

Dynamische Erprobung einer Karosserie am Virtuellen Prüfstand

MSC Usermeeting 2013

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MAGNA Powertrain – Engineering Center Steyr

- Vehicle components are dynamically loaded during usage
- Deformation of components leads to modified contact situation and stresses
- Fatigue assessment
 - Virtual test rig in early development phase
 - Reproduction of load situation on test track
- Goal: reliable method for fatigue calculation of dynamically loaded flexible structures with contacts

- Workflow of virtual test rig
- Virtual iteration of measured loads
- NASTRAN and ADAMS modeling of test rig
- Durability analysis of spot welded body structures
- Example: Durability of battery carrier

Workflow

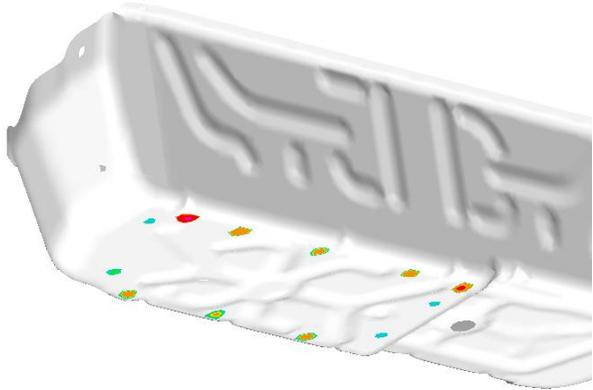
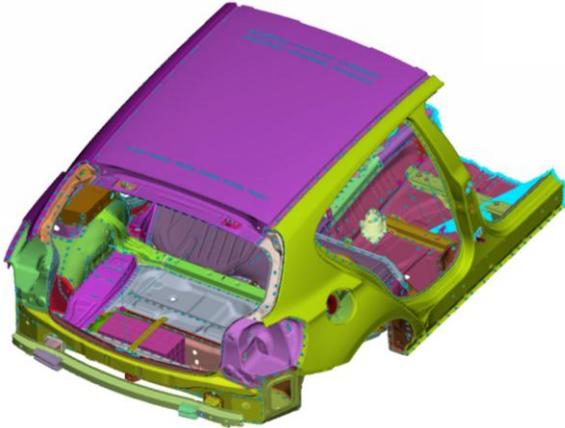


flex body
NASTRAN
MAMBA

ADAMS model
of test rig

FEMFAT LAB vi

durability analysis e.g.
FEMFAT max

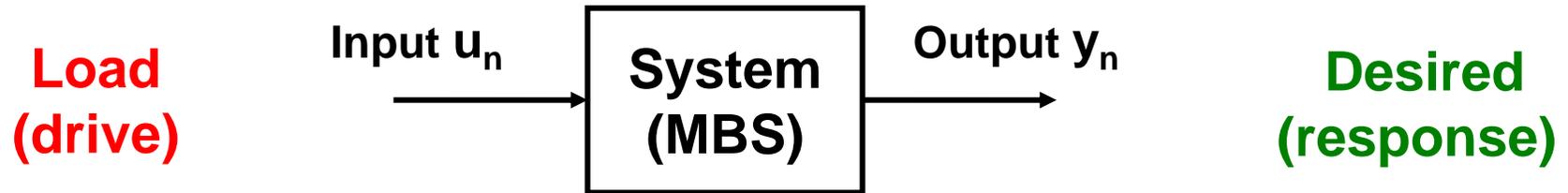


Virtual Iteration of Loads Using FEMFAT Lab

Axles			Attachment parts
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FEMFAT LAB vi
LOAD DATA ANALYSIS
Applications

