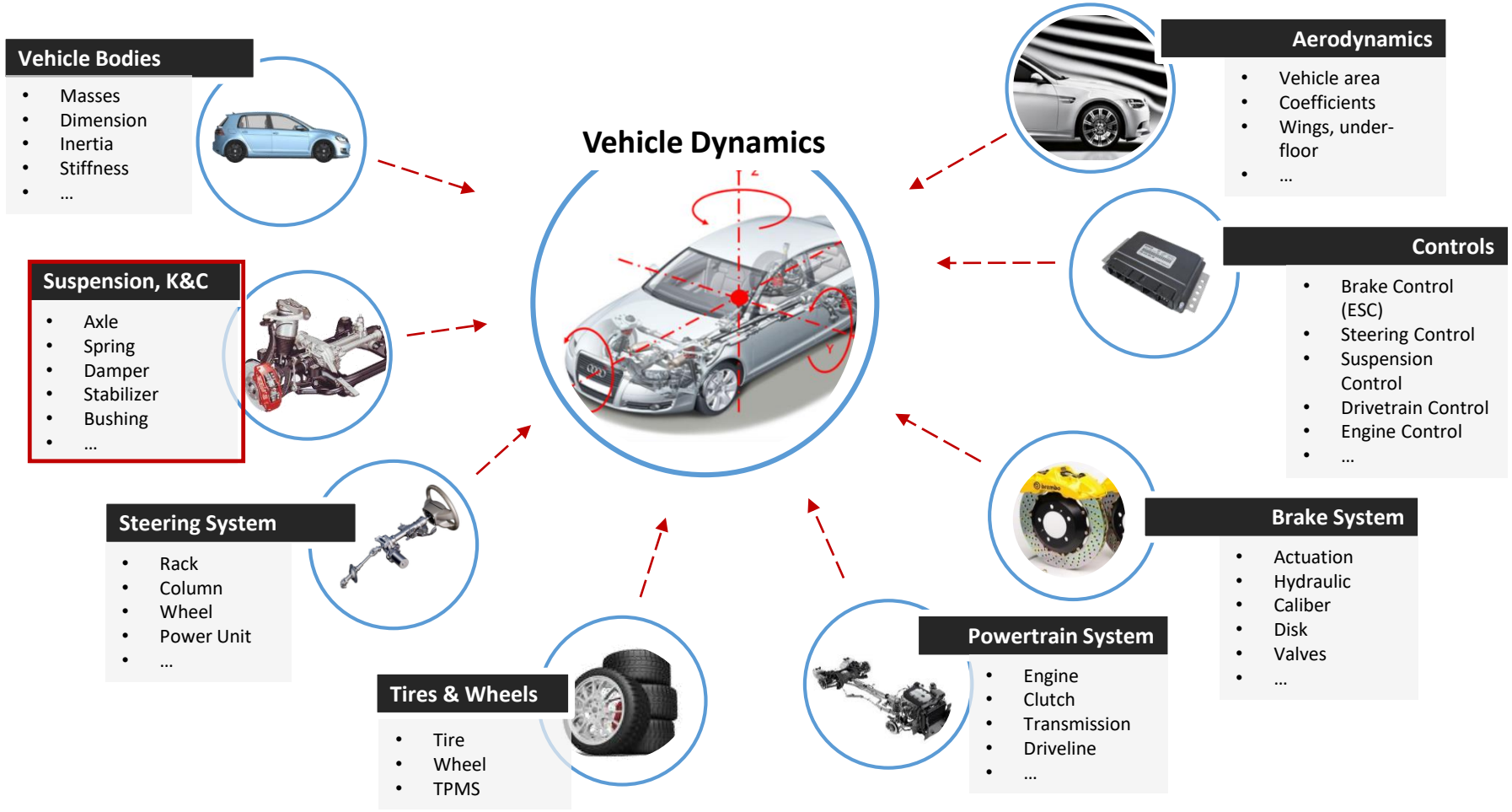
https://moodle2.hs-kempten.de/moodle/course/view.php?id=2914

Nr.	Datum	Inhalt	Ort	Von Wem
1	**01.10.**	**Virtual Test Driving (VTD)** **CarMaker Quick Start Guide**	**T314**	**Self-study**
2	08.10.	Requirements for vehicles and their global attributes	T314 Zoom	Schick
3	15.10.	Vehicle dynamics attributes and their target conflicts	T314 Zoom	Schick
3	22.10.	Test and evaluation methods for vehicle attributes (1) **with practical simulation**	T314 Zoom	Schick
4	29.10.	Test and evaluation methods for vehicle attributes (2) **with practical simulation**	T314 Zoom	Schick
5	**05.11.**	**ADAS DRIVING EVENT** Measurement Tech. Introductions	**Living Lab**	Günther/Riedlmüller/ Schwandke
6	12.11.	Basic vehicle dynamics calculation and vehicle models with exercise	T314 Zoom	Schick
7	**19.11.**	Chassis components and functions (1) Tire & Wheels	T314 Zoom	Schick
8	26.11.	Chassis components and functions (2) Axle & Suspension	T314 Zoom	Schick
9	03.12.	**TEND: ADAS Development for a sports car manufacturer**	T314 Zoom	Manuel Höfer (Porsche)
10	10.12.	Chassis controls and functions (1) Overview & Brakes & Steering	T314 Zoom	Schick
11	17.12.	Chassis controls and functions (2) ESP–Functions & Application & Process	T314 Zoom	Herr Lutz (BOSCH)
12	07.01.	**Chassis controls and functions (3)** **ESP–Application & Hands-On Workshop**	T314 Zoom	Herr Lutz (BOSCH)
13	14.01.	Analysis of international standards and application into the simulation	T314 Zoom	Schick
14	**21.01.**	**Exam preparation**	**T314**	**Schick**

Chassis components and functions – axle & suspension

The chassis provides the link between the vehicle body and the tyres/road.

Vehicle dynamics behavior is impact by numerous components



Chassis components and functions – axle & suspension

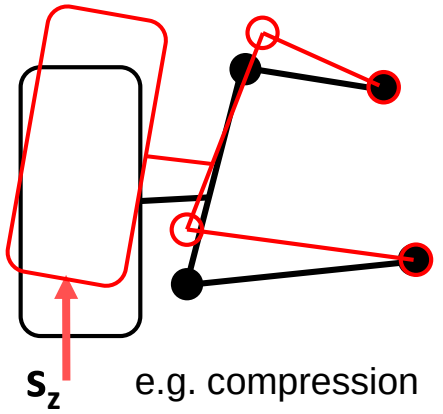
Chassis is responsible for the interconnection between the vehicle - including passengers and luggage - and the road

- Outer forces and moments are transferred via the tires via the suspension to the vehicle inner forces.
- The suspension is responsible to bring the tire into a optimal position for the force am moment transfer.

Important suspension characteristic behavior

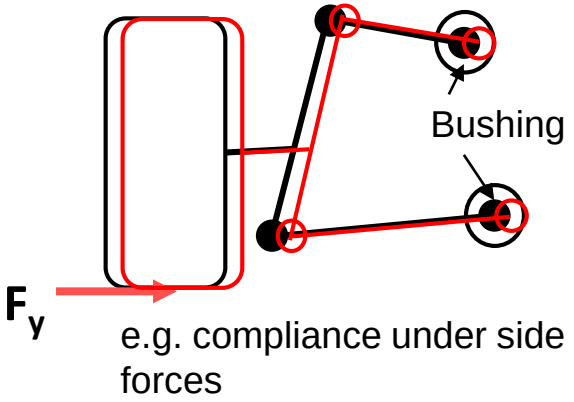
Kinematics

Description the change in the 3D wheel position which occur due to suspension compression, rebound and by steering movements.



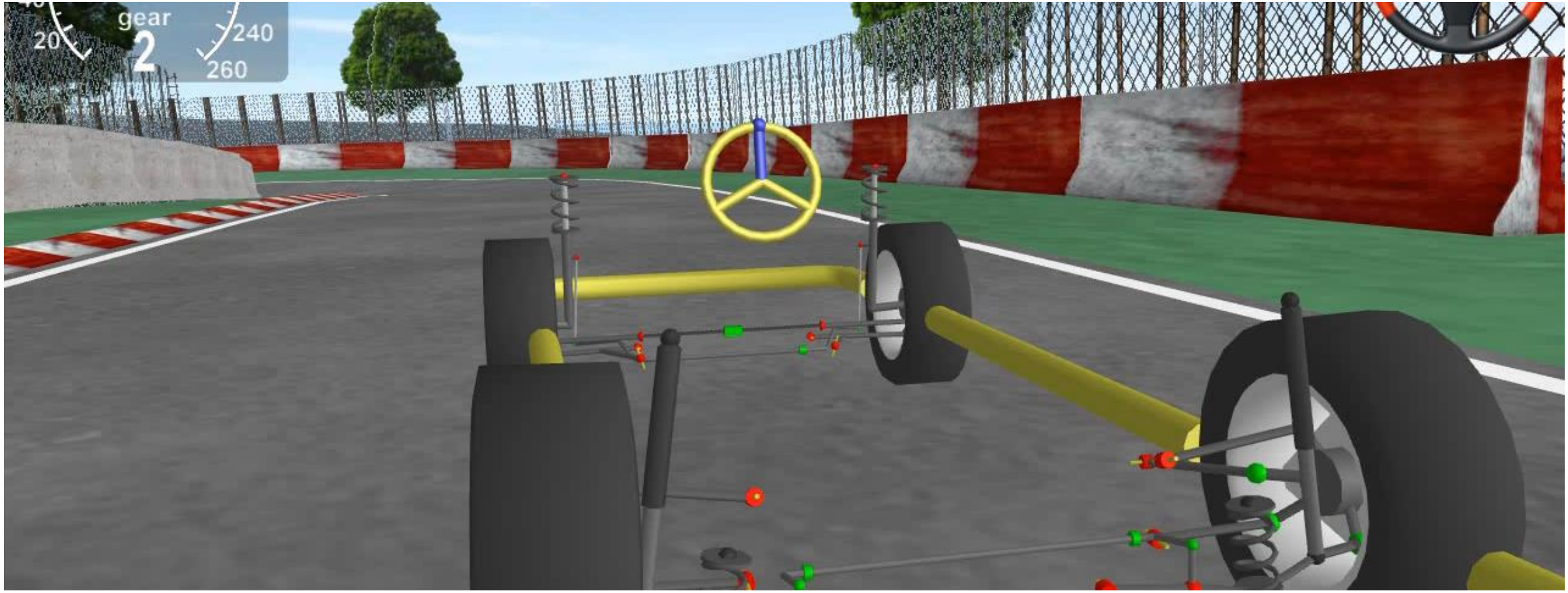
Compliance (elastokinematic)

Description the change in the 3D wheel position, which occur due to the forces and torques on the wheel / tire under targeted elastic interpretation of suspension parts.

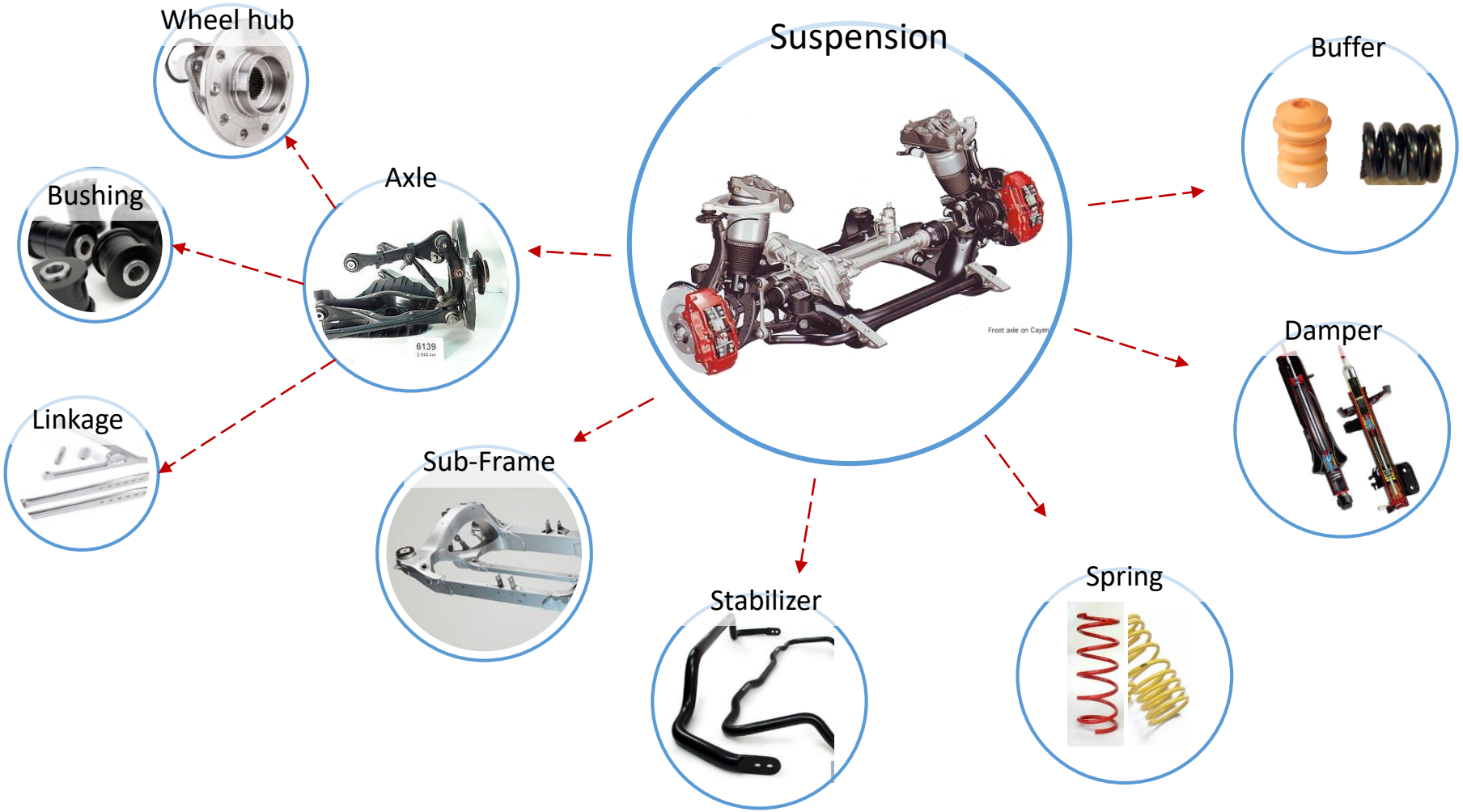


Chassis components and functions – axle & suspension

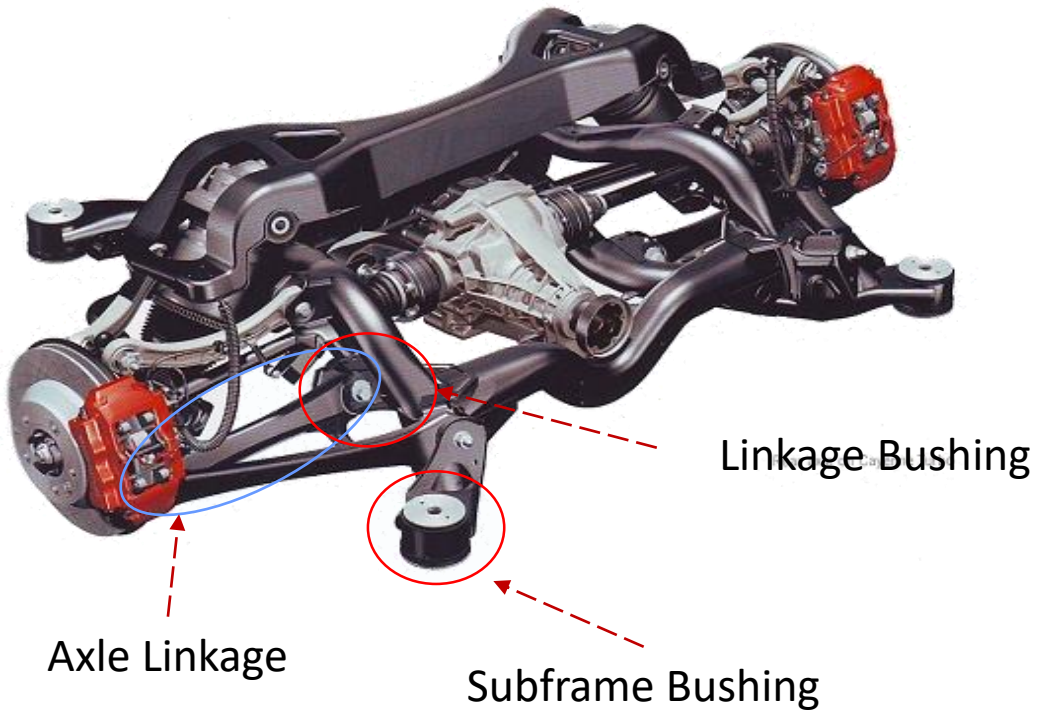
Axle, suspension, kinematics & compliance characteristics

