

The CASIMIR Model for Simulation in Seating Comfort Applications - A Status update for LS-DYNA -

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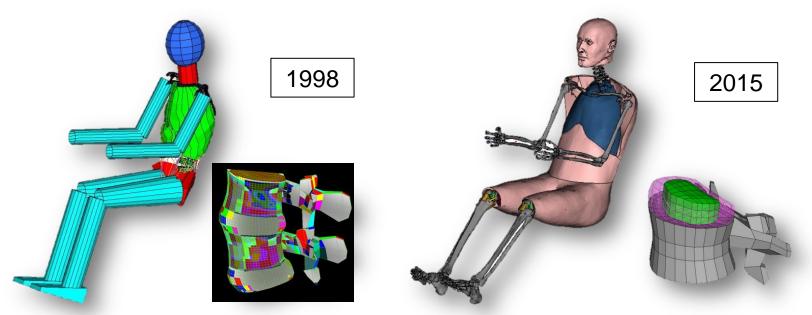




# Casimir - Human Body Model - History

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



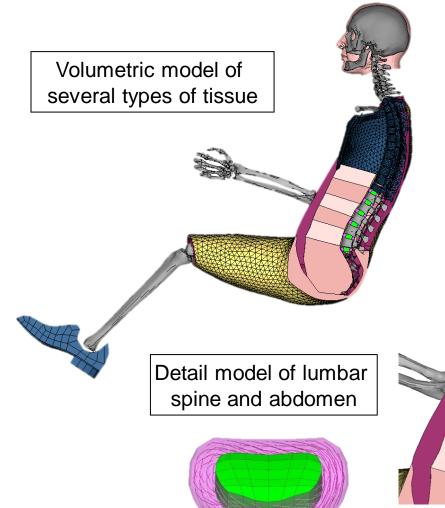
Accordingly the model included a detailed model of the lumbar spine

Step by step the range of application is enhanced with focus on applications in the automotive, commercial vehicle and aerospace industry

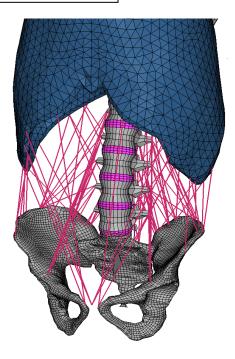




# Casimir - Human Body Model - Setup



Detailed muscle approach for stabilized posture



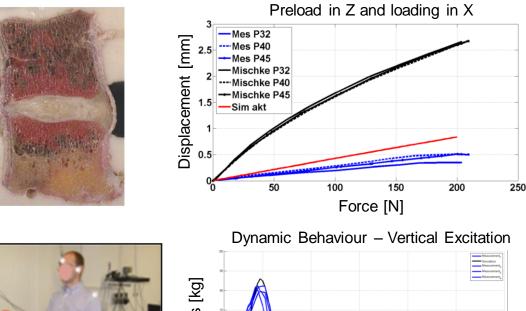




# Casimir - Human Body Model - Validation

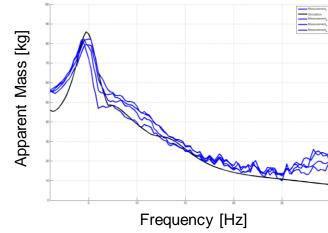
The properties of the different model parts are validated in comparison to real subject or tissue test

Validation of lumbar spine segments via data of cadaver tests



Validation of dynamic behaviour via data of test with real persons



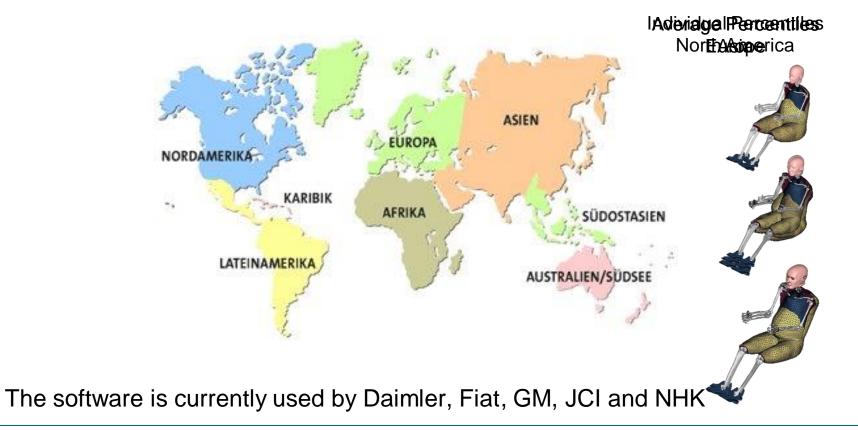






### **CASIMIR/Automotive - Overview**

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

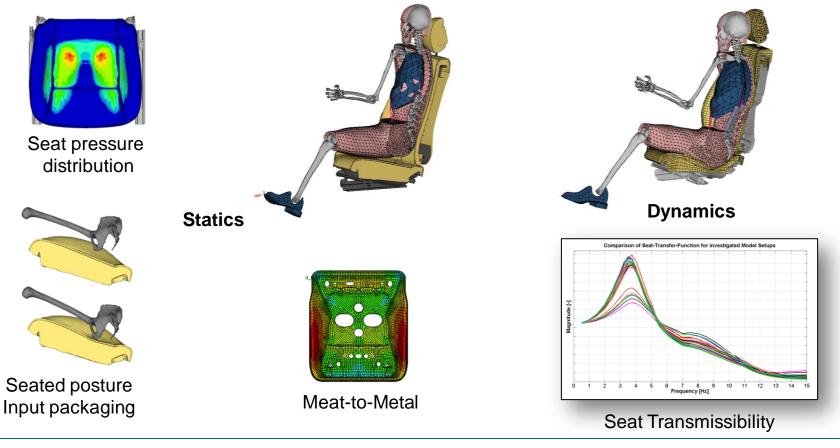






### **CASIMIR/Automotive - Objective**

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







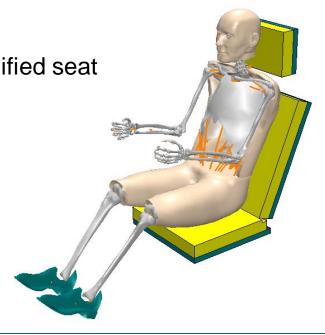
# LS-DYNA integration and validation process





# 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

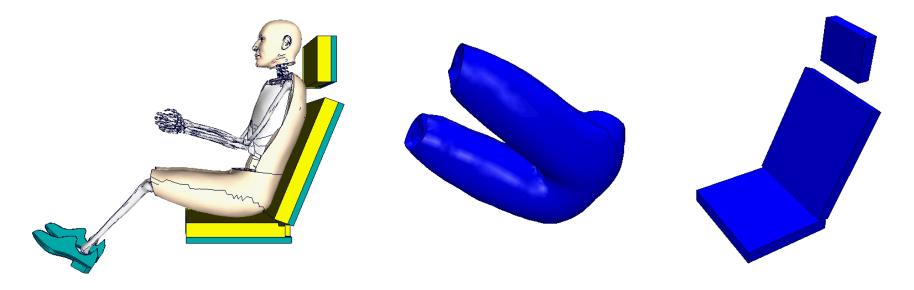






# The CASIMIR model in LS-DYNA

- 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





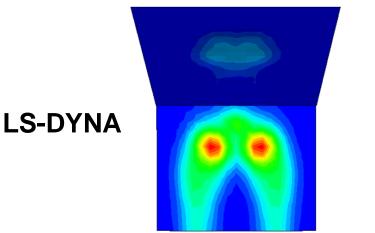


### **Case 1 – All linear materials**

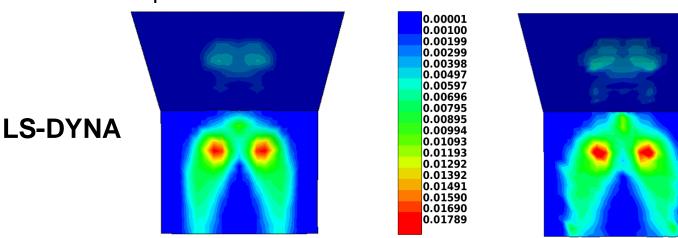
0.00001 0.00096 0.00191 0.00286 0.00381 0.00476 0.00572 0.00667 0.00762 0.00857

0.00952 0.01048 0.01143 0.01238 0.01333 0.01428 0.01524 0.01619 0.01714

Von Mises stress distribution on the seat in MPa



Seat contact pressure distribution in N/mm<sup>2</sup>



ABAQUS





### **Case 1 – All elastic materials**

Seat contact nodal normal force in N

0.678 1.356 2.035 2.713 3.391 4.069 4.748 5.426 6.104 6.782 7.461 8.139 8.817 9.495 10.173 10.8522 11.530 12.208

0.000

LS-DYNA

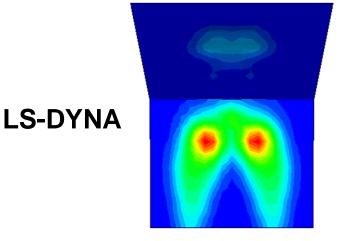
- Difference at the peaks of the contact normal pressure
- Almost identical results for the contact nodal normal force
  - $\rightarrow$  both solvers provide the same output
  - → difference in the contact normal pressure due to not equal projection approaches of the contact definitions and due to different post-processing





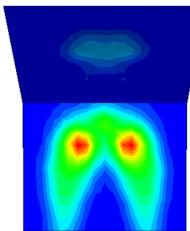
### Case 2 – Nonlinear pelvis tissue, linear seat foam material

Von Mises stress distribution on the seat in MPa



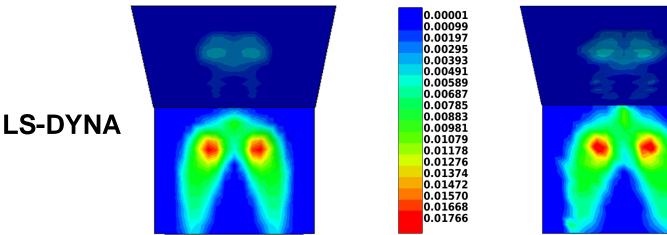
0.00095 0.00190 0.00285 0.00380 0.00475 0.00569 0.00664 0.00759 0.00854 0.00949 0.010430.01138 0.01233 0.01328 0.01423 0.01517 0.01612 0.01707

0.00001



#### ABAQUS

Seat contact pressure distribution in N/mm<sup>2</sup>

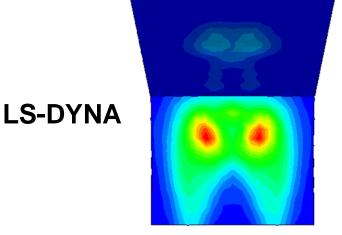




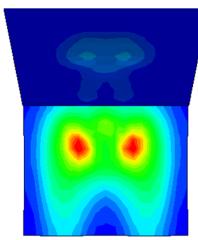


### **Case 3 – All non-linear materials**

Von Mises stress distribution on the seat in MPa

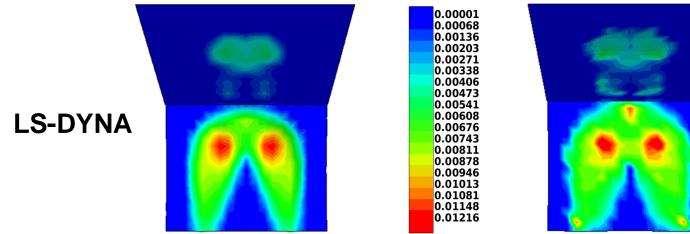


0.00001 0.00108 0.00216 0.00324 0.00431 0.00539 0.00647 0.00754 0.00862 0.00970 0.01077 0.01185 0.01293 0.01401 0.01508 0.01616 0.01724 0.01831 0.01939



#### ABAQUS

Seat contact pressure distribution in N/mm<sup>2</sup>







### 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	LS-DYNA	Corresponds	ABAQUS	%-deviation	Eigenvalue	LS-DYNA	Corresponds	ABAQUS	%-deviation
number	Frequency	to eigenvalue	Frequency		number	Frequency	to eigenvalue	Frequency	
	[Hz]	# in ABAQUS	[Hz]			[Hz]	# in ABAQUS	[Hz]	
1#	1.7253	1	1.8258	6	1#	1.7974	1	1.7516	3
2#	1.9357	2	1.9589	1	2#	1.9463	2	1.8116	7
3#	2.3016	3	2.5076	9	3#	2.5074	-	2.5652	-
4#	2.5473	4	2.6895	6	4#	2.5312	-	2.5910	-
5#	2.8850	6	3.3436	24	5#	2.9565	6	3.4318	19
6#	3.0194	5	3.5661	11	6#	3.3033	5	3.5212	4
7#	3.6048	7	3.6662	2	7#	3.7671	7	3.7293	1
8#	4.0966	9	3.8916	5	8#	4.3467	8	4.0654	7
9#	4.1404	8	4.2818	6	9#	4.5327	9	4.5315	0
10#	4.6040	10	4.7088	2	10#	4.6276	10	4.8326	4
11#	5.5026	11	5.4855	0	11#	5.6947	11	5.4166	5
12#	5.8972	13	5.8922	1	12#	5.9603	12	5.8255	2
13#	5.9130	12	5.9280	0	13#	6.0169	13	5.9114	2
14#	6.4276	14	6.3443	1	14#	6.4290	14	6.3990	0
15#	6.5237	15	6.5000	0	15#	6.5839	15	6.6685	1

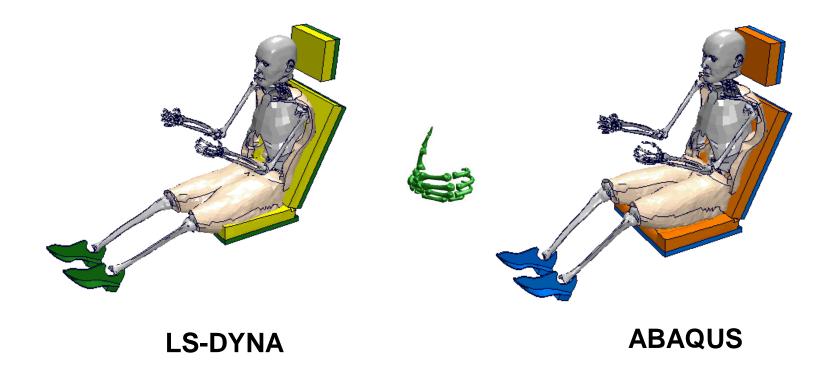






### **Eigenvalue and eigenmode evaluation**

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

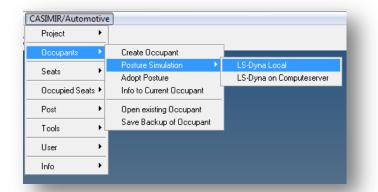






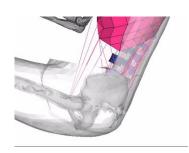
### **CASIMIR/Automotive for LS-DYNA**

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





Setup Occupant Ider	viñer								
Name of the C	lccupant N	dodel within proj	ect Ism5	0_4					
	Select M	odel and Percen	tile						
		<ul> <li>Classic</li> </ul>		C Detail		frogmi			
	Selec	t a percentile mo	del	m50					
Seat Angles (*									
Cushion 16	Ir	nfo Backre	st 25	Info					
Define Posture									
Angles, Lowe		m			-Angles, Upper Body	m			
		ight left			Torso, relativ	0	Info		
Thigh, relative 0 0			Info		Torso, absolu	16.7	Info		
Thigh, abs			Info			right	left		
Spread of t Rotation of t	-		Info		Shoulder, frontal Shoulder, sagittal	1.2	-1.2	Info	
	highs  -4. Knee  -54		Info		Shoulder, sagittal Elbow		22.9	Info	
Ankle -9.1 -9.1			Info		Spread of forearm		21	Info	
Angle of Visio	n, horizont	al [*]						Info	
								info	
Minimum Mus	cle Activat N	ion [%]							
0				5				Info	
Lordotic Angle	- m								
-10		0		10				Info	
Difset Node- /	Element-N	lumbers							
Node-I	Offset	0			Element-Offset		0		
Vehicle Coord	inate Svste	m							
		against driving o	firection		C x-axis	in driving	direction		
Create Inputde	eck for Pos	stural Change							
				0	1				
				Create					





### **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

Positioning CASIMIR/Automotive     Prepositioning     Positioning symmetrical to the seat     Mask     Skin only Unmask     Rotate whole Model     Whole Model     ·Y + Y     Fine positioning	
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	
Knee:         -Y         +Y         -Y         +Y           Heet         -Y         +Y         -Y         +Y           Heel angel:         -33.8         -31.93	3456





### 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

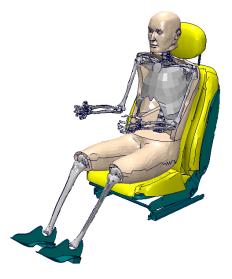




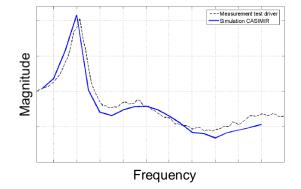
# Outlook

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



PM_compF	(ero)																
File																	
Data					Referenc												
Passet XSN (Test) 1:d)						Manually edited Reference Values							Percentage Yelow [%] 5 **				
						Seve							Ref-Bandwidth (%) 10				
Backrest																	
		EP 1			1P 2 1P 3							DP 4 DP 5					
	min	max	Value	min	max	Value	nin	max	\due	min	max	\alue	min	max	Value		
Peak Pressure (N/Um?)	0	0.609	0.483	0	0.609	8.414	0	0.609	8.241	0	0.609	9.427	0	0.689	0.248		
Average Pressure [Nitm*]	0	0.689	0.198	0	0.689	8.151	0	0.689	0.0351	0	0.689	0.10	0	0.689	4.8359		
Load (N)	0	60	31.7	0	40	26.6	0	- 5	3.76	0	50	42.8	0	50	4.14		
Load Distribution [1]	0	50	21.1	0	50	\$7.7	0	50	2.54	0	50	28.6	0	50	2.76		
Ana (un?)	0	200	160	0	200	176	0	200	587.2	0	300	238.4	0	290	115.2		
Max. Gradient	0	1	nie	0	1	mia	0	1	nie	0	1	nia	0	1	nia		
		EP 6			EP 7-			EP 8			EP 9		-		_		
	min	max	\Mue	min	max	\due	min	max	Value	min	max	Value					
Peak Pressure [Nilon*]	0	0.609	0.31	0	0.609	8.234	0	0.609	6.214	0	0.669	0.296					
Average Pressure (Nitm?)	0	0.689	8.123	0	0.689	0.067	0	0.669	0.0511	0	0.669	0.0658					
Load (N)	0	28	27,8	0	10	5.36	0	15	2.64	0	1	5.26					
Load Distribution [1]	0	50	18.5	0	50	3.57	0	50	1.74	0	50	3.51		#5			
Ana (uni)	0	300	225.6	0	100	80.81	0	150	51.21	0	1	88.91		-	82		
Max. Gradient	0	1	nie	0	1	nie	0	1	mia	0	1	mit					
Cushion													-	~	-		
		- EP 10-			DP 11-			EP 12-			BP 13						
	min	-	Value	min	max	Value	nin	max	\alue	- min	max	Value					
Peak Prezoure (Nilon')	0		8.593	0	1	0.662	0	0.609	0.538	0	0.609	0.055	-	_	_		
Average Prezoure (Nitom?)	0	0.689	0.548	0	0.609	8.466	0	0.609	0.0001			0.367		F10			
Load [N]	0	150	110	0	100	94.8	0	20	16.6	0	100	72.8			· 11		
Load Distribution [%]	0	50	24.6	0	50	21.2	0	50	3.73	0	50	96.3			-1		
Ansa (um?)	0	300	200	0	300	203.2	0	180	188.8	0	250	198.4			- MA - 1		
Mex. Gradient	0	1	n'a	0	1	nia	0	1	nia	0	1	mb		<b>-</b>			
	-	BP 14-	Whee	-	BP 15-	Value	nin	EP 16	Value	min	- BP 17-	Value		/	#17		
Park Pressore (Nilon')	0	0.609	8.614	-	0.609	8.586	0	0.609	8.65	0	0.609	8.64	· · · /				
Average Pressure (Niture)	-	0.609	8.321		0.609	8.14	0	0.609	4.292	0	0.609	8.103	-		_		
Lord INI		100	63.2	0	30	28.4	0	50	- 41	0	20	21.6					
Load Distribution (%)	-	50	14.2	0	50		0	50	-	0	50	4.85					
dena lom"		250	196.8		2250	198.4	0	210	281.2	0	200	198.4					







# Thank you for your attention!

