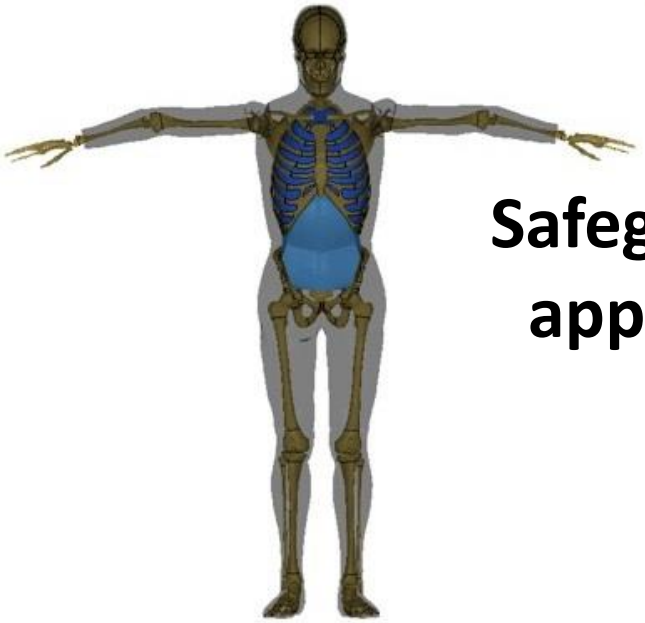

Safeguarding a reliable validation and application of a FE human model in different crash codes

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[1] University of Munich, Germany, [2] Hochschule Furtwangen University, Germany, [3] ESI GmbH, Germany, [4] DYNAmore GmbH, Germany

crash.tech 2016

Munich, 20th of April, 2016

Agenda

1. The THUMS User Community
2. Challenges in the validation of FE Human Models
3. Application of FE Human Models: pre- and post-processing examples

THUMS User Community (TUC)

Core Partners

Audi, Autoliv, BMW, DAIMLER, OPEL, PORSCHE, TOYOTA, VOLKSWAGEN AKTIENGESELLSCHAFT

Associated Partners

AGU Zürich, bast, IAT, pdb Partnership for Dummy Technology and Biomechanics, Université de Strasbourg, virtual vehicle