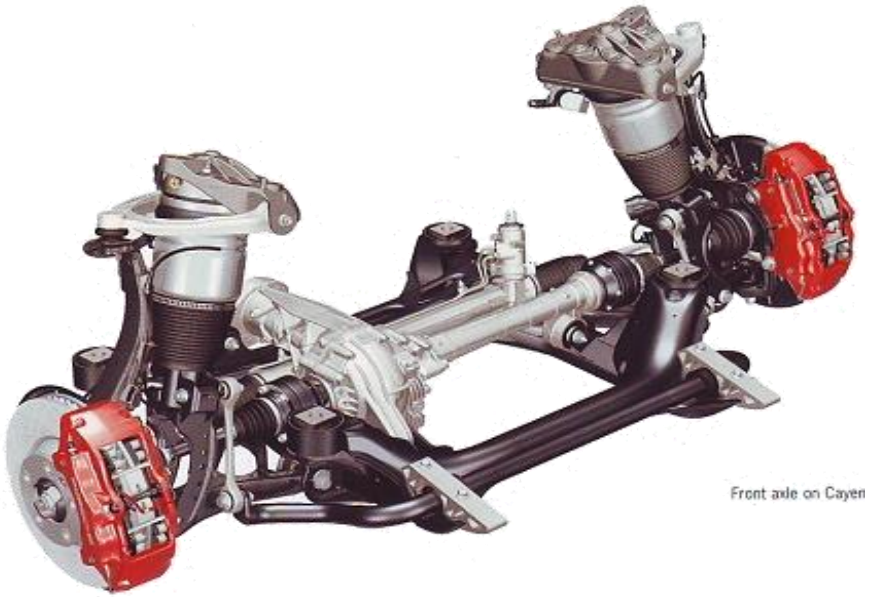


Suspension components

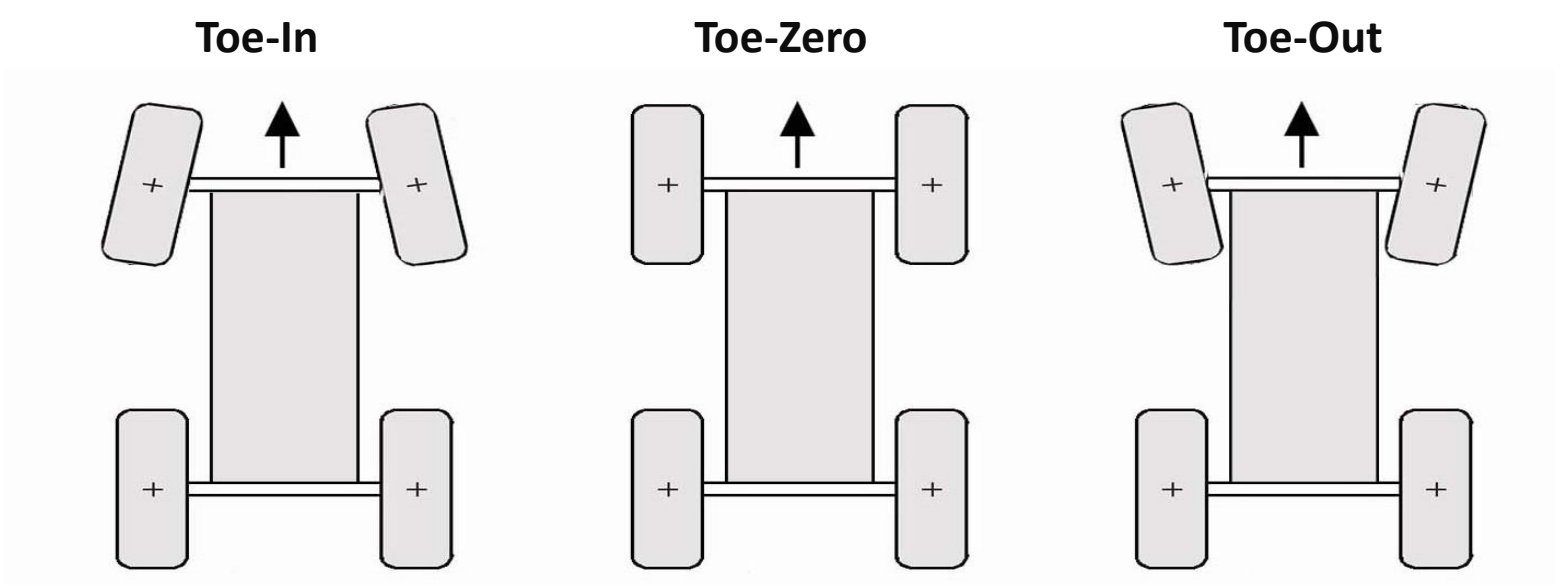


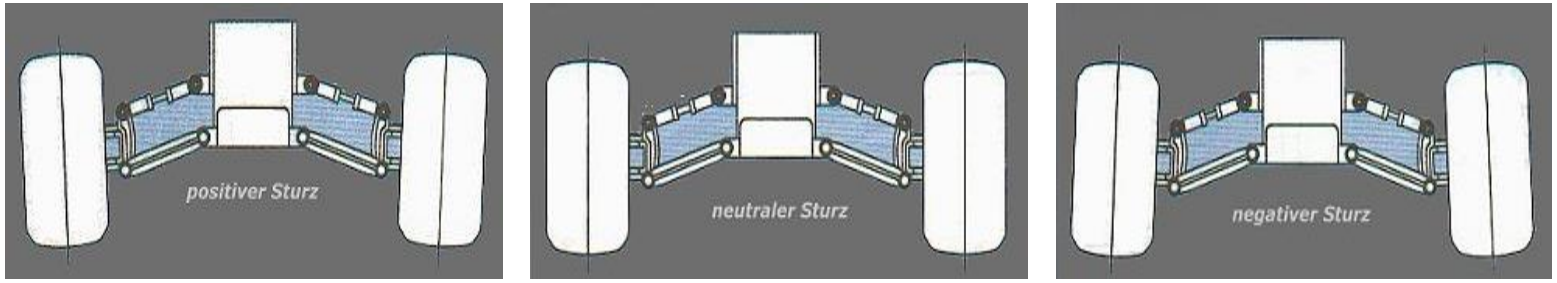
Suspension components



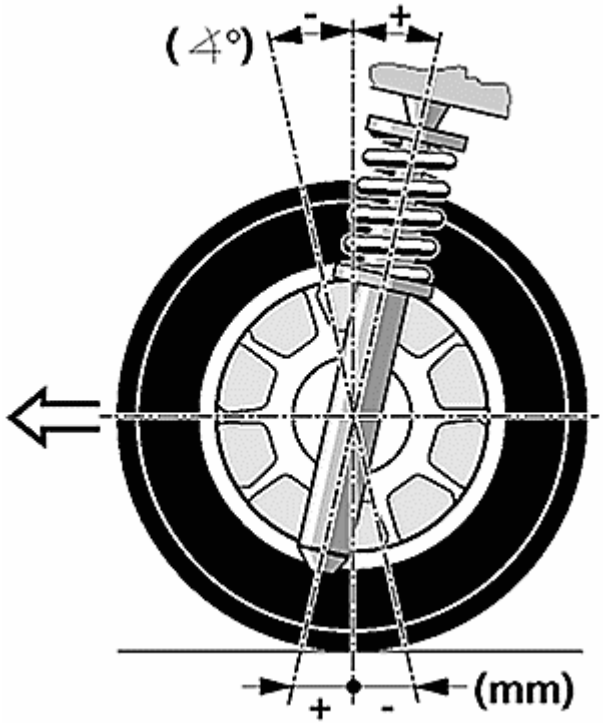


Static axle alignment



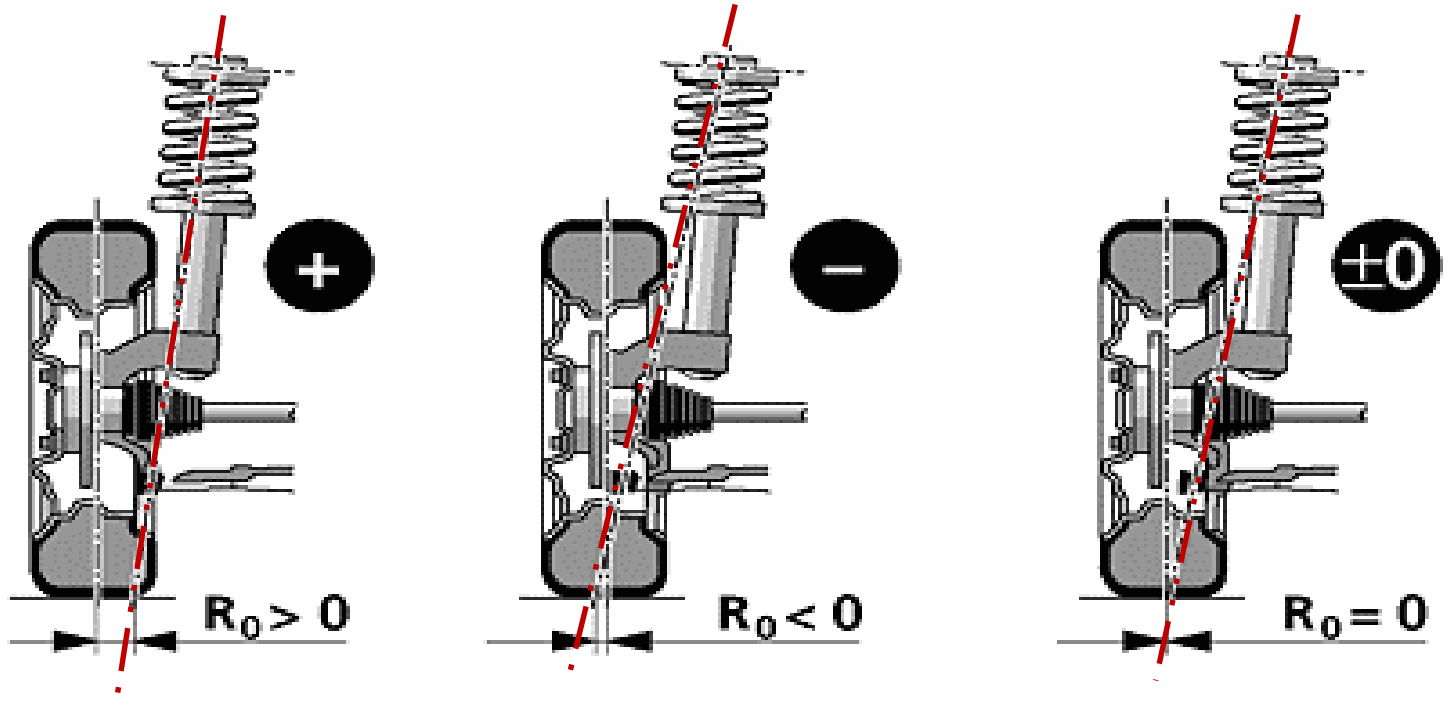


Important geometrical suspension characteristic values

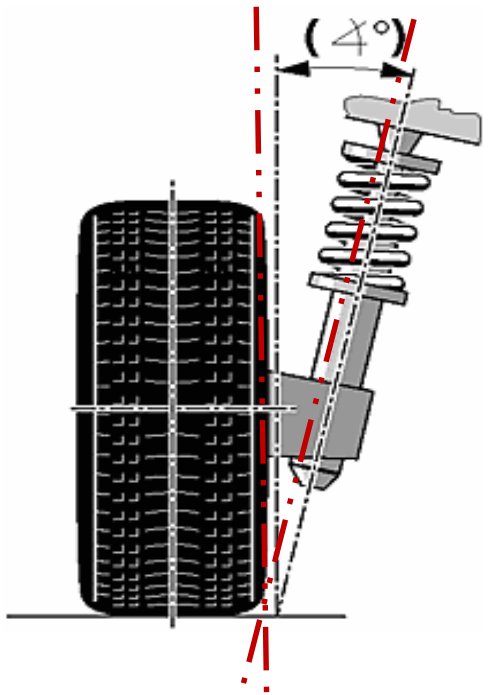


→ Bigger caster leads more wheel stability but higher steering torque.

Important geometrical suspension characteristic values

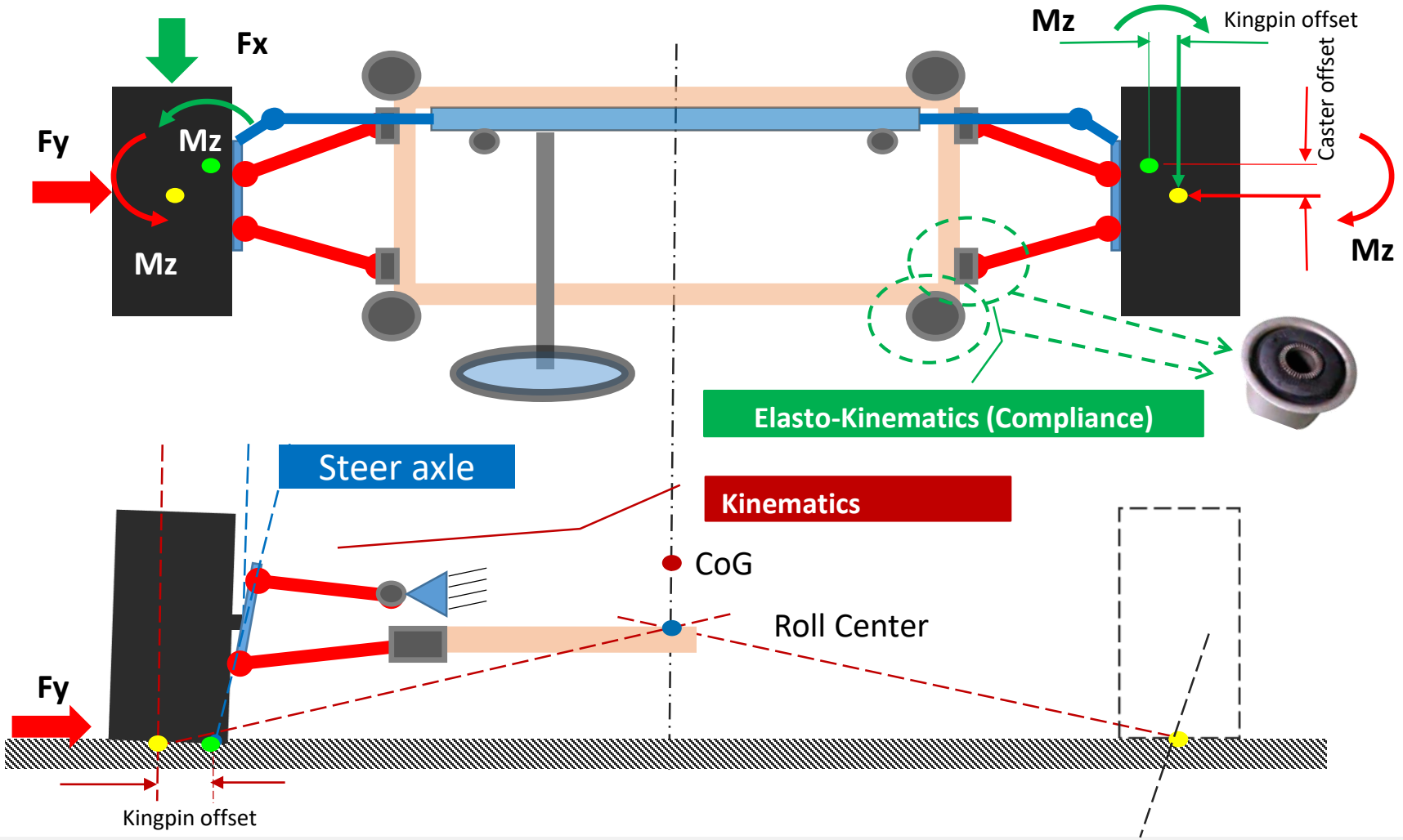


King-Ping Offset (Lenkrollhalbmesser)

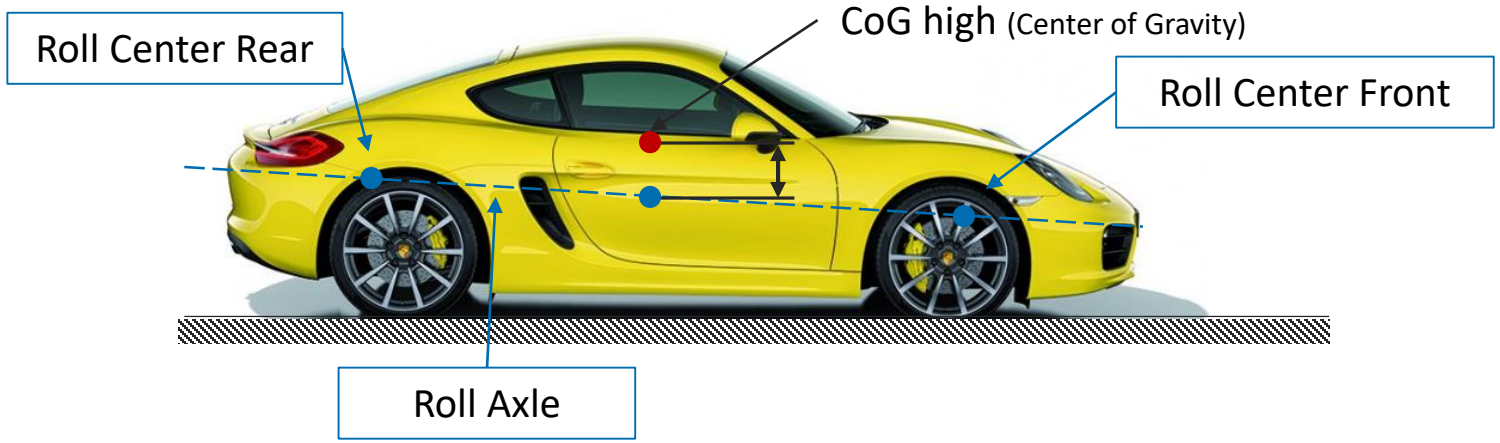


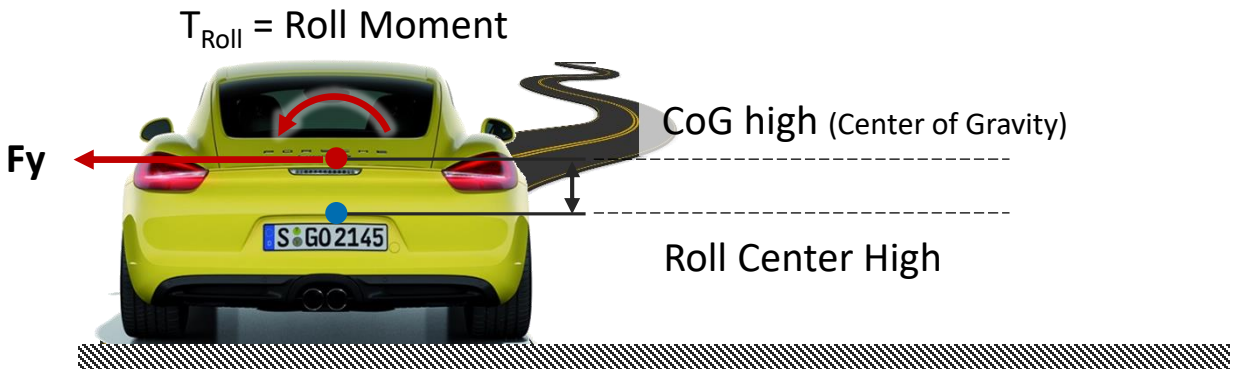
King-Ping Inclination

Important geometrical suspension characteristic values



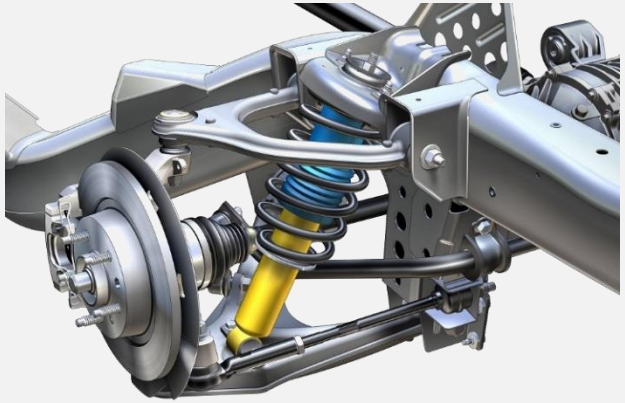
Important geometrical suspension characteristic values

