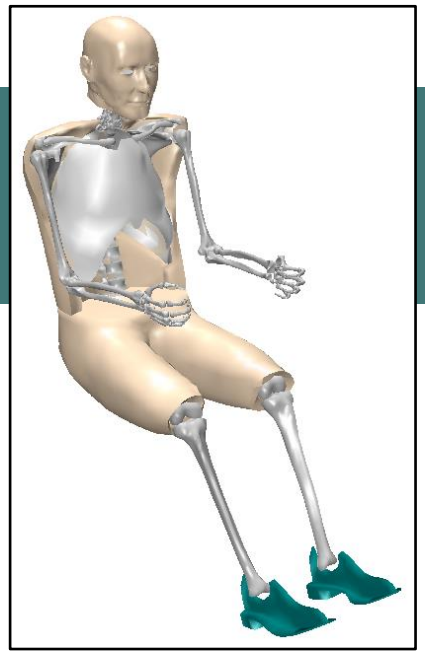

The CASIMIR Model for Simulation in Seating Comfort Applications

- A Status update for LS-DYNA -

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Infoday Human Models

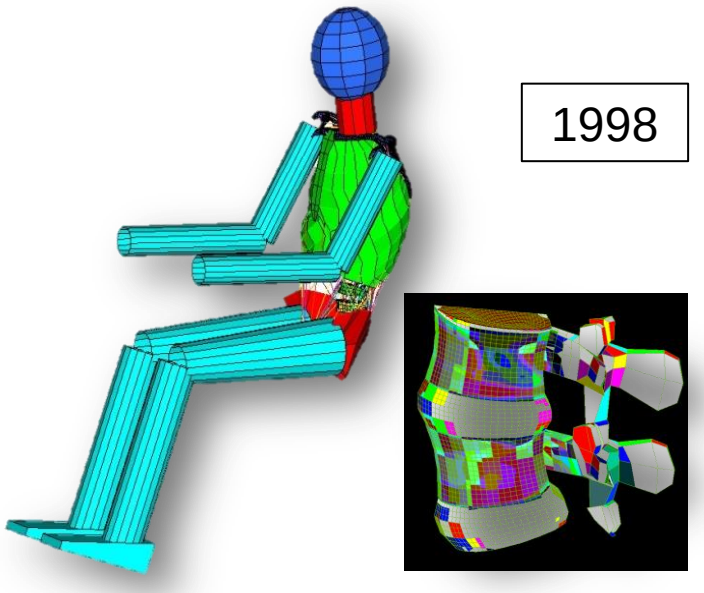
02 June 2016, Stuttgart, Germany

Contents

- Introduction to the CASIMIR model and seat development with *CASIMIR/Automotive*
- LS-DYNA integration and validation process
- Summary
- Outlook

Casimir - Human Body Model - History

- Initially the CASIMIR model was developed in the 1990ies at the TU Darmstadt
- First applications were investigations with respect to the risk of occupational diseases due to whole human body exposures



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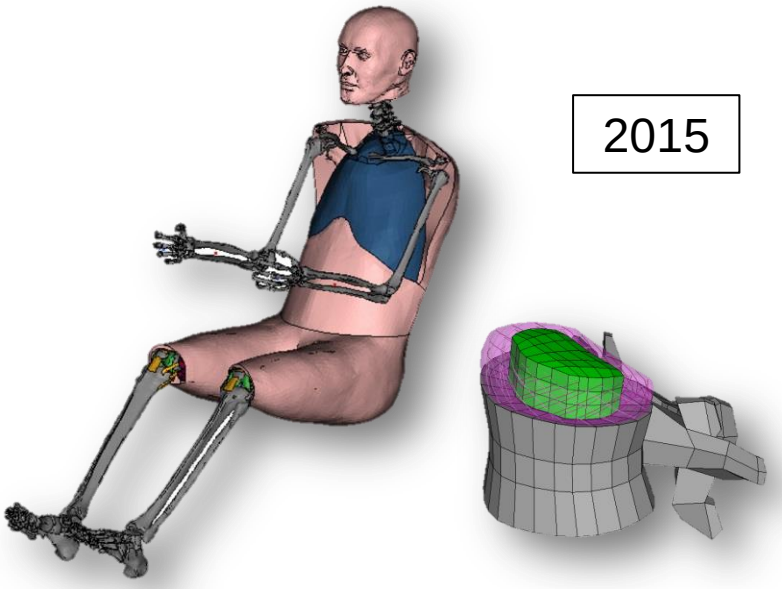
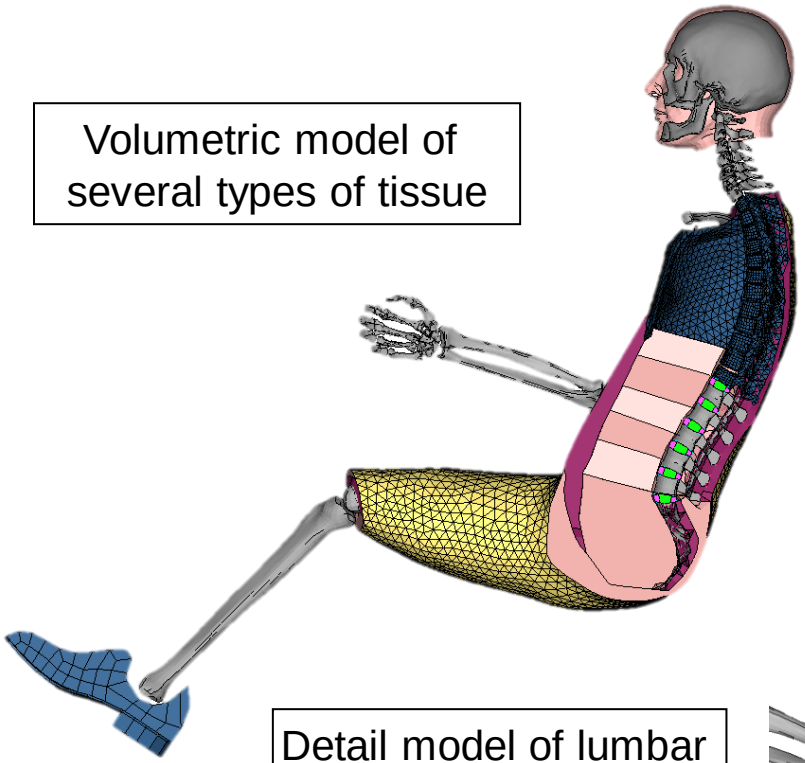