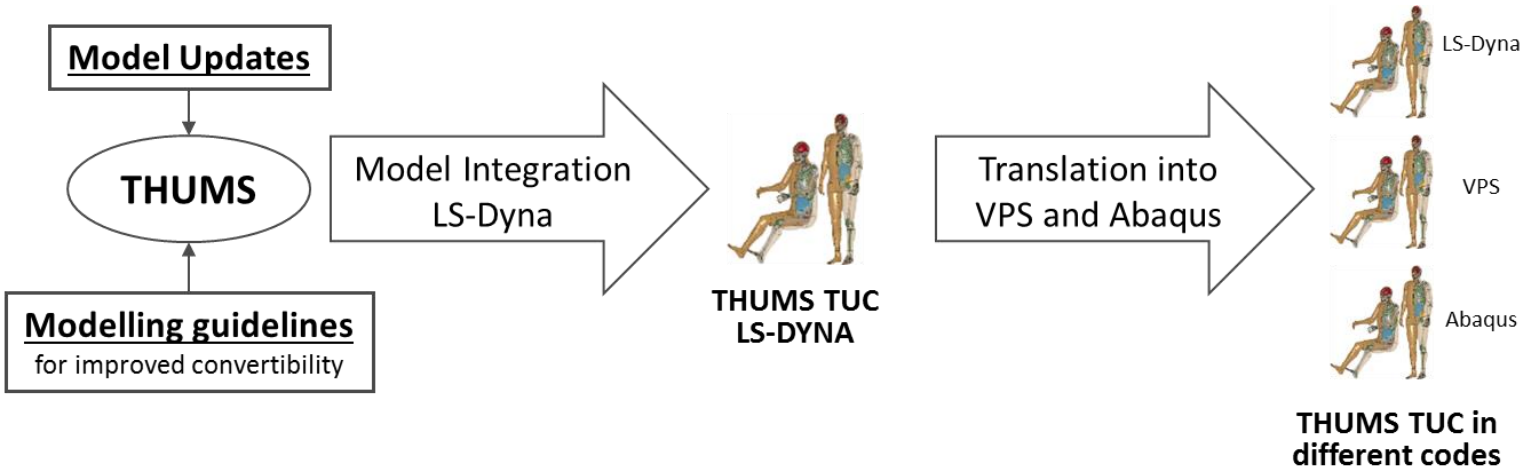
Subcontractor / Software Companies

DYNA MORE, esi get it right

Motivation of TUC

1. Harmonisation, provision and maintenance of a FE Human Body Model (THUMS^{TM}) in the three crash codes LS-DYNA, VPS and Abaqus

2. Development of agreed procedures for the use of Human Body Models
   - Guidelines for an improved model convertibility between codes
   - Development of validation procedures
   - Development of harmonised pre- and post-processing methods



Collaborations

COHERENT - project

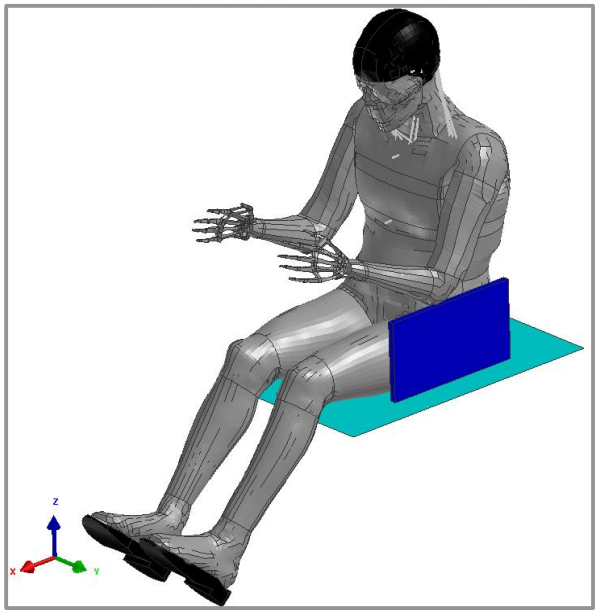
Validation of FE Human Models - Challenges

1. Choice of adequate reference experiments
   - Lack of physiological response at injurious levels of loading
   - Ethical issues
   - Surrogate response variability
   - Choice of experimental boundary conditions (Suitable for numerical modelling?)
   - Documentation (“Old” reference?)
   - System-immanent uncertainties

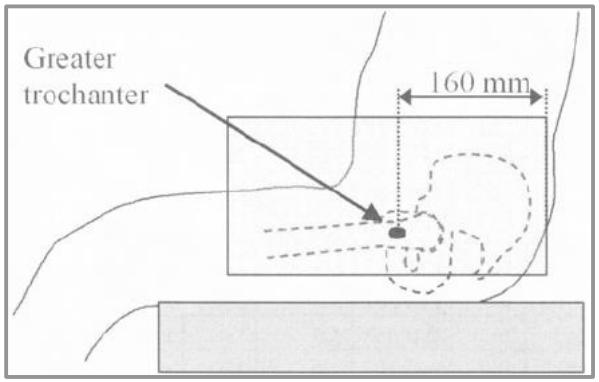
2. Numerical realisation
   - Response variability due to choice of boundary conditions, output definition etc.
   - Harmonisation between codes (control settings, transformation, belt/airbag modelling)
   - Pre-simulation/Positioning
   - System-immanent uncertainties

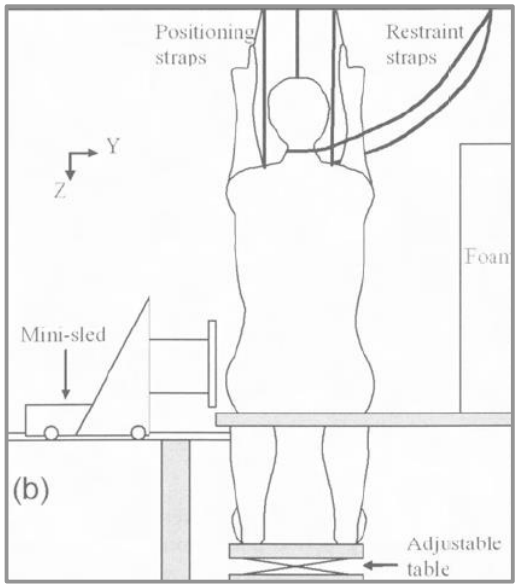
3. Evaluation of validation results
   - Filtering
   - Biofidelity rating
   - Objective rating

