Driving Dynamics Evaluation of Body Structural Stiffnesses

Using Adams Real Time on a DIM 400 Driving Simulator

Dr. Andreas Apel, Volkswagen AG
Dennis Schütte, Volkswagen AG
Elmar Teipen, Volkswagen AG
Helmut Schmitz, VI-grade

Udine | May 19th – 21st, 2026

Agenda

Introduction

Chassis Development Process and Increasing Virtualization

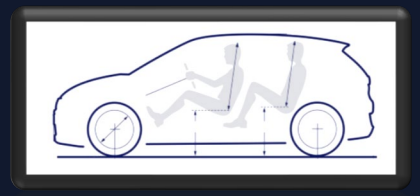
Experimental Design and Transfer to Driving Simulator

- Driving Task while Chassis Tuning and in Driving Simulator
- Adams Real Time Vehicle Model
- Model Complexity vs Computer Performance vs Perception of Driving Dynamics

Experimental Procedure and Results

Summary

Introduction
Application Areas of Virtual Methods



High Potential for Virtual Methods, Developing KPIs

Testing Phase, High Portion of Subjective Evaluation

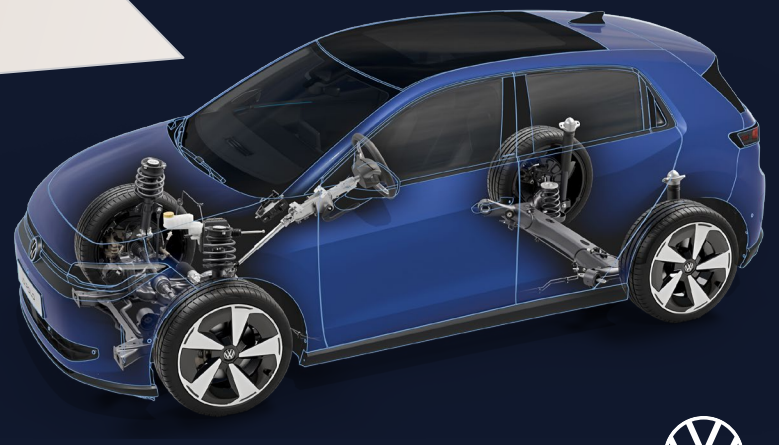
Concept

Construction

Functions

Fatigue Strength

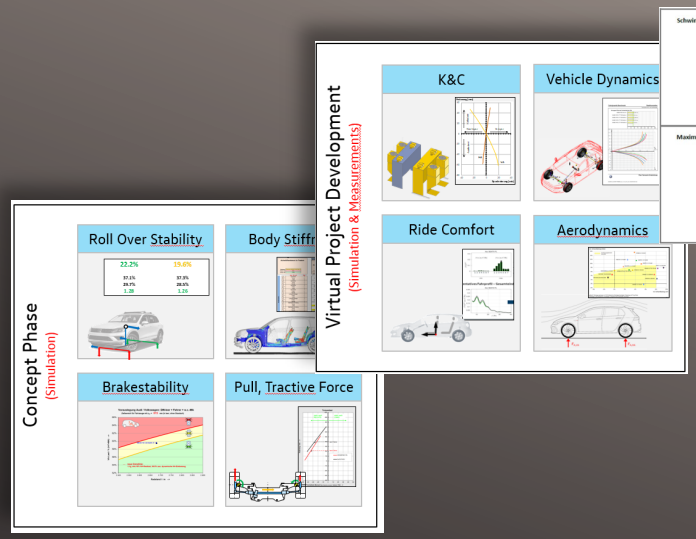
Driving Characteristics

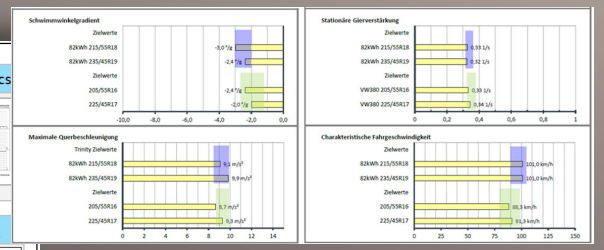


Chassis Development Process and Increasing Virtualization

Chassis Development Process and Increasing Virtualization
Securing Driving Characteristics using Virtual Methods

