



# **The Influence of Electronic Stability Program on the safety of commercial vans with special regard to load distribution**

**Winfried Tomaske**

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### Motivation/ Accident Analysis

Accident statistics of trucks/ N1 light trucks, Influence of ESP (Electronic Stability Program)

### Measurement of vehicle data

Tyre characteristics, Damping characteristics, Axle kinematics, ...

### Rollover protection / Loading unit

calculation/design

### Handling Tests

The Influence of ESP; Validation Tests

### Driving Simulator Tests

The Influence of ESP

### Summary

## Accidents with trucks



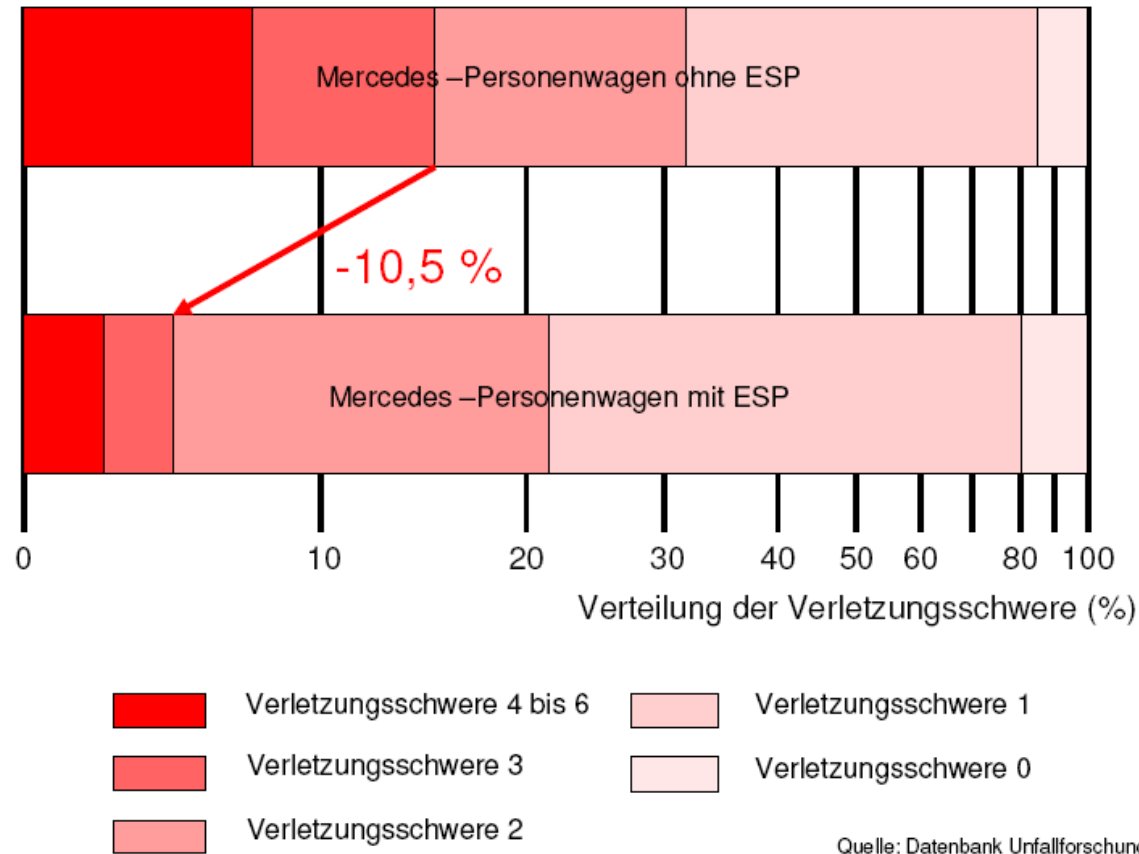
Datenquelle: Knorr-Bremse Group

## Road accidents in 2011 with driver of N<sub>1</sub> vehicle (GVM ≤ 3.5 t) as main responsible

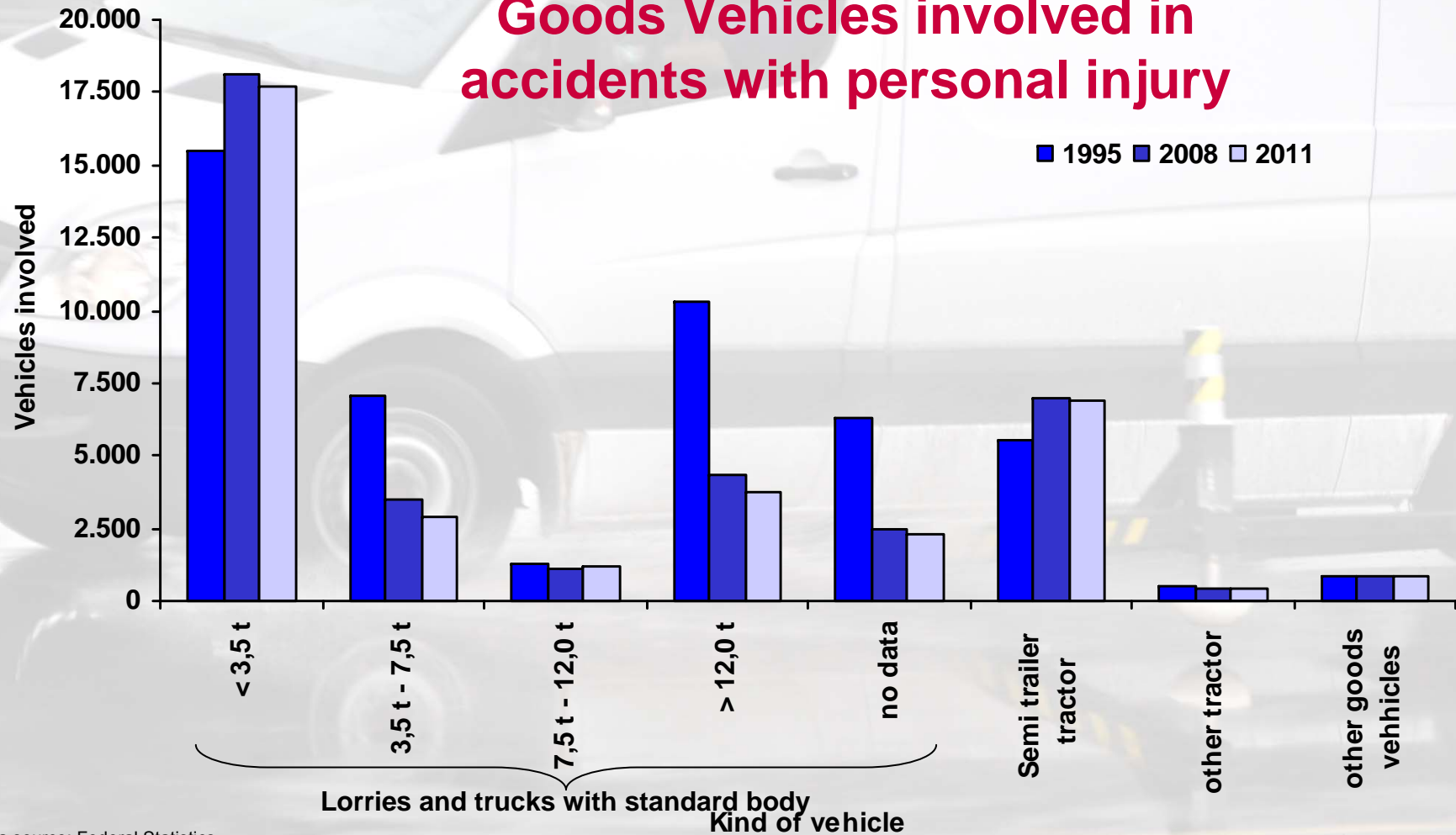
Kind of accident		Casualties			
		Total	Fatalities	Severely injured	Slightly injured
Collision with another vehicle ...	which starts, stops or is stationary	1.137	3	96	1.038
	moving ahead or waiting	3.894	15	256	3.623
	moving laterally in the same direction	717	3	88	626
	oncoming	1.210	40	307	863
	turning into or crossing the road	4.125	14	560	3.551
Collision with vehicle and pedestrian		1.027	24	263	740
Collision with an obstacle in the carriageway		44	1	7	36
Leaving the carriageway	to the right	833	17	213	603
	to the left	585	14	165	406
Accident of another kind		857	4	102	751
<b>Total</b>		<b>14.429</b>	<b>135</b>	<b>2.057</b>	<b>12.237</b>