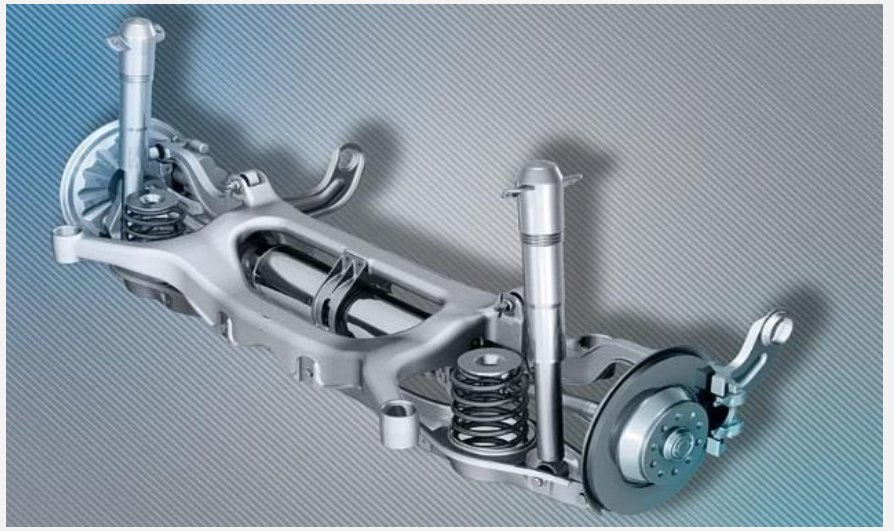




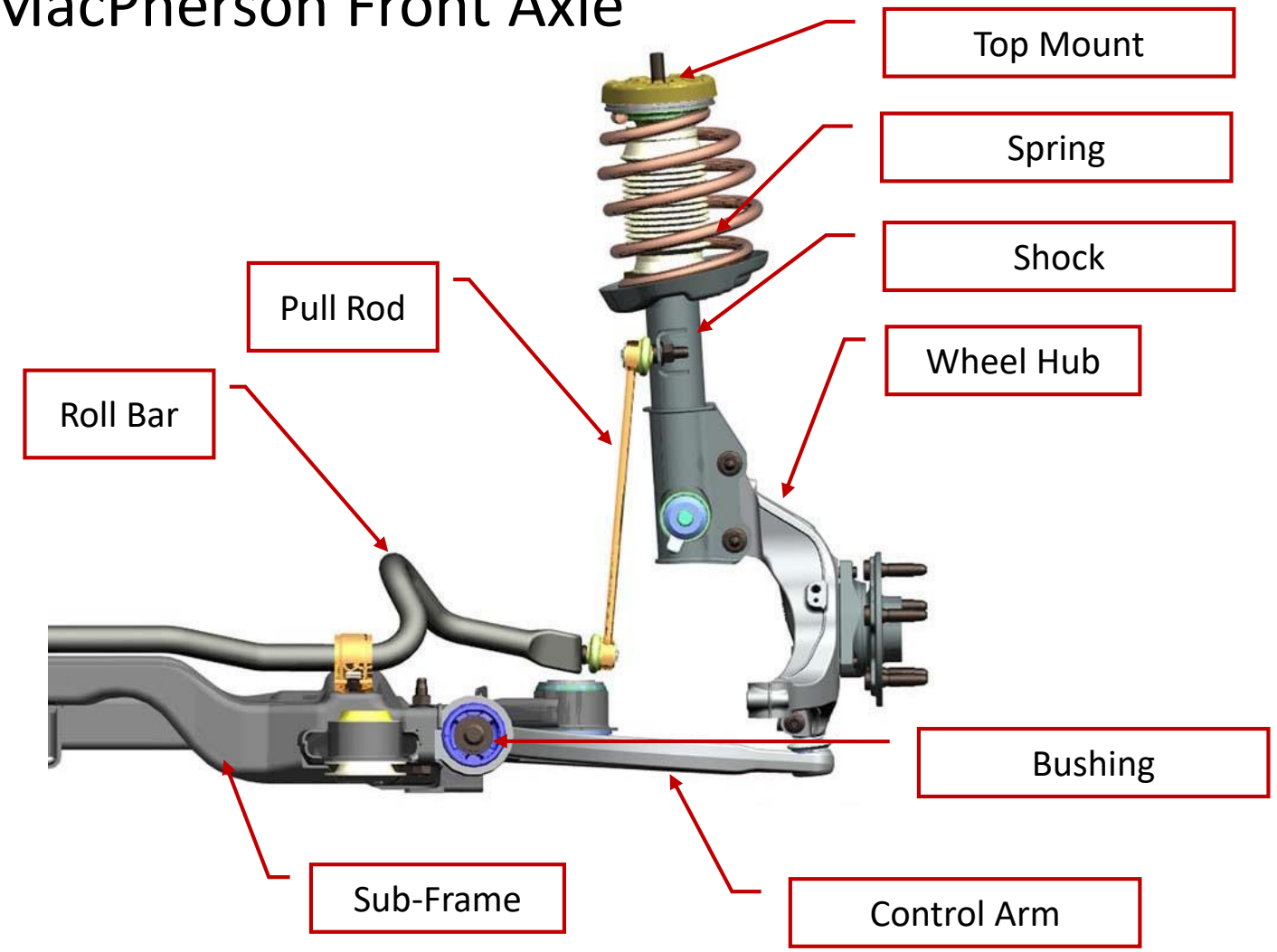
Suspension types

Front Suspension	Rear Suspension
• McPherson Axle • Double Wishbone Axle • Rigid axle • Strut Axle • …	• Rigid axle • Twist Beam Axle • Double Wishbone Axle • 4-Linkage Axle • Multi-Linkage Axle • Sword Linkage Axle • Strut Axle • Longitudinal Linkage Axle • Semi Trailing Arm Axle • …



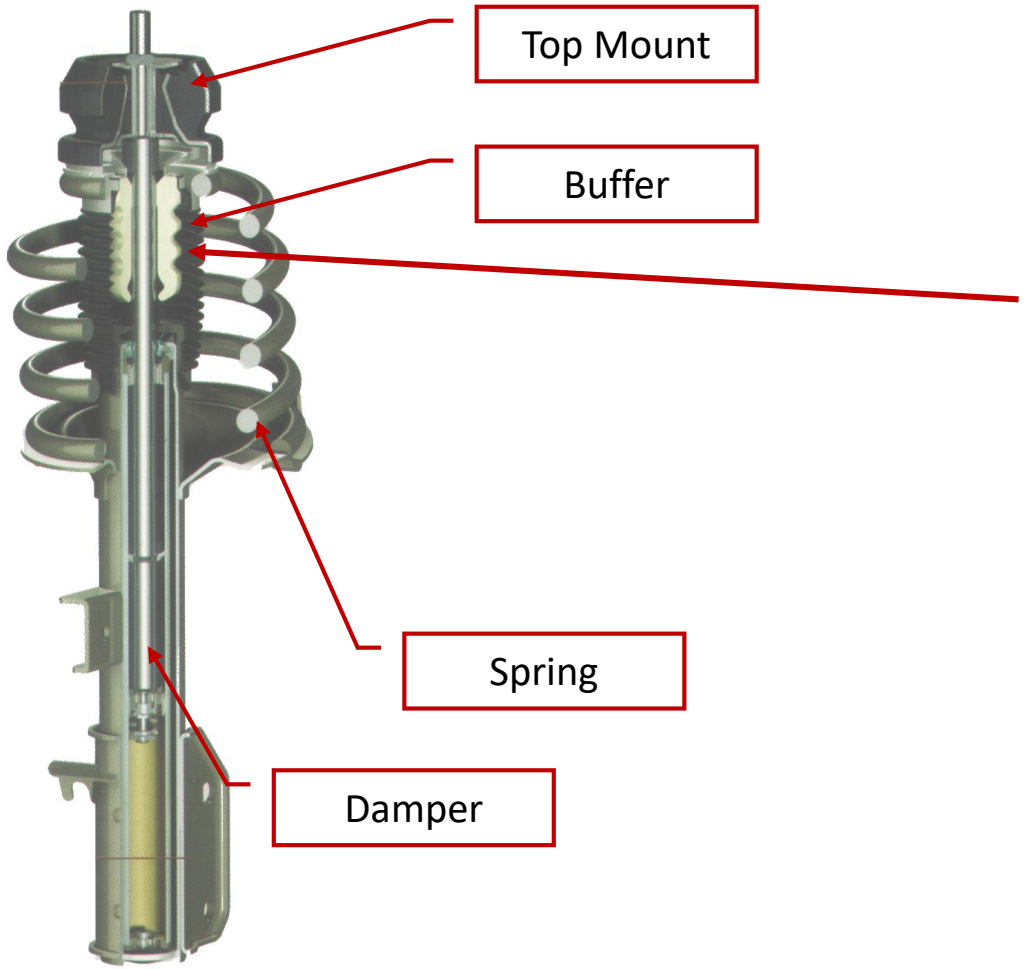


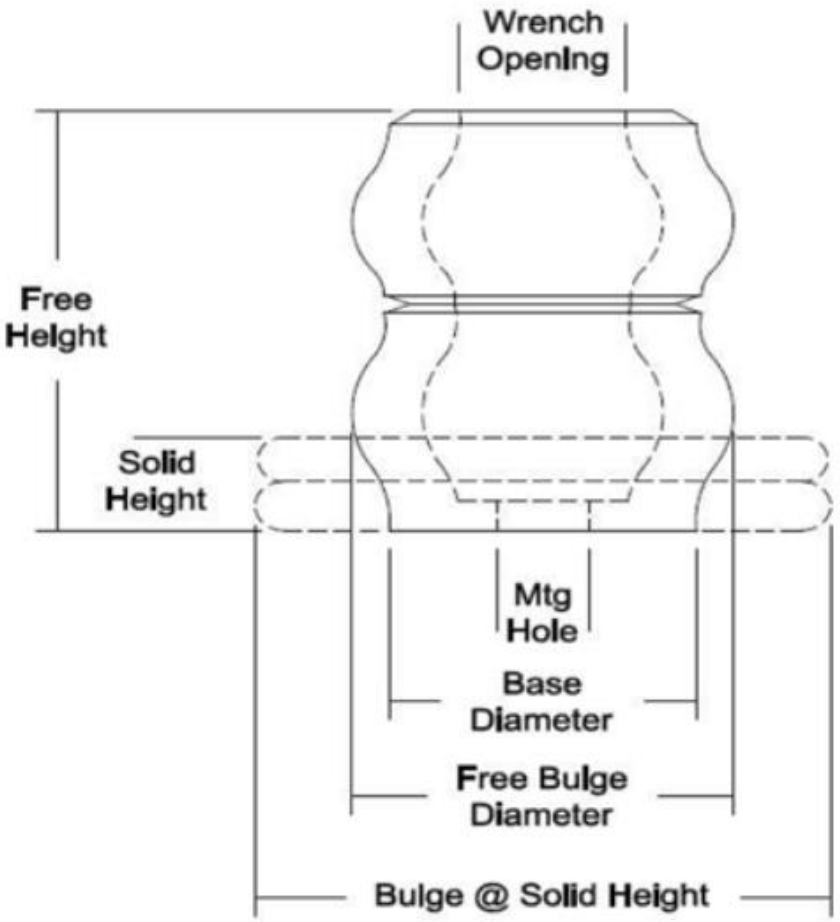
Suspension types: MacPherson Front Axle



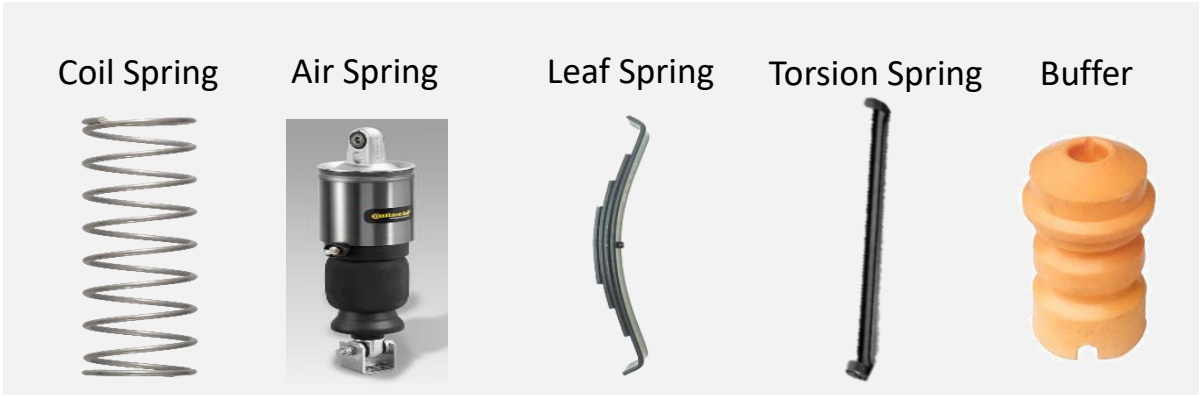
Bushing for force reactive wheel position and isolation

