DaimlerChrysler

Analysis Commercial Vehicles, PBE/DAD

Set up of an Automotive Test Rig in SIMPACK

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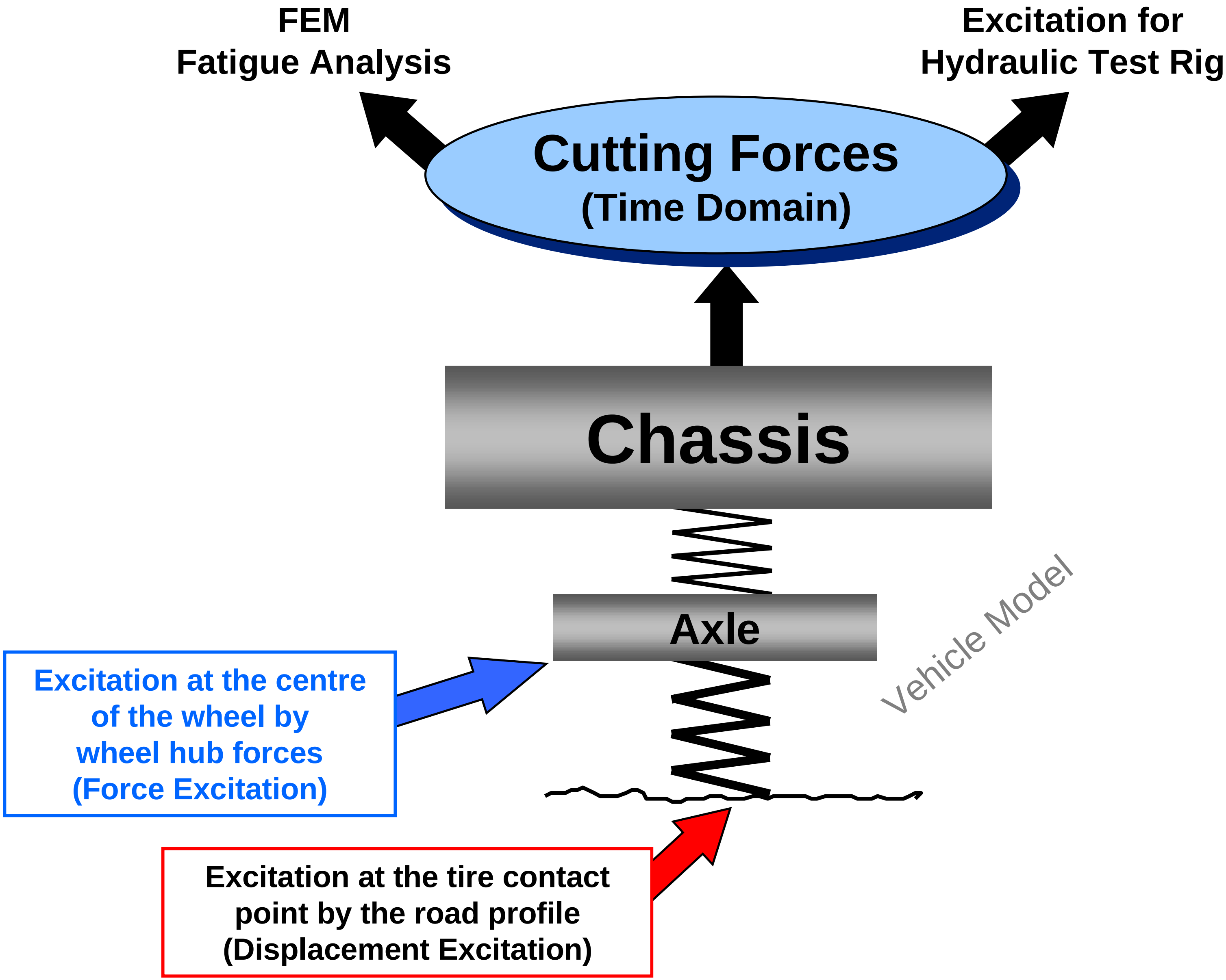
Overview