2015

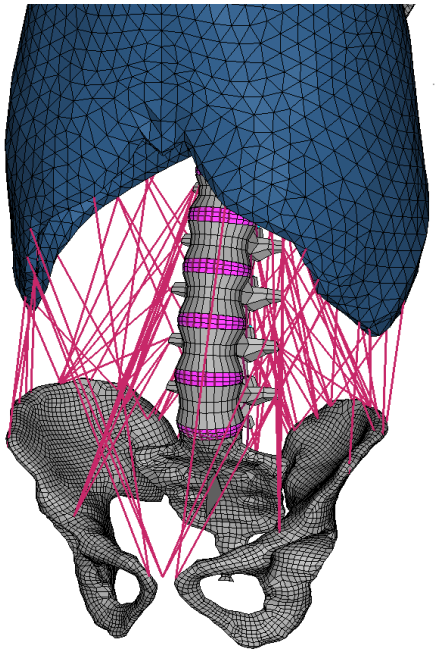
- Accordingly the model included a detailed model of the lumbar spine
- Step by step the range of application is enhanced with focus on applications in the automotive, commercial vehicle and aerospace industry

Casimir - Human Body Model - Setup

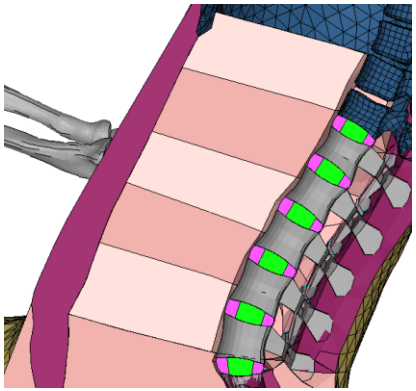
Volumetric model of several types of tissue

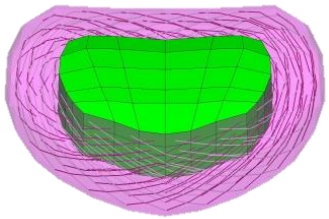


Detailed muscle approach for stabilized posture



Detail model of lumbar spine and abdomen

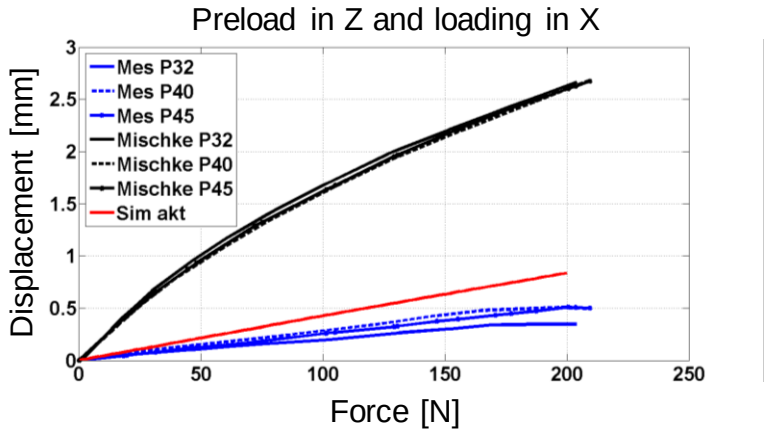




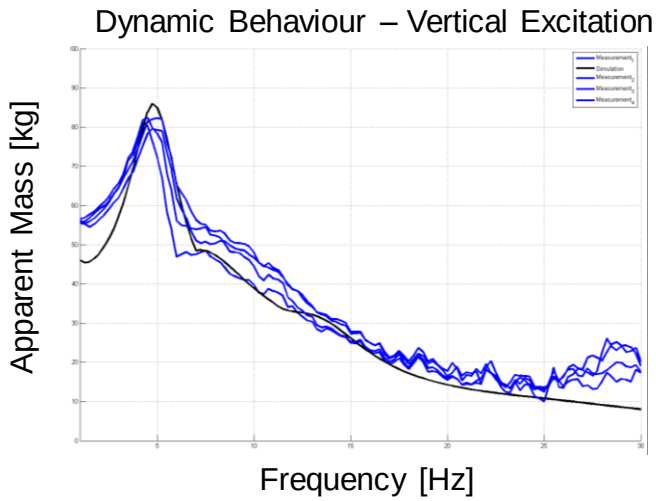
Casimir - Human Body Model - Validation

- The properties of the different model parts are validated in comparison to real subject or tissue test

Validation of lumbar spine segments via data of cadaver tests



Validation of dynamic behaviour via data of test with real persons



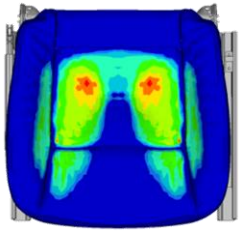
CASIMIR/Automotive - Overview

- Today model is the main part of a software package CASIMIR/Automotive to evaluate the seating comfort
- There are different occupant models available

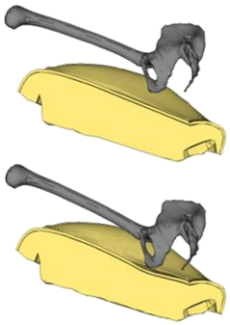
- The software is currently used by Daimler, Fiat, GM, JCI and NHK

CASIMIR/Automotive - Objective

- Using the human body model in combination with detailed seat models taking into account nonlinear and frequency dependent quantities enables a virtual seat development with increased efficiency and quality

