



Engineering Center Steyr GmbH & Co KG (ECS)

5. Grazer Nutzfahrzeug Workshop, 11. Mai 2012

Virtuelle Iteration von Lastdaten zur Komponenten und Fahrzeugbewertung

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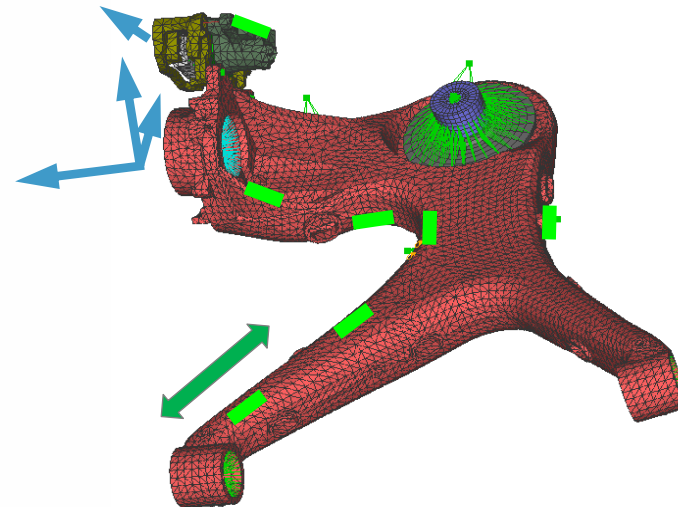
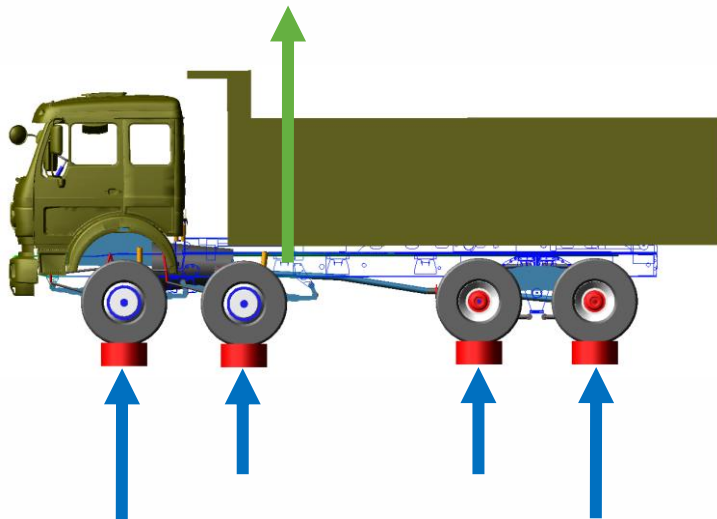
Content

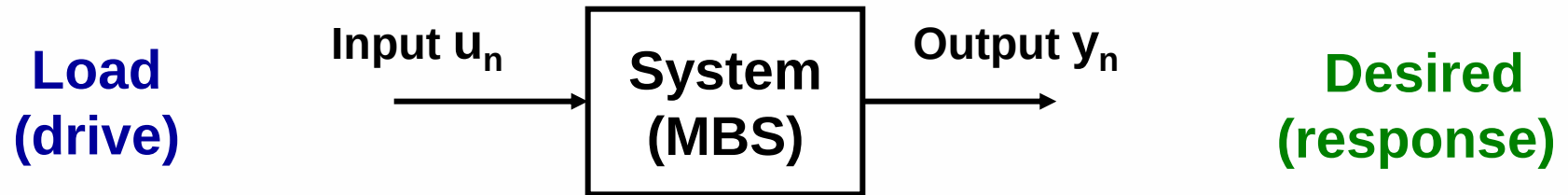
- **Motivation for Virtual Iteration**
- **General Approach of Virtual Iteration**
- **Example „8x4 Truck” (Full Vehicle) with invariant road excitation for fatigue and comfort**
- **Example „Suspension Test Rig” with invariant strains for test bench modifications**



Motivation:

- to generate **external loads** based on internal, measured **response**
- to get invariant excitations for parameter variation
- for fatigue and comfort investigation
- for modification/optimization of test bench concepts





- Inverse non-linear problem: *find loads for given responses*

Drive

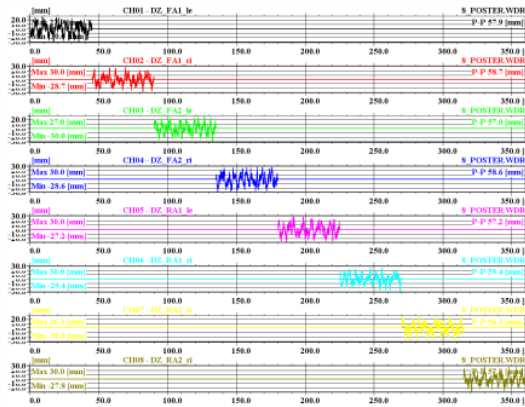
- Forces (external)
- Displacements (absolute)

