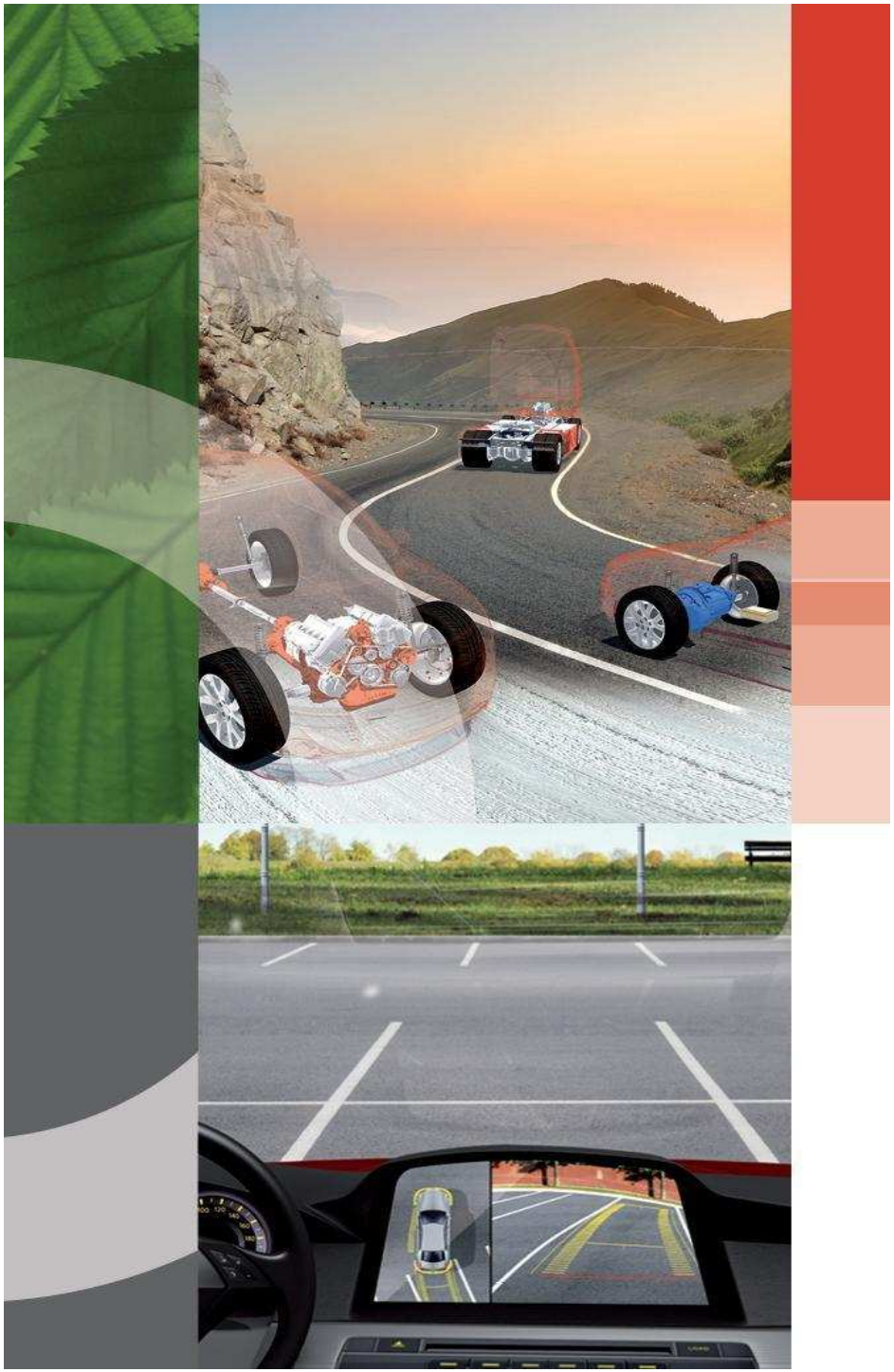


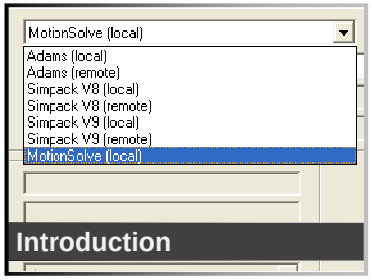
MAGNA POWERTRAIN

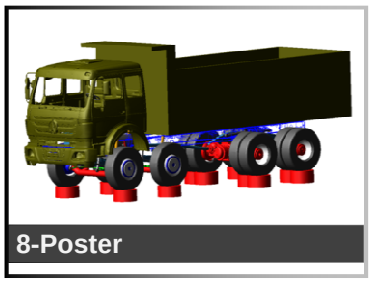
MAGNA ELECTRONICS

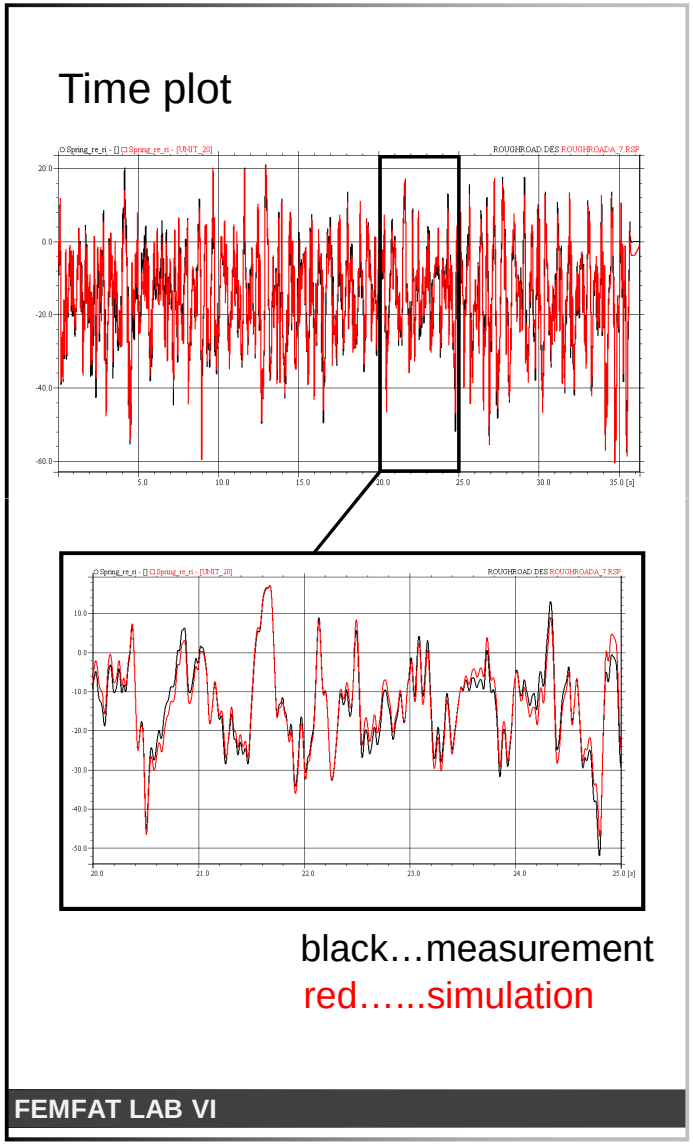
FEMFAT Lab Virtual Iteration

1st Indian FEMFAT User Conference 2013

Otmar Gattringer, 22. January 2013
Engineering Center Steyr







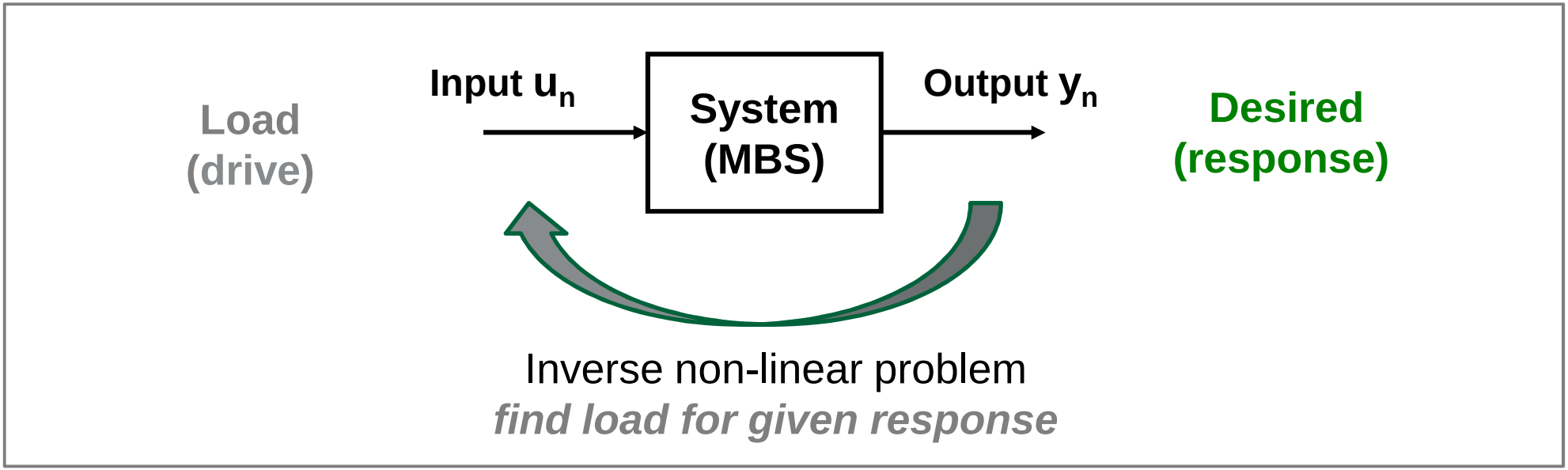
Content

- Introduction
- Measurement signals
- Example: McPherson suspension
- Example: 8-poster
- Conclusion