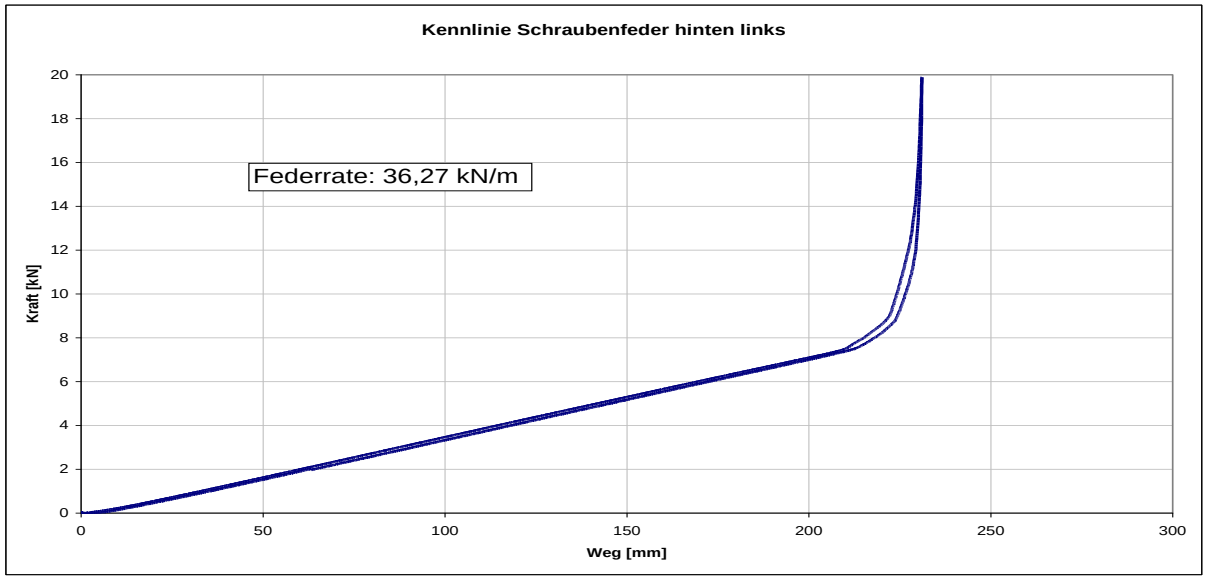
Bumper the additional spring



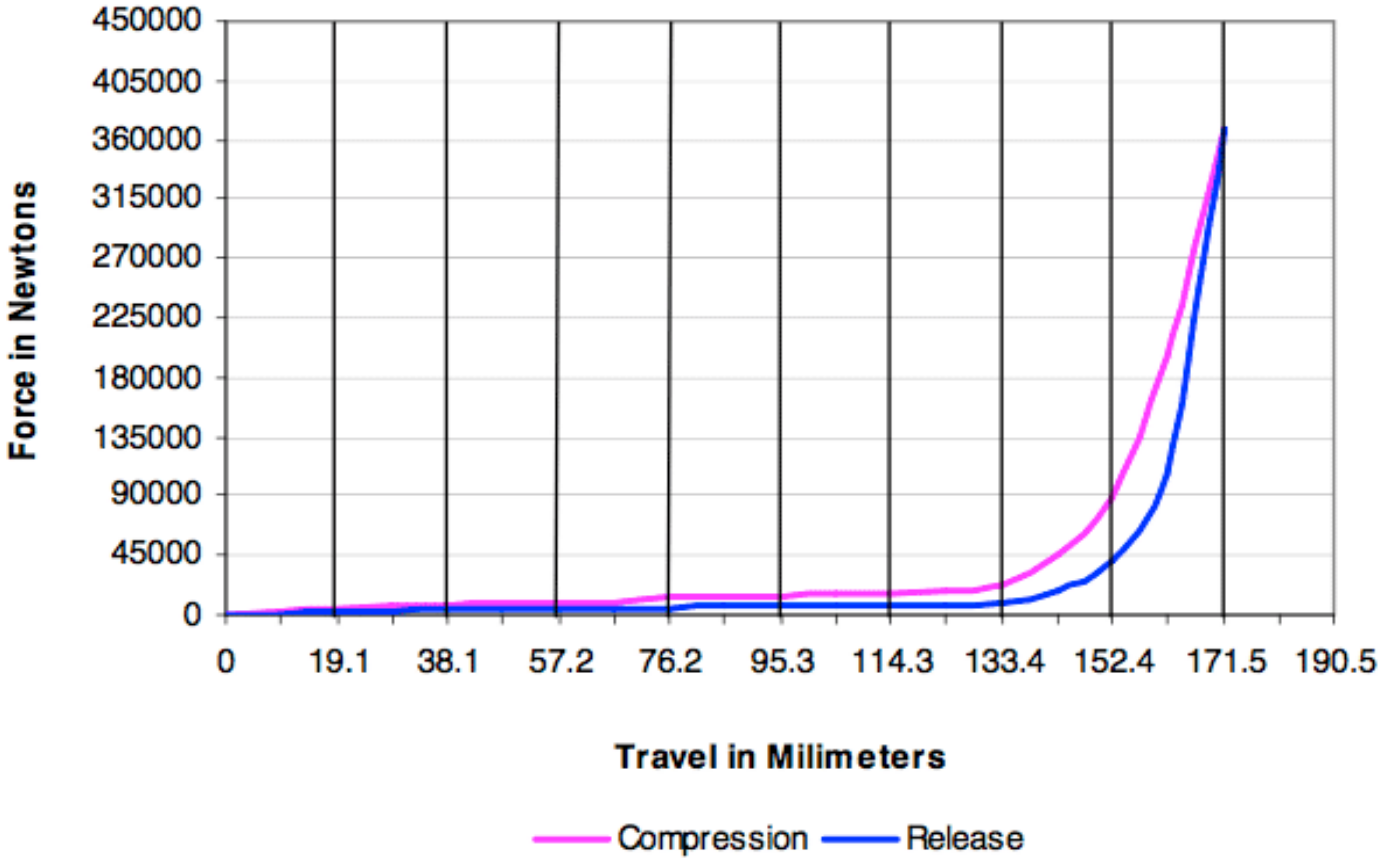


Spring & Damper & Buffer

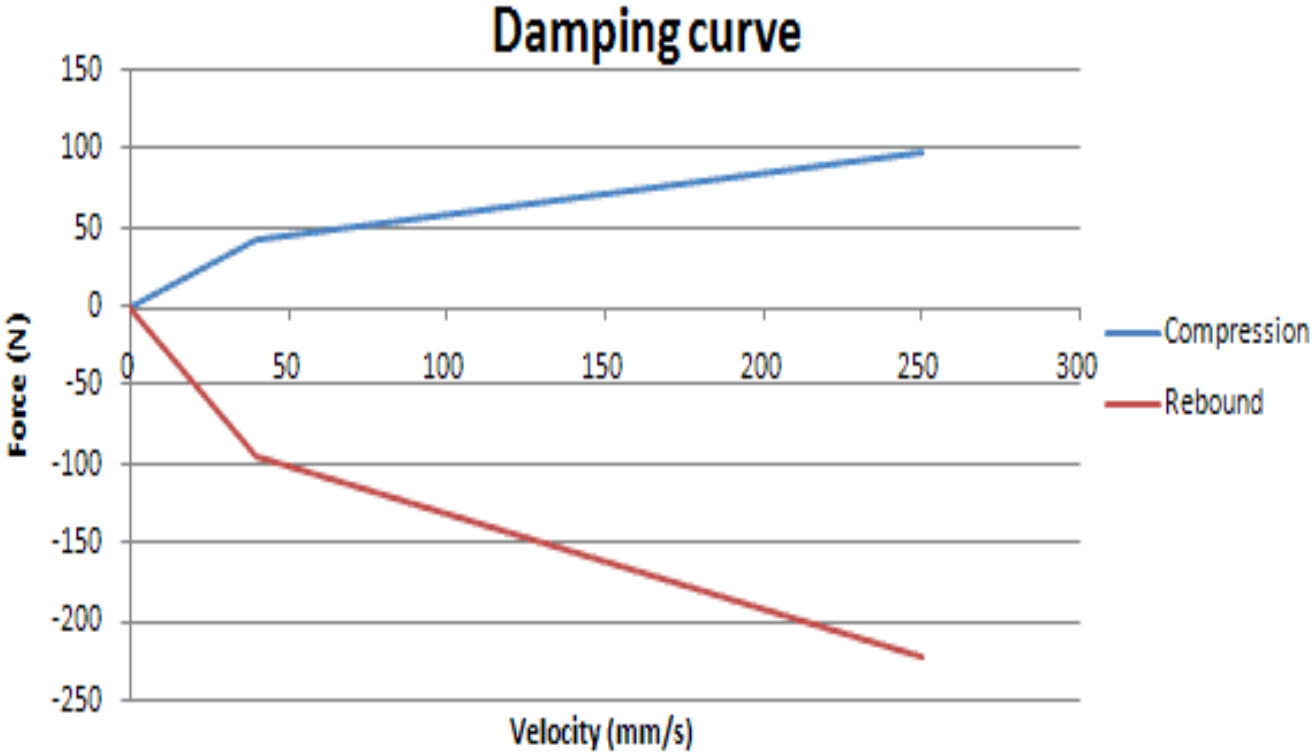


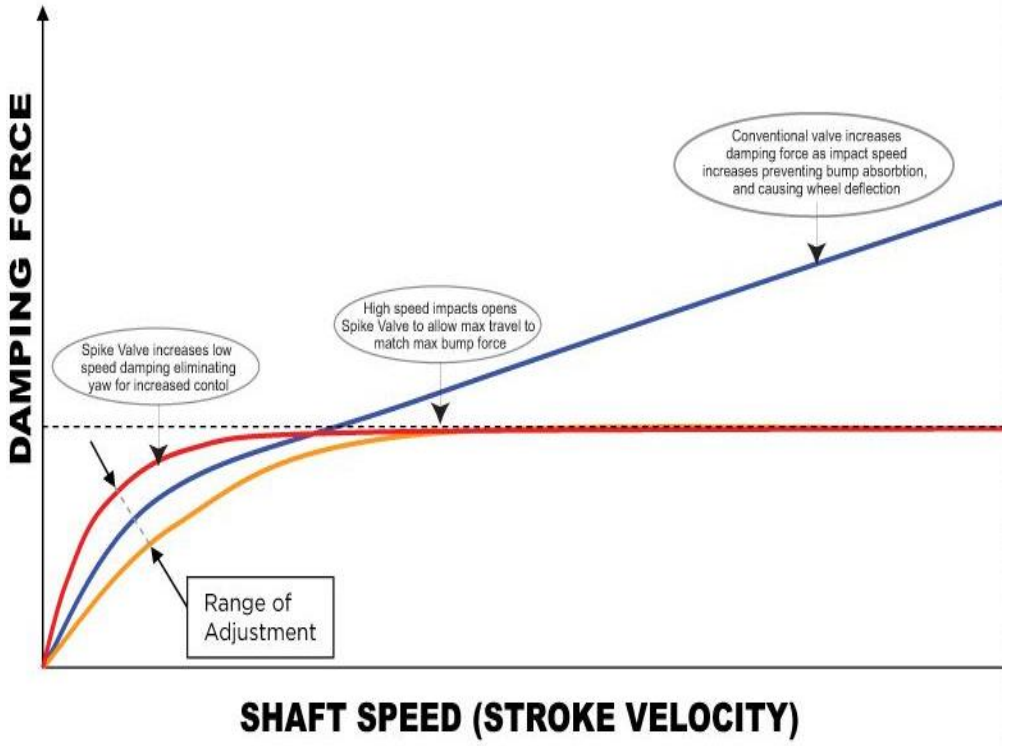


Bumper the additional spring

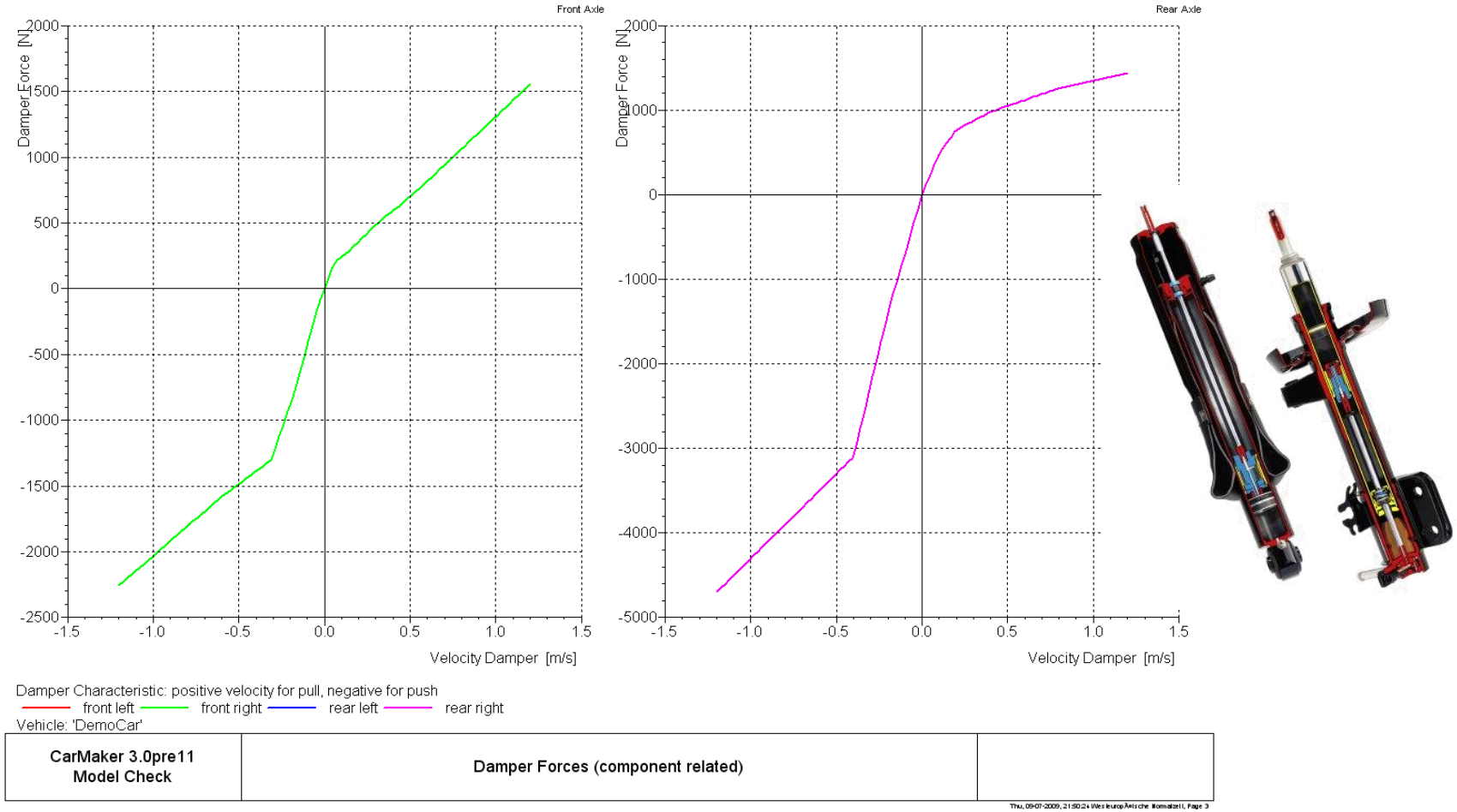


Damping curve and measurement

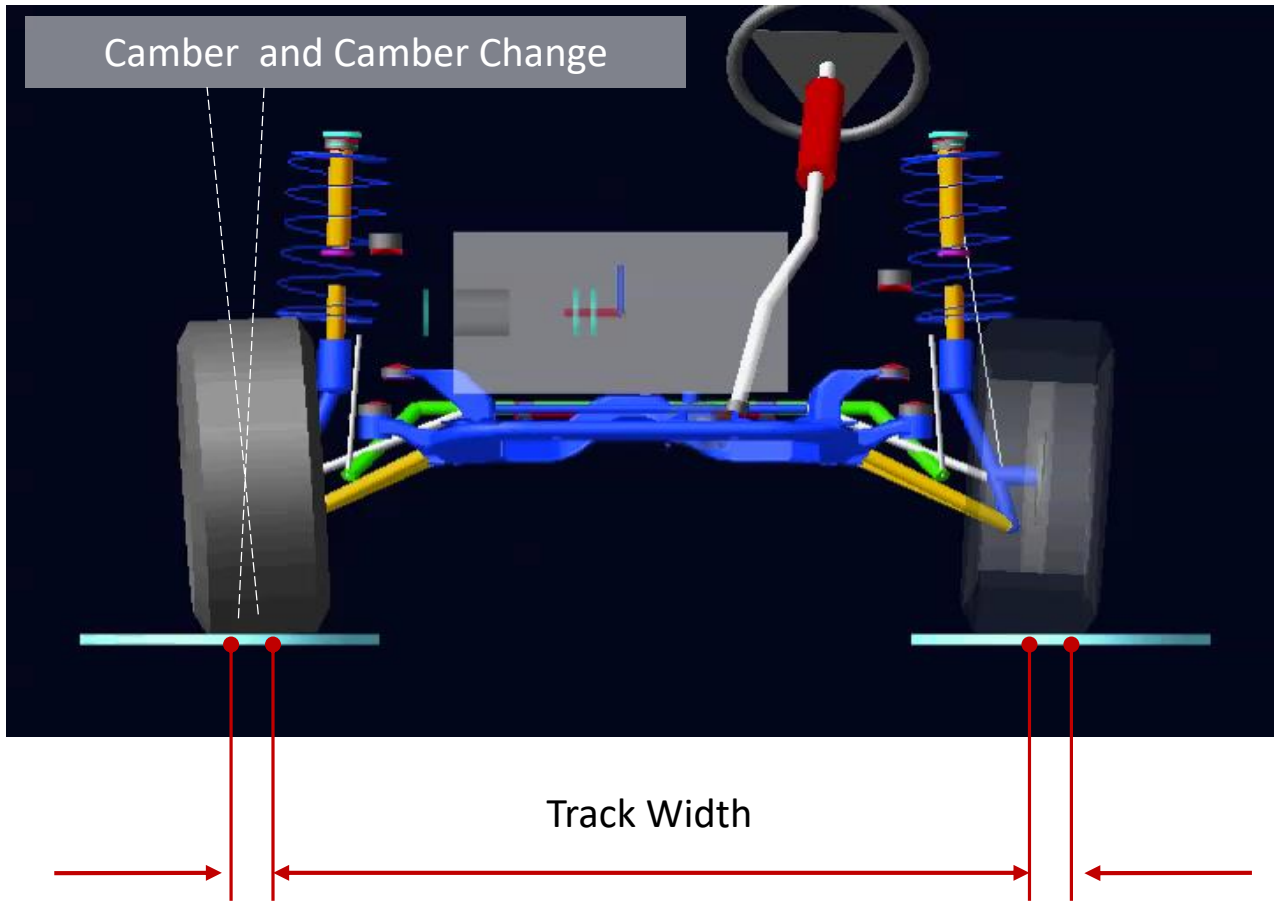


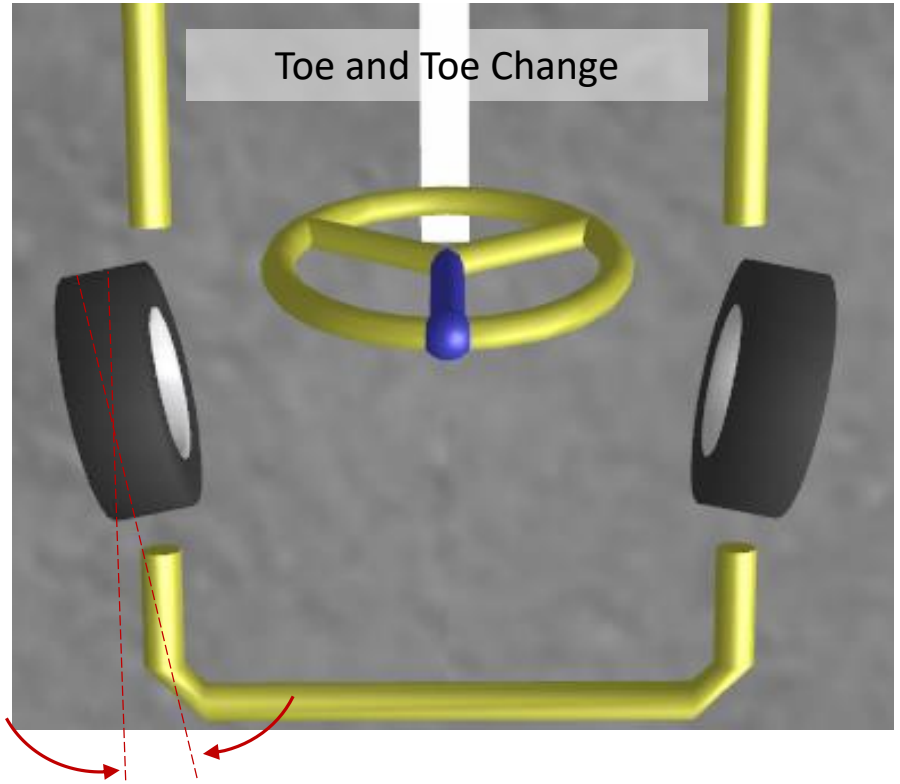


Damping curve and measurement



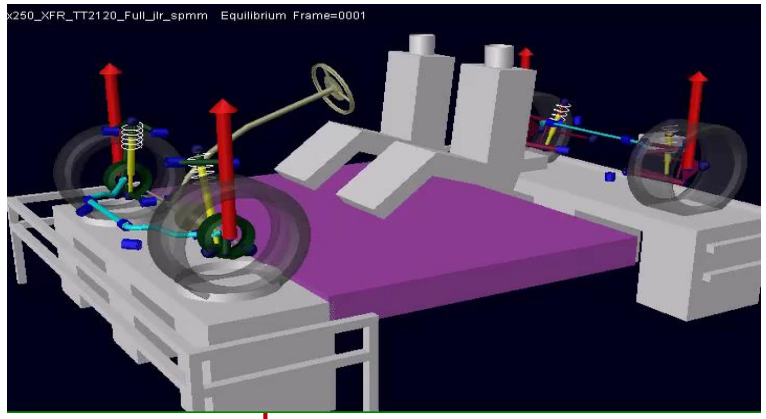
K&C (kinematic & compliance) behavior





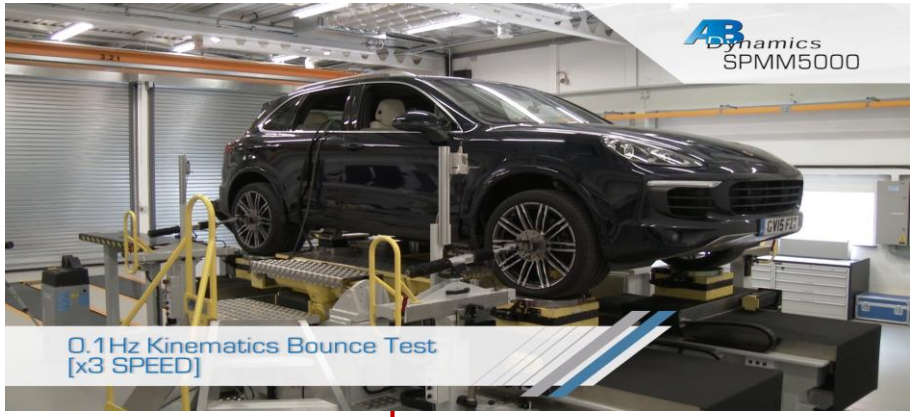
Virtual and real K&C test benches in a modern development

