WorldSID Dummy Model Development in Cooperation with German Automotive Industry

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WorldSID^{50th} Dummy Model Development in Cooperation with German Automotive Industry

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1st October 2008

Content

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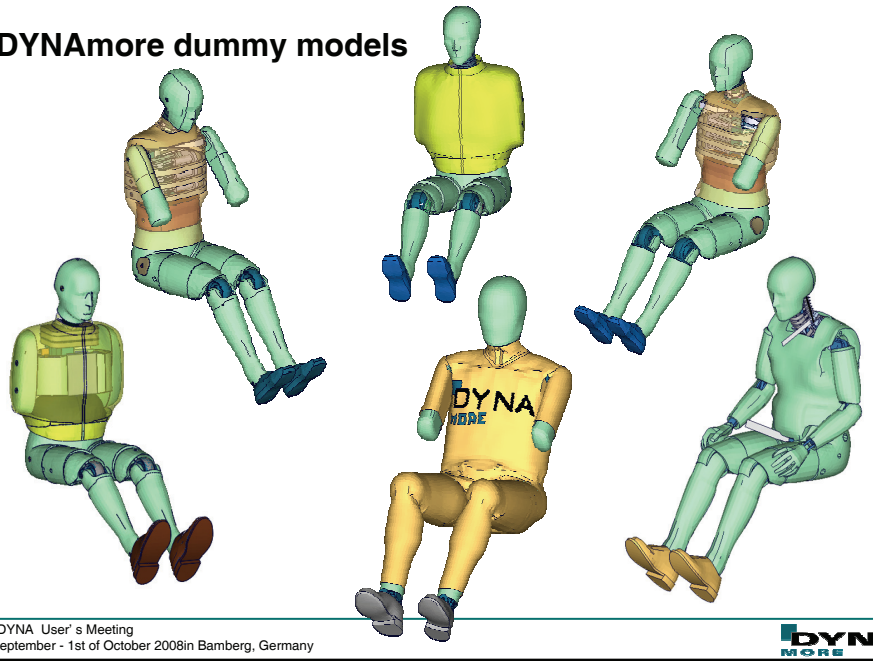
Introduction

DYNAmore dummy models



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Introduction

The FAT

- FAT is abbreviation for:

  German Association for Research on Automobile Technology
- FAT is part of the VDA
- VDA is: German Association of the Automotive Industry
- FAT was founded in 1971 to join scientific research for members
- VDA and FAT are located in Frankfurt
- Members:
  - OEMs: Audi, BMW, Daimler, Opel, Porsche, Volkswagen
  - Supplier
- Many working groups on different automotive research issues

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Introduction

The PDB and its work

- **P**artnership for **D**ummy Technology and **B**iomechanics
- Members

- Task
  - Providing a WSID 50th finite element model for the crash codes used by the members
  - Similar to known FAT projects
- Project budget over 1 100 000 $

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- Introduction
- **Hardware test database**
  - Material tests
  - Component tests
- Introduction of WSID 50th Version 0
- Dummy validation in selected tests
  - Sled tests
  - Barrier design
  - Abdomen calibration
- Conclusion

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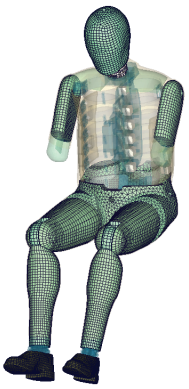
Hardware test database

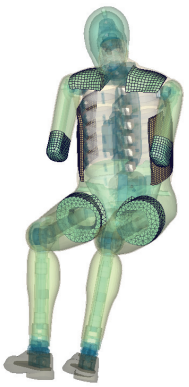
Material of the WorldSID

- Majority of the materials is rubber or rubber-like
- Very few foam parts
- Plastics
- Neoprene
- Nitinol
- Rib damping material
- Aluminum
- Steel

Rubber parts



Foam parts



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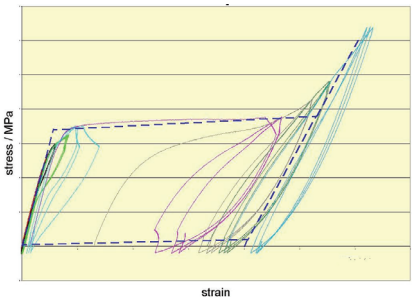
Hardware test database

