TECOSIM
best partner for simulation

General considerations for the influence of mesh density in LS Dyna

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Agenda

- Tecosim-best partner for simulation
- Introduction
- FE Experiments with varied parameters
- Analysis of Results/ Conclusion
- Automatic Meshing Pro’s and Con’s
- Summary

The Company

- Company Founded 1992
- Strategic CAE Partner of Major OEM‘s and Suppliers
- Turnover € 7,1 Mio in 2004
- Currently **75 Employees** at 5 European Locations
- State-of-the-Art IT Infrastructure
- Comprehensive liability insurance
- Quality Management System according to ISO 9001, UM 14001 and Customer Specific Requirements (FORD Q1 Award)
- Associated member of the FAT (Forschungsvereinigung Automobil Technik) research team for finite element coupling for crash calculation

Locations & References

Rüsselsheim

Köln

- Audi AG
- Adam OPEL AG
- Claas
- Daimler Chrysler
- Daihatsu
- Fiat
- FORD
- General Motors
- HONDA
- ISUZU
- KIA
- John Deere
- Jaguar
- Landrover
- Nissan
- PORSCHE AG
- Toyota

- AMG
- Autoliv
- Bayer AG
- Bentler
- Bertone
- Bosch/ Blaupunkt
- Degussa-Hüls AG
- Dynamit Nobel
- EADS
- Faurecia
- Getrag
- Hella KG
- Johnson Controls
- Karmann
- Lear
- Magna
- Thyssenkrupp
- TRW Automotive
- Mahle
- MAN
- Mannesmann/Sachs
- Siemens VDO
- Wagon Automotive

Leonberg

Basildon (UK)

Coventry (UK)

Igenie Office Tokio (Japan)

The Company - Hard- & Software

TECOSIM

- State-of-the-Art scalable NEC MPP Linux cluster (64 CPU) with short Turnaround Time for Full Car Crash Analysis
- 64 bit Numbercruncher (Itanium/Opteron) for Implicit codes
- Branches Interlinked by 2 Mbit Leased Lines
- ENX Access
- Major CAE and CAD Systems
- Development of Methods, Routines and Templates

Explicit Codes
- LS-Dyna
- PAMCrash/PAMSafe
- Radioss
- Abaqus explicit

Implicit Codes
- Nastran, Abaqus
- Ansys, Mechanica

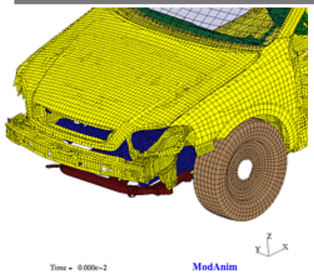
CFD Code
- StarCD

Pre-/Postprocessor
- Ansa
- HyperWorks
- Animator
- Sofy
- Medina
- Patran

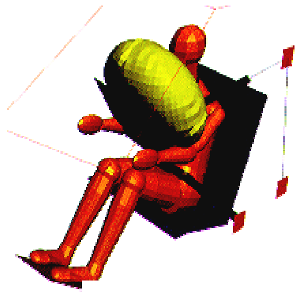
Optimisation
- OptiStruct
- HyperOpt
- HyperStudy
- I- Sight

MKS Codes
- Madymo
- Adams
- Motion solve

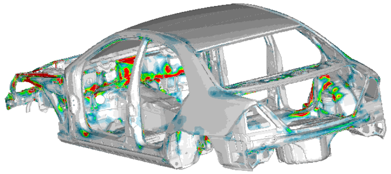
CAE Portfolio



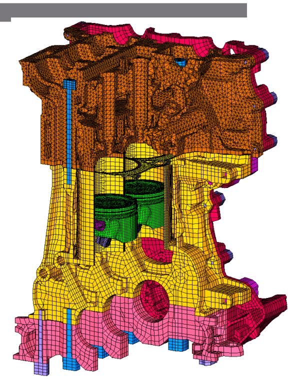
CRASH



Safety



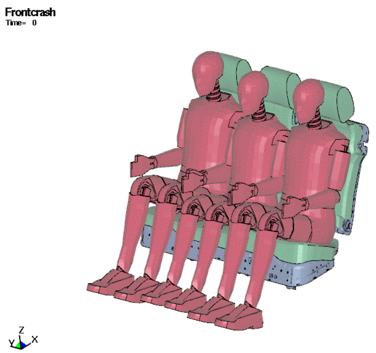
NVH / Durability



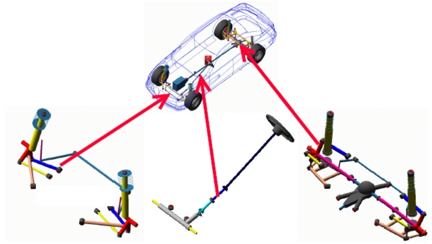
Powertrain

9. Optimization

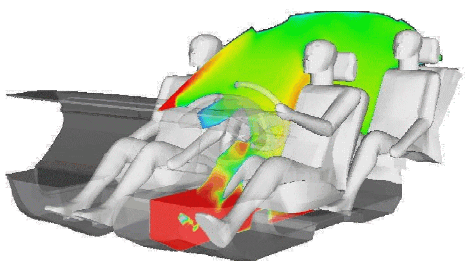
- Linear Parameter Optimization
- Non- Linear Parameter Optimization
- Design Optimization



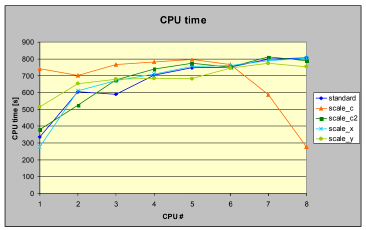
Seats



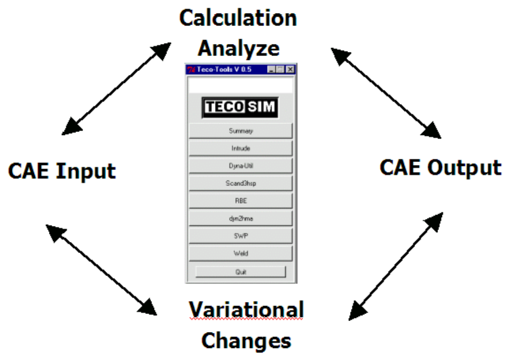
Multi Body Systems (MBS)



CFD



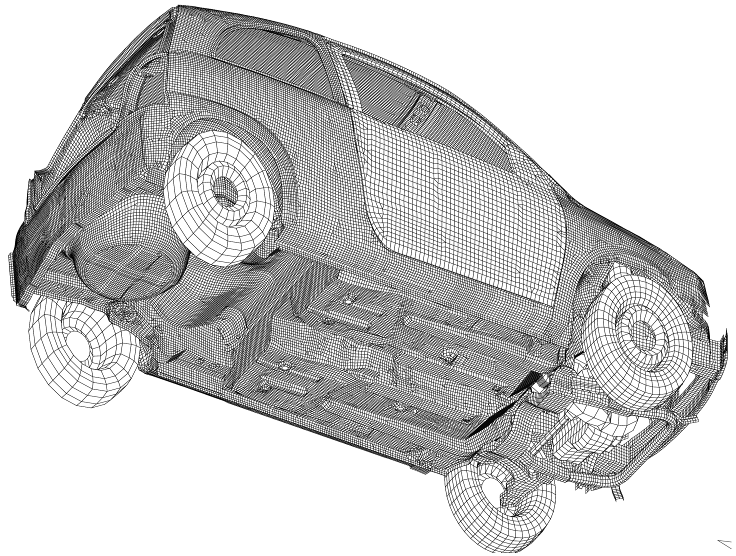
Optimization



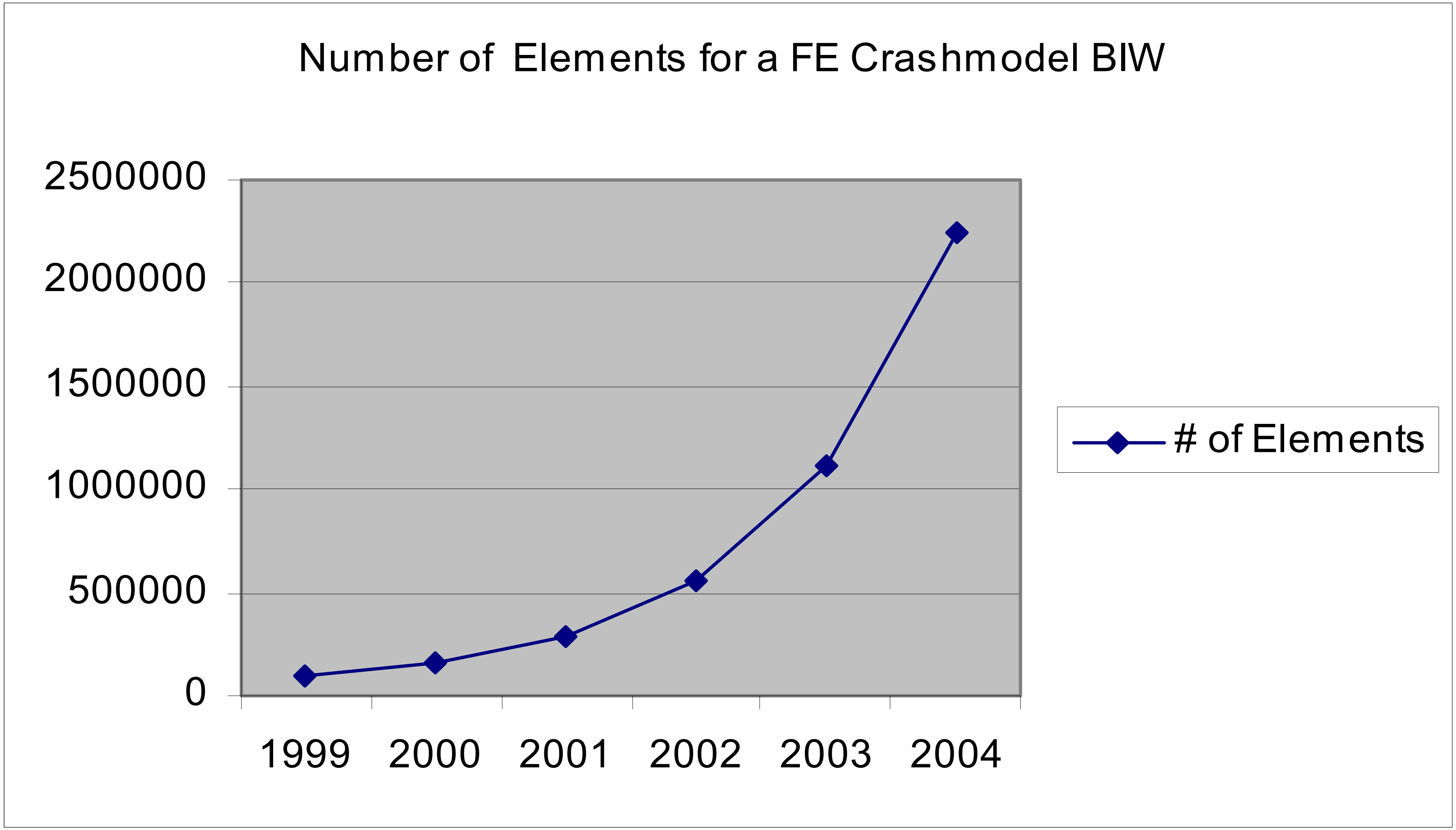
Software dev

Any sufficiently advanced technology is indistinguishable from magic.

„Profiles of the future" (1961) by Arthur C. Clarke (2003)

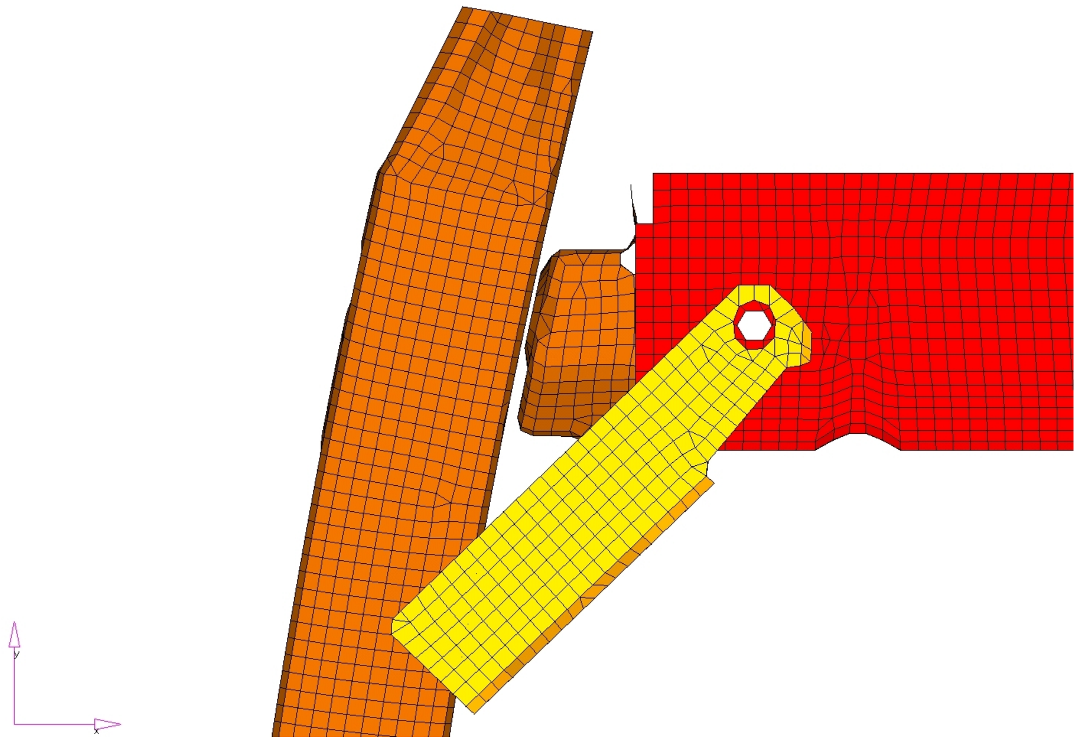


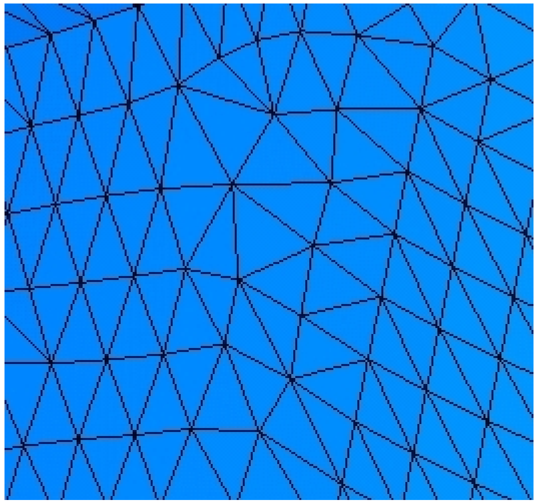
- Why do we simulate?
- Cost effective
- Fast
- Proven method
- *We cannot test!*