Concept → Construction → Virtual Validation → Testing → Production





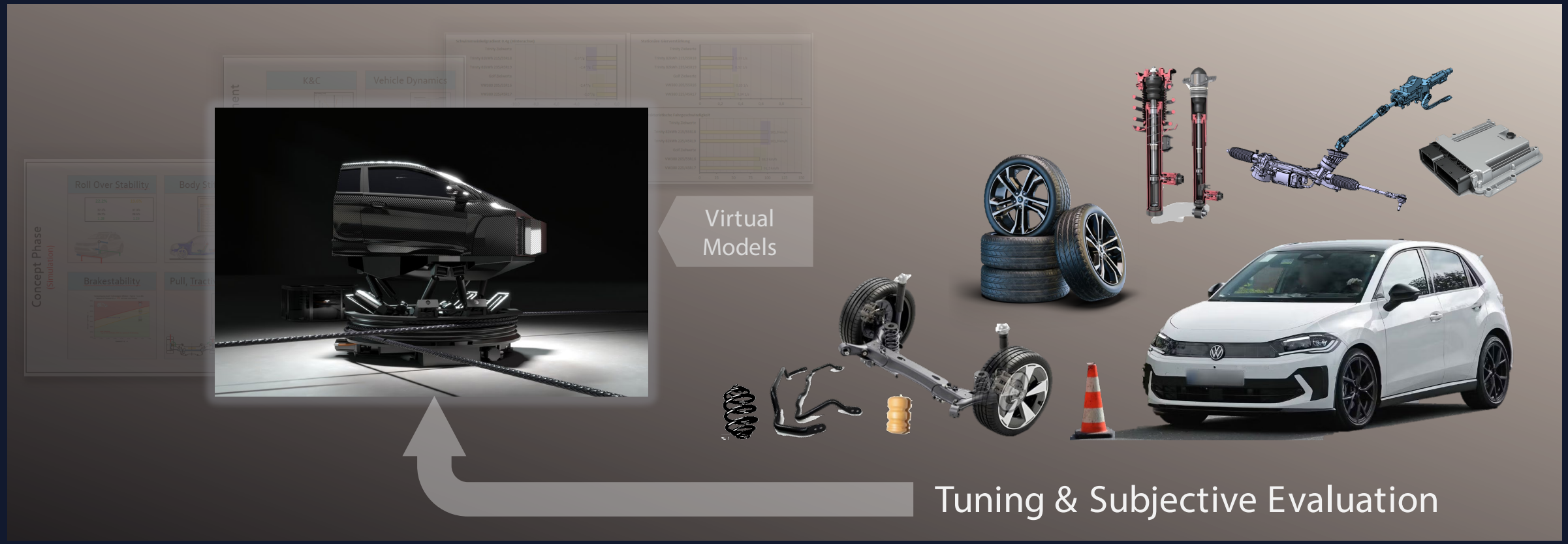
Base for Driving Dynamics DNA

Objective Evaluation & KPIs

Tuning & Subjective Evaluation

Chassis Development Process and Increasing Virtualization Integrating Subjective Evaluation as KPI for Virtual Development

Concept | Construction | Virtual Validation | Testing | Production

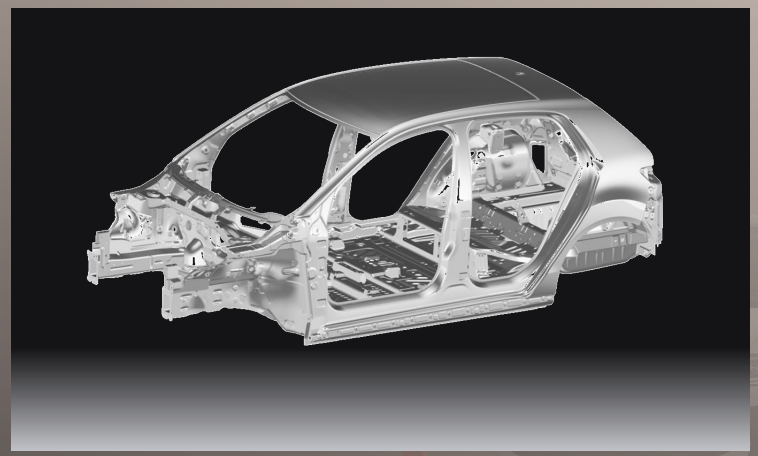


Chassis Development Process and Increasing Virtualization
Adjusting Body Stiffness as Base for Driving Dynamics

