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11. LS-Dyna Forum 2012
October 9-10, 2012, Ulm, Germany

TEC|BENCH™ - Virtual Benchmarking:
Experiences in correlating simulation models
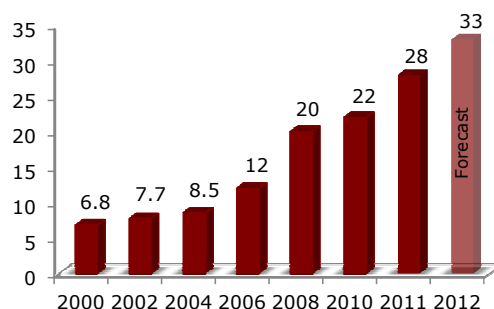
Martin H. Müller-Bechtel, TECOSIM GmbH

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TECOSIM

- **Company**

Solutions

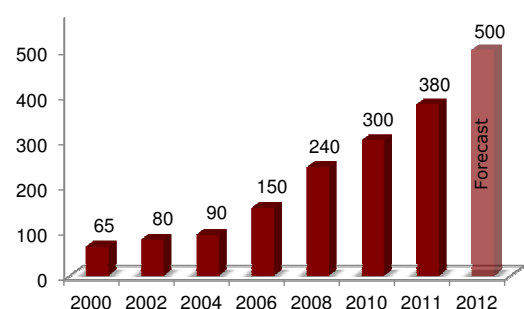## Facts & Figures

- Foundation: 1992
- Business Area: TECOSIM is Europe's largest CAE development partner with focus on Computer Aided Engineering – the computer-based development and optimization of components, structures and products
- Markets: Original Equipment Manufacturers (OEMs) and suppliers in following industries
  - automotive   - aerospace
  - chemical   - energy
  - railway   - medical   …
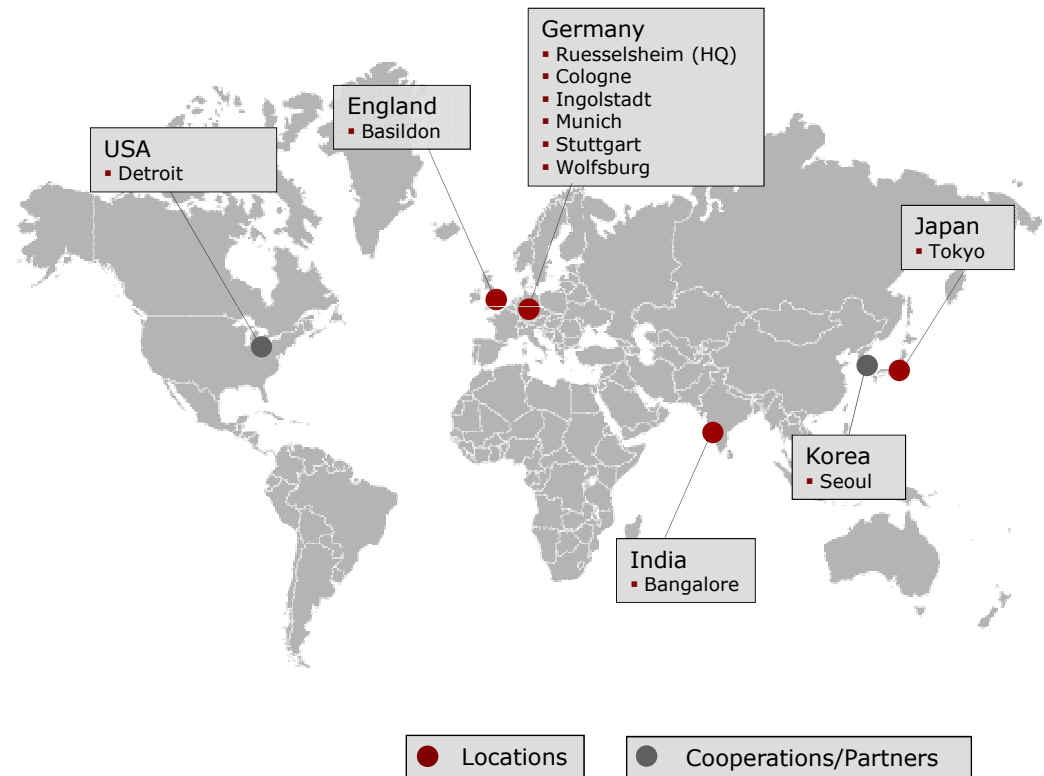- Vision: Global Leader in Computer Aided Engineering

Revenue (Mio. €)