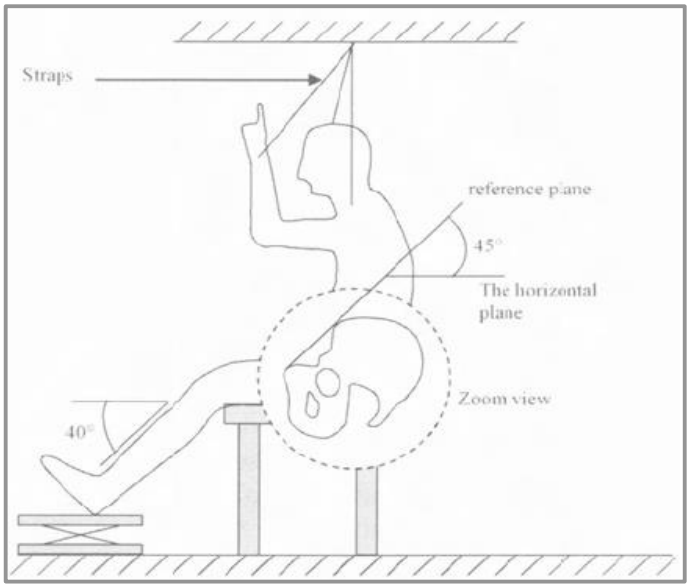
Validation - Example



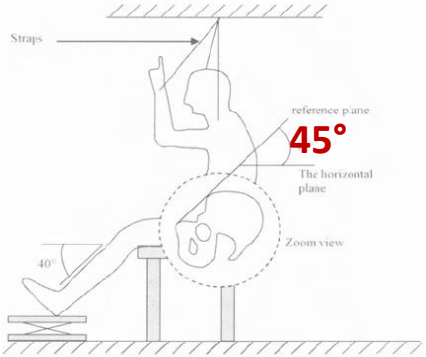
Body region	Pelvis
Level	Full Scale
Load case	Lateral sled
References	Leport et al. (2007): *Assessment of the pubic force as a pelvic injury criterion in side impact.* SAE Technical Paper, no. 2007-22-0019