Introduction

- FEMFAT LAB
  - Load data analysis software
- Module Virtual Iteration:
  - Load data generation for simulation models based on measurement data (test track or test bench)
- General approach
  - Generate external load based on internal, measured response
- Same approach as the iteration process in the laboratory (test bench)
- Excellent convergence between measurement and simulation
- Method is automated for
  - ADAMS
  - SIMPACK
  - MotionSolve

Virtual Iteration



Drive

High effort or not measureable

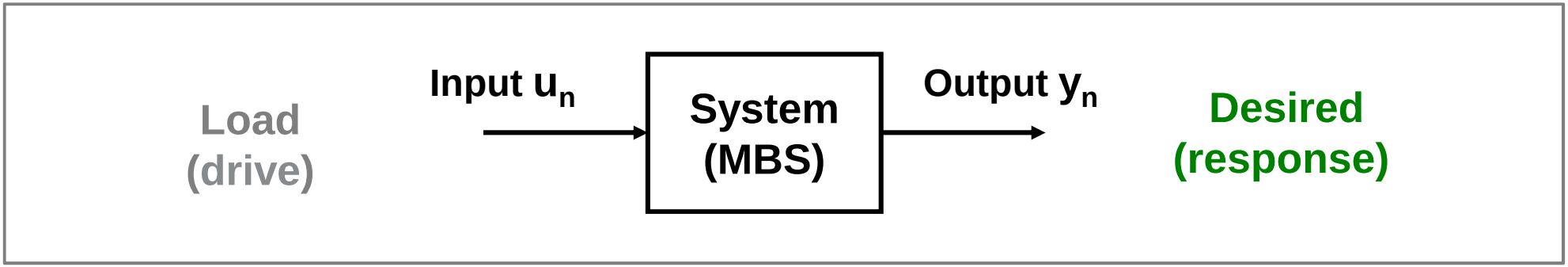
- Forces (external)
  - WFT
  - Load cell
  - Strain gauges
- Displacements (absolute)

Response

Often simply and cheaply measureable

- Accelerations
- Displacements (relative)
- Strains
- Forces (internal)

Introduction



Calculation of the transfer function (MBS):

$F(s) = y_0(s) / u_0(s)$ pink noise signal and its response

Calculation of first drive:

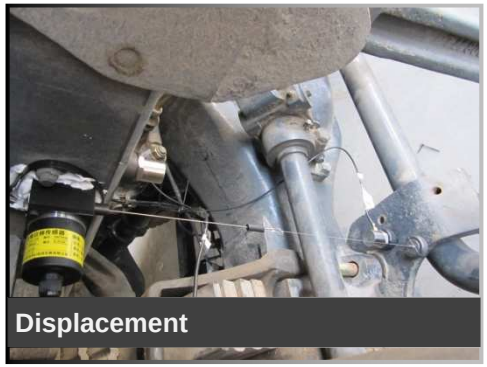
$u_1(s) = F^{-1}(s)\ y_{Desired}(s)$

Calculation of further iterations:

$u_{n+1}(s) = u_n(s) + F^{-1}(s)\ (y_{Desired}(s) - y_n(s))$

Measurement signals


Acceleration


Displacement


Strain – twist beam


Strain – ball joint

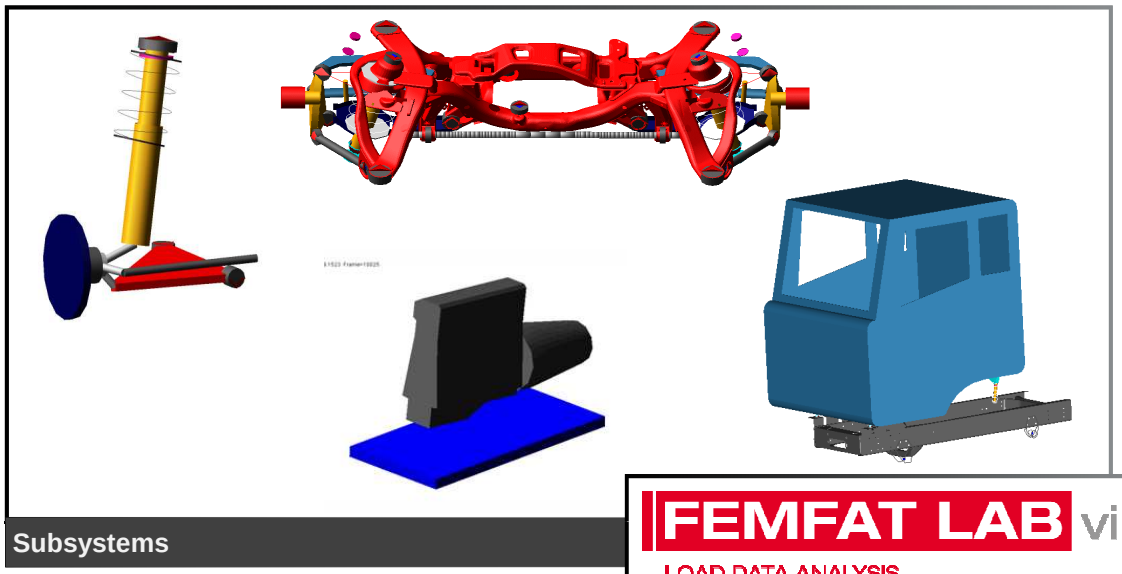

Strain - link


Load cell

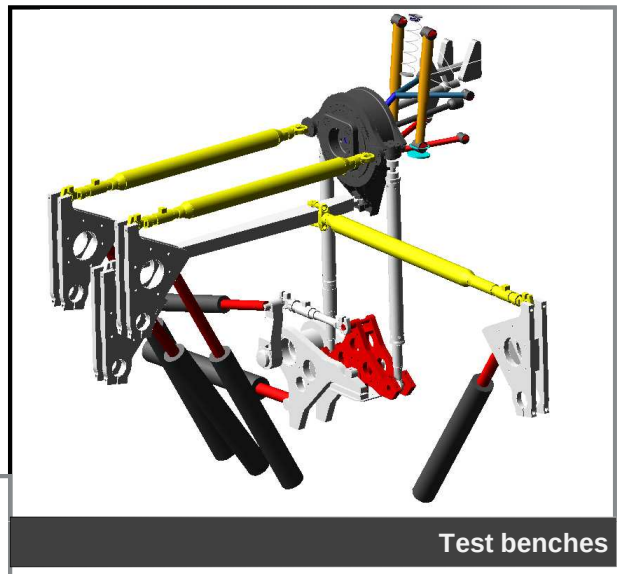
Typical responses

- Accelerations
  - 1-axial
  - 3-axial
- Displacements
  - Draw wire displacement sensor
- Frame torsion
- Strains (directly/calibrated to forces)
  - Axle
  - Ball joint
  - Link
  - Rod
  - Spring
  - Stabilizer
- Load cells
  - Mount

Examples

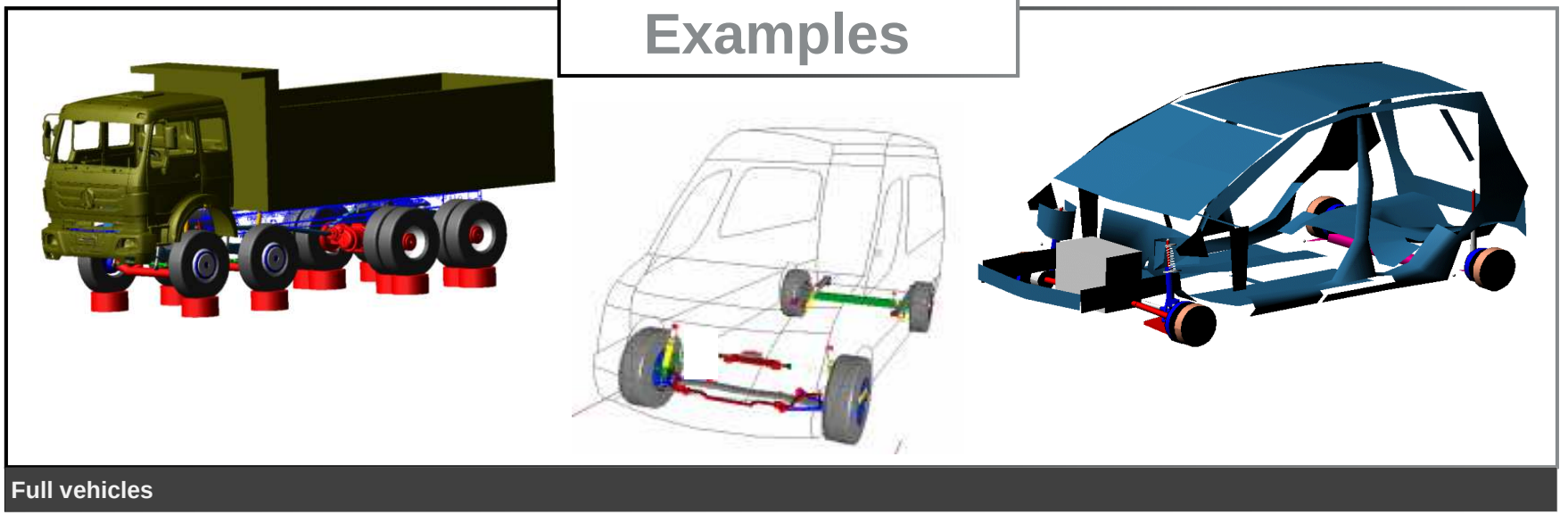


Subsystems



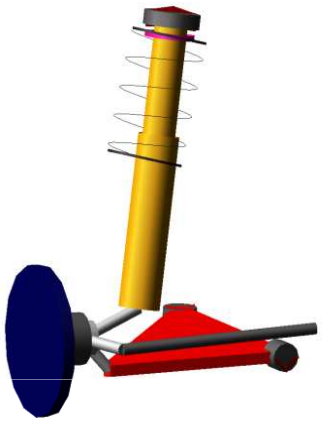
Test benches

FEMFAT LAB vi
LOAD DATA ANALYSIS
Examples



Full vehicles

McPherson suspension



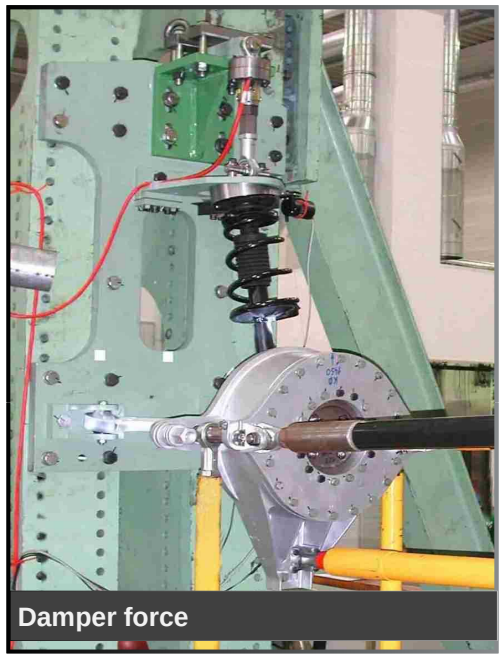
- MSC.ADAMS model of front axle of a passenger car (half axle)
- Computing internal forces for fatigue analysis of the knuckle with