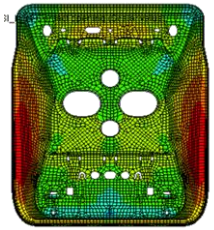


Seat pressure distribution

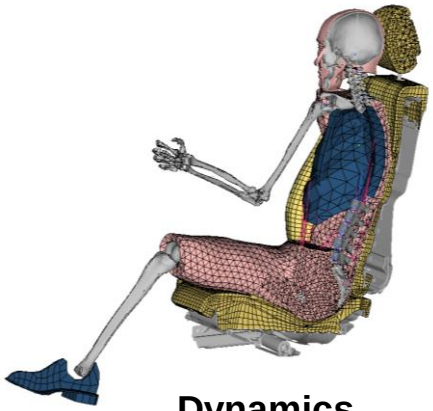


Seated posture Input packaging

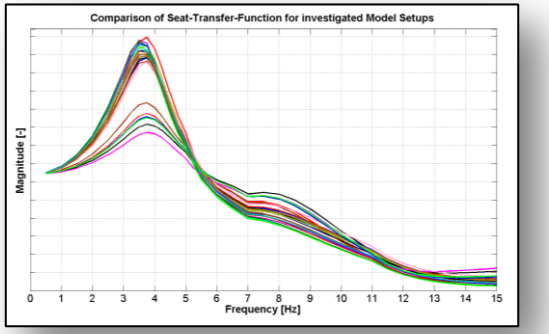
Statics



Meat-to-Metal

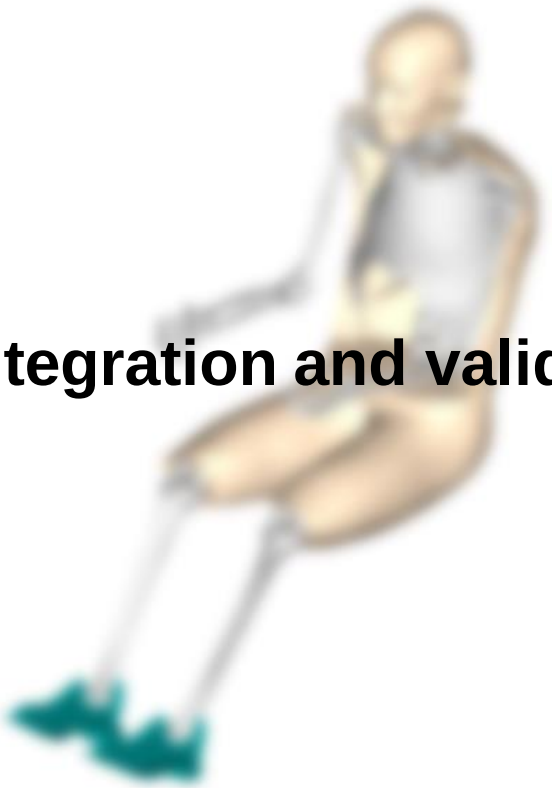


Dynamics



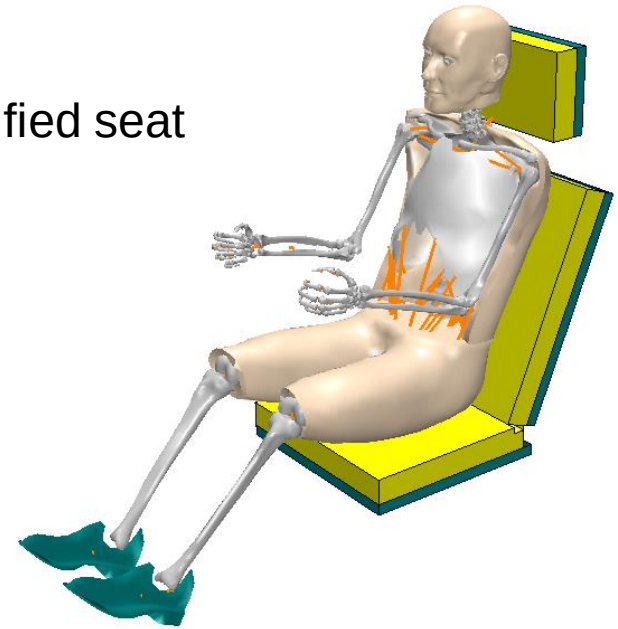
Seat Transmissibility

LS-DYNA integration and validation process



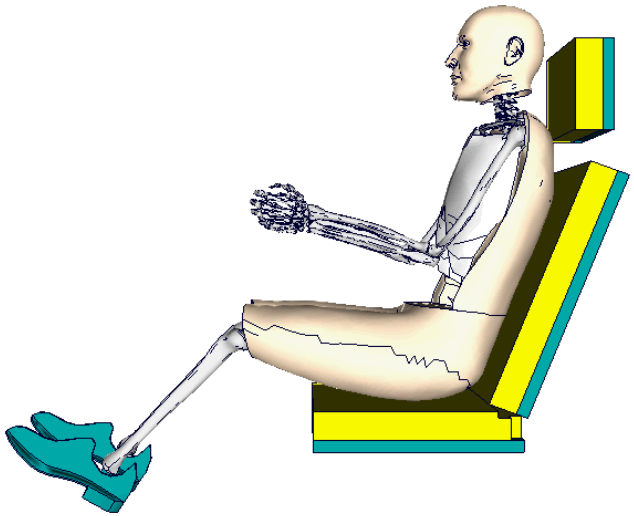
The CASIMIR model in LS-DYNA

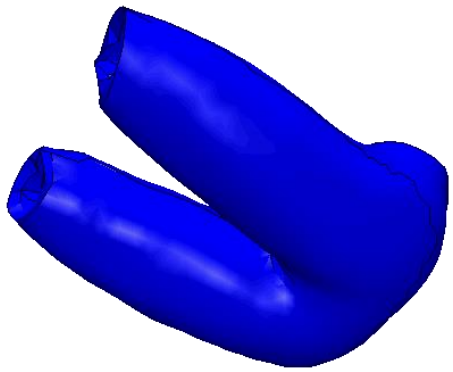
- *CASIMIR/Automotive* currently only available for ABAQUS
- First steps of the translation to LS-DYNA
- Model setup
  - Rigid body chain with joints
  - Special stiffness definition of the lumbar spine
  - Deformable tissue
  - Springs and dampers representing the muscles
- Converted human body model validated on a simplified seat
  - Implicit solution schemes
    - Static non-linear seating procedure
    - Subsequent eigenvalue analysis