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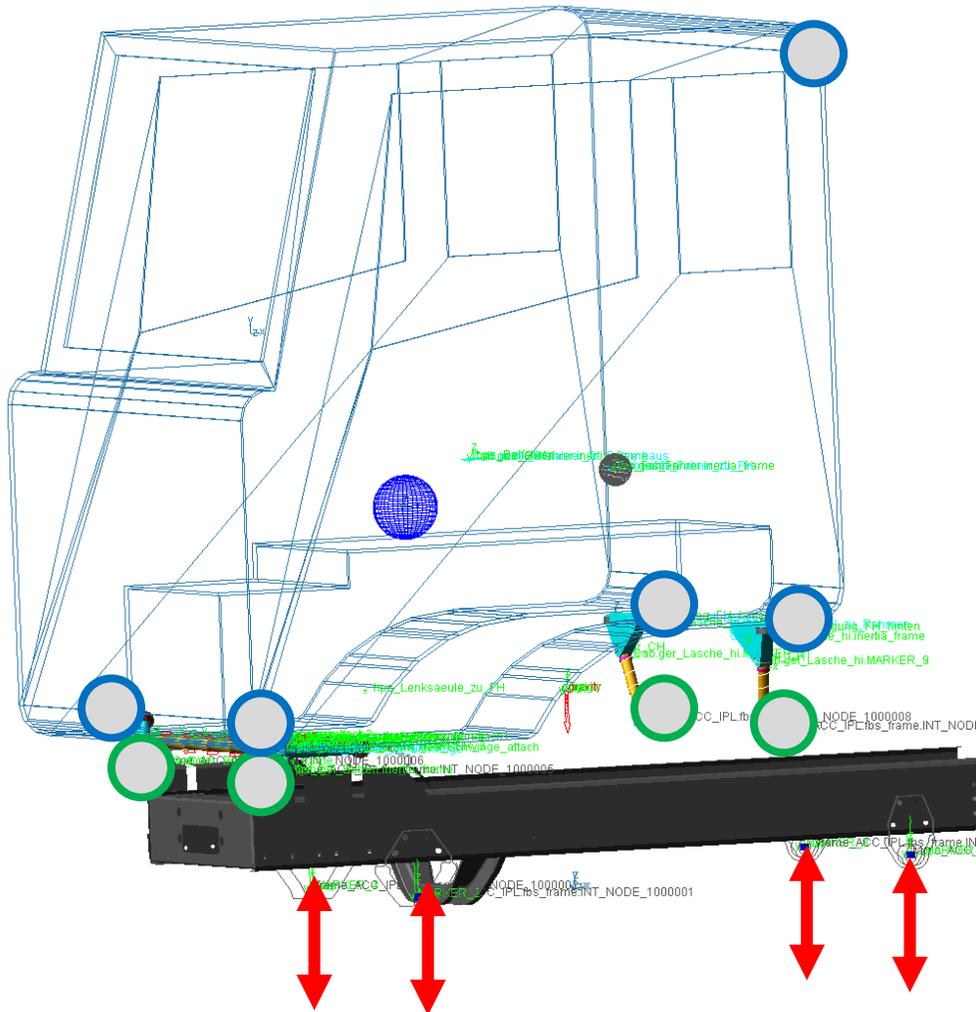
Inverse non-linear problem: *find loads for given responses*



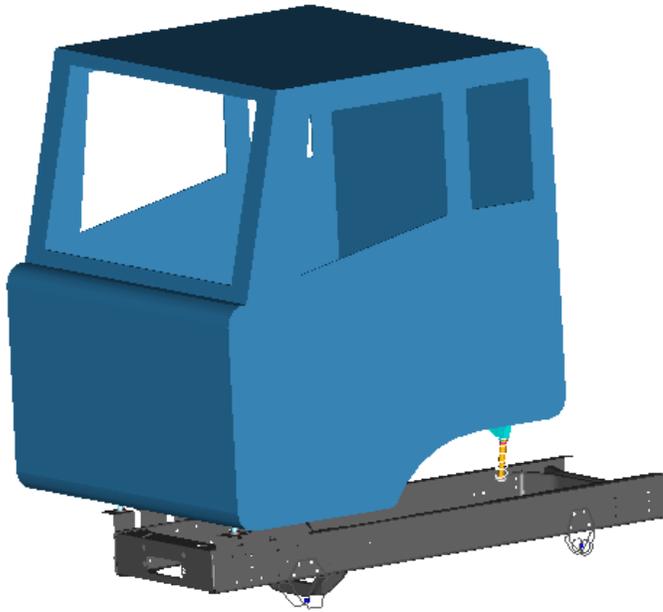
- Forces (external)
- Displacements (absolute)



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

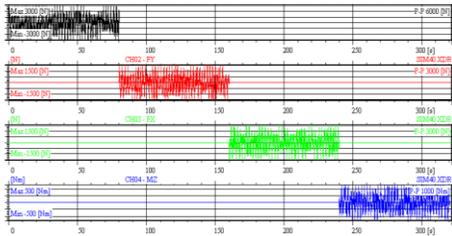


- Measurements from test track
 - Accelerations at frame
 - Accelerations at cabin
- Load
 - Vertical displacement at the frame at 4 positions
- Desired
 - Vertical acceleration at frame
- Model check
 - Vertical accelerations at cabin bottom
 - Acceleration at cabin roof (3-axial)

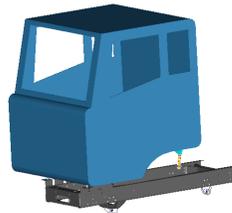
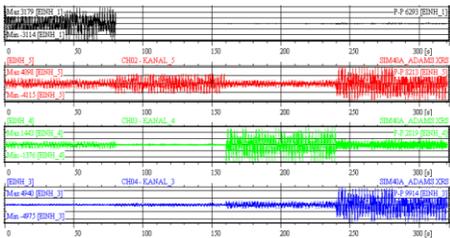


- Components for durability analysis
 - Rigid body -> evaluation of interface loads
 - Flex body -> direct use of flex body modes in durability analysis
- Loads defined in subsystem, splines prepared by VI
 - GFORCE on body
 - MOTION (joint, point or general)
- Simulated response for measurement comparison
 - REQUEST: displacement, acceleration, force,...
 - Scaling to fit unit of measurement channel