  FEMFAT max
  FINITE ELEMENT METHOD FATIGUE

- Measurement signals from test track
- Goal: load at wheel (4 channels)
  - Vertical displacement (wheel center)
  - Longitudinal force (wheel center)
  - Steering torque (wheel center)
  - Lateral force (tire patch)
- Desired (measurement)
  - Damper force
  - Ball joint force longitudinal
  - Ball joint force lateral
  - Tie rod force axial
  - Spring displacement (used for model-check)

McPherson suspension

Measurement signals (responses)


Damper force

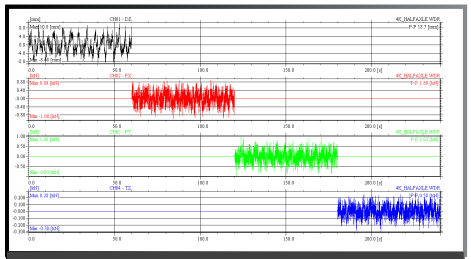

Tie rod force


Ball joint forces

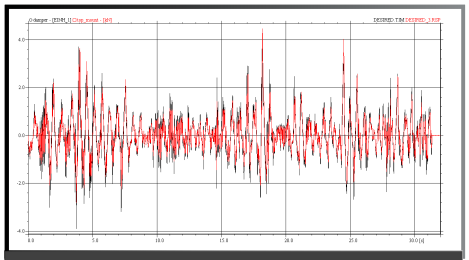

Spring displacement

MBS: requests

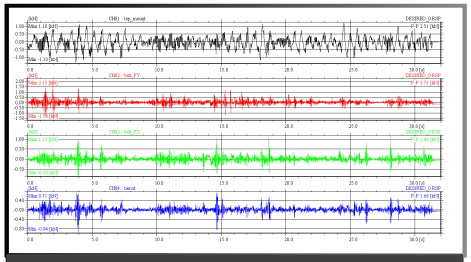
Iteration process



1. Pink noise

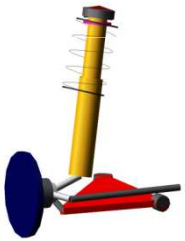


6. Response = desired



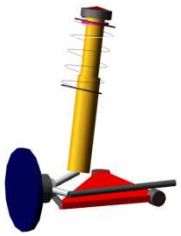
5. Response

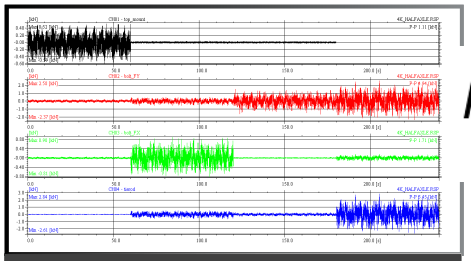
u_{Noise}



y_{Noise}

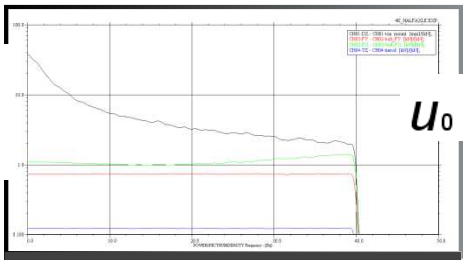
$$u_{n+1} = u_n + F^{-1}\,(y_{Desired} - y_n)$$