Data source: Federal Statistics, Road accidents with goods vehicles 2011

## Influence of ESP on active safety

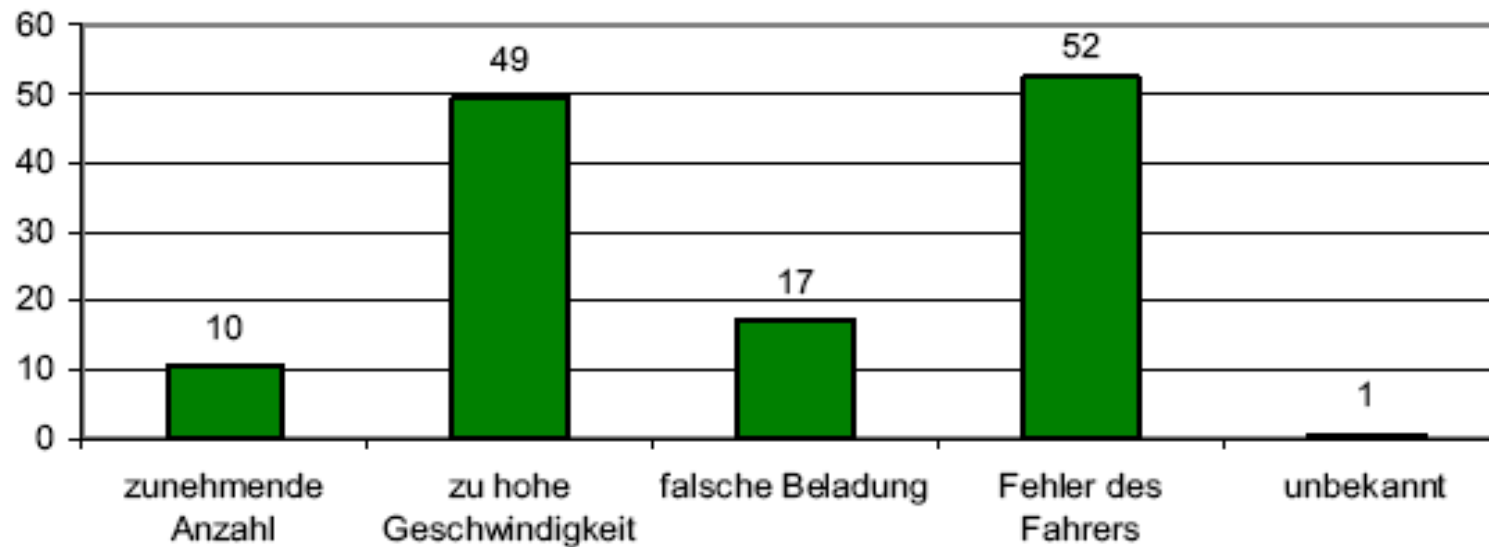


## Goods Vehicles involved in accidents with personal injury

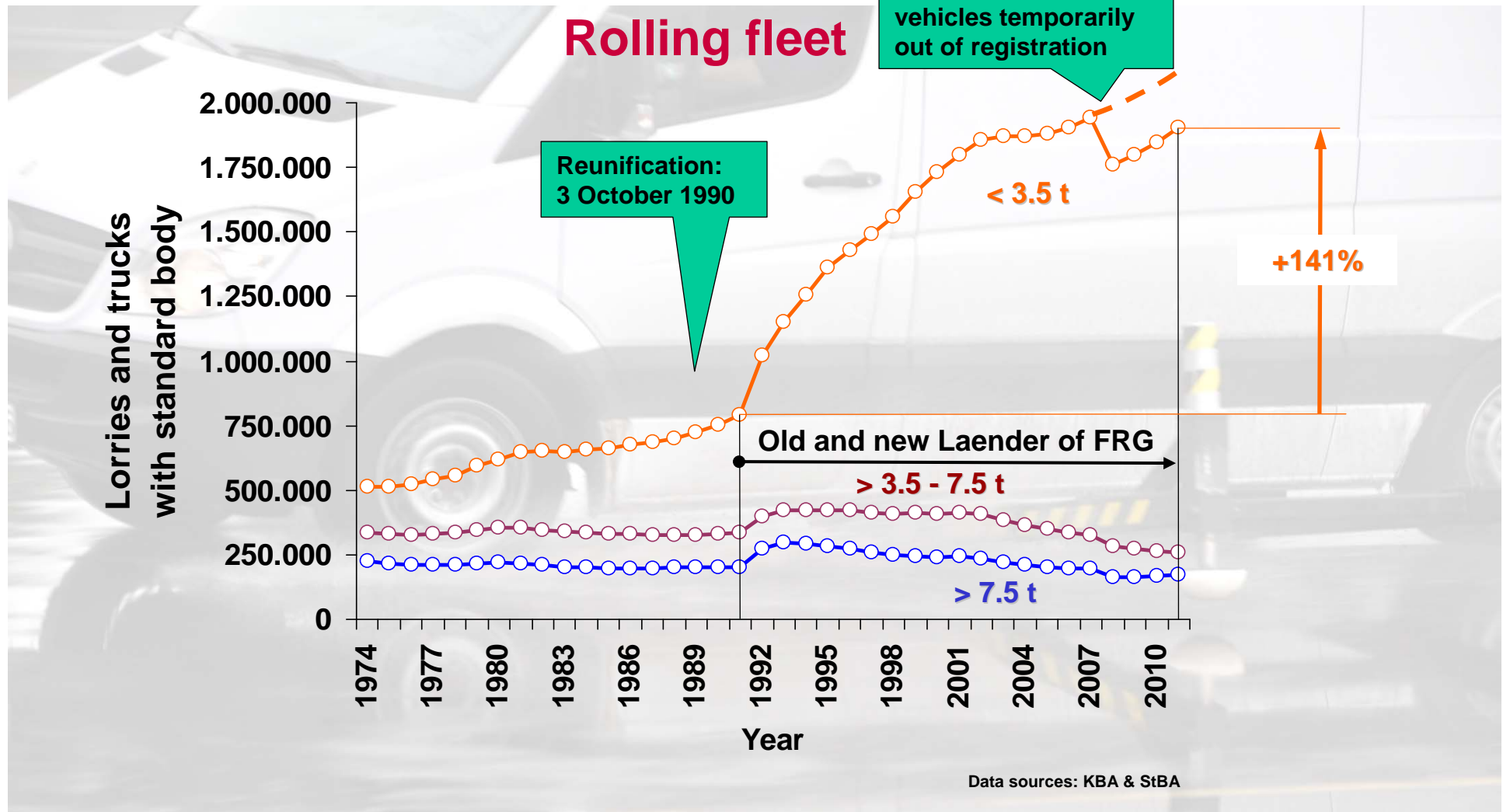


Data source: Federal Statistics

## Accident cause, Dekra



Datenquelle: Berg F.,A. et al: „Sicherheit von Transportern“ DEKRA/VDI Symposium 2004





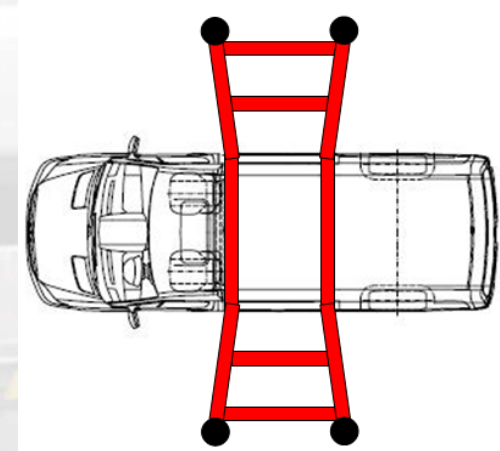
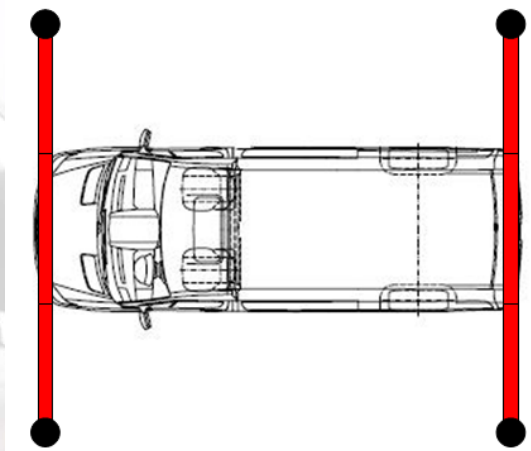
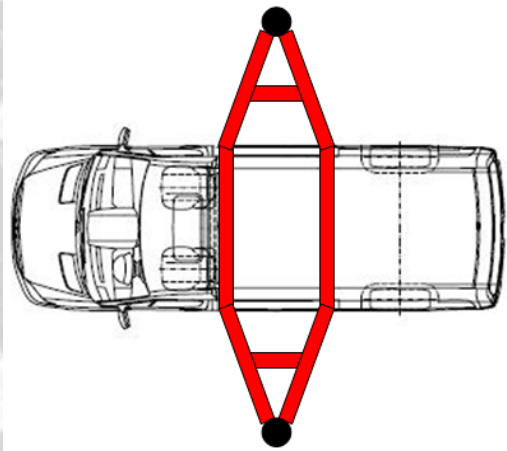


## Vehicle and vehicle data

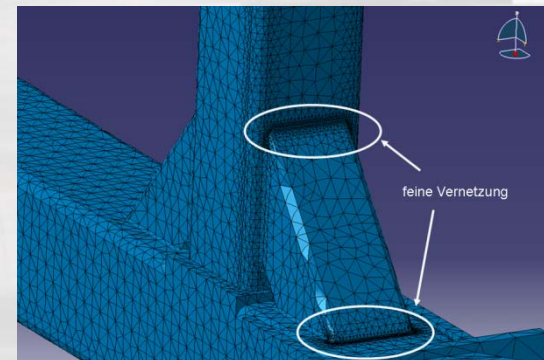
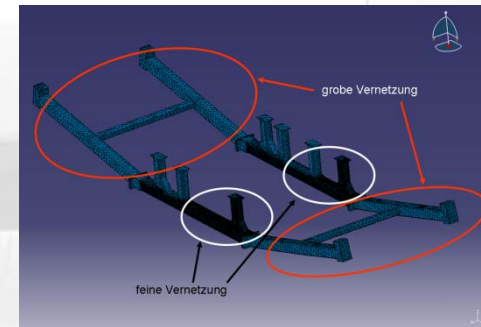
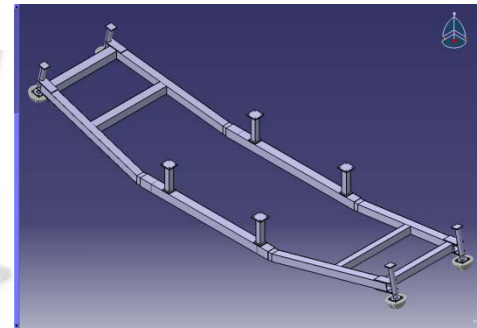
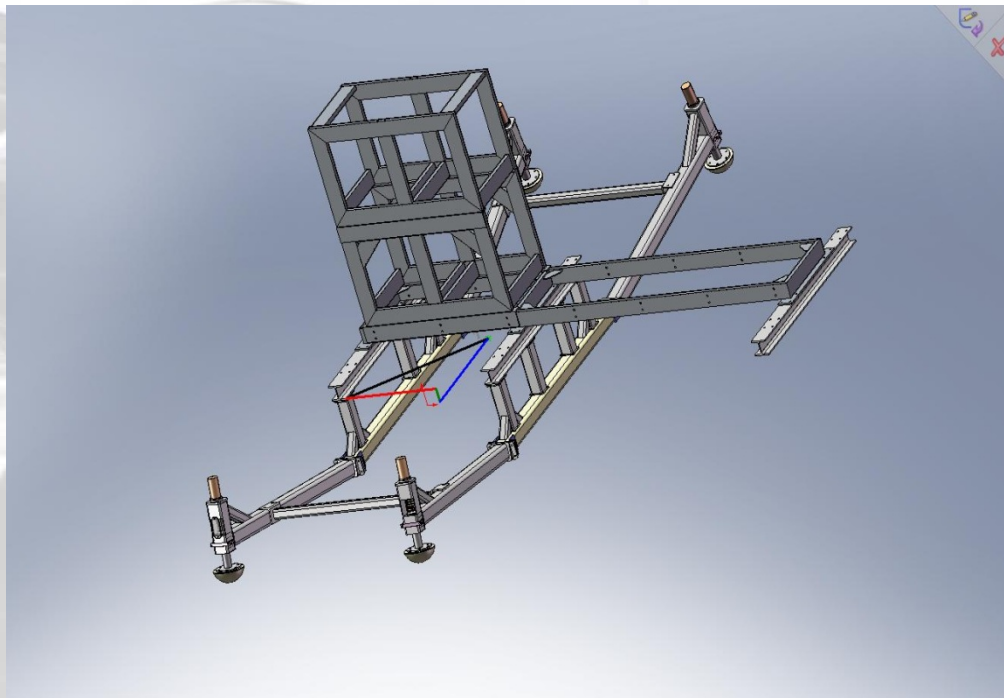
Mercedes Benz Sprinter 215 CDI  
Leistung 110 kW