Response

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

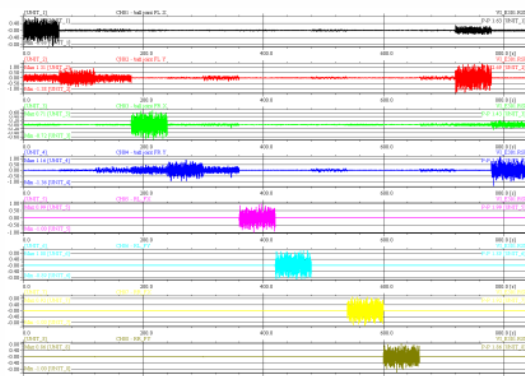
Virtual Iteration General Approach

1. Pink noise



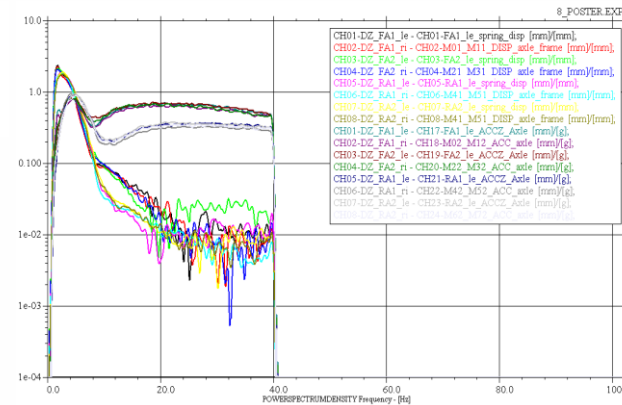
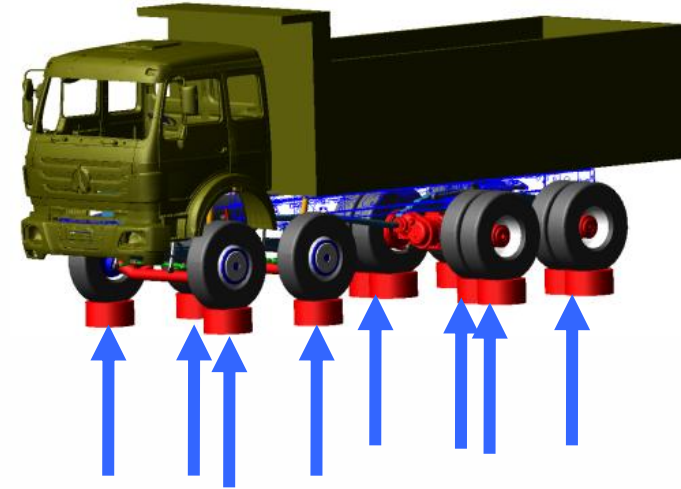
U_{Noise}