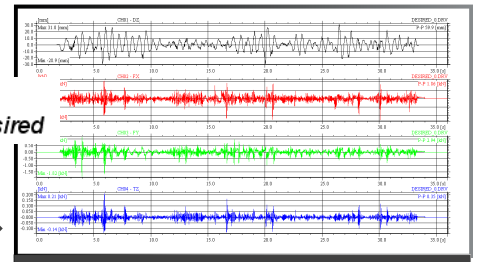
2. Response of noise

$$F = \frac{y_{Noise}}{u_{Noise}}$$



3. Transfer function

$$u_0 = F^{-1}\, y_{Desired}$$

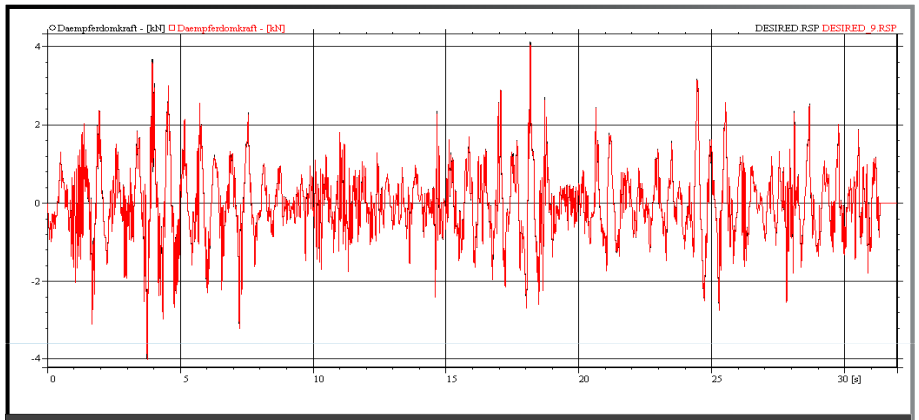


4. Drive signal

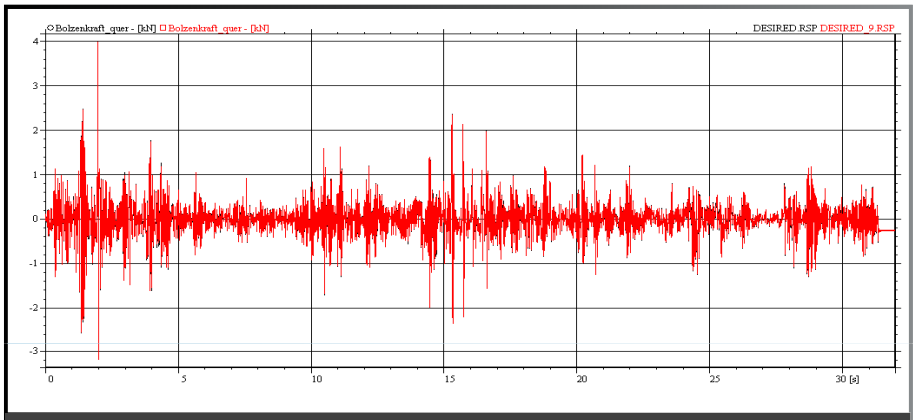
McPherson suspension

Results: 10. iteration, rough road

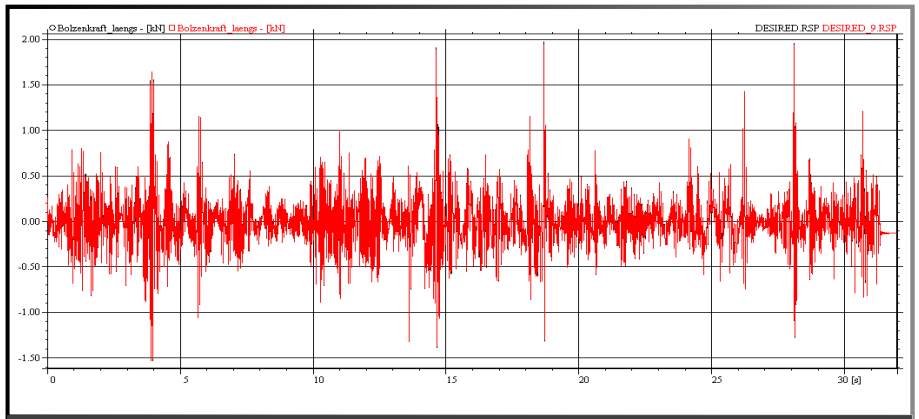
black…measurement
red……simulation



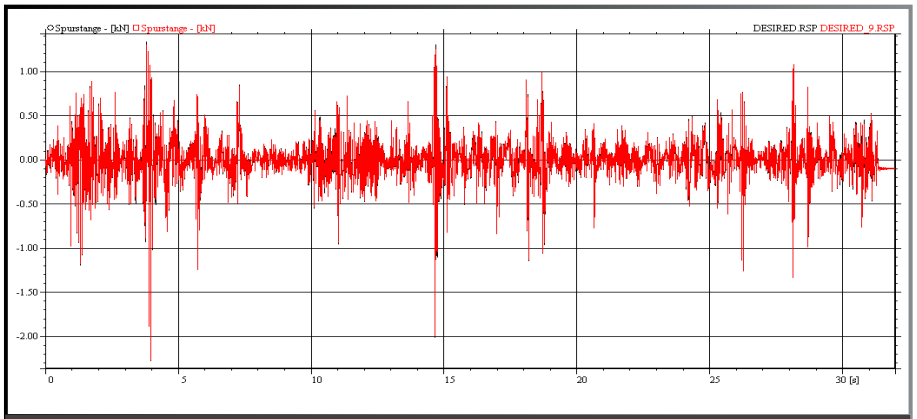
Damper force – time domain



Ball joint force lateral – time domain



Ball joint force longitudinal – time domain

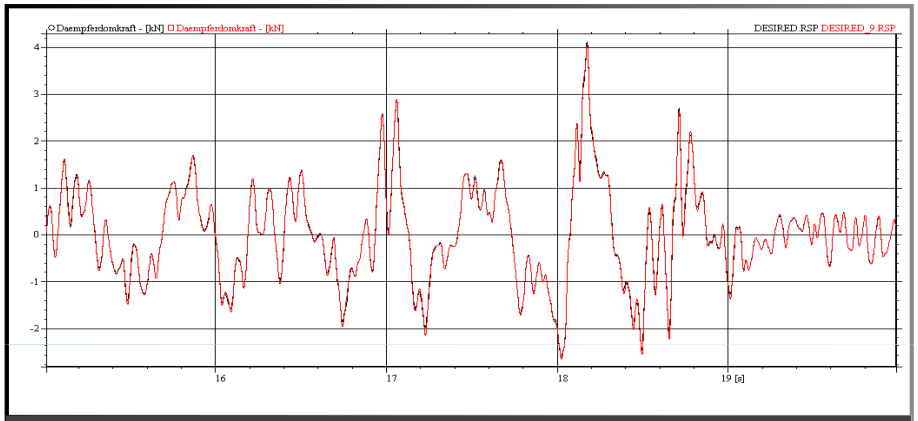


Tie rod force axial – time domain

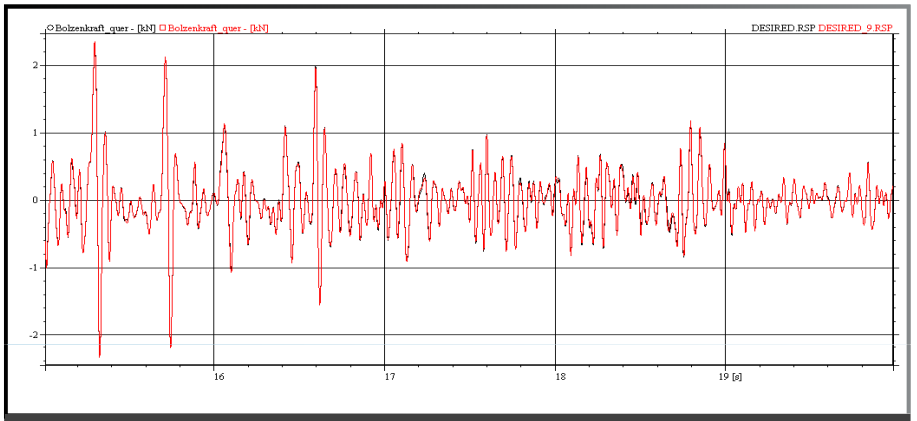
McPherson suspension

Results: 10. iteration, rough road

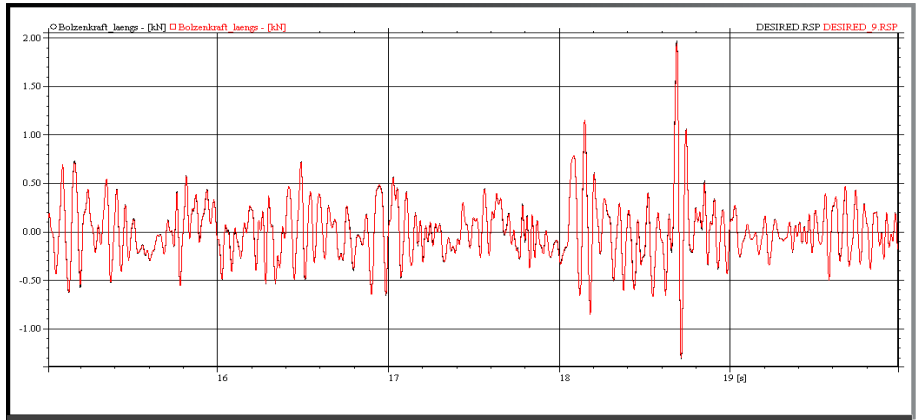
black…measurement
red……simulation



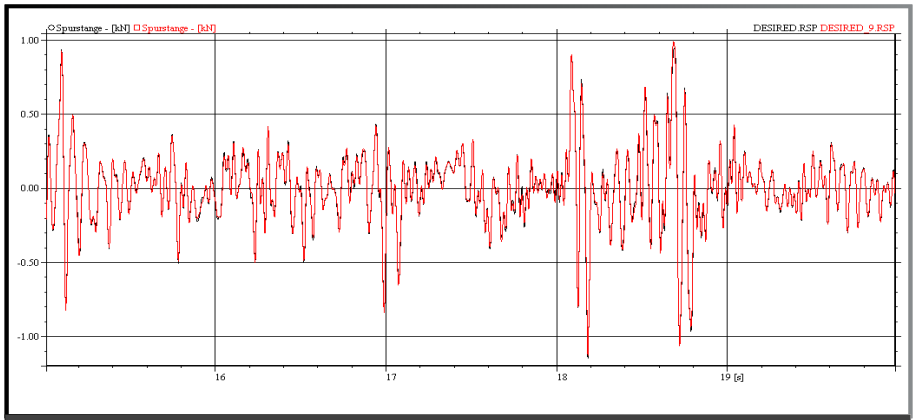
Damper force – time domain 15th to 20th second