Daten	Werte	Maße
Laderaummaße LxBxH	3265x1780x1650	mm
Radstand	3665	mm
Spurweite vorne/hinten	1710/1716	mm
Schwerpunktlage	1475	mm
Schwerpunkthöhe	840	mm
Trägheitsmoment des Fahrzeugs um x-Achse ( $I_{xx}$ )	1300	kgm <sup>2</sup>
Trägheitsmoment des Fahrzeugs um y-Achse ( $I_{yy}$ )	7300	kgm <sup>2</sup>
Trägheitsmoment des Fahrzeugs um z-Achse ( $I_{zz}$ )	6800	kgm <sup>2</sup>
Gesamtgewicht	2342	kg
Nutzlast	880-1070	kg

## Design study of the rollover protection



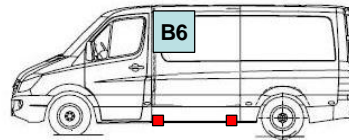
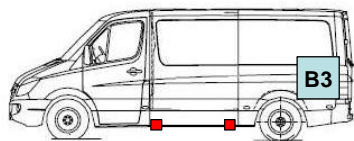
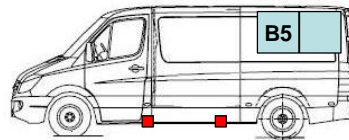
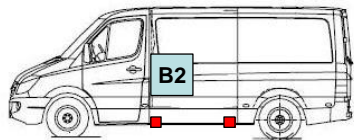
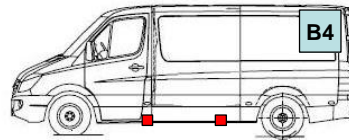
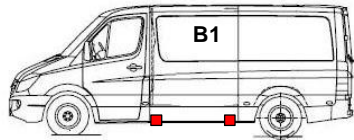
## Construction and calculation of the rollover protection and the loading system