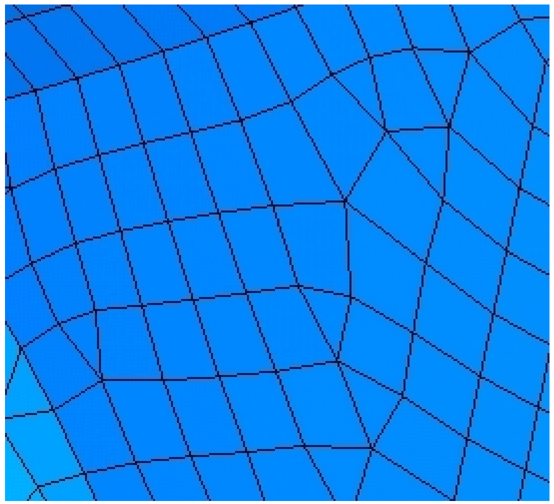

Number of Elements for a FE Crashmodel BIW
2500000
2000000
1500000
1000000
500000
0
1999
2000
2001
2002
2003
2004
# of Elements

Introduction

- How should a mesh look like?







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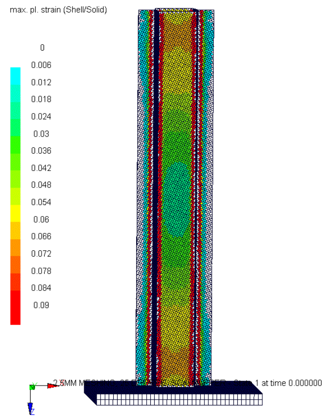
Simple box crash experiment:



Box section 50 mm x 80 x 500mm, t= 1.0mm, mild steel

Varied parameters:

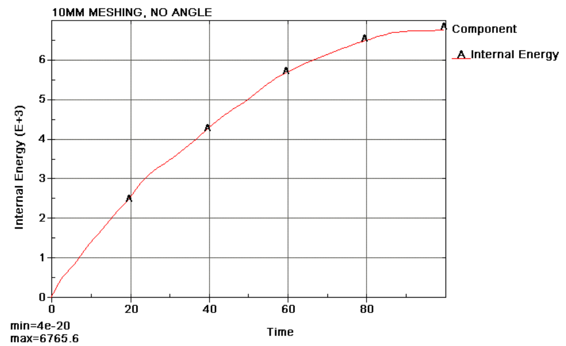
- average edge length 15/10/5/2,5mm
- mesh orientation 0deg/ 25deg
- different mesh/ integration method: Belytschko-Tsay/ Fully Integration
- Varied number of spotwelds
- With and without mapping or stamping data
- Renumbering and move in space

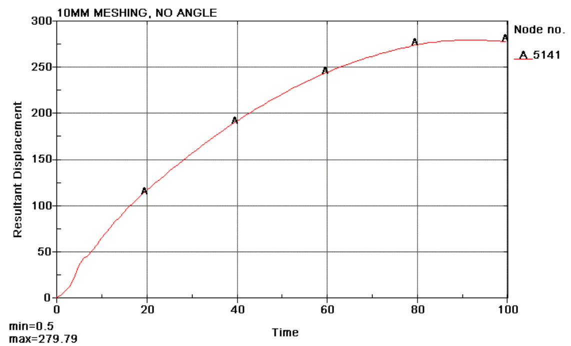
Objective:

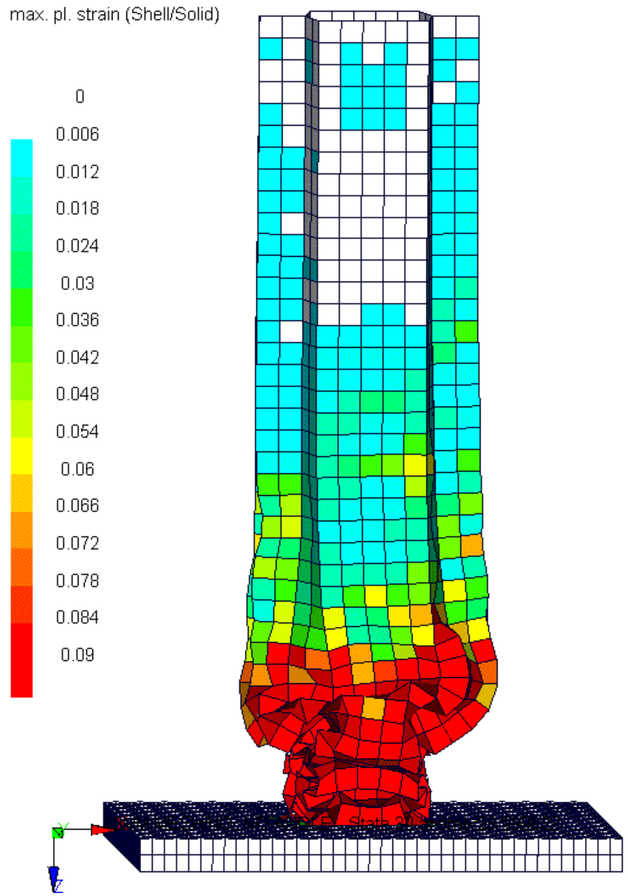
- Is the result depending on the element length?
- Is the result depending on the element orientation?
- How does mapping influence/stabalise the results?
- How do small changes in the input influence the results?

analysis: defomation plots

v10_1: 10mm mesh, 0deg
max internal energy 6766Nmm
max displacement 278mm







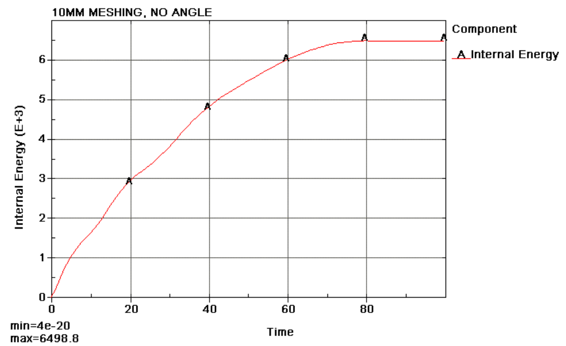
TECOSIM

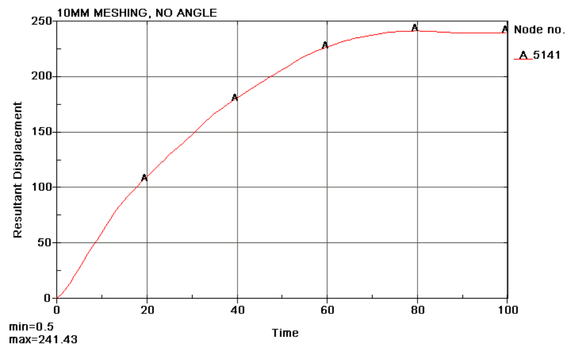
analysis: defomation plots

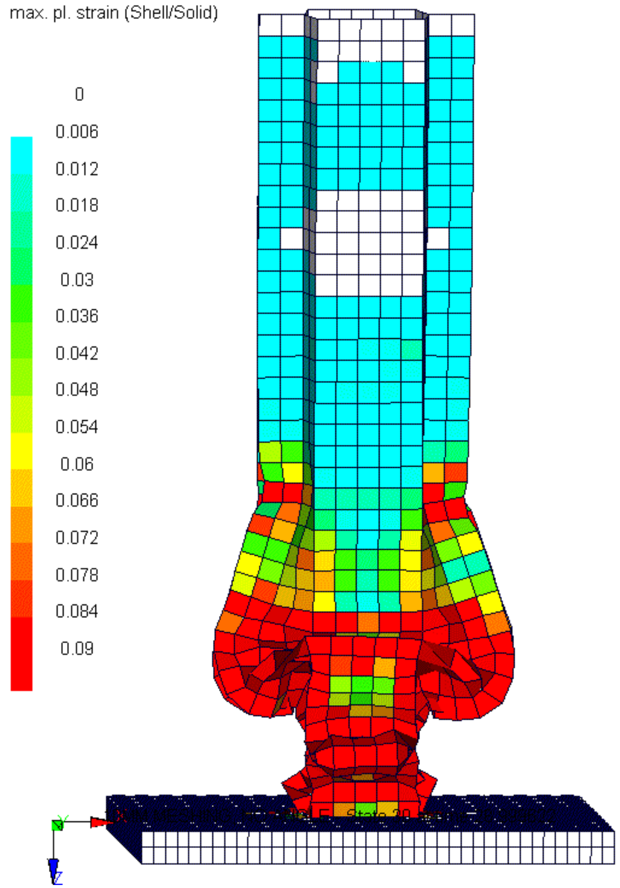
V10_1n: 10mm mesh, 0 deg, full integration