Year	Revenue
2000	6.8
2002	7.7
2004	8.5
2006	12
2008	20
2010	22
2011	28
2012	33 (Forecast)

Employees

Year	Employees
2000	65
2002	80
2004	90
2006	150
2008	240
2010	300
2011	380
2012	500 (Forecast)

Locations

USA
- Detroit

England
- Basildon

Germany
- Ruesselsheim (HQ)
- Cologne
- Ingolstadt
- Munich
- Stuttgart
- Wolfsburg

Japan
- Tokyo

Korea
- Seoul

India
- Bangalore

● Locations   ● Cooperations/Partners

TEC|BENCH™ – better benchmarking by simulation

Competitor analysis	3D geometry	Virtual product development

Benchmarking	Scanning	CAE Simulation

▪ Hardware dismantling
▪ Bill of Materials BOM:
   Parts
   Thickness
   Joining technique
   Material
▪ Design analysis report:
   non common features
	▪ Photogrammetry
	▪ Field Digitizing:
	   Overall scan
	   Detail scan (parts)
	▪ Laser scanning
	▪ Computer tomography
		▪ Full vehicle/Body CAE
		   HS/LS-crash
		   Dynamics/NVH
		   Stability/Durability
		▪ Multi Body Systems
		▪ CFD/Aerodynamics

Testing	Reverse Engineering	Virtual Benchmarking

▪ Structural analysis:
   statics & dynamics
   crash testing
▪ Component testing
▪ Material analysis:
   Classification
   Testing
	▪ CAD data generation
	   based on STL data
		▪ Combines key competences
		▪ Simulation allows:
		   Performance evaluation
		   Better understanding
		   Flexible own studies

⇨ Correlation with test results is relevant indicator for model quality

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■ **Structural model**
Materials
Package model
Summary

Structural model – Data collection

Hardware benchmarking

- Dismantling of the vehicle structure down to part level
- Bill of materials (BOM)
- Single part documentation: part ID, name, material, weight, thickness
- Documentation of joining technique: spot welds, line welds, bolts, glue

3D Scanning

- Performed in parallel to dismantling of the vehicle structure
- Photogrammetry for reference positions of parts
- Field digitizing using projection of fringe patterns
- Result is tesselated facets (STL) comparable to DMU

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■ **Structural model**
Materials
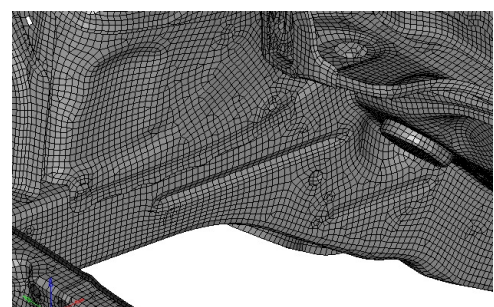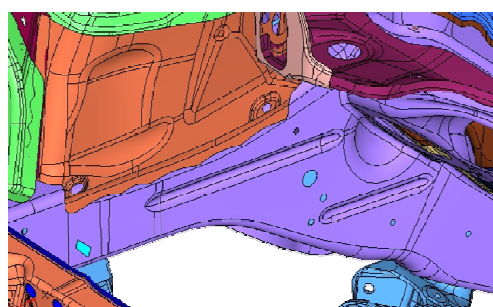**Package model**
Summary

Structural model – Data processing

Geometry preparation

- Creation of a CAD database for structural components
- Structured IGS geometry showing features necessary for FE
- Including manufacturing effects usually hoped to be negligible

TEC|ODM meshing

- Automated meshing of geometry by TEC|ODM batch meshing process
- Global mesh size 6 to 10mm with minimum length for crash 3 to 5mm
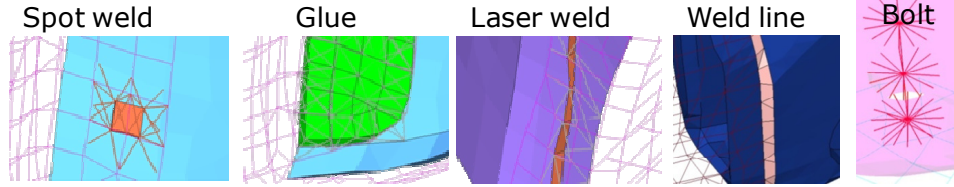- From our experience we did not found the need for strong mesh requirements

Structural model – Data processing

Model assembly

- State of the art modeling of joining technique (Nastran/Dyna)