y_{Noise}



2. Response of noise

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

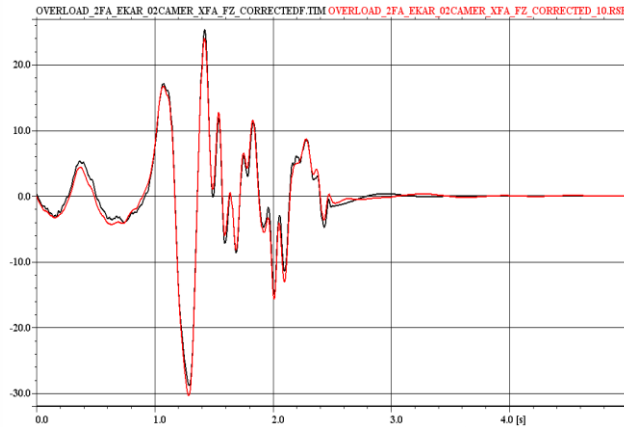


$$U_0 = F^{-1} y_{Desired}$$

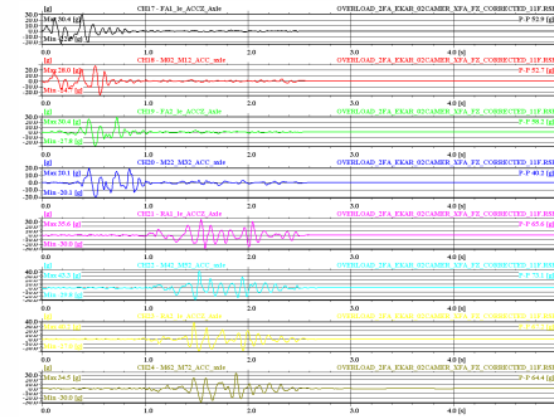


3. Transfer function

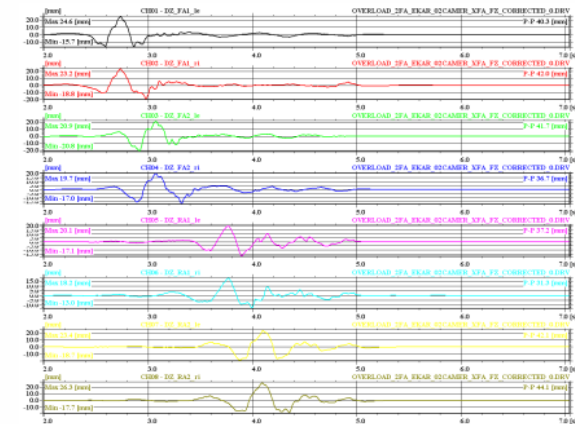
6. Response = desired



5. Response



4. Drive signal

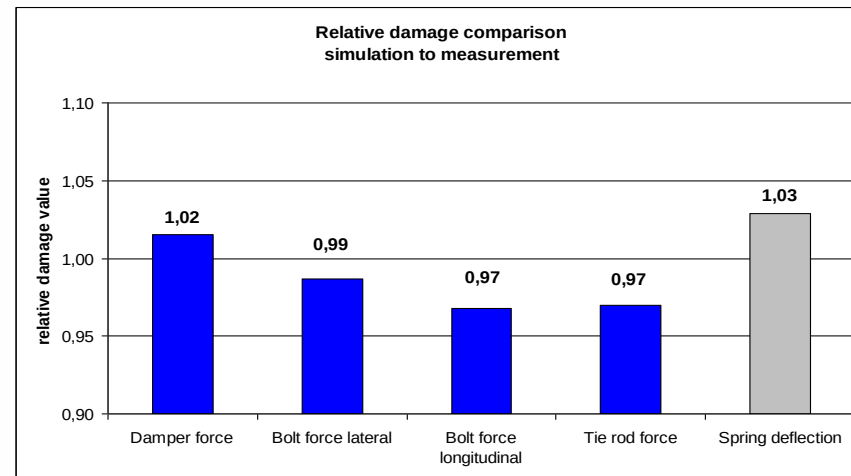
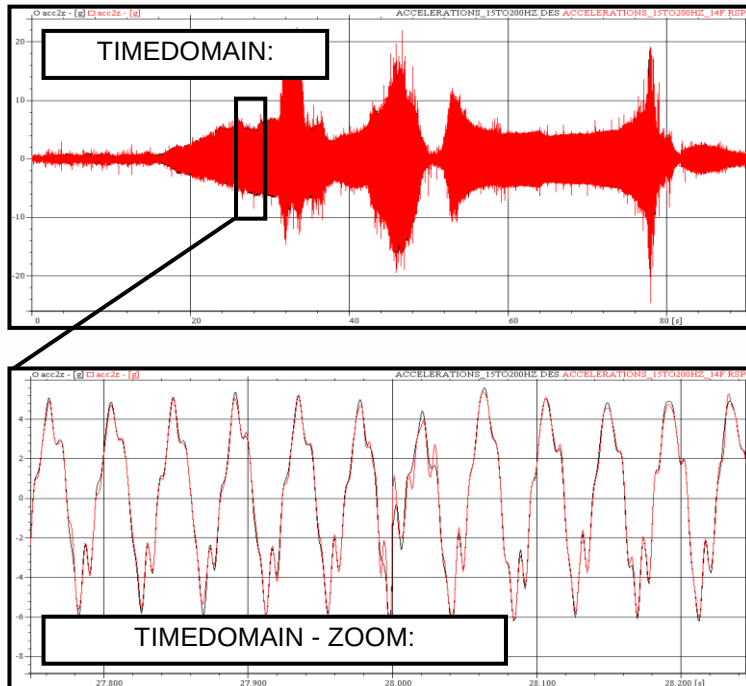


$$u_{n+1} = u_n + F^{-1} (y_{Desired} - y_n)$$

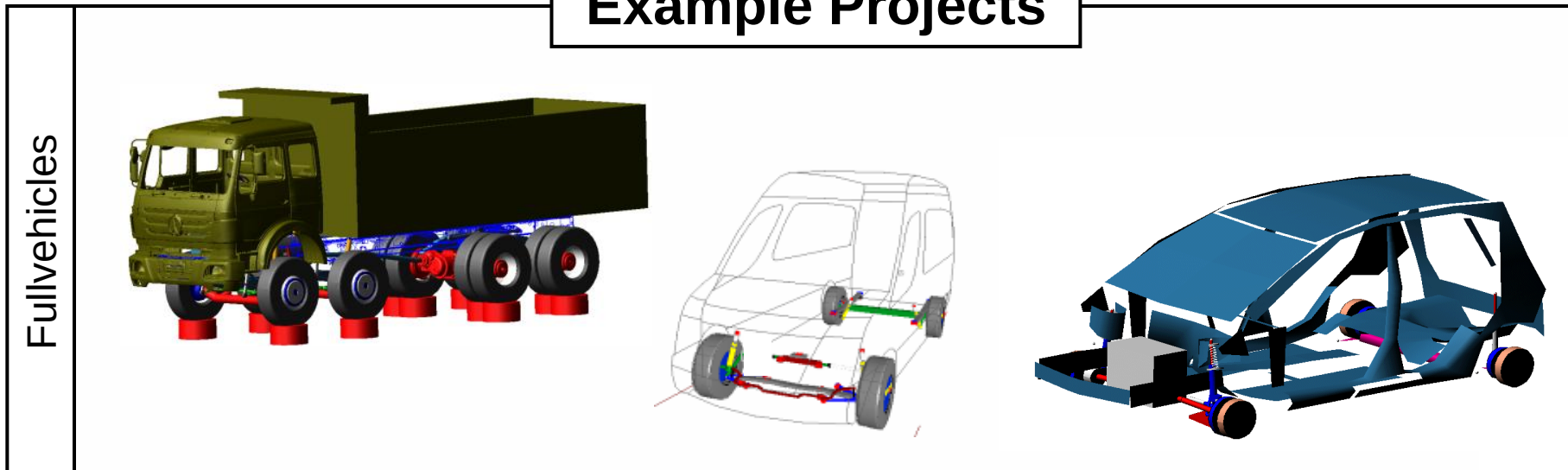
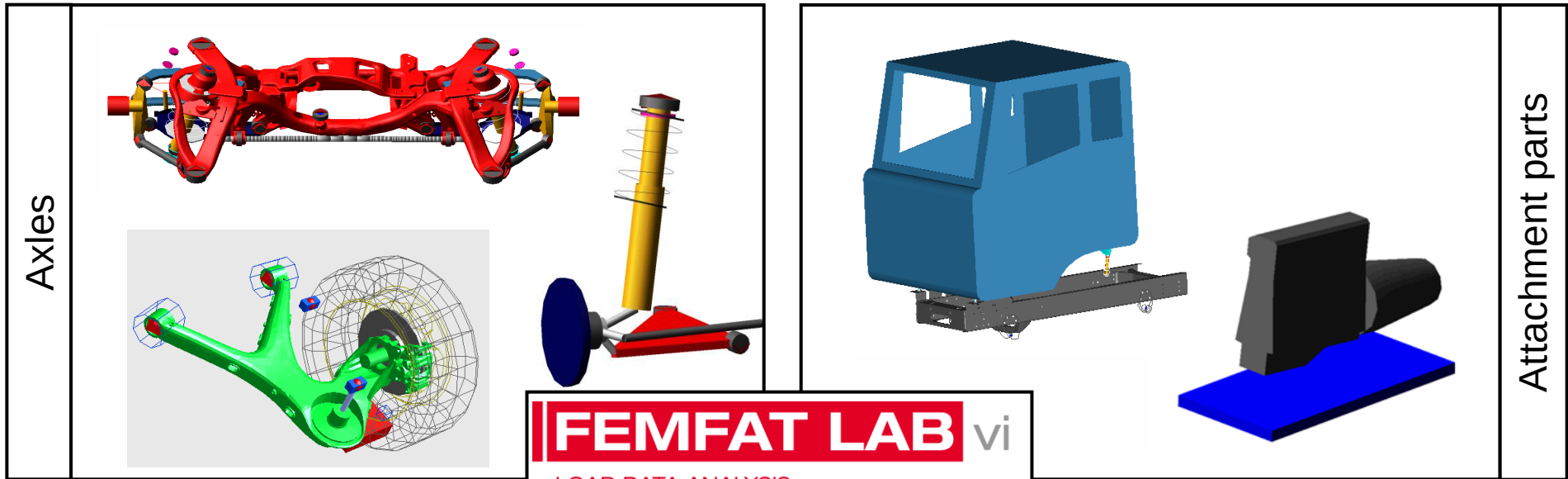
$$u_0 = F^{-1} y_{Desired}$$