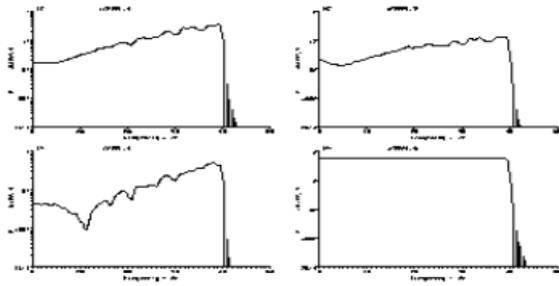
1. Pink noise



2. Response of noise



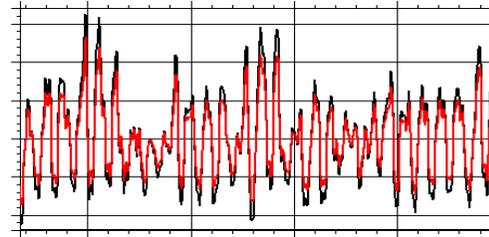
3. Transfer functions



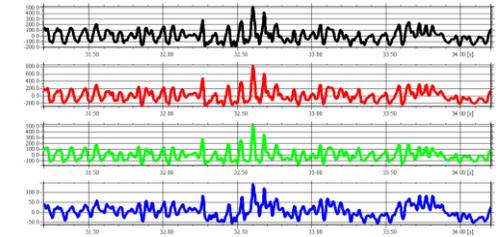
$$F = \frac{y_{Noise}}{u_{Noise}}$$

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

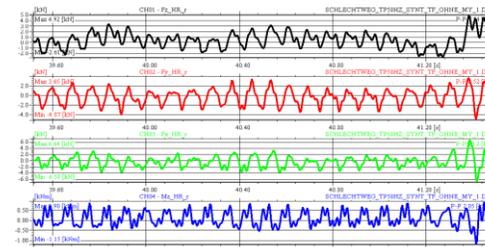
6. Response = desired



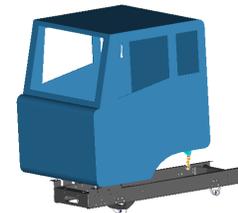
5. Response



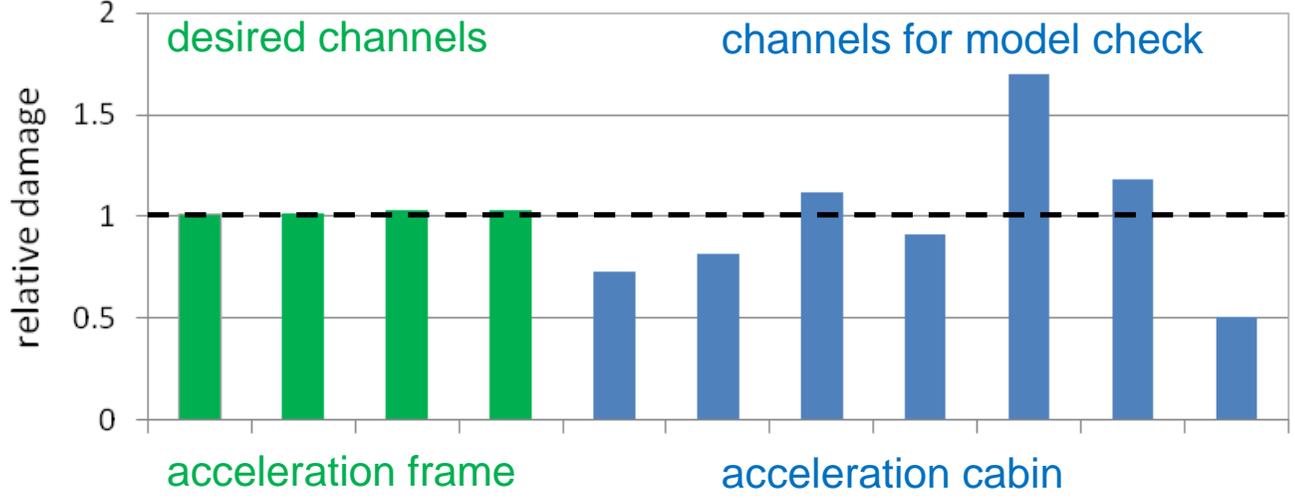
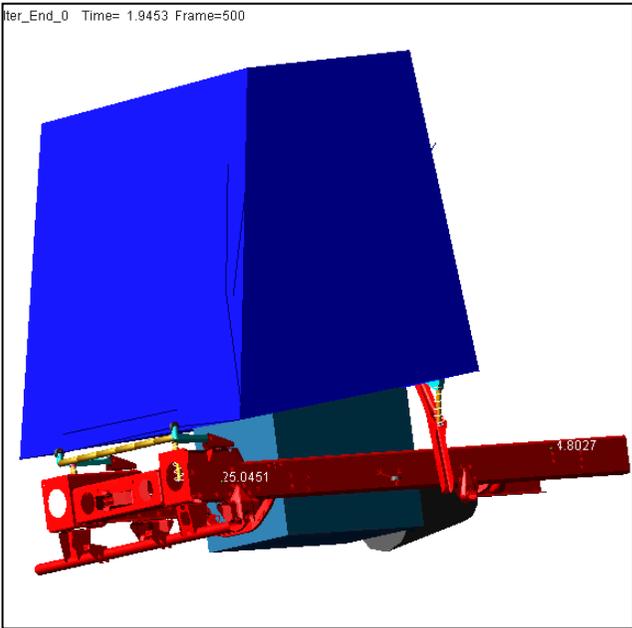
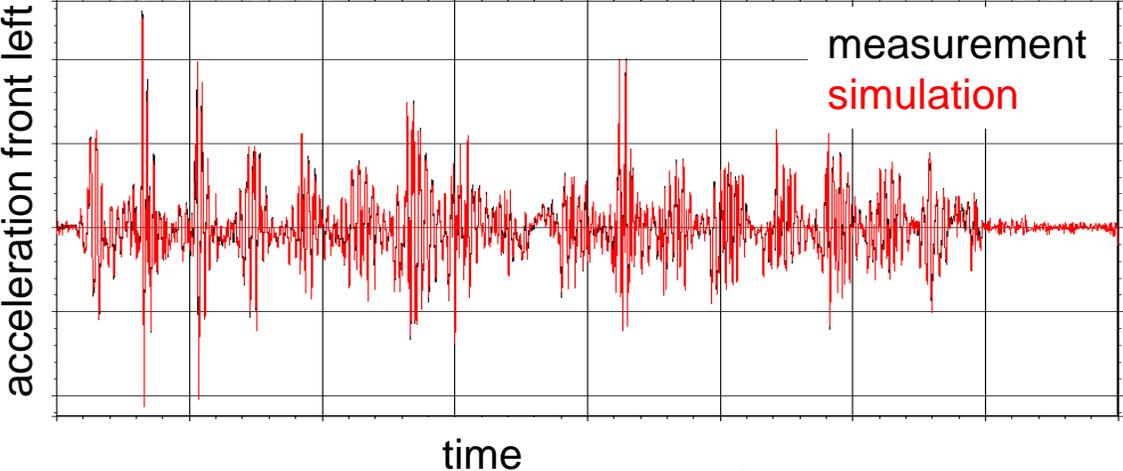
4. Drive signal