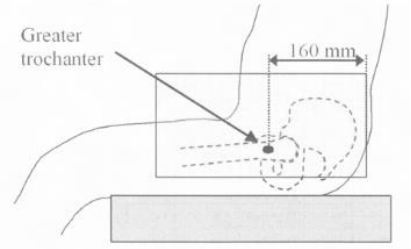




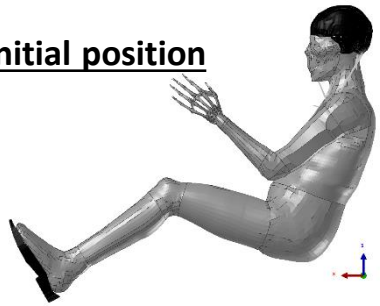


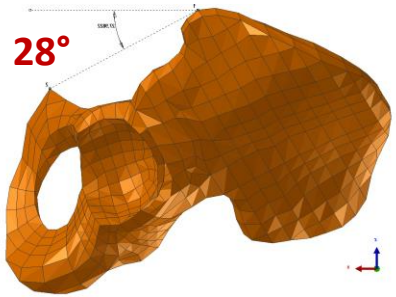
Validation - Example



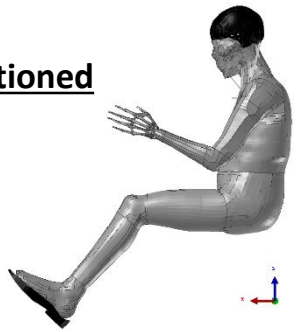


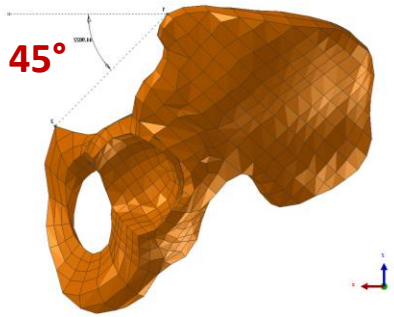
Initial position

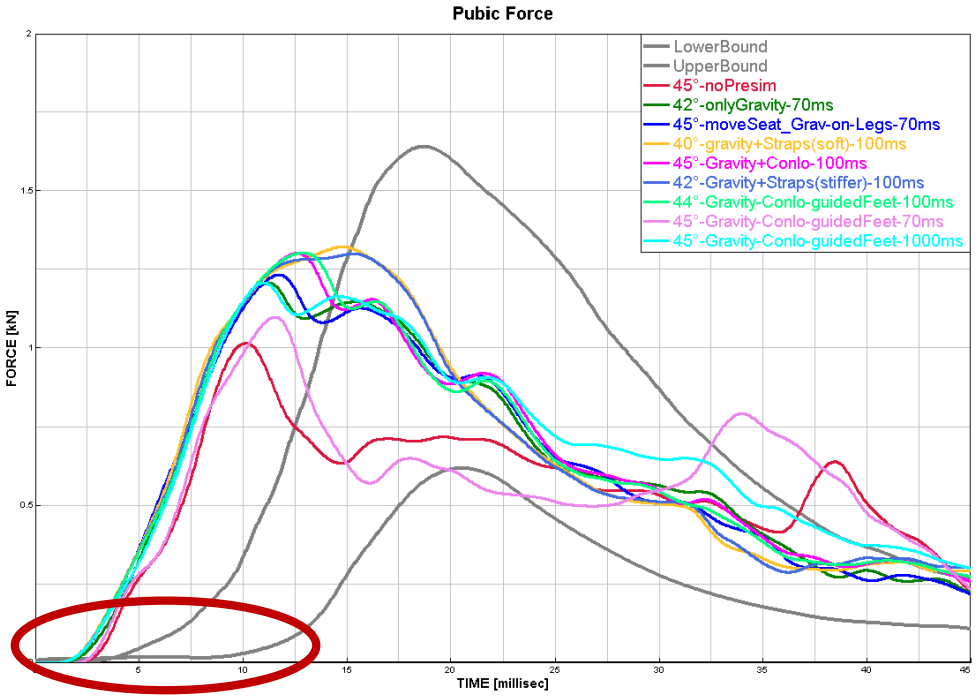




Positioned



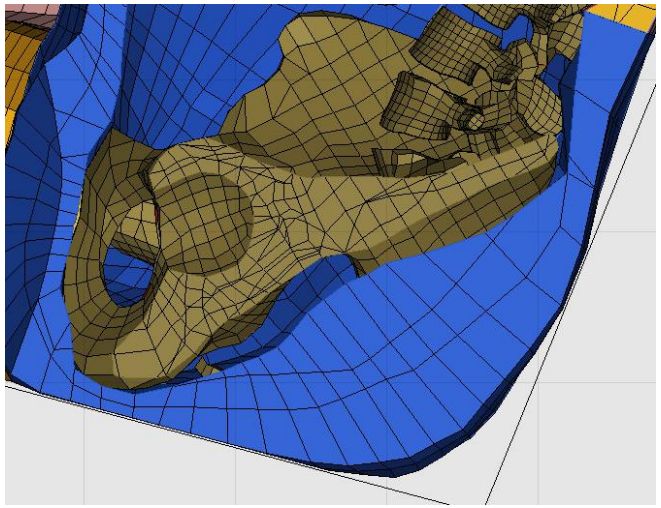




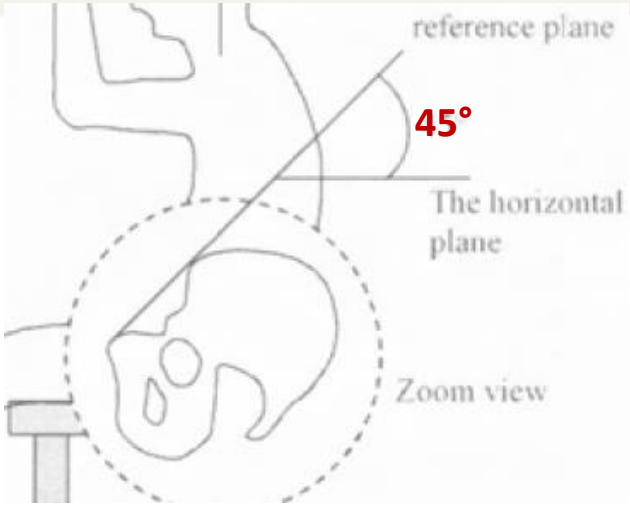
Validation – Harmonisation between codes

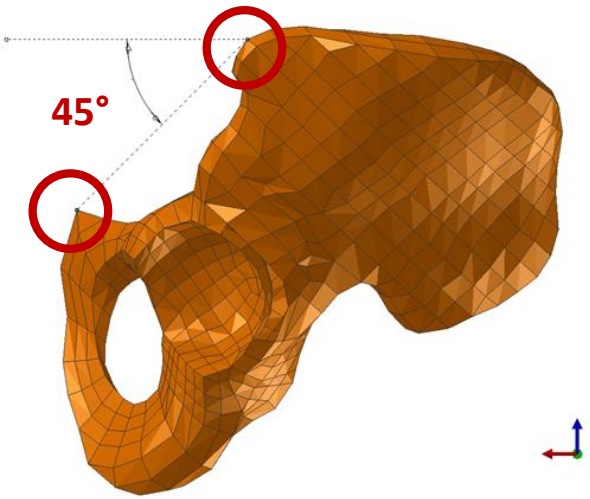
Challenges in obtaining a harmonised position

- Positioning of HBM required to match position of reference subjects