Result check during virtual iteration process basing on:

- signals in time domain (quality check)
- peak-to-peak values of signals in time domain (quantity check)
- signals in frequency domain (PSD)
- relative damage value of simulation compared to measurement

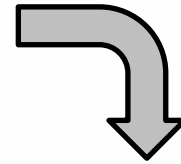


Virtual Iteration Project Overview



Virtual Iteration 8x4 Truck

Road load
data

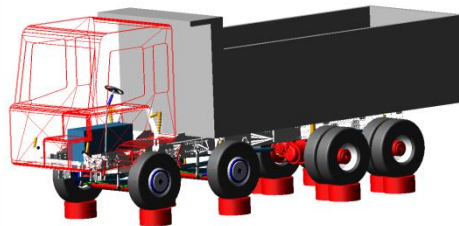


Virtual iteration
of road surface

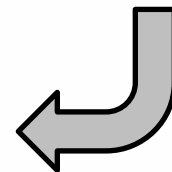


Measurement vehicle

MBS- simulation
with road surface



New developed vehicle



- Road load data acquisition with benchmark vehicle
- Virtual iteration to invariant road excitation (8-poster)
- Transfer of invariant signals to different vehicle
- Analysis of vertical loaded parts or subsystems possible, e.g. frame (chassis parts not suitable)



Virtual Iteration 8x4 Truck

Load (8 channels)

- 8 vertical displacements at the posters



Desired (measurement)

- Spring displacements
- Vertical accelerations on axles

Model-check (measurement)

- Vertical forces at axle
- Damper forces

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

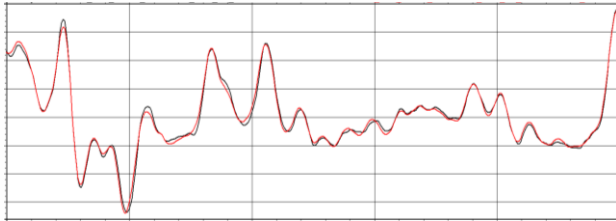


Virtual Iteration

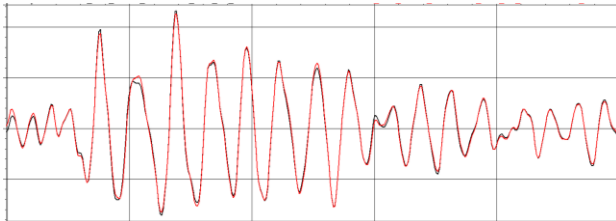
8x4 Truck

Response

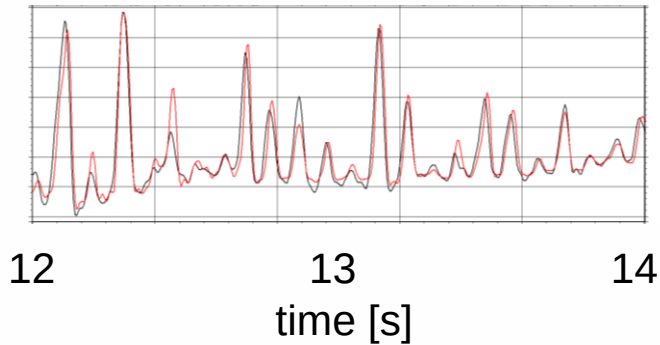
spring
displ.



vertical
acc.

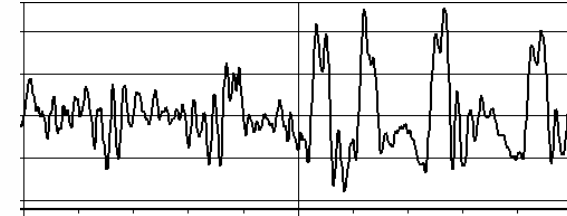


damper
force
(check)