## Test vehicle with equipment



## Variable loading conditions



asymmetric loading conditions

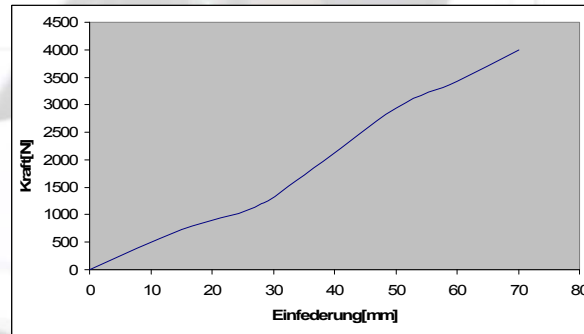
## Test-vehicle with testing wheels



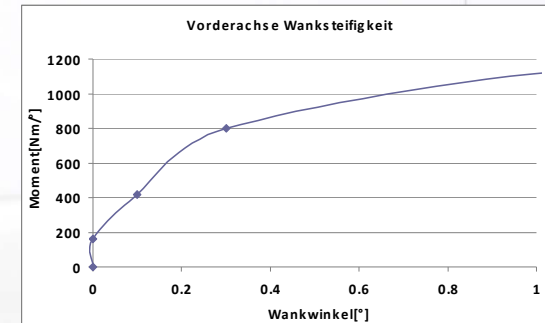
## Measuring of vehicle data



Front axle



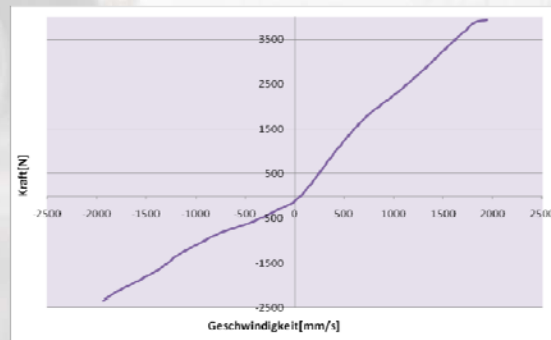
Spring characteristics



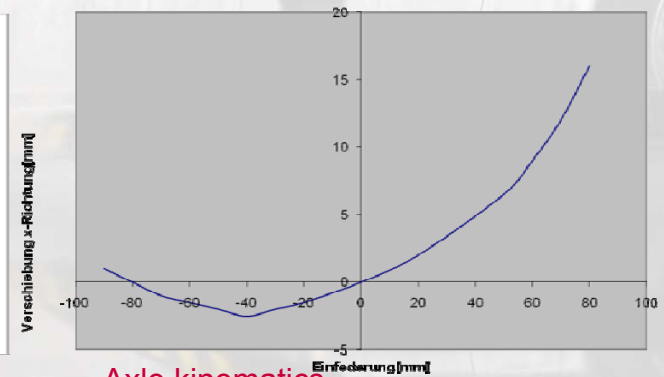
Roll characteristics



Rear axle

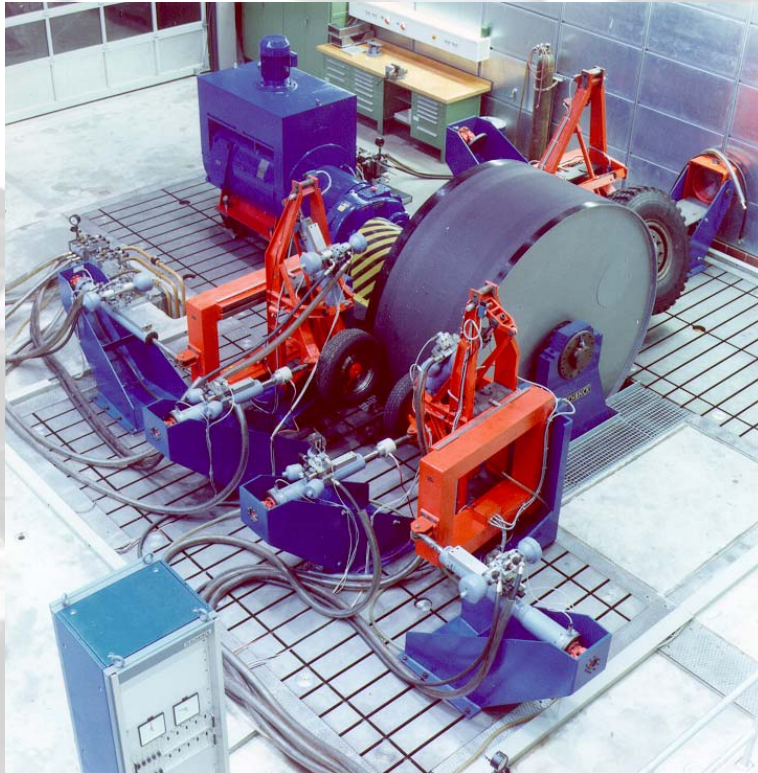


Damping characteristics

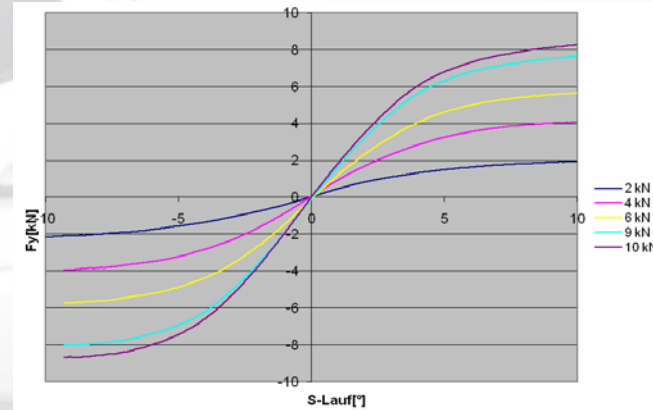


Axle kinematics

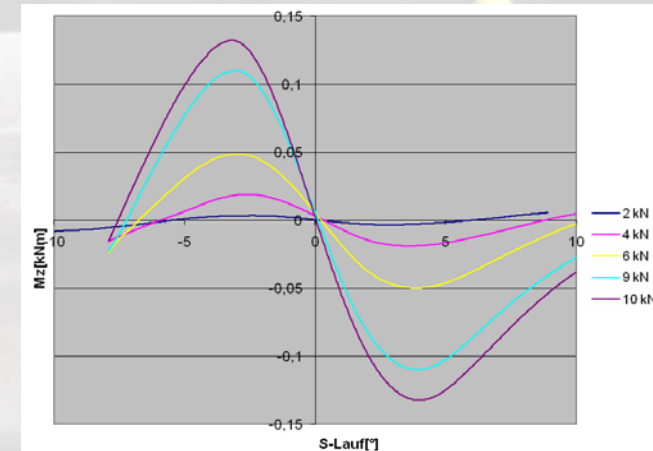
## Tire characteristics



dynamic tire test rig



Lateral force characteristics



Restoring torque characteristics



## Measuring system



Cockpit with steering wheel sensor



GPS sensor



Slip angle sensor



Brake pedal sensor



Steering wheel sensor

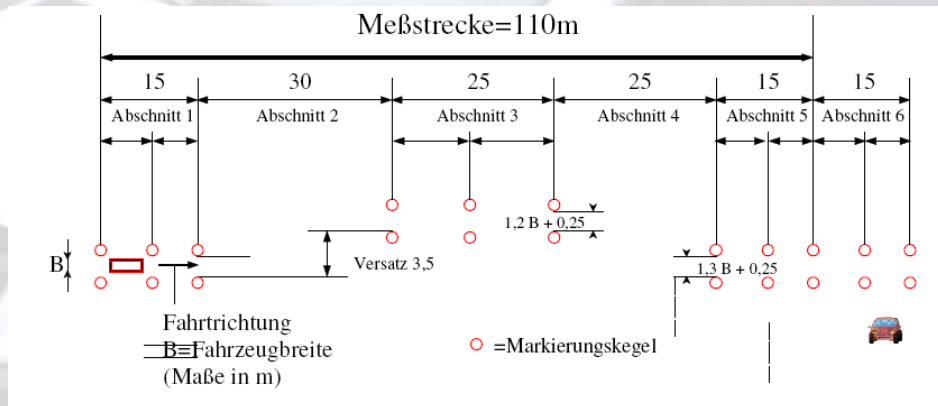


GPS Platform ADMA

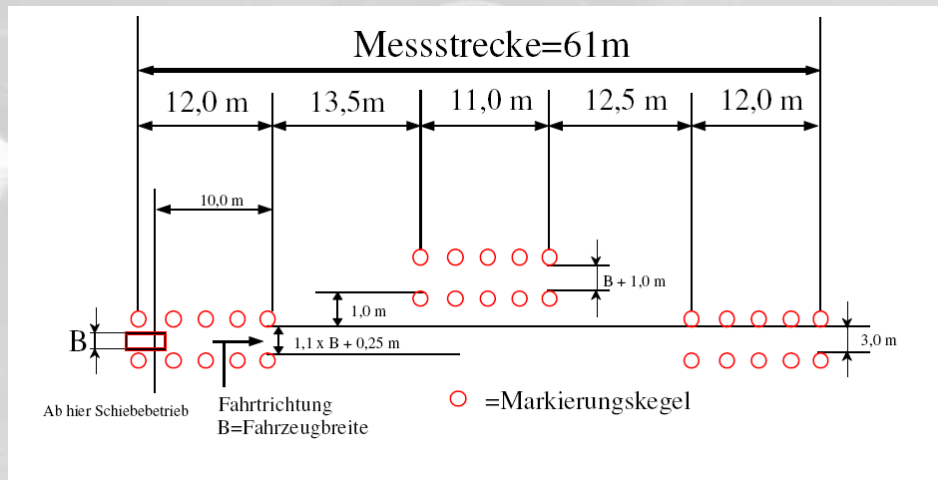


Brake pressure sensor

## Dynamic handling tests

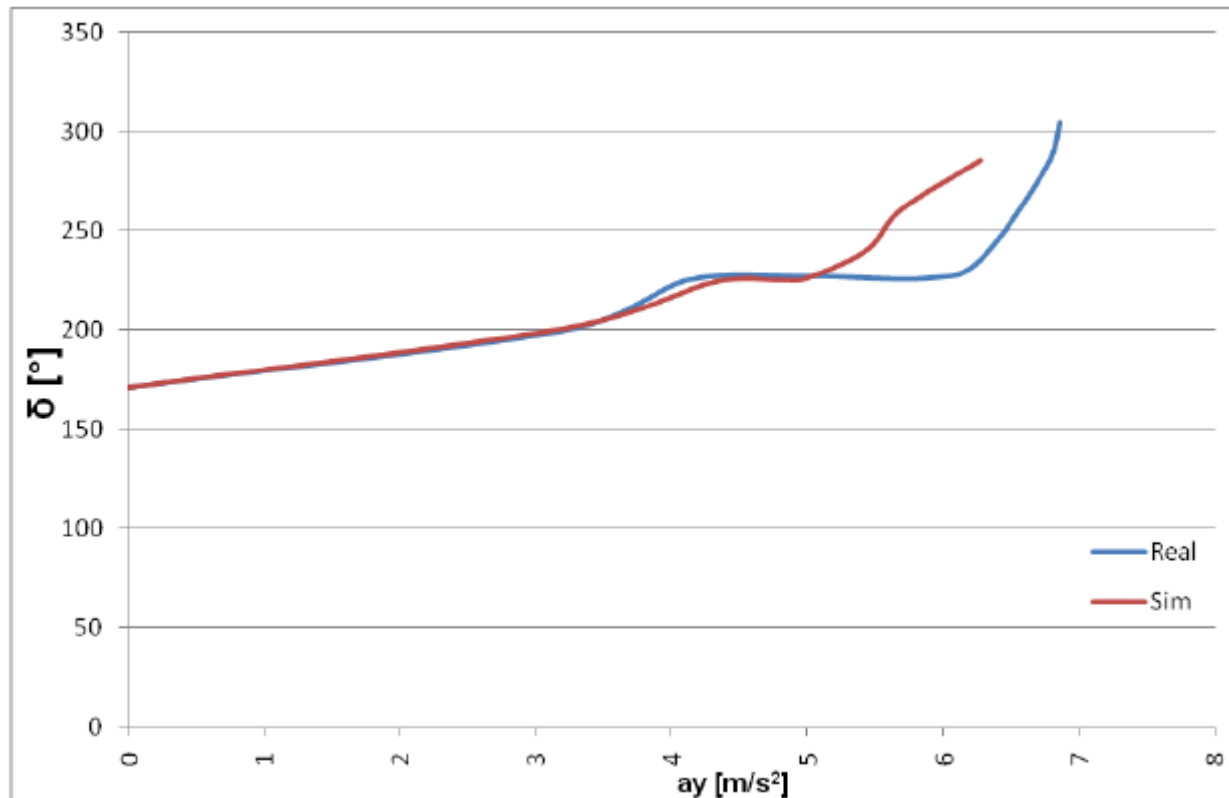


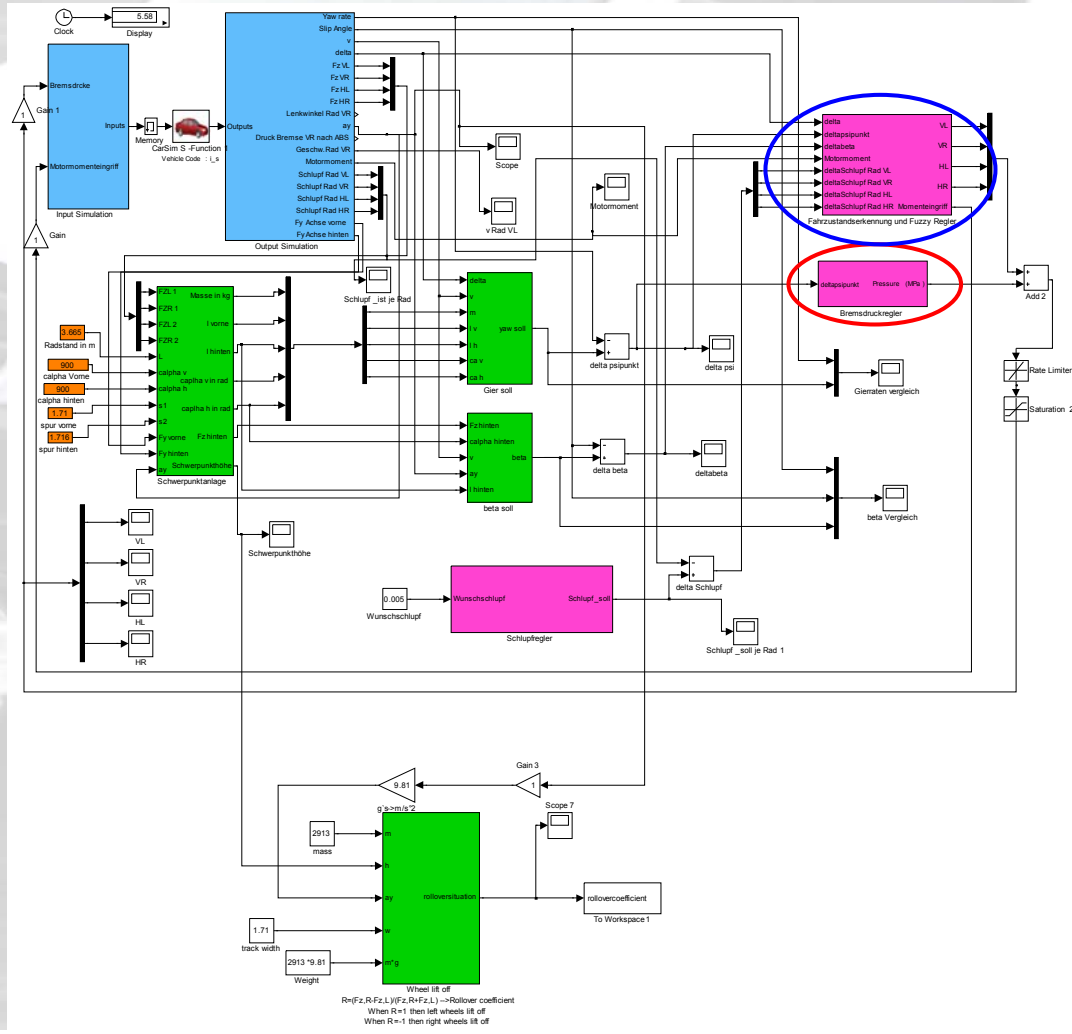
Double lane change manoeuvre  
DIN ISO 3888-1



