5. GMTTB Jahrestagung 2015

Menschmodellierung zur Verletzungsvorhersage – Möglichkeiten und Grenzen

Rainer Hoffmann, carhs gmbh

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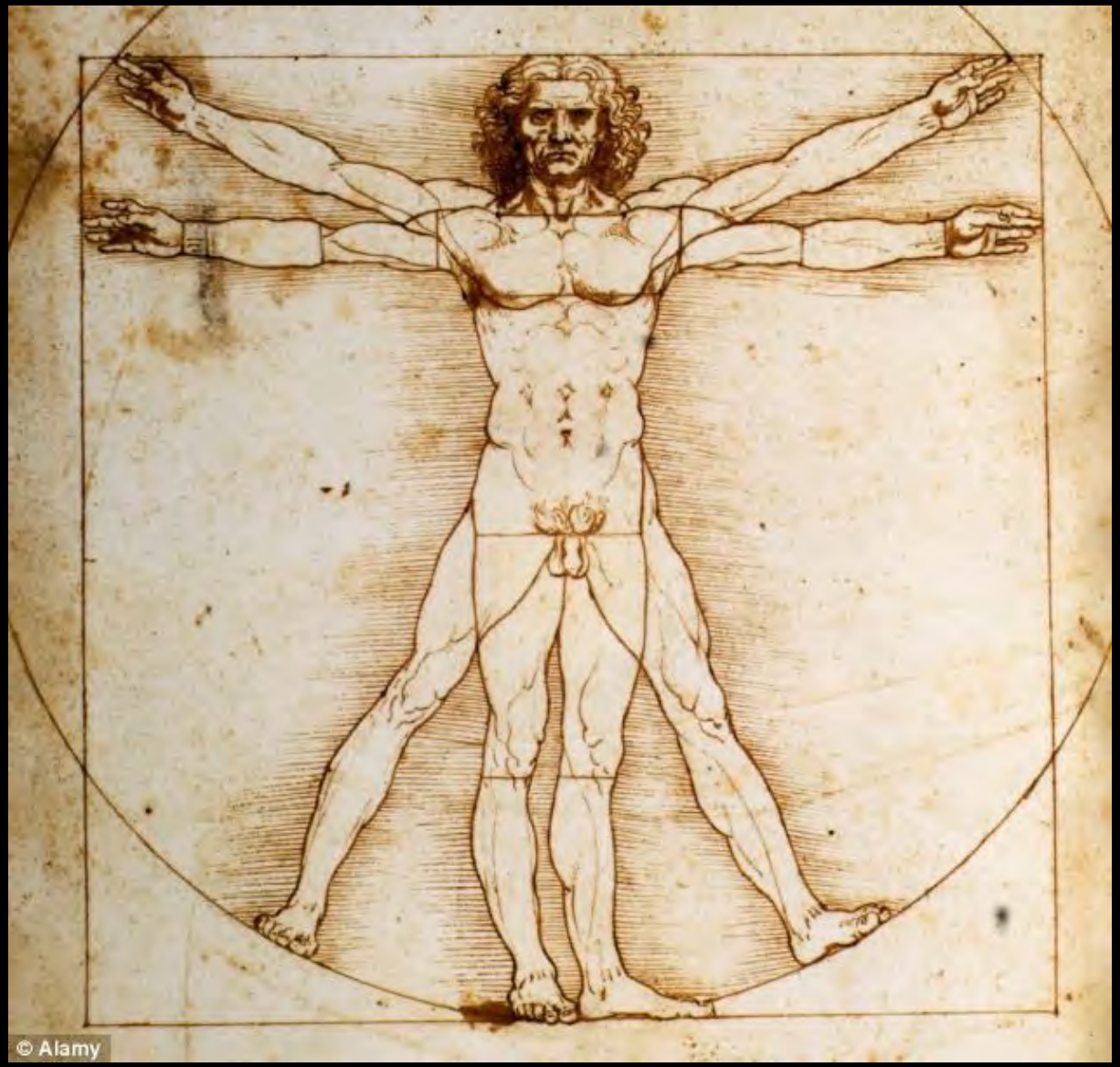

Ist der Mensch berechenbar?

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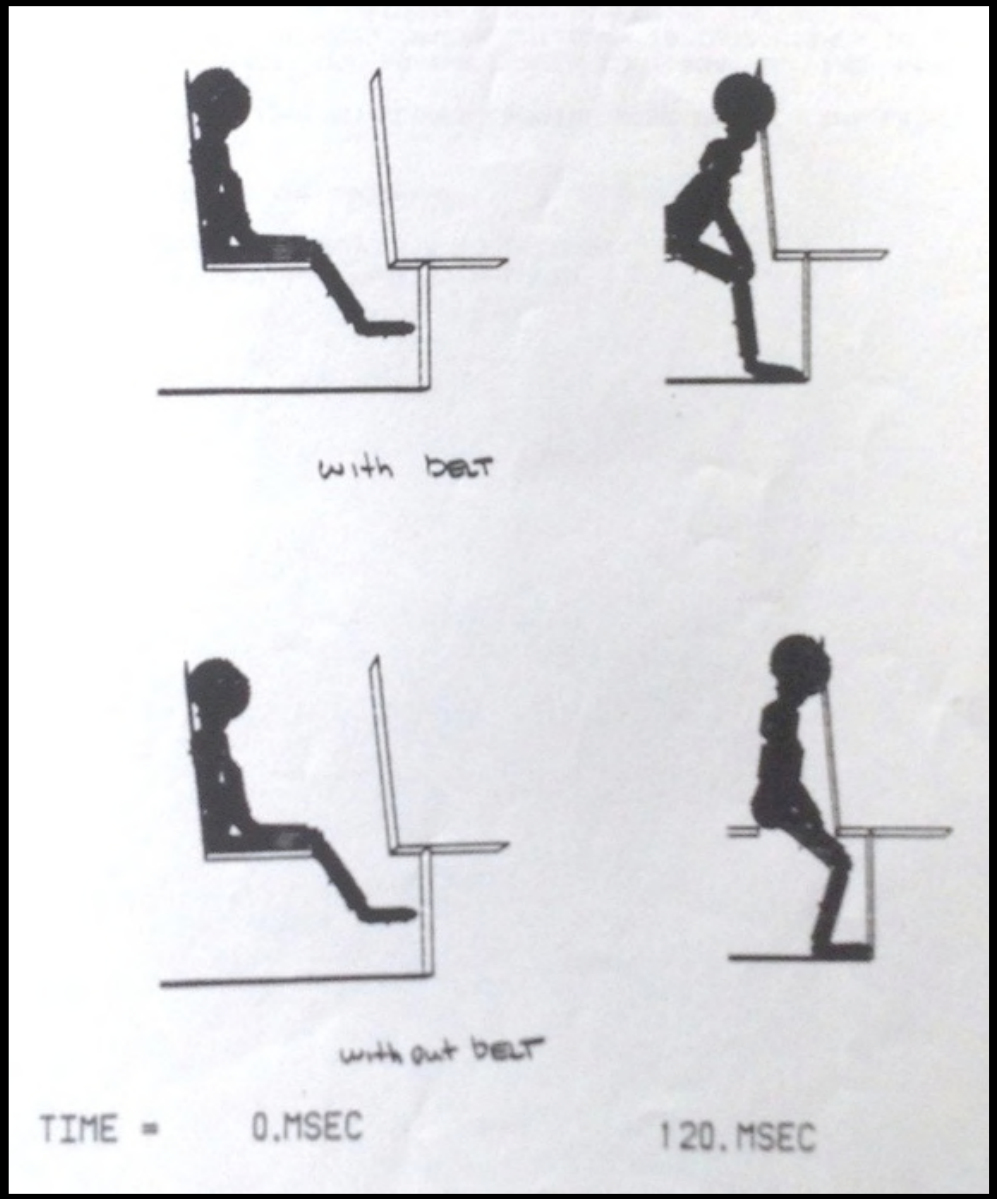

School Bus Accident Simulation using CAL3D

Rainer Hoffmann, ME 710, Wayne State University, 1984

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HUMAN MODELING AND SIMULATION
IN AUTOMOTIVE ENGINEERING

5th International Symposium

Human Modeling and Simulation in Automotive Engineering

Munich, GERMANY

October 16-17, 2014

Organized by

carhs.