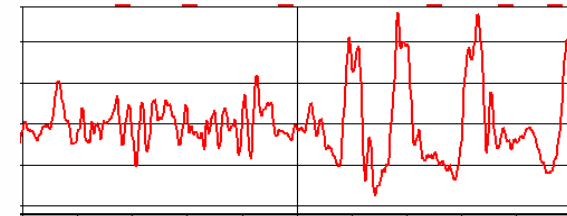


Drive

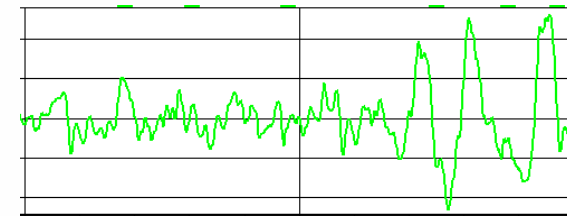
FA1 left



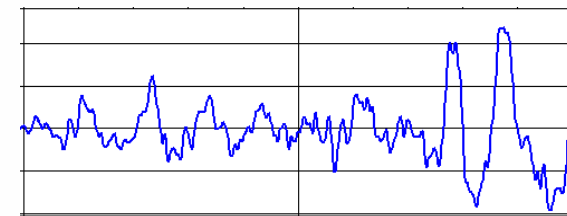
FA2 left



RA1 left



RA2 left



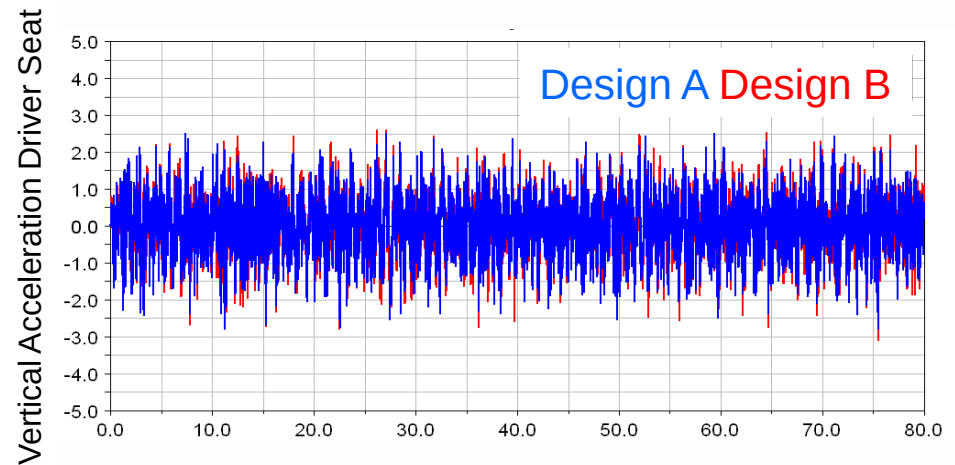
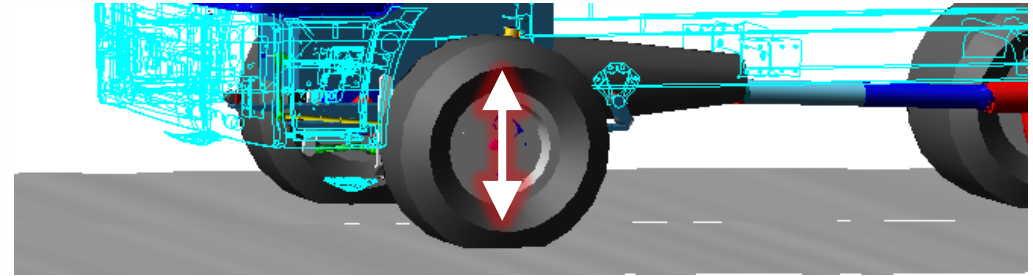
time [s]

Virtual Iteration

8x4 Truck

Results of this investigation can be used for:

- **Fatigue investigation**
investigating different concepts
changing vehicle parameter
allocate to concept vehicle
- **Comfort investigation**
modifying suspension parameter
modifying cab properties



time



COMFORT VALUES A and B

Virtual Iteration Suspension Test Rig



DAIMLER

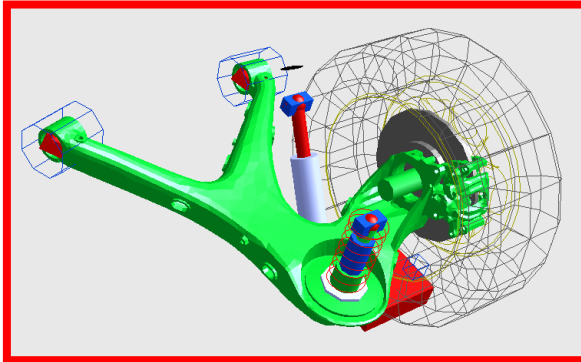


Mercedes-Benz

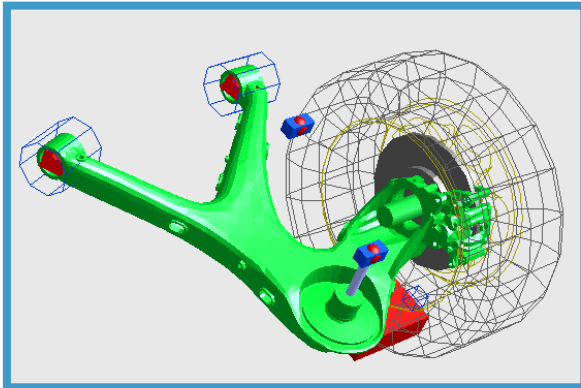


- Endurance strength verification of the chassis is based on proving ground testing (torture track and maneuver like braking, weaving, ...) at Daimler AG
- Development of simplified test rig for semi-trailing arm
- Verification of damage distribution