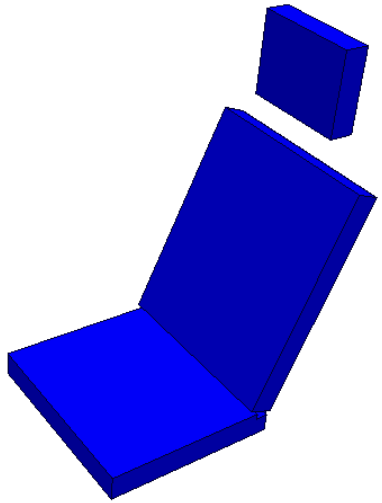


The CASIMIR model in LS-DYNA

- Seating simulation performed under gravity loading
- Segment-based mortar contact with friction between CASIMIR and seat
- For validation purposes, three different cases have been investigated:
  - Case 1 - elastic materials of both human body tissue and seat foam
  - Case 2 - non-linear material behavior of the tissue but linear material for the foam
  - Case 3 - non-linear materials of both human body tissue and seat foam



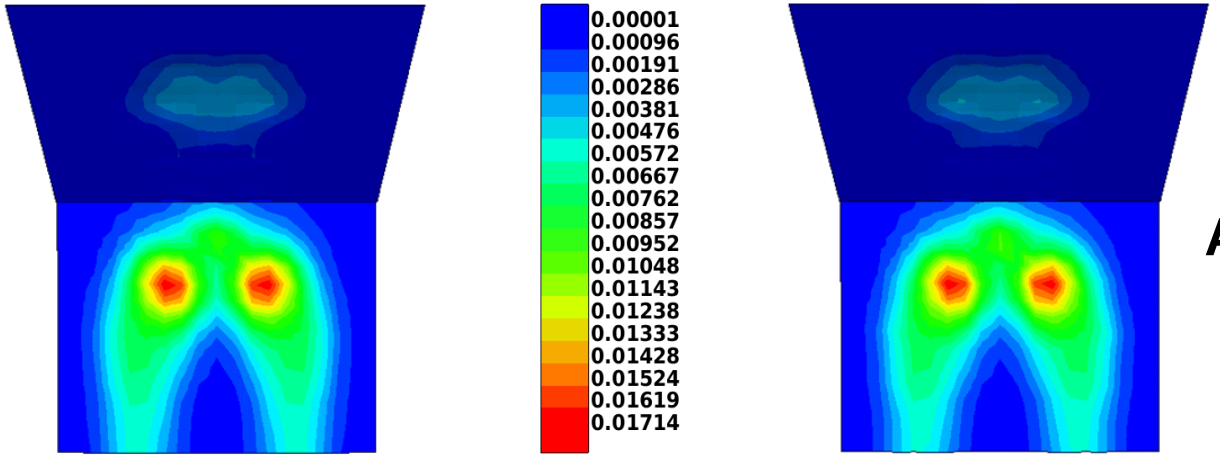




Case 1 – All linear materials

- Von Mises stress distribution on the seat in MPa

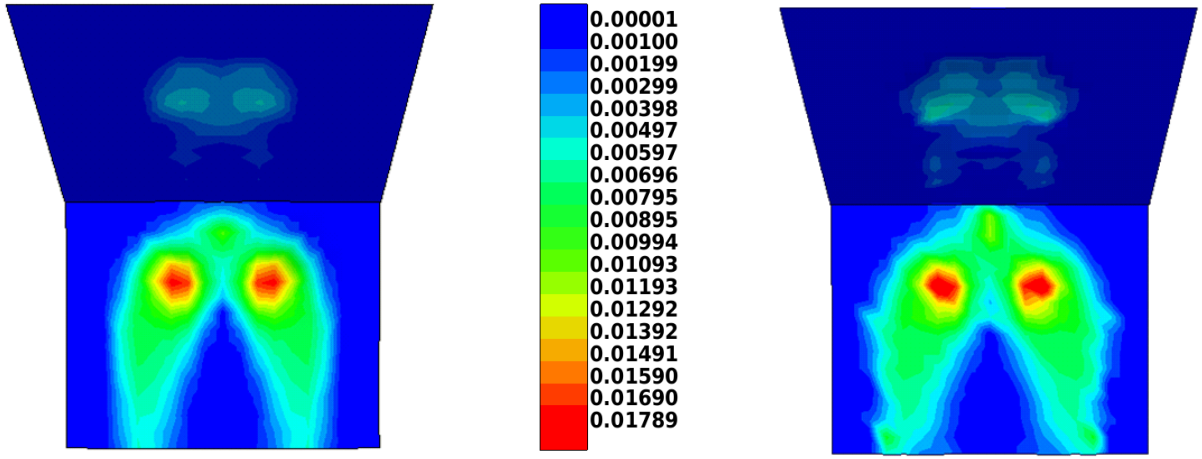
LS-DYNA



ABAQUS

- Seat contact pressure distribution in N/mm^2

LS-DYNA

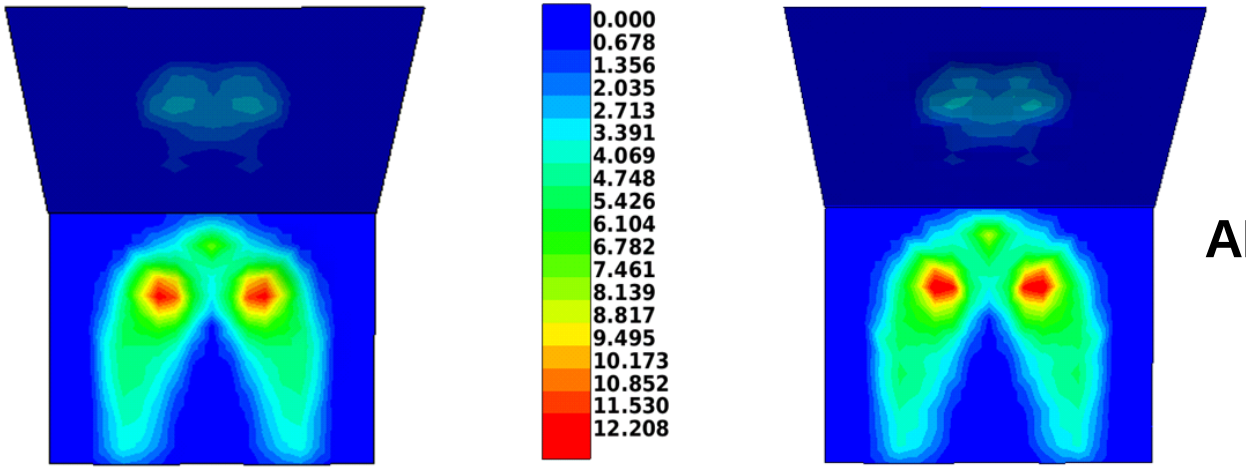


ABAQUS

Case 1 – All elastic materials

- Seat contact nodal normal force in N

LS-DYNA



ABAQUS

- Difference at the peaks of the contact normal pressure
- Almost identical results for the contact nodal normal force