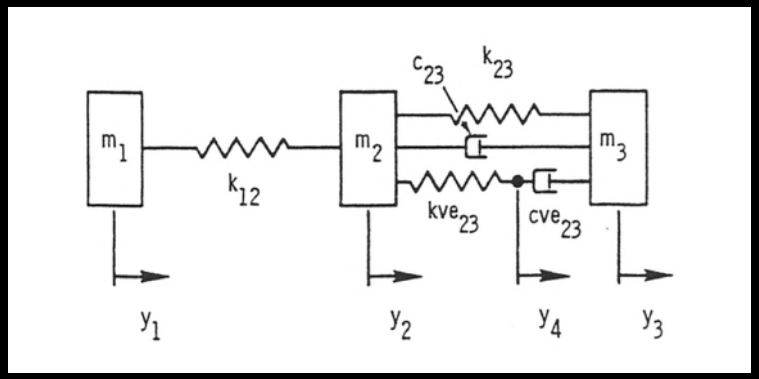
In cooperation with

WAYNE STATE

Inhalt

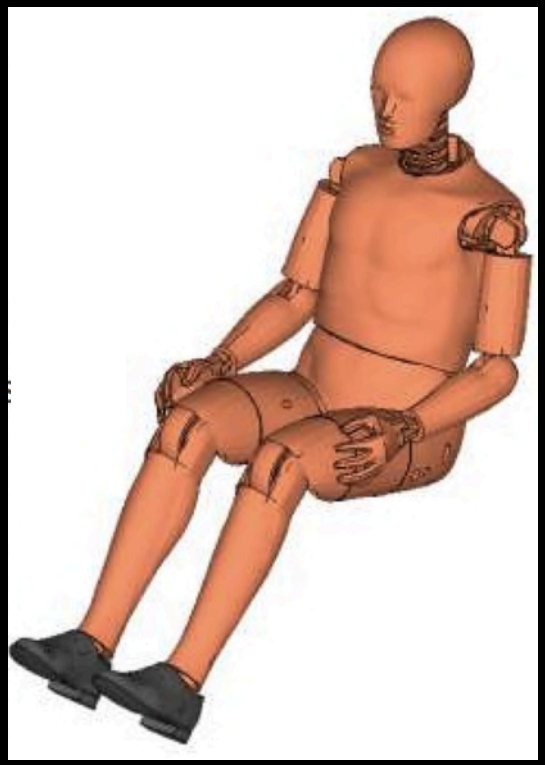
- Crash Victim Simulation
- Status der Modelle
- Möglichkeiten und Grenzen der Verletzungsvorhersage
- Zukünftige Entwicklungen

Crash Victim Simulation



1973: 1-D Lumped Mass Model: Lobdell Thorax Model

1985: 3-D Rigid Body Model: MADYMO3D



2013: 3-D Finite Element Model: Hybrid III 50th%ile male

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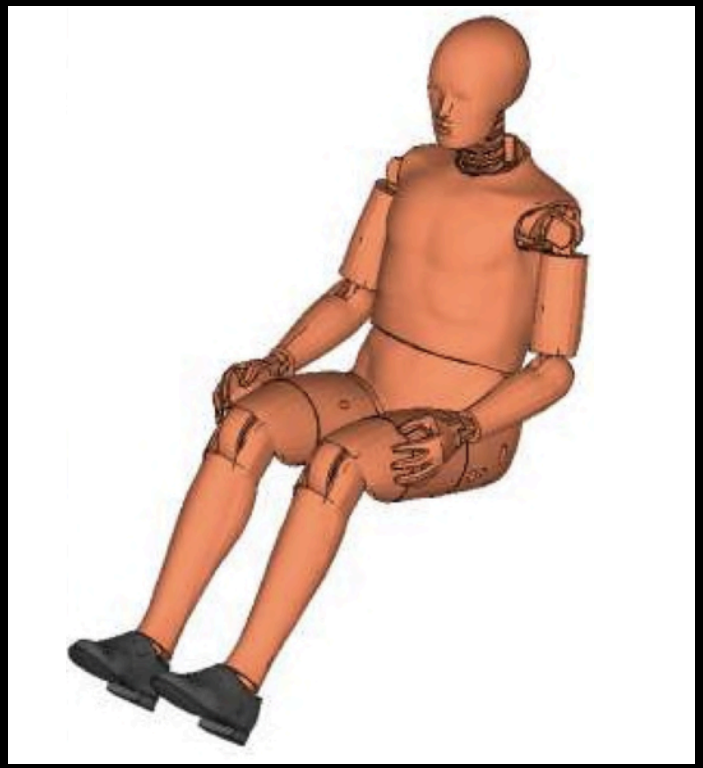
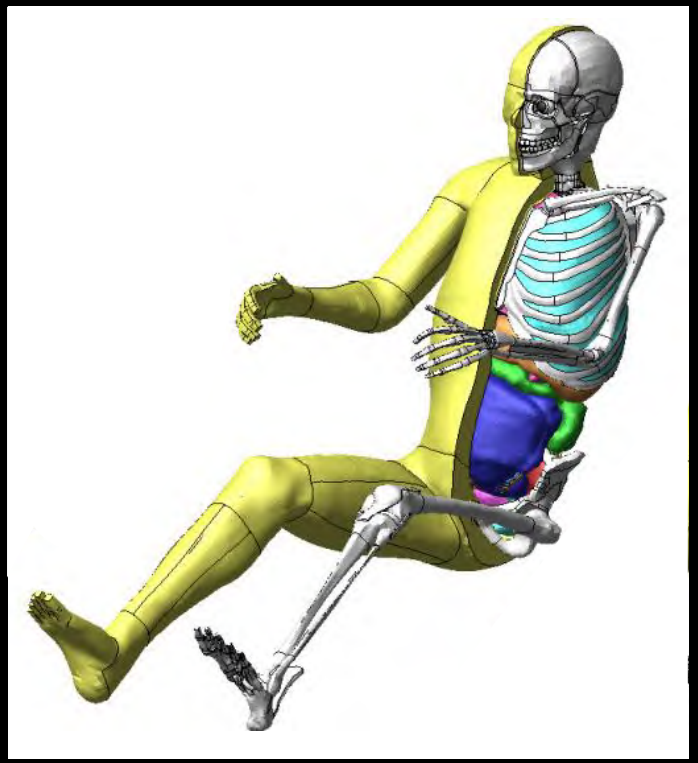
Crash Victim Simulation

Dummy Modelle



Mensch Modelle



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Anwendungsgebiete Mensch Modelle

- Innovative Rückhaltesysteme
- reale Menschen (außerhalb 5th, 50th, 95th)
- Integrale Sicherheit
- Dummy-Entwicklung
- Kopfverletzungen
- Unfallrekonstruktion

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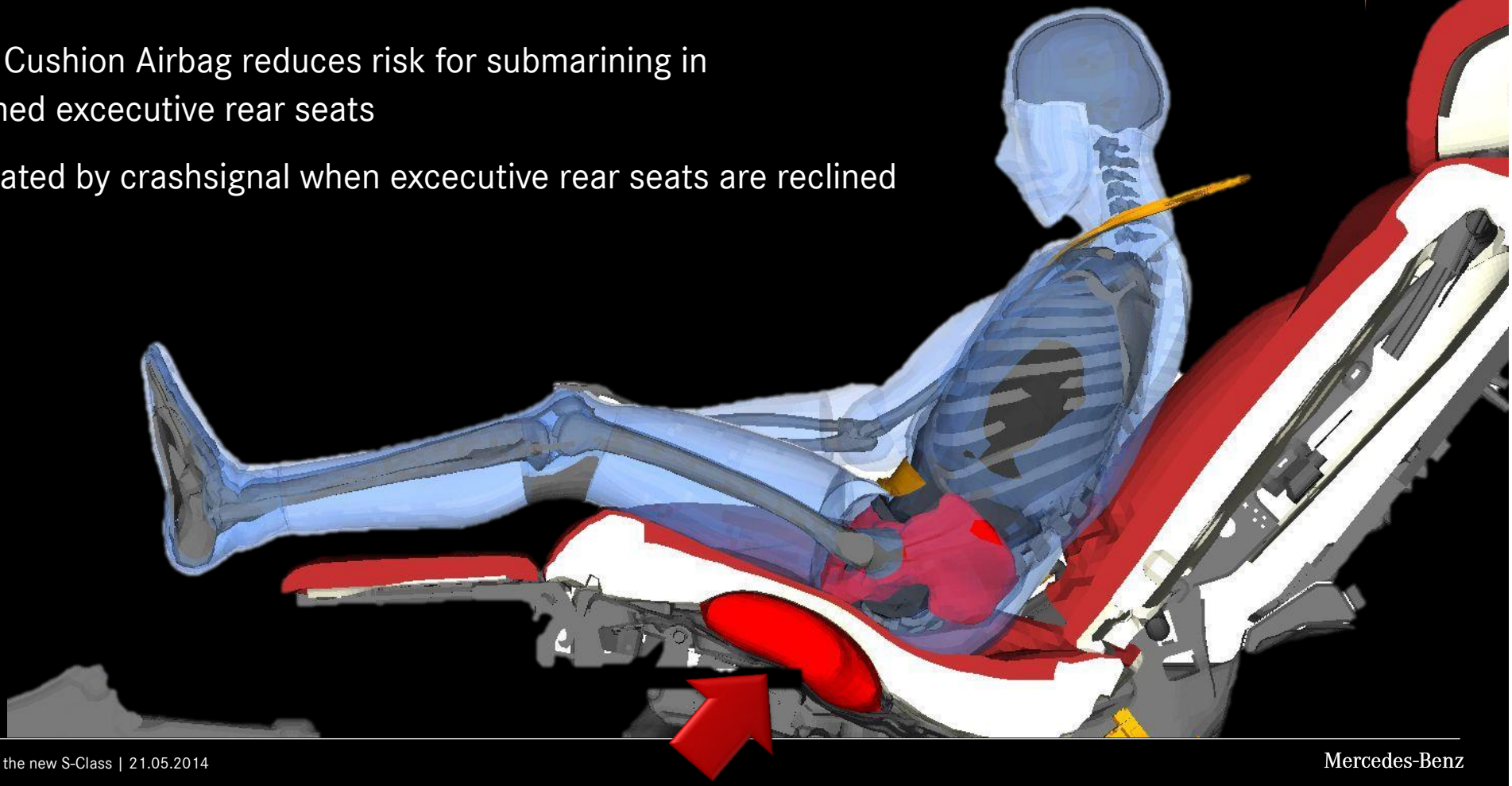
Seat Cushion Airbag

- Seat Cushion Airbag reduces risk for submarining in reclined excecutive rear seats
- Activated by crashsignal when excecutive rear seats are reclined