vehicle configuration:
spring and damper

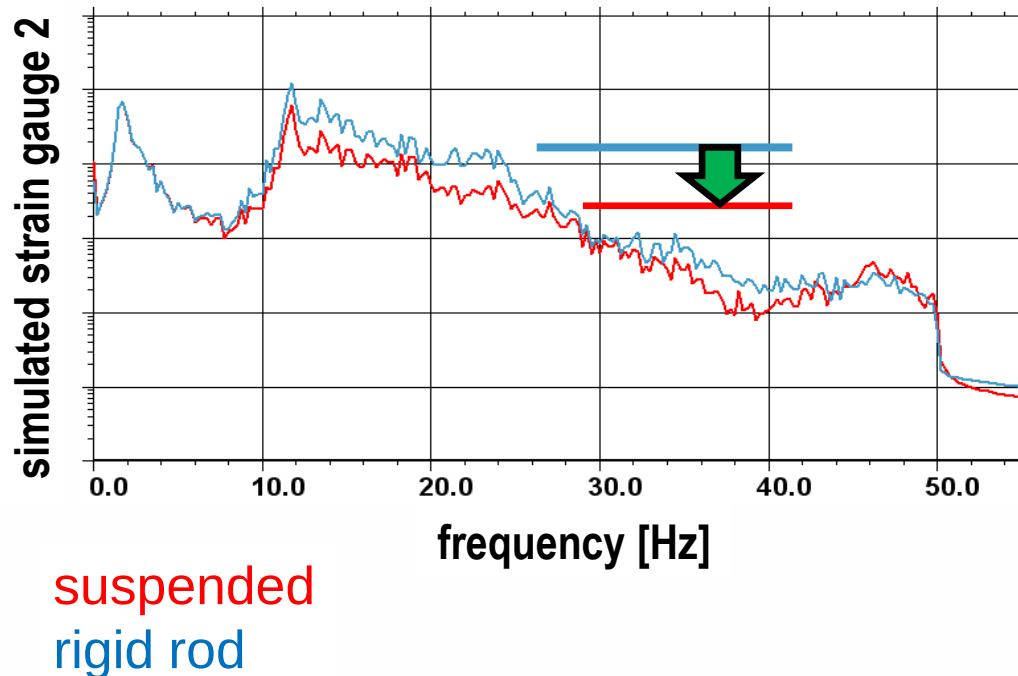


test rig configuration:
rigid rod, no damper

- Efficiency improvement with a rigid spring/damper
- No cooling of damper necessary
- Replacement of elastomer omitted
- Target: Strain gauge signals unchanged
- Excitation: Torture track, braking, weaving

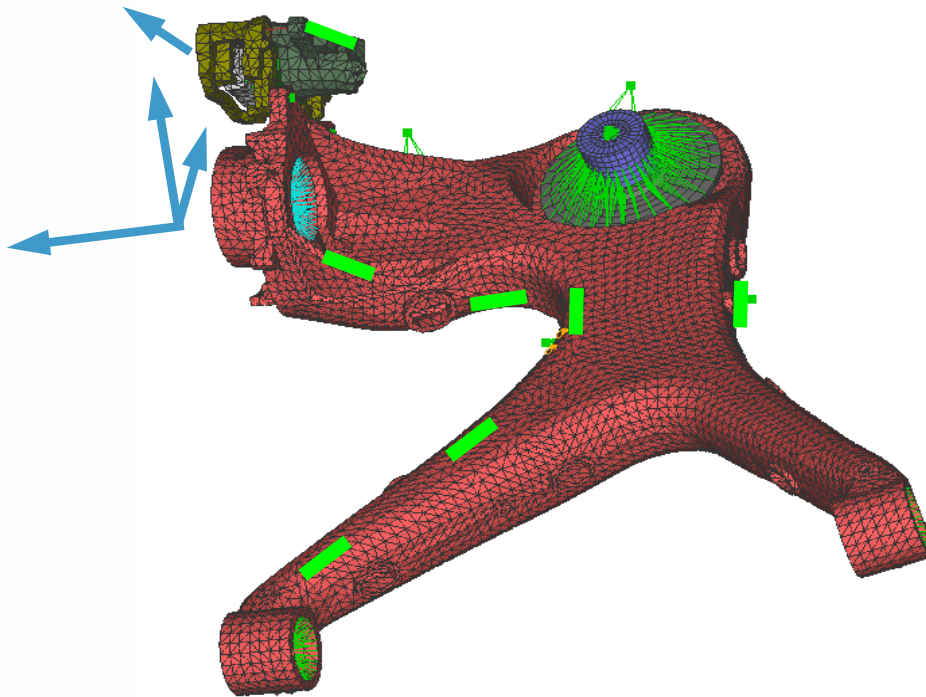


Why do we need Virtual Iteration?



- Different boundary conditions for test bench: suspended and with rigid rod
- Excitation of both systems with identical loads on wheel hub
- Different strain results inside semi-trailing arm due to changed boundary conditions
- Target: tuning of excitation to gain identical strains at semi-trailing arm