Ball joint force lateral – time domain 15th to 20th second



Ball joint force longitudinal – time domain 15th to 20th second

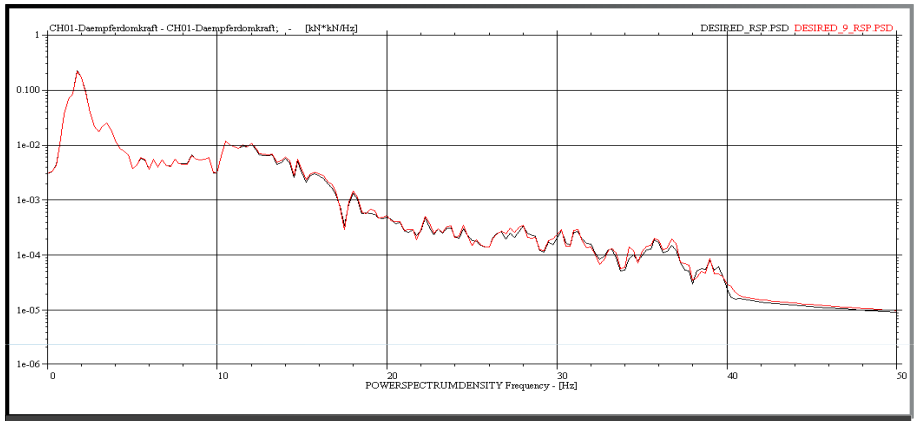


Tie rod force axial – time domain 15th to 20th second

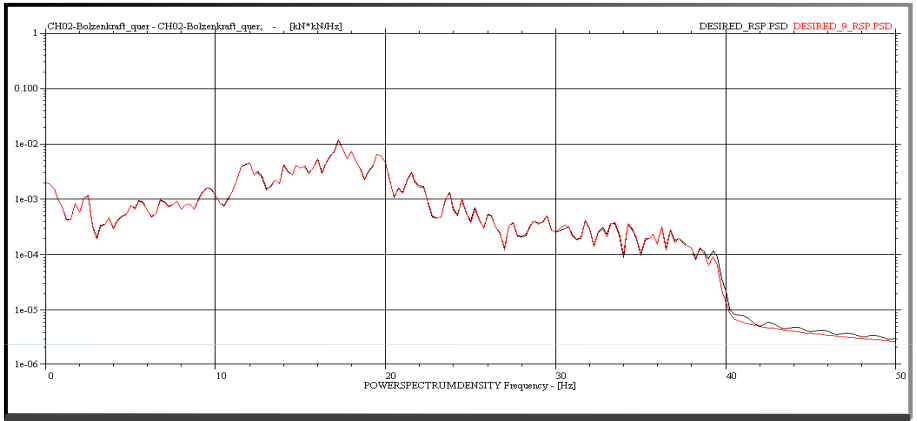
McPherson suspension

Results: 10. iteration, rough road

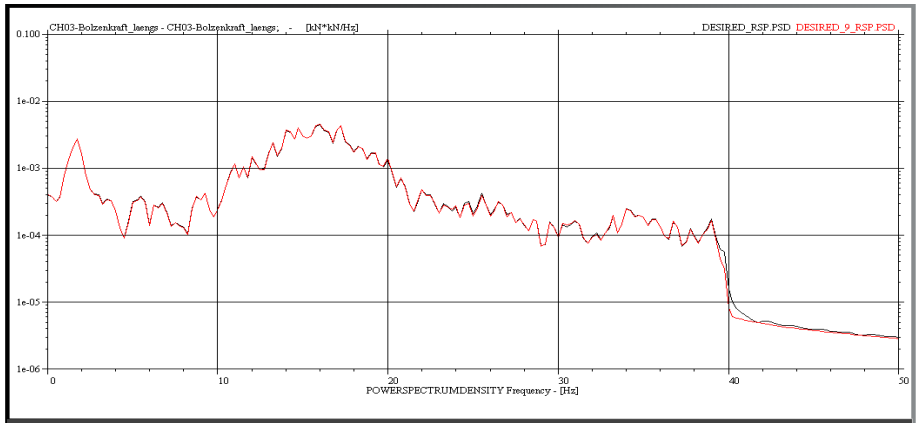
black…measurement
red……simulation



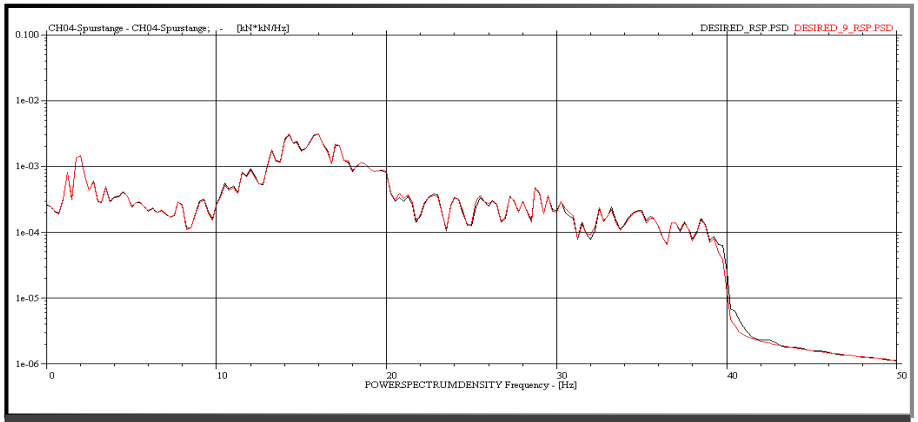
Damper force - frequency domain



Ball joint force lateral - frequency domain

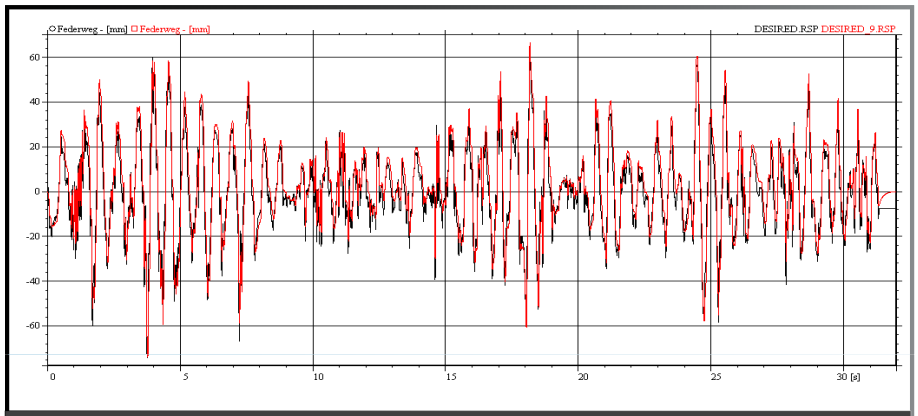


Ball joint force longitudinal - frequency domain



Tie rod force axial - frequency domain

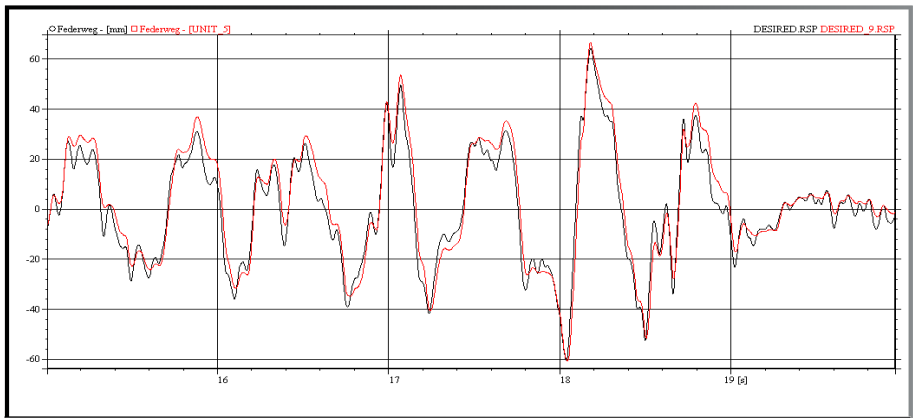
Results: 10. iteration, rough road



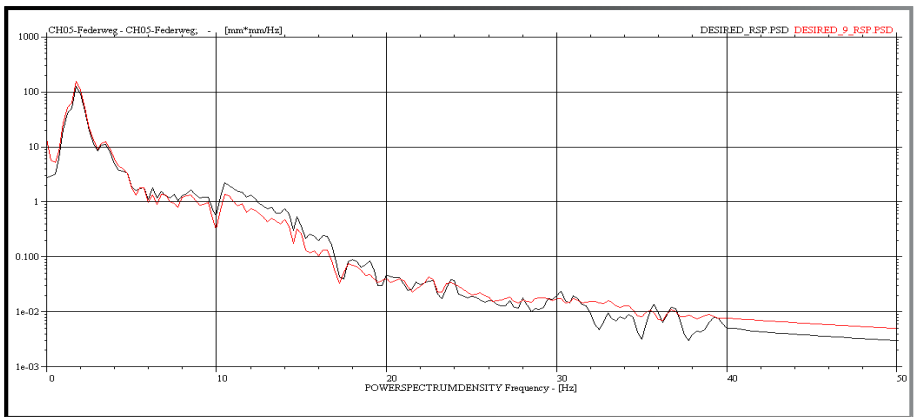
Spring displacement – time domain

Spring displacement
(model check)