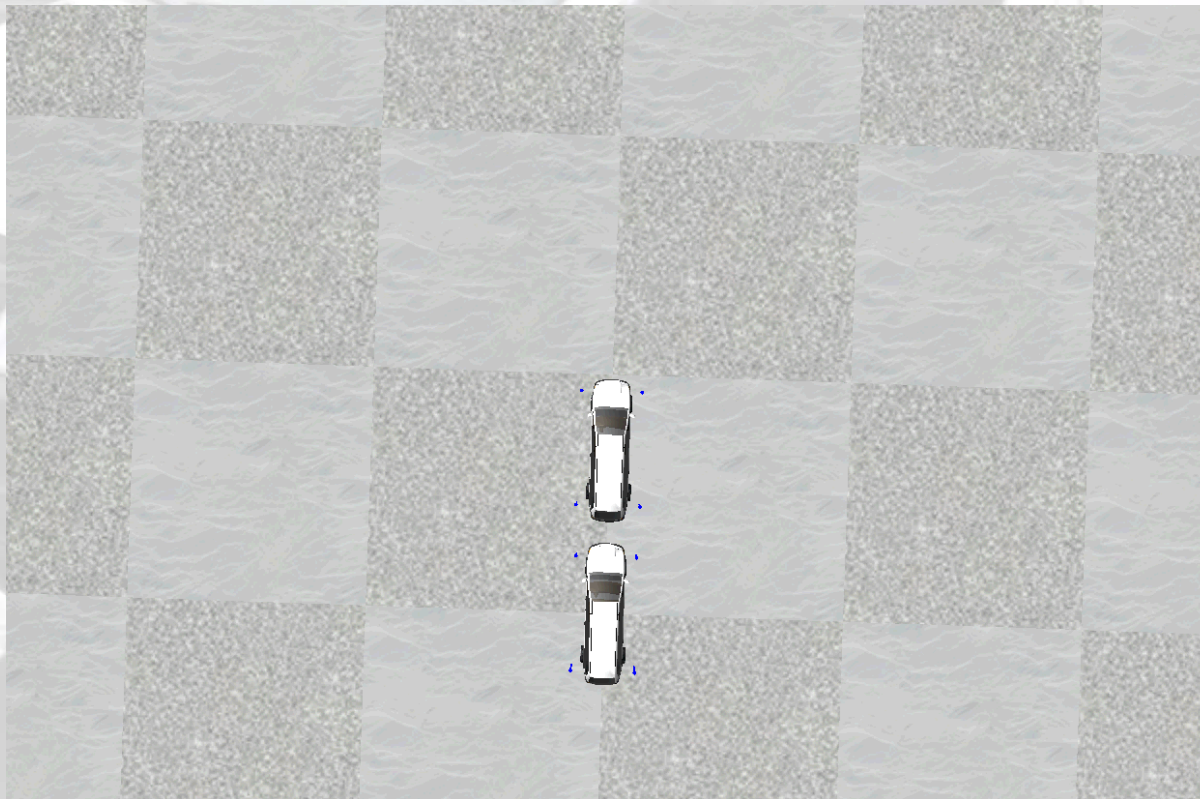
Double lane change manoeuvre  
DIN ISO 3888-2