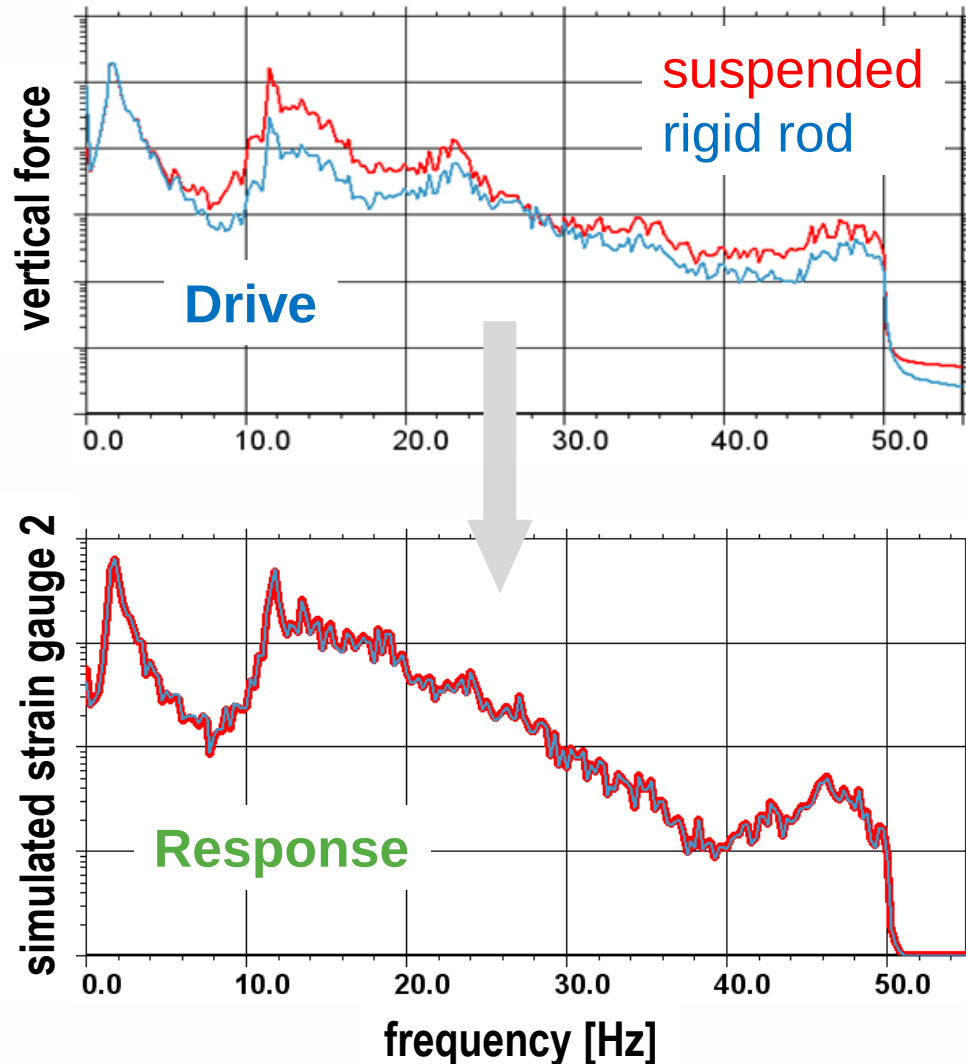




- **Drive**
forces and torques applied on wheel hub
- Lateral torque not applied on wheel hub during driving
- Additional constraint during breaking maneuver
- **Response**
seven strain gauges on semi-trailing link