Durability Testing

- **Proving Ground Test**

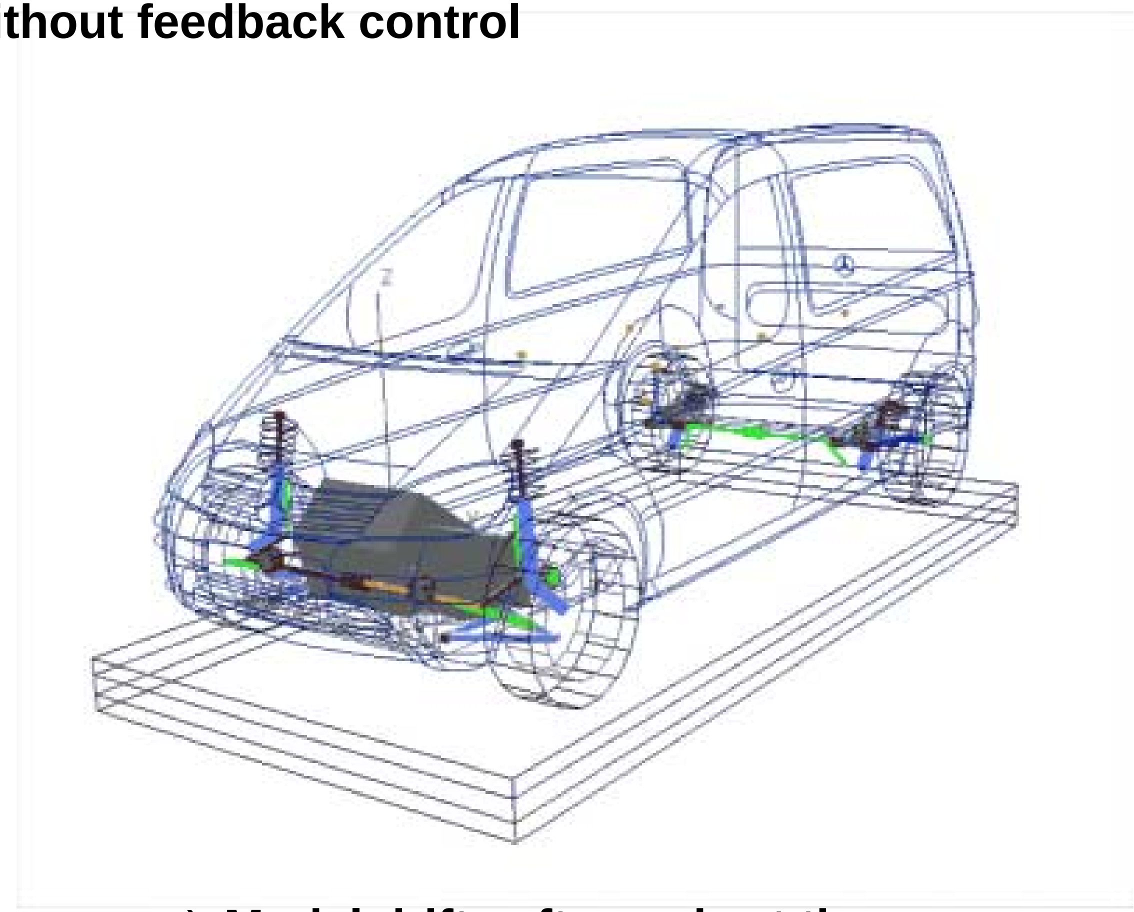
- **Hydraulic Test Rig**

Calculation of Cutting Forces



SIMPACK-Modell of the Vaneo

SIMPACK model excited with wheel hub forces without feedback control



$\Rightarrow$ **Model drifts after a short time**

Causes of Drift:

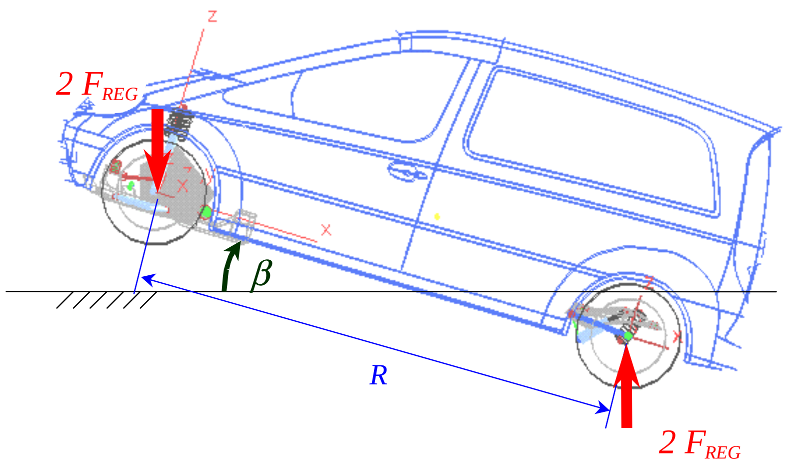
- **Inaccuracies in the wheel hub forces**
- **Missing initial states (position, velocity, acceleration)**
- **Inaccuracies in the model parameters (mass, inertia, stiffness, damping)**