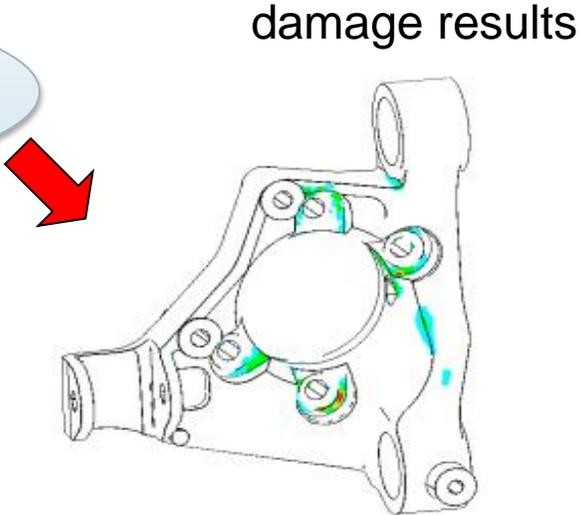
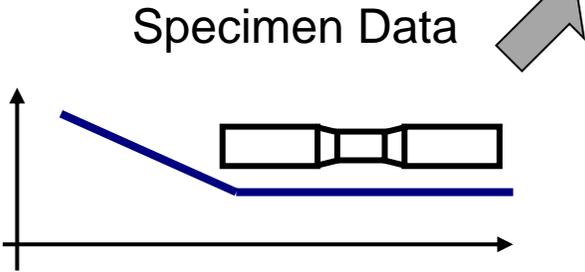
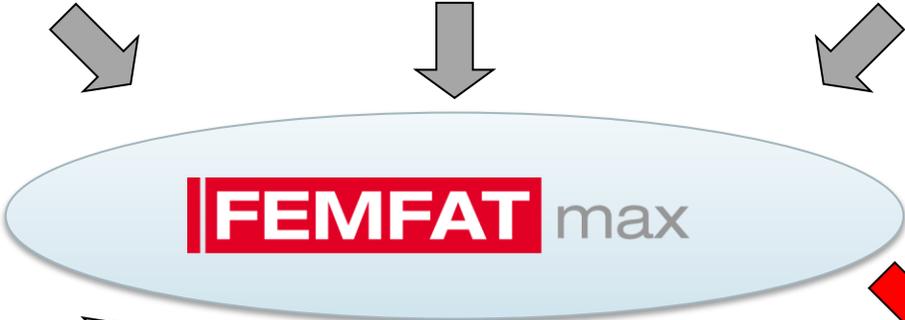
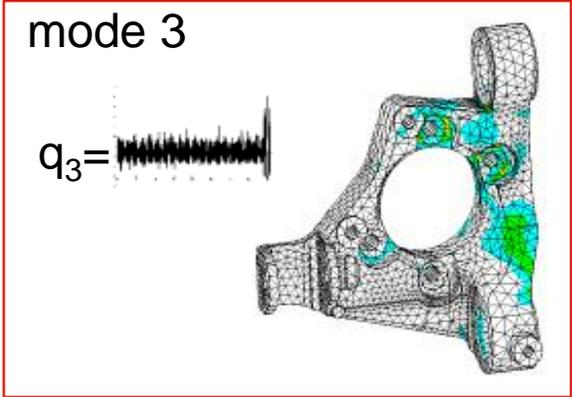
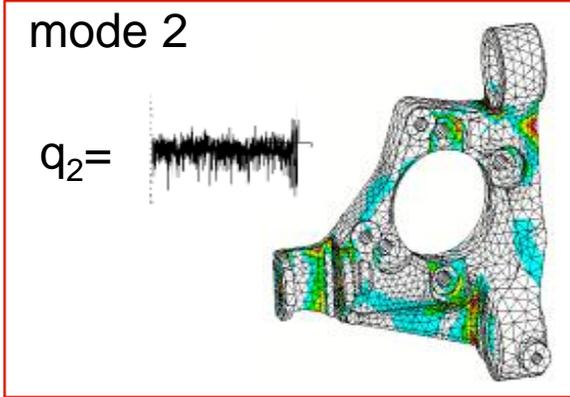
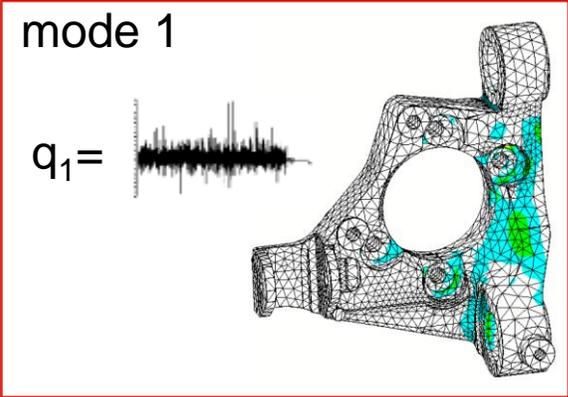
$$u_{n+1} = u_n + F^{-1} (y_{Desired} - y_n)$$