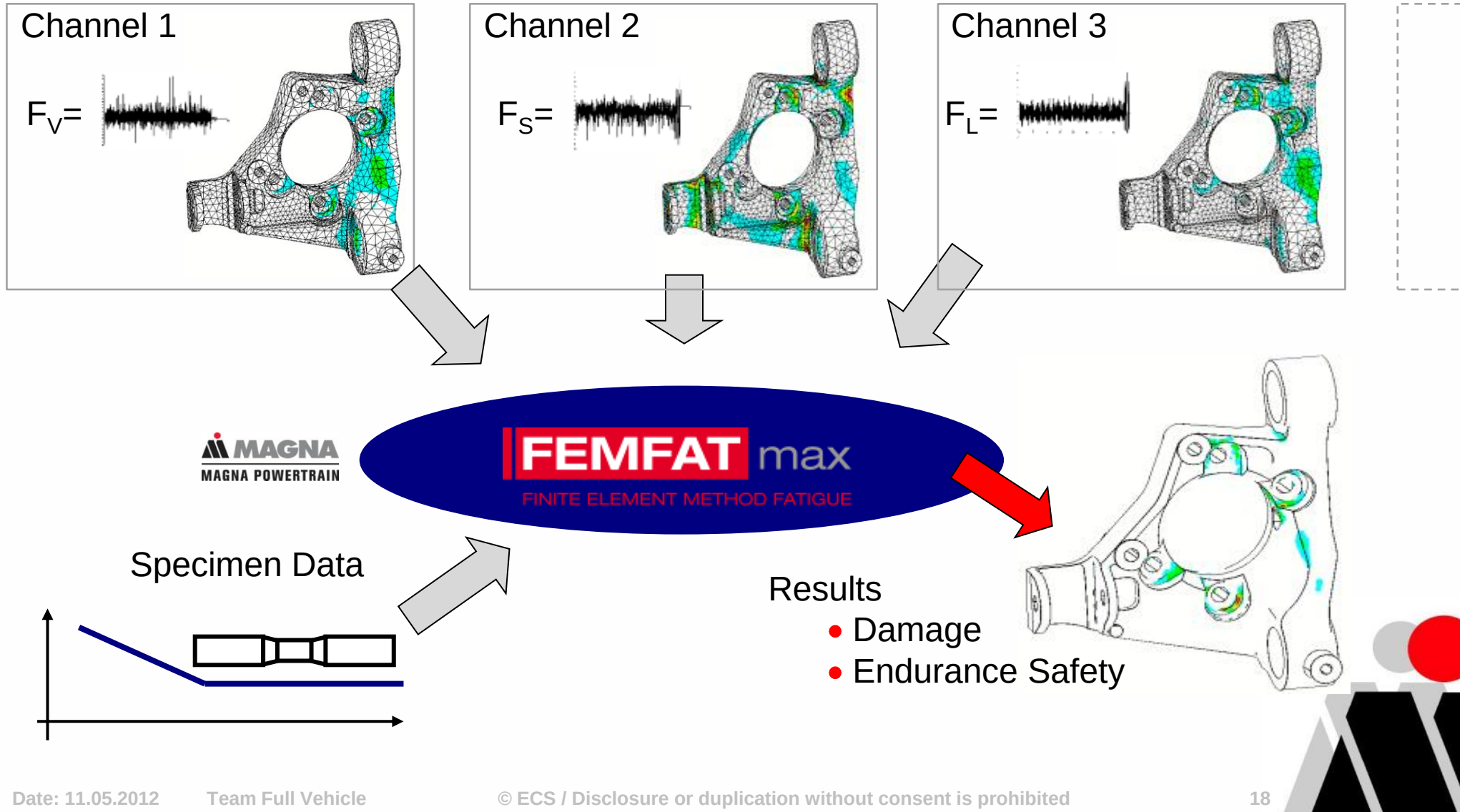
Virtual Iteration Suspension Test Rig



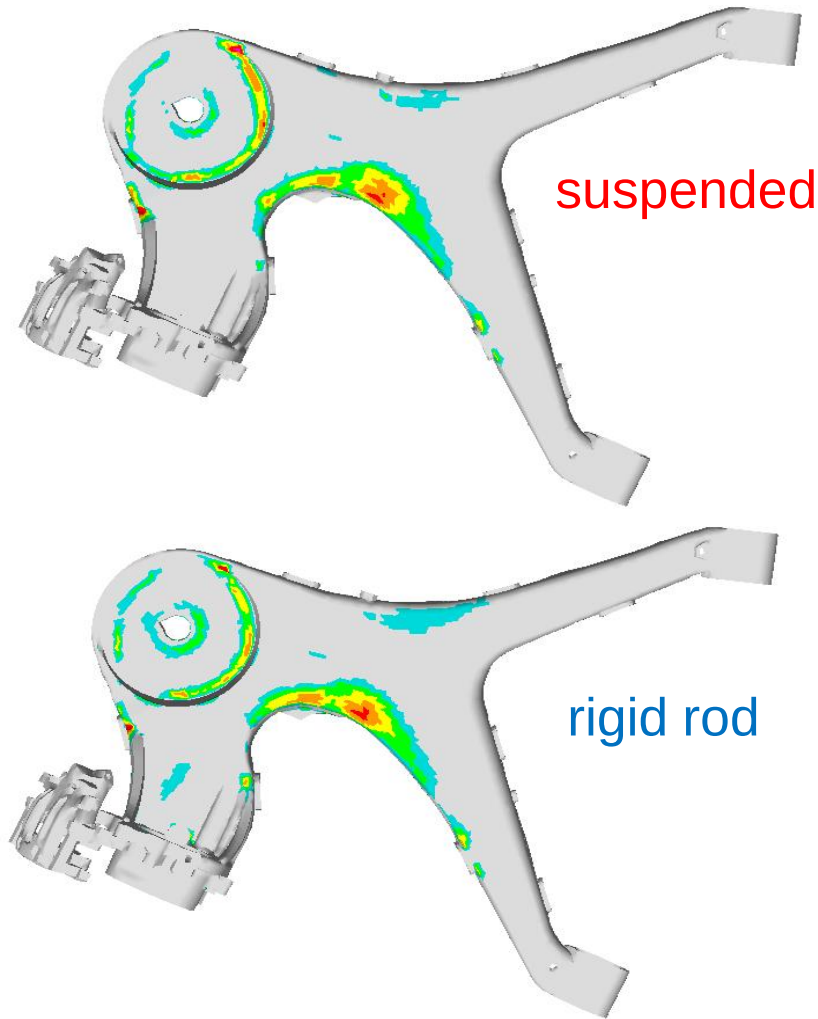
- **Iteration result:**
Modified time signal for all forces and torques of rigid test bench
- **Simulation of strains by application of modified loads on model with rigid rod**
- **Goal accomplished:**
Same strains in both models



Virtual Iteration Suspension Test Rig



Virtual Iteration Suspension Test Rig



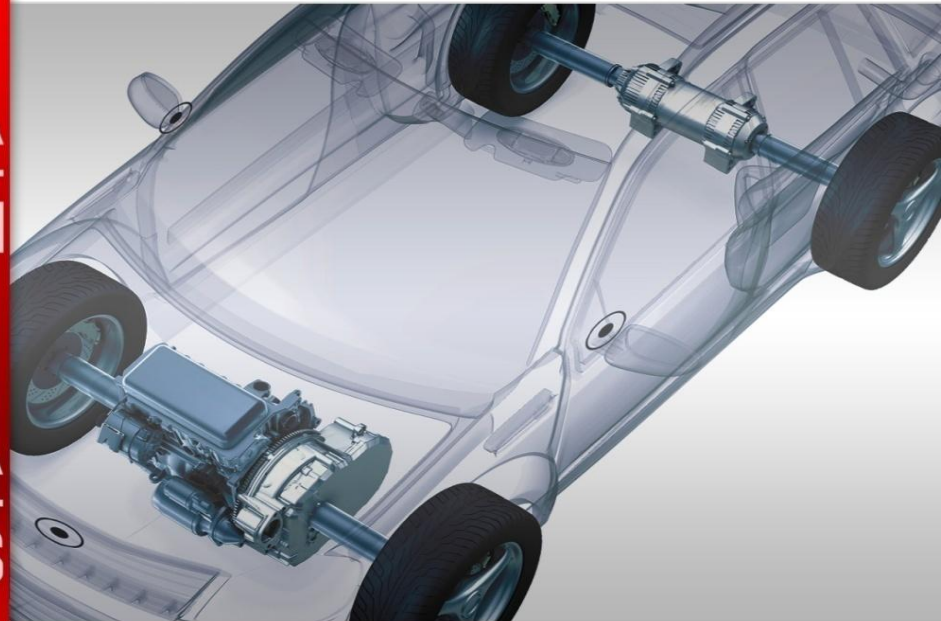
- Verification of damage location with modified boundary conditions and loads
- Calculation of damage distribution based on simulation results for both models
- Comparison:
Similar damage distribution with no additional hot spots



Benefits of Virtual Iteration:

- Simple and cheap measurements for vertical road excitations
- Efficient method to generate absolute displacements (e.g. wheel patch, frame movement)
- No complex tire model required for vertical load
- No road surface scanning required
- Model verification and trimming by additional checking signals
- Absolute fatigue life prediction possible
- Efficient parameter studies and transfer to similar vehicles
- Method applicable for wide range of vehicle components
- Assessment of test bench concepts (viability, simplifications)





Thank you for your kind attention!