Corina Klug TU Graz, Austria
Johan Iraeus Chalmers University, Sweden
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Erik Svenning Dynamore
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Alexander Schubert TU Graz, Austria
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www.projectvirtual.eu

Introduction of the VIVA+ Vulnerable Road User Models

Human Modeling and Simulation in Automotive Engineering

Event: Human Modeling and Simulation in Automotive Engineering
Location: Online
Date: 20/11/2020

virtual

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768960.

Project VIRTUAL

Open access virtual testing protocols for enhanced road user safety

using Human Body Models

Male, female, elderly, obese and child occupants

Male, female, pedestrians and cyclists

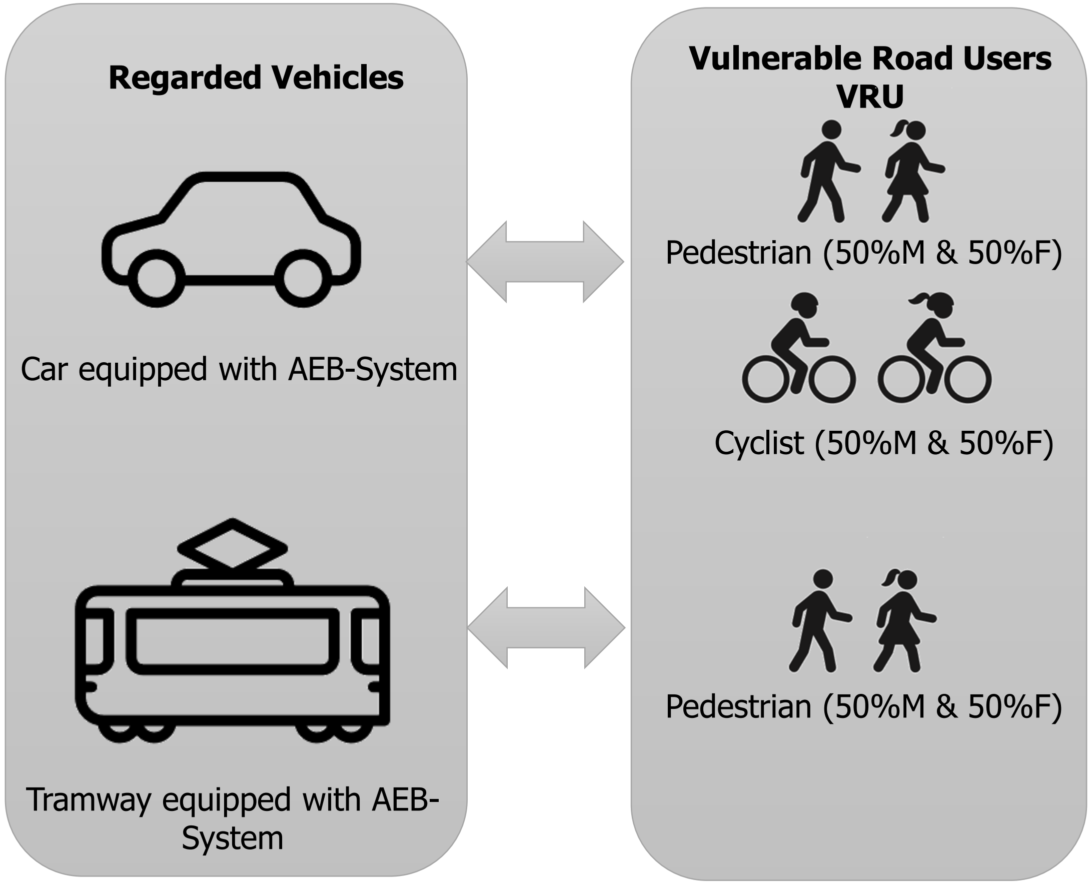
Public transport users

Aim of VRU assessment in VIRTUAL

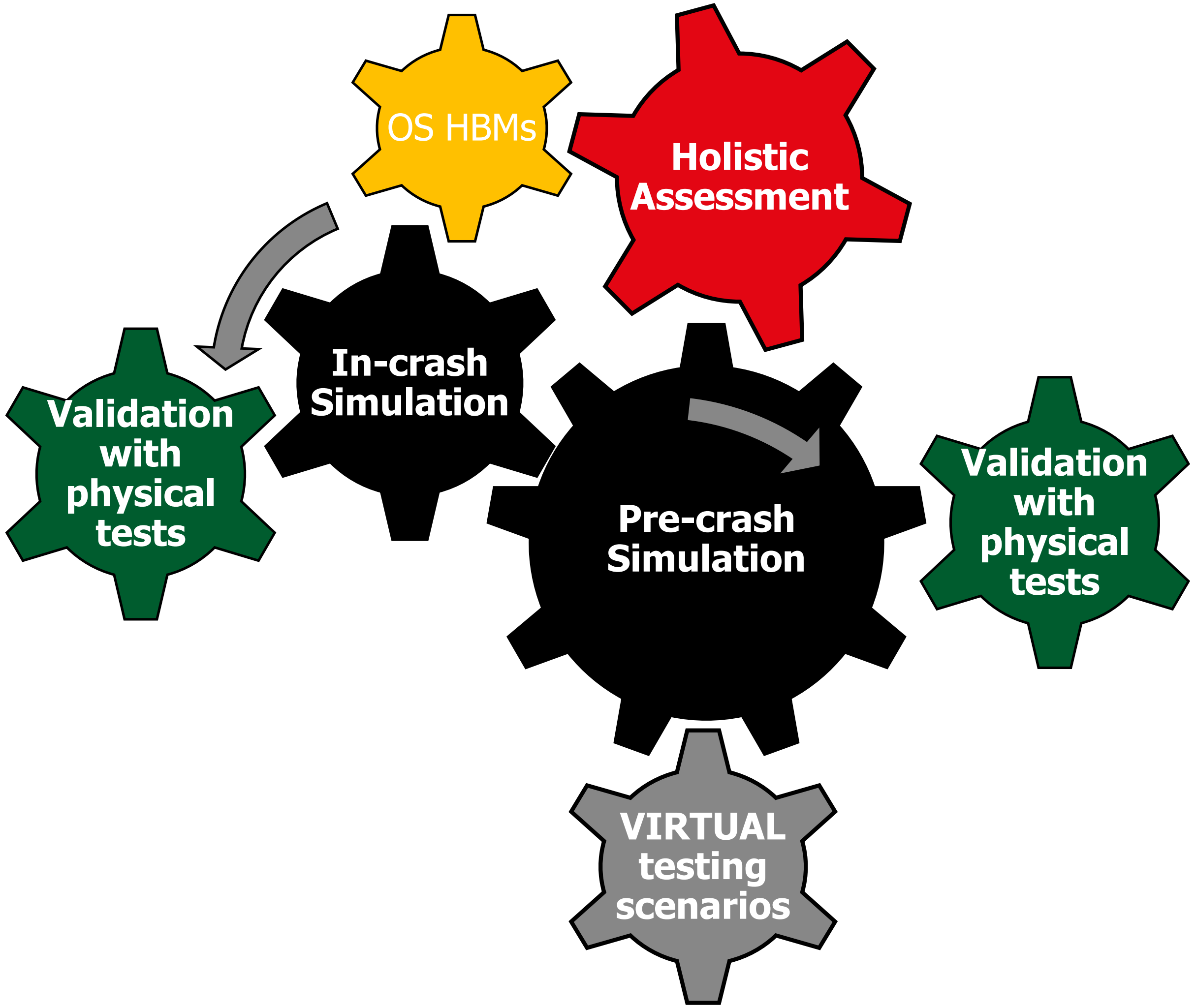
- Demonstration of integrated VT chain for **VRUs outside the vehicle**, subjected to potential **future impact scenarios**.

- Holistic assessment considering **accident avoidance and injury mitigation.**

→ Virtual Assessment protocols with all tools openly available

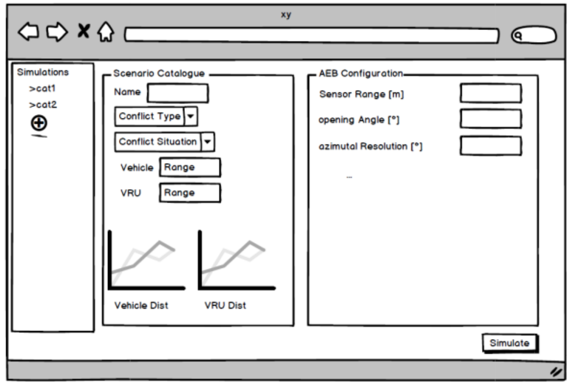


How are VIVA+ VRU models going to be used?