Stabilization Methods:

- **Restraining the vehicle body using spring and damper elements**
- **Vehicle stabilization using feedback control (control input: Position of the car body)**

Control Layout

Position of vehicle body for control input



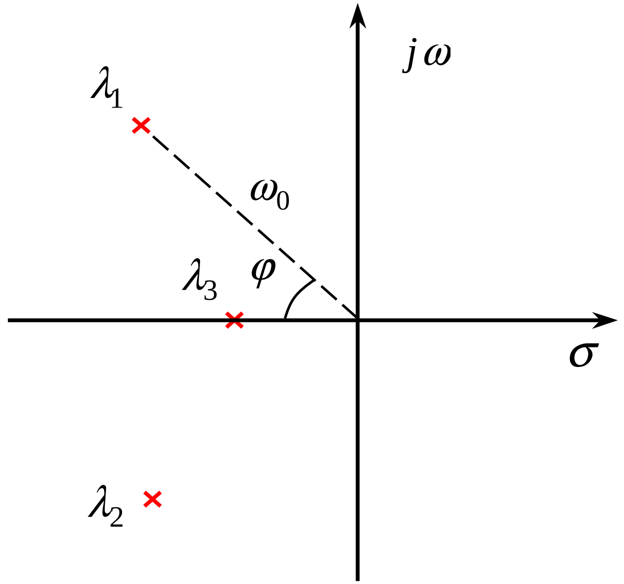
conservation of angular momentum: $J_{YY} \cdot \frac{d^2}{dt^2}\beta = -2 \cdot R \cdot \cos(\beta) \cdot F_{REG}$

control law (PID-control): $F_{REG} = c_{IR} \cdot \int \beta \, dt + c_{PR} \cdot \beta + c_{DR} \cdot \frac{d}{dt}\beta$

$\Rightarrow$ **char. polynomial:** $s^3 + \frac{2 \cdot R \cdot c_{DR}}{J_{YY}} \cdot s^2 + \frac{2 \cdot R \cdot c_{PR}}{J_{YY}} \cdot s + \frac{2 \cdot R \cdot c_{IR}}{J_{YY}} = 0$

Eigenvalues: λ_1, λ_2 and λ_3

Eigenvalues in the s-plane:



Choice of eigenvalues:

D=0,71

with cos(φ)=D $\Longrightarrow$ **Re($\lambda_{1,2}$)=Im($\lambda_{1,2}$)**

natural frequency: $\omega_0 = 2\pi \cdot f = \sqrt{\mathrm{Re}(\lambda_{1,2})^2 + \mathrm{Im}(\lambda_{1,2})^2}$

Restraining the Vehicle Body with Spring and Damper Elements:

- **Coupling of the vehicle body to a stationary reference system**
- **The spring and damper elements are attached to the c.g. of the vehicle body.**

Translation:

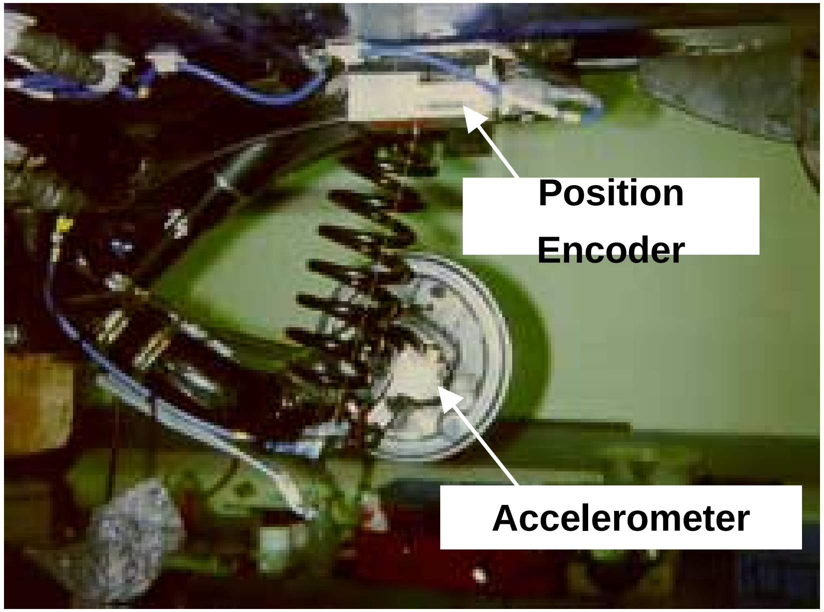
$$m_F \cdot \frac{d^2}{dt^2} z = -(c \cdot z + d \cdot \frac{d}{dt} z)$$