Material tests

- Rubber materials:
  - *MAT_SIMPLIFIED_RUBBER
  - Stress-strain table, unloading curve
- Foam materials:
  - *MAT_FU_CHANG_FOAM
  - Stress-strain table, unloading cure
- Nitinol:
  - Shape Memory alloy
  - *MAT_SHAPE_MEMORY
  - 4 corner points



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Hardware test database

Material tests

- Tested materials
  - Rubbers, foams, Vinyl, Nitinol, rib damping material, Neoprene, …

- Test types:
  - Static tension and compression
  - Dynamic tension and compression (0.001 1/s, 20 1/s,100 1/s, 400 1/s)
  - For rubber-like materials additional compression tests with constrained lateral expansion

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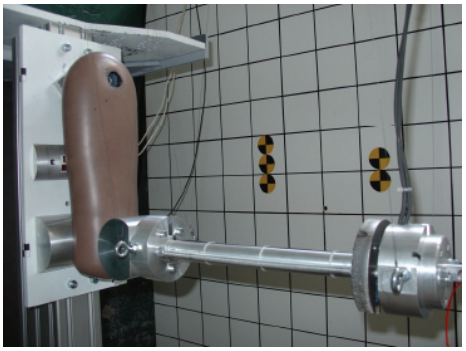
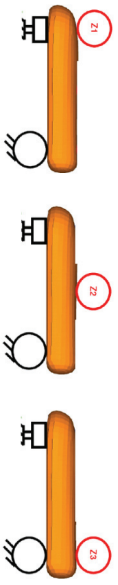
Hardware test database

Arm tests

- Impactor test
- 3 different impact positions
- 2 different impactor masses





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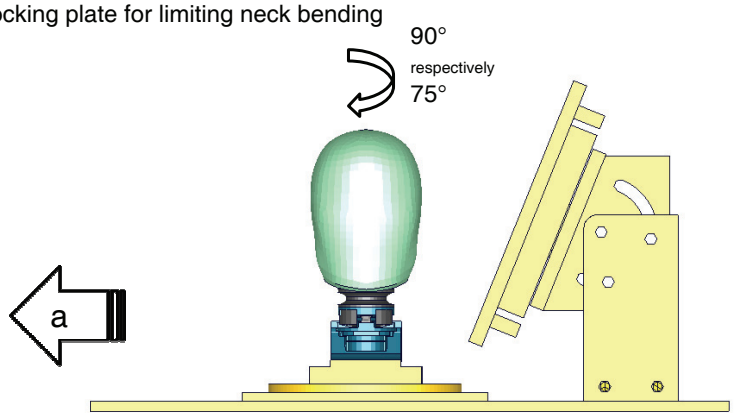
Hardware test database

Head and neck assembly test

- Sled test
- Different pulses and pulse directions
- Blocking plate for limiting neck bending



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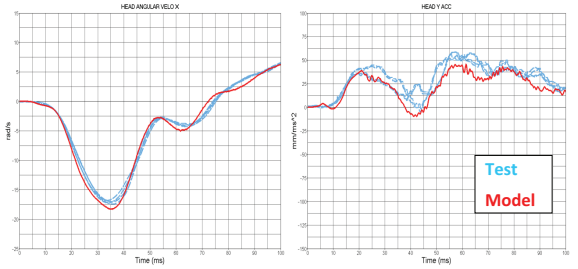
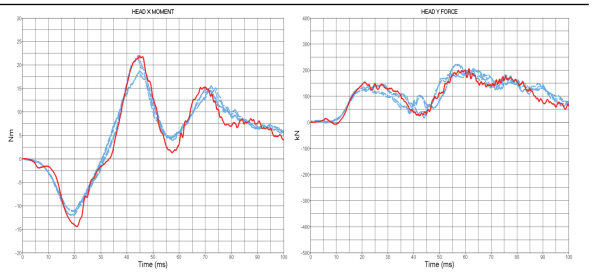
Hardware test database

Neck test example: 20 g – 75 degrees

- Head angular velocity about x-Axis (left) and y-accleration (right)



- Upper neck load cell x-momentum (left), y-Force (right)



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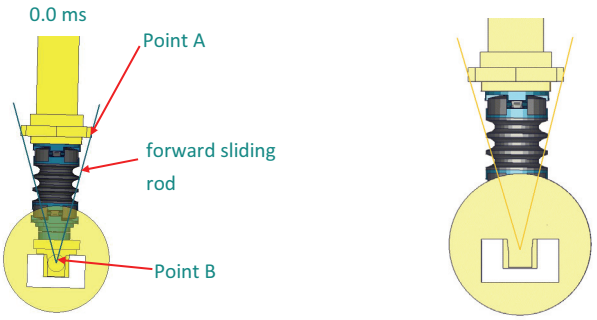
Hardware test database