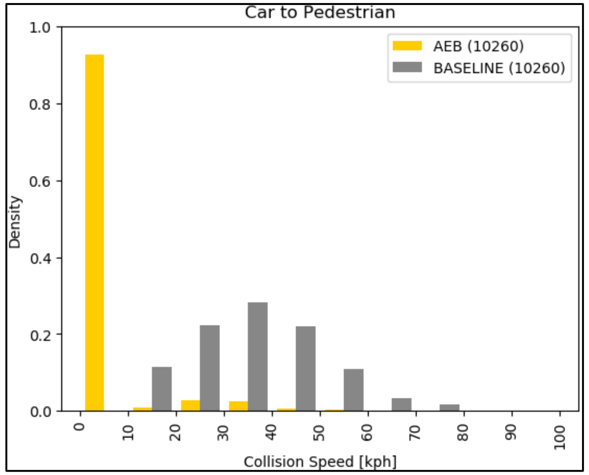


Holistic Assessment

Testing scenarios with underlying probabilities

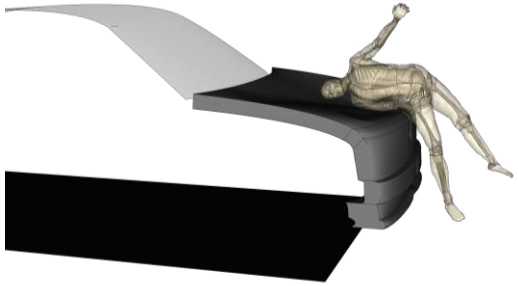


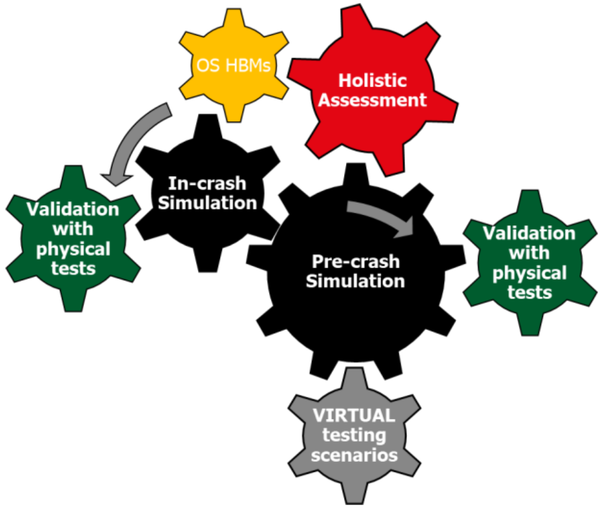
VIRTUAL precrash tool



Probability of accident avoidance

Probability of accident scenario





Overall Probability for specific injuries

Cost Benefit Analysis Tool

VIVA+ VRU models - Requirements

- Representative Anthropometry

Anthropometry

Technical Report Documentation Page

1. Report No.

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
DEVELOPMENT OF ANTHROPOMETRICALLY BASED DESIGN SPECIFICATIONS FOR AN ADVANCED ADULT ANTHROPOMORPHIC DUMMY FAMILY, Volume 1

5. Report Date
December 1983

6. Performing Organization Code

7. Author(s) L.W. Schneider, D.H. Robbins, M.A. Pflüg, R.G. Snyder

8. Performing Organization Report No.
UMTRI-83-53-1

9. Performing Organization Name and Address
The University of Michigan
Transportation Research Institute
2901 Baxter Road
Ann Arbor, Michigan 48109

10. Work Unit No. (TRAIS)

11. Contract or Grant No.
DTNH22-80-C-07502

12. Sponsoring Agency Name and Address
U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

13. Type of Report and Period Covered
FINAL REPORT
Oct. 1980 - Dec. 1983

14. Sponsoring Agency Code

15. Supplementary Notes
Volume 2: Anthropometric Specifications for Mid-Sized Male Dummy
Volume 3: Anthropometric Specifications for Small Female and Large Male Dummies