## Validation Test, stationary driving conditions



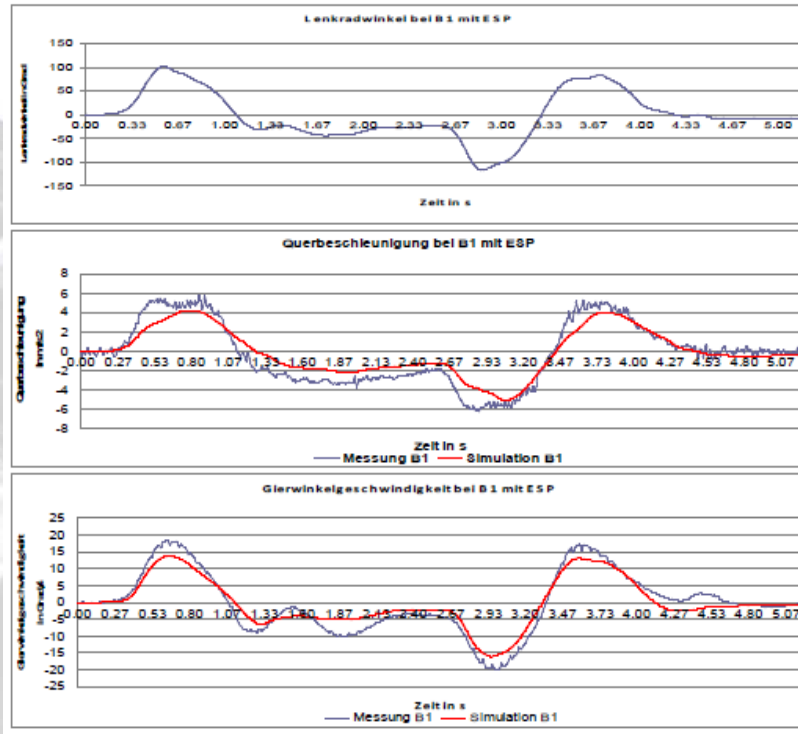


**Load dependent  
 ESP-control**

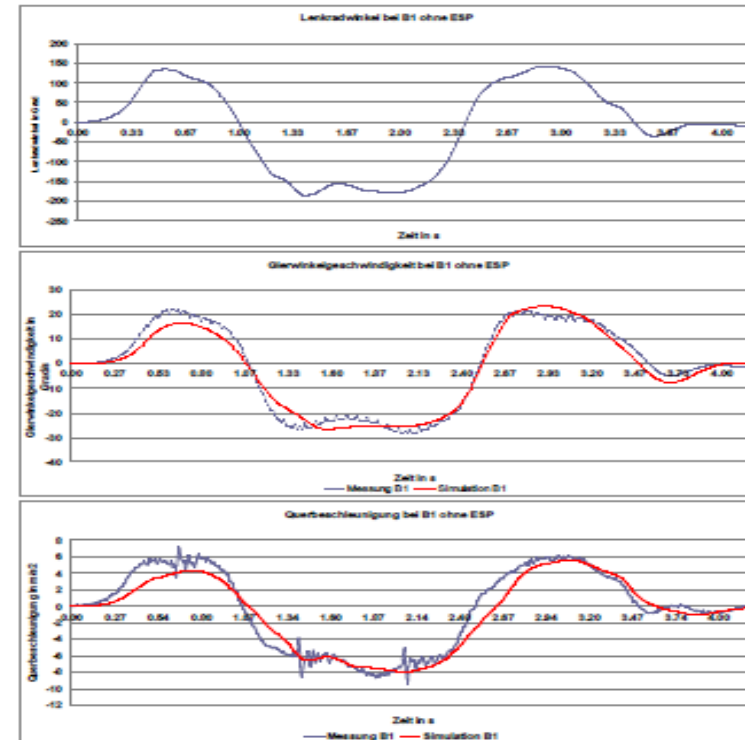


**Simulation**  
**with and without ESP**

# Validation Test, instationary driving conditions

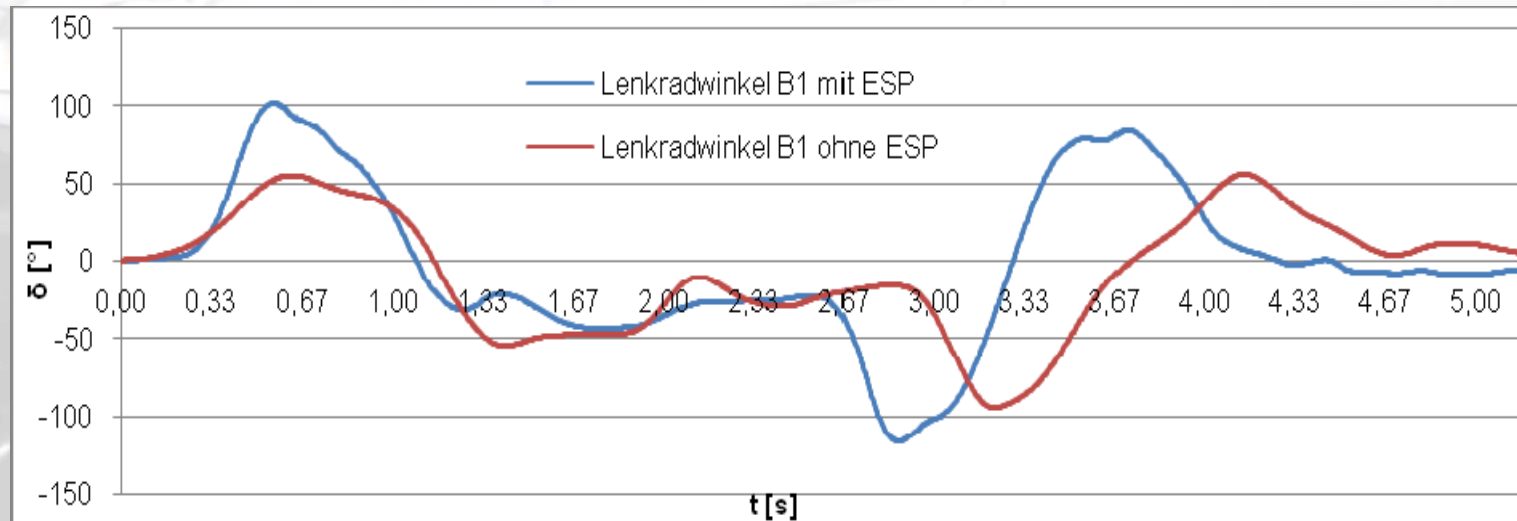


Validation ISO 3888-1; B1 with ESP



Validation ISO 3888-2; B1 without ESP

# Influence of ESP on the handling behaviour

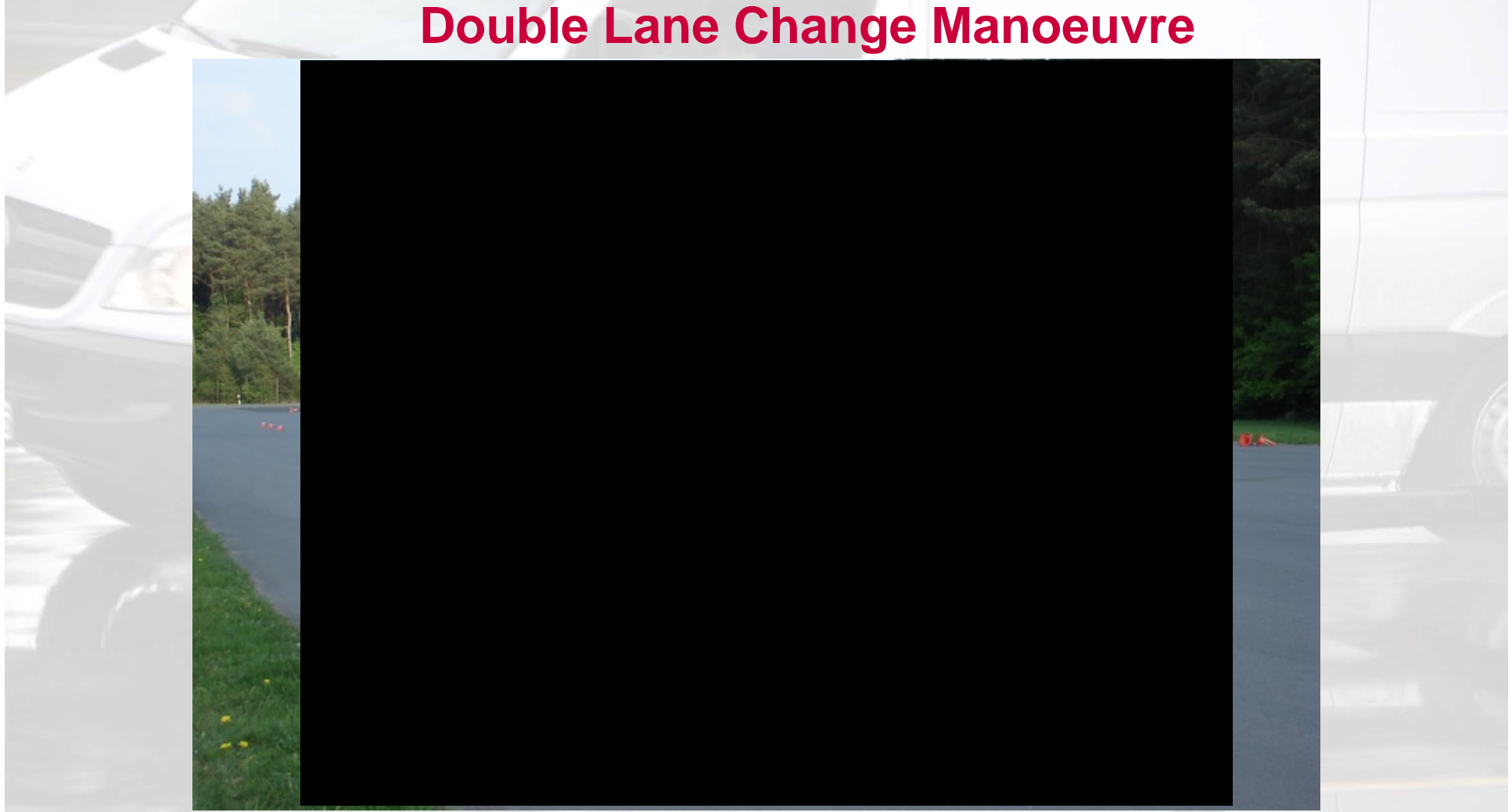


## Double Lane Change Manoeuvre

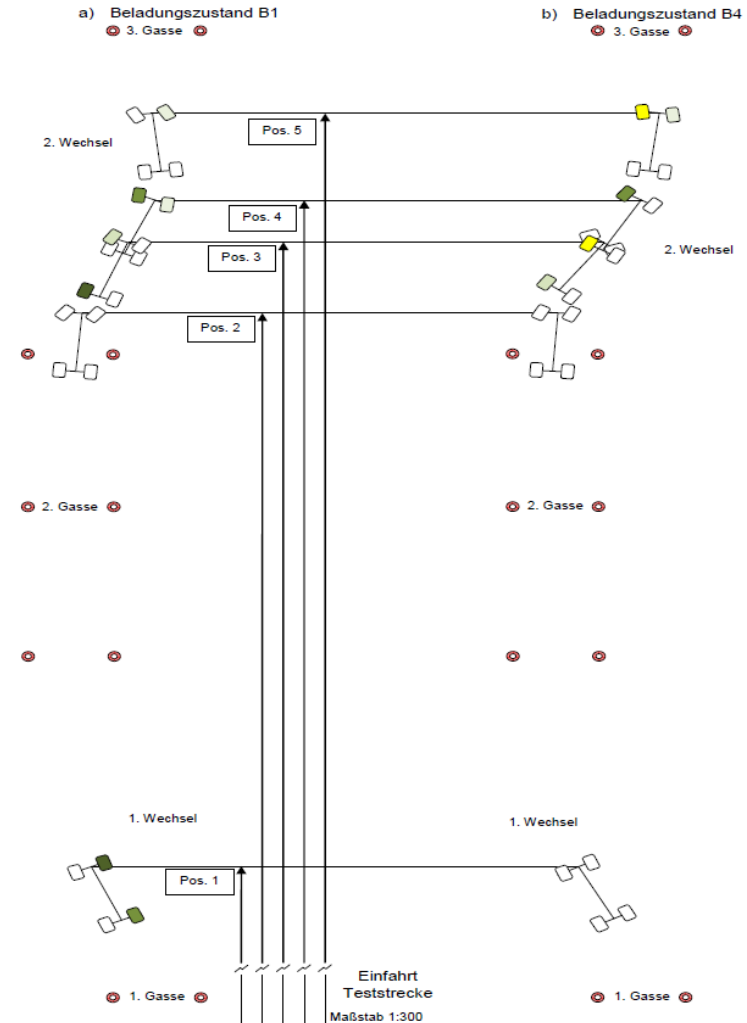
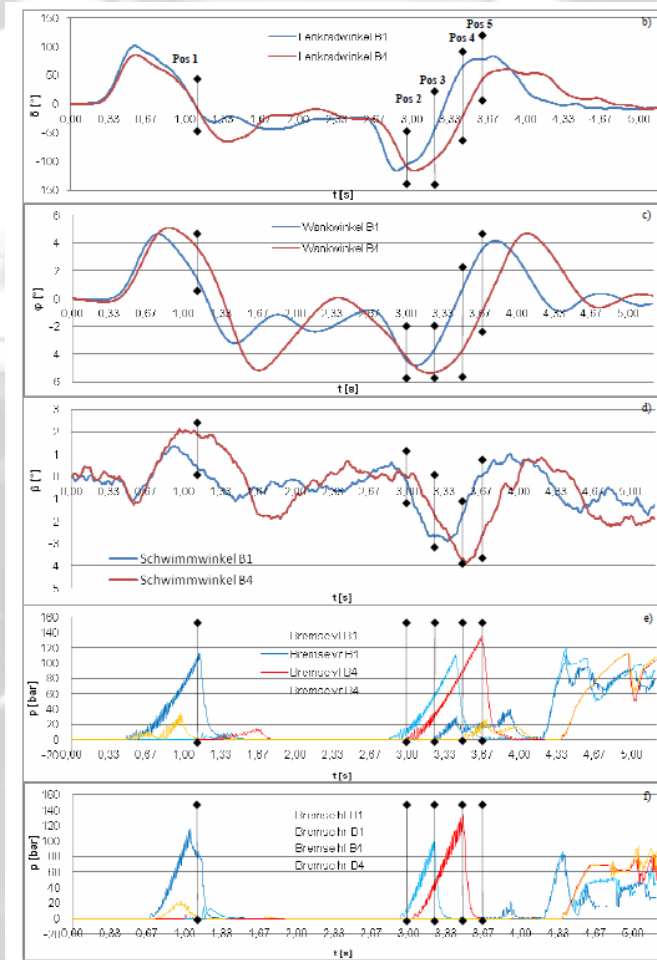




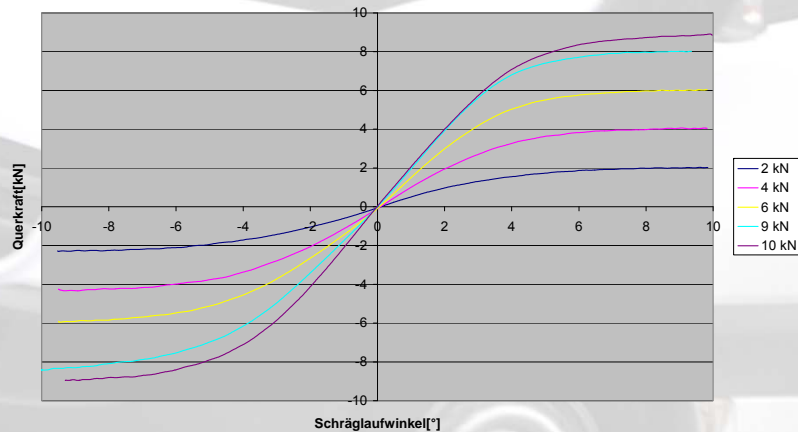
## Double Lane Change Manoeuvre



# The effect of loading conditions on ESP

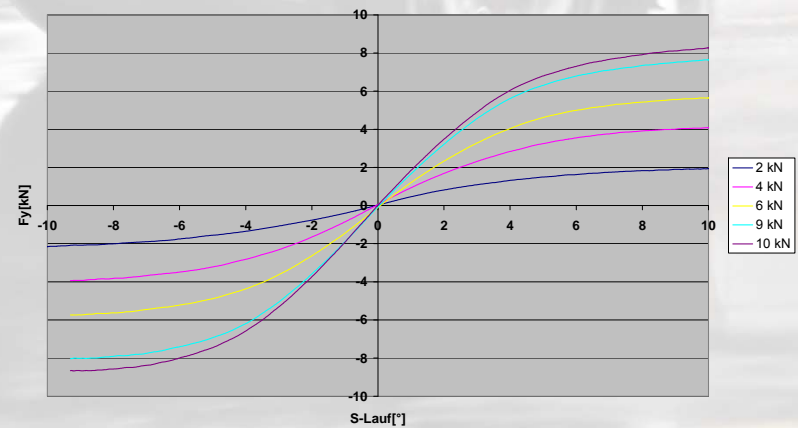


Querkraft i. Abh. vom Schräglaufwinkel bei 3 bar



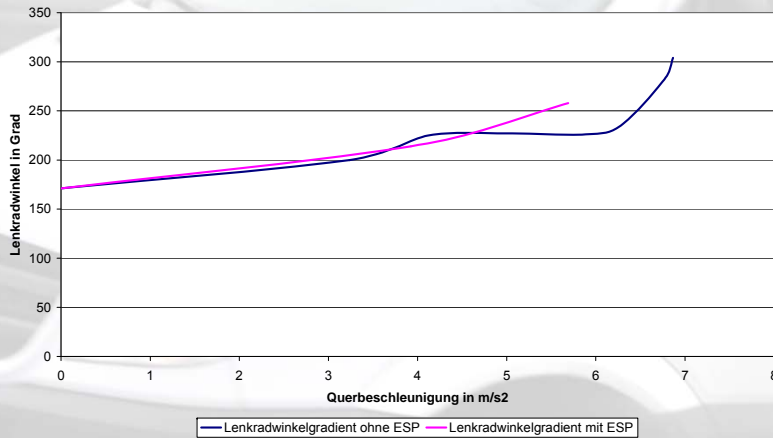
Tyre characteristics: Continental summer