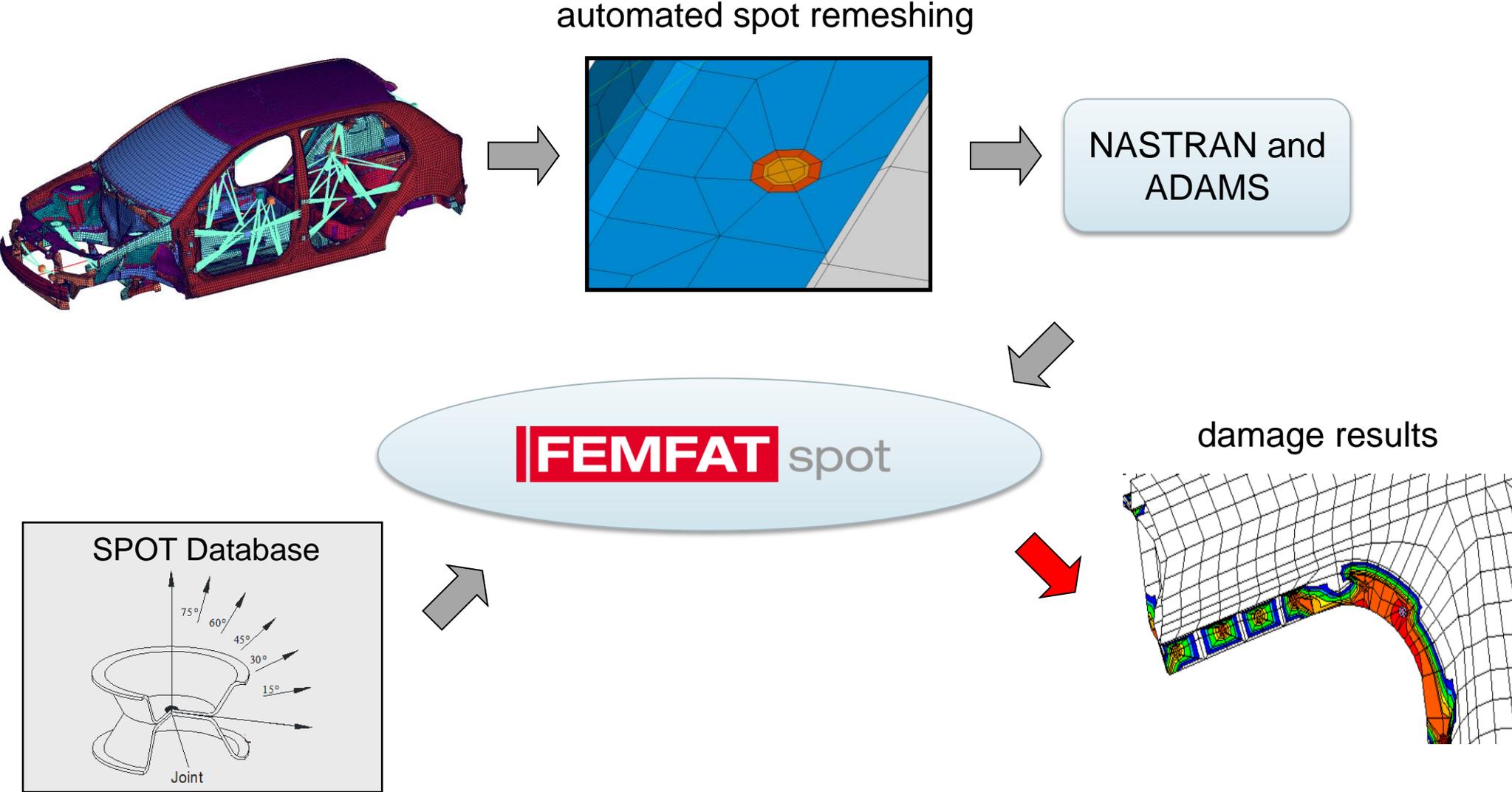
Result of virtual iteration after 11 iterations (rough road)