Mercedes-Benz

Quelle: Bogenrieder, SafetyUpDate 2014

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Inhalt

- Crash Victim Simulation
- **Status der Modelle**
- Möglichkeiten und Grenzen der Verletzungsvorhersage
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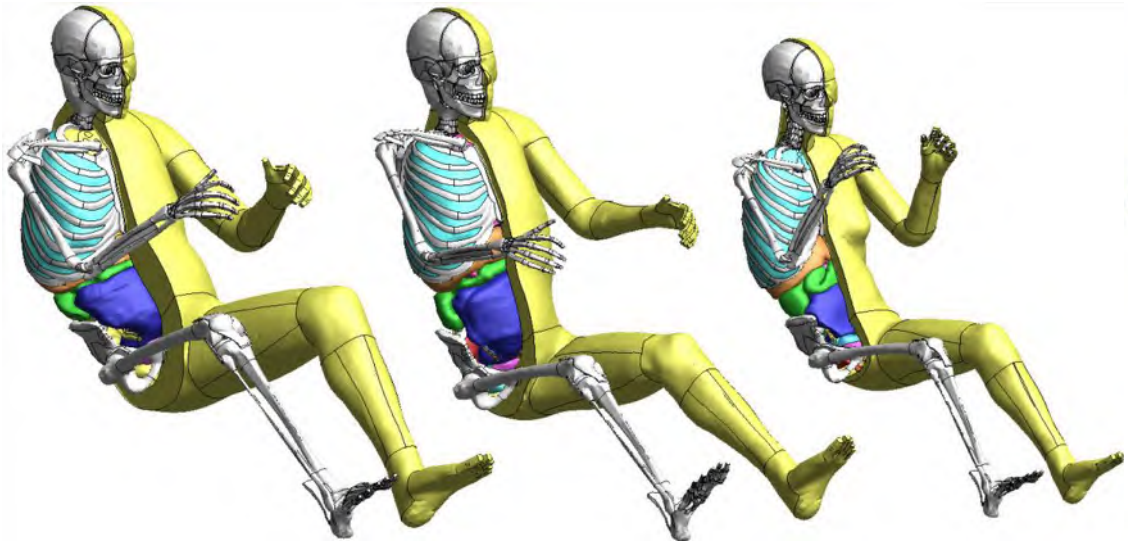
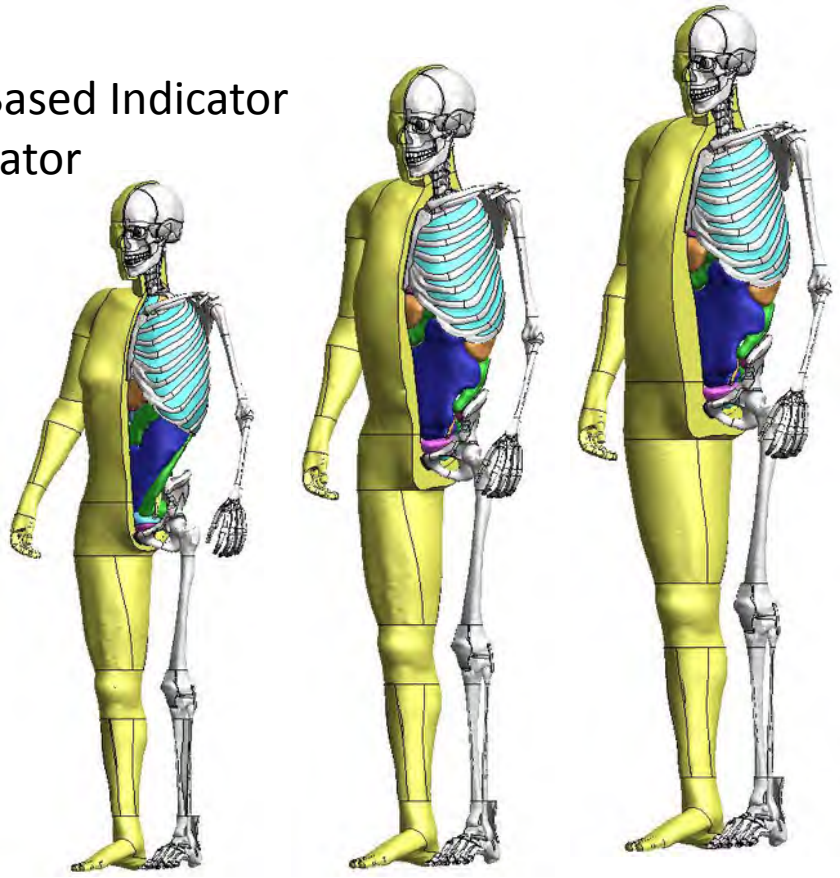
THUMS (Total Human Model for Safety)

- entwickelt von Toyota seit 2000
- aktuell: Version 4 (1.8 Mio. Elements)

Tissue Damage and Rupture:

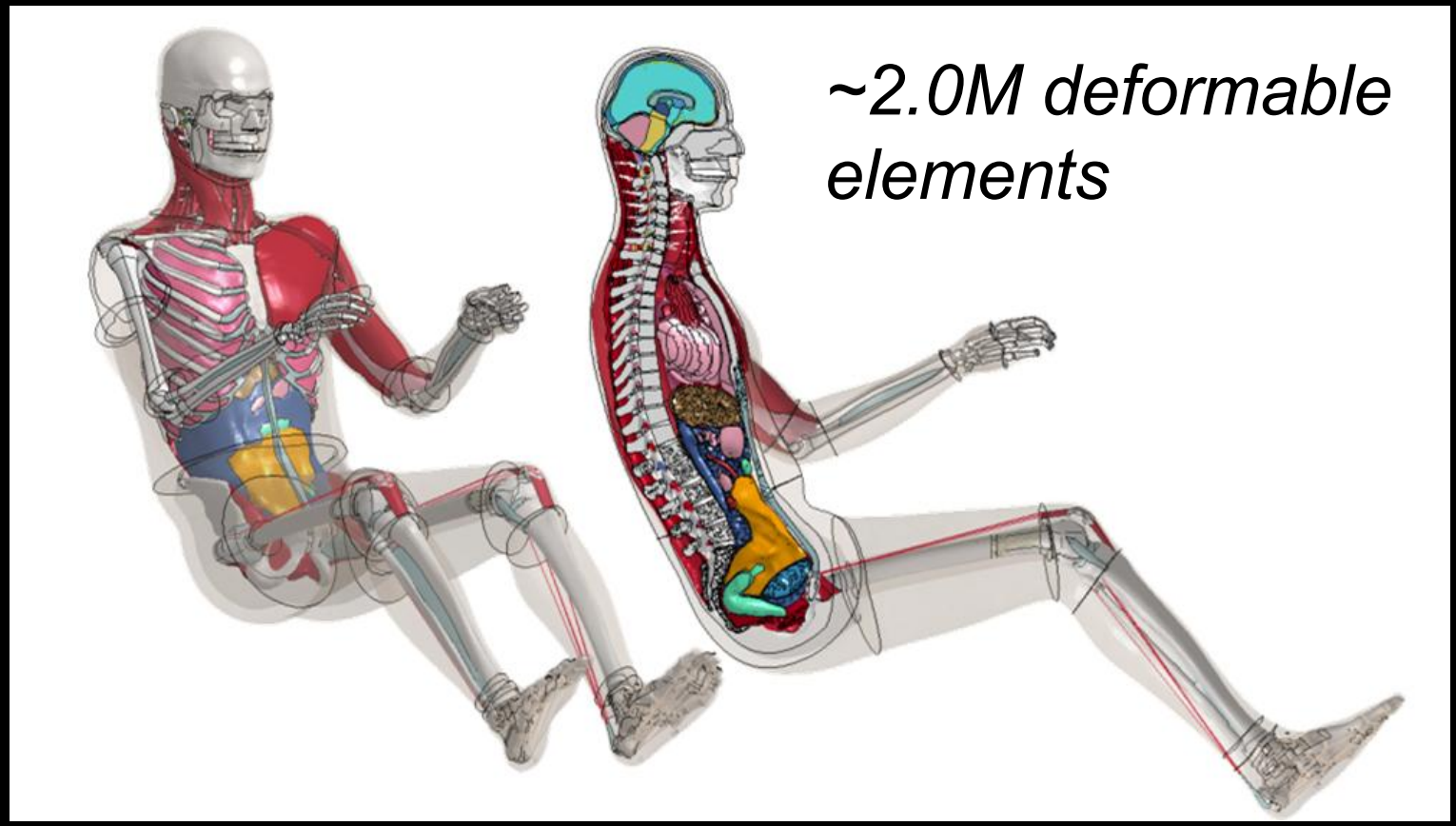
- Internal Organ Injury (Contusion, Laceration) ... Strain Based Indicator
- Brain Injury (Diffuse Axonal Injury) ... Strain Based Indicator
- Skeletal Injury (Bony Fracture) ... Element Elimination





GHBM (Global Human Body Model)

- entwickelt vom GHBMC seit 2006
- aktuell: M50 4.1.1



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GHBM (Global Human Body Model)

- Vorhersage von Crash Induced Injuries (CII)
- Stand der Vorhersagefähigkeit dokumentiert