- Two approaches to obtain harmonised positions in LS-Dyna and VPS:
  - Apply same BCs in both codes for pre-simulation to position models independently
  - Export nodal coordinates of positioned VPS model into LS-Dyna (or vice versa)
- Problems with distorted elements in both cases
  - ➢ Manual mesh updates necessary in both codes after positioning



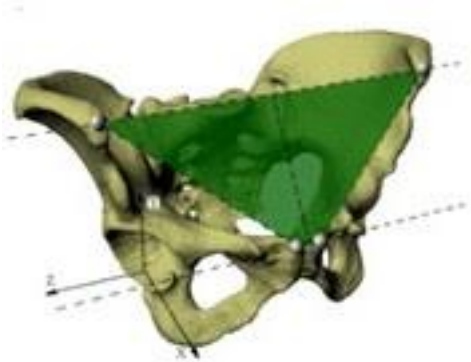
Application: Reference Points





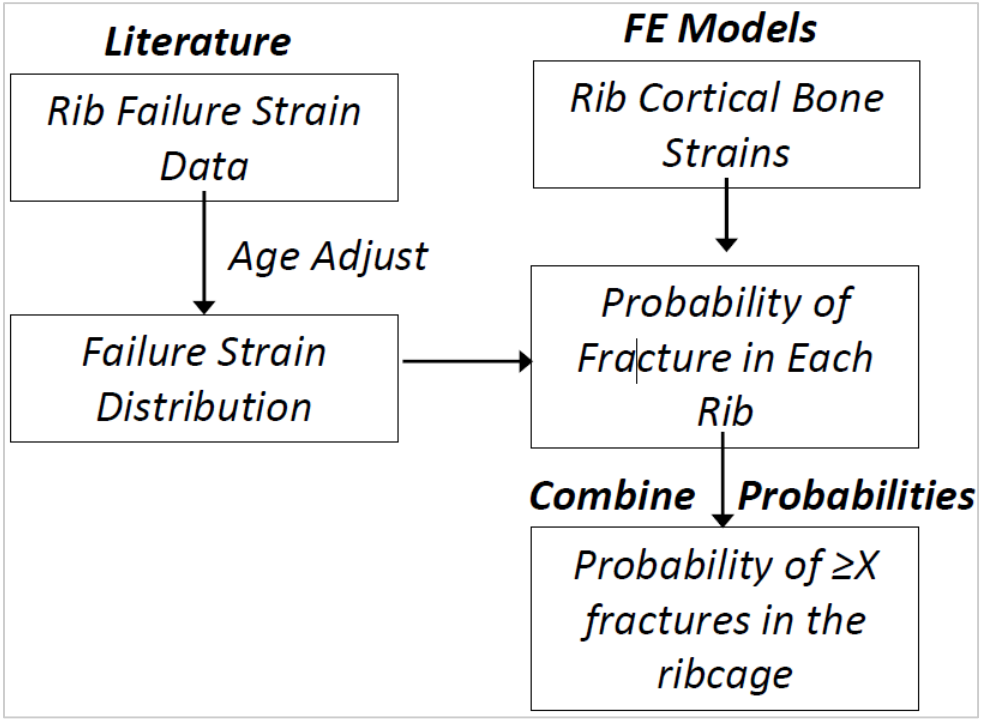
- PMHS positioned such that a 45° angle of the anterior pelvic reference plane relative to horizontal plane

- Anterior pelvic plane is defined by the two anterosuperior iliac spines (ASIS) and pubic tubercles



Application: Rib Fracture Risk Assessment Tool

Method



Pipkorn, 2014 (5th International Symposium on Human Modeling and Simulation in Automotive Engineering)

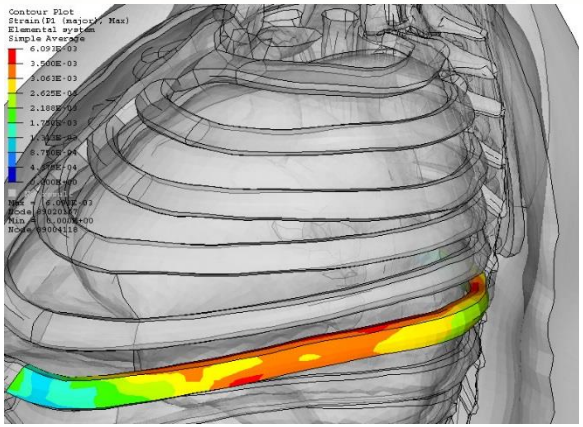
- Strain-based probabilistic method to **predict rib fracture risk** using a material-level failure model
- Age-adjusted ultimate strain distribution used to estimate local rib fracture probabilities
- Strain-failure relationship based on probability that local strains observed in ribcage would exceed ultimate strain of rib cortical bone
  - Estimation based on cumulative distribution of rib cortical bone ultimate strains derived from experimental data from literature
  - Kemper et al. (2005 & 2007): ultimate strain values obtained from uniaxial tensile testing of rib cortical bone

Application:
Rib Fracture Risk Assessment Tool

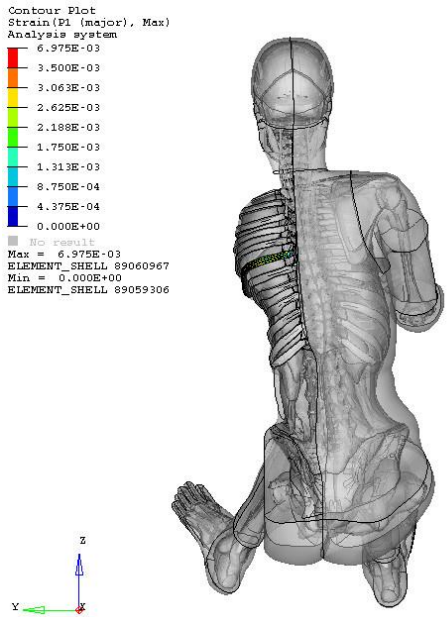
Tool

Definition of output request of full model simulations

→ **Simulation**



Input for RSP → **Rib Strain Processor**



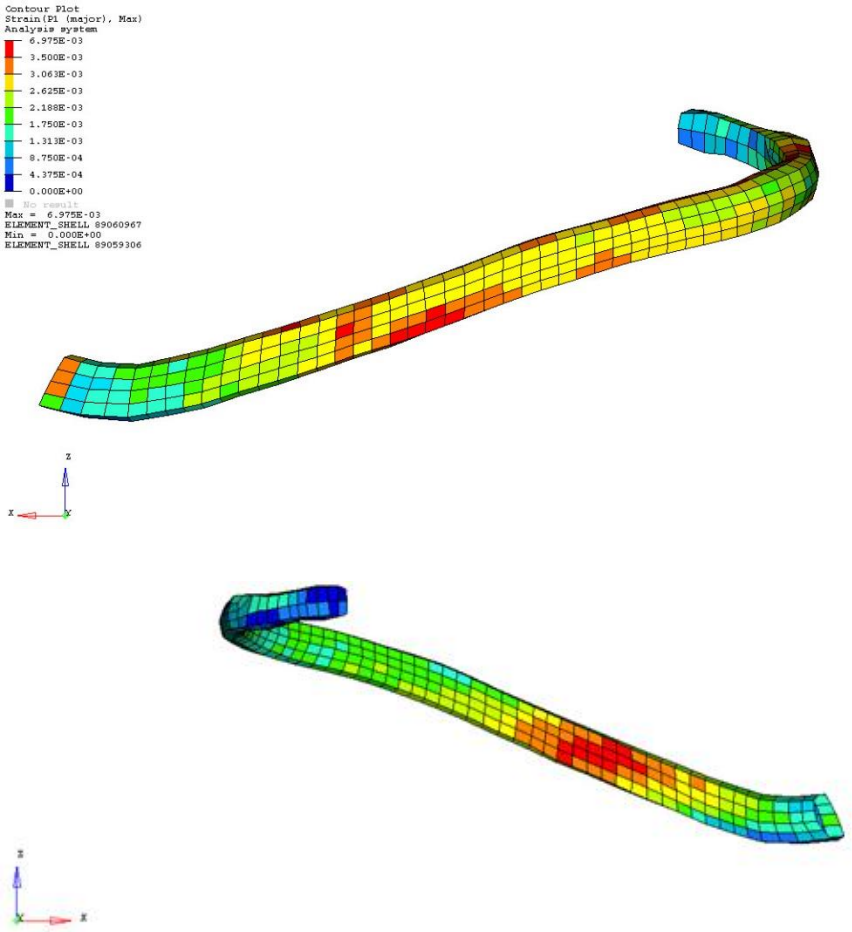
→ **ASCII file containing peak strain values**

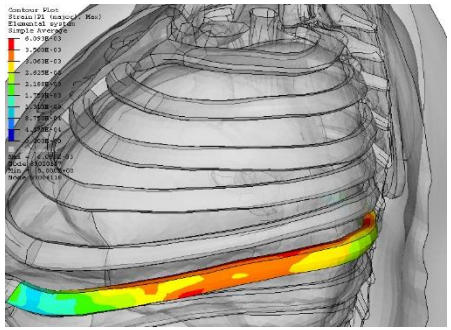
Output of RSP
=
Input for RFRP

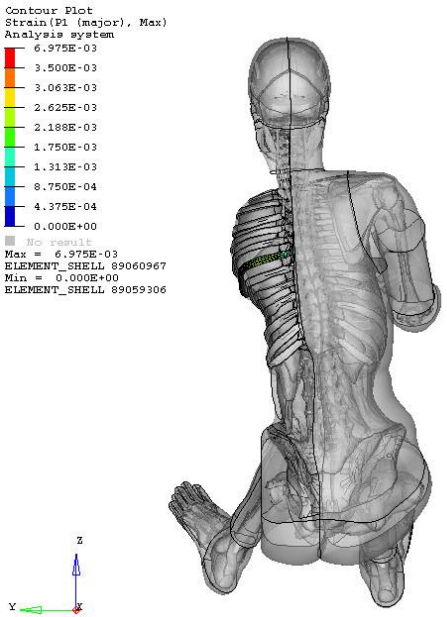
→ **Rib Fracture Risk Predictor**

Output of RFRP → **Predicted risk of a person of target age sustaining specific number of fx**

Application:
Rib Fracture Risk Assessment Tool







Outlook

- Providing database of simulation setups for validation
- Development of harmonised pre-processing methods for the application of HBMs
- Post-processing: Development of objective criteria for the evaluation of the performance of HBMs, including improved tracking/reference points

Web link: www.TUC-project.org

THANK YOU!

Acknowledgment:

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