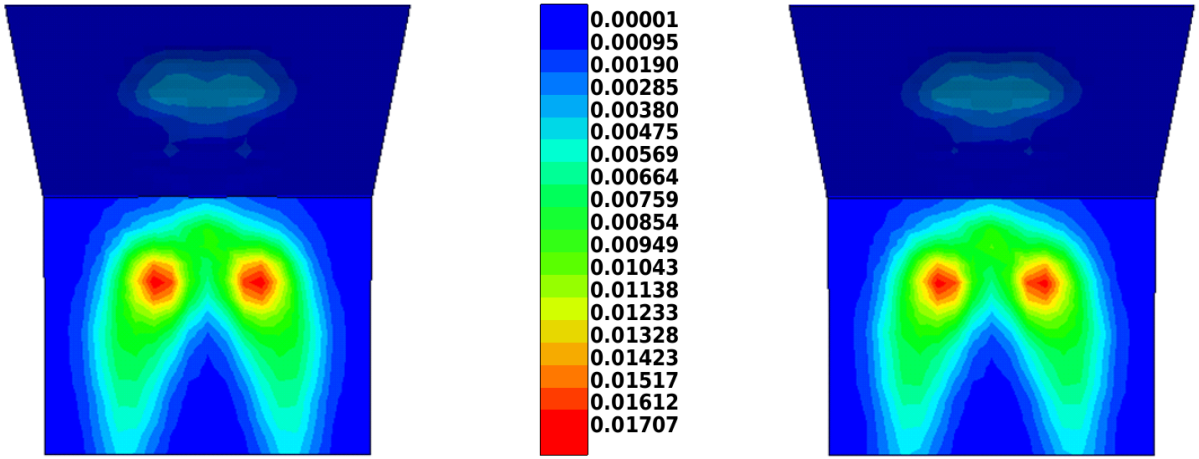
  → both solvers provide the same output

  → difference in the contact normal pressure due to not equal projection approaches of the contact definitions and due to different post-processing