Rotation:

$$J_{XX} \cdot \frac{d^2}{dt^2} \alpha = -(c_{Dreh} \cdot \alpha + d_{Dreh} \cdot \frac{d}{dt} \alpha)$$

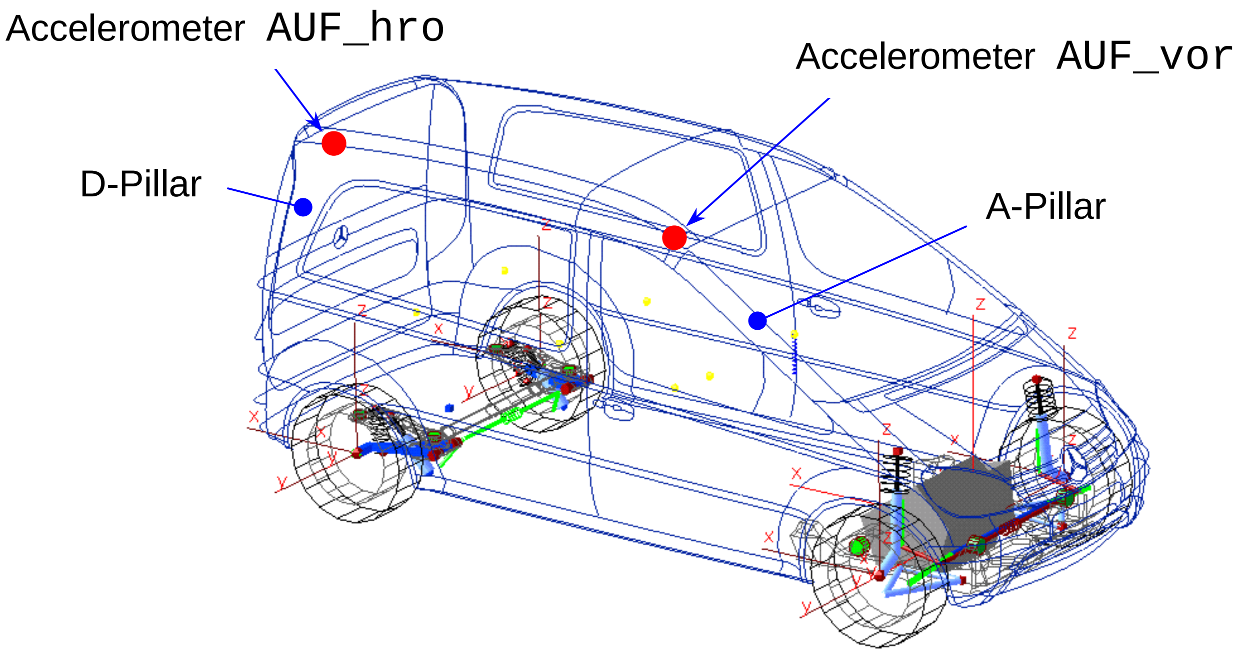
Reference Measurements (empirical Data)

- **Vertical hub acceleration of the right hand side** (az_VA_r, az_HA_r)
- **Distance between wheel and vehicle body** (sz_VA_r, sz_VA_l, sz_Ha_r, sz_HA_l)



Reference Measurements (empirical Data)

- **Vehicle accelerations**
  (ax_AUF_vor, ay_AUF_vor, az_AUF_vor, ay_AUF_hro, az_AUF_hro)



Quality Criteria:

Standard deviation of the difference between the measured and simulated data

Standard deviation for n function values x_i:

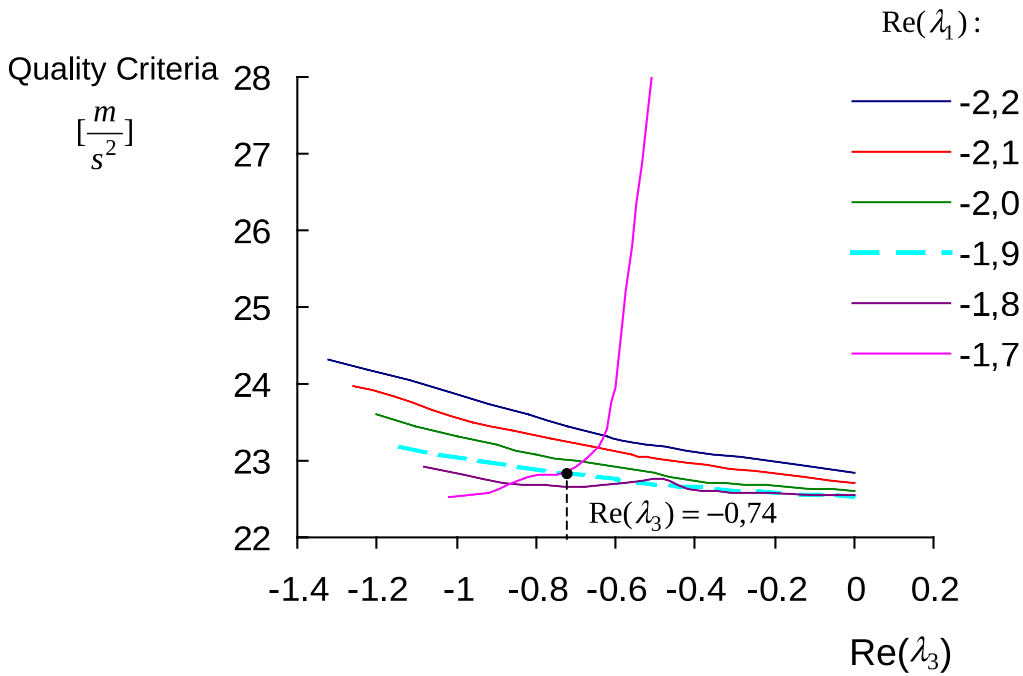
$$s = \sqrt{\frac{1}{n-1}\left(\sum_{i=1}^{n}(x_i - \bar{x})^2\right)} \quad \text{with} \quad \bar{x} = \frac{1}{n}\sum_{j=1}^{n} x_j$$

Parameter Variation

- **Variation by a batch file(*.bat). The variables in the parameter file are changed. A SIMPACK simulation is carried out and the quality criteria are stored in a result file.**
- **Variation of the real part of the eigenvalue λ_1 and λ_3**
- **15 seconds realtime simulation**

Results of the Parameter Variation

- **Feedback control delivers a better overall result**
- **Choice of control parameters for the example of the acceleration** az_VA_r:

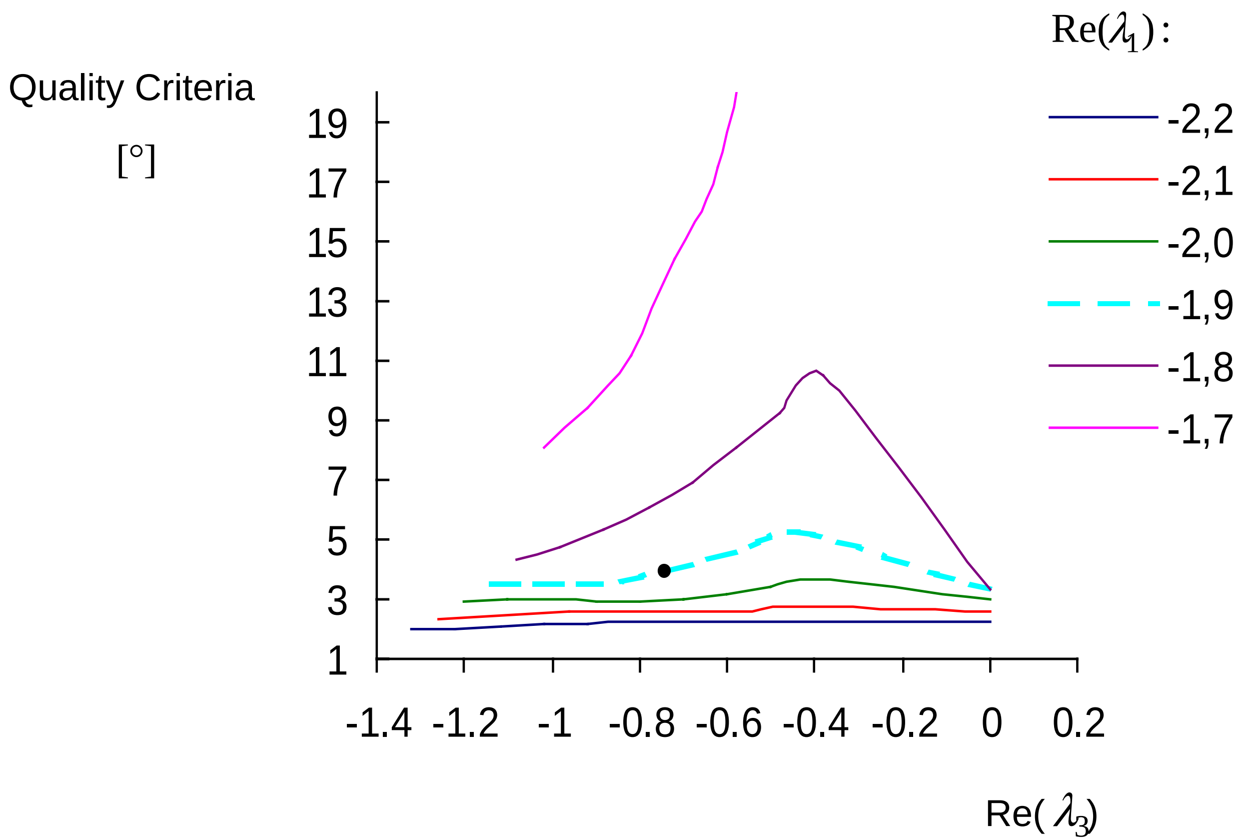


Chosen eigenvalues:

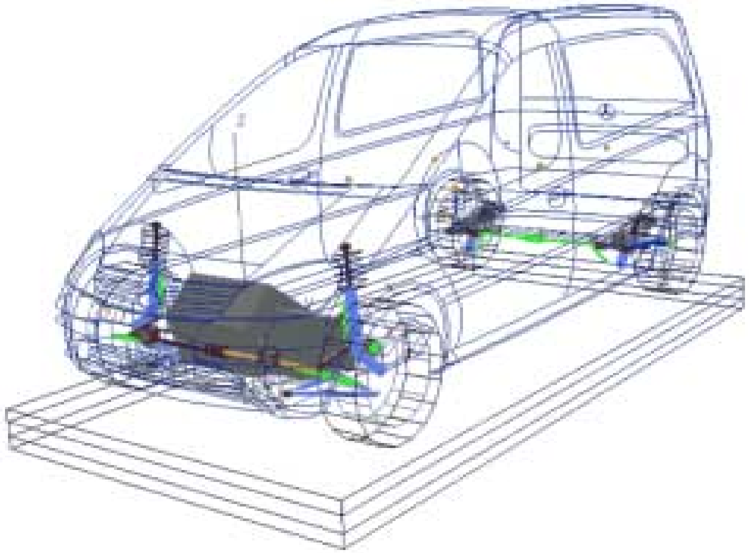
$$\lambda_1 = -1,9 + 1,9i \qquad c_{IR} = 2350$$
$$\lambda_2 = -1,9 - 1,9i \quad \Rightarrow \quad c_{PR} = 2020$$
$$\lambda_3 = -0,74 \qquad c_{DR} = 4464$$

equivalent to 0,43 Hz

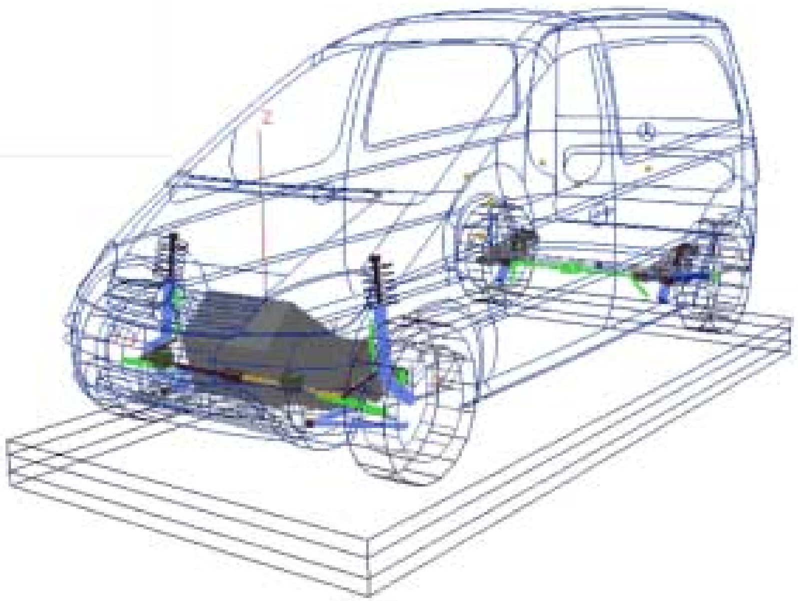
Results of the Quality Criteria of the x-Axis Rotation