Level	Capability Subcategories
0	Model detail sufficient, test data available, injury mechanism understood, correlation carried out
1	Model detail sufficient, test data available, injury mechanism understood, but validation work is incomplete or inconclusive
2	Model detail sufficient, but test data unavailable or insufficient
3	Model detail insufficient, test data available, additional modeling should help predict this CII
4	Model detail insufficient, test data unavailable; additional modeling effort and test data should help predict this CII
5	Injury mechanism needs some more investigation
6	Injury mechanism needs extensive additional investigation

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GHBM (Global Human Body Model)

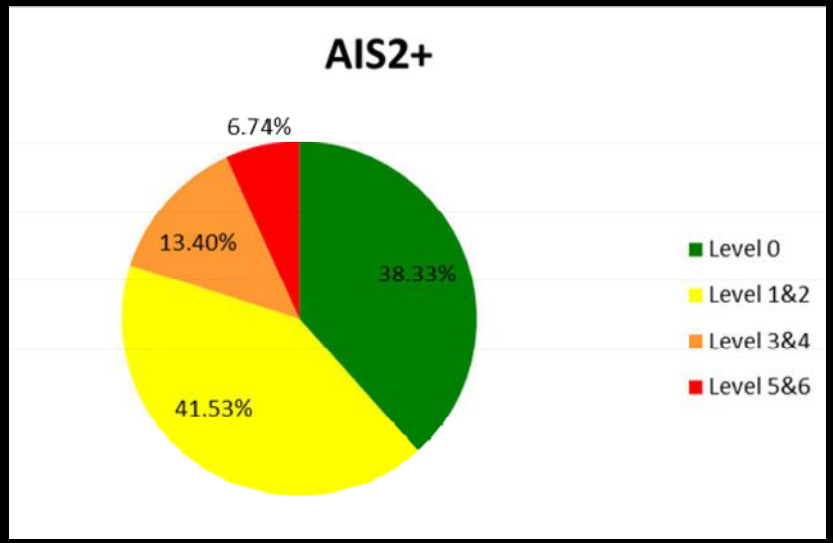
Beispiel: CII Capability: Level „0“

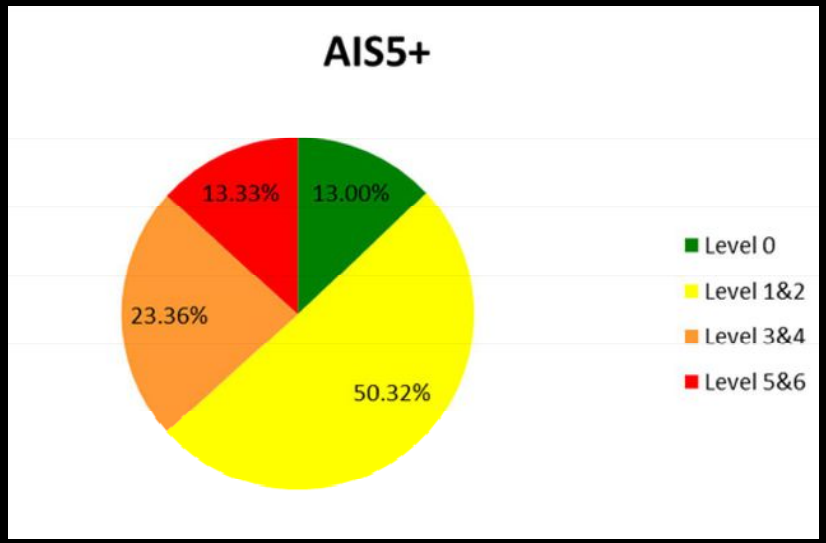
Body Region	Crash-Induced Injury (CII) Description		GHBMC M50 Capability
	Main	Sub	
Head	Skull Fracture	Cortical Layer, Diploe Layer, Vault, Base	0
Head	Facial Bone Fracture		0
Neck	Intervertebral Disc	Disc Injury	0
Neck	Ligament Injury		0
Thorax	Rib Cage Injuries	Rib Fracture	0
Abdomen	Solid Organ Injury	Liver Injury	0
Abdomen	Solid Organ Injury	Spleen Injury	0
Plex	Pelvis	Pelvis, pubic rami fracture	0
Plex	Pelvis	Pelvis, hip fracture	0
Plex	Thigh, Knee, Leg	Proximal femur fracture	0
Plex	Thigh, Knee, Leg	Mid-shaft femur fracture	0
Plex	Thigh, Knee, Leg	Distal femur fracture	0
Plex	Foot	Calcaneus fracture	0
Plex	Foot	Talus fracture	0
Plex	Foot	Ankle and sub-talar joint injury	0

Quelle: J.T. Wang, SAE G&I 2014

GHBM (Global Human Body Model)

- GHBMC M50 model is validated for
  - 38% of all crash-induced AIS2+ injuries
  - 13% AIS5+ injuries
- GHBMC M50 model is detailed enough for simulating
  - 80% of all crash-induced AIS2+ injuries
  - 63% AIS5+ injuries





Quelle: J.T. Wang, SAE G&I 2014

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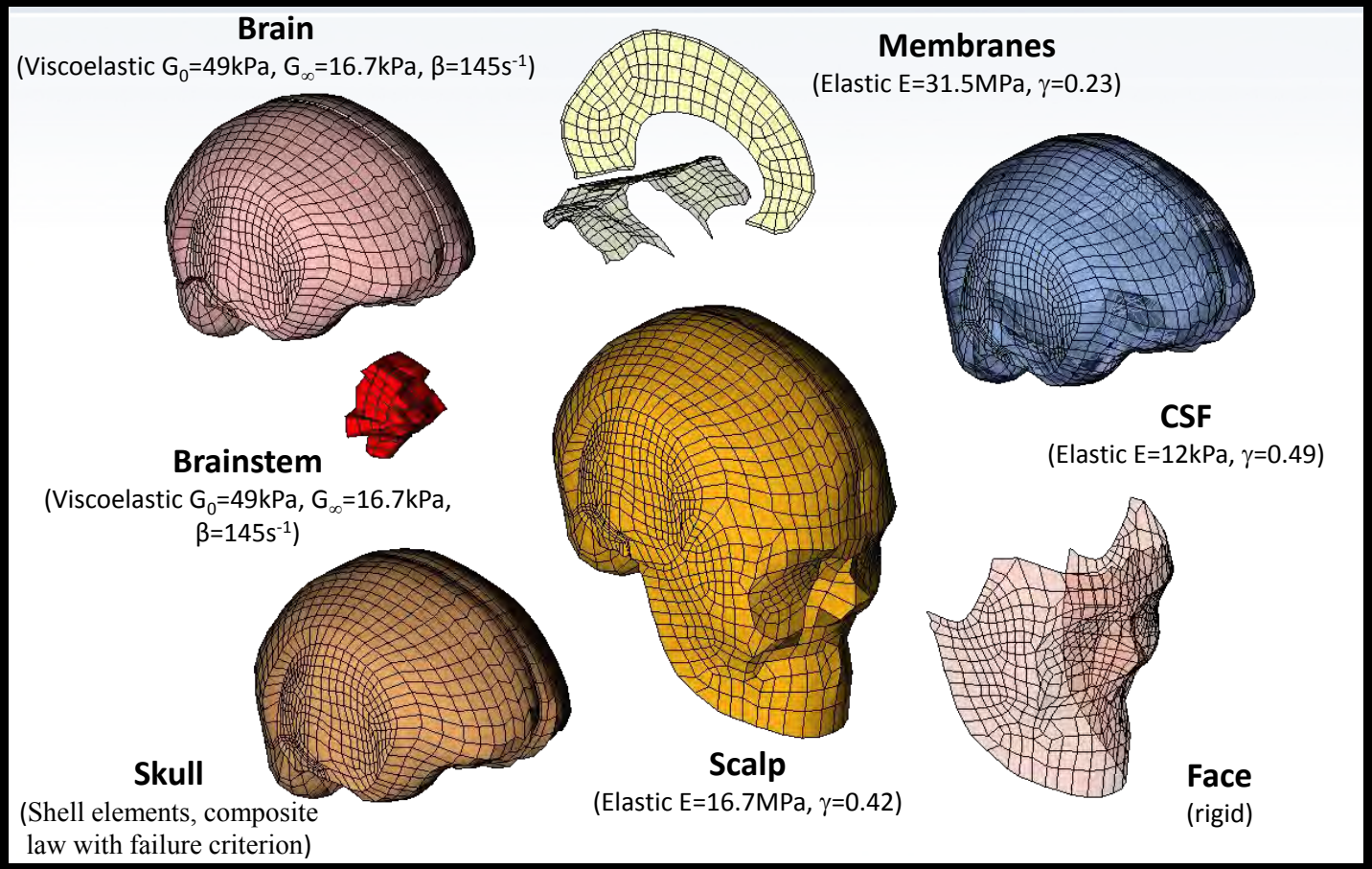
SUFEHM
(Strasbourg University FE Head Model)