Spot weld	Glue	Laser weld	Weld line	Bolt

Body in white structural model

- Modal analysis as check for elastic properties (example VW Golf)

Frequency (Test) [Hz]: 78.95, 73.29, 70.15, 67.68, 63.46, 62.91, 56.02, 48.88, 46.83, 42.92, 42.21, 33.20

MAC [-]: 0,000 – 1,000

Frequency (Simulation) [Hz]: 32.23, 43.06, 43.87, 46.25, 47.48, 56.44, 61.99, 64.04, 67.11, 69.10, 74.89, 77.14

## Materials – Characterization

Material classification

- Classification of steel types according to Vickers hardness
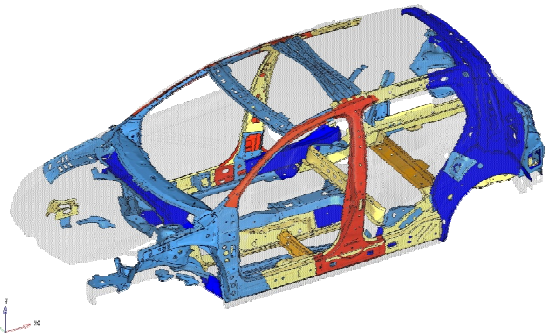
Tensile tests

- Tension test for specific representative parts
- Test specimen cut out of the parts of the vehicle
- Test of different parts shows material scatter
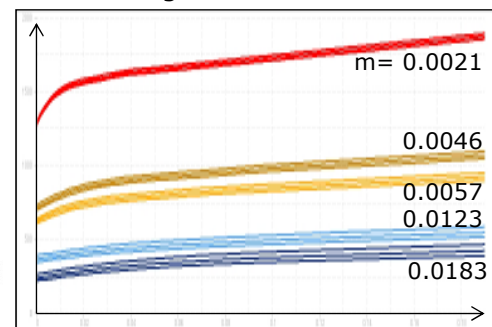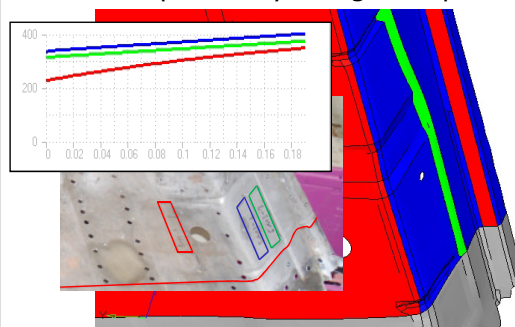- Test at different positions shows influence of manufacturing process

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Structural model
■ Materials
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Materials – Modeling
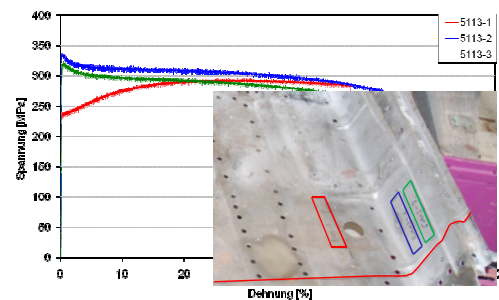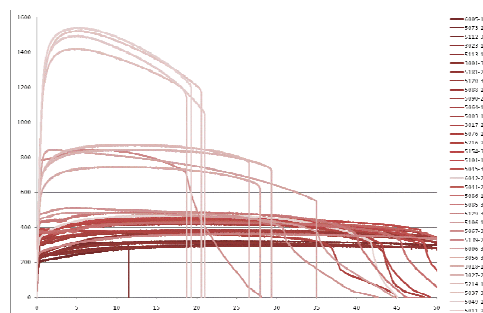
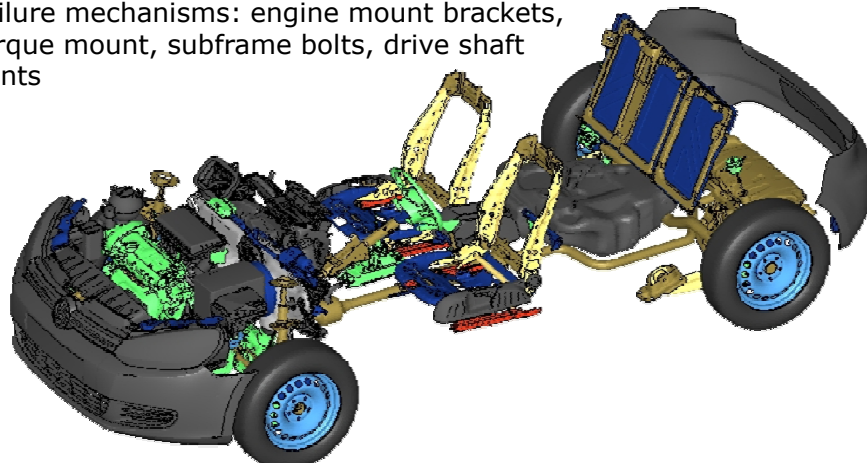### Earlier projects (2007)