1. A *small female* whose height and weight are approximately the 5th percentile values for all U.S. adult females;

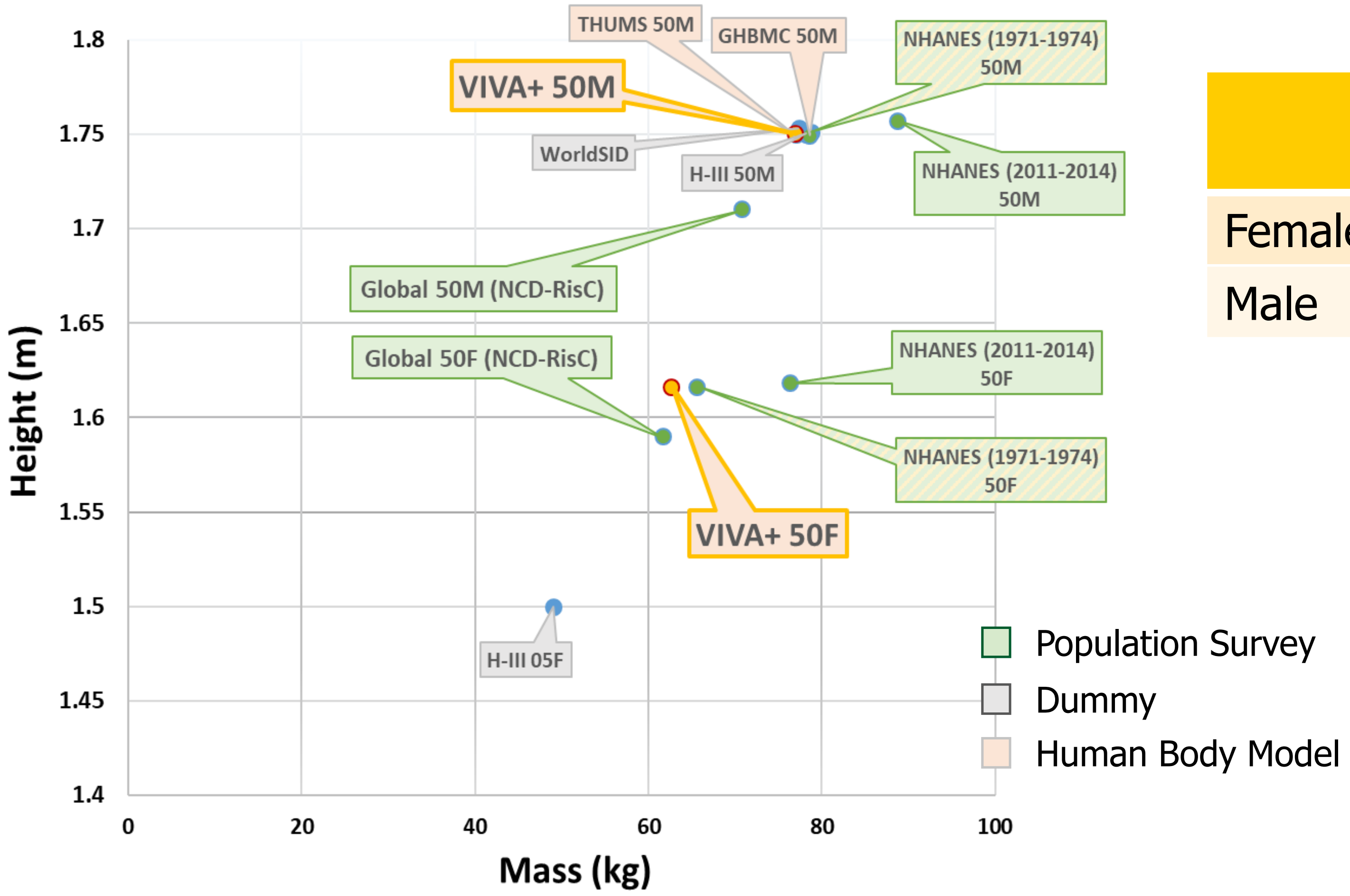
2. A *mid-sized female* whose height and weight are approximately the 50th percentile values for all U.S. adult females;

3. A *mid-sized male* whose height and weight are approximately the 50th percentile values for all U.S. adult males;

4. A *large male* whose height and weight are approximately the 95th percentile values for all U.S. adult males.

Anthropometry

Definition of male and female averages



	Mass [kg]	Height [m]	BMI [kg/m]	Age [years]
Female	62	1.62	24	50
Male	77	1.75	25	50