Case 2 – Nonlinear pelvis tissue, linear seat foam material

- Von Mises stress distribution on the seat in MPa

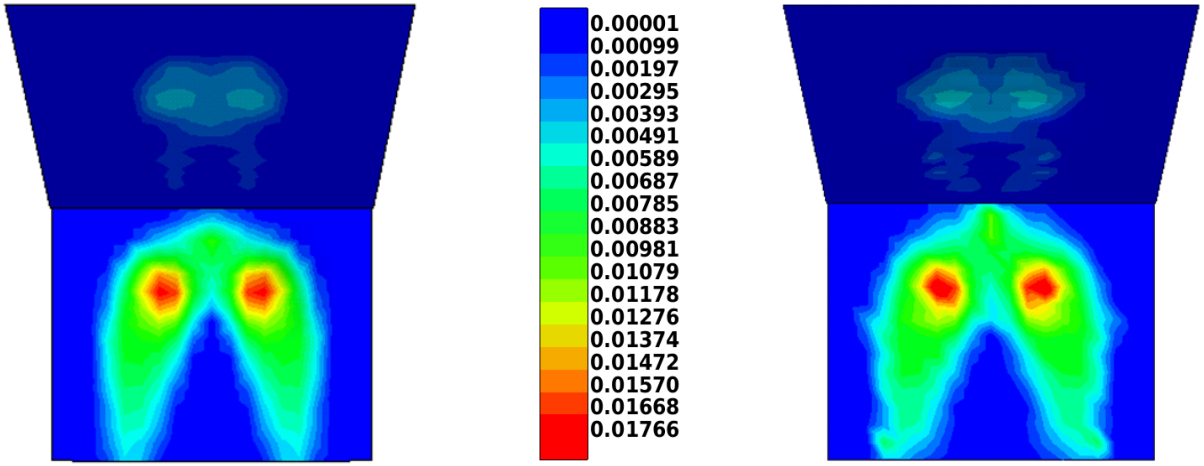
LS-DYNA



ABAQUS

- Seat contact pressure distribution in N/mm^2

LS-DYNA

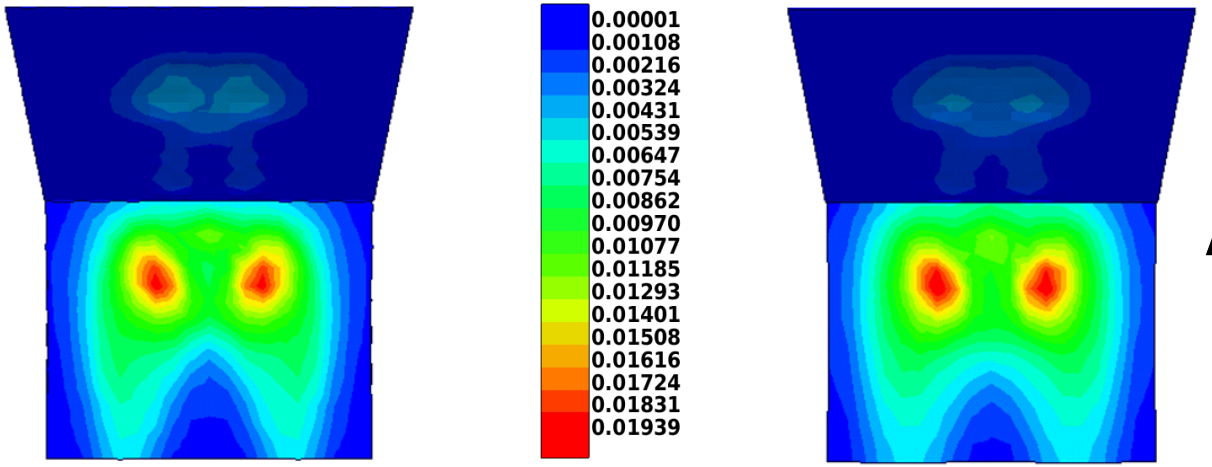


ABAQUS

Case 3 – All non-linear materials

- Von Mises stress distribution on the seat in MPa

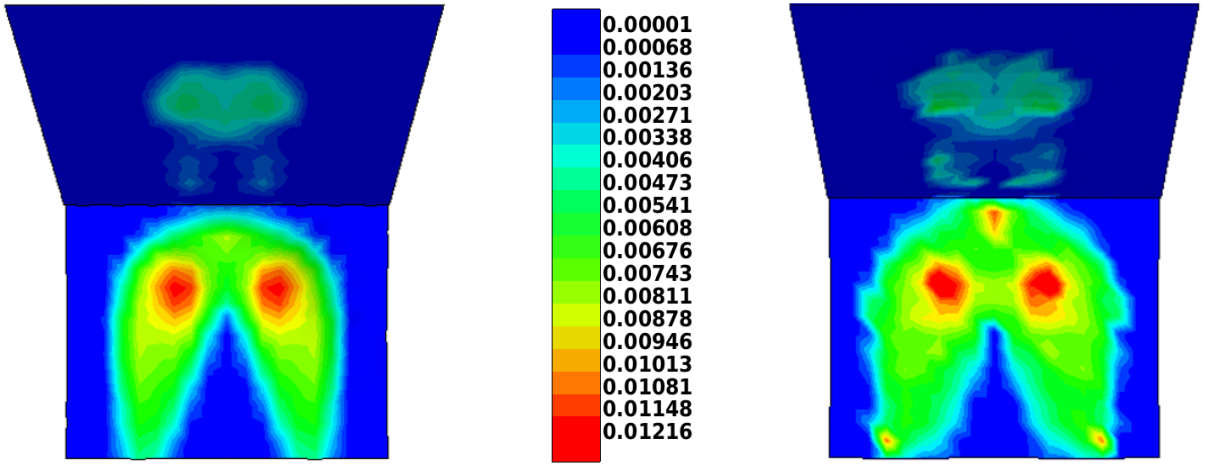
LS-DYNA



ABAQUS

- Seat contact pressure distribution in N/mm^2

LS-DYNA



ABAQUS

Eigenvalue and eigenmode evaluation

- Eigenvalues of the already seated model extracted and evaluated as further validation criteria
- Eigenmode comparison also considered as model quality check
- The first 15 eigenvalues taken into account in the range of 0 ~ 6.5 Hz
- Results of case 2 omitted due to similarity to Case 1

Eigenvalue number	LS-DYNA Frequency [Hz]	Corresponds to eigenvalue # in ABAQUS	ABAQUS Frequency [Hz]	%-deviation
1#	1.7253	1	1.8258	6
2#	1.9357	2	1.9589	1
3#	2.3016	3	2.5076	9
4#	2.5473	4	2.6895	6
5#	2.8850	6	3.3436	24
6#	3.0194	5	3.5661	11
7#	3.6048	7	3.6662	2
8#	4.0966	9	3.8916	5
9#	4.1404	8	4.2818	6
10#	4.6040	10	4.7088	2
11#	5.5026	11	5.4855	0
12#	5.8972	13	5.8922	1
13#	5.9130	12	5.9280	0
14#	6.4276	14	6.3443	1
15#	6.5237	15	6.5000	0