Concept | Construction | Virtual Validation | Testing | Production

Definition of Body Structural Stiffnesses

Virtual Model



Tuning & Subjective Evaluation

Experimental Design and Transfer to Driving Simulator

Experimental Design and Transfer to Driving Simulator
Customer Experience and Corresponding Simulator Experiment

Customer Experiences

Simulator

- VW-specific steering feel & high quality steering characteristics
- Intuitive and comfortable steering with high everyday usability - including long-distance driving
- High subjective sense of driving safety in construction zones and in narrow lanes

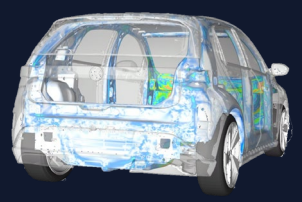
Experimental Design and Transfer to Driving Simulator
ADAMS Real Time Vehicle Model

ID.PoloModel	DoF
MBSmodel at current project stage	221
EPS Steering Functions	
MF Tyre 5.2	
Body Structure	262
Front Subframe	232
Rear Twist Beam	83
Total	798

- **Simplified Model:**
  remove all elements without effect to perception of straight line driving
- **Steering System:**
  emulates the latest EPS characteristics of ID.Polo tuning
- **Tyres:**
  latest characteristics from virtual tyre development of ID.Polo
- **Flex Bodies:**
  integrated as exchangable mtx-files

Experimental Design and Transfer to Driving Simulator Effects on Real Time Performance

Full MBS Model



av. CPU Time [µs]

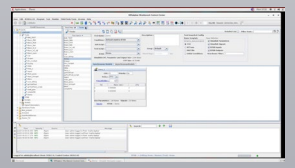
Hardware Performance

15700

10400

AH16 AH24e

Extended Parallelization

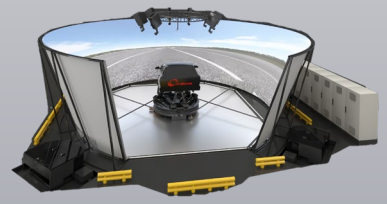


1850

850

AH16 AH24e

Simulator I/O



Instability

850

AH24e

ReducedComplexity

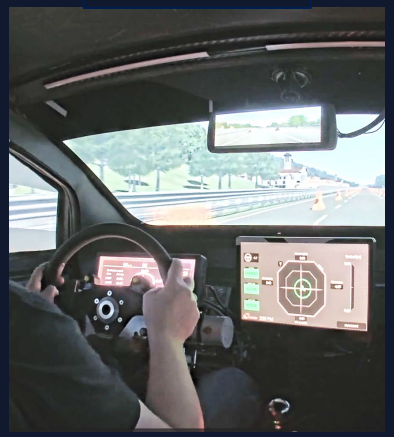
Body Structure	63
Front Subframe	47
Rear Twist Beam	6