black…measurement
red……simulation

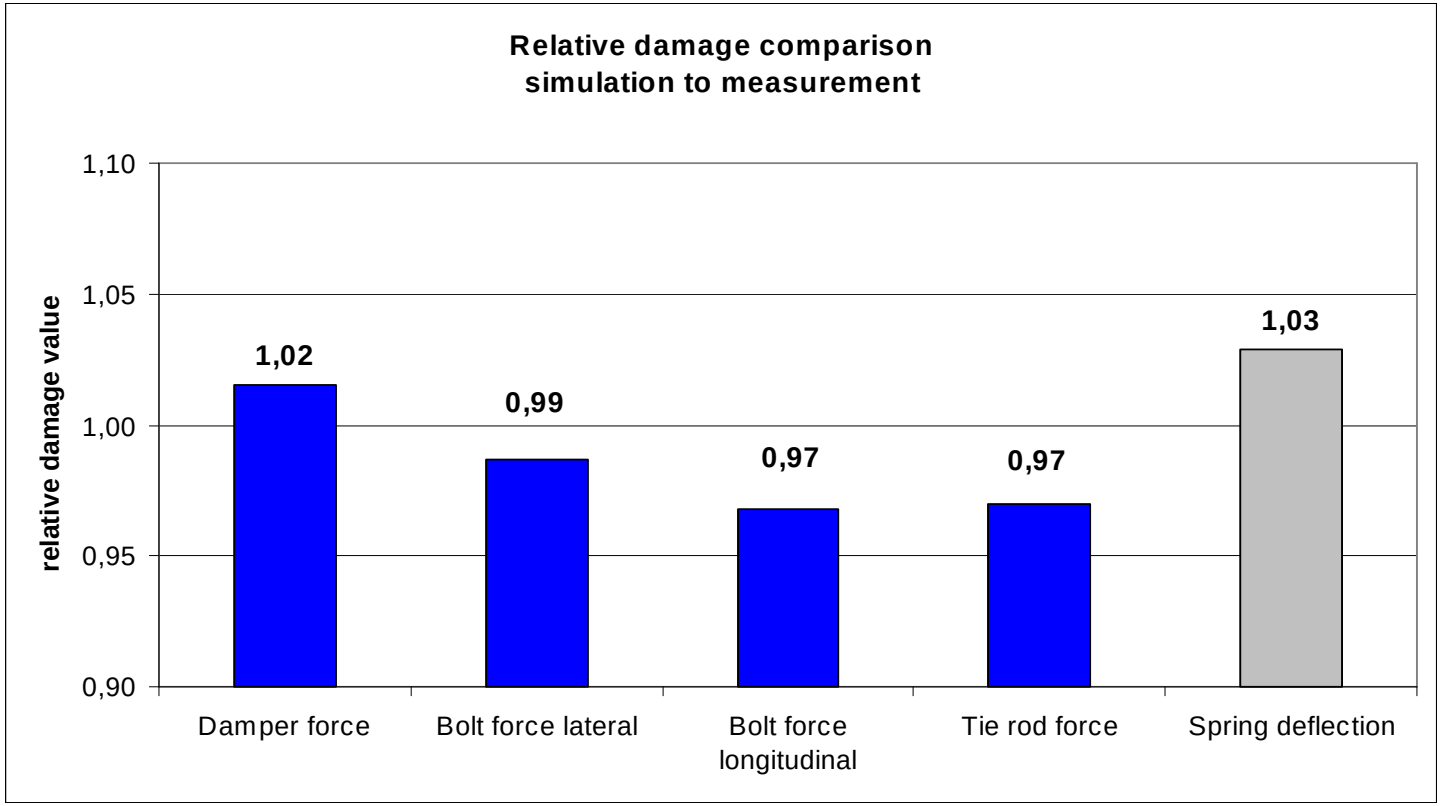


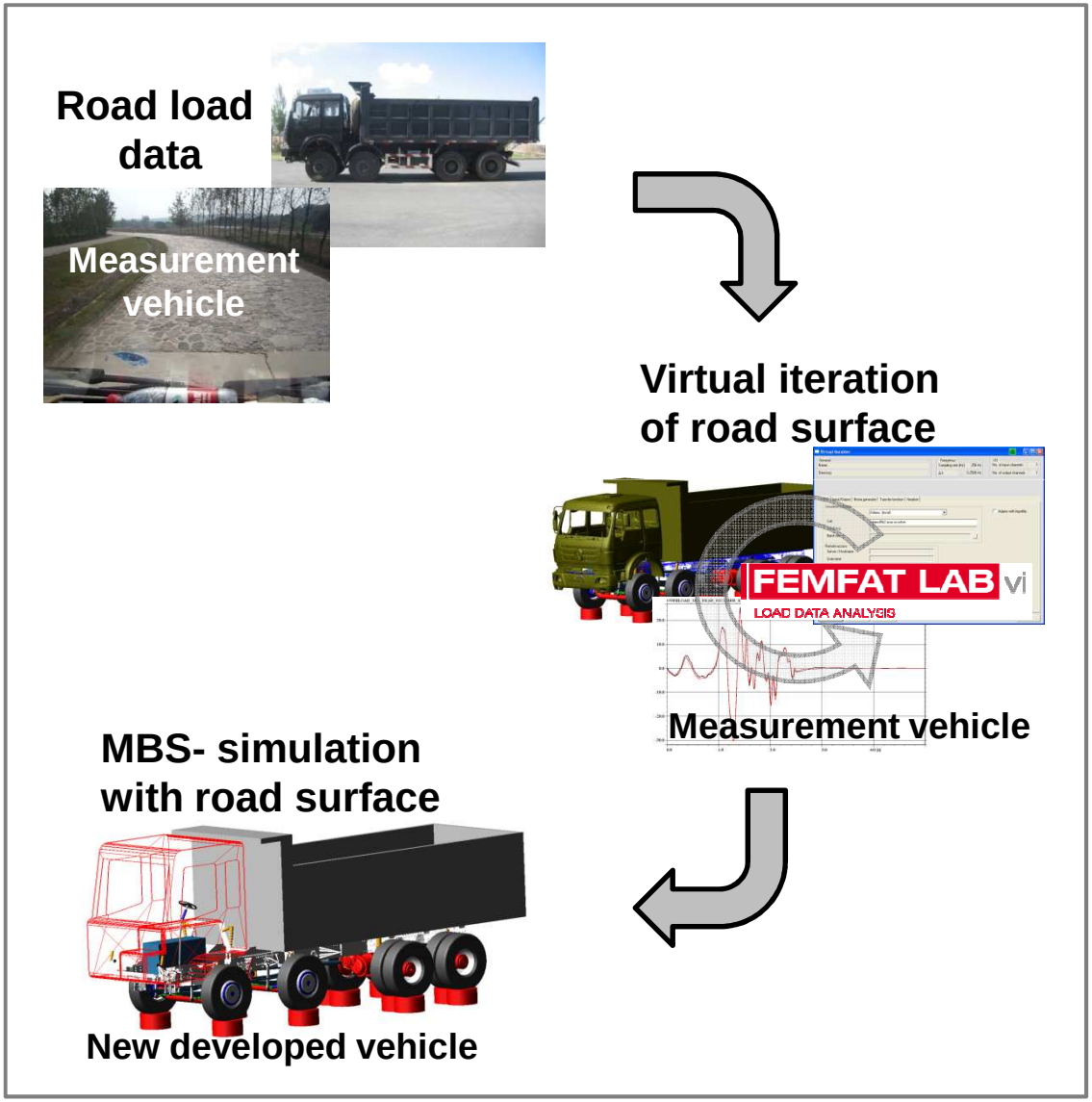
Spring displacement – time domain 15th to 20th second



Spring displacement – frequency domain

Results: 10. Iteration – relative damage values





Transfer of invariant signals to different vehicle

- Identification of road surface 4-, 6- or 8- poster
- Road surface can be transferred to different vehicle
- Analysis of vertical loaded parts or subsystems possible, e.g. frame
  (chassis parts not suitable)

- Goal of 8-Poster simulation
  - Internal forces for fatigue analysis of frame with

FEMFAT max
FINITE ELEMENT METHOD FATIGUE

8 - Poster

Load (8 channels)

- 8 vertical displacements at the posters

ADAMS/Car model

Desired (measurement)

- Spring displacements
- Vertical accelerations at axle

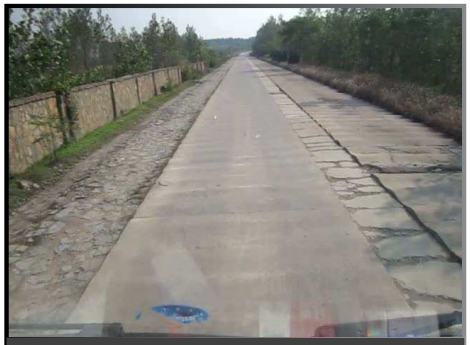
- MBS model of measurement vehicle
- Virtual iteration of different test tracks (bumps, rough roads, washboards, twisting,…)

Model-check (measurement)

- Vertical forces at axle
- Damper forces

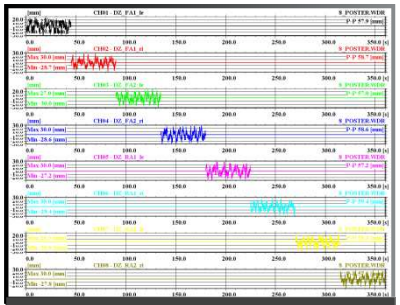
Broken road

Bumps

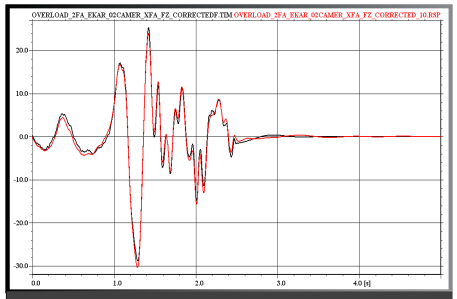


Small washboard

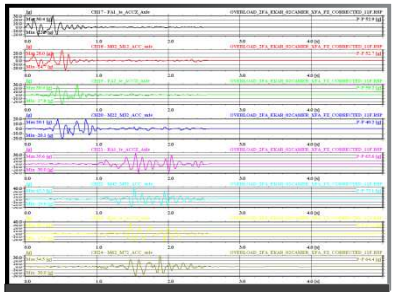
Iteration process



1. Pink Noise



6. Response = desired

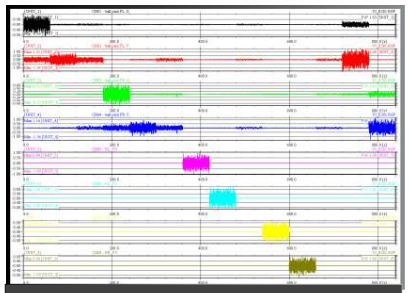


5. Response

u_{Noise}

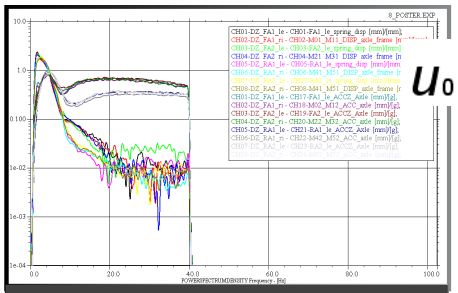
y_{Noise}

$$u_{n+1} = u_n + F^{-1} (y_{Desired} - y_n)$$



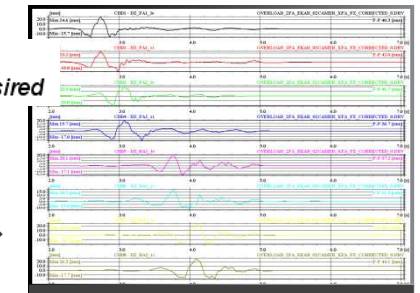
2. Response of noise

$$F = \frac{y_{Noise}}{u_{Noise}}$$



3. Transfer function

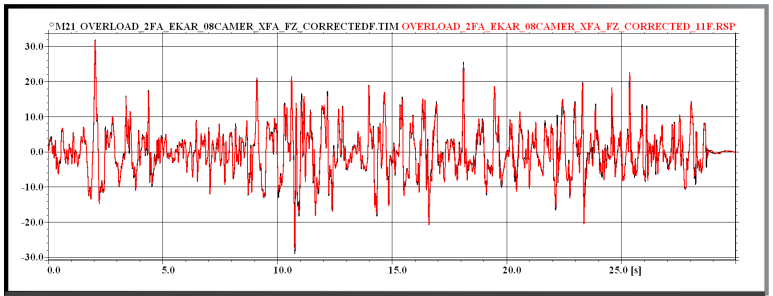
$$u_0 = F^{-1} y_{Desired}$$



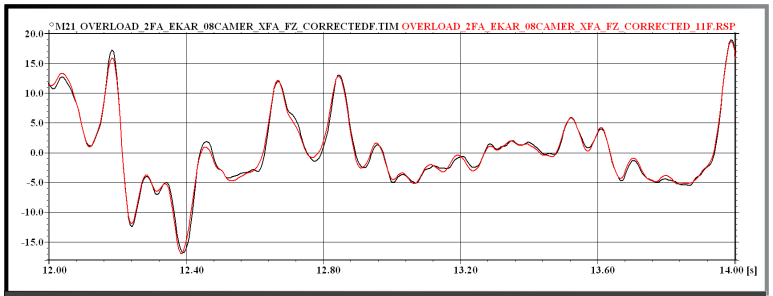
4. Drive signal

Results: 10. iteration, stone paved road

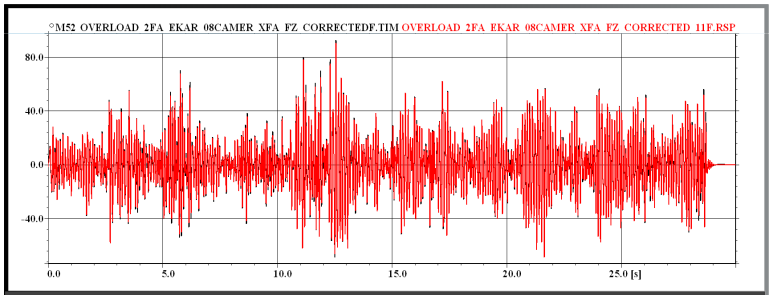
black…measurement
red……simulation



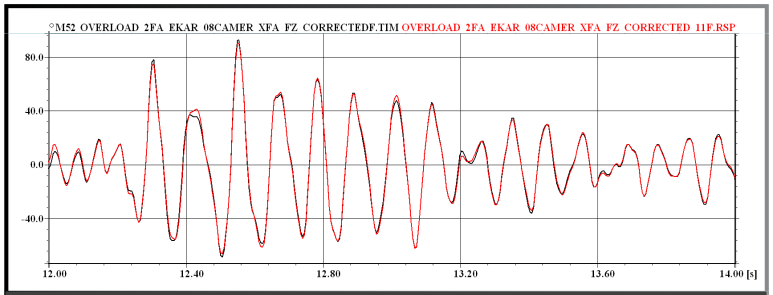
Spring displacement FA1 – time domain



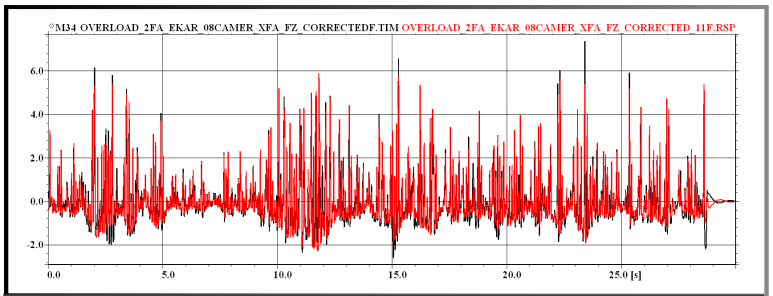
Spring displacement FA1 – time domain 12th to 14th second