- 50th%ile Adult Human Head, 13.208 Elemente



Quelle: R. Willinger, carhs Seminar T141

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Inhalt

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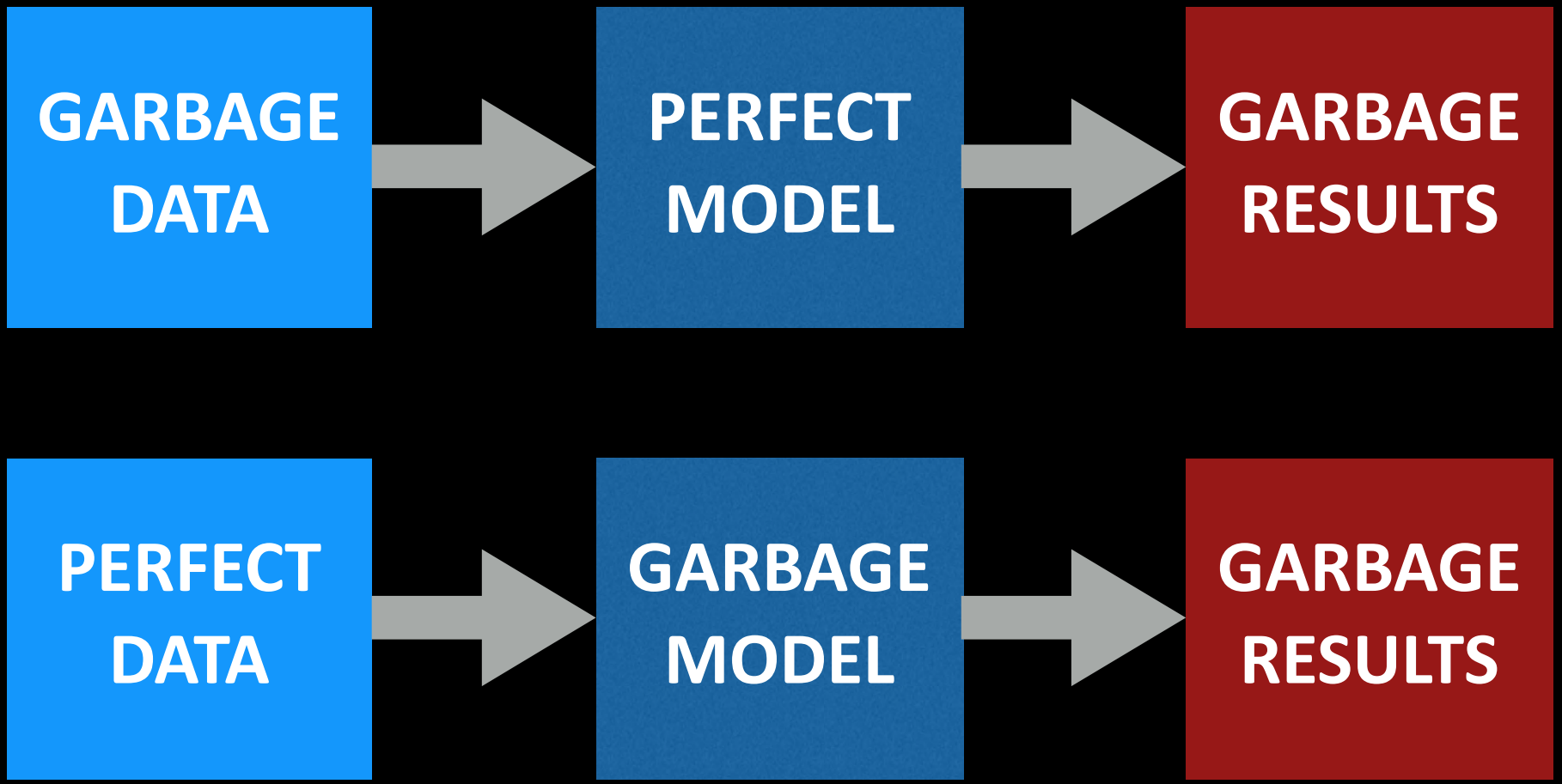
- Zukünftige Entwicklungen

Garbage in,
garbage out.

„Garbage In-garbage Out“ Paradigma



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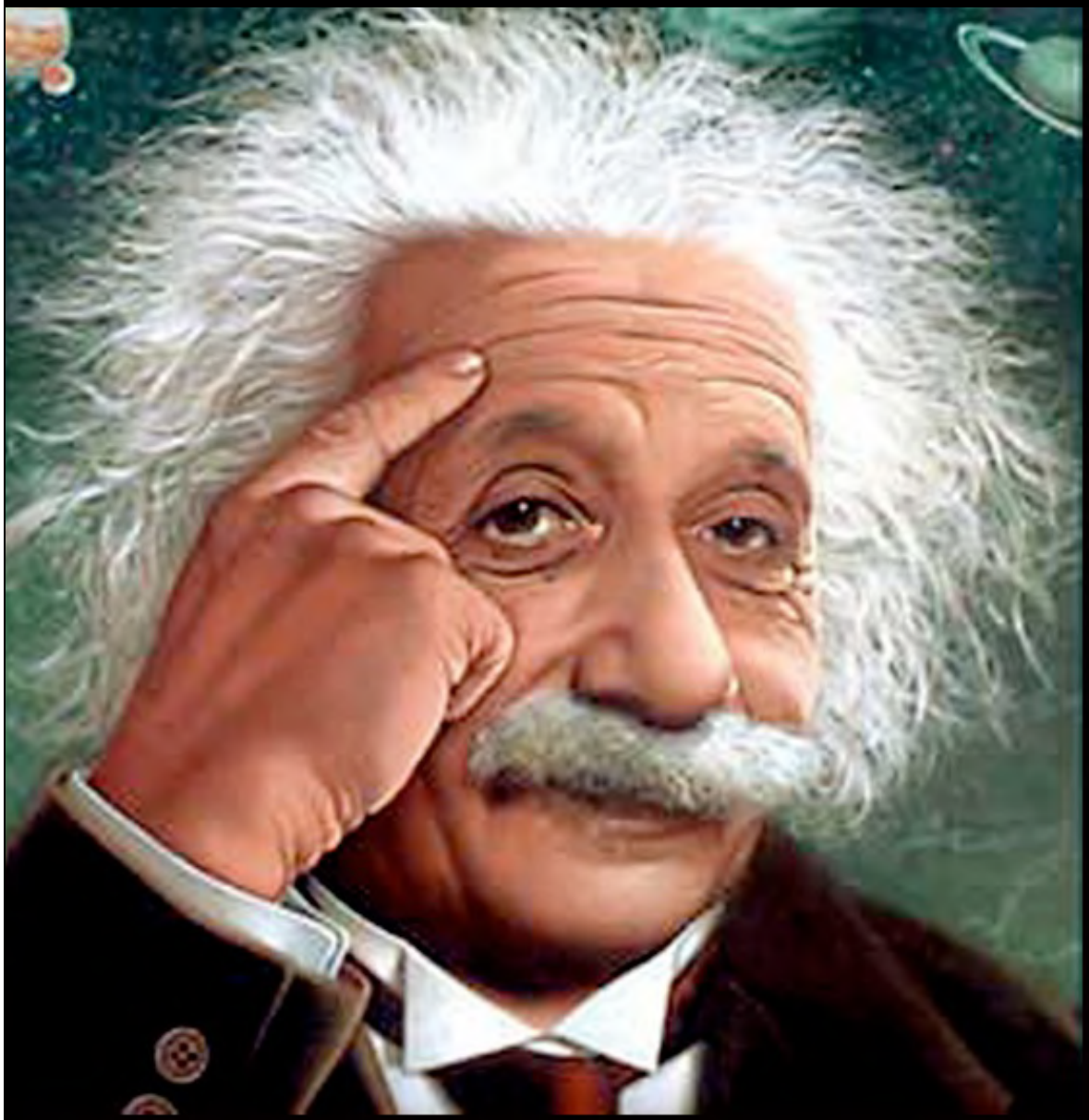

EVERYTHING SHOULD BE MADE AS SIMPLE AS POSSIBLE, BUT NOT SIMPLER.

ALBERT EINSTEIN

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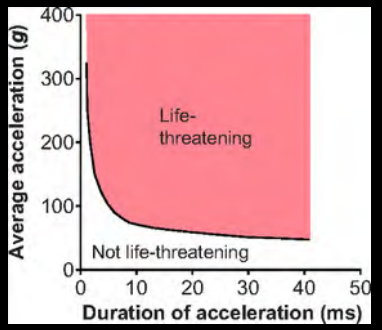
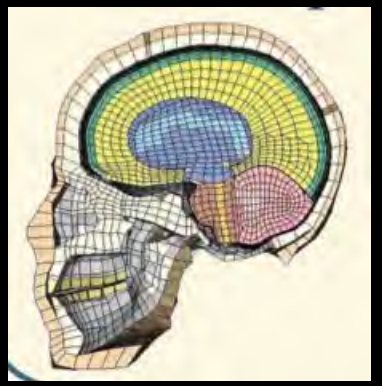
How simple is simple enough?