Overruns

730

AH24e

Real Time

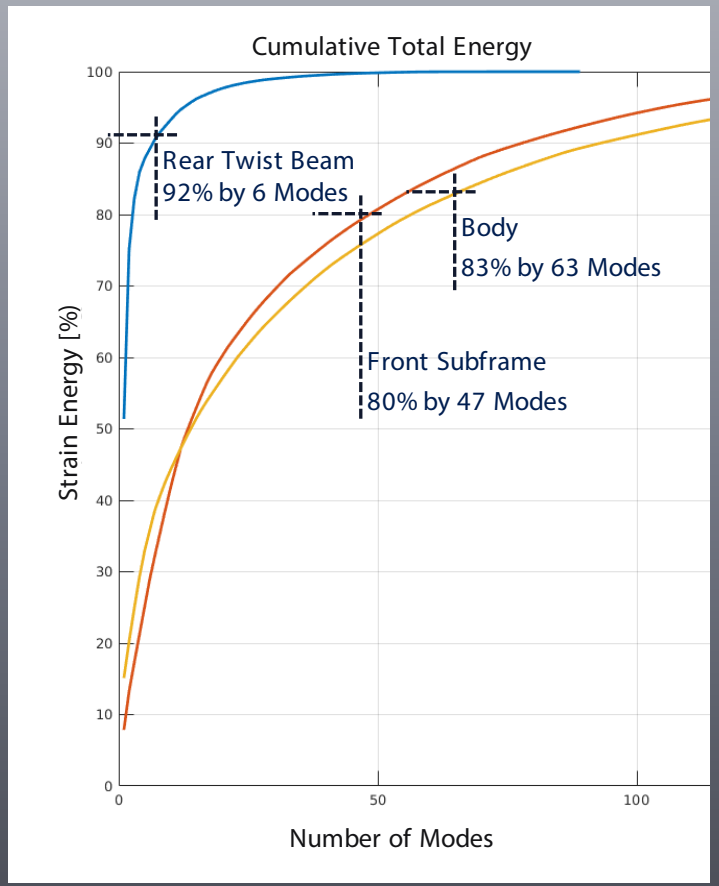


798 DoF

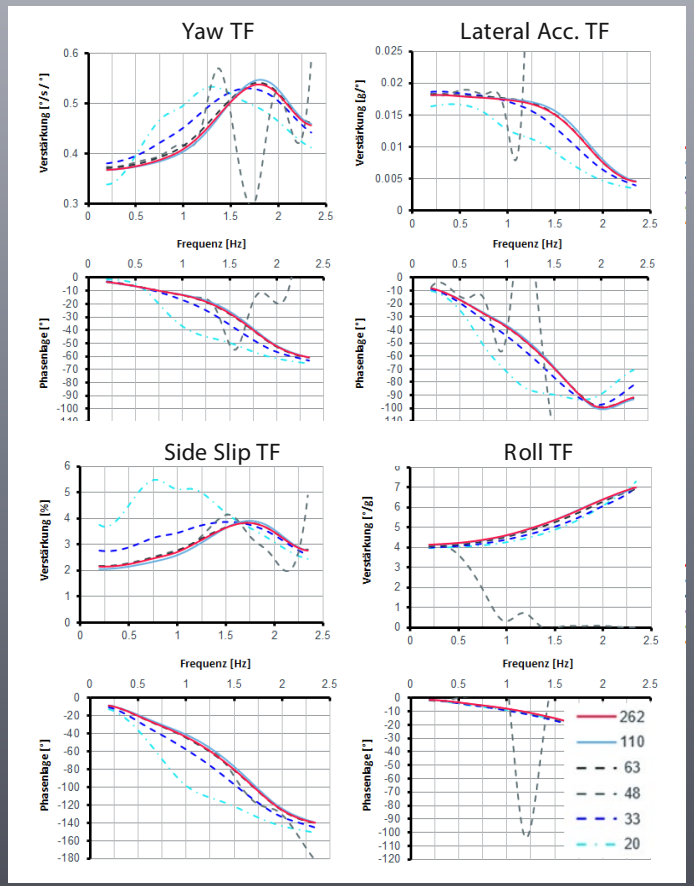
337 DoF

Experimental Design and Transfer to Driving Simulator
Mode Reduction of Flexible Structures considering Driving Dynamics

Number of Modes
Ordered by Energy Content



Driving Dynamic Characteristics
Transient Maneuvers



Resulting Minimum
Model Complexity

ID.PoloModel	DoF
Base Model	221
Body Structure	63
Front Subframe	47
Rear Twist Beam	6
Total	337

Experimental Procedure and Results

Experimental Procedure and Results
Driving Task and Subjective Assessment Program