Querkraft i. Abh. Schräglaufwinkel



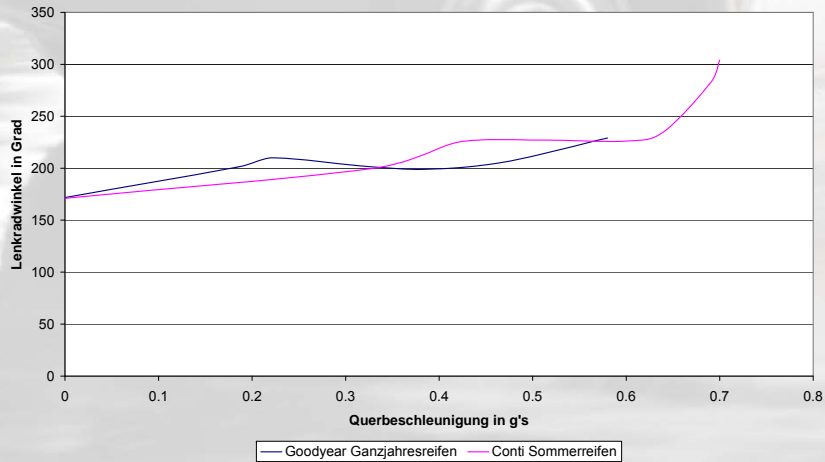
Tyre characteristics: Goodyear all season

Lenkradwinkelgradient bei B1

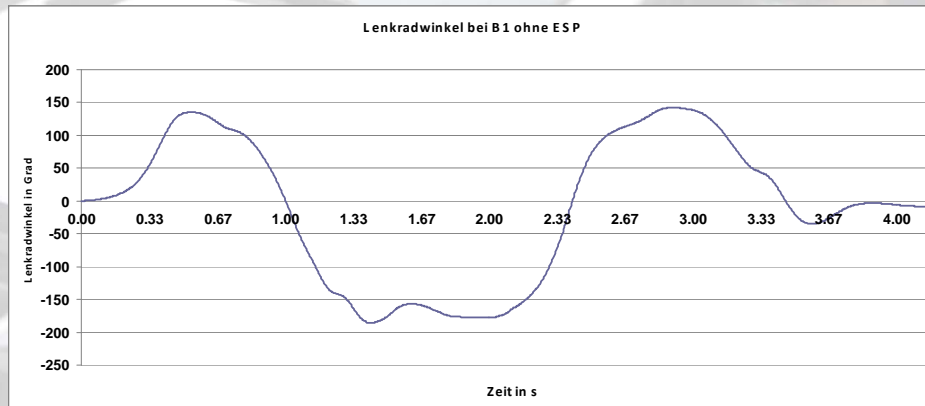


steady-state cornering (ISO 4138)  
 with and without ESP

Lenkradwinkelgradient

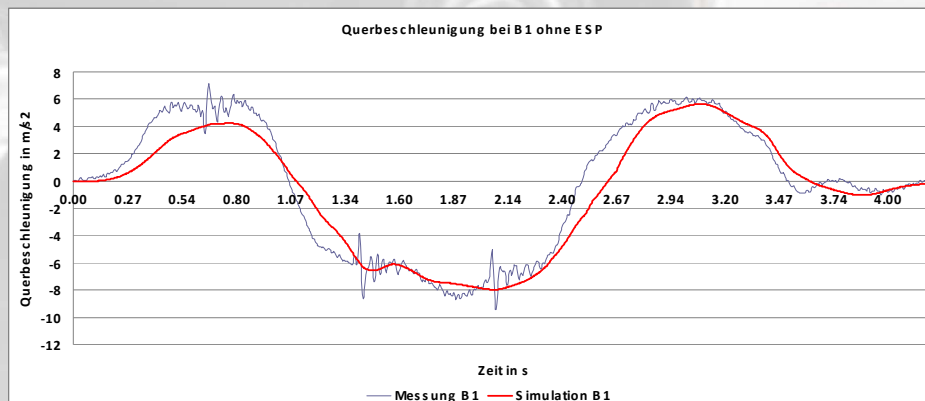


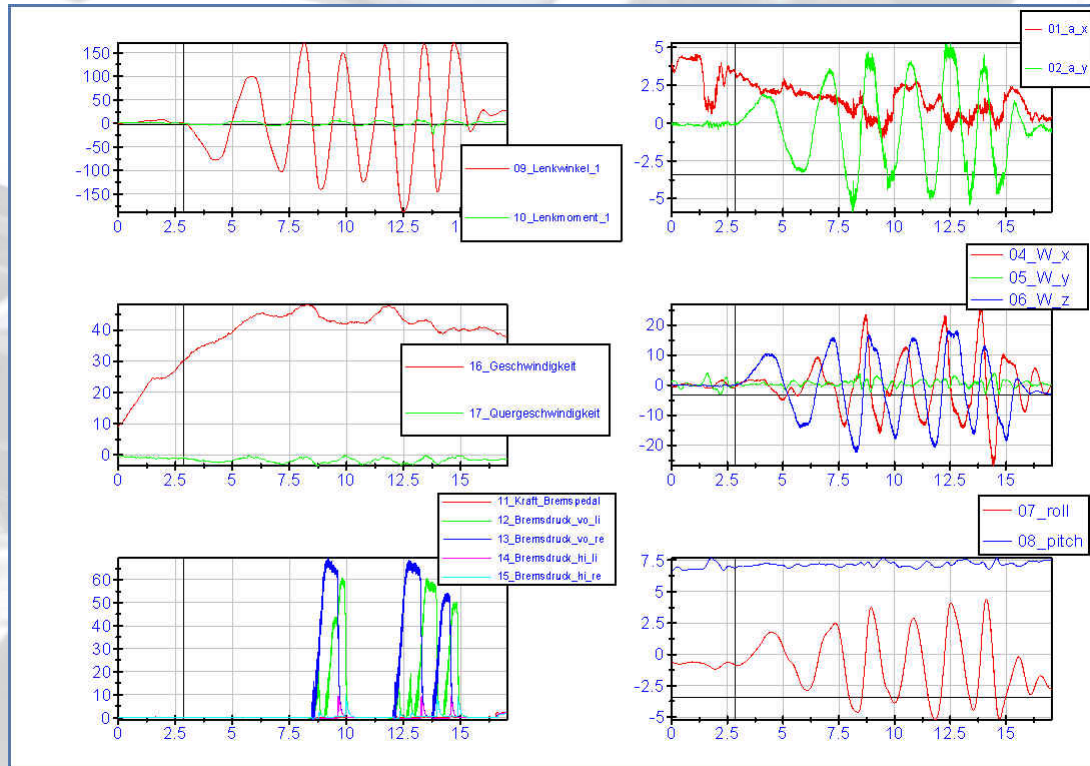
steady state cornering (ISO 4138)  
 without ESP  
 different tyres



Double Lane change manoeuvre

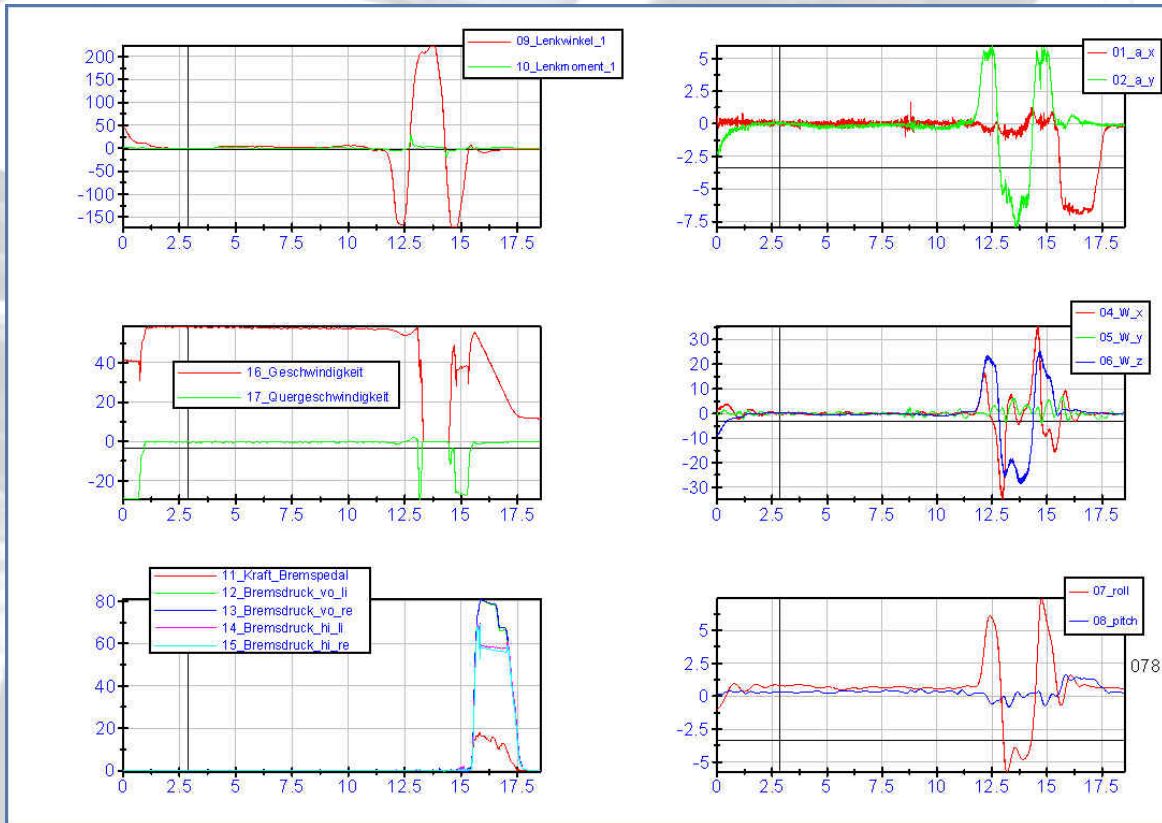
Max. lateral acceleration  $6 \text{ m/s}^2$