Beispiel: Hirnverletzung

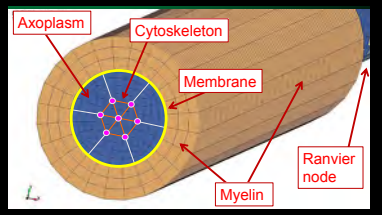
1 Element - Head Injury Criterion (HIC)



10K - 300K Elemente - Strain-Based Criterion



10^{11}-10^{16} Elemente - Axonal Damage



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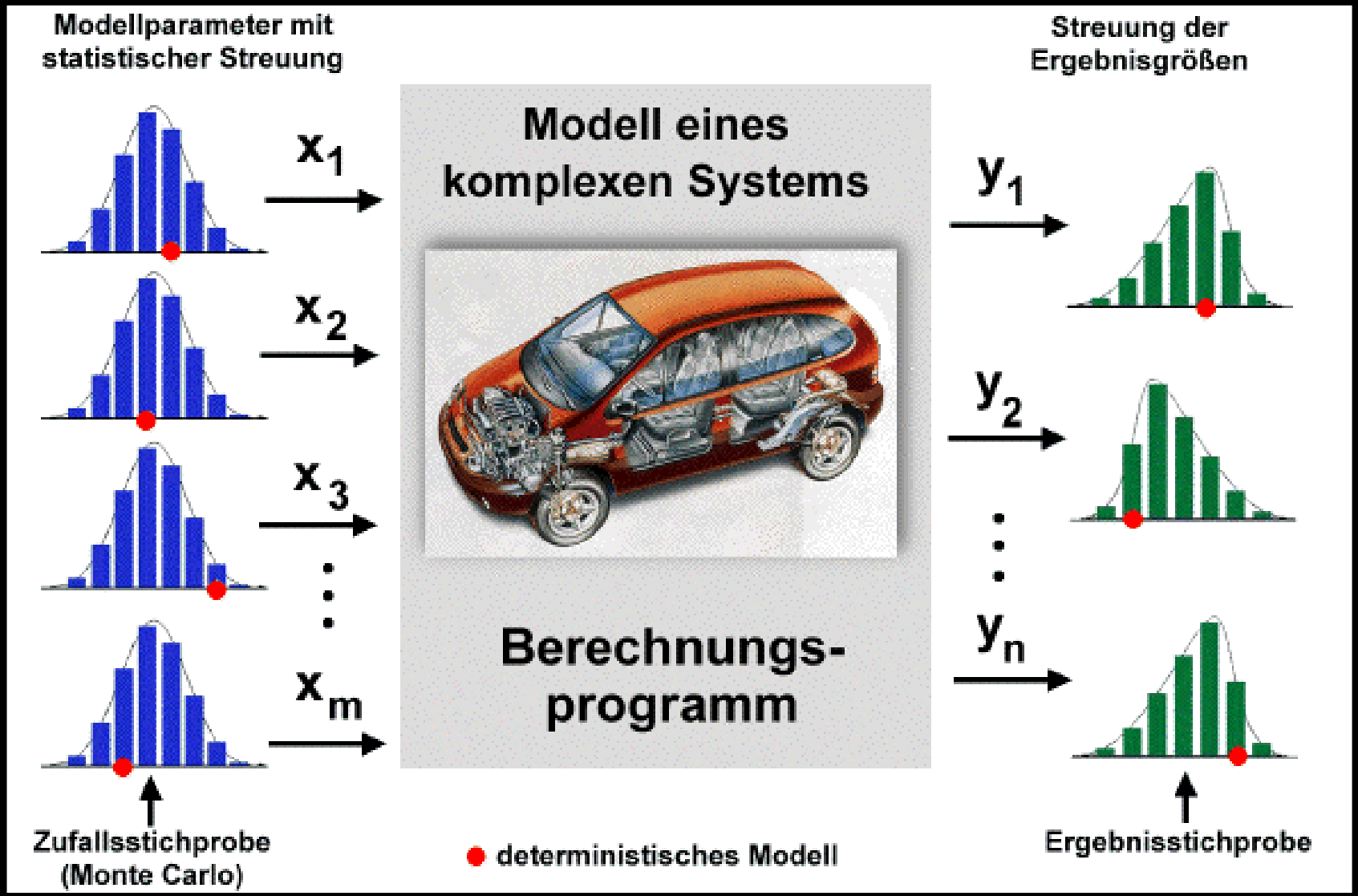
Variabilitäten

- Variabilität in den Materialien
- Variabilität in der numerischen Lösung
- Variabilität in den Randbedingungen

Variabilitäten



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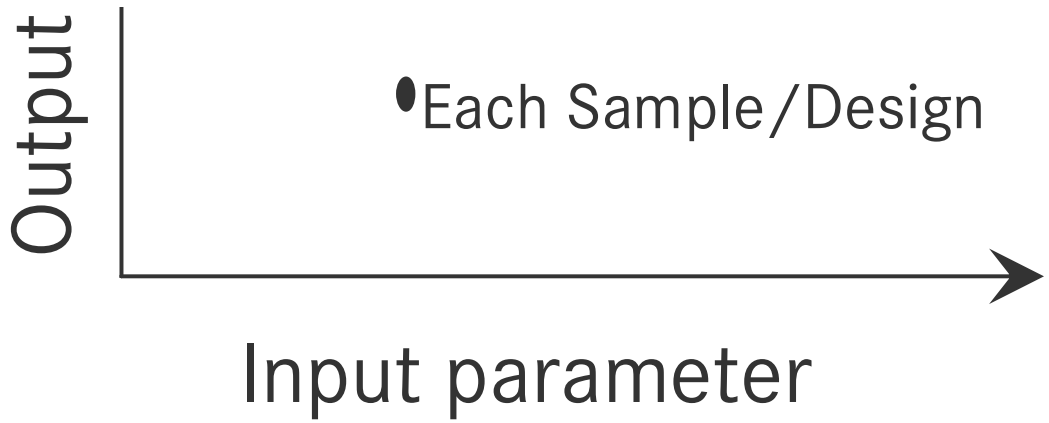
Variabilitäten

Stochastic approach
(Realistic Distributions)

Eine Simulation ist nicht genug um die Biomechanik des Menschen zu verstehen oder zu erklären!



Quelle: Kethu, CAE Grand Challenge, 2012

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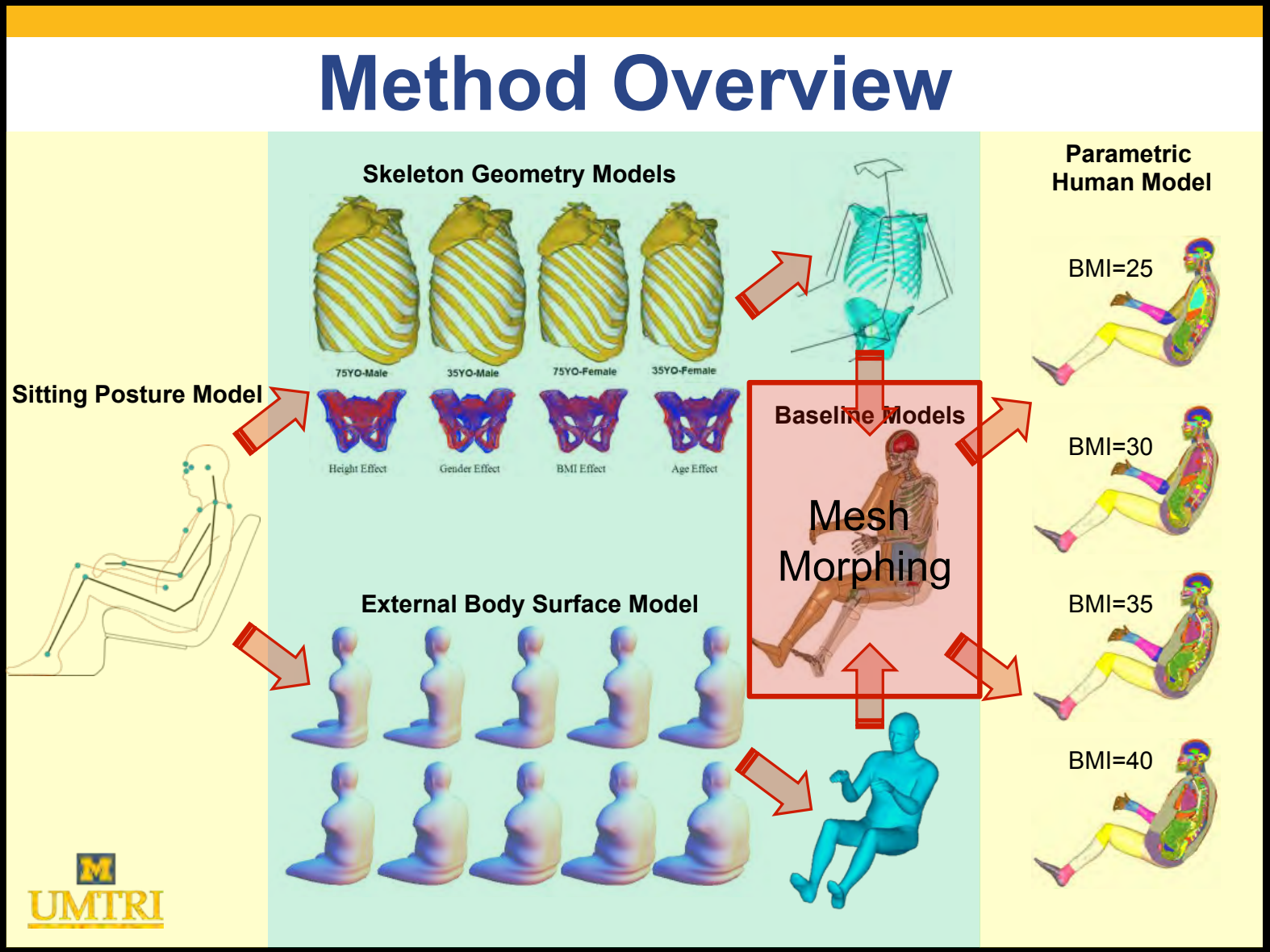
Individualisierung