Virtual K&C Test Bench
MBS-Model

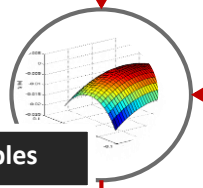


- Bounce Test
- Roll Test
- Steer Test
- Side Force Test
- Accel. & Brake Test

Real K&C Test Bench
Sample ABD SPMM 5000



K&C Variants

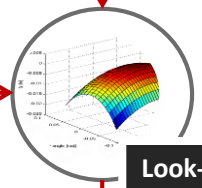


Look-up Tables

Parametrization

Validation

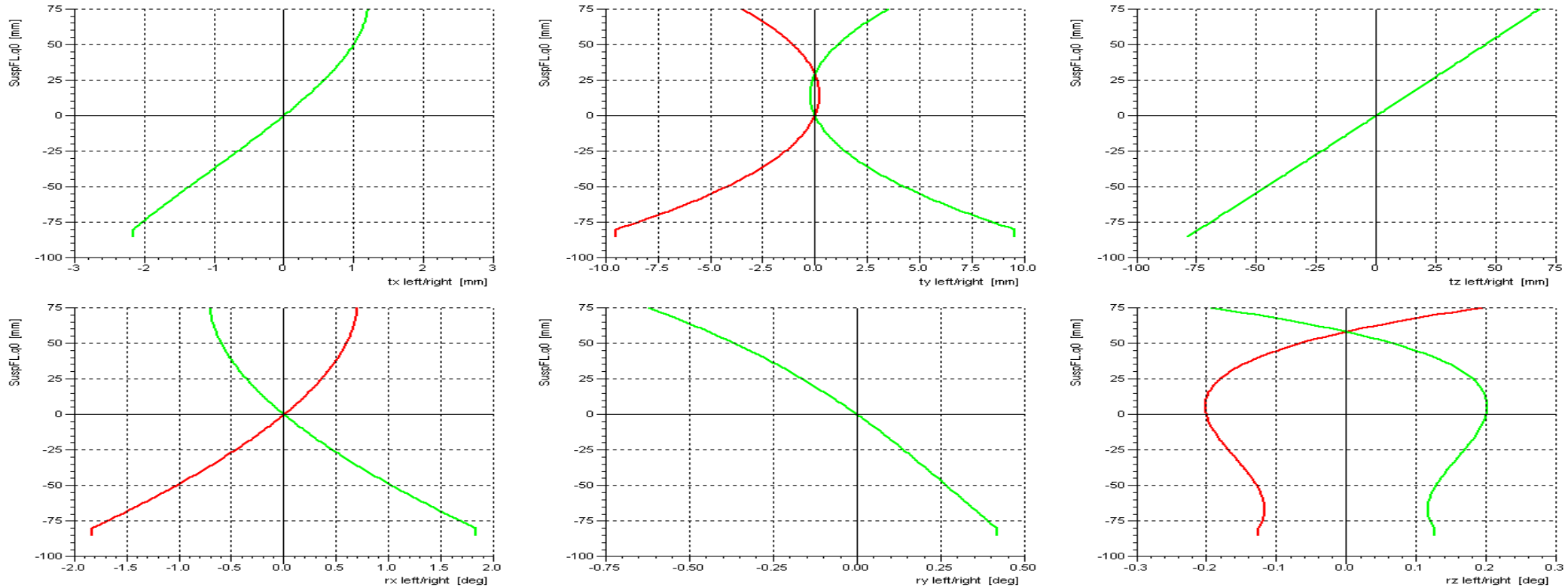
K&C Variants



Look-up Tables

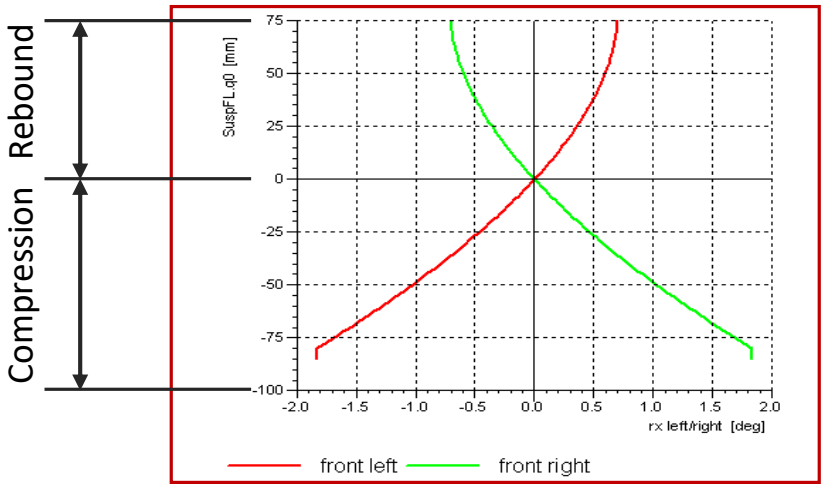
Parametrization

Suspension – Kinematics & Compliance

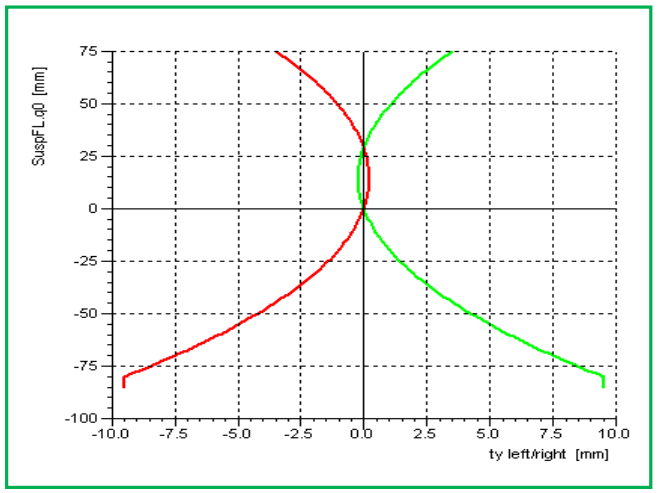


Suspension – Kinematics & Compliance

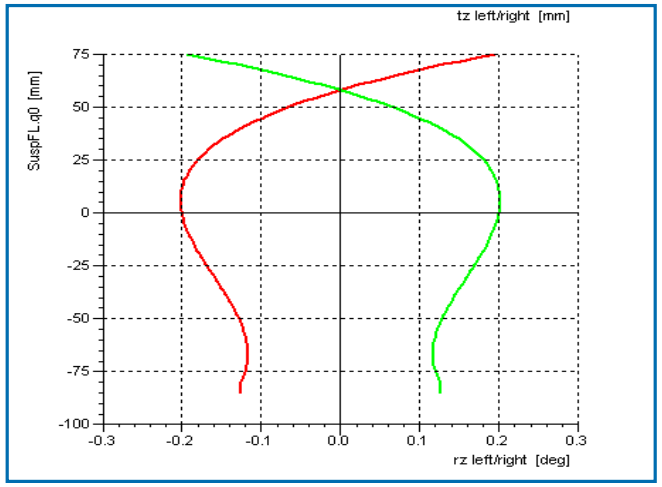
Chamber Change



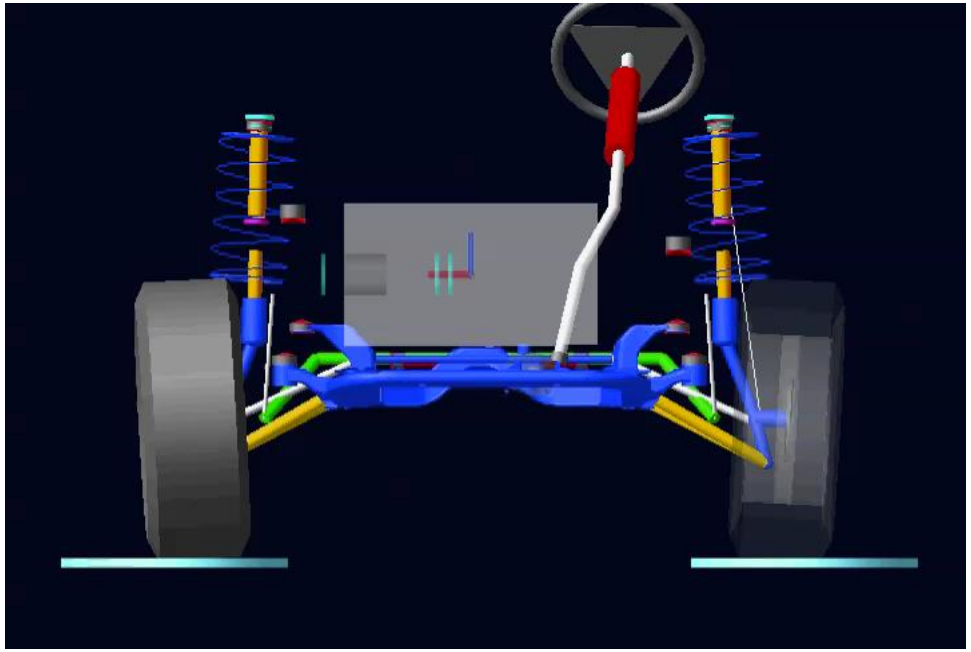
Track Width Change

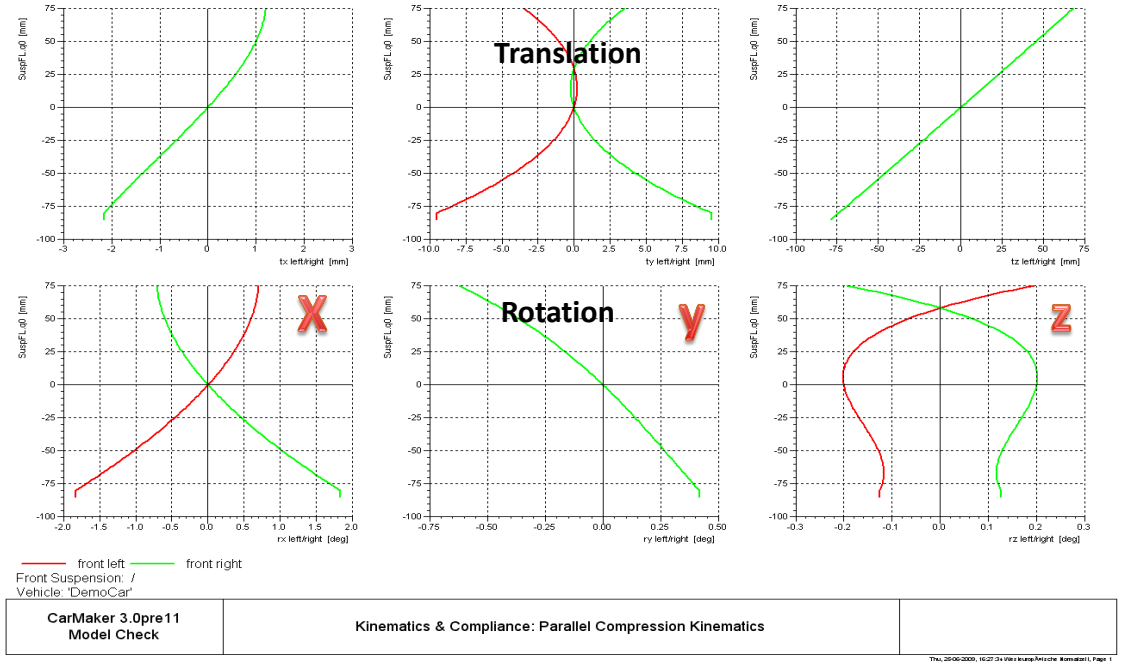


Toe Change

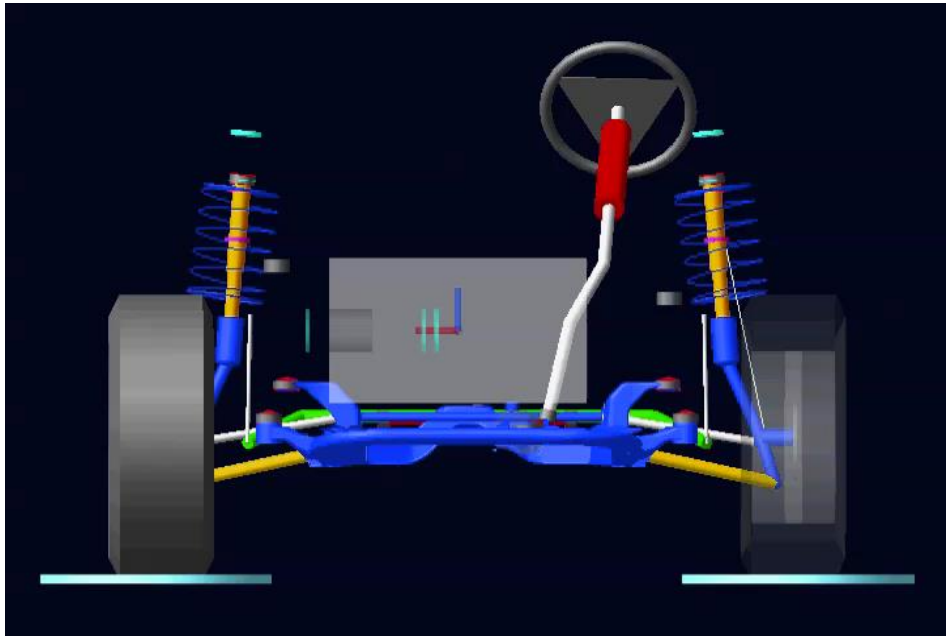


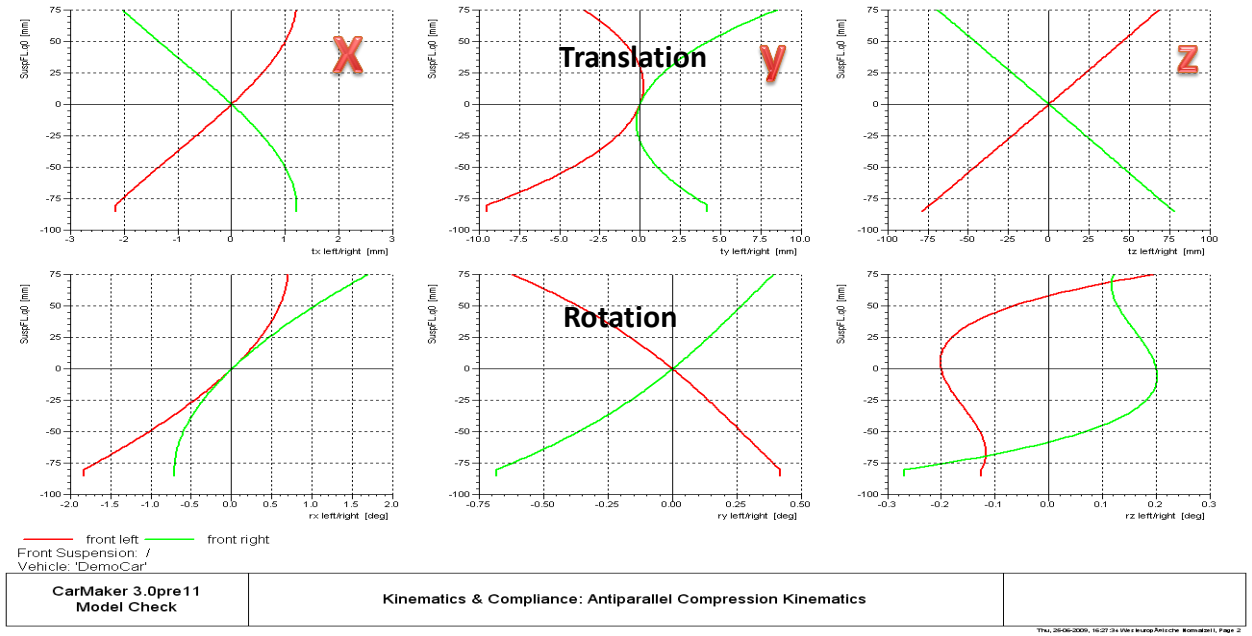
Kinematics & Compliance – Stroke or Bounce Test



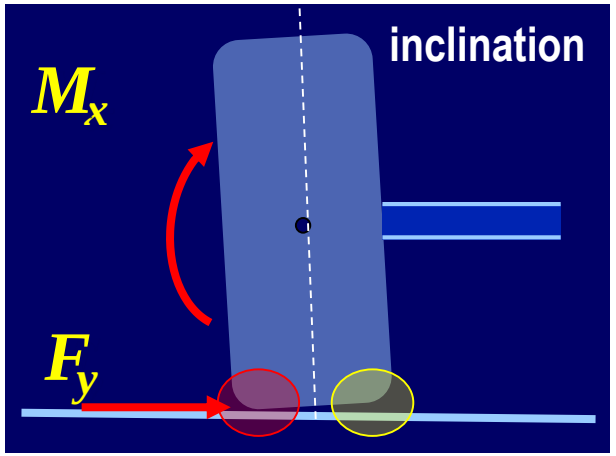


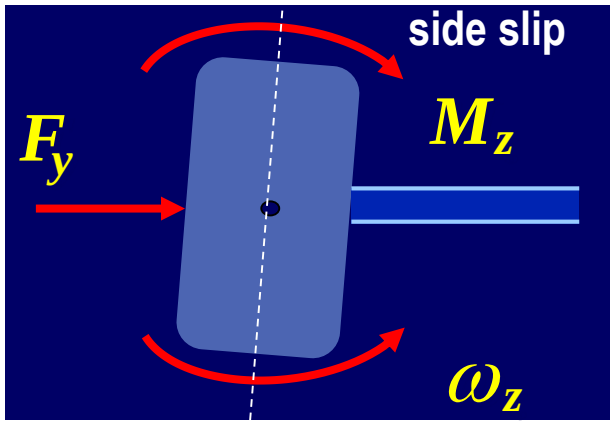
Kinematics & Compliance - Roll Test

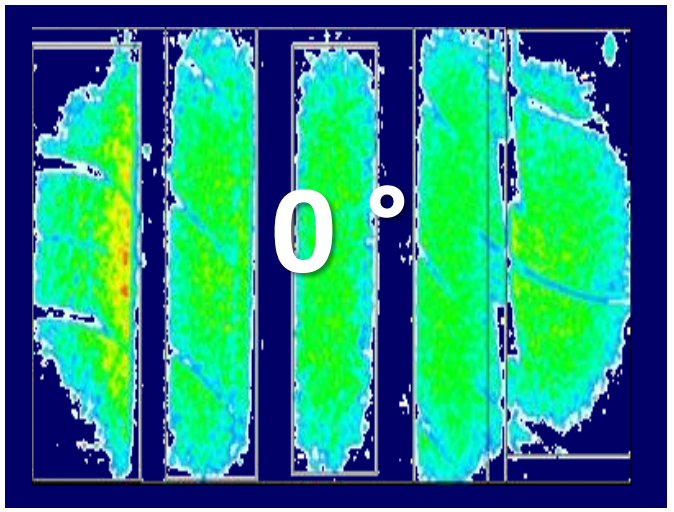


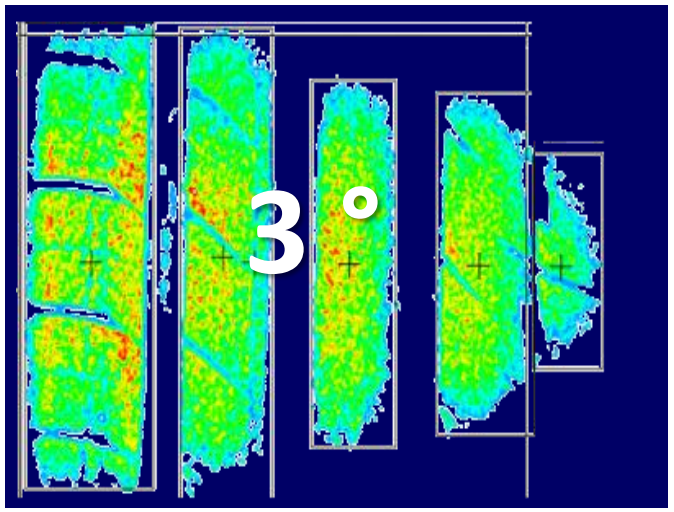


Suspension – Kinematics & Compliance





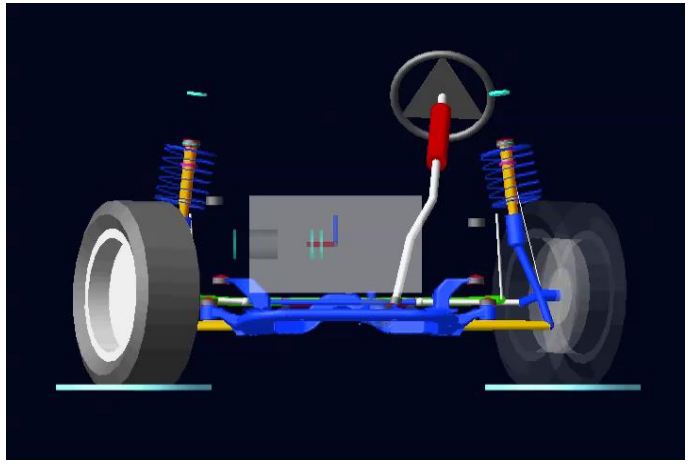


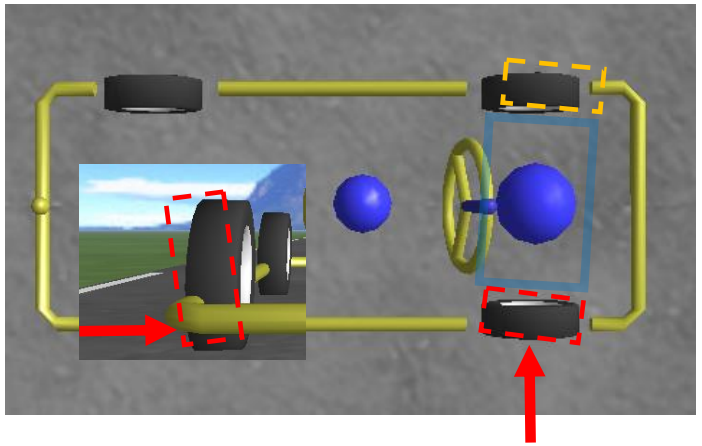


Vehicle Dynamics Rule No. 2:

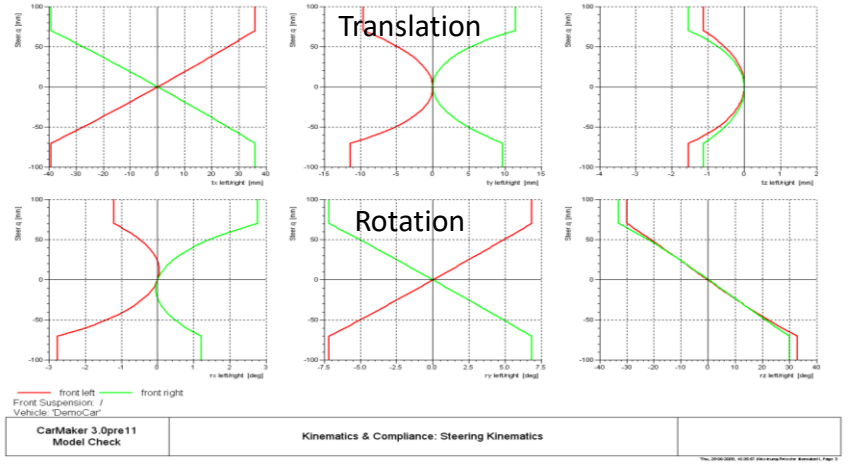
Produce a harmonic foot print

Suspension – Kinematics & Compliance

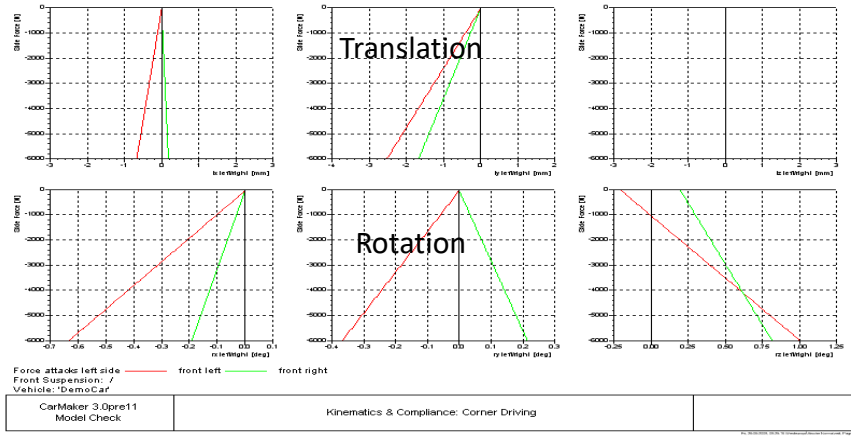




Steer Test



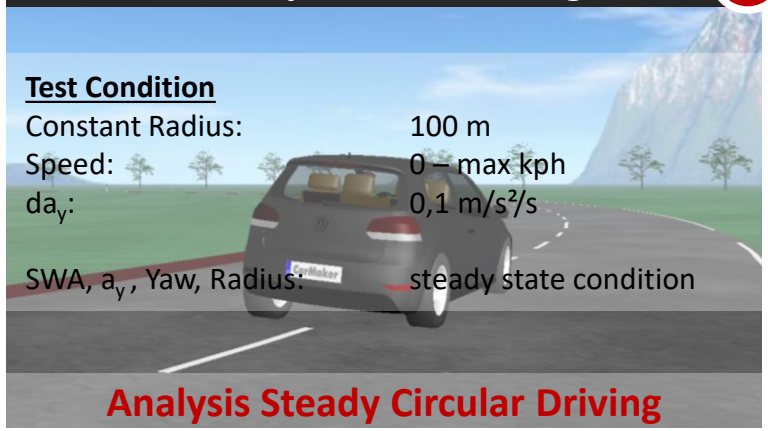
Side Force Test



Parameter Study for K&C, spring, damper, roll bar

Steady Circular Driving

1

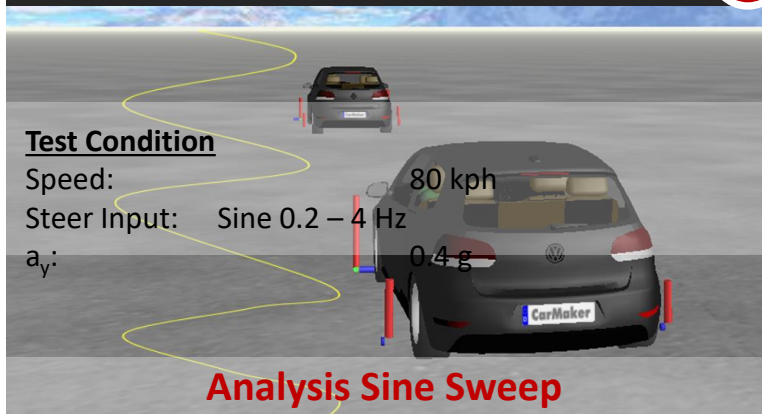


Find the sensitivity of parameters such as

- Roll bar stiffness
- Spring, buffer
- Toe change front / rear (K&C)
- Camber change front / rear (K&C)
- …

Sine Sweep

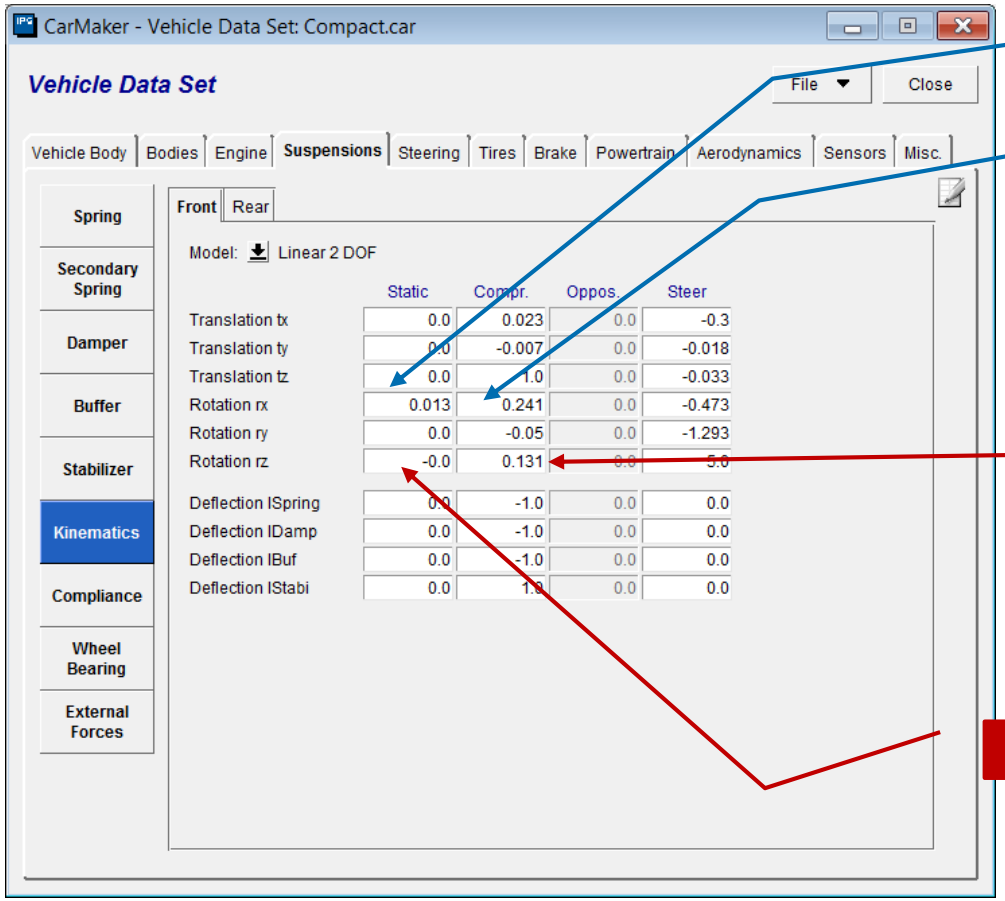
2



Find the sensitivity of parameters such as

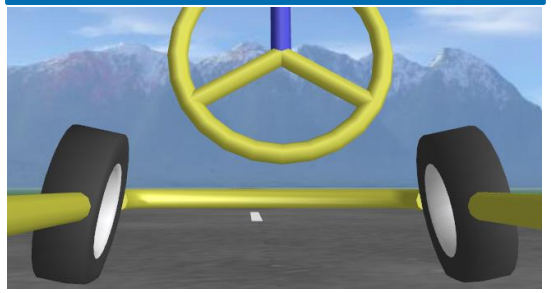
- Mass/Mass distribution / inertia
- Roll bar stiffness
- Damper
- Tire side slip stiffness
- …

Linear 2DOF kinematic model (bounce &steer) parameter

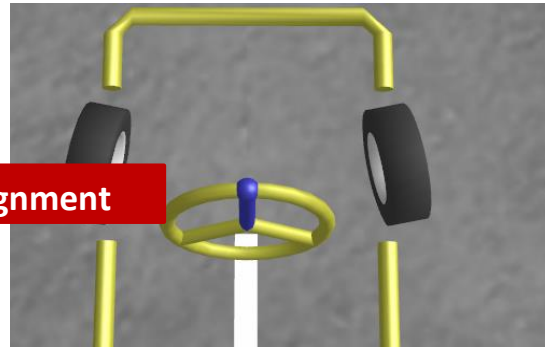


Static Camber of axle alignment

Camber In (stroke)

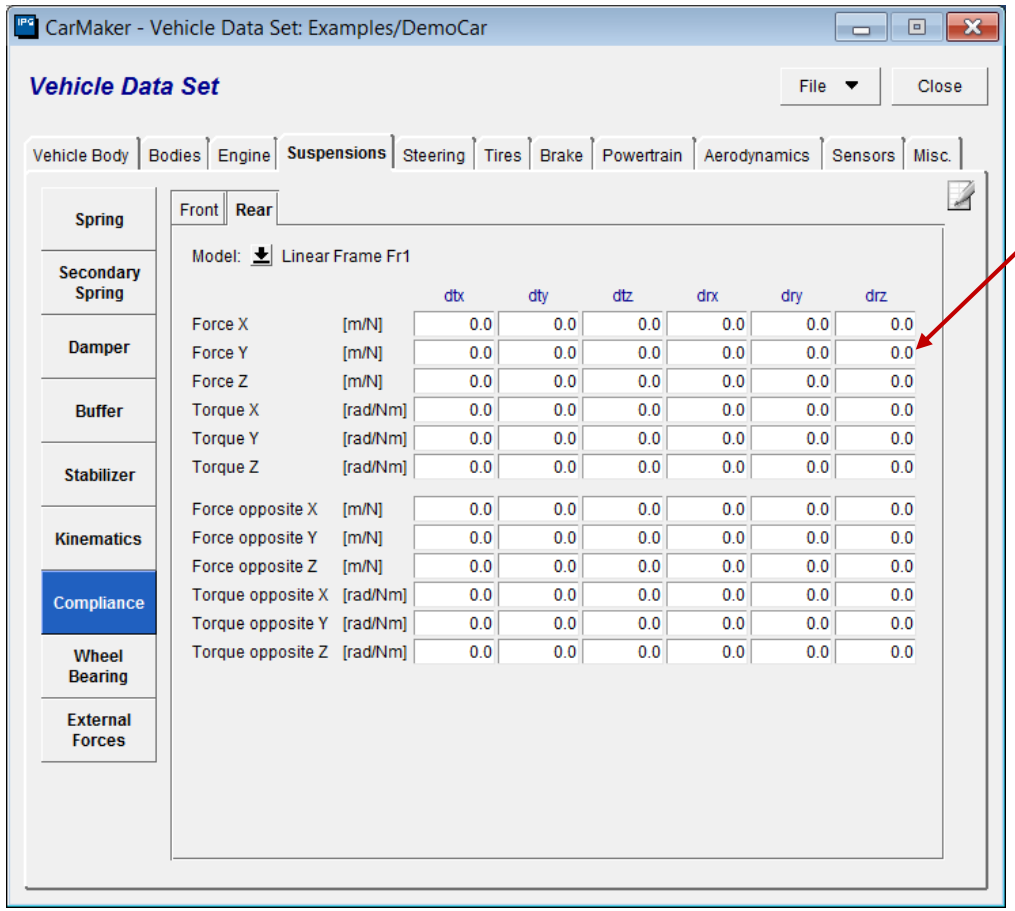


Toe In (stroke)

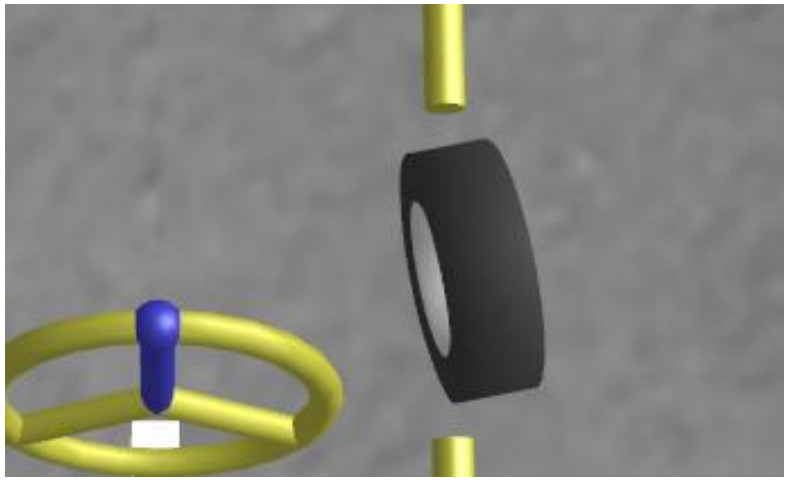


Static Toe of axle alignment

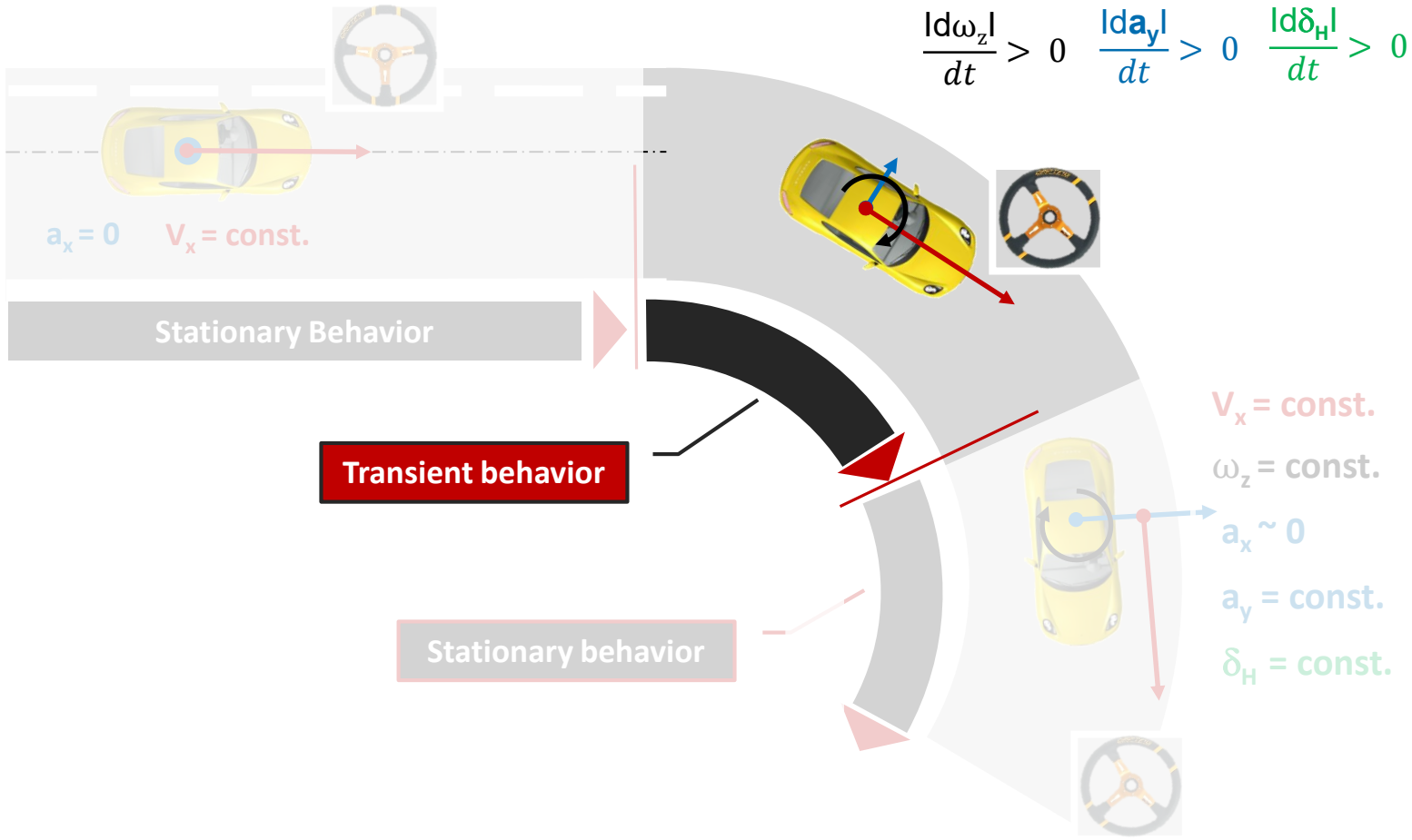
Linear compliance model parameters



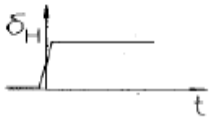
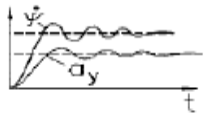
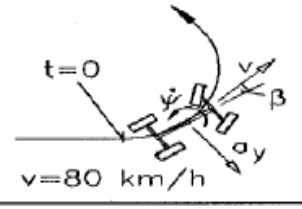
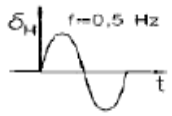
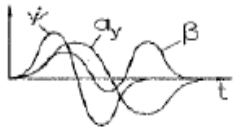
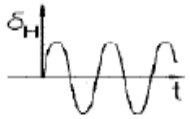
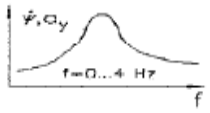
Side Force Steer



Lateral Dynamics: Stationary and transient behavior

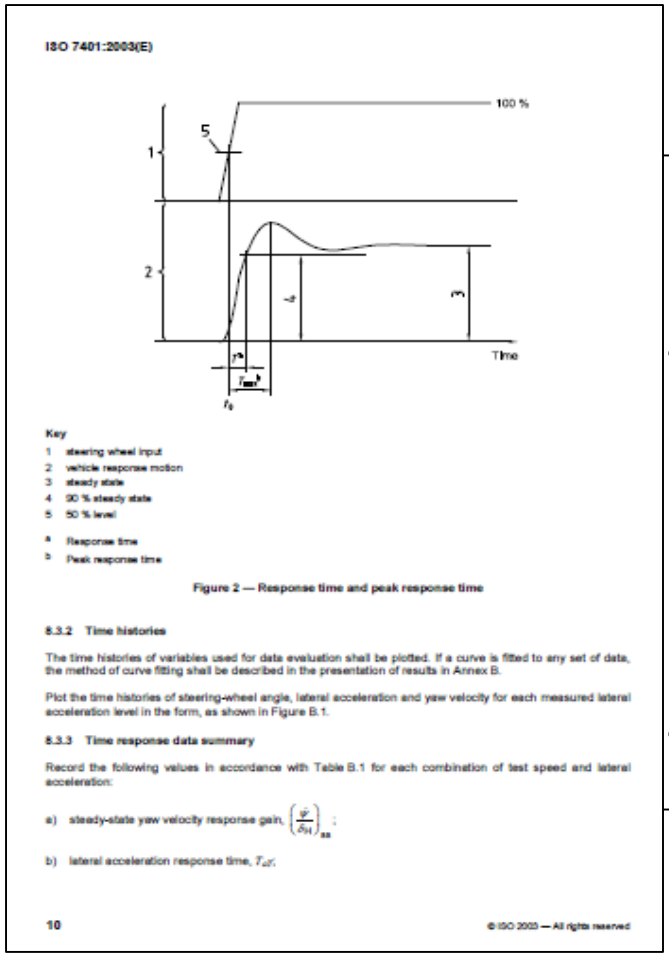


Lateral response tests to evaluate transient behavior

Lenkwinkel-sprung DIN ISO 7401	Sprungfunktion des Lenkrad-winkels: 	Querbeschleunigung a_y, Gierwinkelgeschwindigkeit $\dot{\psi}$: 	
Lenk-Einzel-Sinus DIN ISO 7401	Lenkradwinkel-Vorgabe: 	(Bestimmung von Zeitverzügen) 	
Lenk-Sinus DIN ISO 7401	Lenkradwinkel-Vorgabe: 	(Auswertung im Frequenzbereich) 	

Time Domain:
- Step Steer
- Sinus Steer (one cycle)

Frequency Domain:
- Step Steer
- Stochastic Steer Input
- Triangle Impulse
- Sine Steer (continuous cycles, sweep)



ISO 7401:2003(E)

Key
1 steering wheel input
2 vehicle response motion
3 steady state
4 90 % steady state
5 50 % level
a Response time
b Peak response time

Figure 2 — Response time and peak response time

8.3.2 Time histories

The time histories of variables used for data evaluation shall be plotted. If a curve is fitted to any set of data, the method of curve fitting shall be described in the presentation of results in Annex B.