max internal energy 6499Nmm

max displacement 241mm





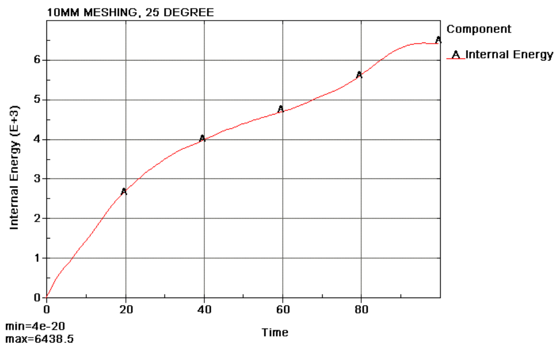


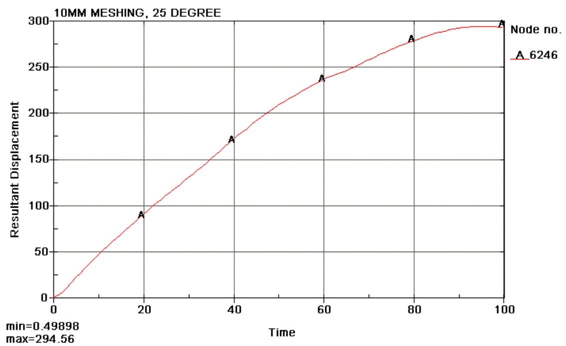
analysis: defomation plots

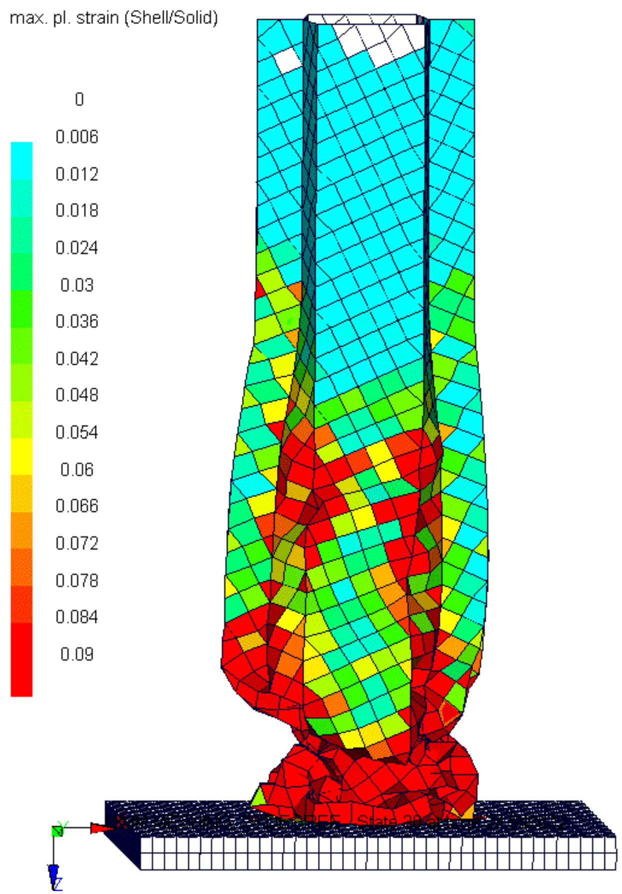
v10_2: 10mm mesh, 25deg

max internal energy 6439Nmm

max displacement 295mm





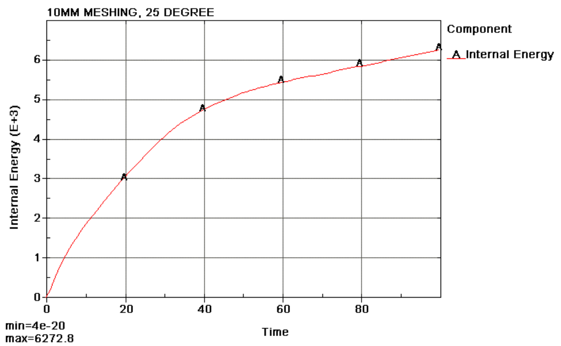


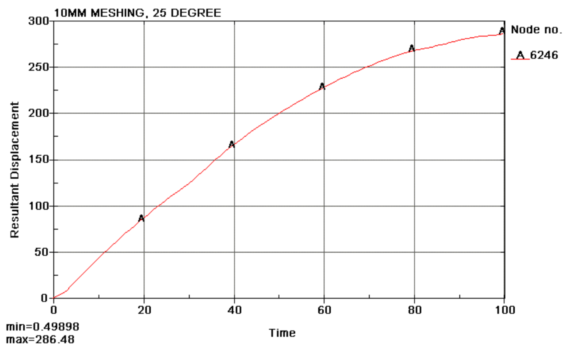
analysis: defomation plots

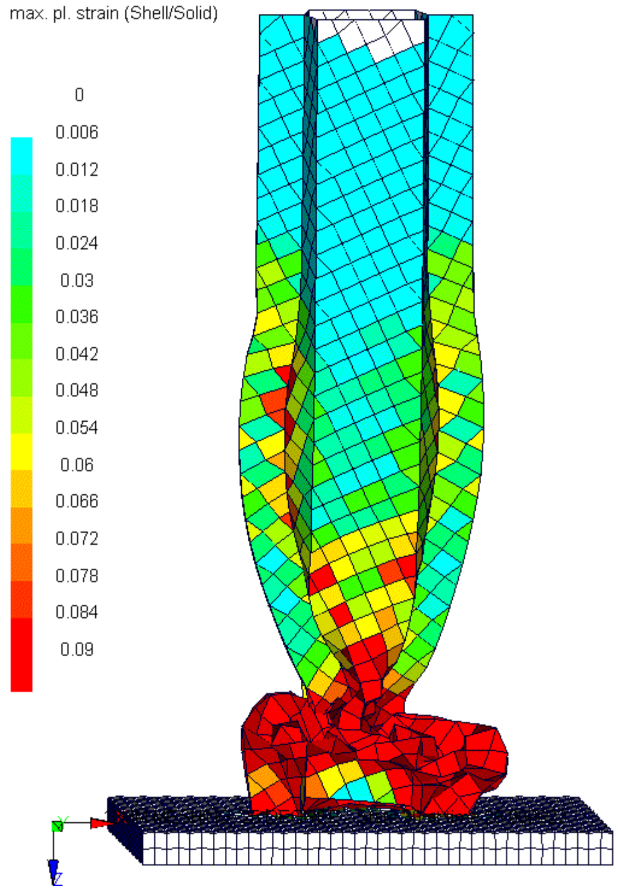
V10_2n: 10mm mesh, 25 deg, full integration

max internal energy 6272Nmm

max displacement 286mm





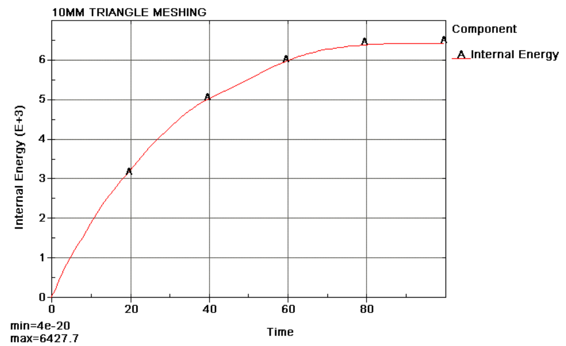


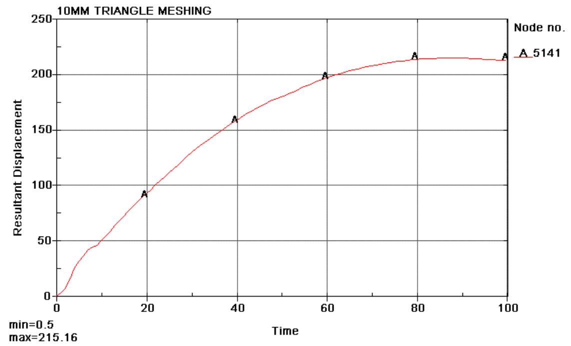
analysis: defomation plots

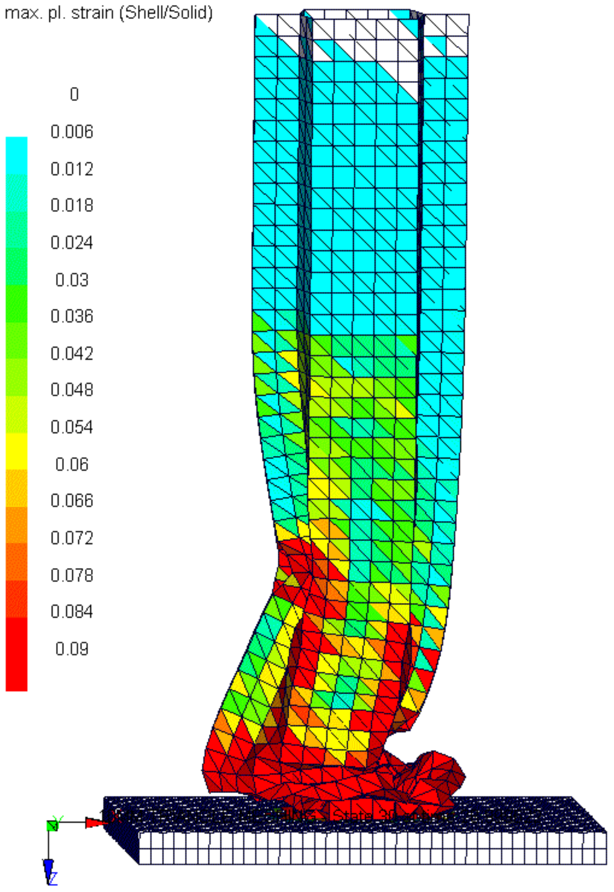
v10_3: 10mm triangle mesh

max internal energy 6428Nmm

max displacement 215mm





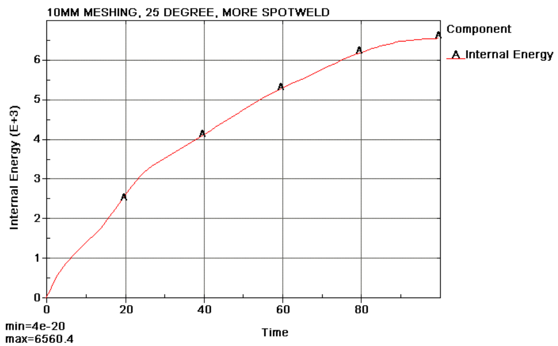


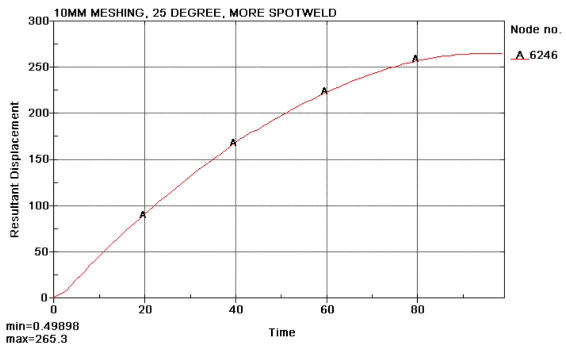
analysis: defomation plots

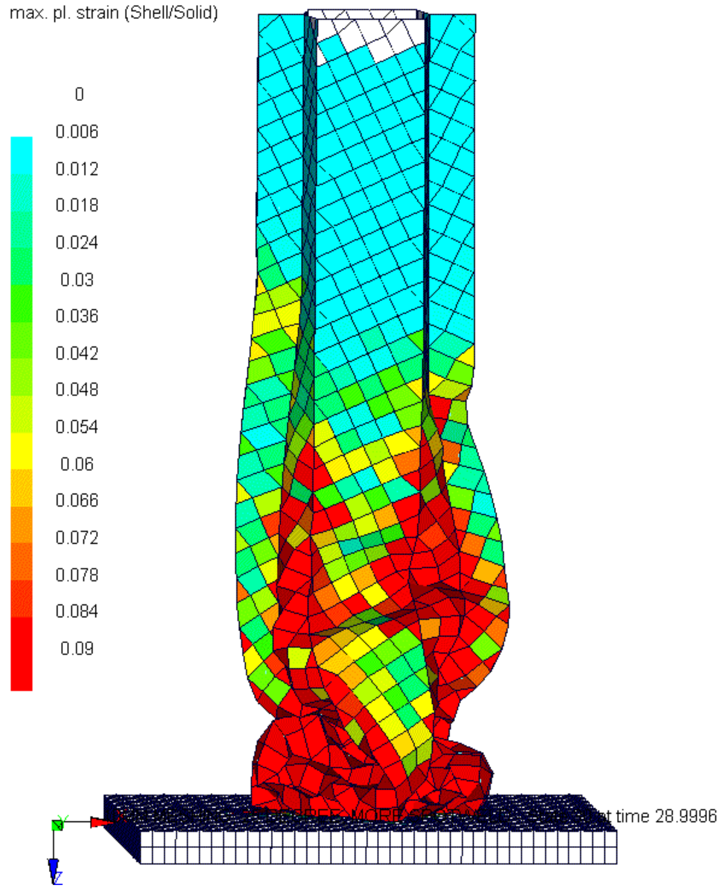
v10_4: 10mm mesh, 25deg, more spotweld

max internal energy 6560Nmm

max displacement 265mm





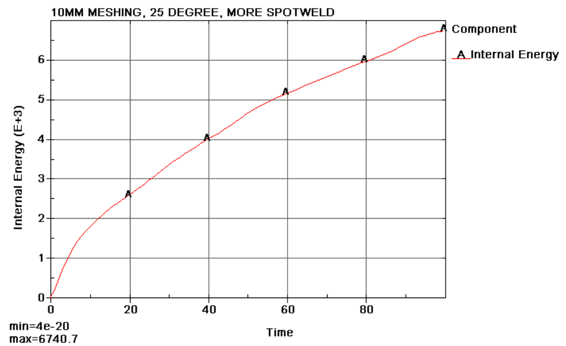


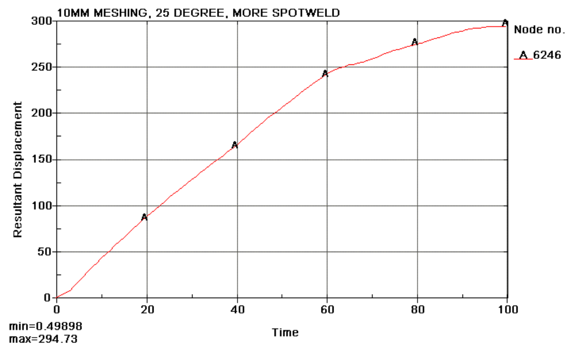
analysis: defomation plots

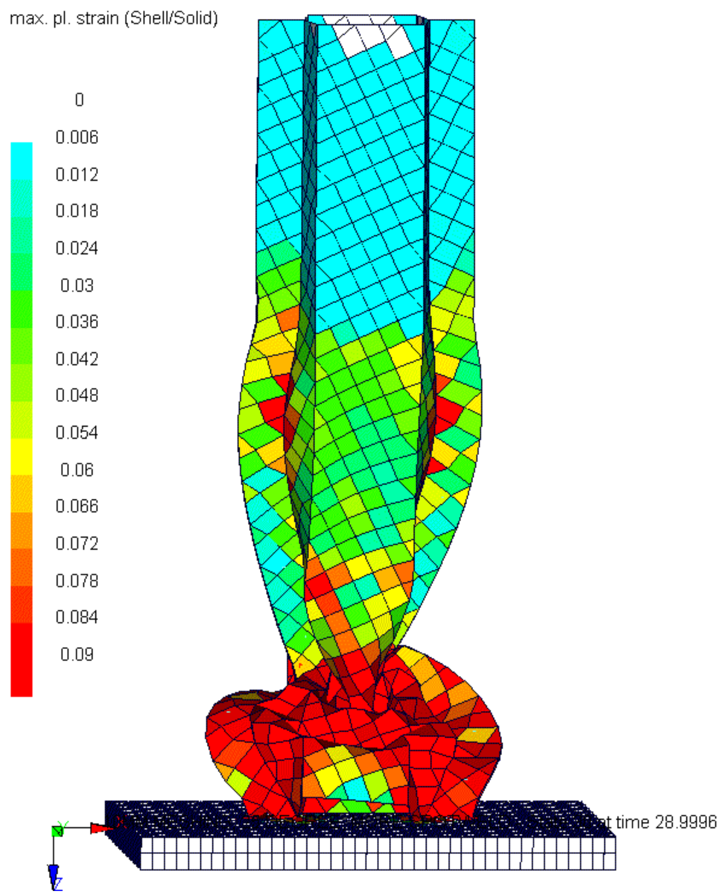
V10_4n: 10mm mesh, 25 deg, more spotweld, full integration