Photo: Howard Schatz

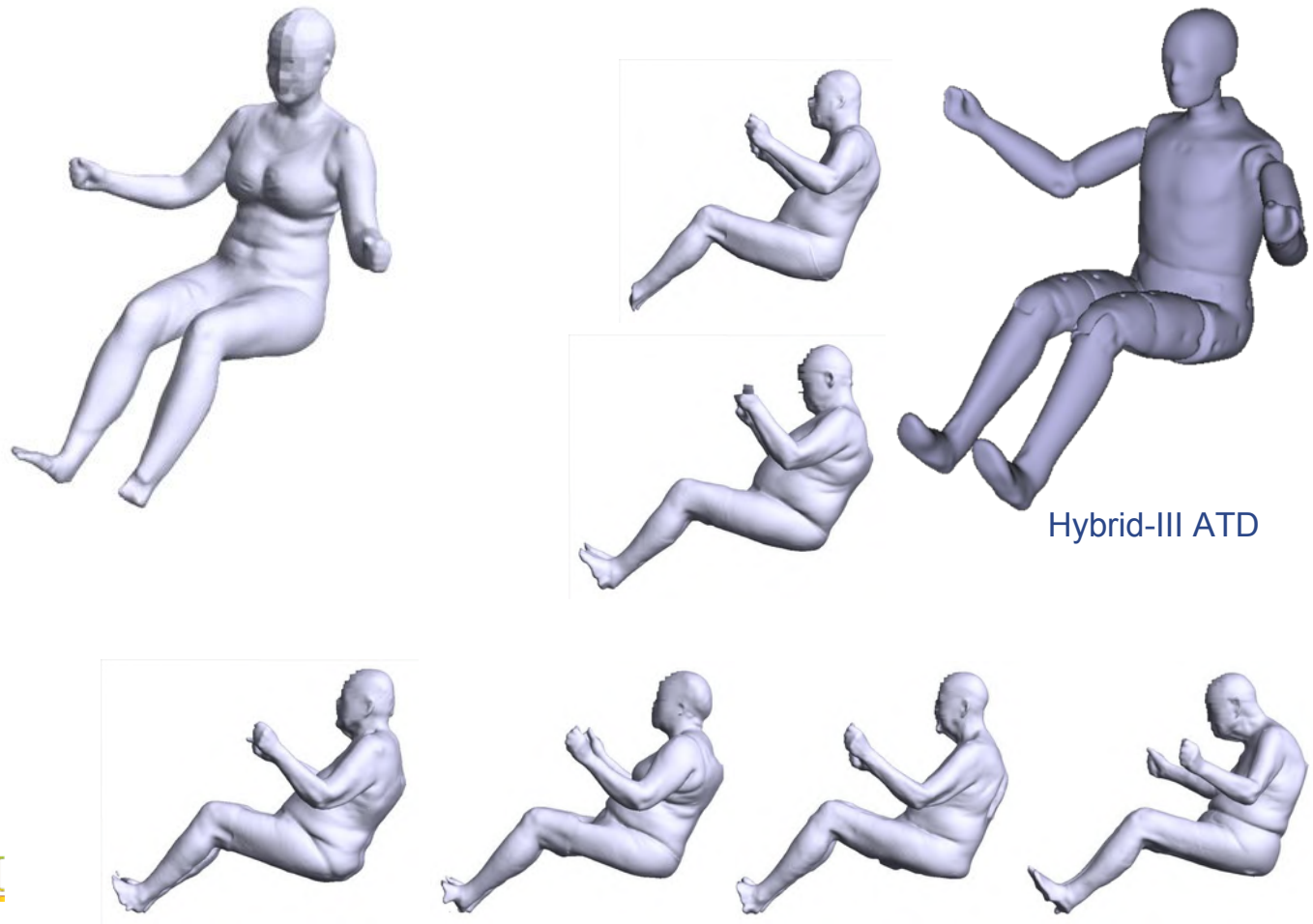
Individualisierung



Quelle: UMTRI, M. Reed

Individualisierung

Results – Body Scans



UMTRI

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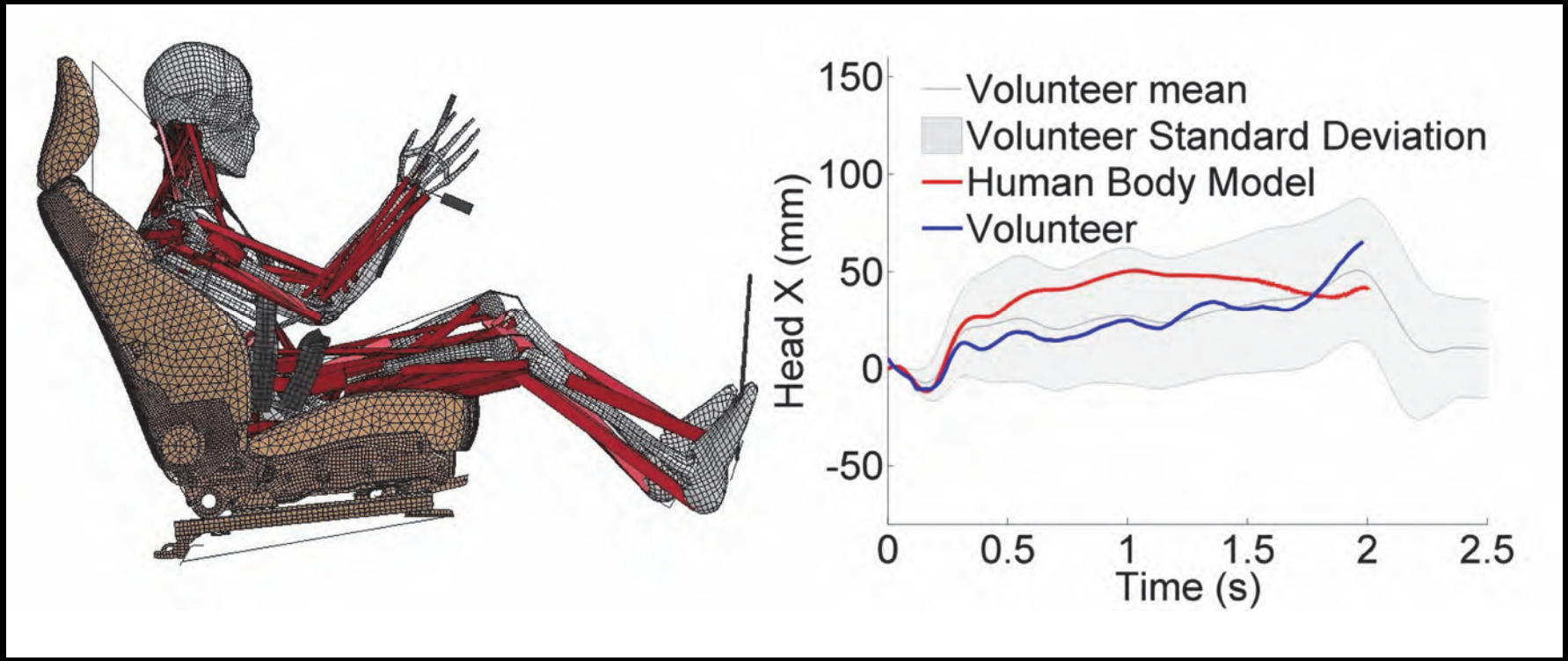
Quelle: UMTRI, M. Reed

Low-G Anwendungen

- Pre-Crash Szenarien
- Heckaufprall
- Fahrdynamik



Quelle: Brolin, HuMoSym 2014

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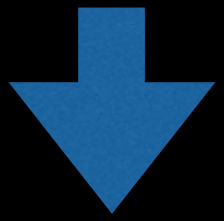
Modell Auswahl

- Welches Modell kann meine Fragestellung beantworten?
- Wie ist der Stand der Validation?
- Wer hat das Modell entwickelt?
- In welchen Programm/Version läuft das Modell?



Modell Auswahl über Verletzungen (AIS-codiert)