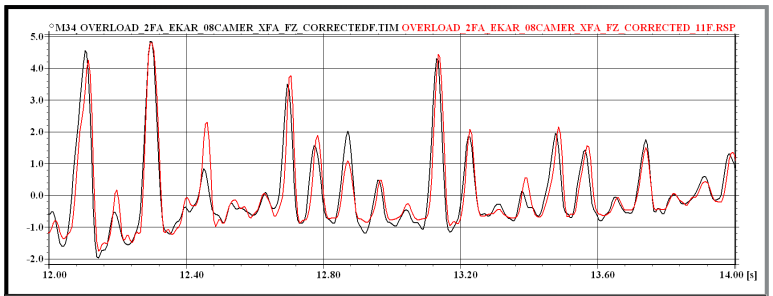
WC acceleration Z RA1 – time domain



WC acceleration Z RA1– time domain 12th to 14th second

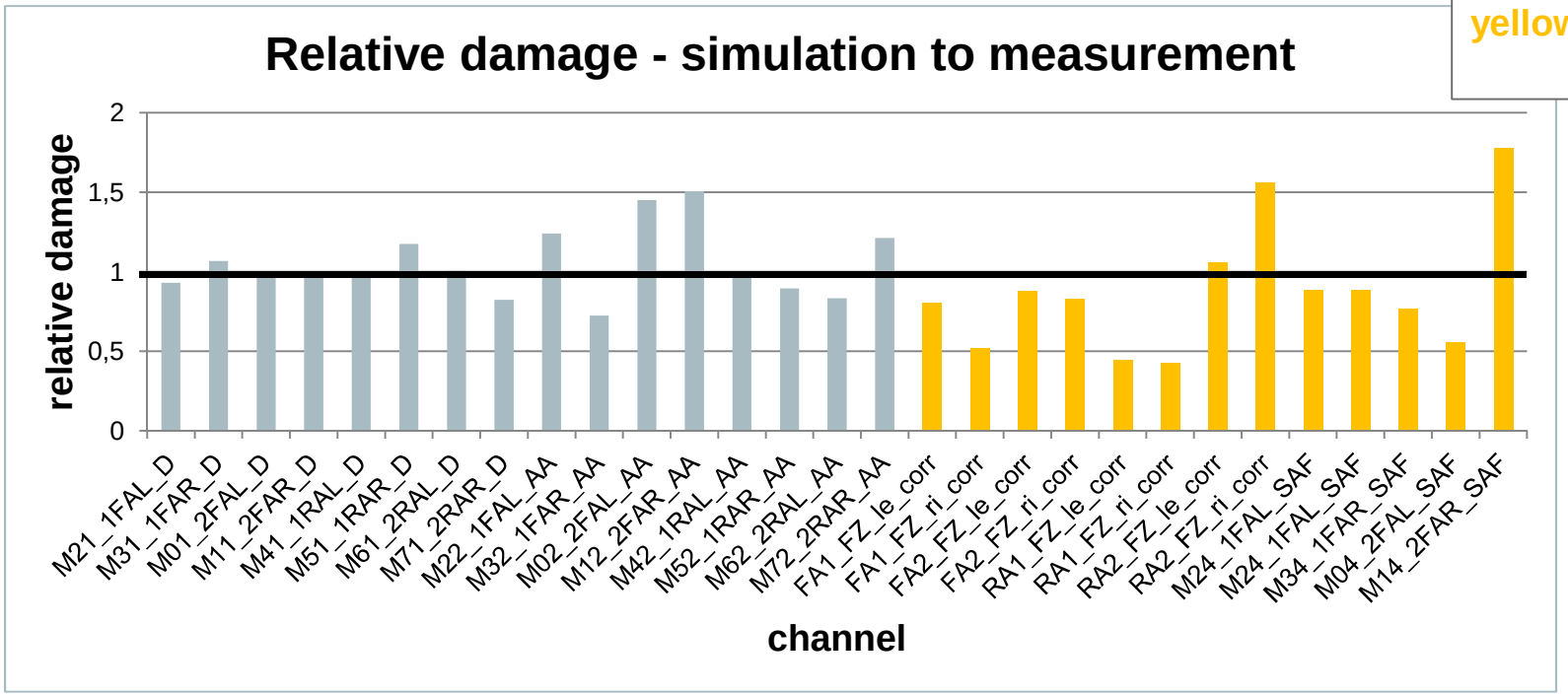


Damper force FA2 – time domain (model check)



Damper force FA2 – time domain 12th to 14th second

Relative damage of all maneuvers in total, linear combined with their repeats



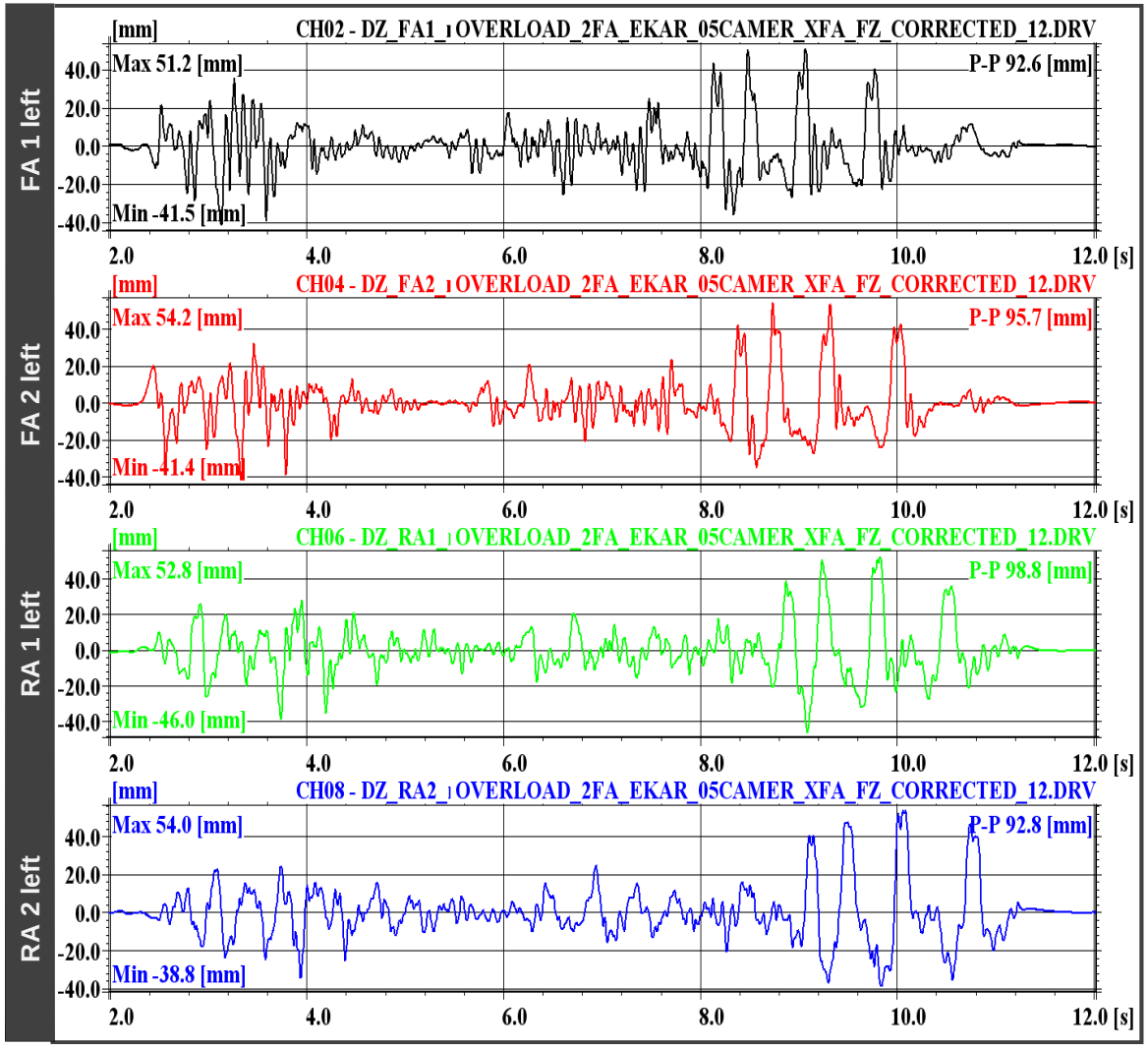
grey……desired channels
yellow…channels for model check

Damage mean values
- Spring displacements: 1.0
- Axle accelerations: 1.1
- Vertical forces: 0.8
- Damper forces: 1.0

D…..spring displacements
AA…axle accelerations

FZ……vertical forces
SAF…damper forces (ShockAbsorberForces)