Plot the time histories of steering-wheel angle, lateral acceleration and yaw velocity for each measured lateral acceleration level in the form, as shown in Figure B.1.

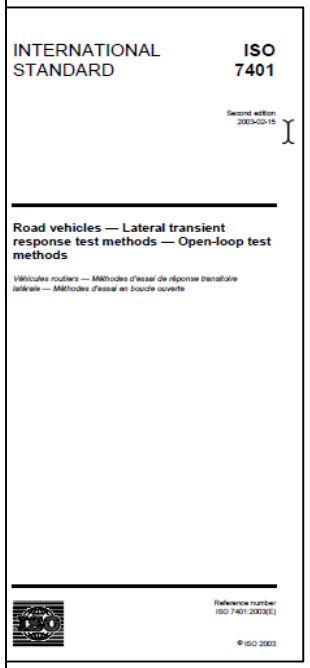
8.3.3 Time response data summary

Record the following values in accordance with Table B.1 for each combination of test speed and lateral acceleration:

a) steady-state yaw velocity response gain, $\left(\frac{\dot{\psi}}{\delta_H}\right)_{ss}$;

b) lateral acceleration response time, T_{ay};

10



INTERNATIONAL STANDARD **ISO 7401**

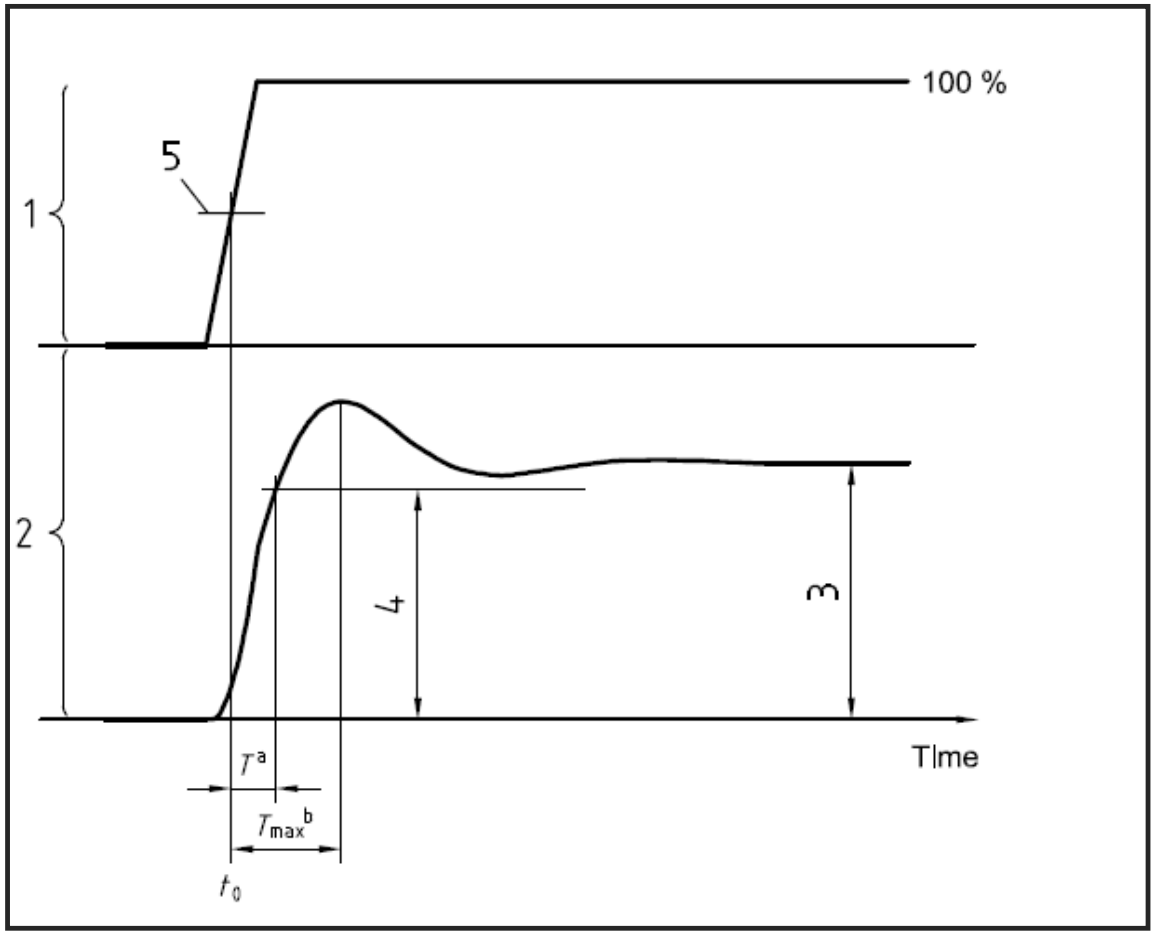
Second edition 2003-02-15

Road vehicles — Lateral transient response test methods — Open-loop test methods

Véhicules routiers — Méthodes d'essai de réponse transitoire latérale — Méthodes d'essai en boucle ouverte

Reference number ISO 7401:2003(E)

Lateral response tests to evaluate transient behavior



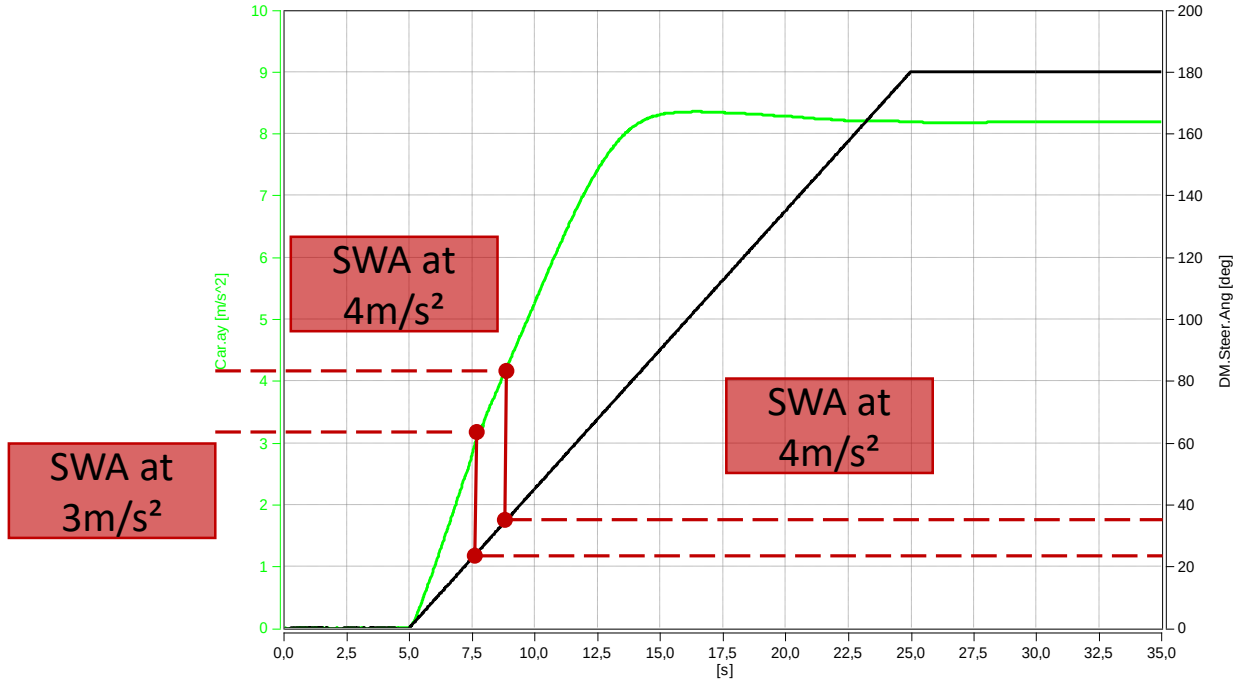
Parameter	Symbol	Unit	Left turn	Right turn	Average
Steady-state yaw velocity response gain	$\left(\frac{\dot{\psi}}{\delta_H}\right)_{ss}$	s^{-1}			
Lateral acceleration response time	T_{aY}	s			
Yaw velocity response time	$T_{\dot{\psi}}$	s			
Lateral acceleration peak response time	$T_{aY,max}$	s			
Yaw velocity peak response time	$T_{\dot{\psi},max}$	s			
Overshoot value of lateral acceleration	U_{aY}	—			
Overshoot value of yaw velocity	$U_{\dot{\psi}}$	—			

Key

1. steering wheel input
2. vehicle response motion
3. steady state
4. 90 % steady state
5. 50 % level

A. Response time
B. Peak response time

Slowly increase steer test (SIS) an option for steady state circular driving and identify maneuver parameter

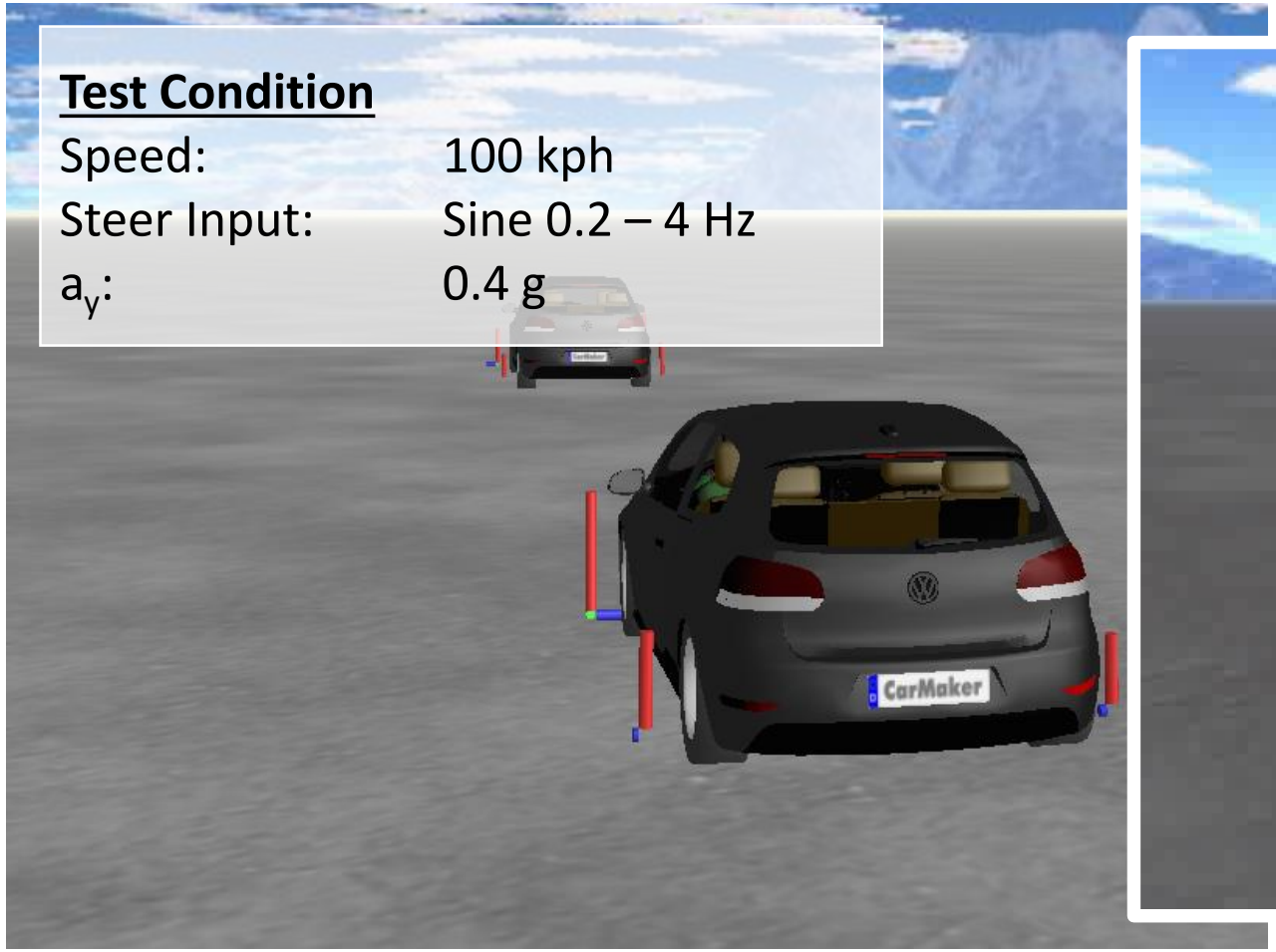


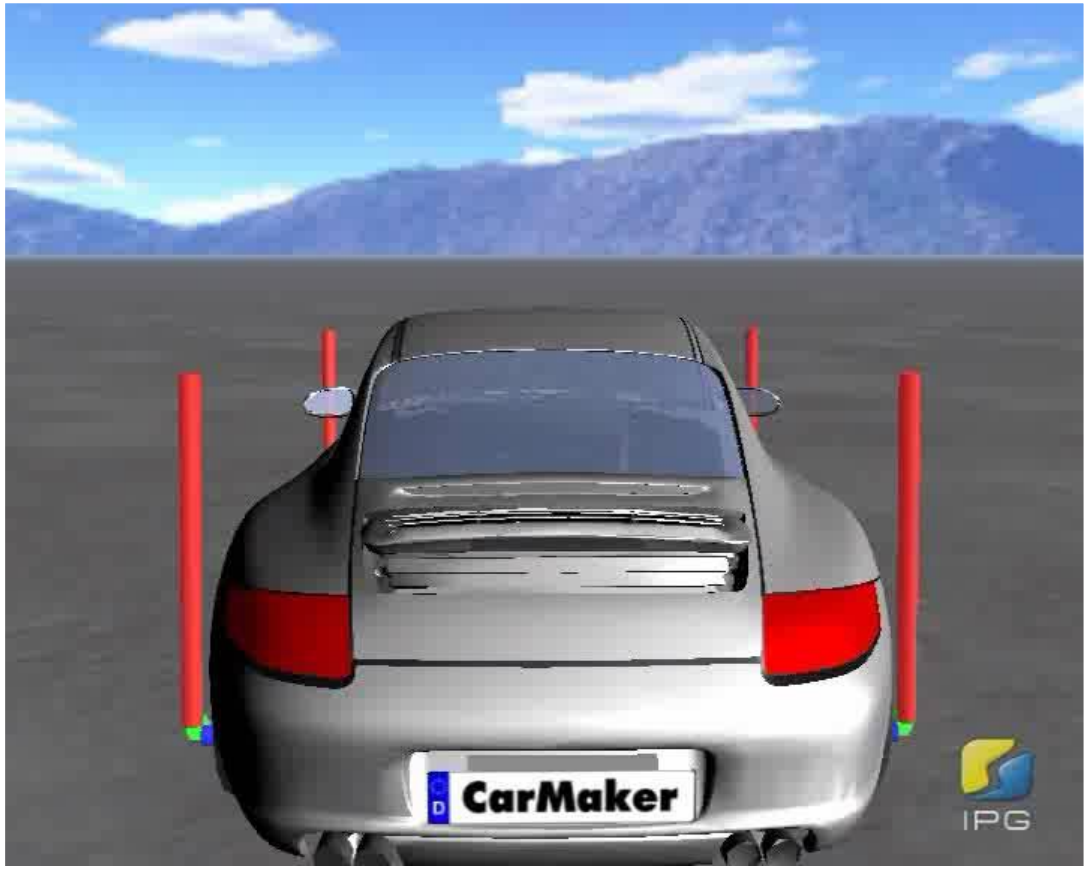
V= 80/100 kph constant SWA Gradient < 13,5°/s