VIVA+ VRU models - Requirements

- Representative Anthropometry
- Enable Injury Risk Assessment[Leo et al., 2019a,b]

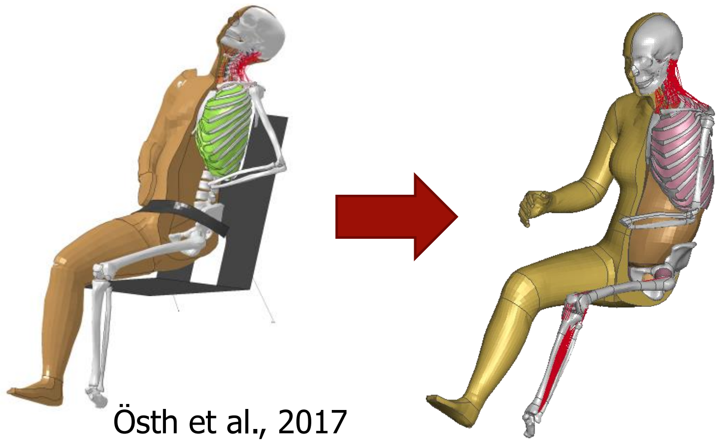
VIVA+ VRU models - Requirements

- **Representative Anthropometry**
- **Enable Injury Risk Assessment** [Leo et al., 2019a,b]
  - Fracture of lower extremities (incl. Pelvis)
  - Knee ligament rupture
  - Rib Fractures
  - *Head Injuries*

  → Results have to be useful for cost-benefit analysis tool
- **Biofidelity**
- **High level of robustness**

Development Process

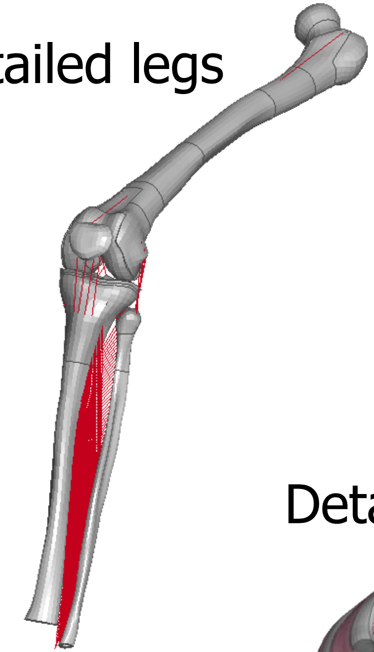
Enhance VIVA 50F Model – Transition from VIVA to VIVA+