Driving Task

Assessment Program

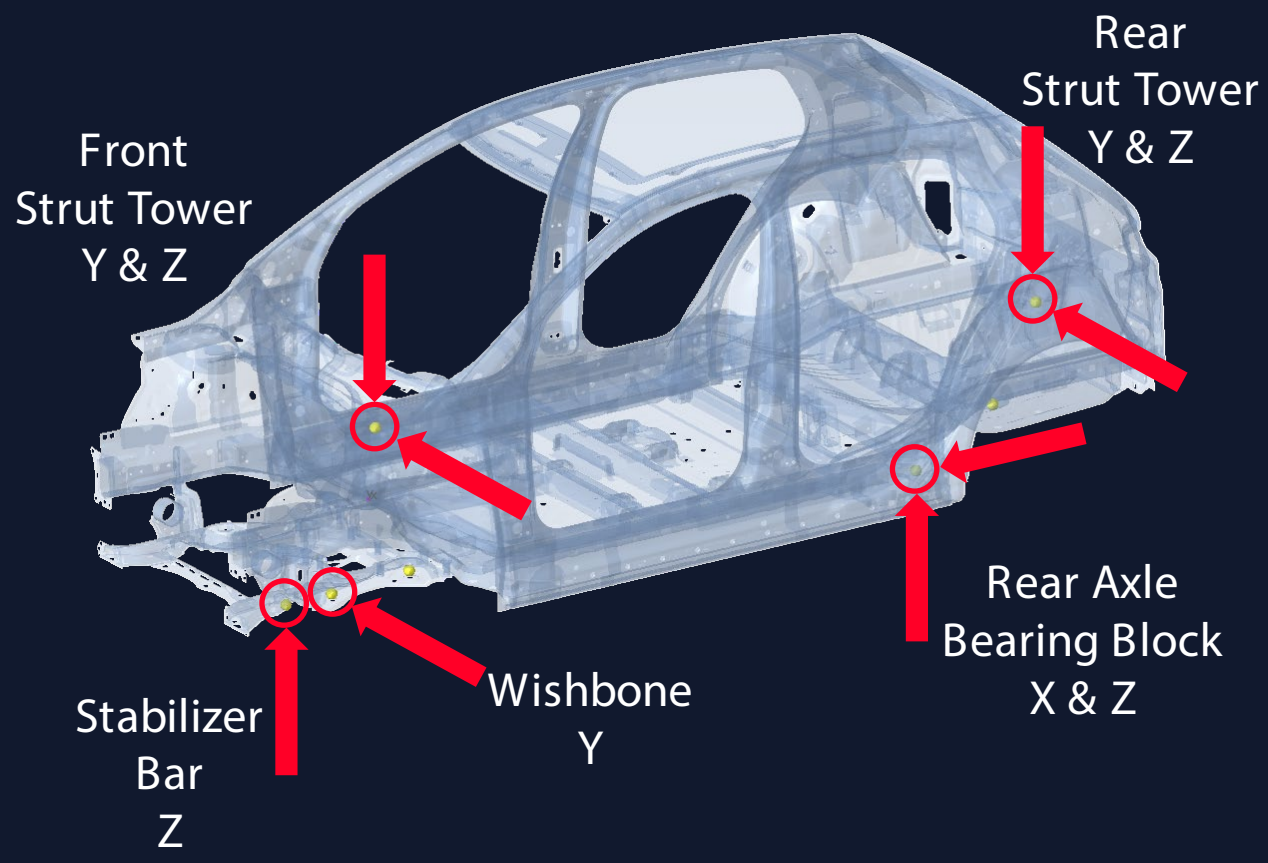
Criterion	Relativ to Reference										Rating
	worse	2	1	½	¼	0	¼	½	1	2	better	
Yaw Rate Progression		2	1	½	¼	0	¼	½	1	2		
Yaw-Lateral Phase Lag		2	1	½	¼	0	¼	½	1	2		
Yaw Deadband		2	1	½	¼	0	¼	½	1	2		
Lateral Precision		2	1	½	¼	0	¼	½	1	2		
Self-centering		2	1	½	¼	0	¼	½	1	2		
Centerpoint		2	1	½	¼	0	¼	½	1	2		
Torque gradient		2	1	½	¼	0	¼	½	1	2		

- Driving and assessment by responsible tuning expert for ID.Polo
- Driving task corresponding to real test drives for evaluating chassis stiffness effects
- Volkswagen in-house form is used for subjective assessments

Experimental Procedure and Results
Model Variants by scaling Local Body Stiffnesses