max internal energy 6741Nmm

max displacement 295mm





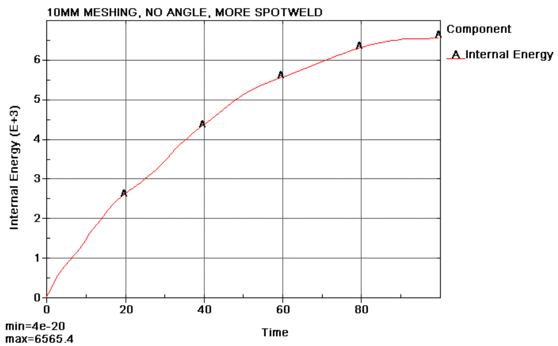


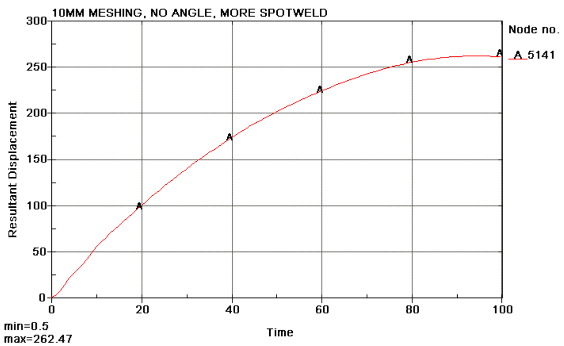
analysis: defomation plots

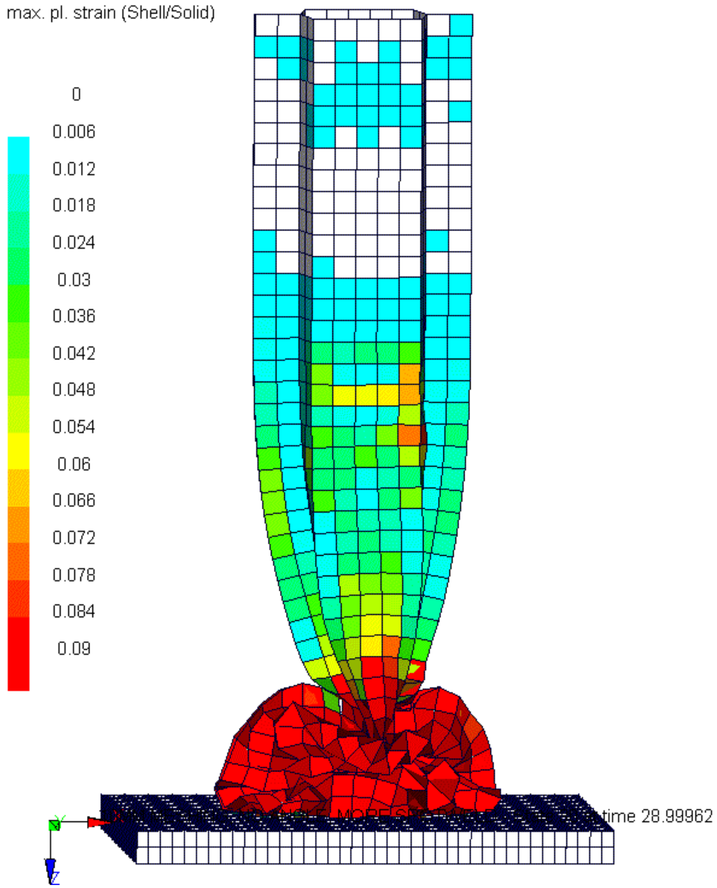
v10_5: 10mm mesh, 0 deg, more spotweld

max internal energy 6565Nmm

max displacement 262mm





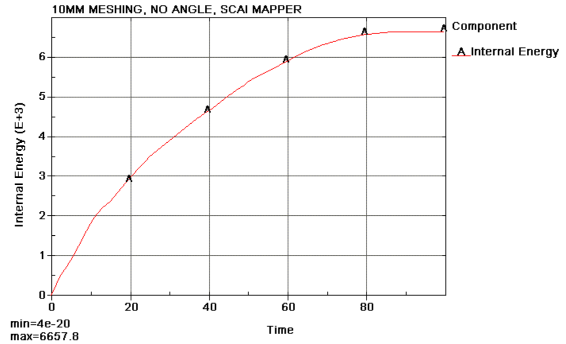


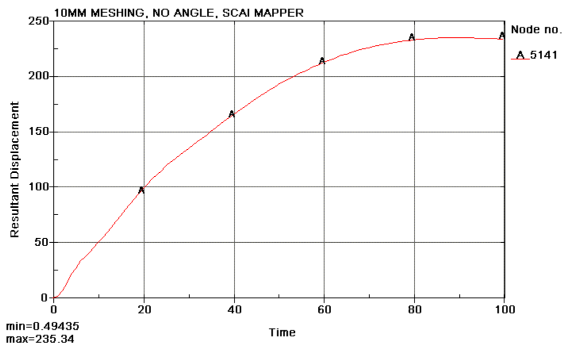
analysis: defomation plots

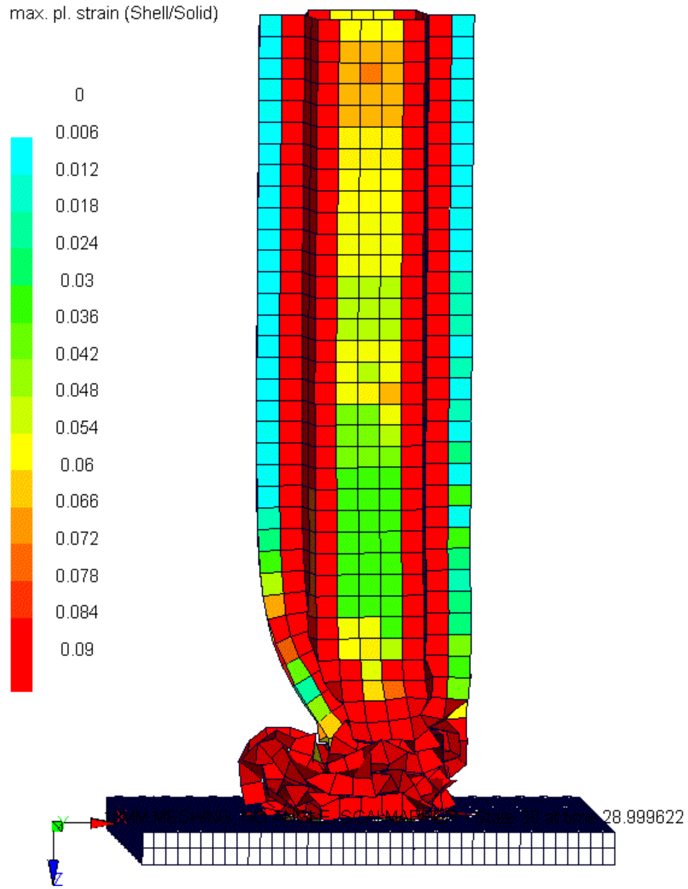
v10_6: 10mm mesh, 0deg mapped stamping data MpCCI

max internal energy 6658Nmm

max displacement 235mm





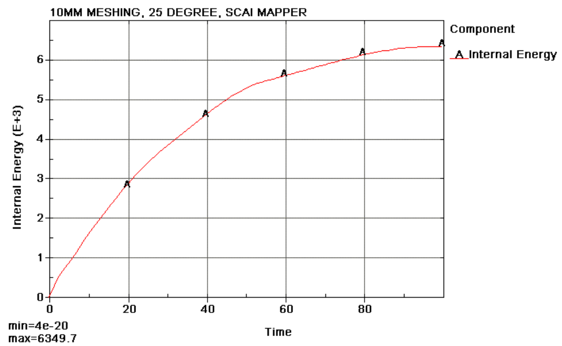


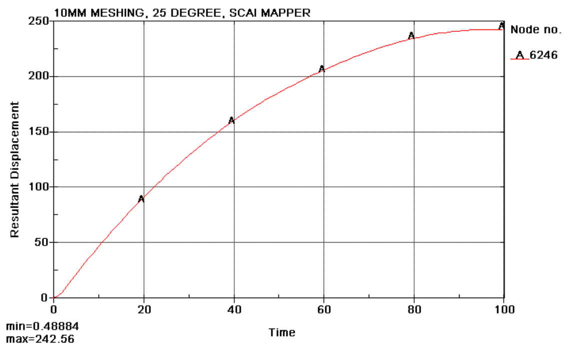
analysis: defomation plots

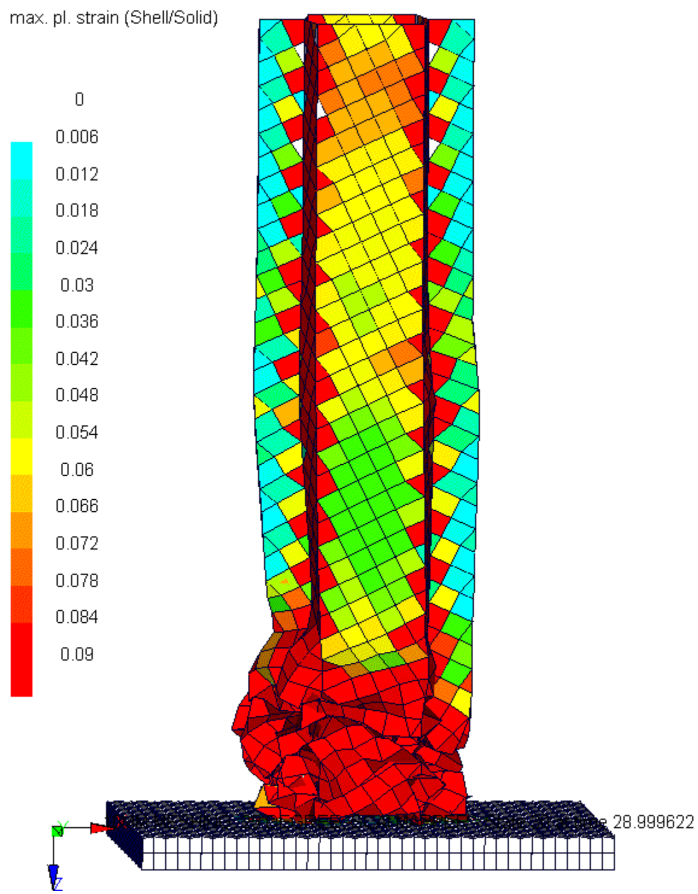
v10_7: 10mm mesh, 25deg mapped stamping data MpCCI

max internal energy 6350Nmm

max displacement 243mm





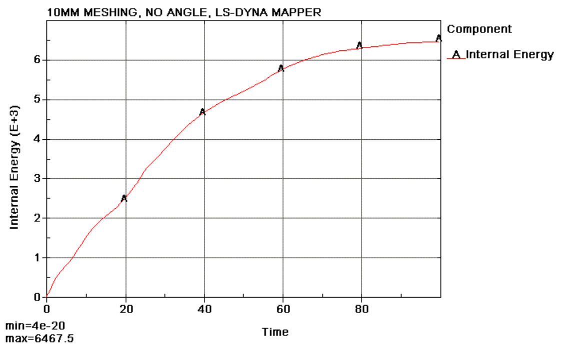


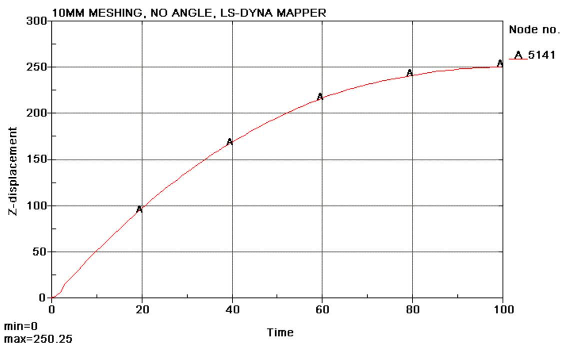
analysis: defomation plots

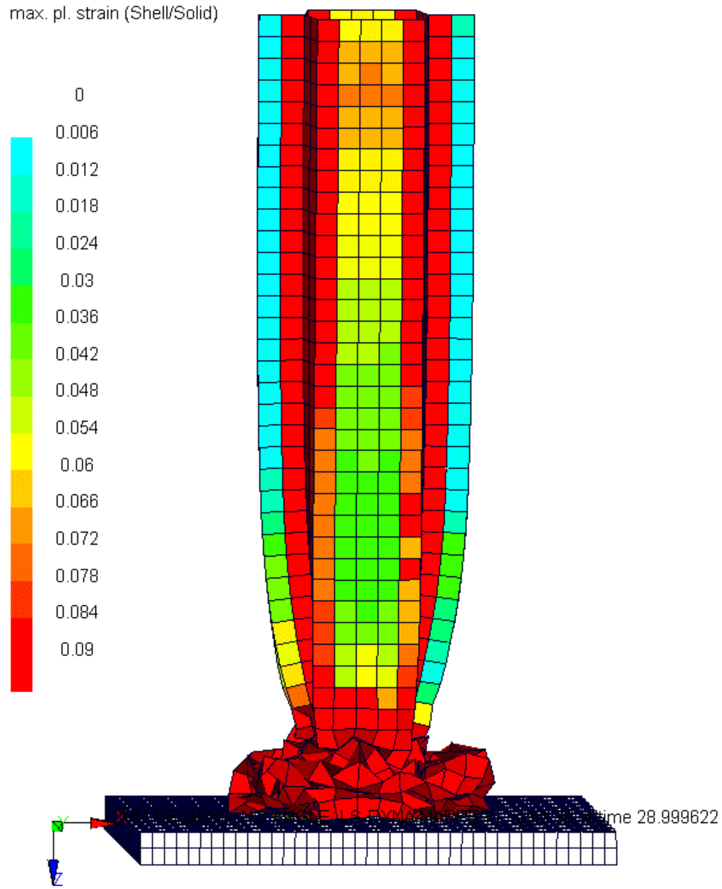
v10_6n: 10mm mesh, 0deg mapped stamping data DYNAIN