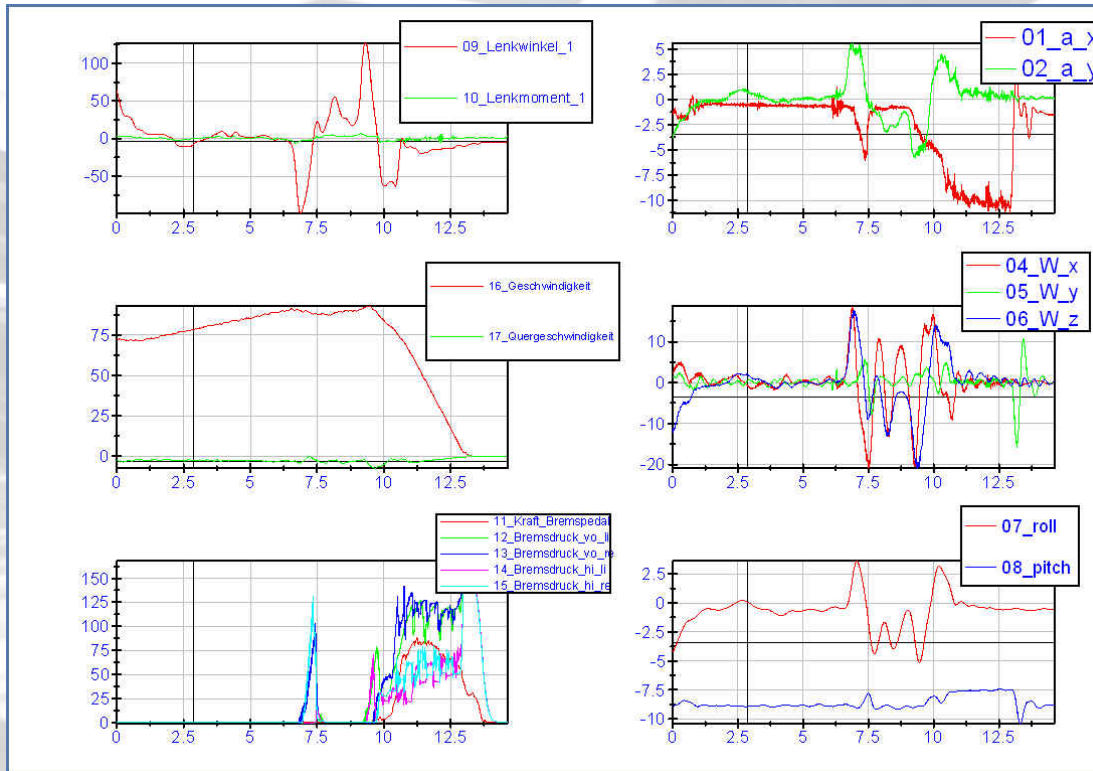


sinusoidal steering input

max. lateral acceleration  $5,5 \text{ m/s}^2$



Double lane-change manoeuvre  
max. lateral acceleration  $7,5 \text{ m/s}^2$



Double lane change manoeuvre  
with full braking  
max. longitudinal deceleration 10 m/s<sup>2</sup>



## Table of max acceleration values

steady-state cornering  
 with ESP  
 without ESP

max. lateral acceleration  
 5,5 m/s<sup>2</sup>  
 7 m/s<sup>2</sup>

Double lane change manoeuvre  
 with ESP  
 without ESP

4 m/s<sup>2</sup>  
 7,5 m/s<sup>2</sup>

max. longitudinal deceleration

10 m/s<sup>2</sup>

## Driving Simulator Tests

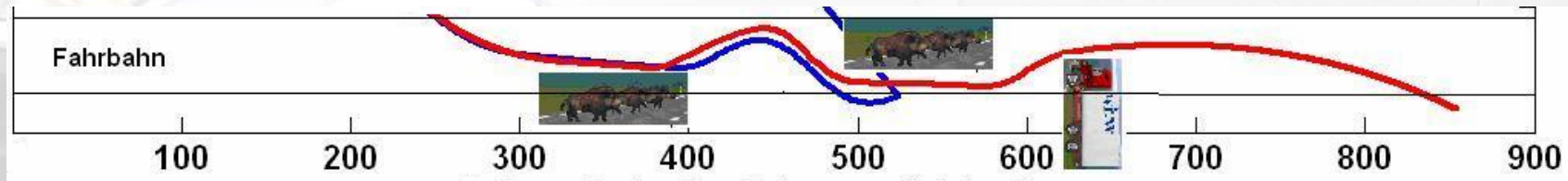


Dynamic Driving Simulator;  
8 DoF



Obstacle avoidance manoeuvre with wild boars

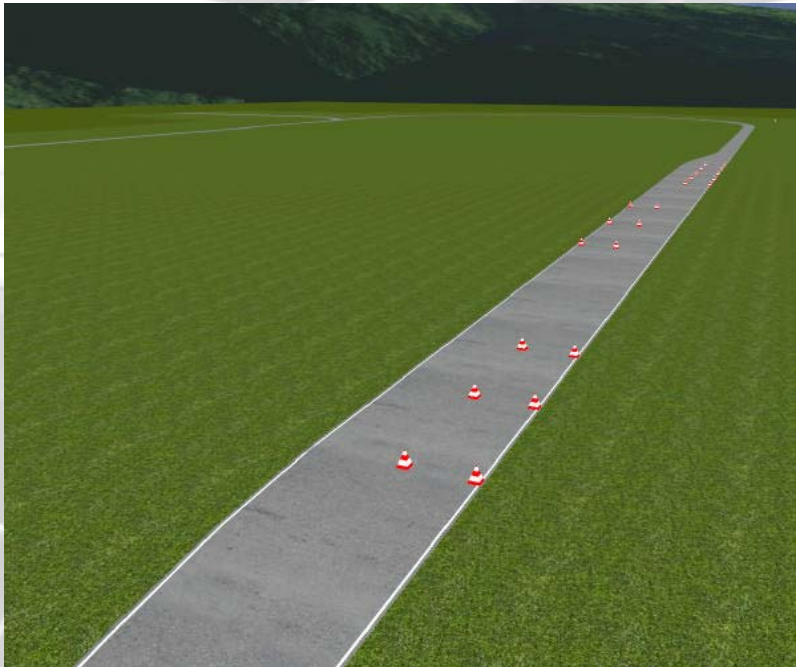
## Typical trajectory, obstacle avoidance manouvre



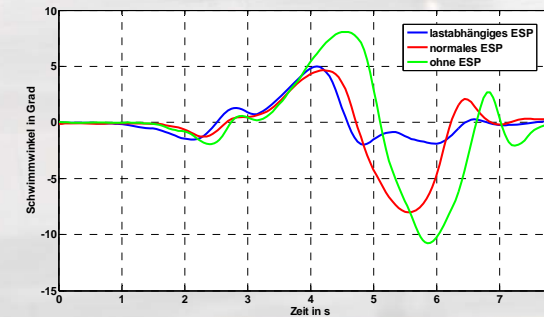
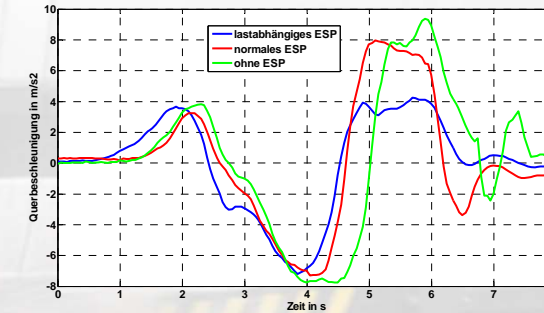
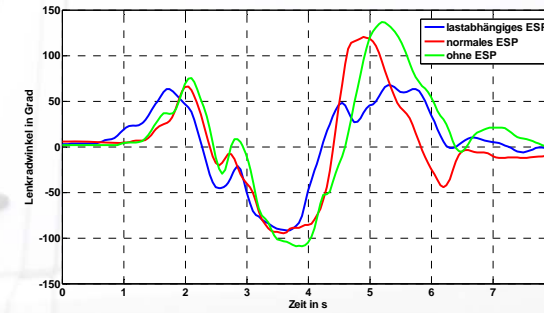
Only 20 % of the driver were able to avoid the obstacle (without ESP);

Given velocity 100 km/h

## Double Lane change manoeuvre with different braking systems



Visuel scene in the driving simulator





The image shows the cover of a brochure for the 'Fahr Simulator MARS'. The background is a photograph of a vehicle chassis on a test rig in a laboratory setting. The text is overlaid in white on a dark blue background. In the top left corner of the brochure is the IFA S logo. In the top right corner is the Helmut Schmidt University logo. The main title 'Fahr Simulator MARS' is in large white font. Below it, the text reads: 'Institut für Fahrzeugtechnik und Antriebssystemtechnik', 'Univ.-Prof. Dr.-Ing. M. Meywerk', and 'Helmut-Schmidt-Universität Universität der Bundeswehr Hamburg'.

**Fahr Simulator MARS**  
Institut für Fahrzeugtechnik  
und Antriebssystemtechnik  
Univ.-Prof. Dr.-Ing. M. Meywerk  
Helmut-Schmidt-Universität  
Universität der Bundeswehr Hamburg

## Summary

- accident analysis shows the importance of ESP
- Especially N1 drivers are mostly involved in accidents
- a test vehicle with an adaptive load control ESP was assembled with a rollover protection and a loading unit
- vehicle data were measured with test rigs
- a vehicle model was designed in CarSim
- Validation tests were done considering stationary and instationry driving conditions
- avoidance tests were done with a dynamic driving simulator
- the importance of a load adaptive ESP system was shown in driving simulator tests, considering especially normal drivers



**Thank you very much**