Durability Analysis – Flex Body Modes



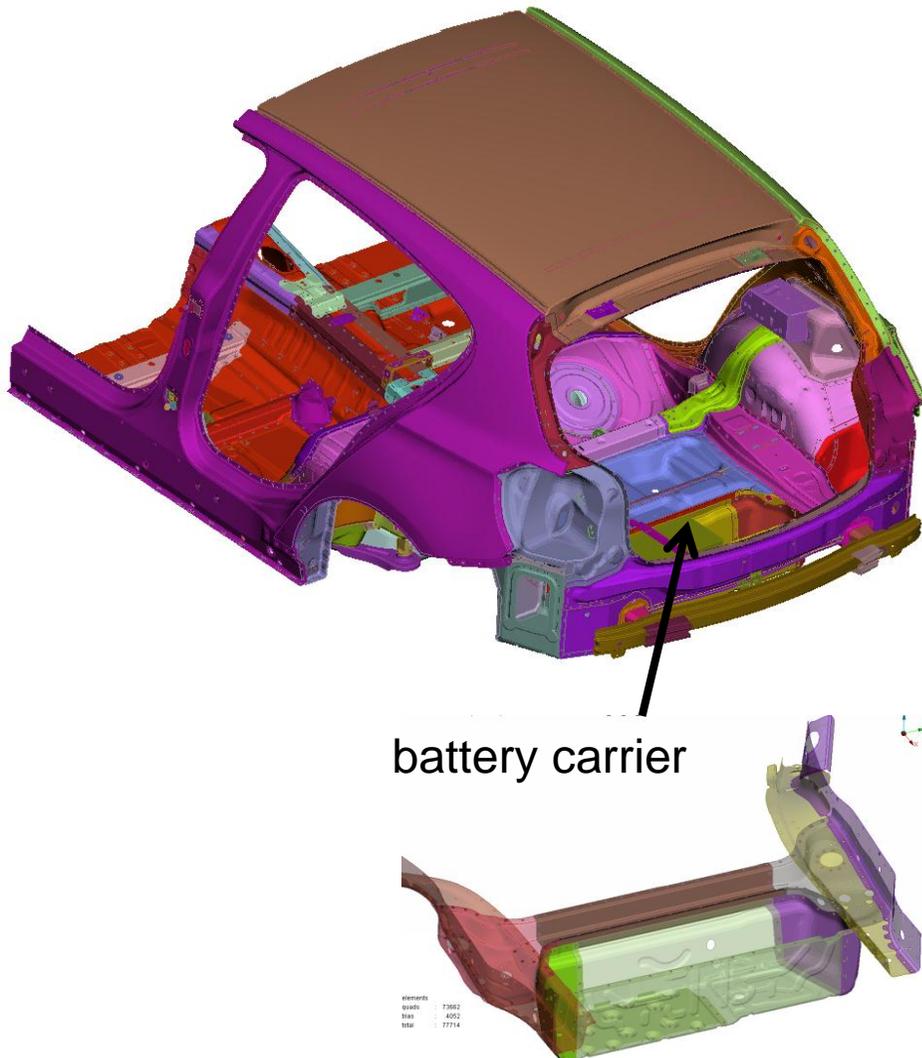
Durability Analysis – Spot Weld



Example

Virtual Test Rig – Durability of Battery Carrier

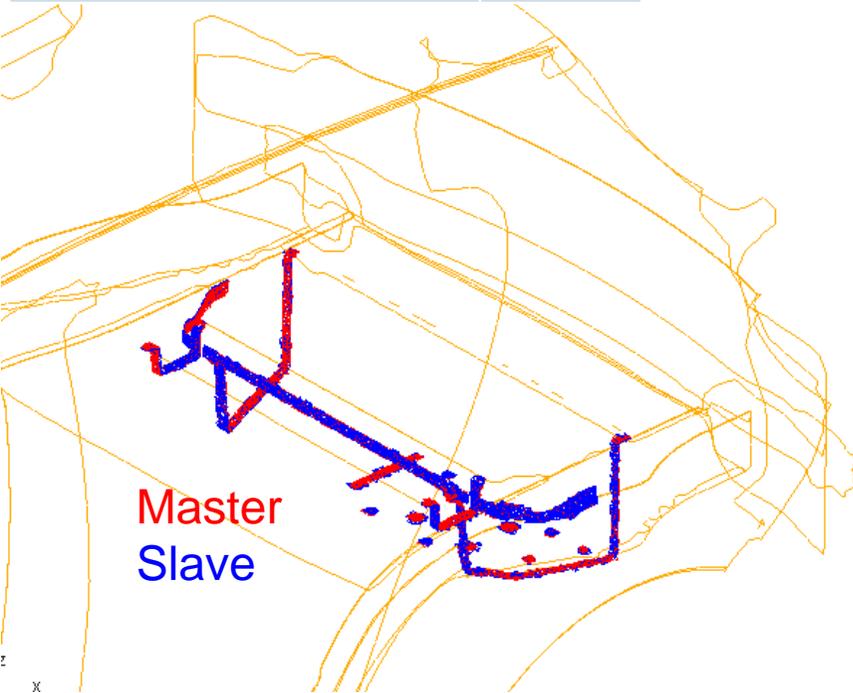
Virtual Test Rig – Durability of Battery Carrier



- Modeling
 - linear NASTRAN Model
 - Contact preprocessing with MAMBA
- Analyses
 - Loads from virtual iteration or pre-defined
 - Full dynamic MSC Adams analysis with contacts
 - Boundary conditions analogous to NASTRAN model
- Result