max internal energy 6468Nmm

max displacement 250mm







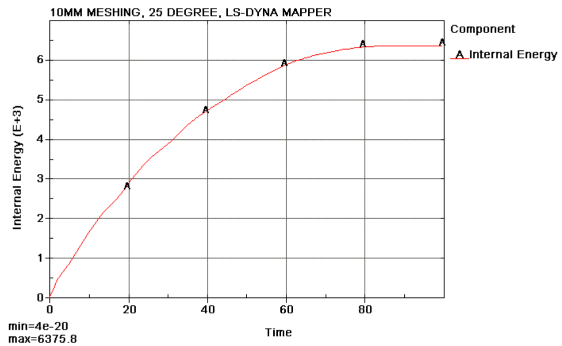
FE Experiments with varied parameters

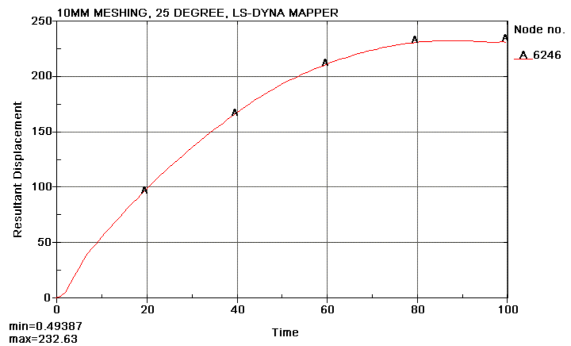
analysis: defomation plots

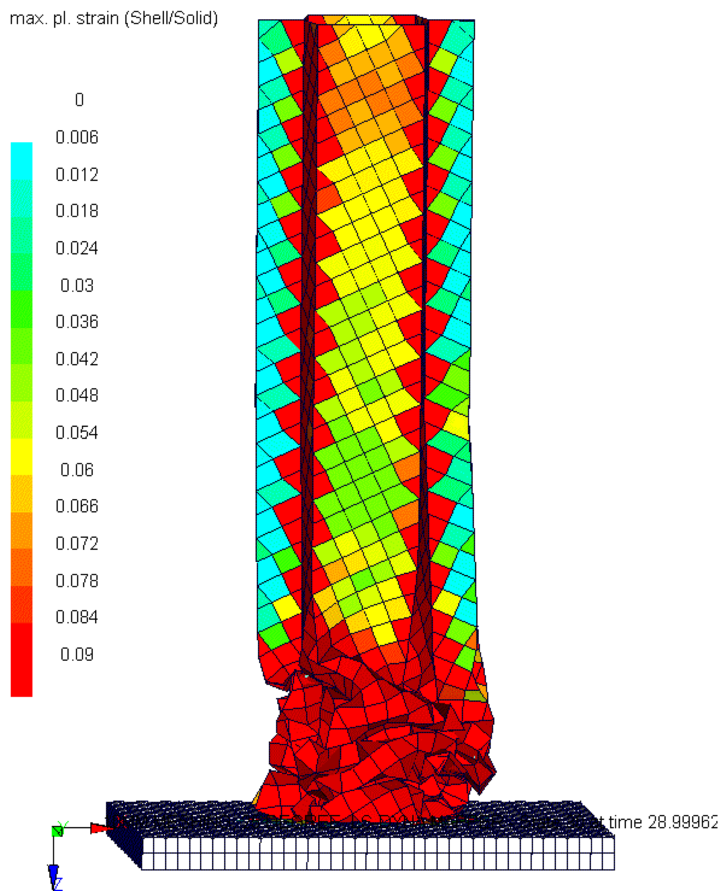
v10_7n: 10mm mesh, 25deg mapped stamping data DYNAIN

max internal energy 6376Nmm

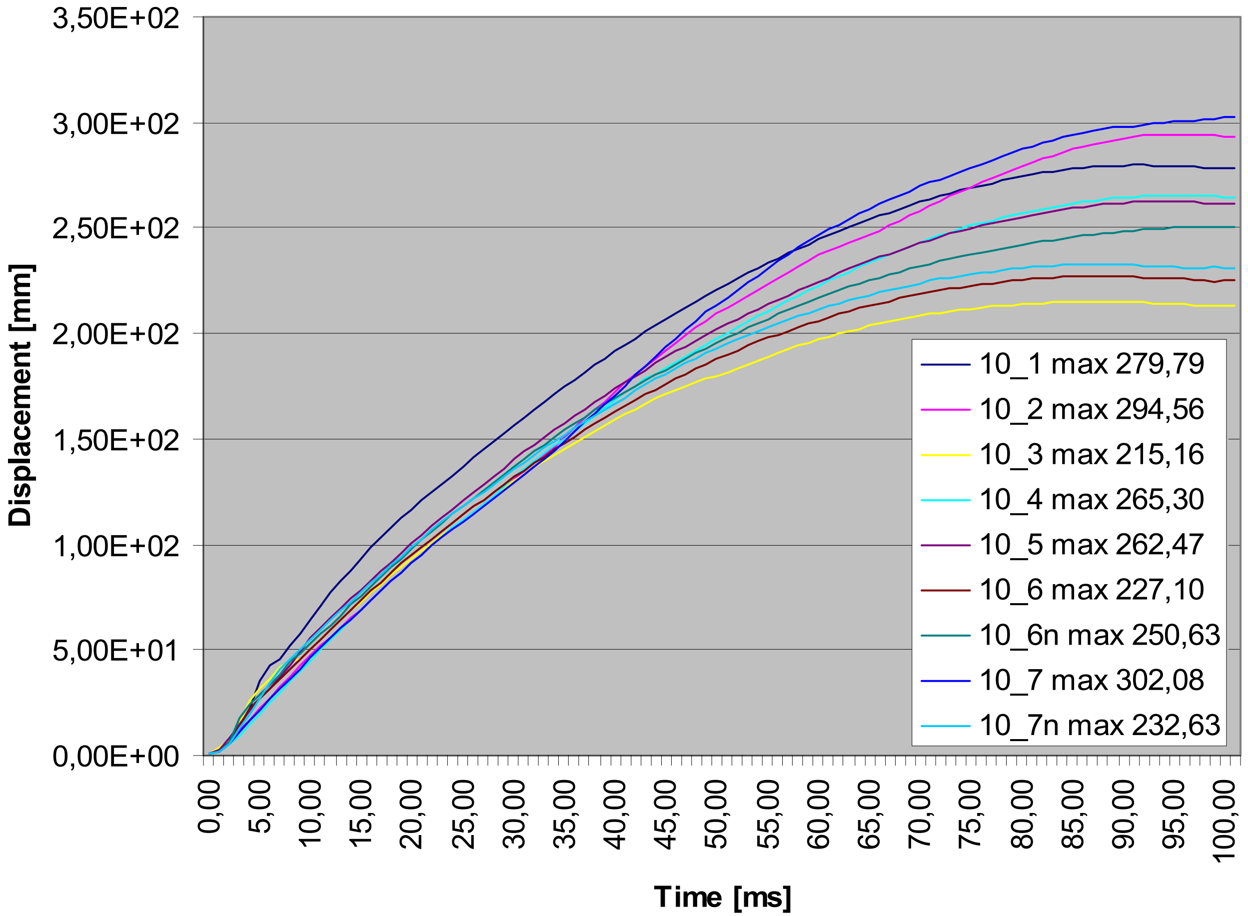
max displacement 233mm



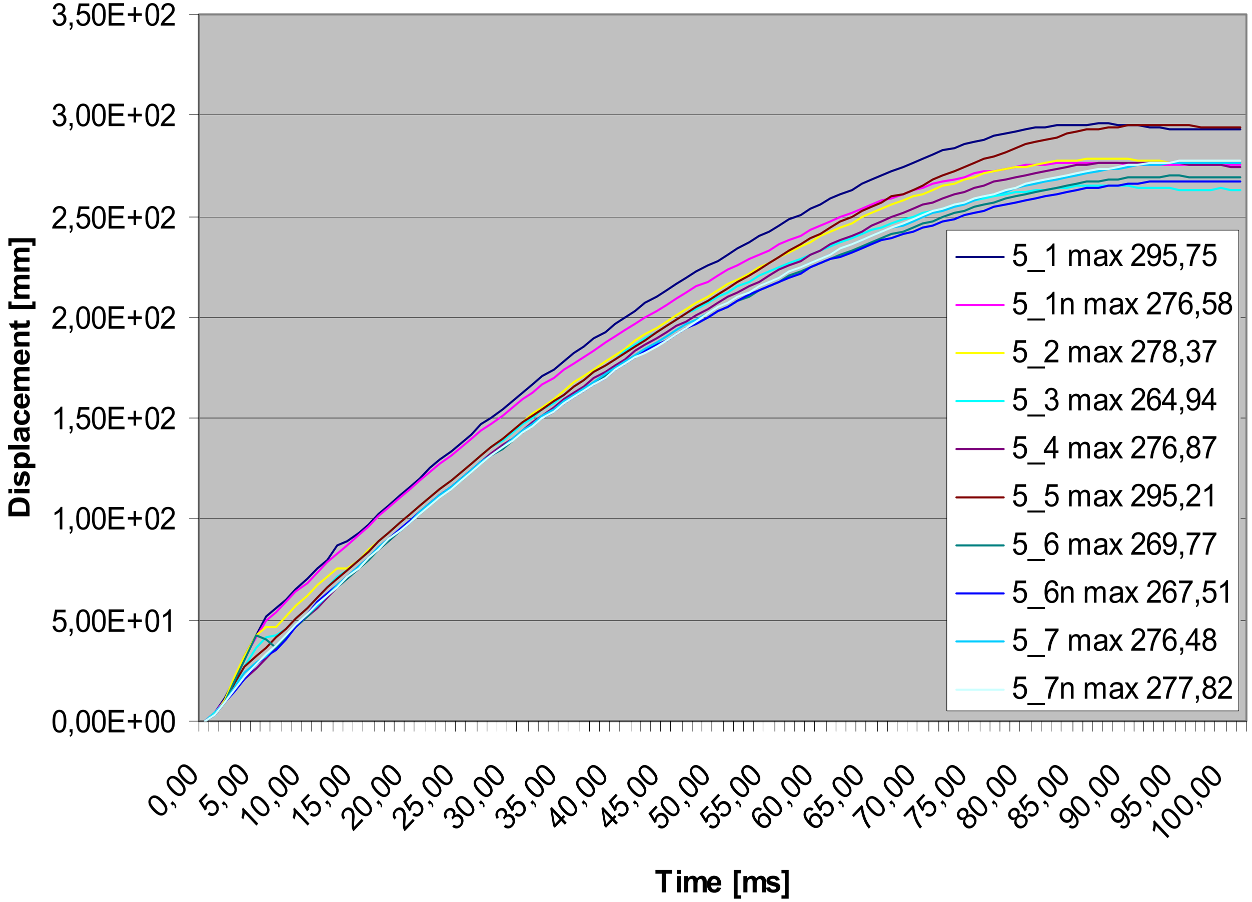




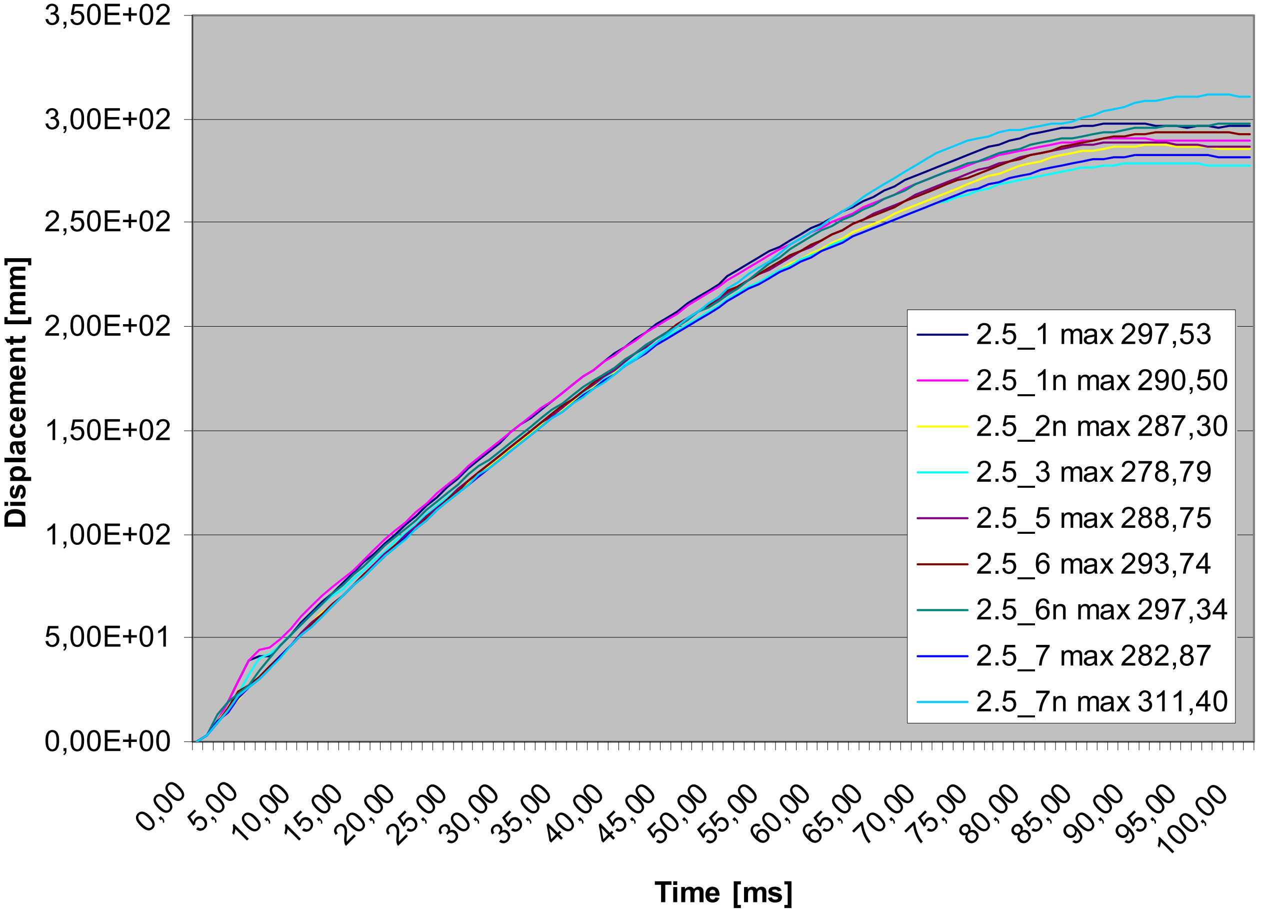
Analysis: comparison of Displacement
10mm meshing