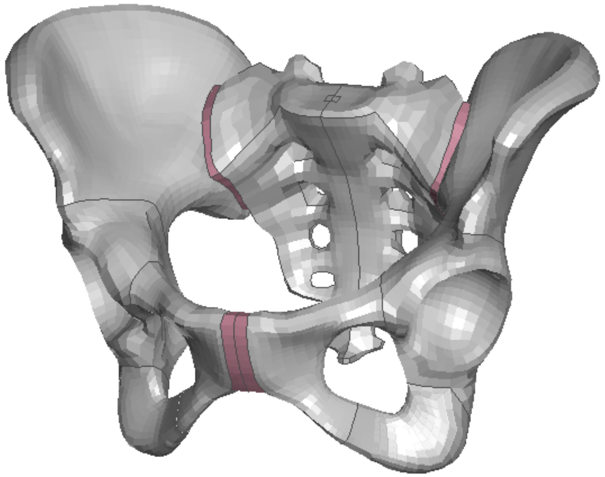
Östh et al., 2017

From VIVA to VIVA+

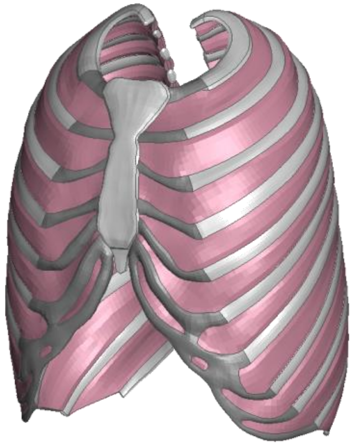
Detailed legs



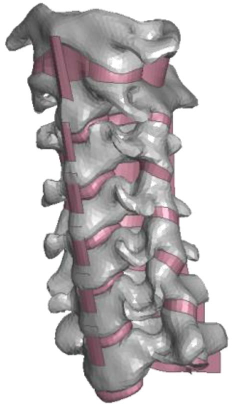
Detailed pelvis



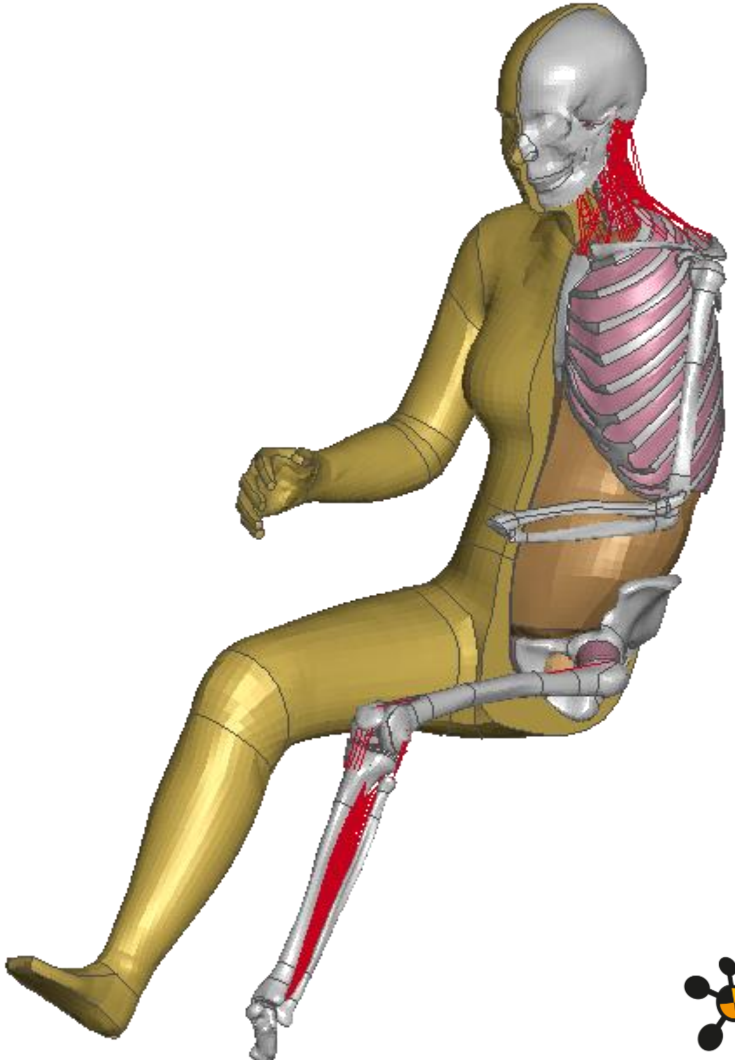
Detailed rib cage



Detailed cervical spine*



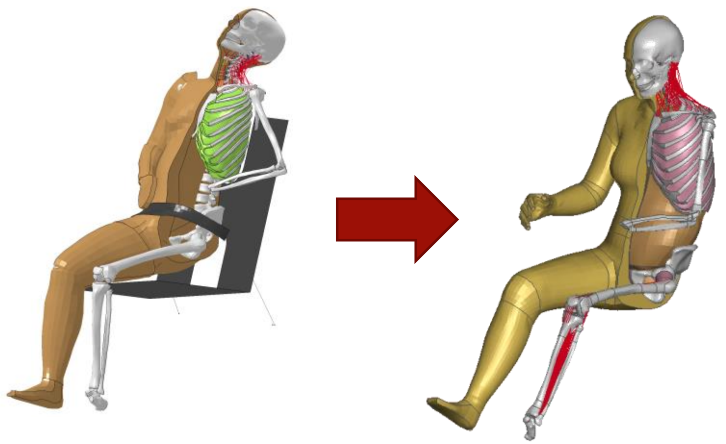
carry over from VIVA

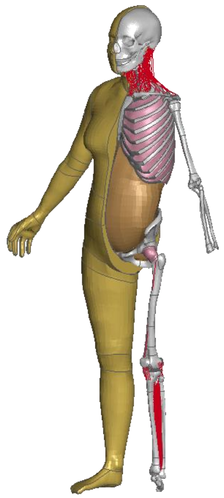