 - Damage of the spots in the area of the battery carrier
 - Damage of base material

Number of Modes

Constraint Modes	6
Normal Modes	110
Contact modes (JIM)	150



Preprocessing of flexible structure

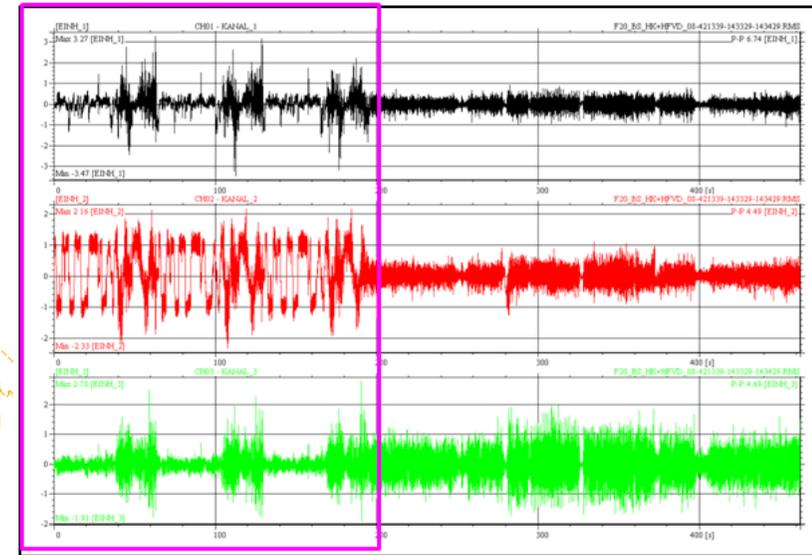
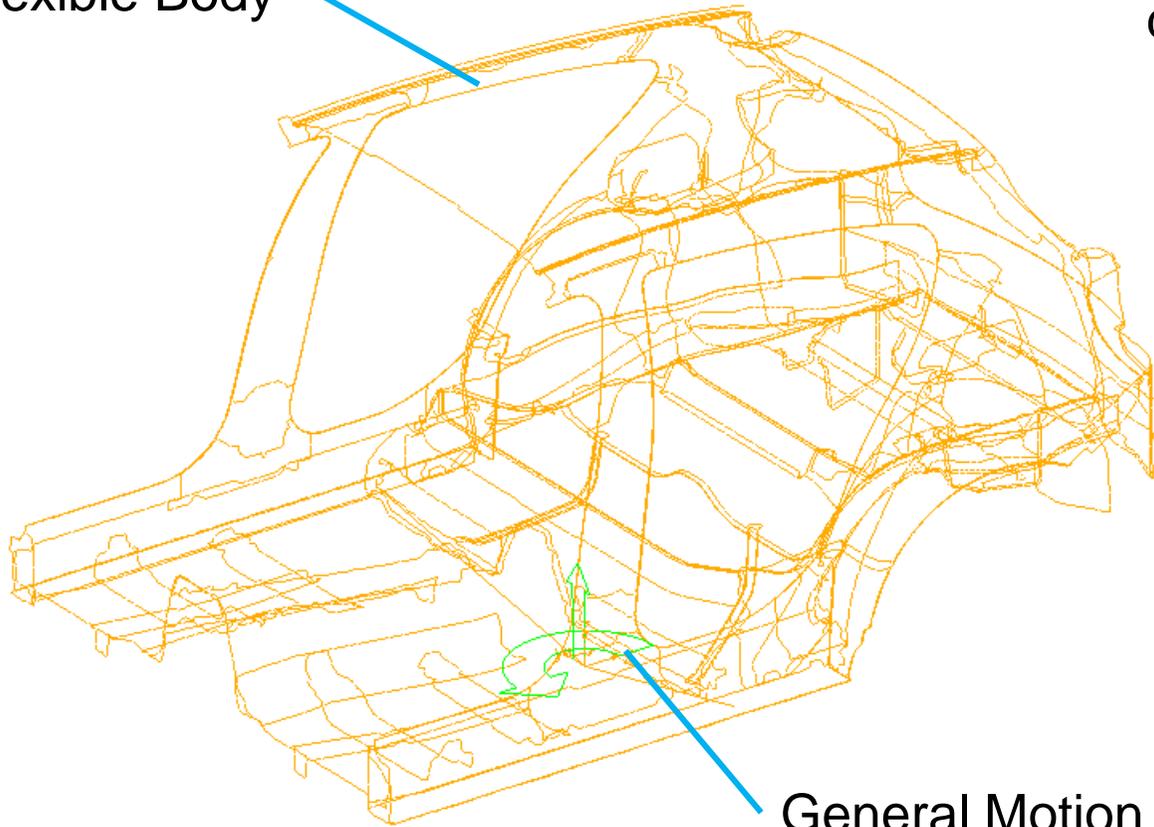
- Definition of PIDs for contact algorithm
 - Self-contact within PID
 - Contact between different PIDs
- Automated definition of contact zones with MAMBA preprocessor
- Clearance tolerance for finding contacts
- Export of contact as ADAMS shell file for visualization