8 - Poster

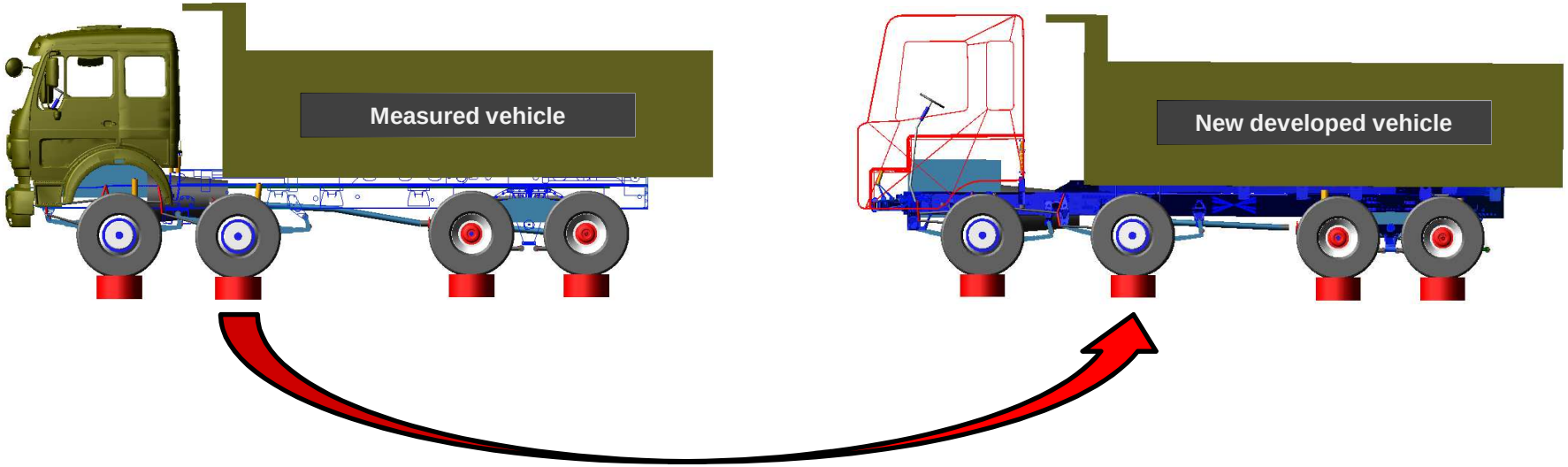


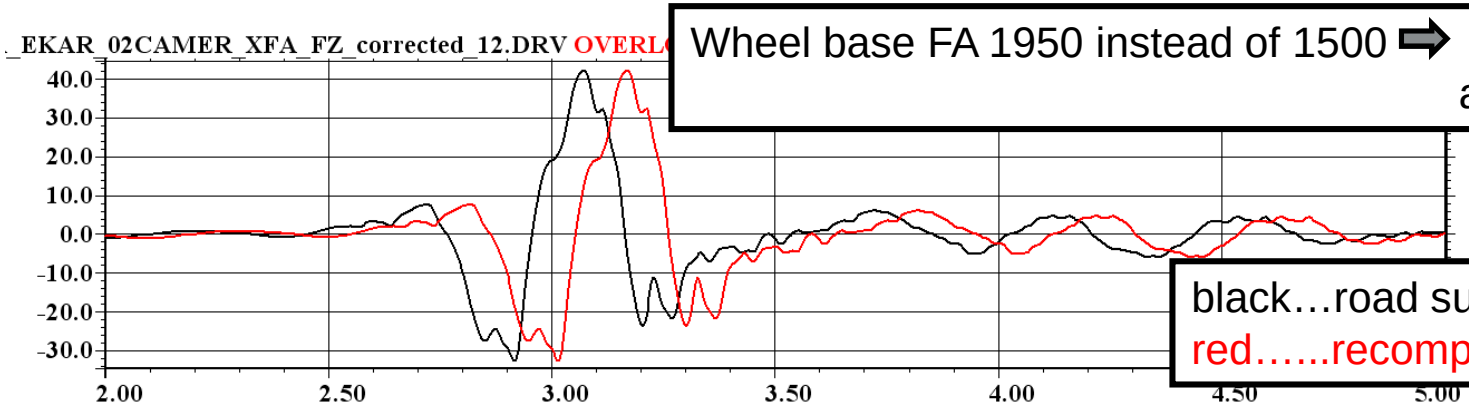
Resulting road surface for broken asphalt

- Left side
- Similar characteristics

Applying road surface to new developed truck

- Road surface recomputed to new wheel base





Wheel base FA 1950 instead of 1500 ⇨ time signal is shifted back according to this difference

black…road surface, measured vehicle
red……recomputed, new developed truck

Conclusion

- Powerful method for load data generation
- Excellent convergence between measurement and simulation
- Efficient method to generate absolute displacements (e.g. tire patch, frame movement for add on parts like cab, tank, engine, exhaust systems)
- Full vehicles, subsystems and test benches can be simulated based on real road load data using simple and cheap measurements
- Efficient parameter studies and transfer to similar vehicles (invariant load)
- Model verification and trimming by additional checking signals
- Absolute fatigue life prediction possible
- Assessment of test bench concepts (feasibility, simplifications)

Conclusion

- FEMFAT LAB Virtual Iteration
  - Automatic iteration process with MSC.ADAMS® , SIMPACK® and MotionSolve®
  - MSC.ADAMS® and SIMPACK® can be executed on a desktop computer or remotely controlled in a network
  - Pre- and post- processing with FEMFAT LAB
  - Well tested and used in different fields of application since many years

- FEMFAT LAB Users

Europe

- AVL
- DAIMLER
- KTM
- MAN
- MTU (ROTORION)
- PORSCHE
- VW
- WINERGY

South America

- VW DO BRASIL

Asia

- BEIBEN
- CHANGAN
- CHERY
- FAW
- FOTON
- FUSO
- GEELY
- HINO
- HMC
- MMC
- 38th INSTITUTE

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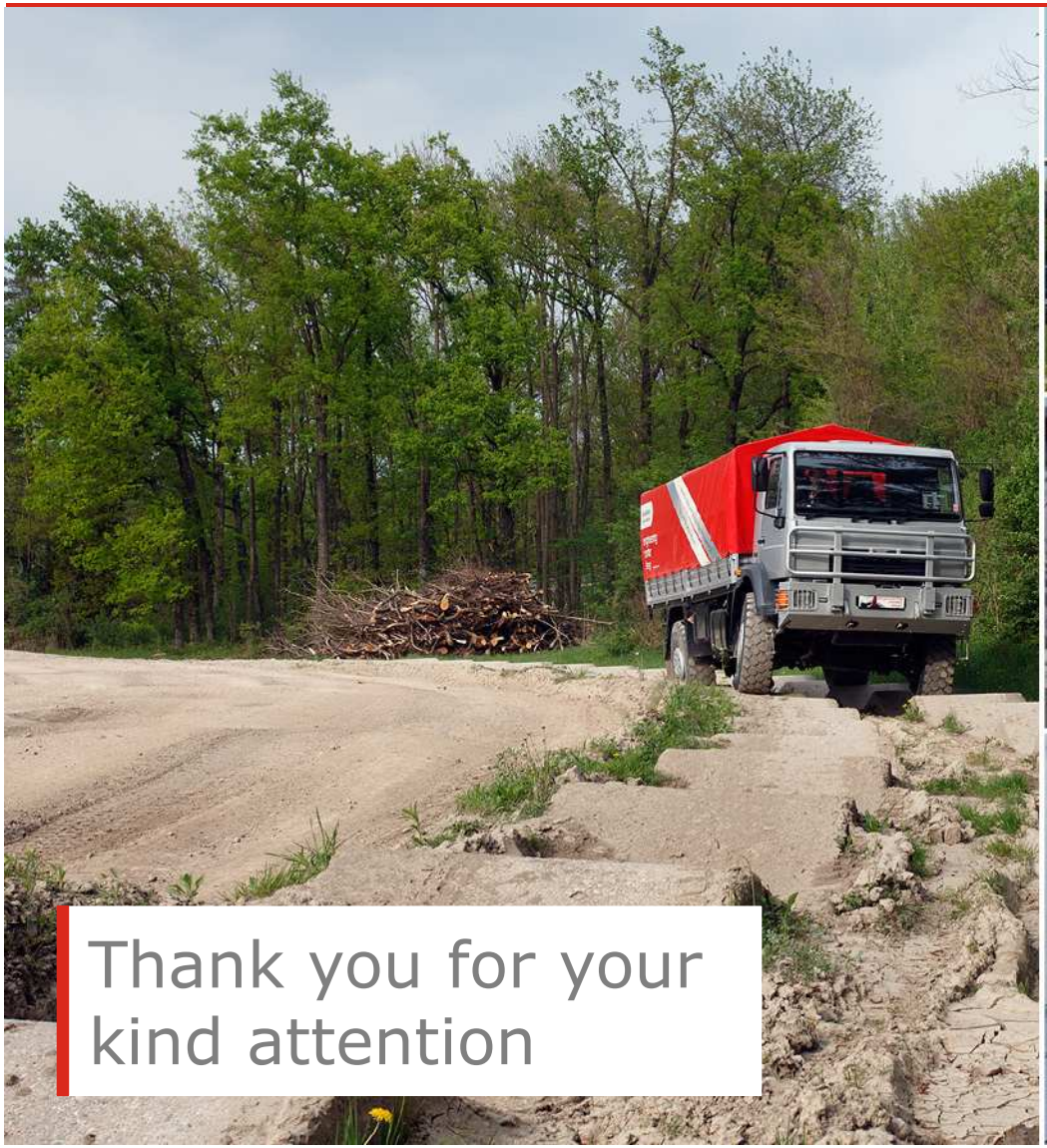

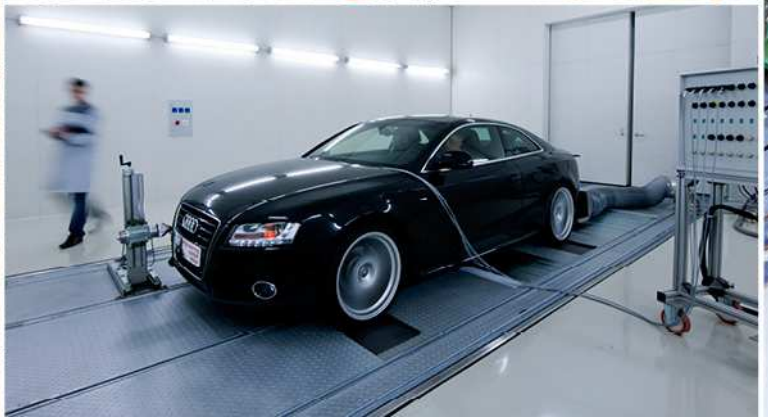

Thank you for your kind attention

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