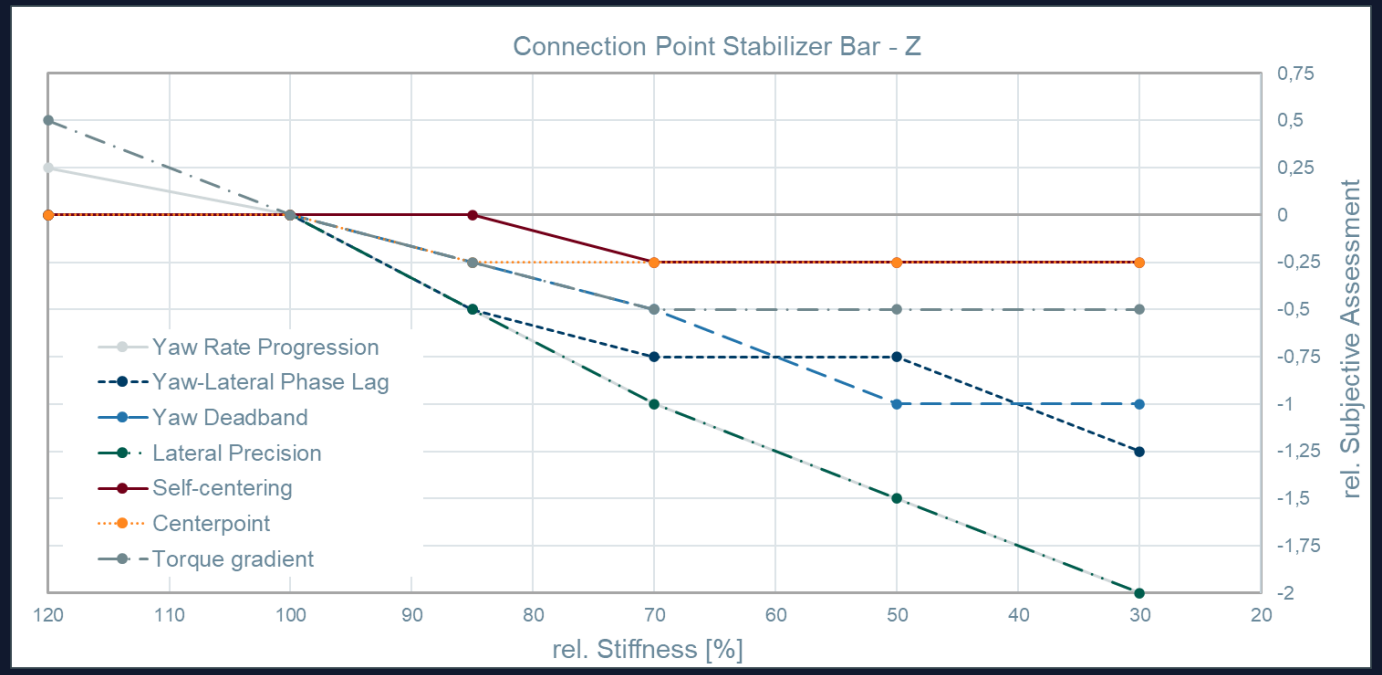
Load Application Points and Directions
for Variations of local Structural Stiffness

Conntection Point	Range of Variants
Stabilizer – Z	120% 30%
Wishbone – Y	100% 70%
Front Strut –Z	100% 80%
Front Strut –Y	100% 80%
Rear Strut – Z	100% 80%
Rear Strut – Y	100% 70%
Rear Axle – XZ	120% 80%



Total of 42 Variations of local body stiffnesses are to be evaluated by expert driver.

Experimental Procedure and Results
Subjective Evaluation of Expert Driver



- The subjective rating decreases as body stiffness decreases
- Different load application points vary in significance but show same trends

- ❖ Perceptability of changes in driving dynamics due to changes in local body stiffness is confirmed
- ❖ The trends in the simulator experiment correspond to real vehicle tests.

Summary and Outlook

Driving Dynamics Evaluation of Body Structural Stiffnesses
Summary and Outlook

Overview of Volkwagen's efforts of applying driving simulators in design of vehicle dynamics – Local body stiffnesses started as new project

Options for achieving real-time capability – Finding the sweet spot between model fidelity and computer performance

In simulator experiments the driving expert confirmes the assessability of body stiffness variations

Future Challenges for driving simulator applications	• More computing power and parallelization • Application of advanced modelling techniques • Options for co-simulations with multiple solvers

Thank you