Development Process

Enhance VIVA 50F Model – Transition from VIVA to VIVA+

Morphing to other postures





50F-VRU

Development Process

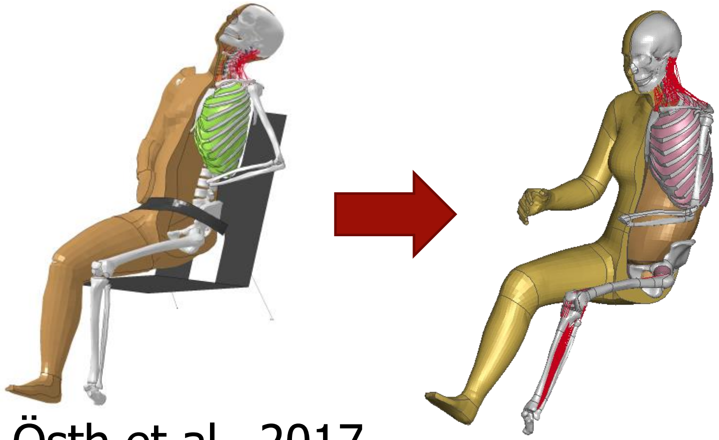
Enhance VIVA 50F Model – Transition from VIVA to VIVA+

→

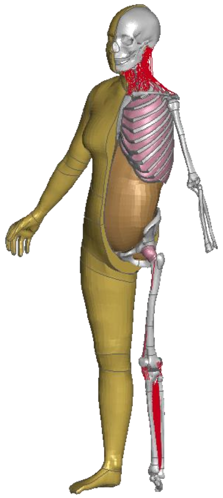
Morphing to other postures

→

Morphing to other anthropometries (50M)