SIMPACK- Model excited by Wheel Forces



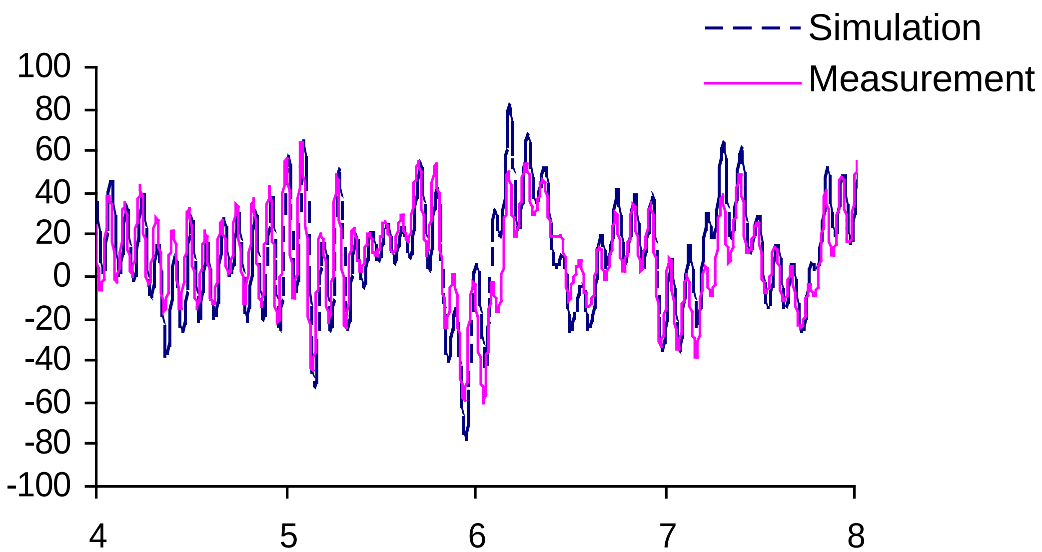
without feedback control
⇒ **Model drifts**