Analysis: comparison of Displacement
5mm meshing

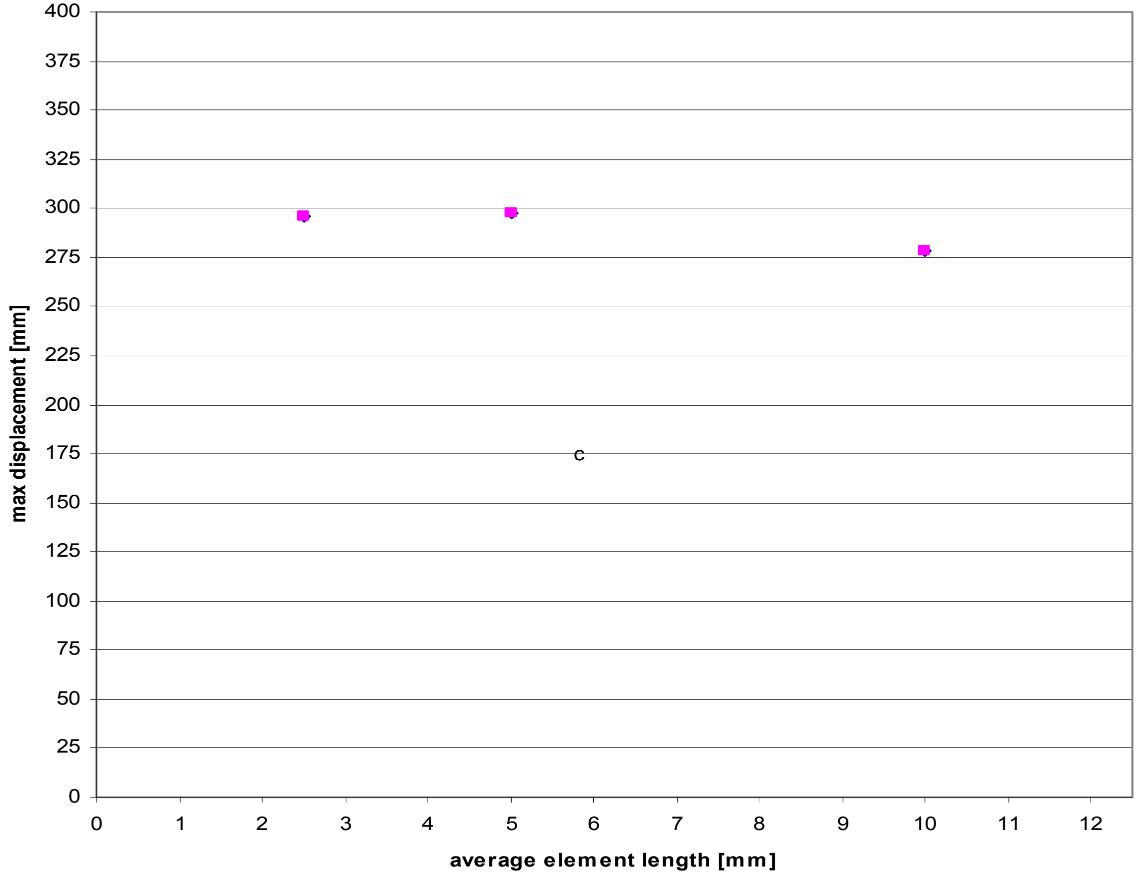


Analysis: comparison of Displacement
2.5mm meshing



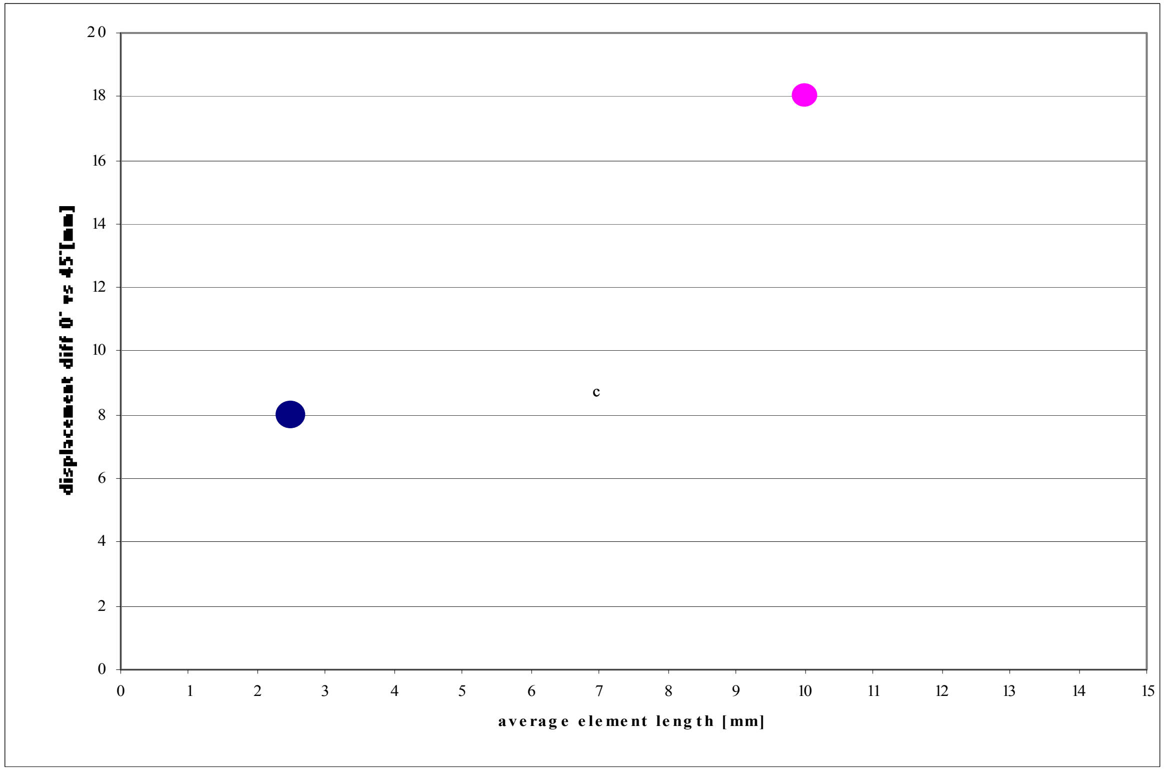
Analysis: Comparison max. displacement

Compression is nearly independent from the element length in a range from 10mm to 2.5 mm for the same element orientation



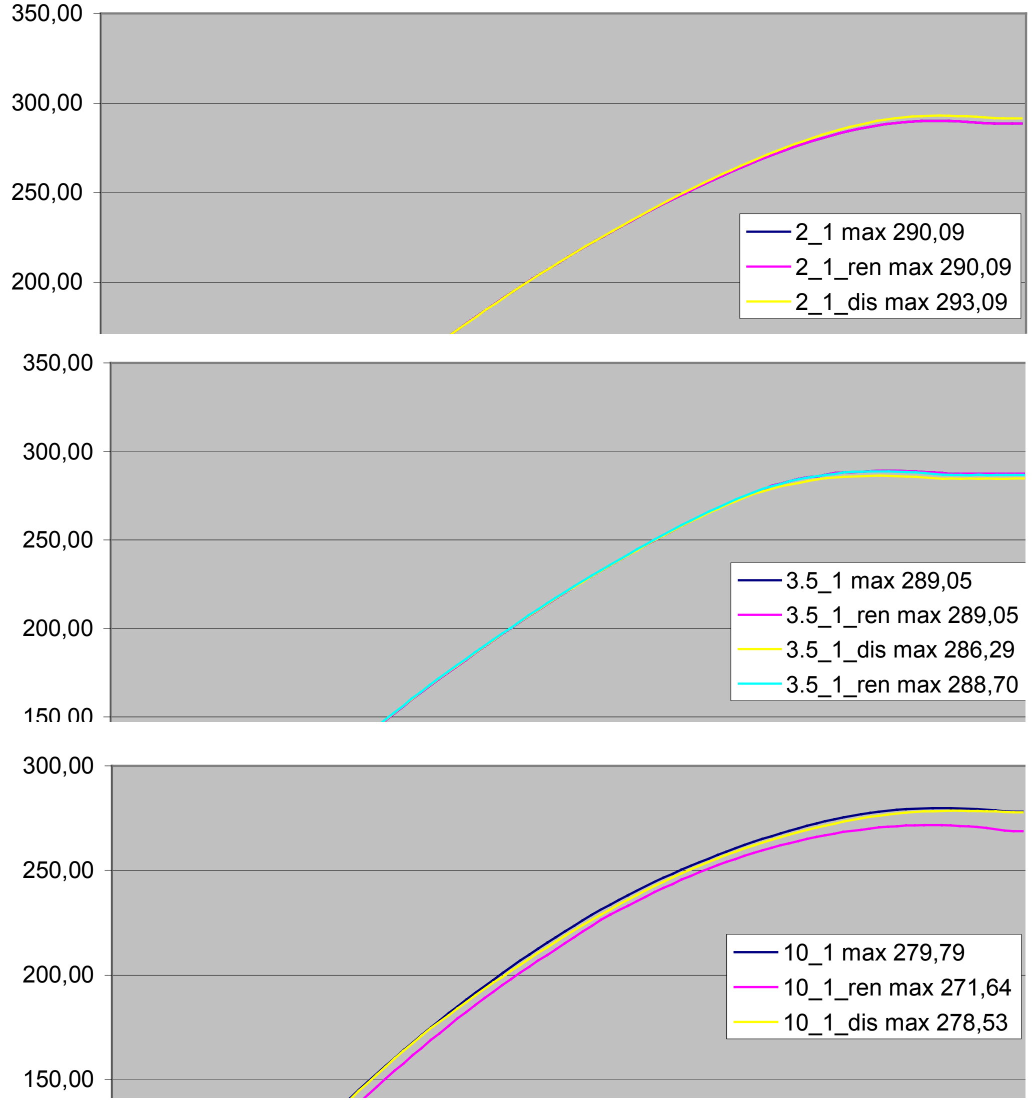
Analysis: Comparison max. displacement

The max displacement difference for 0° mesh and 25° mesh is small for finer meshes and big for coarser meshes



Analysis: Influence on mesh translation and reumbering

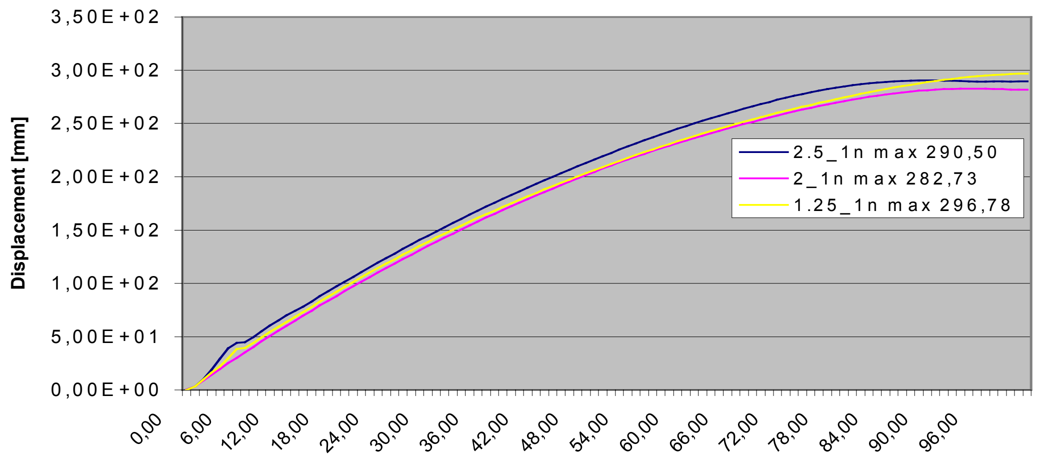
For 10 mm the variation is about 8mm where as the deviation for smaller elements sizes is about 3mm for the same element orientation



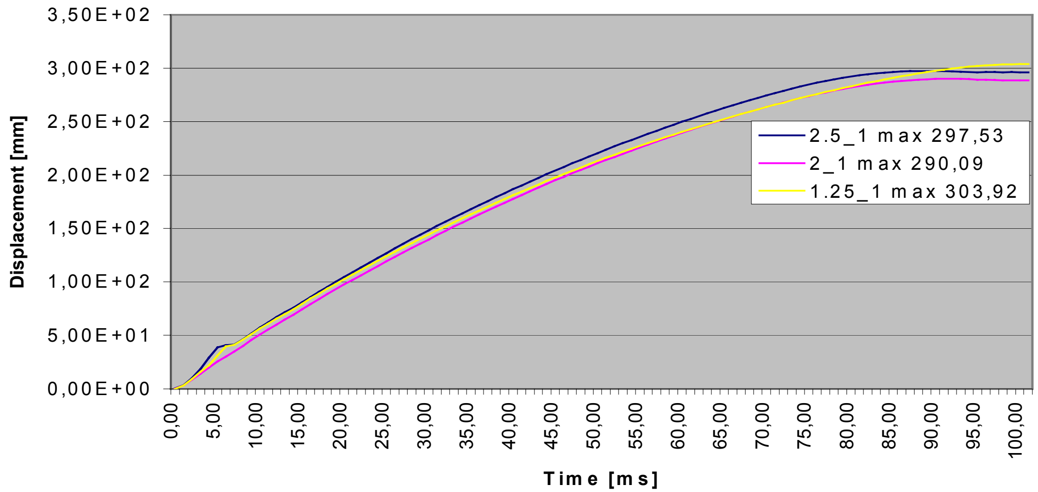
Analysis: Influence on results of very small elements.