Neck calibration test

- Neck column with buffers and upper neck load cell
- Pendulum with honeycomb breaking system
- Evaluation of angles, acceleration, forces and momentum



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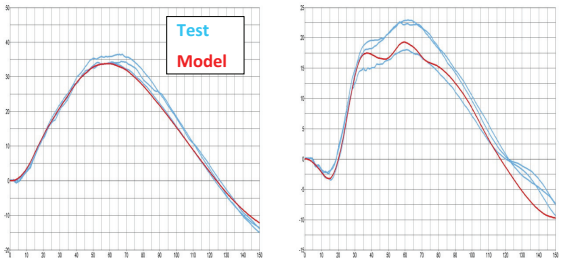
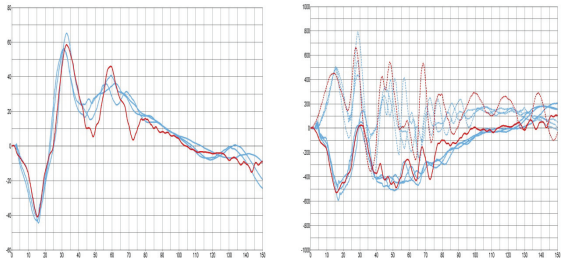
Hardware test database

Neck calibration test

- Angular displacement about A (left) and B (right)



- Upper neck load cell x-momentum (left), y-Force (right, solid) and z-Force (right, dotted)



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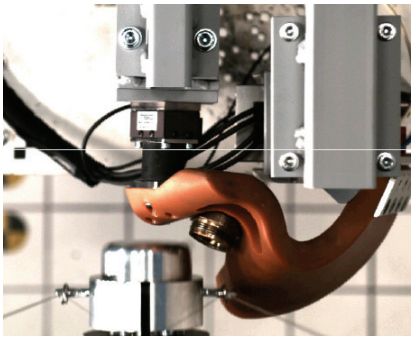
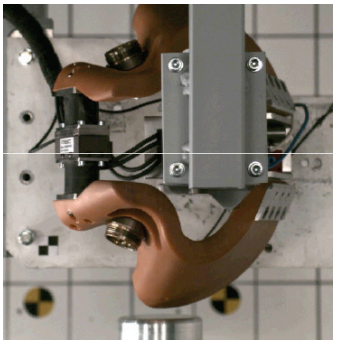
Hardware test database

Iliac wing test

- Pendulum test
- Test configuration with complete inner pelvis assembly
- Sacrum block is fixed
- 2 impact positions





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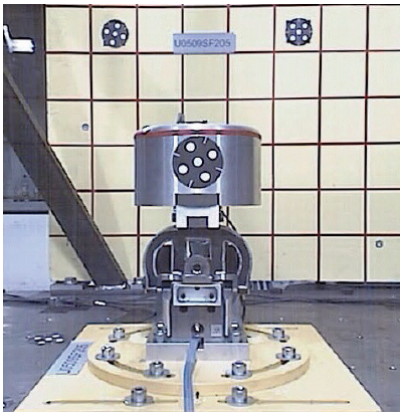
Hardware test database

Lumbar spine test

- Sled test
- Similar to head and neck assembly test
- Mass replacement for the upper torso
- Different pulses



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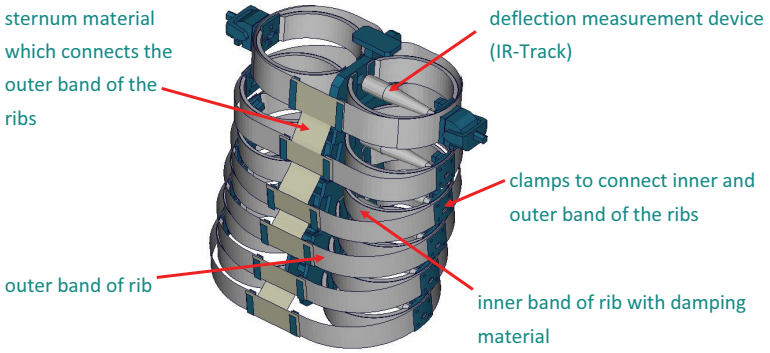
Model validation

Rib assembly tests

- 1 shoulder, 3 thorax and 2 abdomen ribs
- Inner and outer rib bands consist of shape memory material Nitinol