- Yield curve of 'base' material
- Identification of scale factors considering work hardening and rate dependency
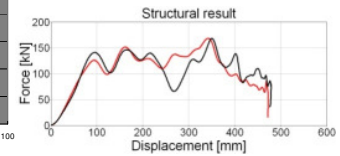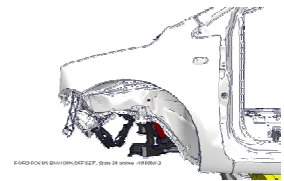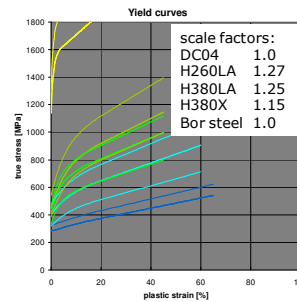
Today's method

- Identification of specific zone of work hardening
- Applying basic mapping procedure
- Rate dependency using m exponents decreasing with tension limit

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Structural model
Materials
■ Package model
Summary

Package model – Effects

Effects considered

- Engine block: rigid body
- Package components with realistic stiffness/material: chassis parts, structural parts like front end carrier, plastic parts
- Engine surrounding aggregates with realistic stiffness: water pump rigid, generator and exhaust system deformable
- Engine mount and chassis bushings with measured characteristics
- Failure mechanisms: engine mount brackets, torque mount, subframe bolts, drive shaft joints

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Summary

Package model – Results

Correlation of the simulation model

- The structural components define the global deformation behavior
- The package contributes in different load paths:
  - Wheel contact to barrier and to rocker influenced by bushing stiffness
  - Engine kinematics is influenced by failure of torque mount, failure of engine mount brackets, rupture of drive shaft joints
  - Resulting in realistic peak levels for differential contact to subframe or steering gear
- Failure levels are determined from simulation with parameter studies
- In summary the important effects can be modeled understandable

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■ Summary

Summary
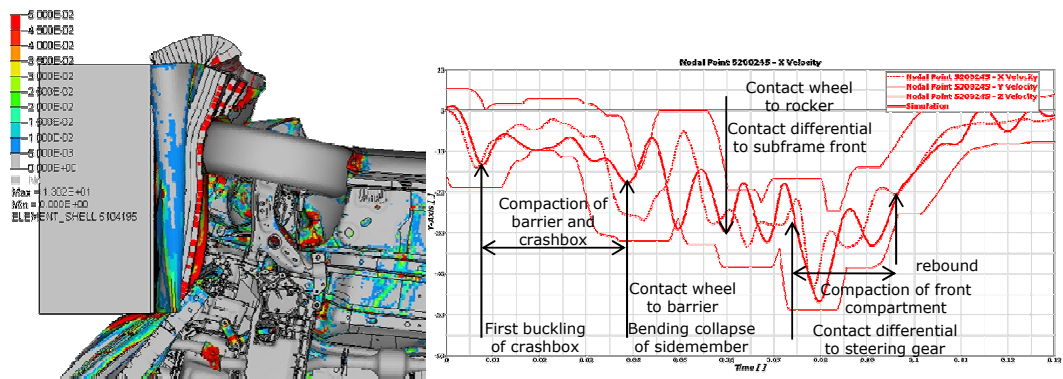
TEC|BENCH™

- combines methods of benchmarking, scanning, and reverse engineering for creating a full vehicle structural model purely from hardware

- suitable for crash application through comprehensive material and component studies

- makes directly available benchmarking information in virtual development environment

- allows for evaluation of structural behavior and a better understanding of the competitor product

- enables insight in structural concepts with a high flexibility for own studies

- is most cost-effective, custom-designed and outcome-driven solution for benchmarking

Your Contact

TECOSIM Technische Simulation GmbH
Dr.-Ing. Martin H. Müller-Bechtel
Technical Manager Virtual Benchmarking
Ferdinand-Stuttmann-Straße 15
D-65428 Rüsselsheim, Germany
Tel.: +49 (0) 6142 / 8272 230
Fax: +49 (0) 6142 / 8272 249
Mail: m.muellerb@de.tecosim.com