For 1,25 mm the BT (typ2) element seems to be to weak. For smaller elements sizes, full integration seems to have better results.

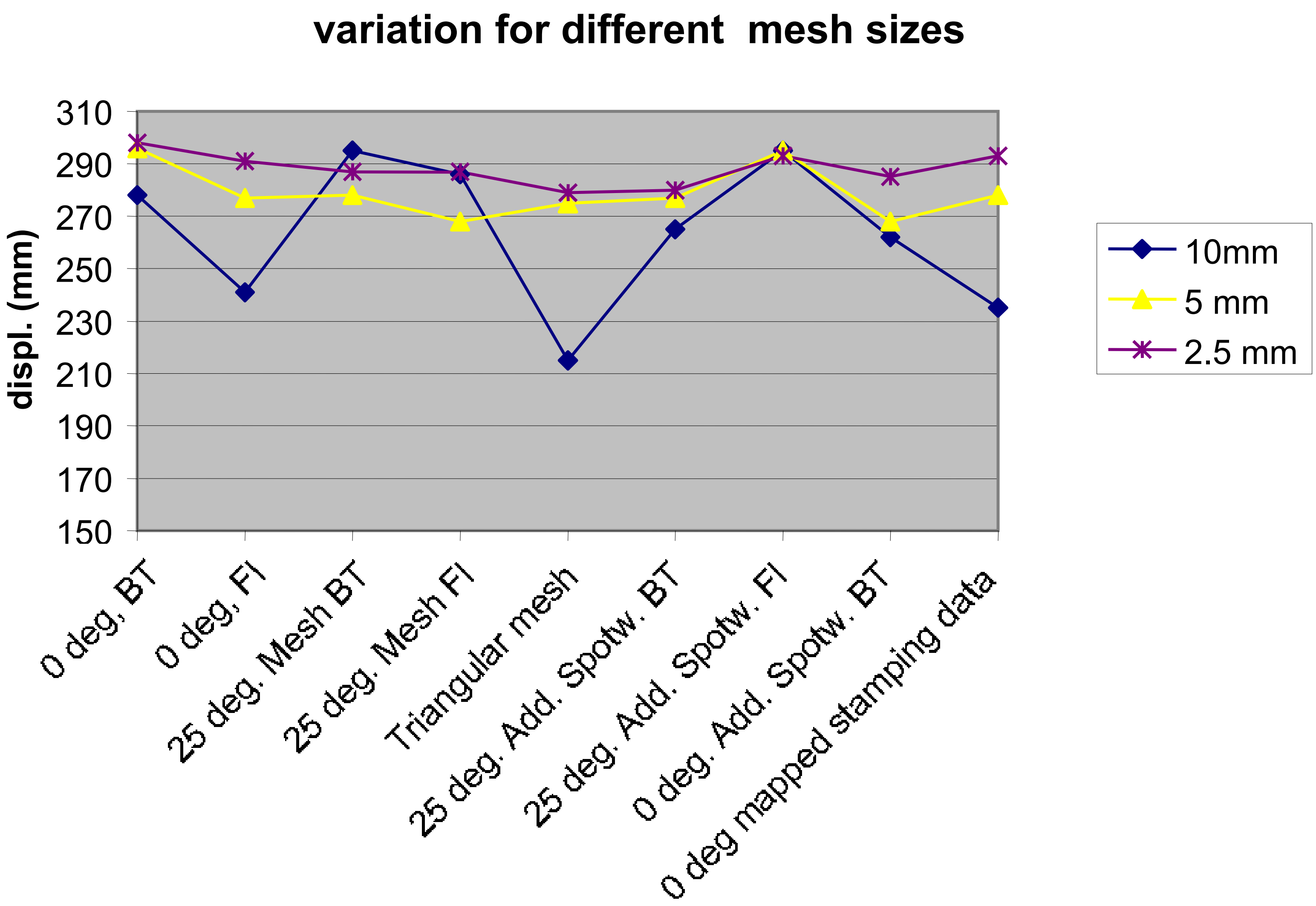
Comparison of Full Integration



Comparison of BT

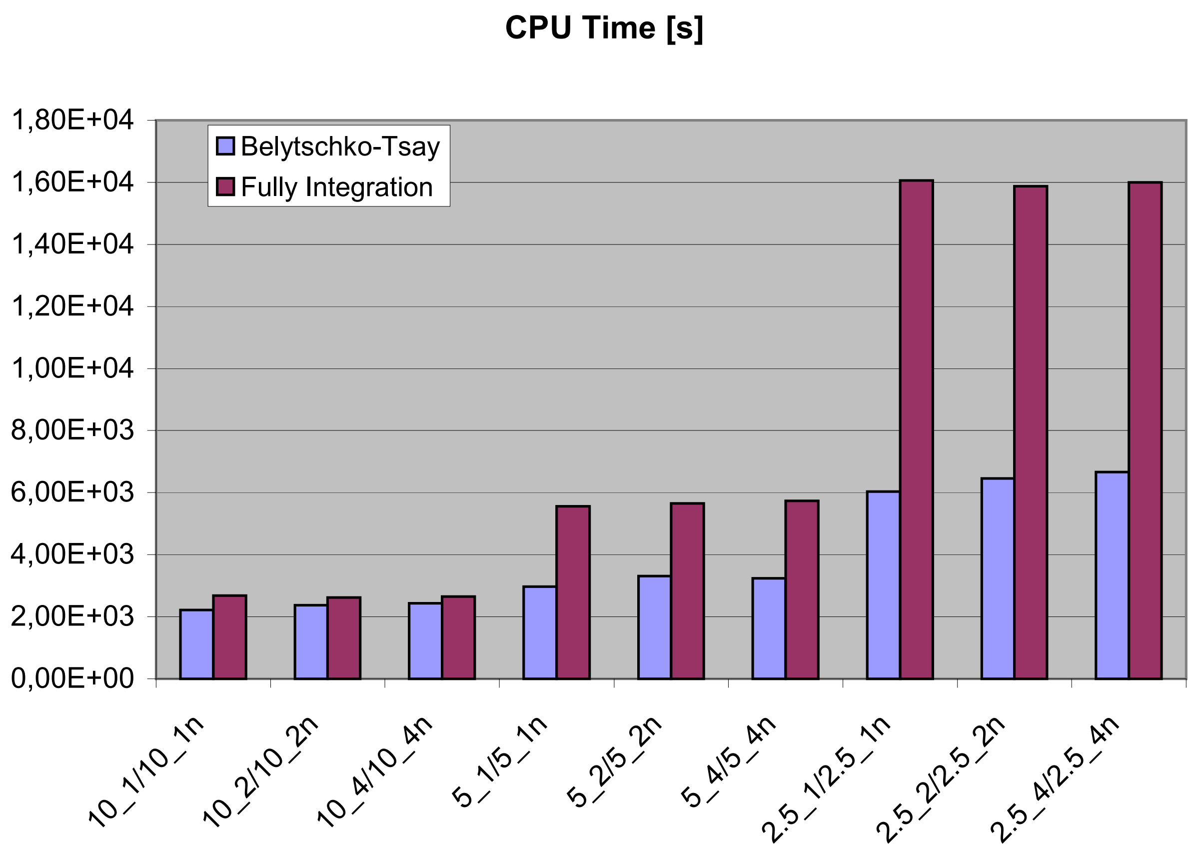


Analysis: comparison max displacement variation



Analysis: Comparison of integration method

Calculation Time



Results

- Results for the displacement and the internal energy seem to be smooth and stable in a range from 15mm to 2,5 mm for orthogonal element orientation
- Different element orientation give different results for coarser meshes
- Finer mesh is not so sensitive for different element orientation, integration method, number of spotwelds, mapping, small changes in the input (renumbering, moving the model in space)
- Mapping tools are easy to use for Crash coupling. The influence of the mapping was getting smaller for smaller element sizes for the influenced zone was getting smaller and the crash mode was very stable in our example.

Conclusion

- If you know the collapse mode of a part you can use a coarse mesh which should be orthogonal in the collapse direction (so you can achieve “superconvergence”)
- If you doesn't know the collapse mode of a part; Please use finer meshes
- No one knows the exact collapse mode of all the parts in a vehicle!
- Meshing rules for orthogonal /Mapping/Integration schemes meshes are important for coarser meshes but not important for finer meshes.

- *Creation of finer meshes can be automated by TEC ODM!*

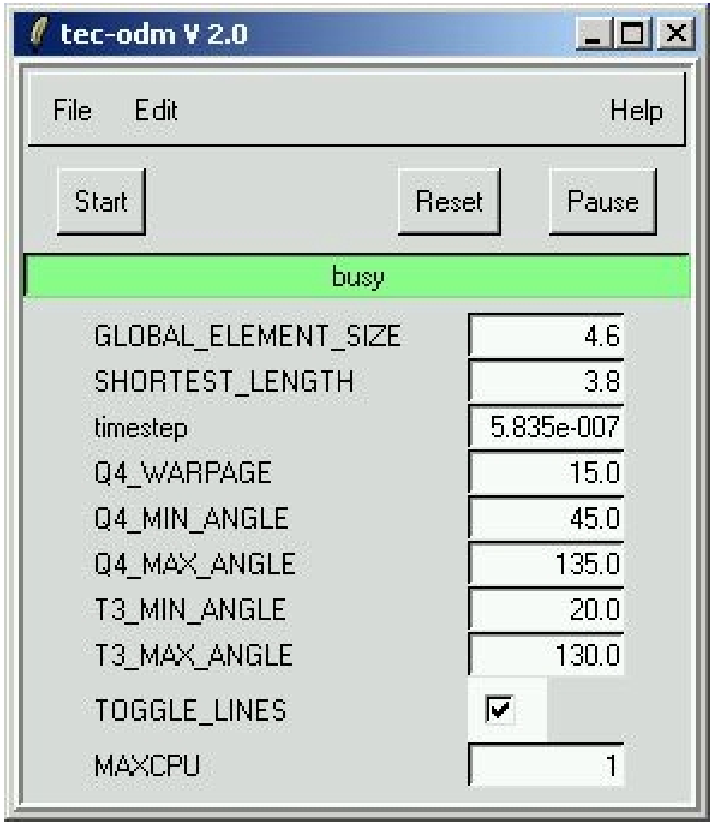
Automatic Meshing Pro's and Con's

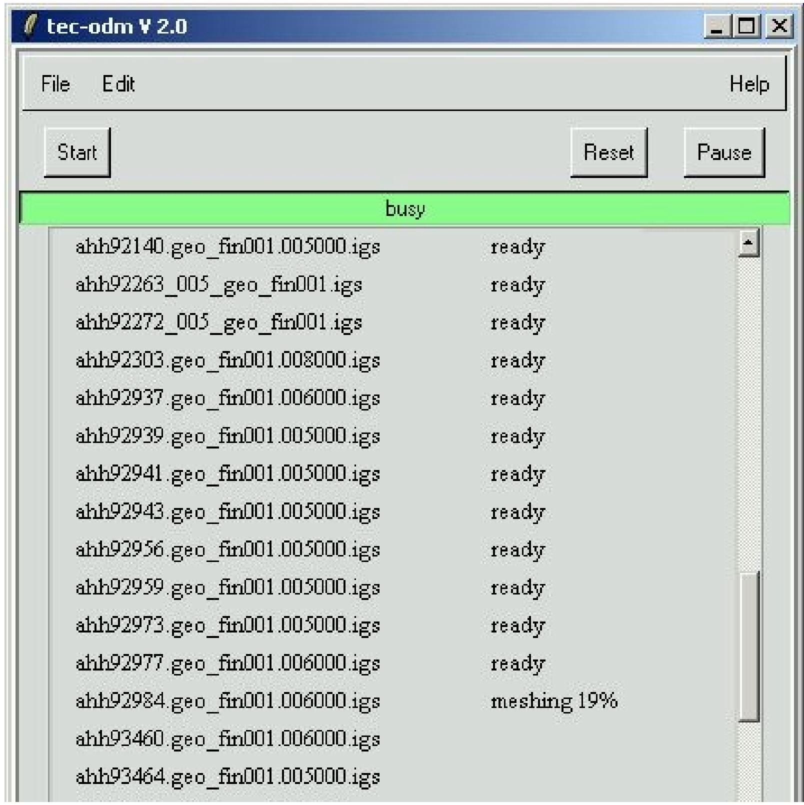
- What is TEC-ODM?
- What can TEC-ODM do?
- How can the development process benefit from TEC-ODM?
- What is the System requirement

Automatic Meshing Pro’s and Con’s

- What is TEC-ODM?