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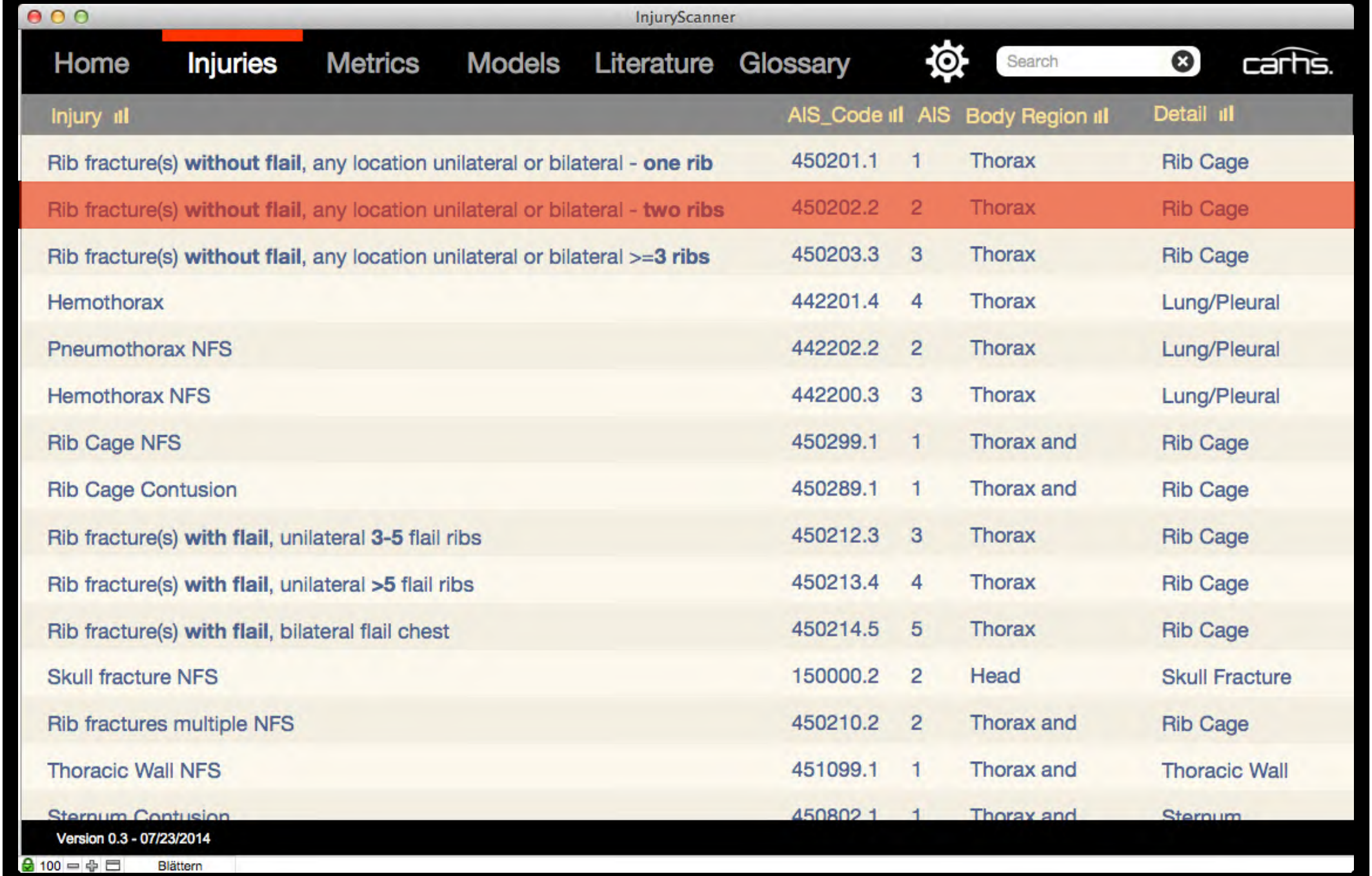
InjuryScanner
Home
Injuries
Metrics
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Search
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Injury
AIS_Code
AIS
Body Region
Detail
Rib fracture(s) without flail, any location unilateral or bilateral - one rib
450201.1
1
Thorax
Rib Cage
Rib fracture(s) without flail, any location unilateral or bilateral - two ribs
450202.2
2
Thorax
Rib Cage
Rib fracture(s) without flail, any location unilateral or bilateral >=3 ribs
450203.3
3
Thorax
Rib Cage
Hemothorax
442201.4
4
Thorax
Lung/Pleural
Pneumothorax NFS
442202.2
2
Thorax
Lung/Pleural
Hemothorax NFS
442200.3
3
Thorax
Lung/Pleural
Rib Cage NFS
450299.1
1
Thorax and
Rib Cage
Rib Cage Contusion
450289.1
1
Thorax and
Rib Cage
Rib fracture(s) with flail, unilateral 3-5 flail ribs
450212.3
3
Thorax
Rib Cage
Rib fracture(s) with flail, unilateral >5 flail ribs
450213.4
4
Thorax
Rib Cage
Rib fracture(s) with flail, bilateral flail chest
450214.5
5
Thorax
Rib Cage
Skull fracture NFS
150000.2
2
Head
Skull Fracture
Rib fractures multiple NFS
450210.2
2
Thorax and
Rib Cage
Thoracic Wall NFS
451099.1
1
Thorax and
Thoracic Wall
Sternum Contusion
450802.1
1
Thorax and
Sternum
Version 0.3 - 07/23/2014
100
Blättern

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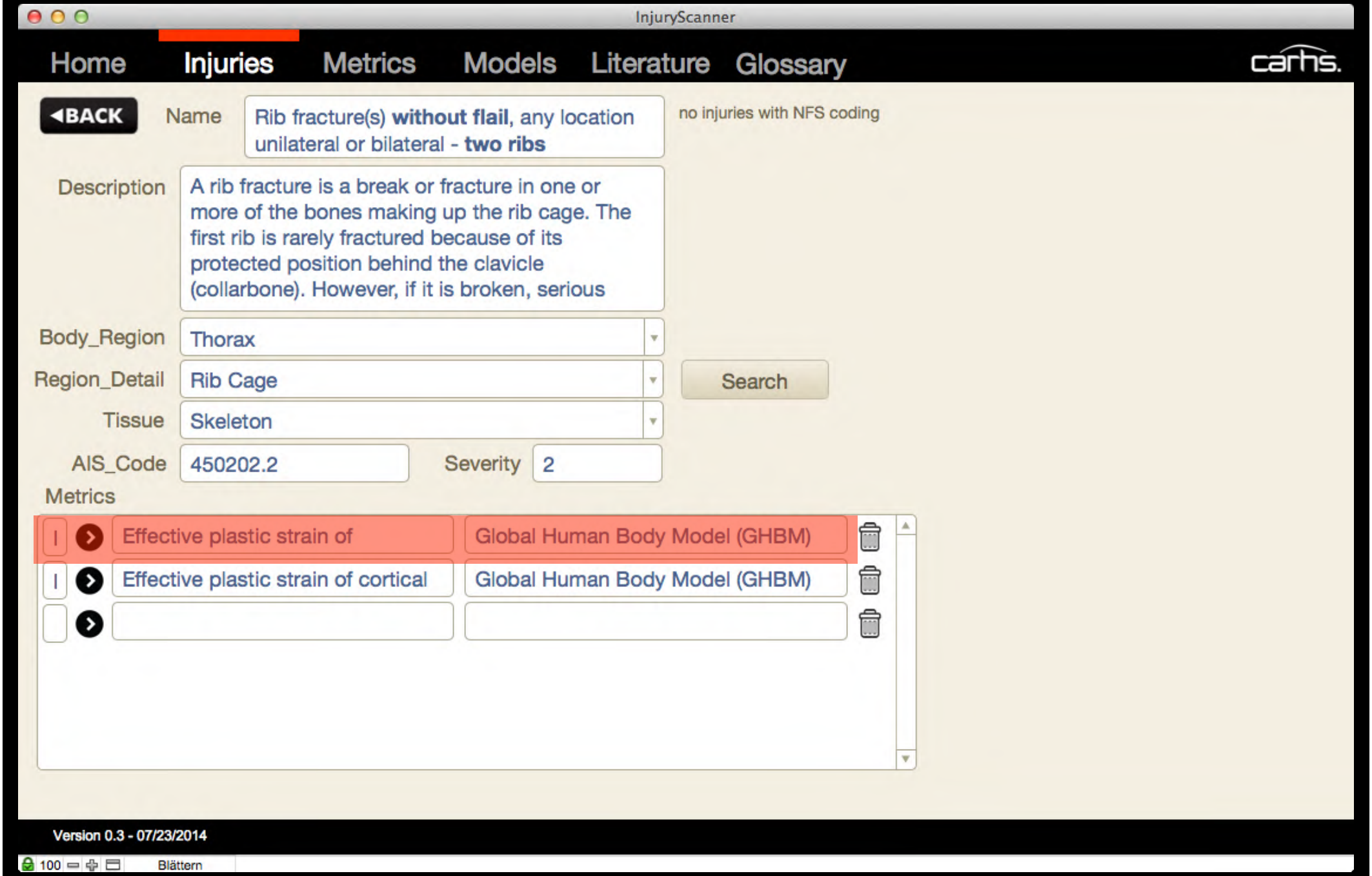
InjuryScanner
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Glossary
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BACK
Name
Rib fracture(s) without flail, any location unilateral or bilateral - two ribs
no injuries with NFS coding
Description
A rib fracture is a break or fracture in one or more of the bones making up the rib cage. The first rib is rarely fractured because of its protected position behind the clavicle (collarbone). However, if it is broken, serious
Body_Region
Thorax
Region_Detail
Rib Cage
Search
Tissue
Skeleton
AIS_Code
450202.2
Severity
2
Metrics
Effective plastic strain of
Global Human Body Model (GHBM)
Effective plastic strain of cortical
Global Human Body Model (GHBM)
Version 0.3 - 07/23/2014
100
Blättern
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InjuryScanner

Home Injuries Metrics **Models** Literature Glossary carhs.

◀BACK

Name: Global Human Body Model (GHBM)

Description: The Total Human Model for Safety, or THUMS™, is a joint development of Toyota Motor Corporation and Toyota Central R&D Labs. Unlike dummy models, which are simplified representation of humans, THUMS represents actual humans in detail, including the outer shape, but also bones, muscles,

Author: Global Human Body Model Consortium

Model Version: 4.1.1 Year: 2014

Code: LS-DYNA Version:

Model Views

Capability Matrix

0	Effective plastic strain	effectiv	0,012 (1,2
0	Effective plastic strain	effectiv	0,045 (4,5
0	Effective plastic strain of	Effectiv	0,130 (13
0	Effective plastic strain of	Effectiv	0,018 (1,8
0	Maximum principal		0.0042
0	Maximum principal		20 MPa
1	Average maximum	Strain	0,48 (48
1	Intercranial Pressure	Pressur	-104 kPa
1	Intracranial pressure	Pressur	237 kPa
1	Strain in bridging veins	Strain	0,13 -

Version 0.3 - 07/23/2014

100 Blättern

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Zusammenfassung

- Menschmodelle können Verletzungen beim Unfall voraussagen
- Simulation mit Menschmodellen sind noch keine industrielle Anwendung
- Zusammenarbeit in der Entwicklung und Transparenz der Modelleigenschaften sind notwendig

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Vielen Dank.

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