SWA at 4m/s² used for steering angle identification

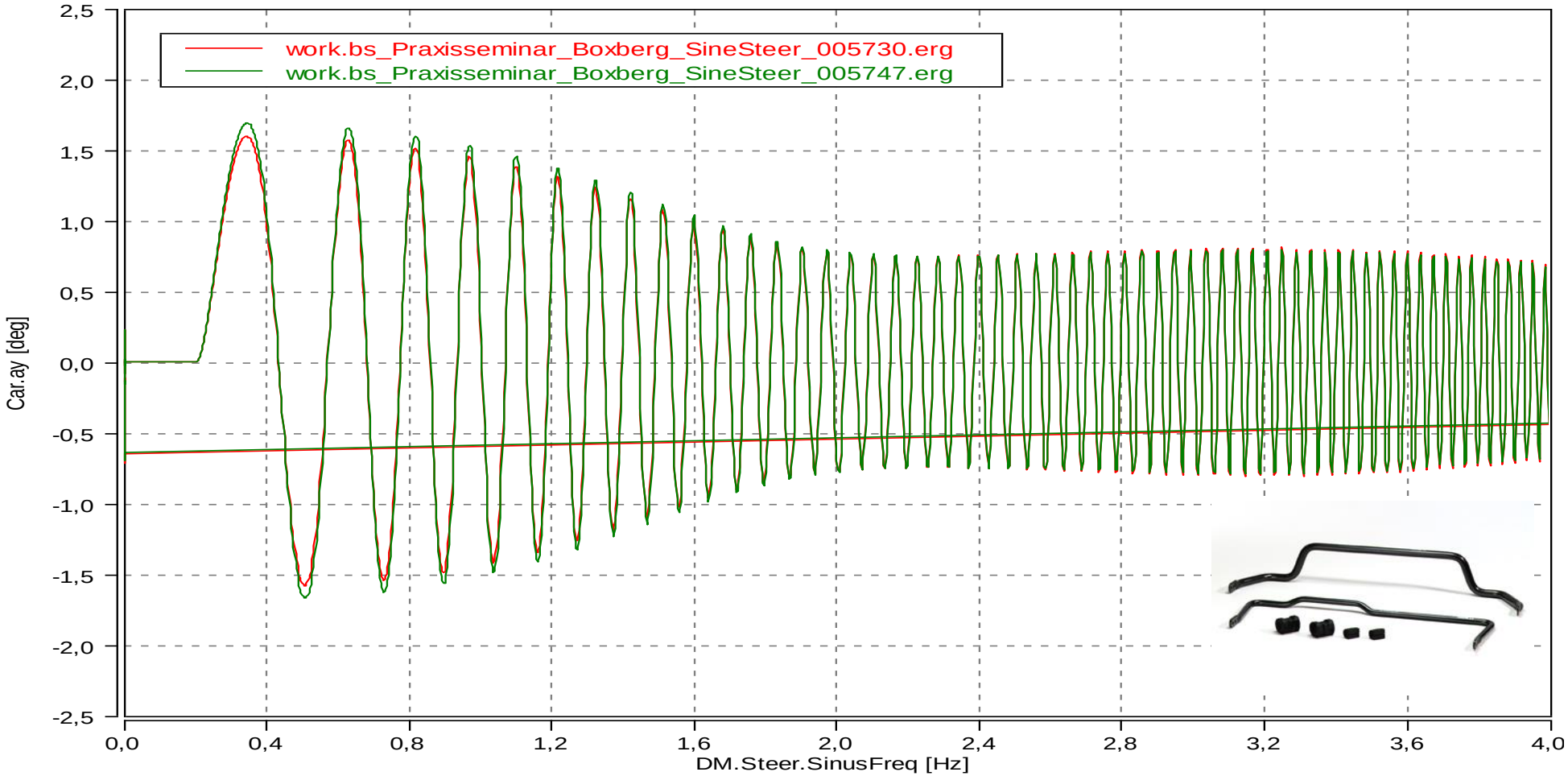
- Step steer (4m/s²)
- Sine steer (4m/s²)
- Sine with Dwell (3m/s²)
- …

Lateral response tests to evaluate transient behavior



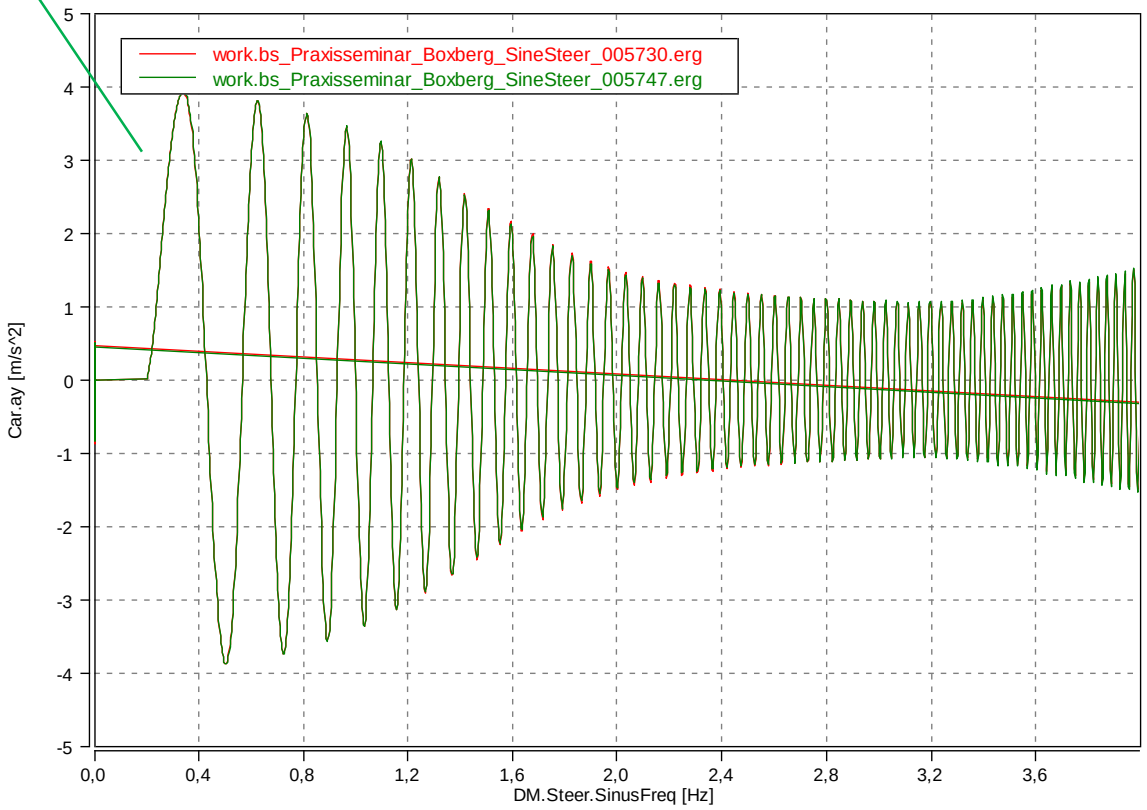


Lateral response tests to evaluate transient behavior

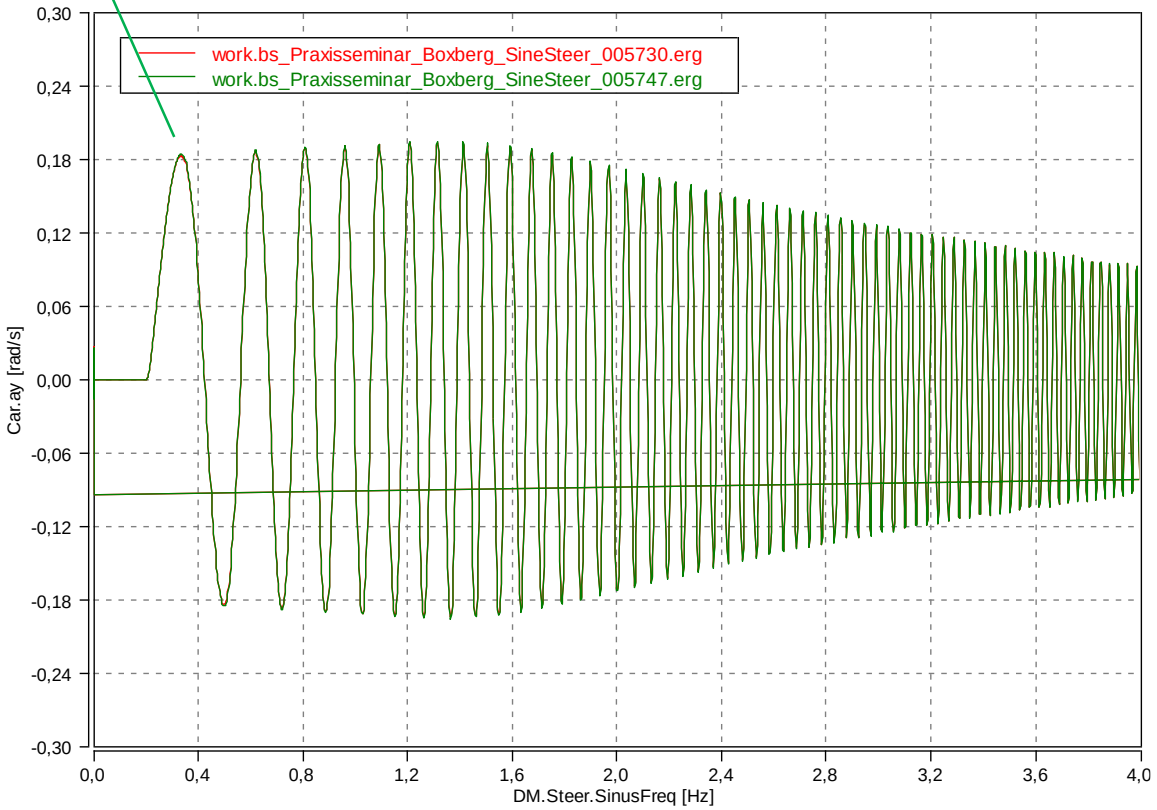


Lateral response tests to evaluate transient behavior

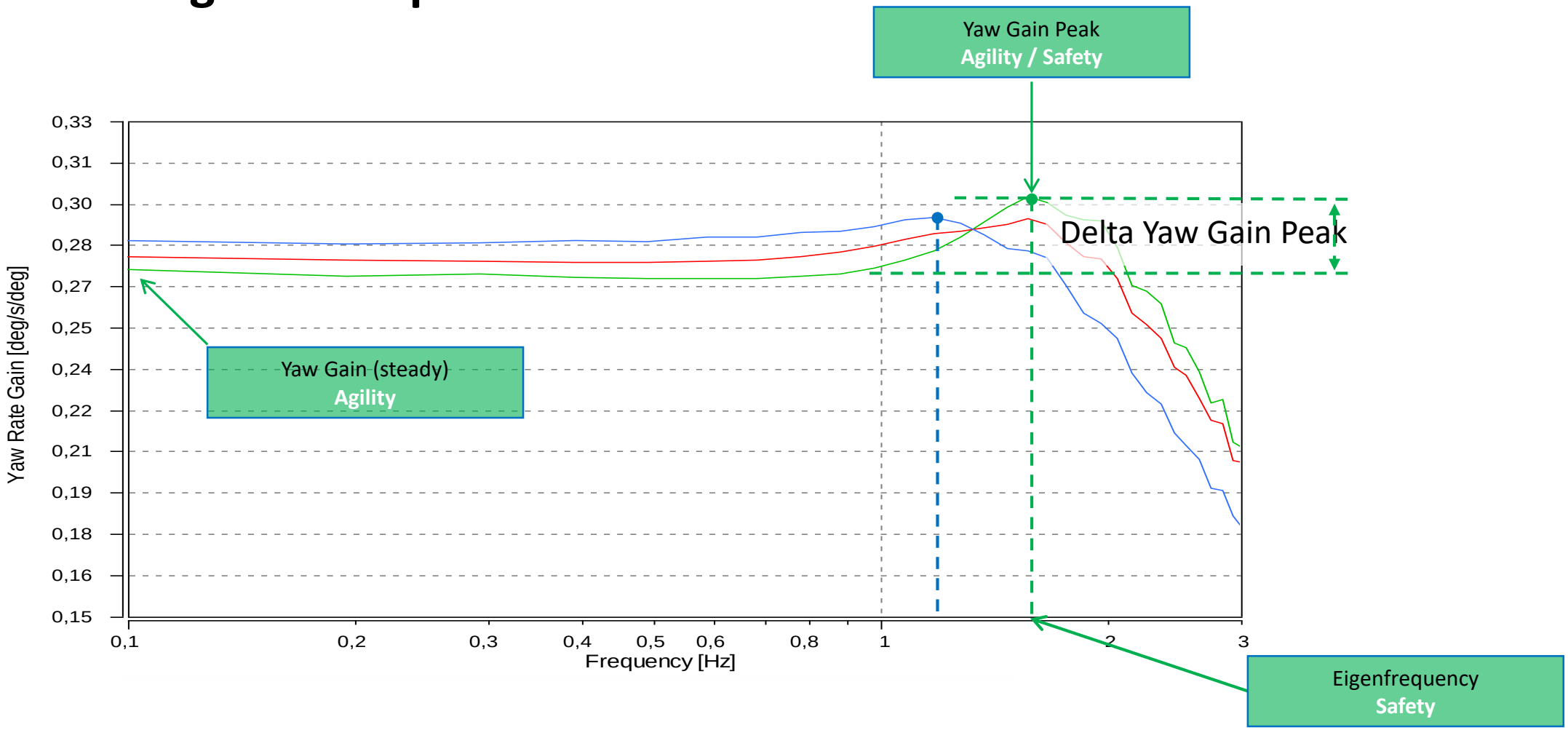
Lateral Acceleration Gain



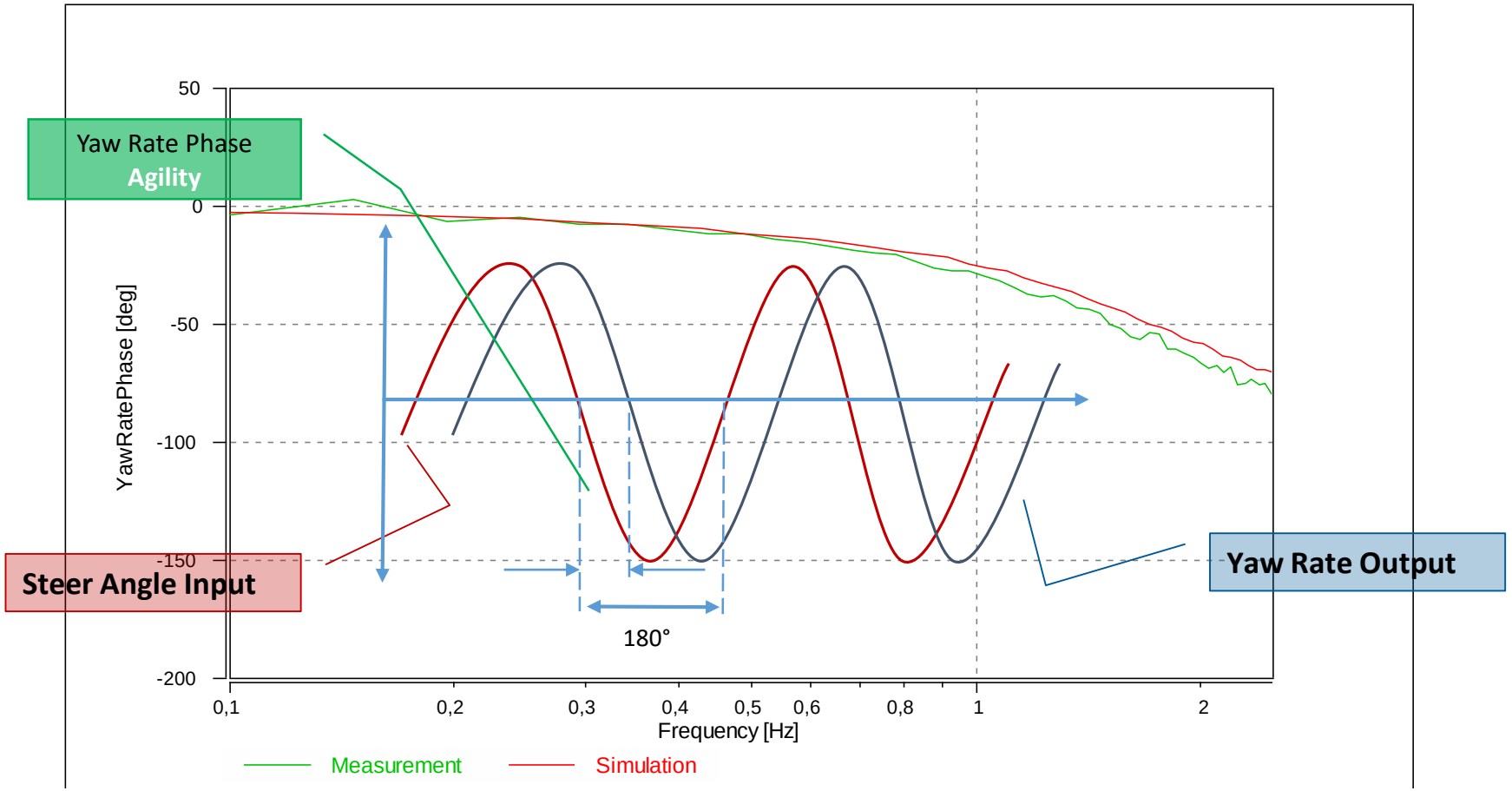
Yaw Gain



Bode Diagram: Amplitude Gain



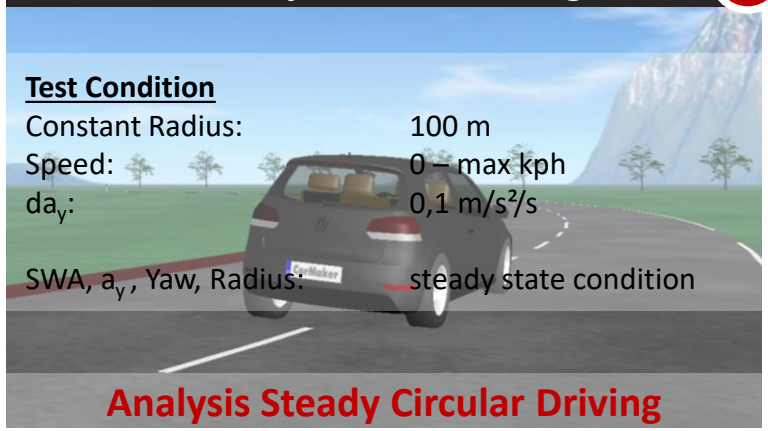
Bode Diagram: Yaw Rate Phase



Parameter Study for K&C, spring, damper, roll bar

Steady Circular Driving

1

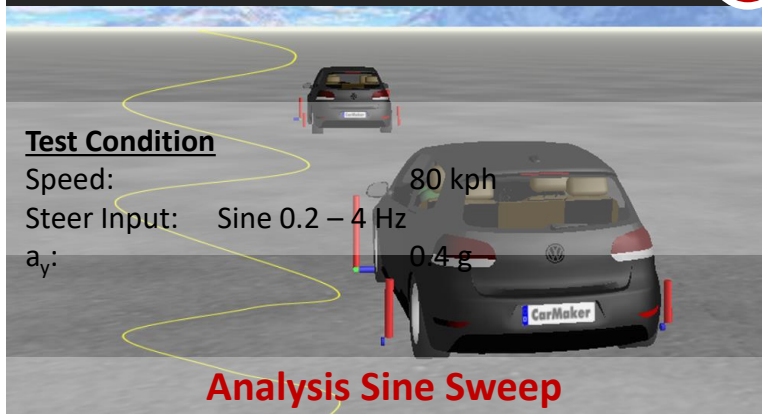


Find the sensitivity of parameters such as

- Roll bar stiffness
- Spring, buffer
- Toe change front / rear (K&C)
- Camber change front / rear (K&C)
- …

Sine Sweep

2



Find the sensitivity of parameters such as

- Mass/Mass distribution / inertia
- Roll bar stiffness
- Damper
- Tire side slip stiffness
- …