• *Tec ODM (**O**ne **D**ay **M**eshing) is a automatic FE batch meshing Software for Body in White meshes for Crash and NVH analysis. Tec ODM is based on a set of 50 different explicit mesh enhancement algorithms which are implemented in iterative loops.*

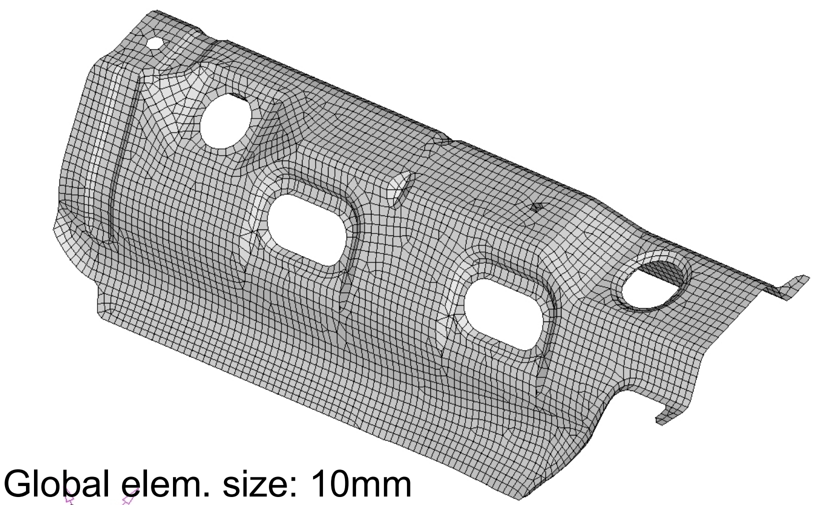




Automatic Meshing Pro’s and Con’s

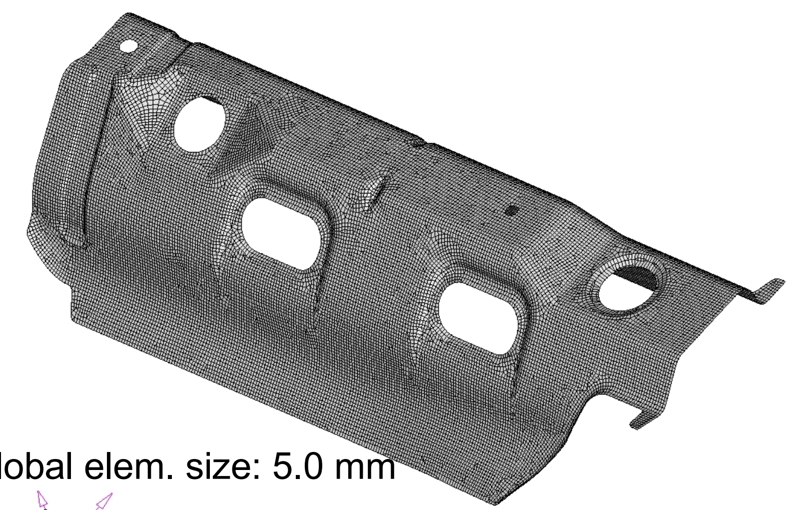
- What can TEC-ODM do?

• *Tec ODM creates FE shell element meshes on CAD surfaces considering different quality criteria. TEC ODM’s output is a mesh with distinguished global element sizes (11 mm or smaller) and smallest element length up to 4.0 mm.*



Global elem. size: 10mm

Smallest elem. Size: 4.0 mm

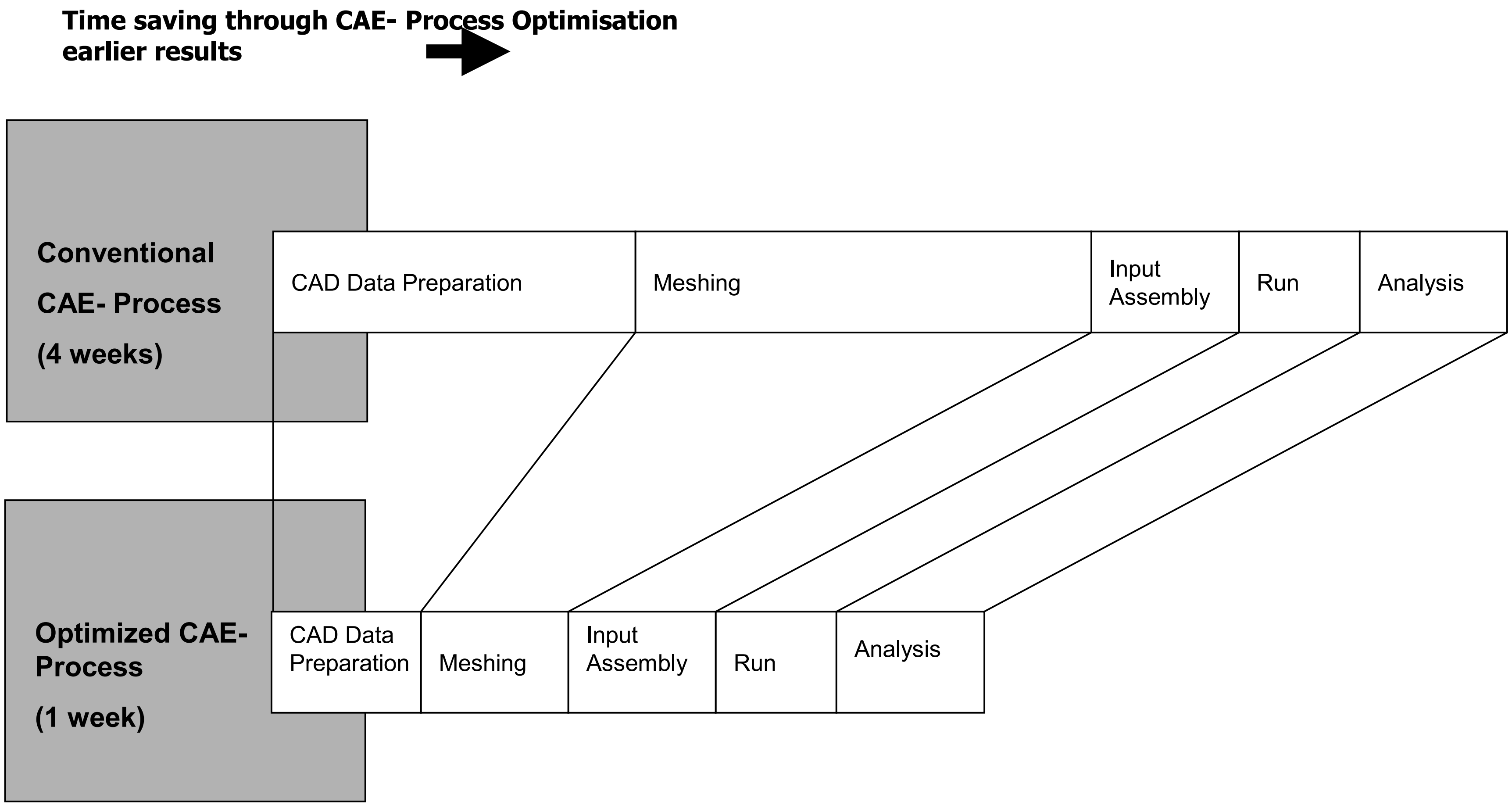


Global elem. size: 5.0 mm

Smallest elem. Size: 3.0 mm

Automatic Meshing Pro's and Con's

- How can the development Process benefit from TEC ODM?



Automatic Meshing Pro's and Con's

TECOSIM

- How can the development Process benefit from TEC ODM?

Cost saving through CAE- Process Optimisation

	Regular FE Process	TEC ODM Process
Additional Software cost for a MPP license	0 €	149.000 €
Cost for an BIW FE Mesh outsourced from CAE supplier	40.000 €	0 €
Number of updates per Year per Platform	5	5
Number of platforms @ car manufacturer	10	10
Total cost for BIW FE mesh per year	2.000.000 €	149.000 €
Investment needed for additional Hardware eg. Linux Cluster with 192 Processors		€ 288.000
Manpowerl inhouse cost for TEC ODM operation (50 days for 50 BIW FE Mesh update)		€ 30.000
Total cost	2.000.000 €	467.000 €
Possible savings with TEC ODM per year		*1.533.000 €*

Automatic Meshing Pro's and Con's

TECOSIM

Manual Mesh **ODM mesh**

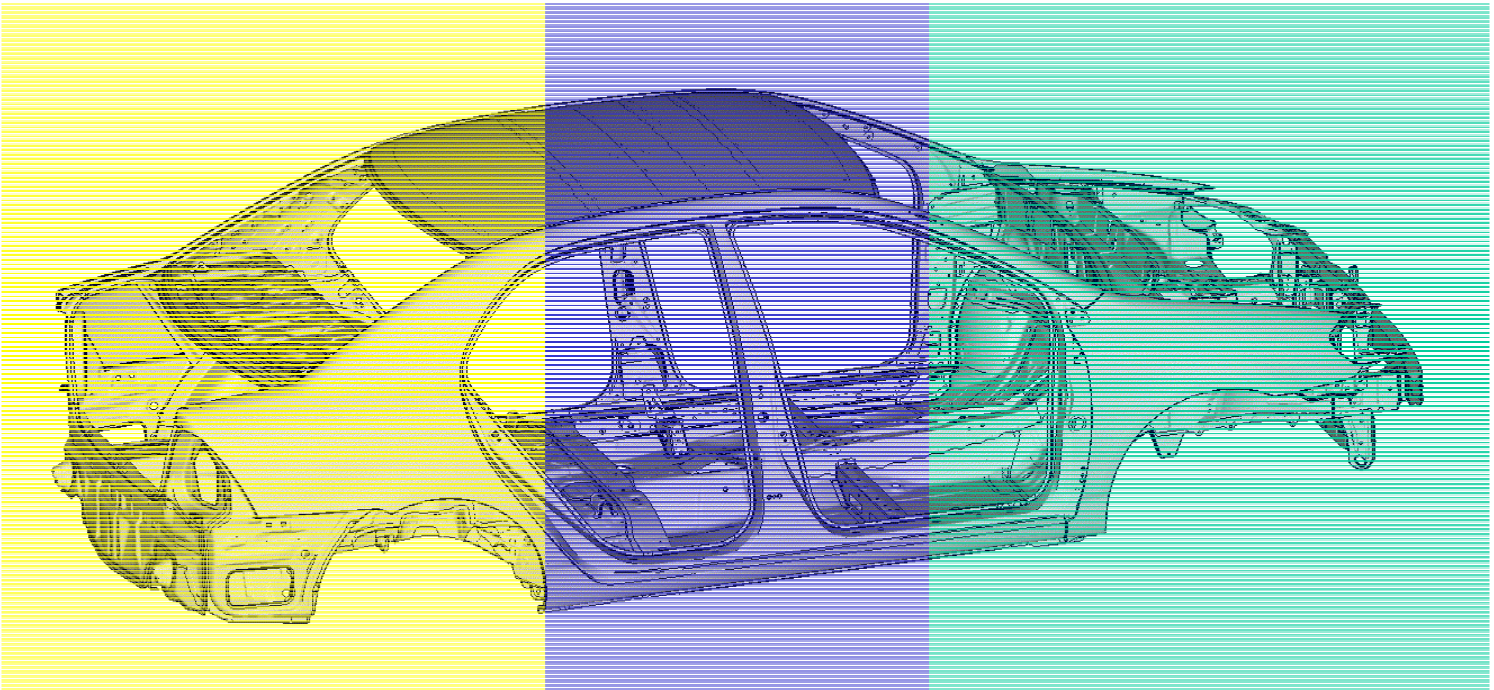
		Number of elements
	complete model	804819

	Number of elements	
complete model	1922676	

„Model size is getting bigger with TEC ODM therefore some investment in numbercrunching is needed.

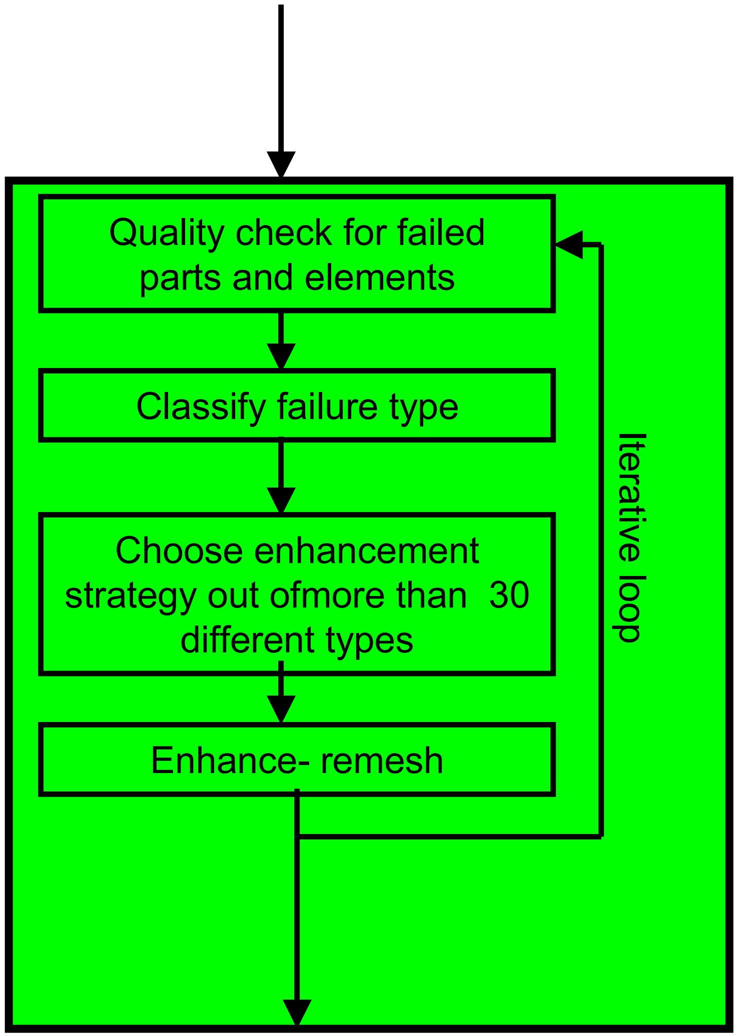
Automatic Meshing Pro’s and Con’s

- *Ways of using TEC ODM*



15-20 mm 6-12 mm 3-6 mm

Automatic Meshing Pro's and Con's



Summary

- TEC ODM automesh process is ready to use
- TEC ODM will result in bigger FE models
- ODM process will result in faster answers to engineering questions and reduced modelling cost
- TEC ODM has nearly no “human influence” in the modelling process
- Meshing engineer becomes a quality and process checker

- Thank you!

- Any questions?