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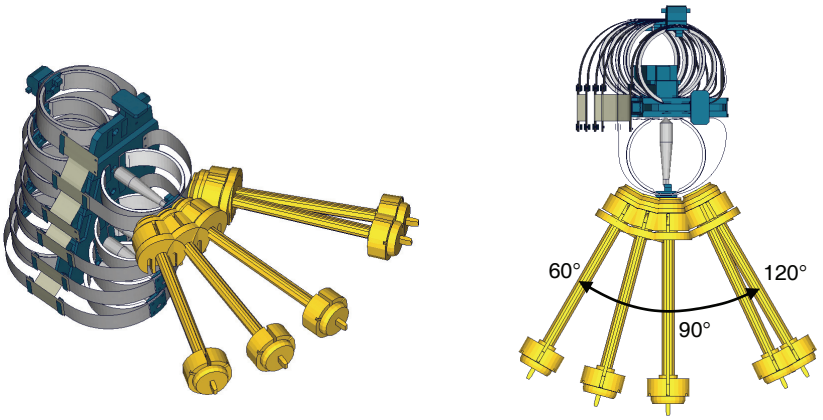
Model validation

Rib assembly test matrix

- Pendulum: 2 different masses, 3 different impact velocities
- Number of tests: 4 ribs x 3 velocities x 2 masses x 5 angles = 120 load cases



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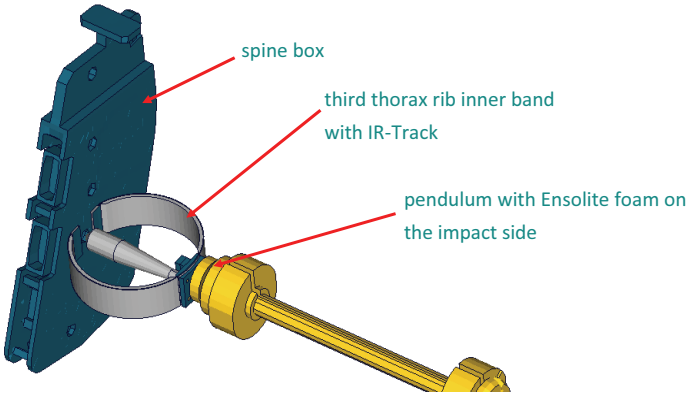
Model validation

Rib assembly tests – an example

- Separate validation of the inner rib band due to complex behavior
- Test configuration:



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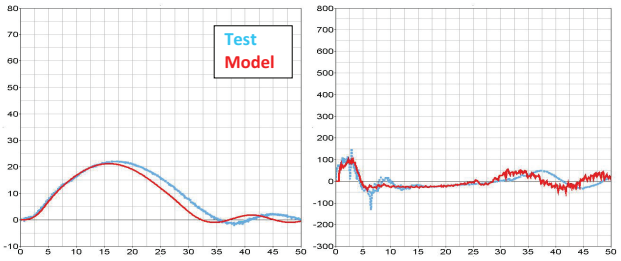
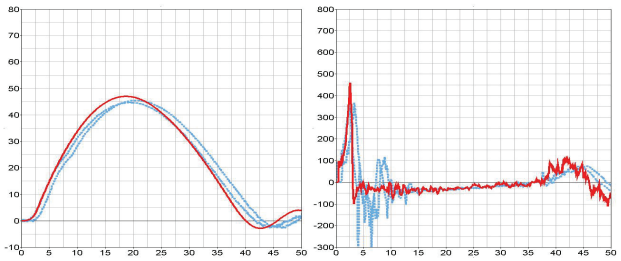
Model validation

Rib assembly tests

- Rib component test at 3.5m/s pendulum velocity; deflection [mm] (left), acceleration [g] (right)



- Rib component test at 6.0m/s pendulum velocity; deflection [mm] (left), acceleration [g] (right)



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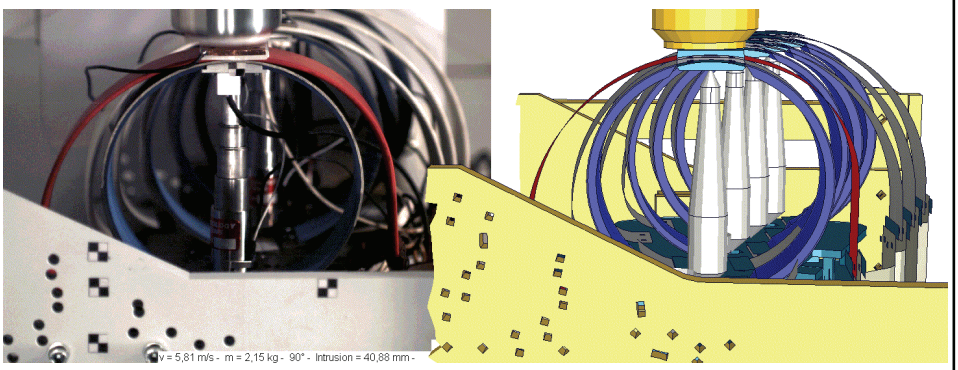
Model validation

Rib assembly tests – an example

- Test of a thorax rib assembly



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  - Component tests
- **Introduction of WSID 50th Version 0**
- Dummy validation in selected tests
  - Sled tests
  - Barrier design
  - Abdomen calibration
- Conclusion

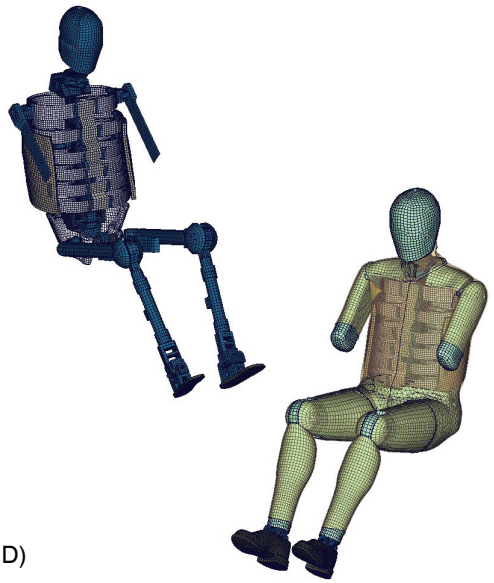
Introduction of WSID 50th Version 0

WSID 50th model overview

- Based on the CAD data of ISO 15830/2005
- Model size:

	WSID	ES2re
Nodes	~135000	~100000
Shell	~97500	~95000
Hexa	~64200	~25000
Tetra	~40000	~140000
Parts	~560	~250

- Very few tetrahedron elements
- 54 sensor signals extractable
- Uses FAT material data (ES2, BioRID)



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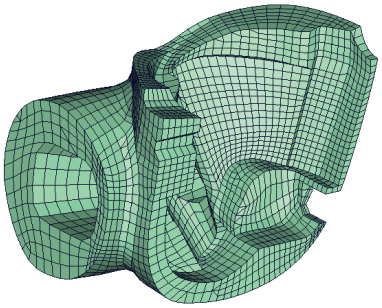
Introduction of WSID 50th Version 0

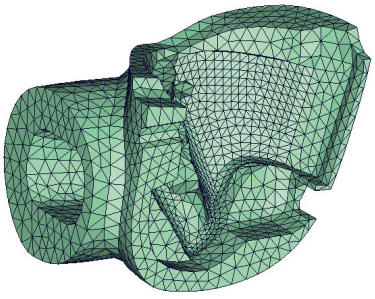
WSID 50th model development

- Element length between 4mm to 7mm
- Model time step: 1 microsecond
- Reducing CPU time by meshing pelvis flesh with hexaedrons

~13 000 hexas



~40 000 tetras



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Introduction of WSID 50th Version 0

WSID 50th model development

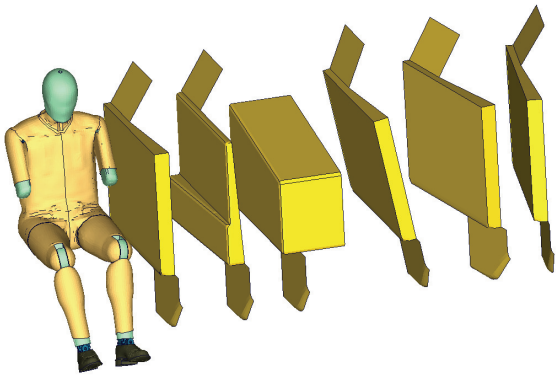
- Project was launched in 2006
- Monthly workshop meetings
- 2.5 engineers are currently working on the WSID development
- Milestones:
  - September 2007: complete mesh of the WorldSID is available
  - April 2008: Version 0 is finished
  - November 2008: first real production release will be available
  - Following years: updates
- Complete dummy development on LS-Dyna 971.R2

Content

Dummy validation

Sled tests

- For the investigation of component interaction sled tests are necessary
- Many of the ES2 barriers are used for the WSID development



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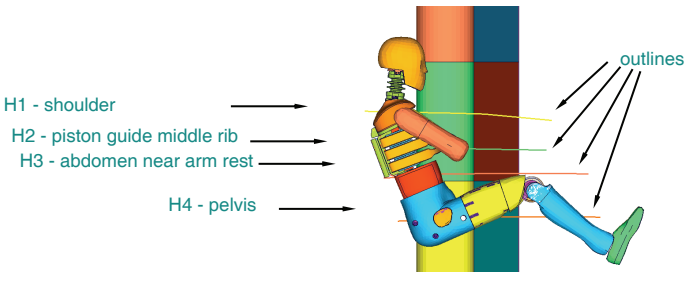
Dummy validation

Sled tests – new barrier design

- Additional barrier
- Due to FMVSS214 oblique pole test a new barrier shape was developed
- Typical intrusion profiles of all PDB members were collected



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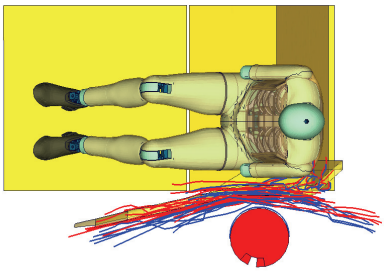
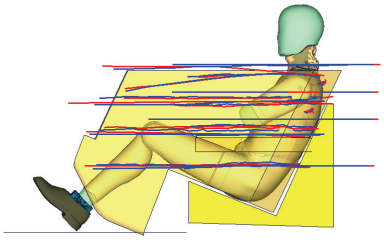
Dummy validation

Sled tests – new barrier design

- Wooden barrier with simplified shape generated out of the outlines
- Design supported by pre-simulations using the ES2-Dummy model
- Adjustment of heights and edge characteristics with respect to real crash scenarios

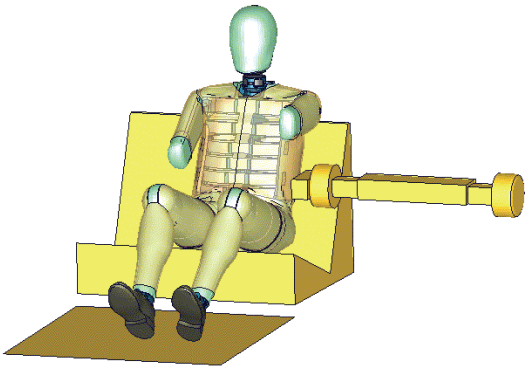




Dummy validation

Abdomen calibration test

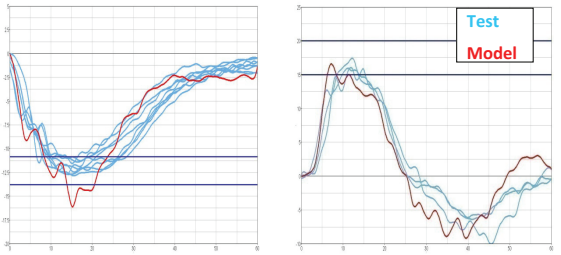
- Simple pendulum test
- Dummy sits fully assembled with jacket on the WSID bench
- Pendulum mass 24.4kg, velocity 4.3m/s



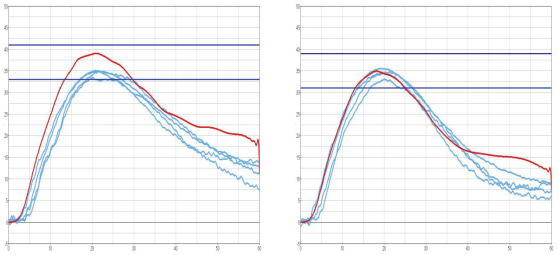
Dummy validation

Abdomen calibration test

- Pendulum acceleration [g] (left) , T12 acceleration [g] (right)



- Upper abdomen rib deflection [mm] (left), lower abdomen rib deflection [mm] (right)



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Conclusion

- A large number of hardware and material test are defined
- Despite of a moderate number of elements the WSID 50th LS-Dyna model captures the hardware geometry very well
- More tests (sled, component) will be defined by using the experience from the Version 1 dummy model
- Version 1 of WSID 50th will be released in the fall of 2008
  - All material data from the tests will be included
  - Validation based on the first series of component tests
- Available at your local distributor

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