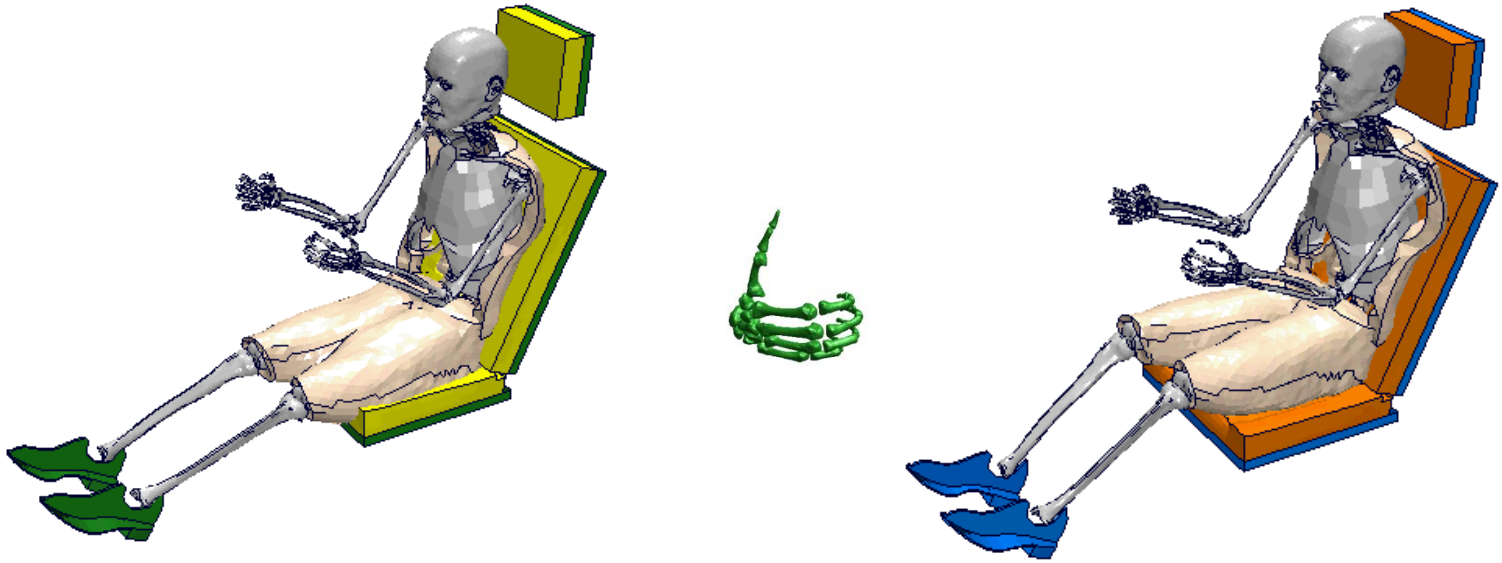
Case 1

Eigenvalue number	LS-DYNA Frequency [Hz]	Corresponds to eigenvalue # in ABAQUS	ABAQUS Frequency [Hz]	%-deviation
1#	1.7974	1	1.7516	3
2#	1.9463	2	1.8116	7
3#	2.5074	-	2.5652	-
4#	2.5312	-	2.5910	-
5#	2.9565	6	3.4318	19
6#	3.3033	5	3.5212	4
7#	3.7671	7	3.7293	1
8#	4.3467	8	4.0654	7
9#	4.5327	9	4.5315	0
10#	4.6276	10	4.8326	4
11#	5.6947	11	5.4166	5
12#	5.9603	12	5.8255	2
13#	6.0169	13	5.9114	2
14#	6.4290	14	6.3990	0
15#	6.5839	15	6.6685	1

Case 3

Eigenvalue and eigenmode evaluation

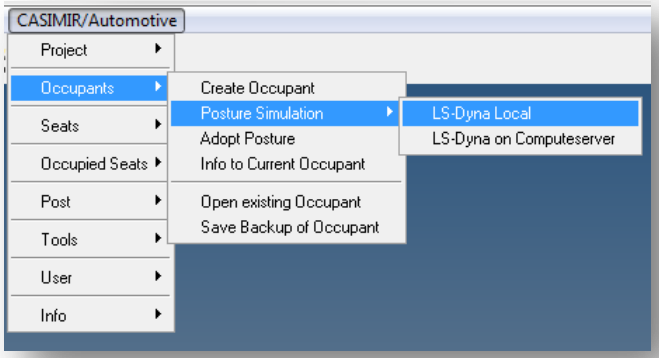
- Samples of the eigenvectors for the eigenvalue 8# near 4 Hz
- Pre-stresses and deformations considered by both solvers

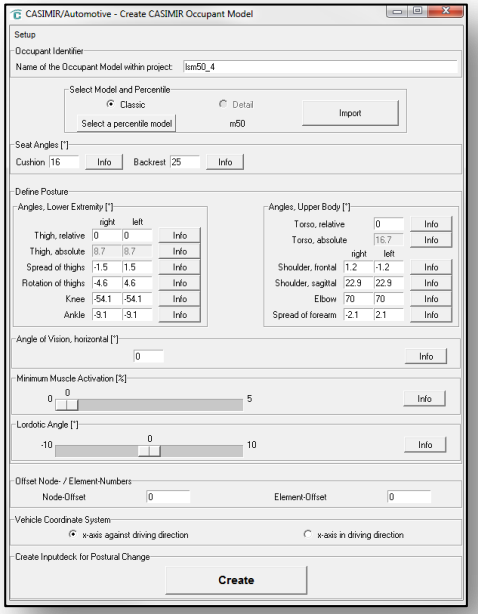


LS-DYNA **ABAQUS**

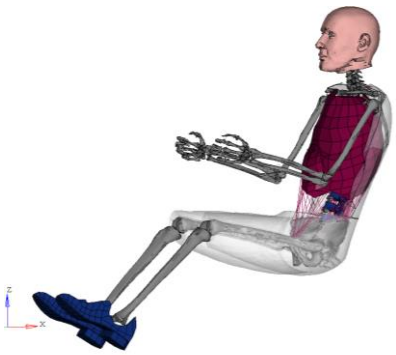
CASIMIR/Automotive for LS-DYNA

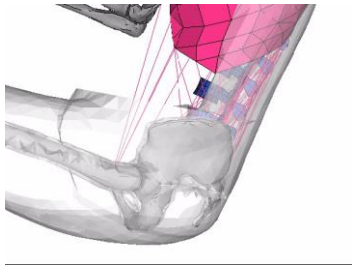
- The pre-processing is currently implemented in HyperMesh using a plugin menu





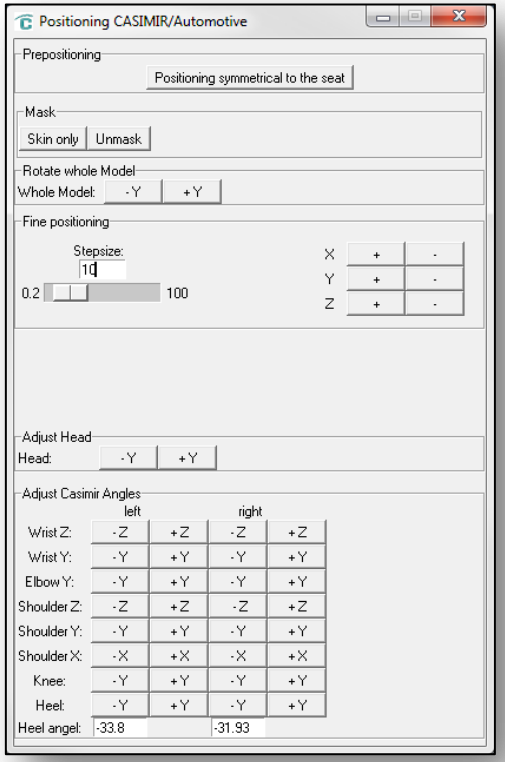
- The adaption of the posture can be carried out by the Posture Manager