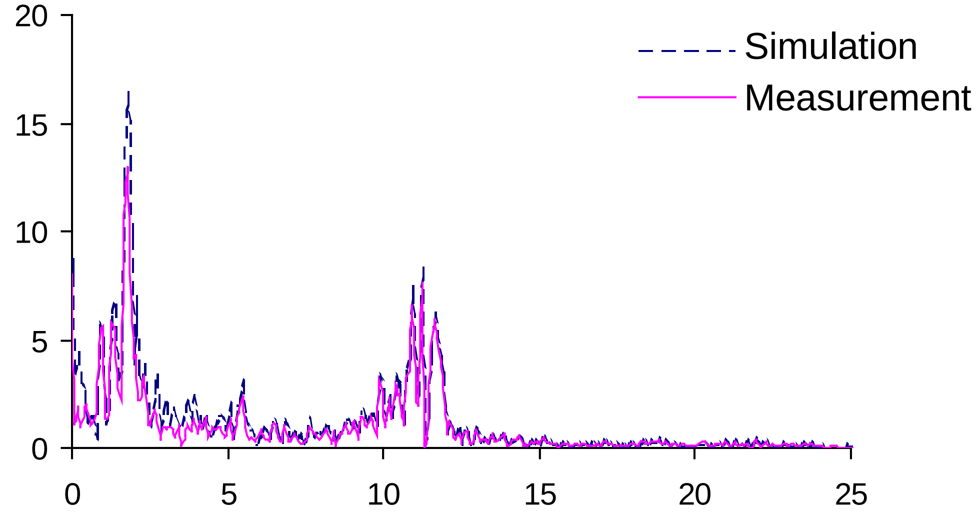
with feedback control
⇒ **no drift**

Results

Comparison of the relative displacement sz_VA_r



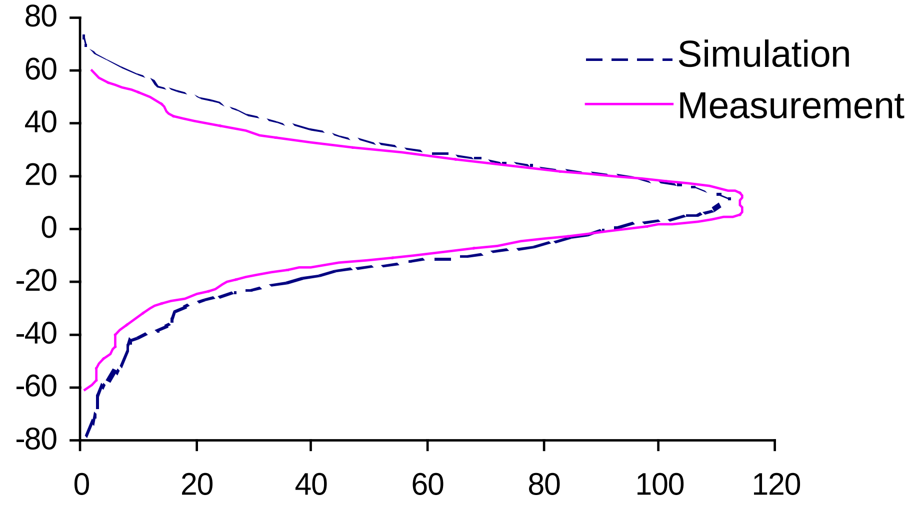
Fast-Fourier-Transformatior of the signals



Results

Level crossing counting (30 classes)

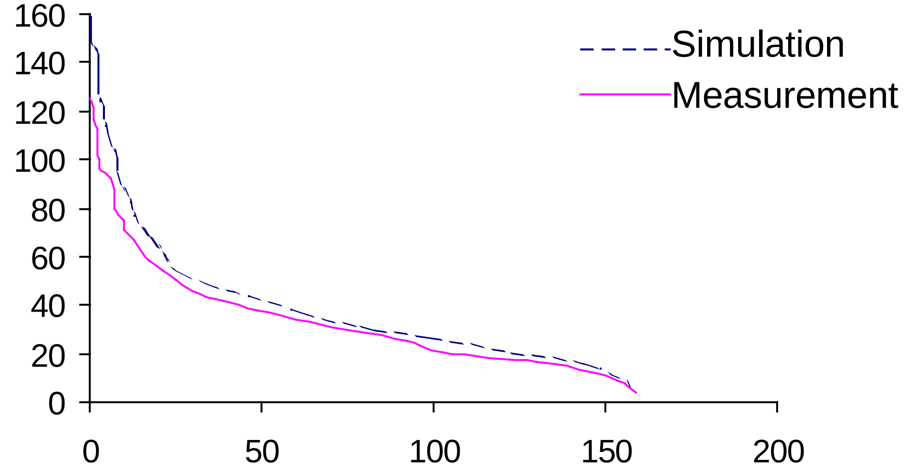
sz_VA_r [*mm*]



rate of level crossings

Range pair counting (30 classes)

sz_VA_r [*mm*]

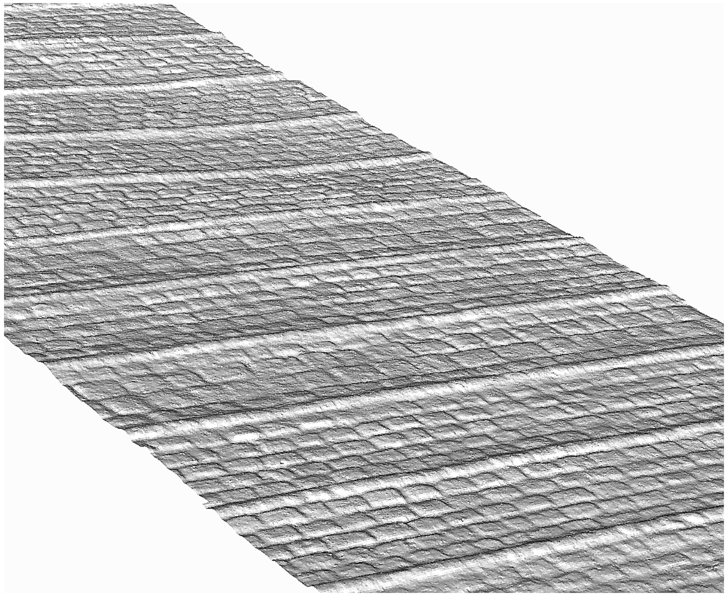


cumulative cycle count

Outlook

Modelling of the elastic vehicle body

3D measured proving ground surface (Africa):



Simulation with RMOD-K: