LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

THUMS User Community

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Agenda

1. What is THUMS User Community ?

    a. Background
    b. Motivation
    c. Aims and Objectives

2. Process to THUMS TUC

3. Validation Catalogue A - results

Project Partners

Core Partners

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

Associated Partners

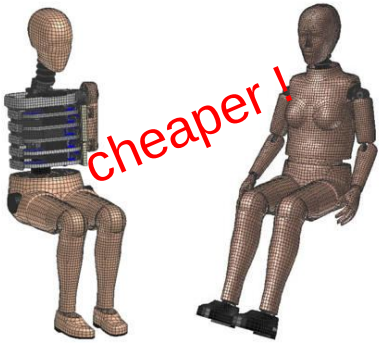
bast, pdb Partnership for Dummy Technology and Biomechanics, virtual vehicle

Subcontractor

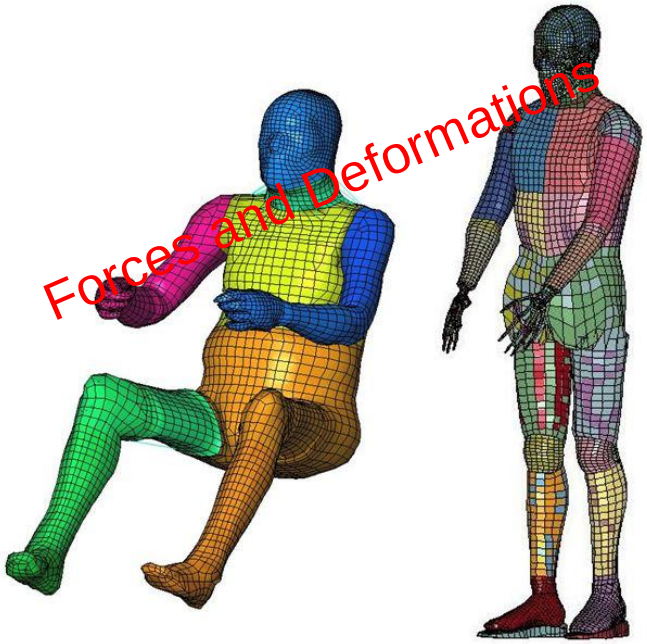
esi get it right, DYNA MORE

Background

Chrashtest Dummy Family: Hybrid III



Virtual Dummy-Models

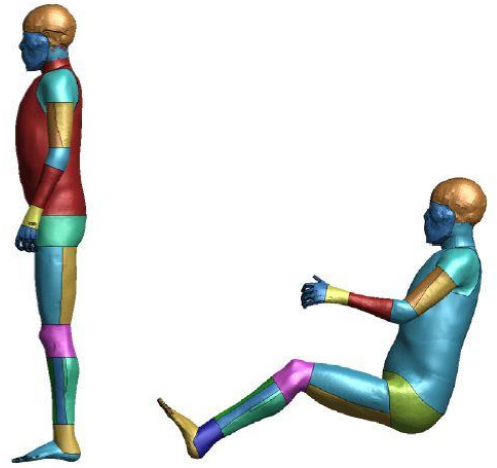


Finite-Element Human Body Models (HBM)
HUMOS (EU Project) and THUMS 3 (TMC)

Multi-Body Model Madymo von (TNO)

Finite-Element Human Body Models

- ✓ Based on real geometries gathered from CT or MRI scans
- ✓ Definition of material models and parameters (e.g. Young's Modulus)
- ✓ Gain in importance in the field of passive safety
- ✓ Several advantages of HBMs towards Dummies:
  - ✓ High biofidelity
  - ✓ Simulation of stress and strain distribution within tissues
  - ✓ Estimation of injuries possible, e.g. rib fracture, injuries of internal organs
  - ✓ Influence of muscle activity



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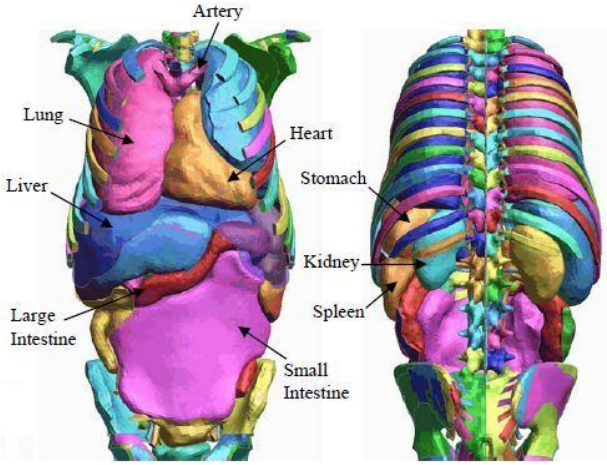

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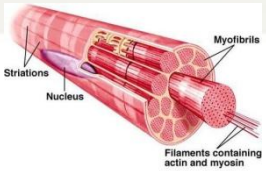
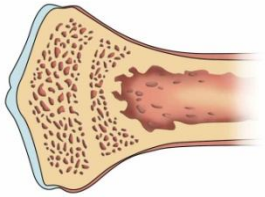
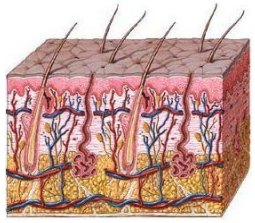
Human Models: Challenges

Biological Materials

non-linear
viscoelastic
anisotropic



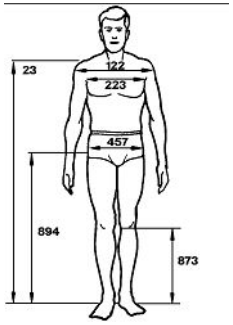


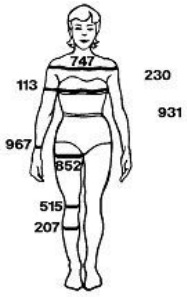


Complex Geometries

Anthropometric Diversity

Children
Men/ Women
Elderly

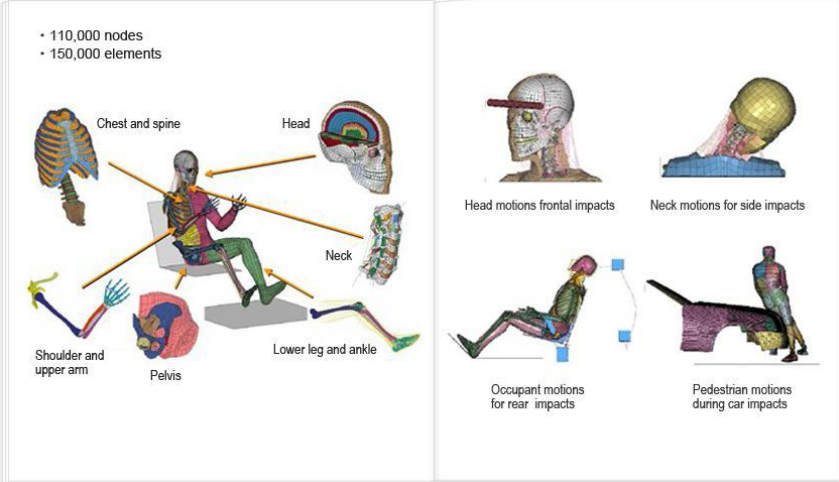




Different impact scenarios:

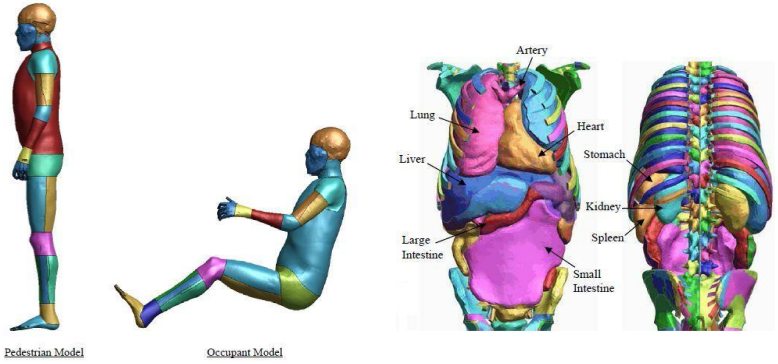
e.g. frontal/ lateral
Interaction between occupant and belt/ airbag

THUMS
Total HUman Model for Safety



THUMS version 3 (© JSOL Corporation)

- FE Human Model
- Developed by Toyota Motor Corporation and Toyota Central R&D Labs
- Human-like behaviour in crash
  - Human-like kinematics
  - Realistic loading representation in crash
- Representing American male body 50th percentile size (175cm, 77kg)
- Available in different versions



THUMS version 4 (© JSOL Corporation)

Injury Mode	Version 1	Version 3	Version 4
Fracture and Tendon rupture	Yes	Yes	Yes
Brain damage	No	Yes	Yes
Organ damage	No	No	Yes

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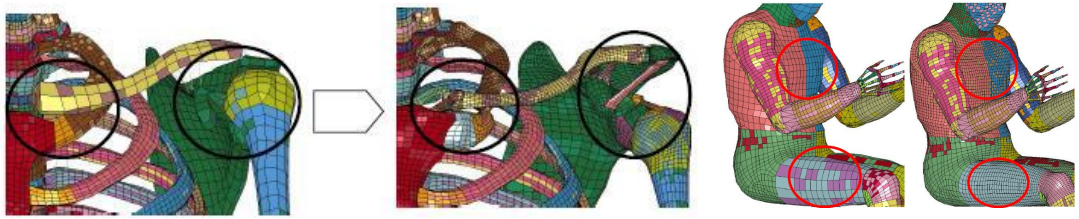
Used within THUMS User Community

Motivation

- Common motivation and interest of project partners to constantly improve vehicle and traffic safety
  - Implementation of HBMs as tool for the evaluation of passive safety systems

- Harmonisation, provision and maintenance of THUMS in 3 different codes (DYNA, VPS, Abaqus)
  - No uniform model available among project partners
    - THUMS was further developed by several project partners
      - Daimler: shoulder, improved mesh



© Daimler AG

© Daimler AG

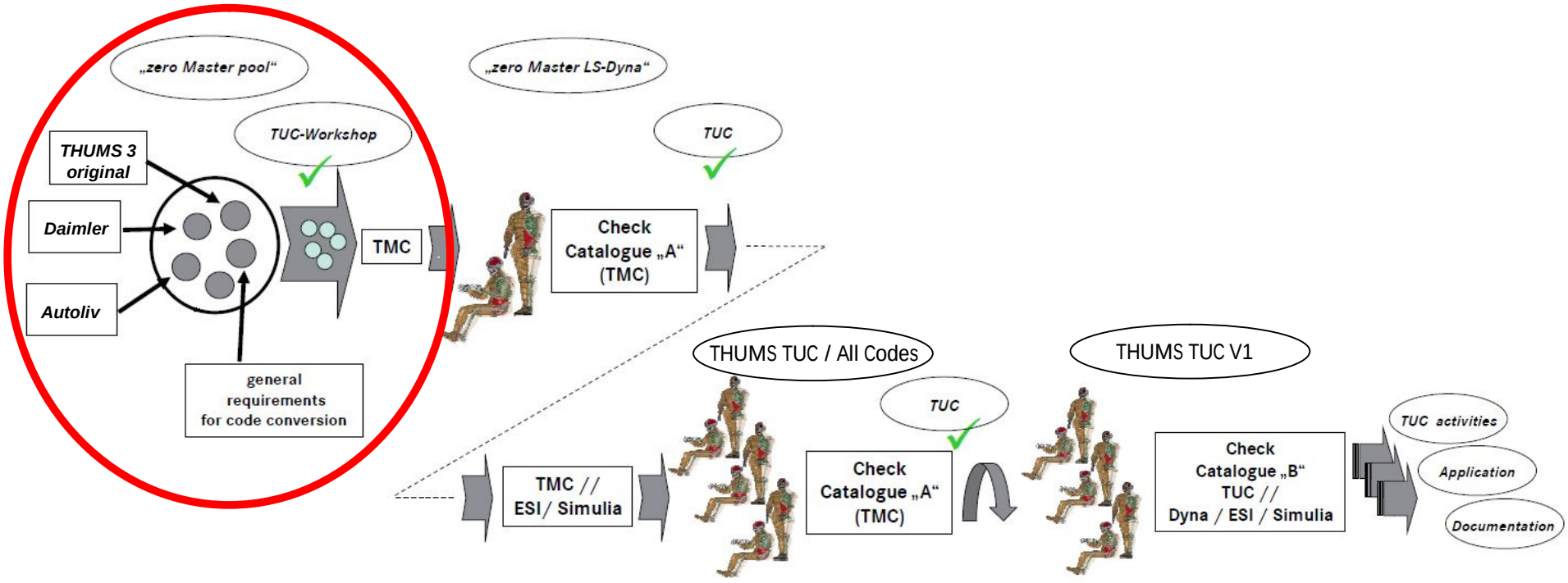
      - Autoliv: thorax

Aims and Objectives

Harmonisation, provision and maintenance of a FE – Human Body Model for vehicle and traffic safety application

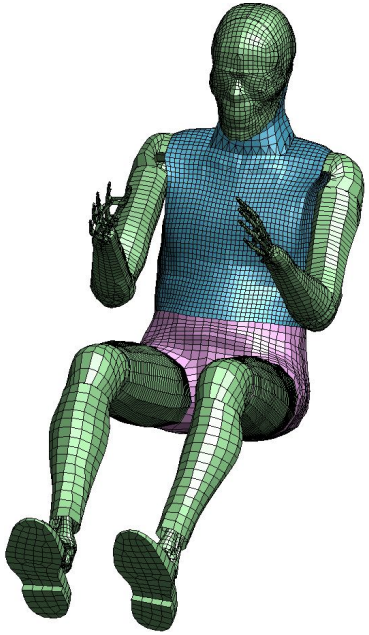
- ✓ Safeguarding effective and robust usability of THUMS by implementation of a dedicated tool management, support and documentation.
- ✓ Initiation of further research activities to improve biomechanical model quality and validity.
- ✓ Exchange and documentation of research results and initiation of further research activities
- ✓ Set up a platform to share and exchange pre-competitive know-how and experience with the application of THUMS.
- ✓ Discuss and formulate framework requirements to establish a permanent institution by the end of this project to continue this platform approach.
- ✓ Gain new members contributing to the project

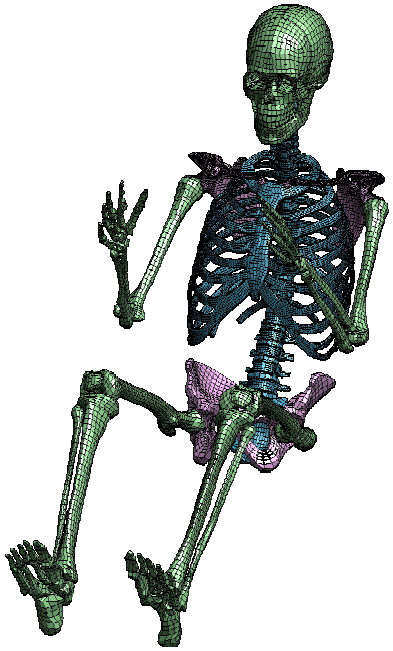
Process to THUMS TUC



Model Integration (TMC)

- ✓ TUC 1st Master Model was developed integrating Daimler Pedestrian and Occupant Models and Autoliv Occupant Model.





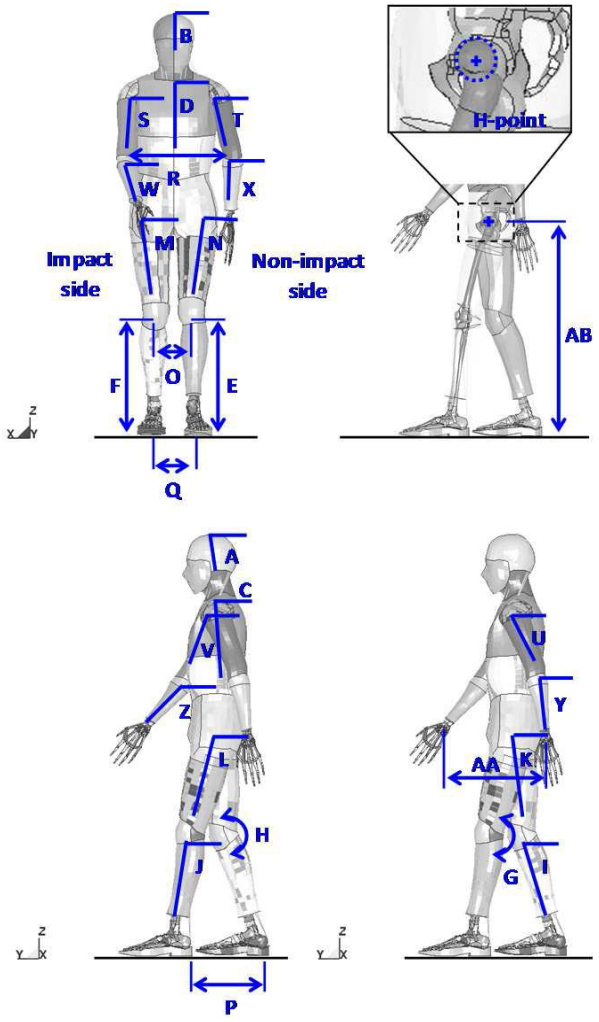
- Daimler Pedestrian
- Daimler Occupant
- Autoliv Occupant

Model Specification

Elements:	227,744
Nodes:	165,993
Parts:	1,576
Time Step:	2.77E-1

Body Region	Daimler Pedestrian	Daimler Occupant	Autoliv Occupant
Head			
Neck			X
Thorax		X	X
Abdomen			X
Pelvis		X	X
Extremities	X		

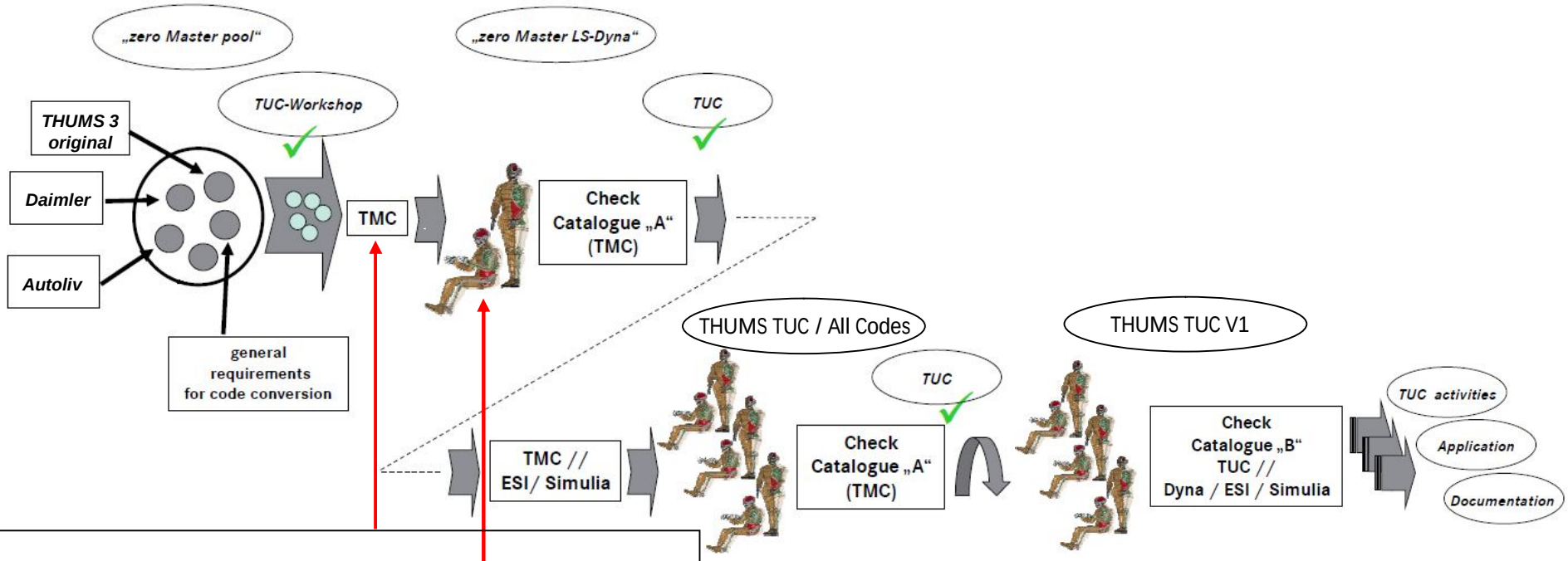
Positioning for Pedestrian (TMC)



- ✓ THUMS TUC pedestrian obtained by positioning the occupant model
- ✓ Positioned to SAE J2782 (EuroNCAP T/P V7 compatible)

Segment	Aspect	Units	Axis	SAE J2782	TUC AM50
Head angle		deg	About X	83 ±5	83
		deg	About Y	90 ±5	90
Torso angle		deg	About X	83 ±5	85
		deg	About Y	90 ±5	90
Knee height	Non-impact side	mm	Z	505 ±10	505
	Impact side	mm	Z	520 ±10	493
Knee bend angle	Non-impact side	deg	Angle in YZ plane	171 ±5	182
	Impact side	deg	Angle in YZ plane	164 ±5	182
Tibia angle	Impact side	deg	About X	73 ±5	79
	Non-impact side	deg	About X	98 ±5	100
Femur angle	Impact side	deg	About X	89 ±5	78
	Non-impact side	deg	About X	107 ±5	97
	Impact side	deg	About Y	87 ±5	84
	Non-impact side	deg	About Y	94 ±5	96
Knee to knee width		mm	X	280 ±10	171
Heel to heel distance		mm	Y	310 ±10	311
		mm	X	280 ±10	97
Elbow to elbow width		mm	X	420 ±10	436
Upper arm angle	Impact side	deg	About Y	-	95
	Non-impact side	deg	About Y	-	78
	Non-impact side	deg	About X	-	65
	Impact side	deg	About X	-	111
Lower arm angle	Impact side	deg	About Y	-	82
	Non-impact side	deg	About Y	-	269
	Non-impact side	deg	About X	-	-89
	Impact side	deg	About X	-	136
wrist to wrist distance		mm	Y	-	410
H-point		mm	Z	-	949

Process to THUMS TUC



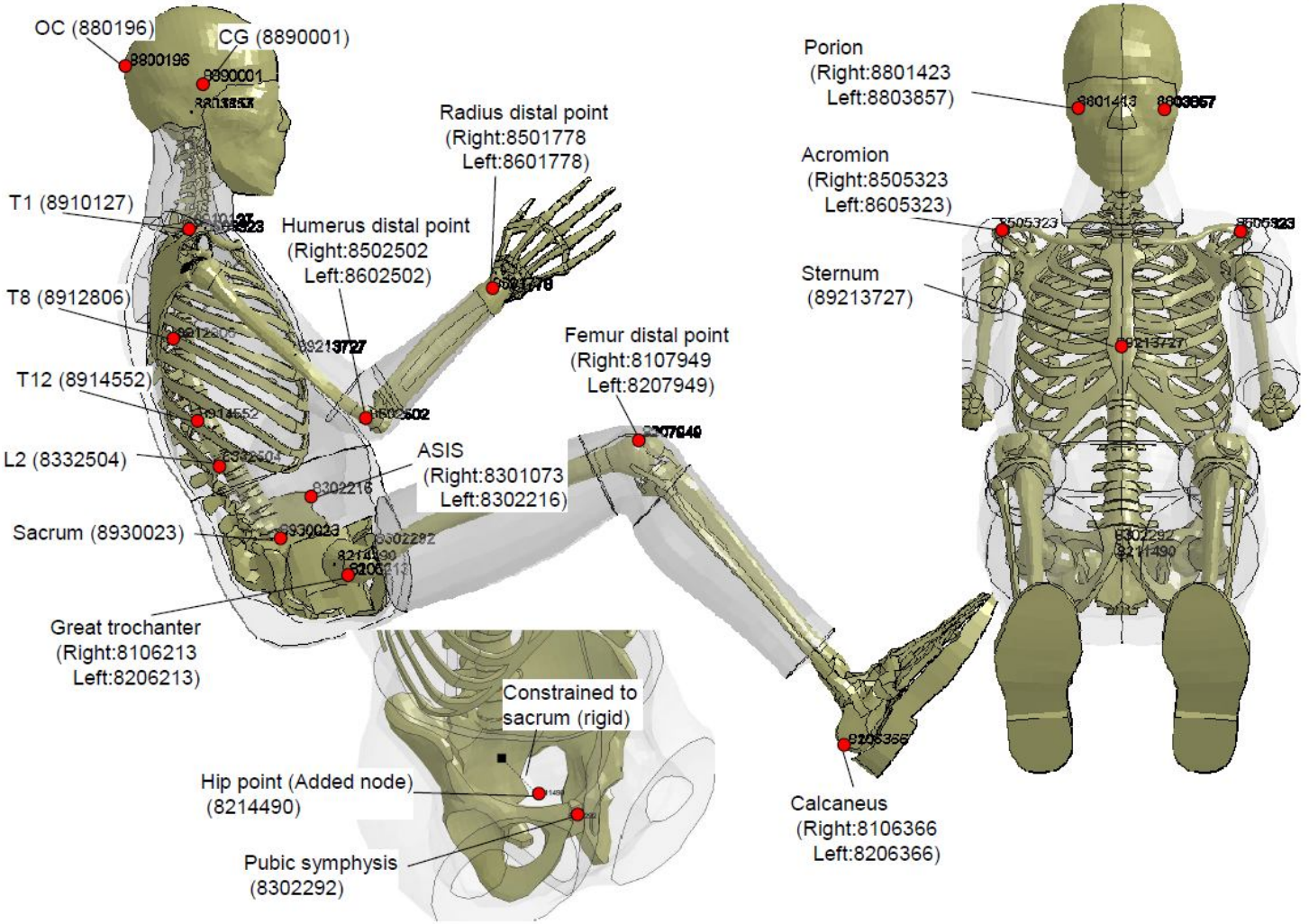
TUC Element Criteria

✓Check of the assembled Master Model by commonly defined element criteria

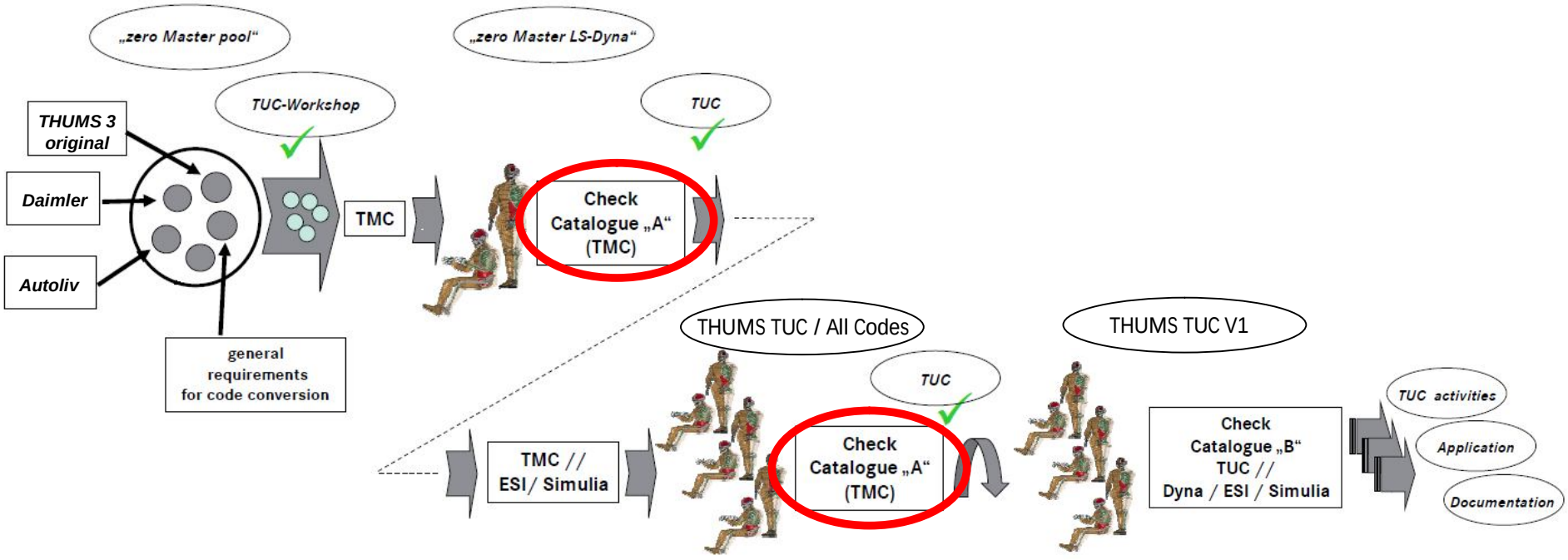
TUC Tracking Points

✓Basic tracking of the occupant's kinematics

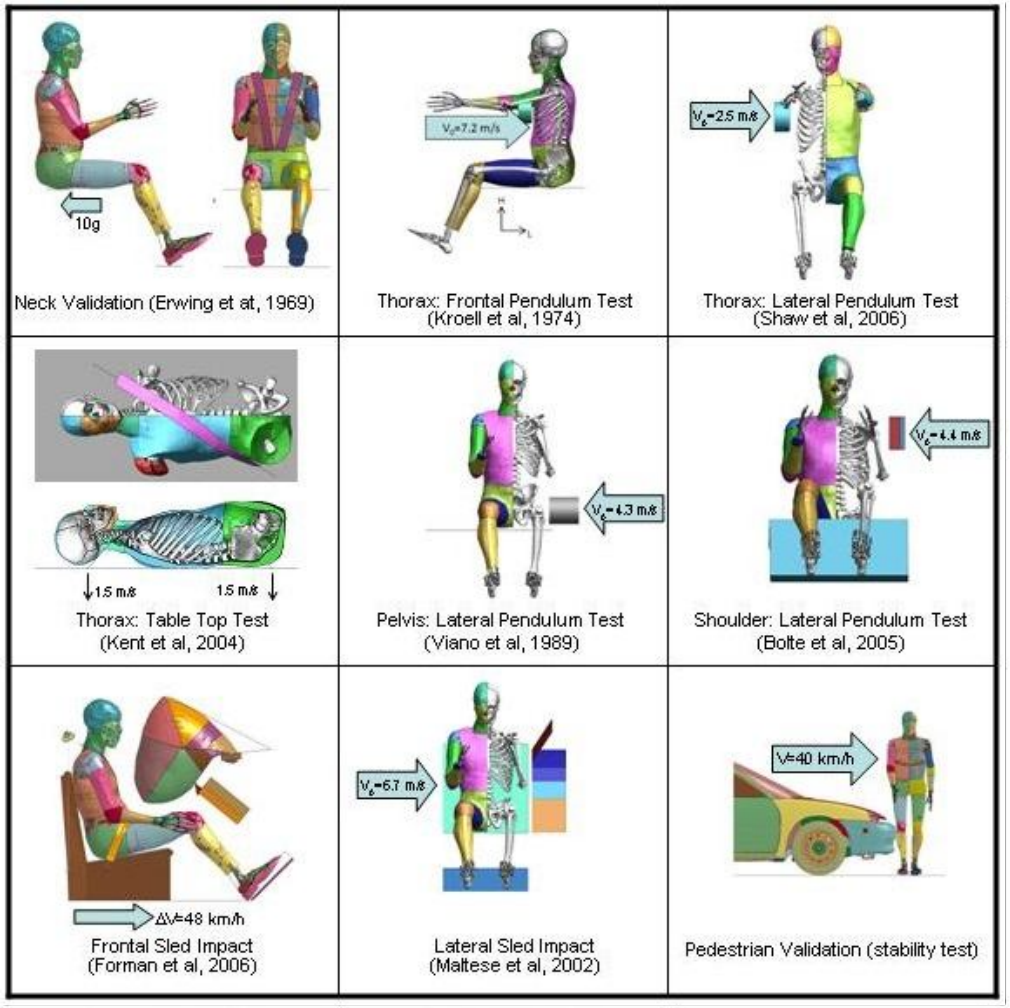
TUC Tracking Points



Process to THUMS TUC



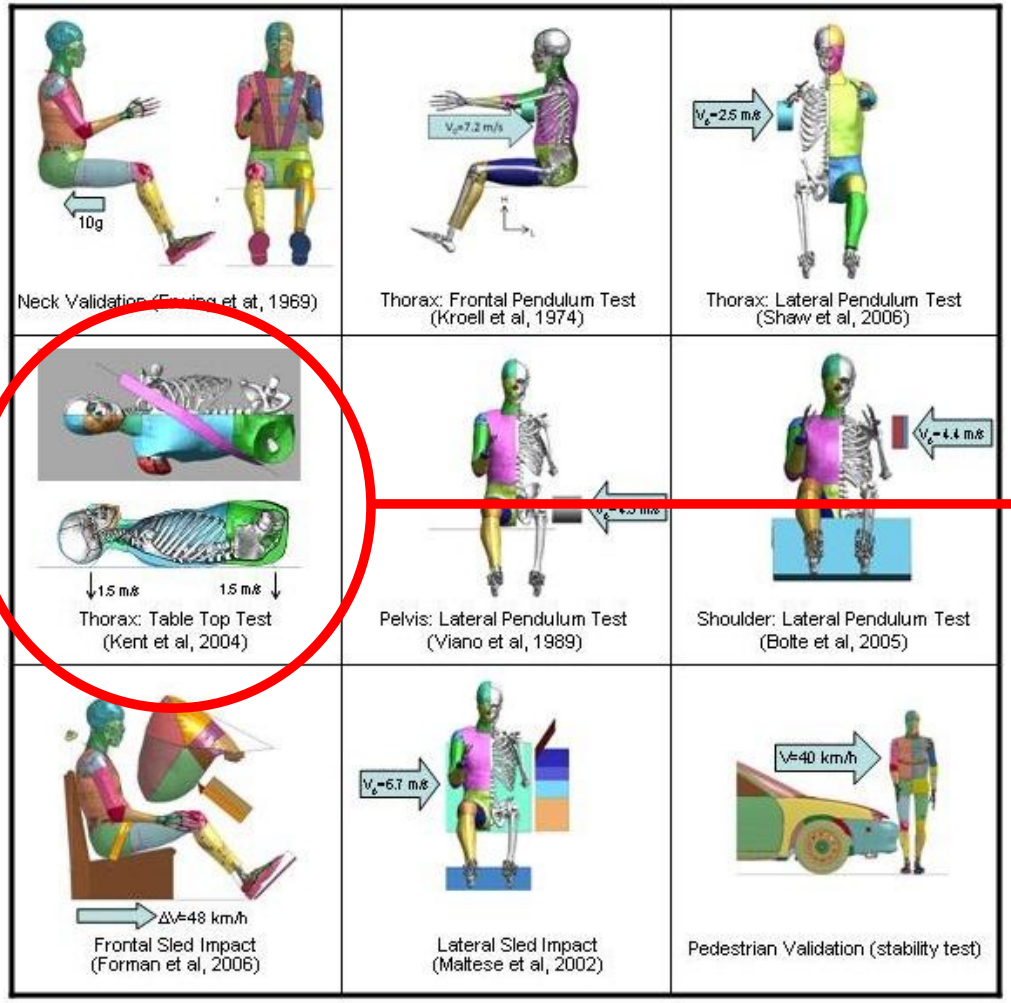
Validation Matrix



Validation Catalogue A

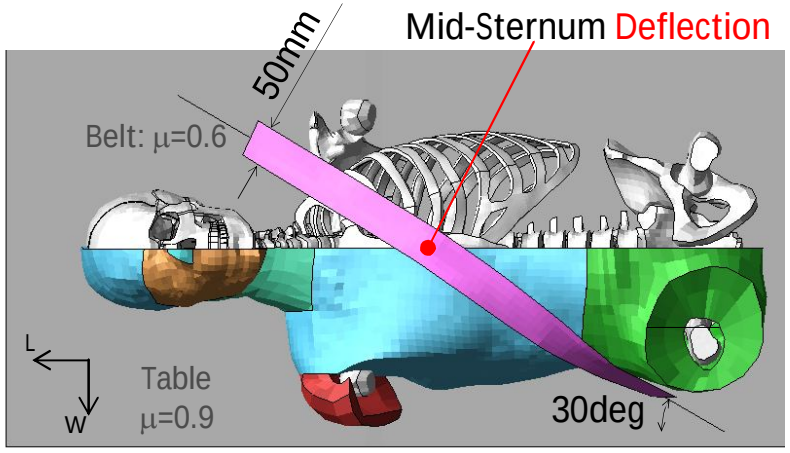
- ✓ 9 validation cases on neck, thorax, pelvis, shoulder, whole body (occupant and pedestrian)
- ✓ Basic validation checks
- ✓ Robustness checks
- ✓ Basic tracking
- ✓ Cases defined for occupant and pedestrian validation independently

Validation Matrix

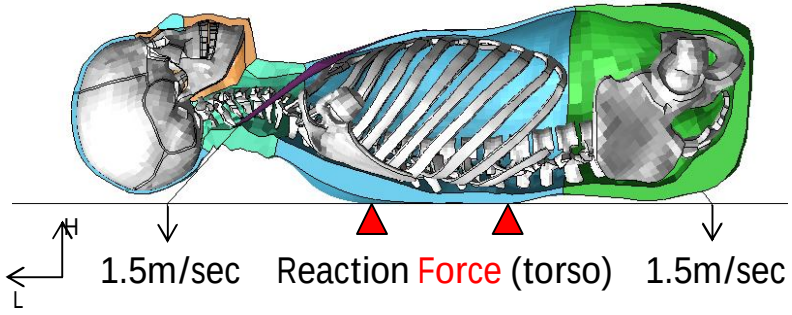


1. example: Thorax Validation

Table Top Test (Kent et al, 2004)



Horizontal View



Lateral View

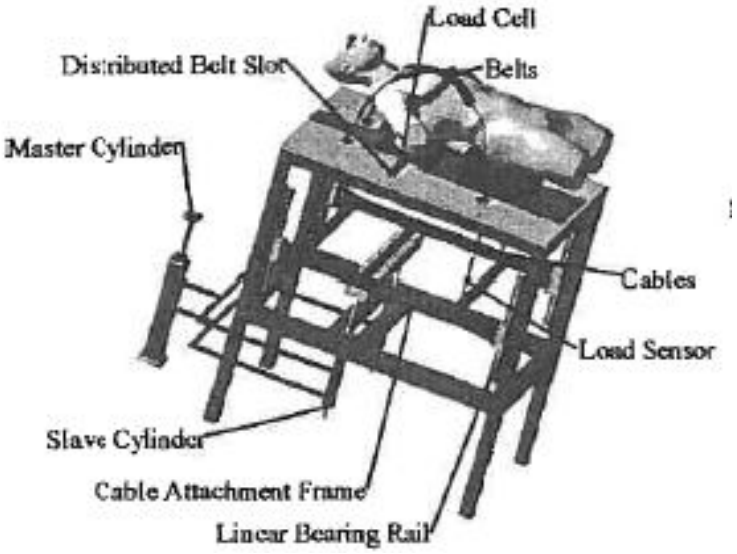
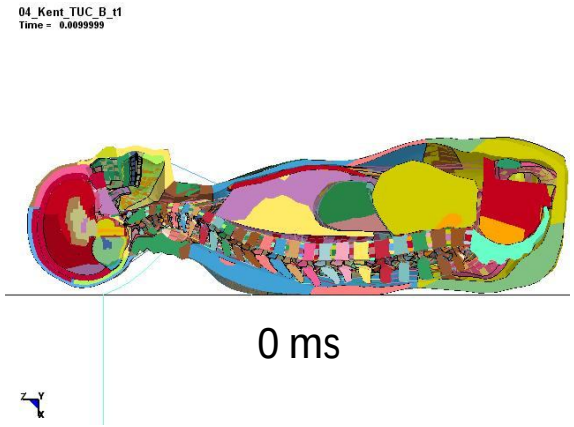


Table Top Test View
(R. Kent et al, 2004)

Table Top Test (Kent et al, 2004)



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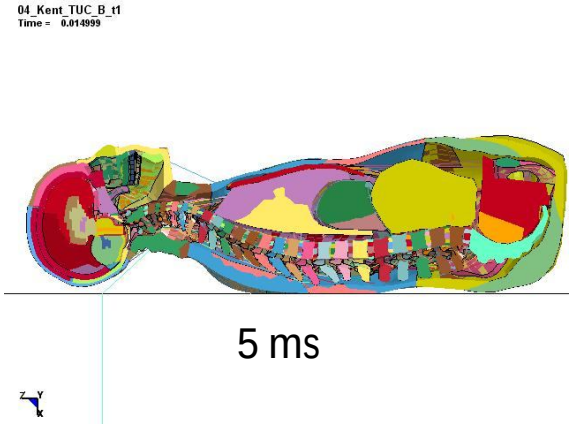

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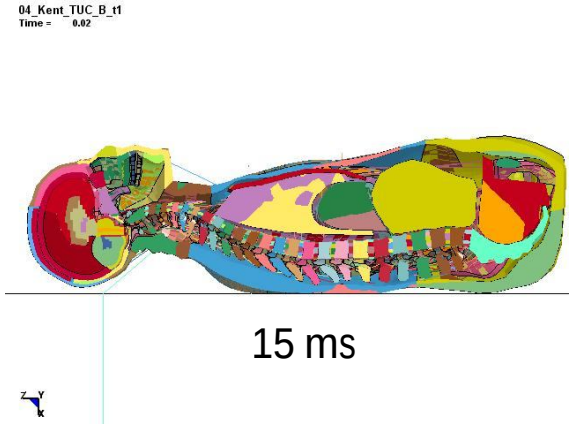
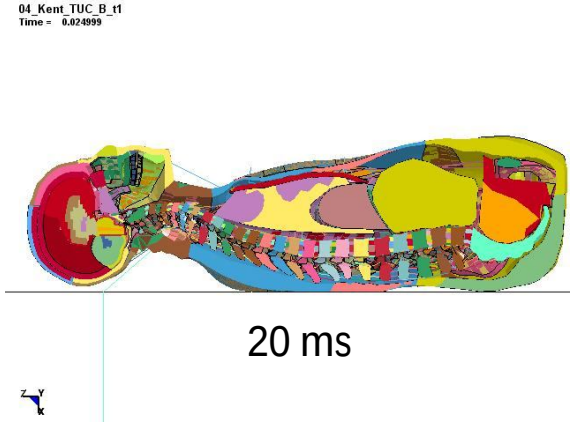


15 ms



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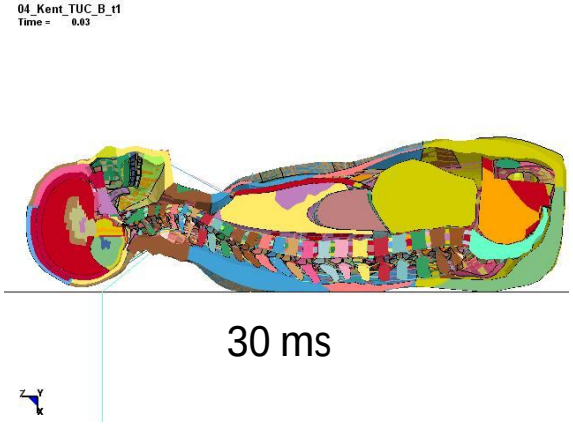

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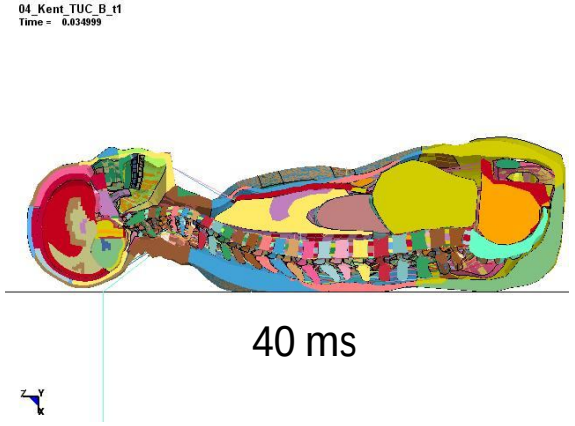
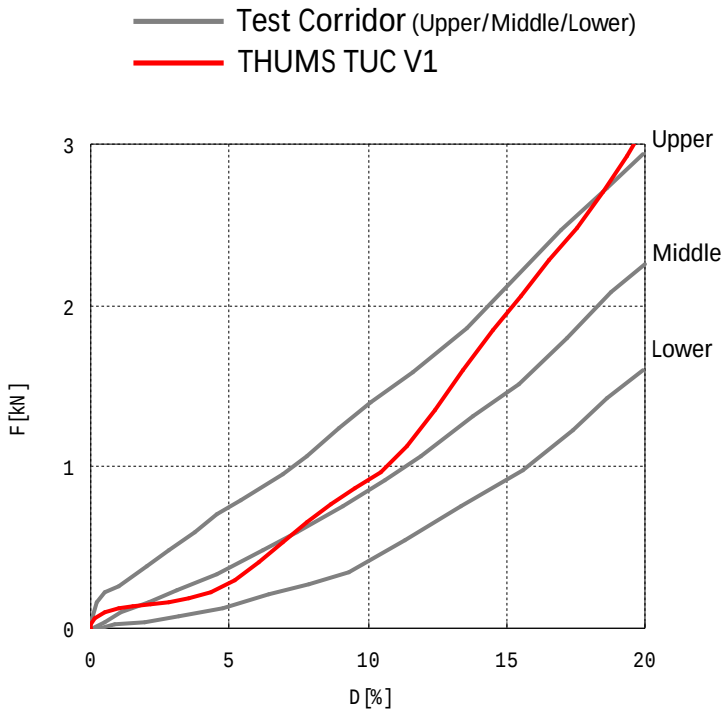


40 ms

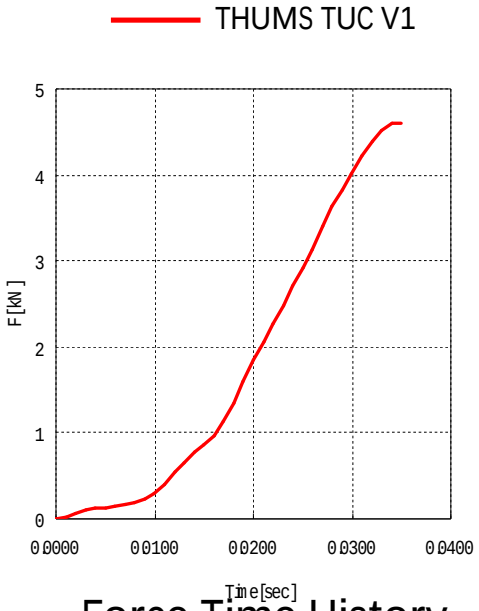
Table Top Test (Kent et al, 2004)

✓Calculated force-deflection curve in agreement with test corridor.

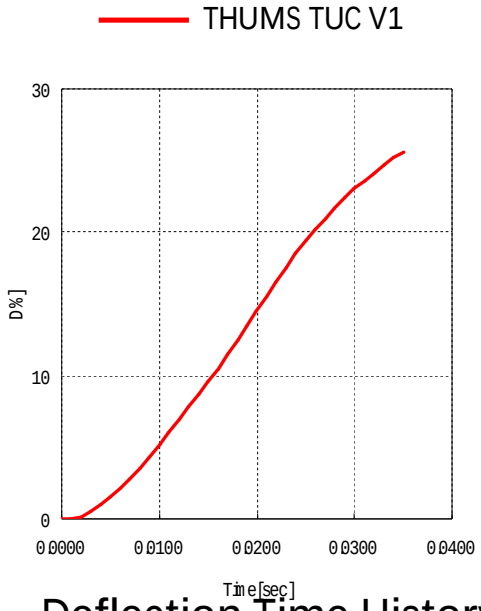


Force-Deflection

For reference:

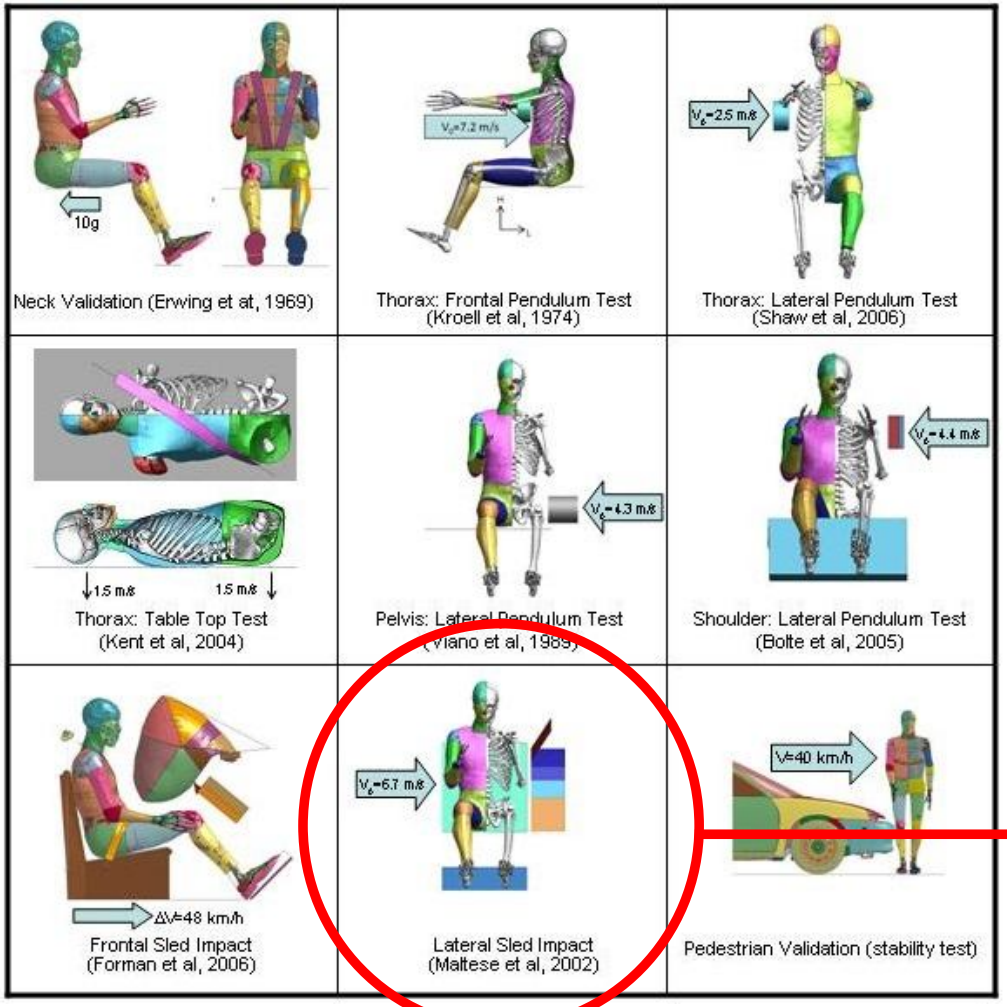


Force Time History
(Reaction Force at Table)



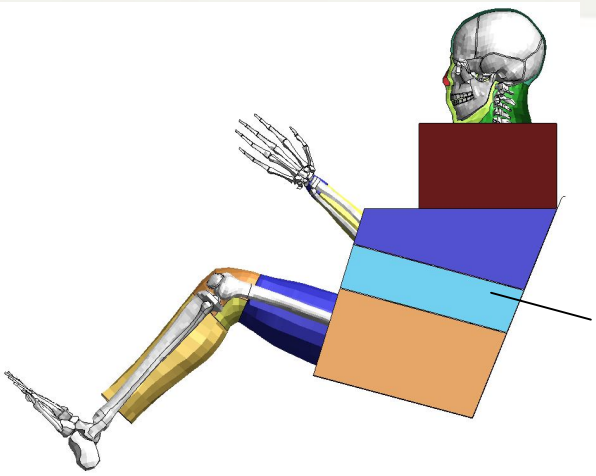
Deflection Time History
(Mid-sternum Deflection)

Validation Matrix

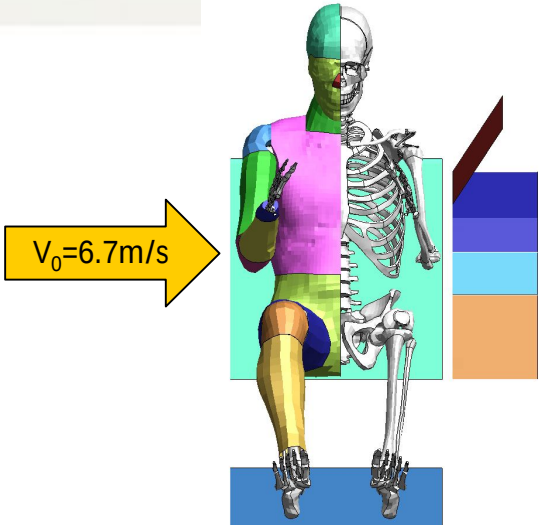


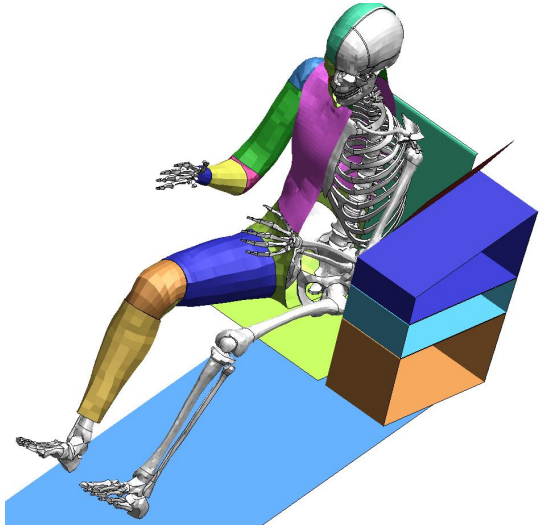
2. example: Lateral Sled Impact

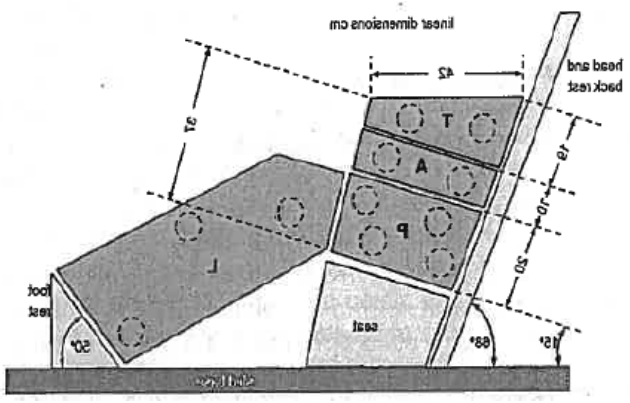
2. Lateral Sled Impact (Maltese et al, 2002)



[Flush Wall]
MAT : Rigid

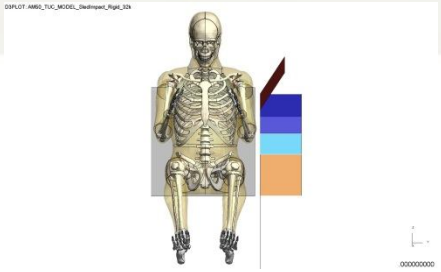






Lateral Impact Test (Maltese et al, 2002)

2. Lateral Sled Impact (Maltese et al, 2002)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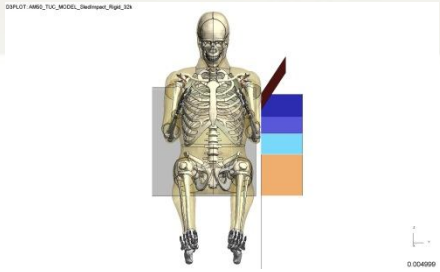
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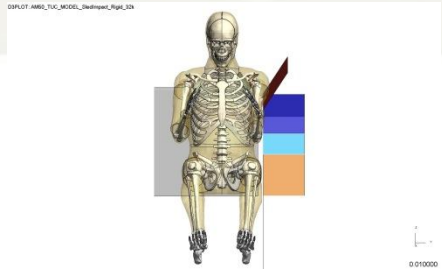
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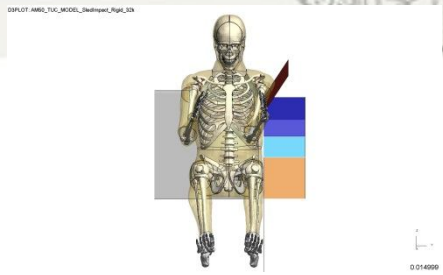
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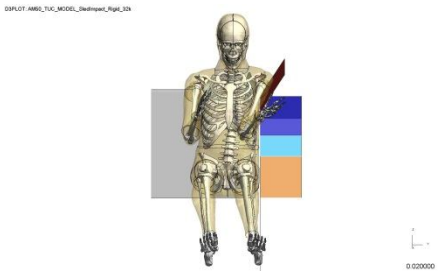
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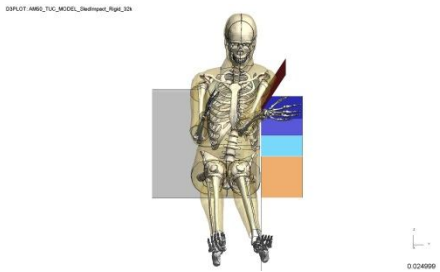
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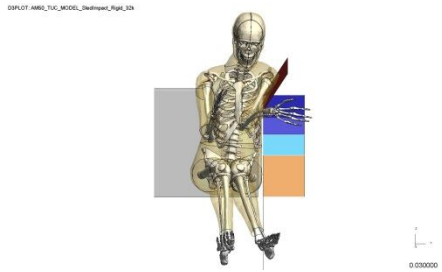
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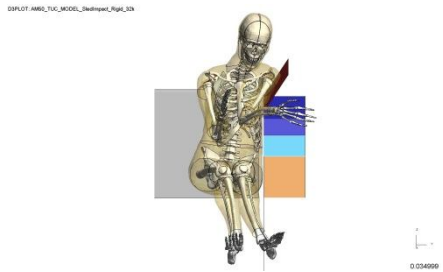
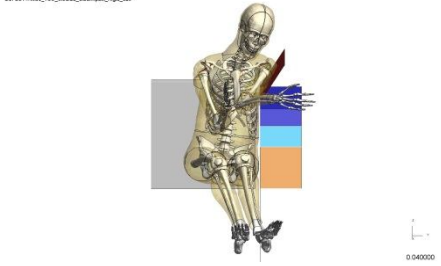
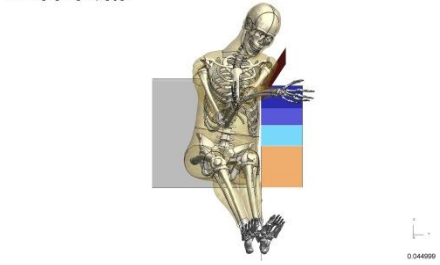
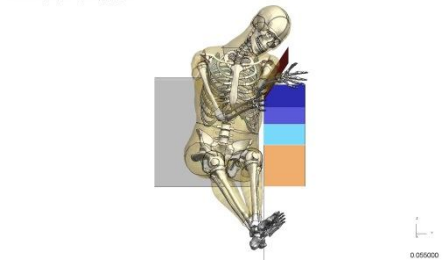

35 ms


40 ms

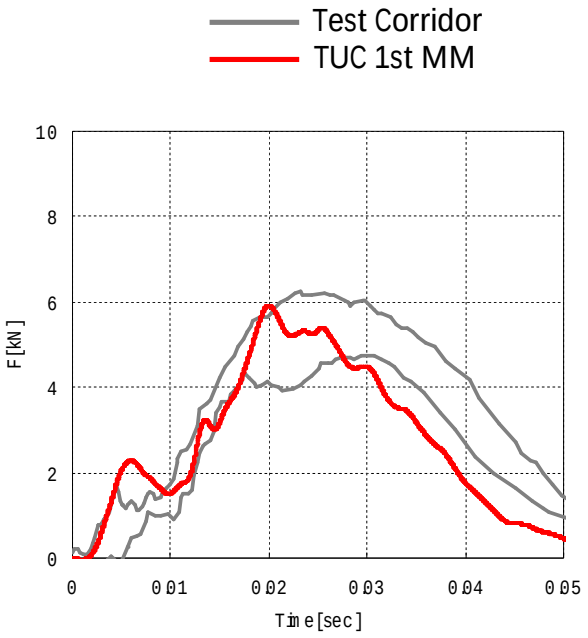

45 ms


50 ms

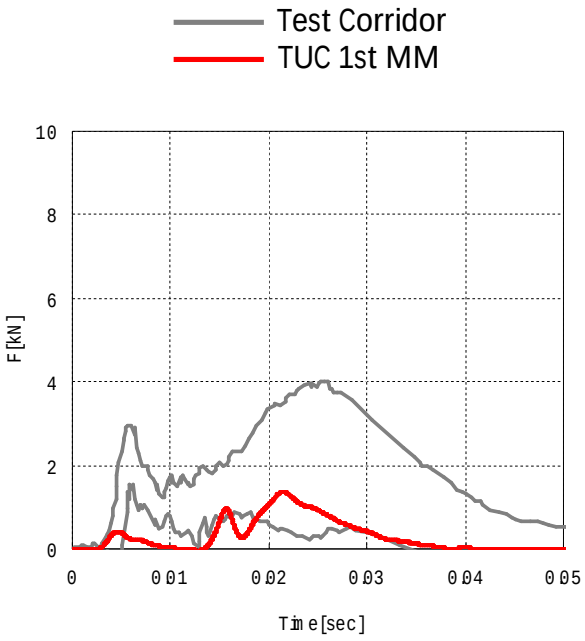

55 ms

2. Lateral Sled Impact (Maltese et al, 2002)

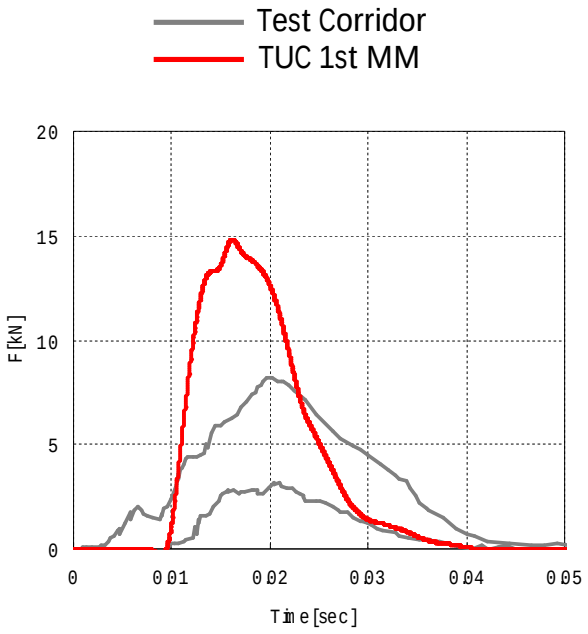
- ✓Thorax force: Good match.
- ✓Abdomen force: Lower boundary of test corridor.
- ✓Pelvis force: Greater peak.



Thorax Force



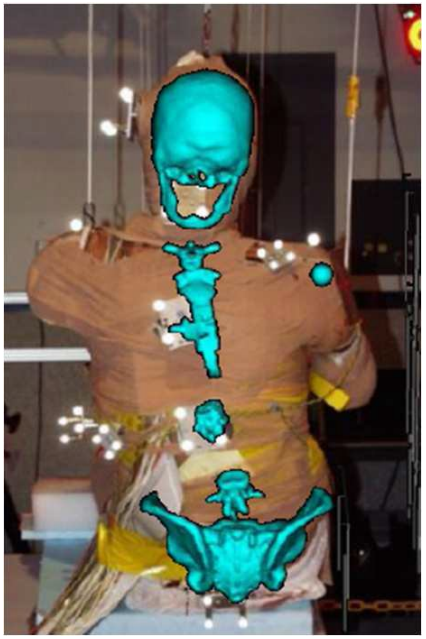
Abdomen Force



Pelvis Force

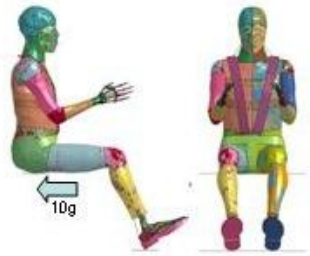
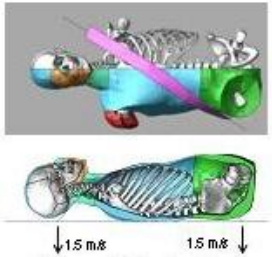
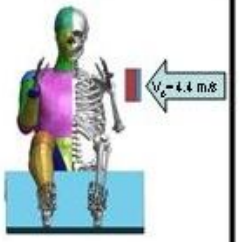
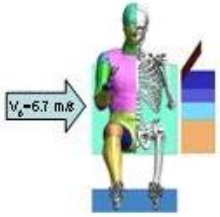
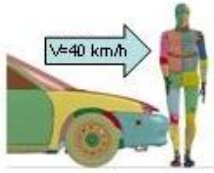
2. Lateral Sled Impact (Maltese et al, 2002)

Differences in pelvis force possibly caused by difference in the initial posture and surface geometry between test subject and simulation model



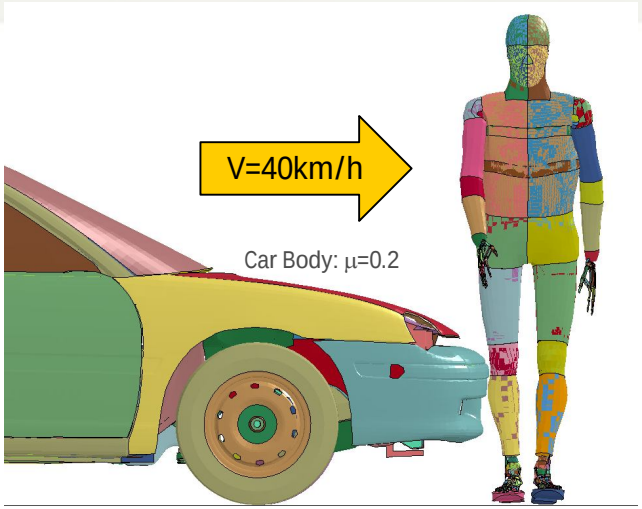
Lessley et al. (2010)

Validation Matrix

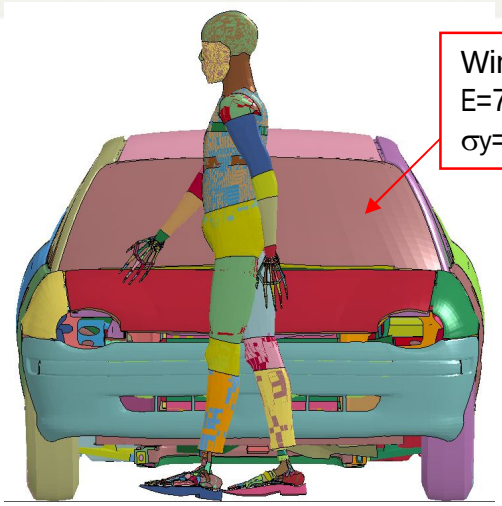
 Neck Validation (Erwing et at, 1969)	 Thorax: Frontal Pendulum Test (Kroell et al, 1974)	 Thorax: Lateral Pendulum Test (Shaw et al, 2006)
 Thorax: Table Top Test (Kent et al, 2004)	 Pelvis: Lateral Pendulum Test (Viano et al, 1989)	 Shoulder: Lateral Pendulum Test (Bolte et al, 2005)
 Frontal Sled Impact (Forman et al, 2006)	 Lateral Sled Impact (Maltese et al, 2002)	 Pedestrian Validation (stability test)

3. example: Pedestrian Validation

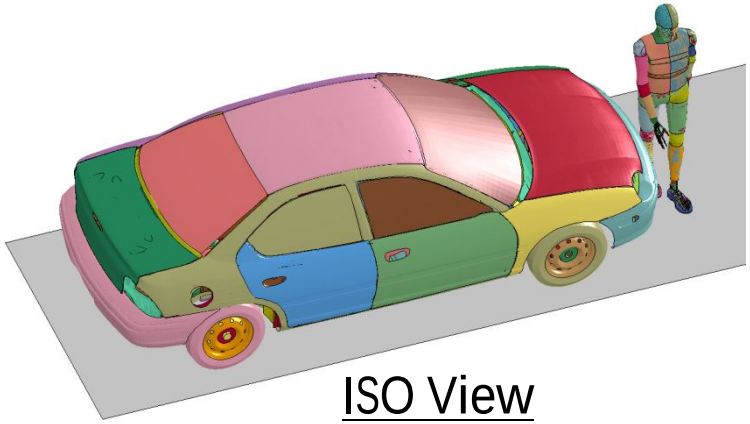
3. Pedestrian Validation



Car Lateral View

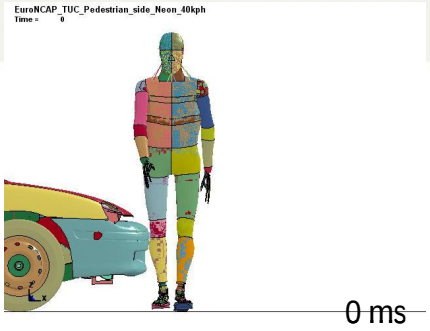


Car Frontal View

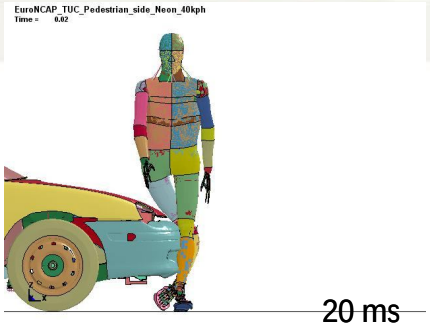


ISO View

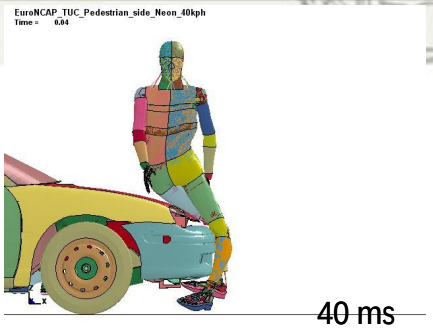
3. Pedestrian Validation



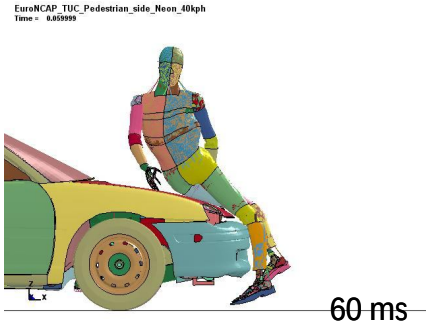
0 ms



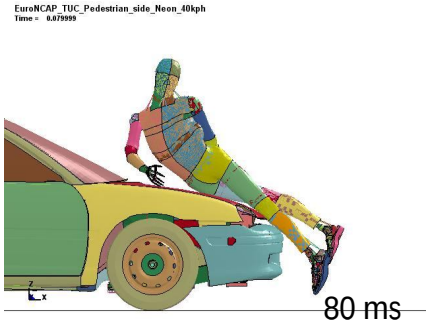
20 ms



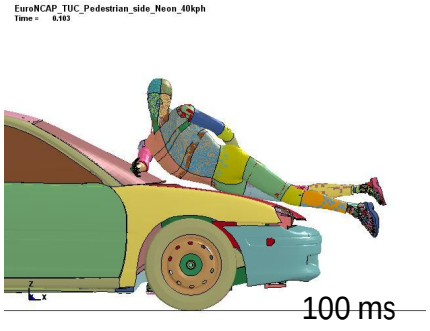
40 ms



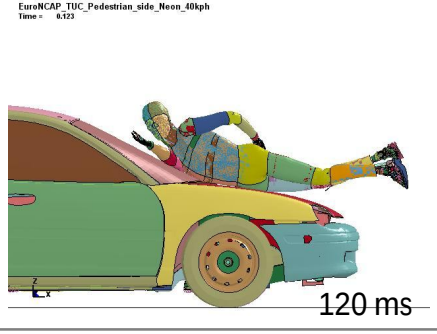
60 ms



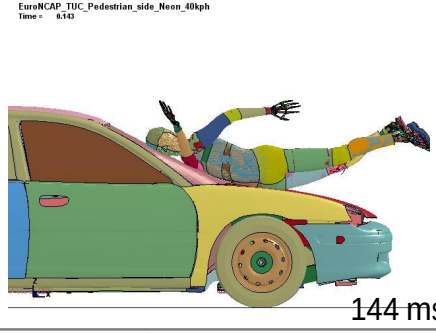
80 ms



100 ms

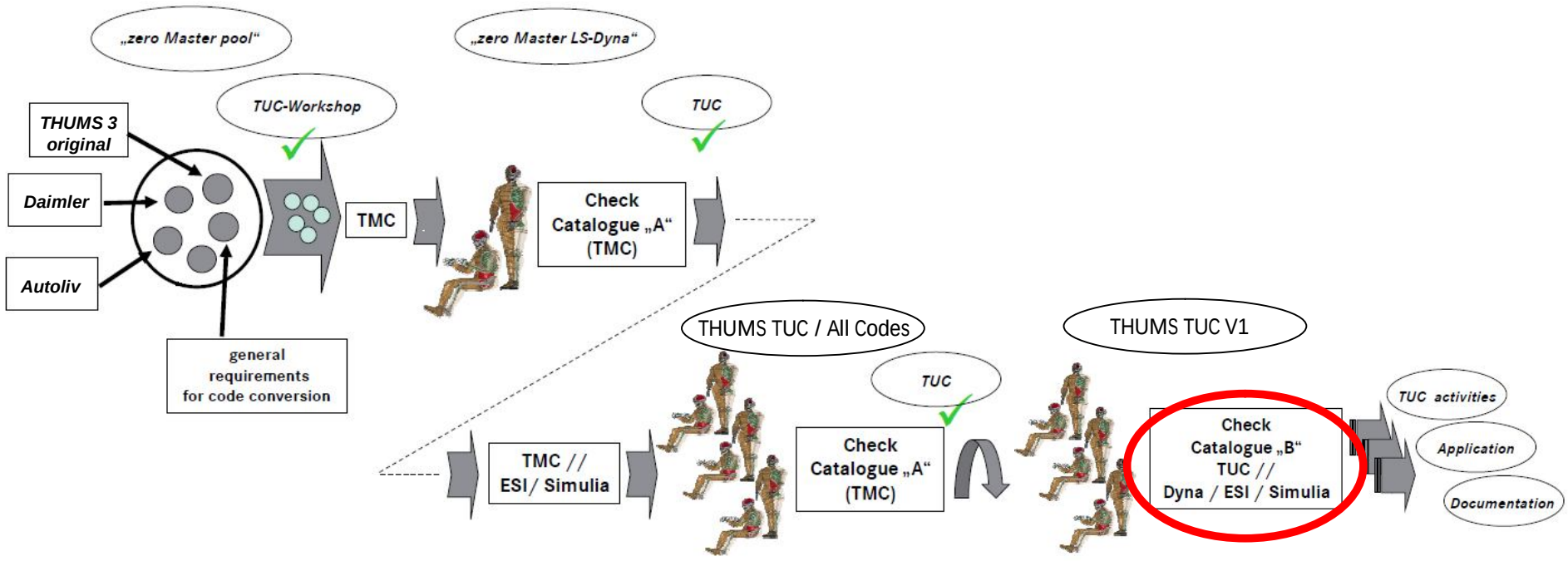


120 ms



144 ms

Process to THUMS TUC



TUC Validation Catalogue B

- ✓ List of validation cases (approx. 35) for biomechanical assessment
- ✓ Currently reviewed: over 50 references checked for their suitability

THANK YOU!