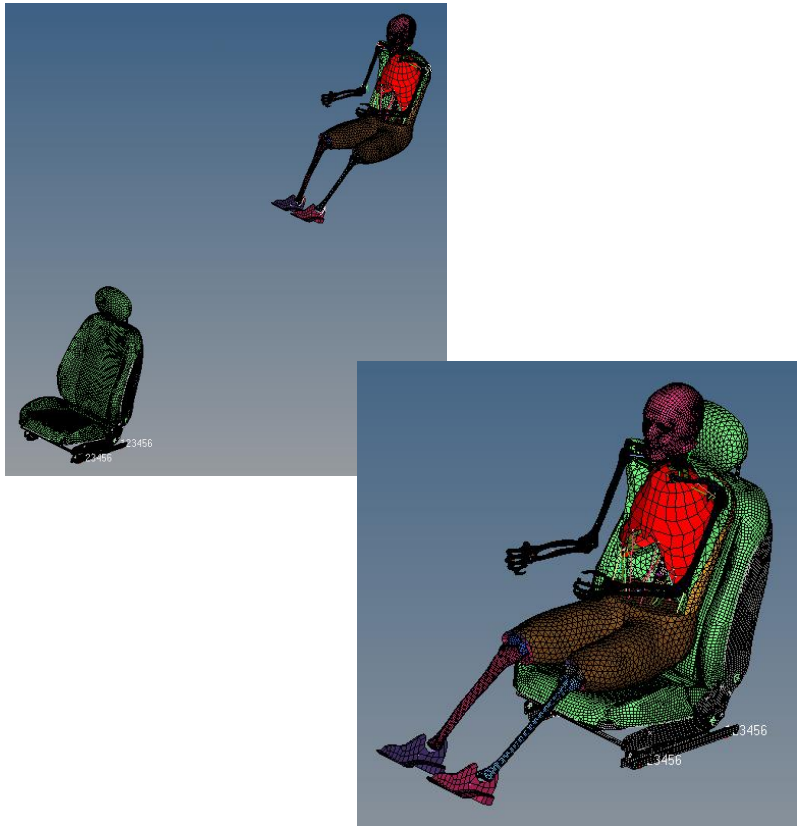




CASIMIR/Automotive for LS-DYNA

- The combination with an existing seat model is supported by the project manager in combination with a graphical user interface for positioning



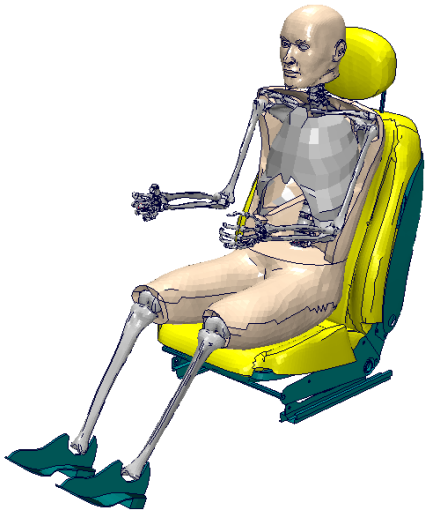


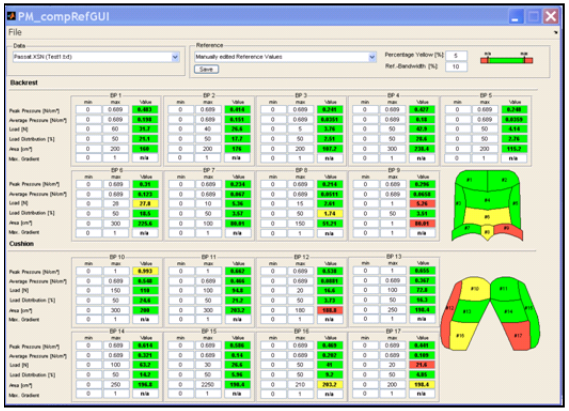
Summary

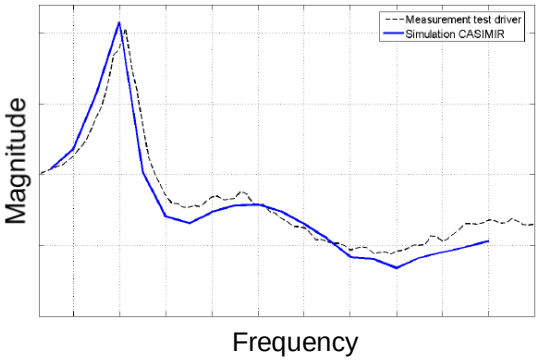
- The CASIMIR model for seating comfort simulations presented
- Human body model currently converted to LS-DYNA
- Translation and validation still in progress
- First LS-DYNA simulations with simple seat model showed good correlation to the ABAQUS results regarding:
  - Seat stress distribution
  - Seat contact pressure distribution
  - Eigenvalues respectively eigenmodes in seated position
- Both linear elastic and non-linear elastic behaviors of the seat foam respectively human body tissue considered

Outlook

- Further developments in the model conversion
  - Consideration of more complex seat models
  - Frequency dependent materials
  - Extension to pre- and post-processing tools for LS-DYNA
  - Steady state dynamic analysis



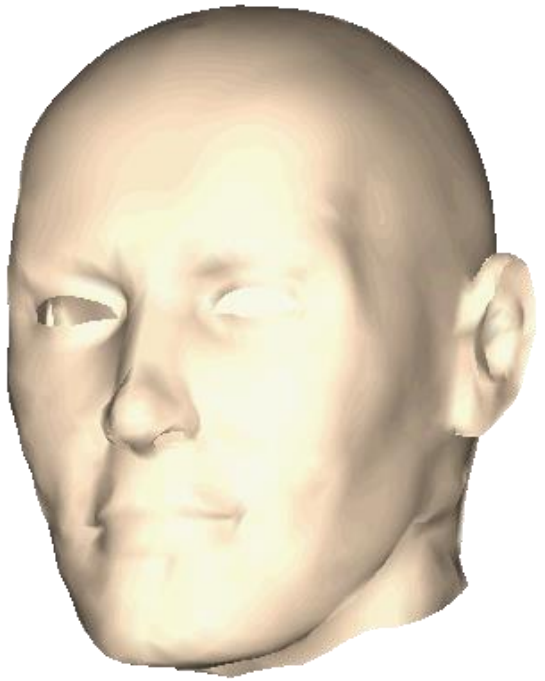




Thank you for your attention!

DYNA MORE

Your LS-DYNA distributor and more



Wölfel

Beratende Ingenieure