Virtual Test Rig – Durability of Battery Carrier

load history

damaging interval

Flexible Body

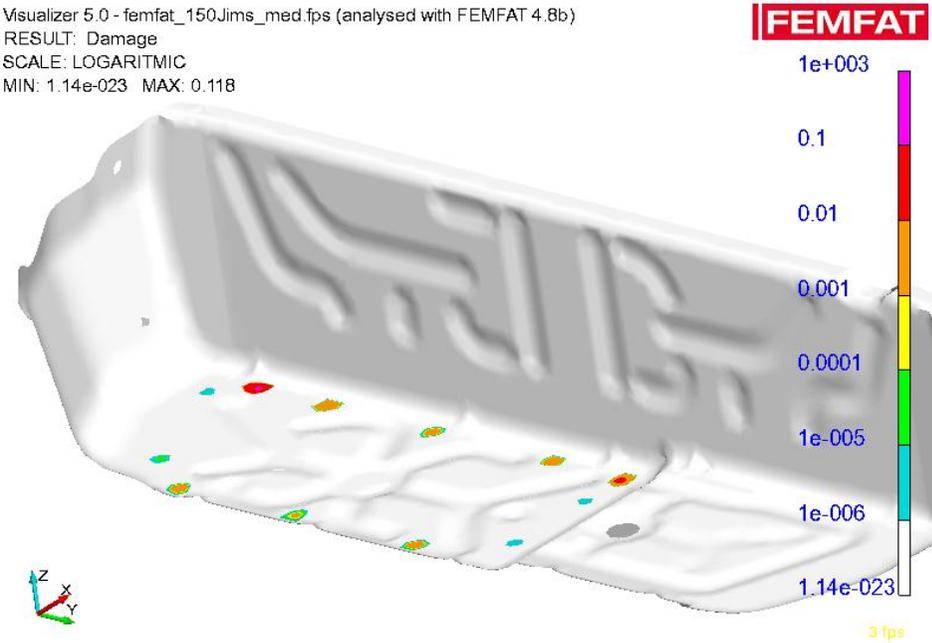


Virtual Test Rig – Durability of Battery Carrier

test rig - fracture at spots



simulation – comparable damage at spots



- Process applicable for wide range of vehicle components
- Investigation of virtual prototypes or test rig concepts
- Model for part of the vehicle to reproduce local dynamics
- ADAMS model verification and trimming by additional checking signals
- Nonlinear contact behavior of flexible structure considered
- Absolute fatigue life prediction possible
- NASTRAN and ADAMS are fully compatible with MAMBA and FEMFAT



The future is ours to make.