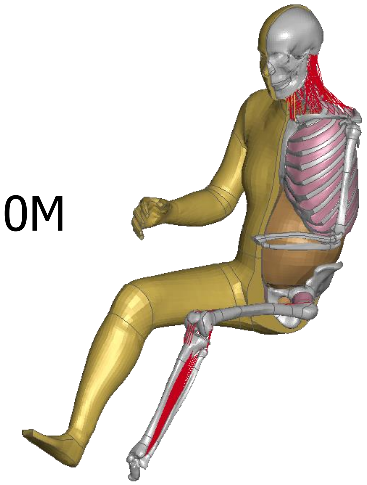


Östh et al., 2017



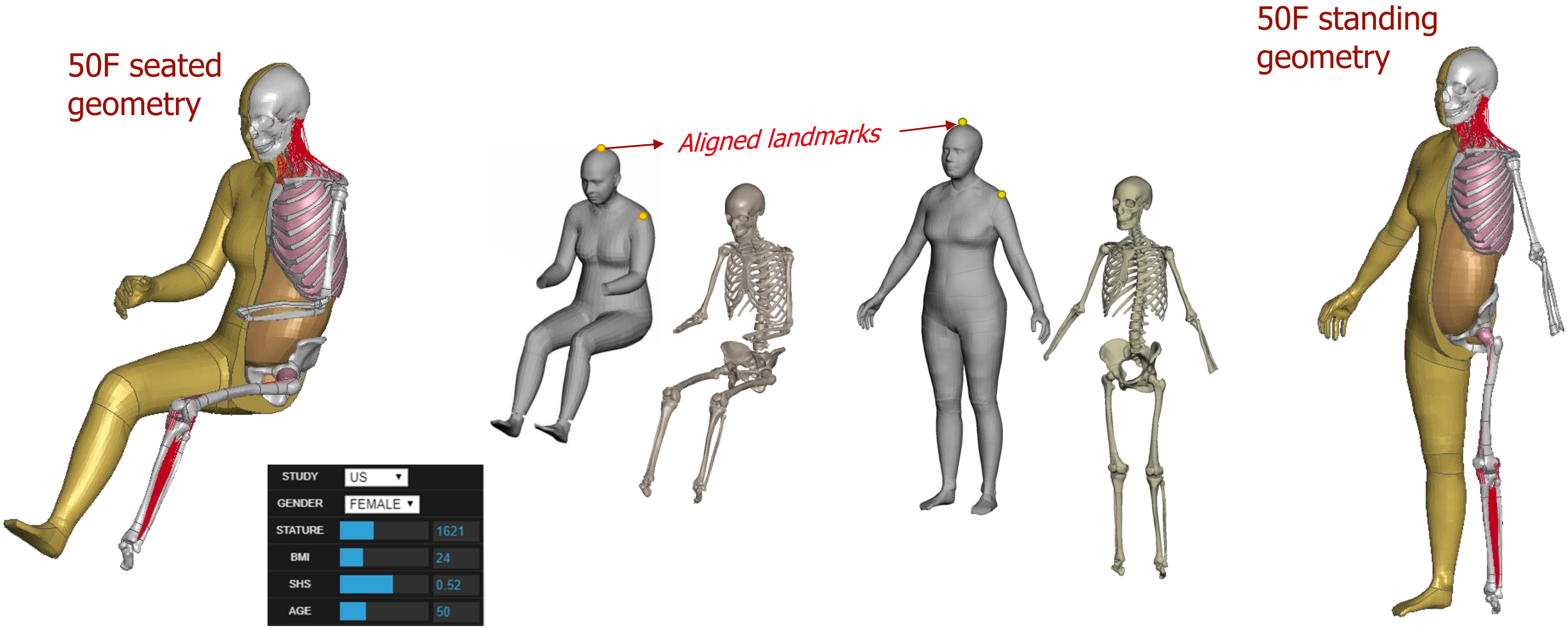
50F-VRU

50M

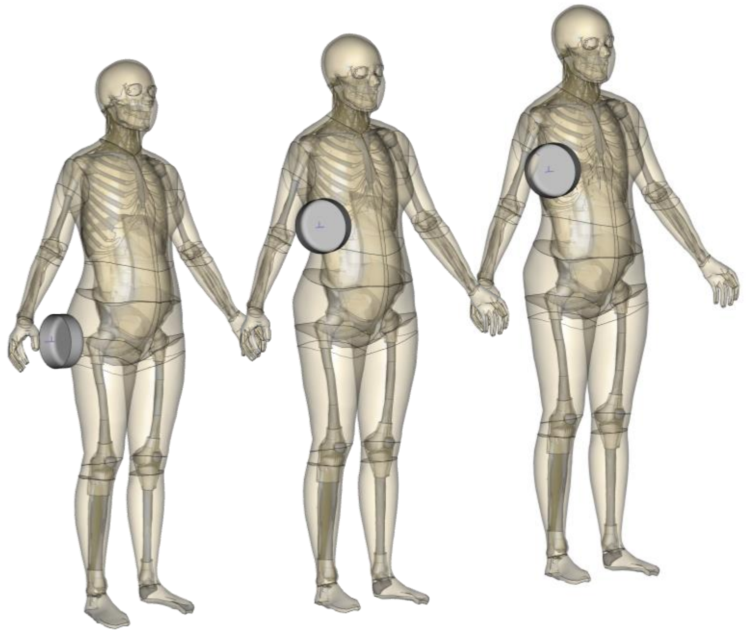


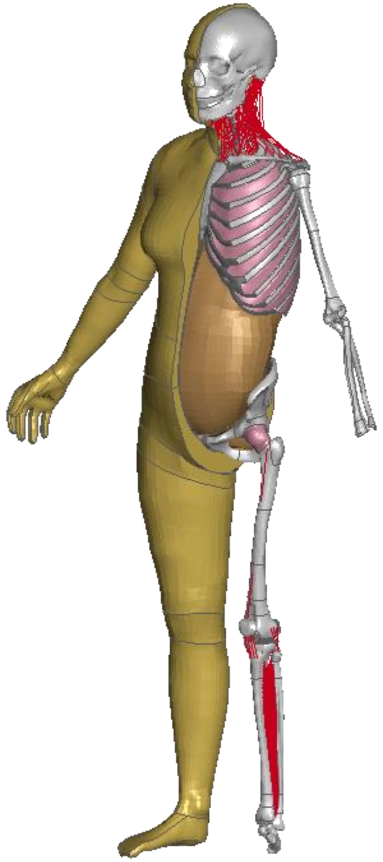
VIVA+ HBM Development

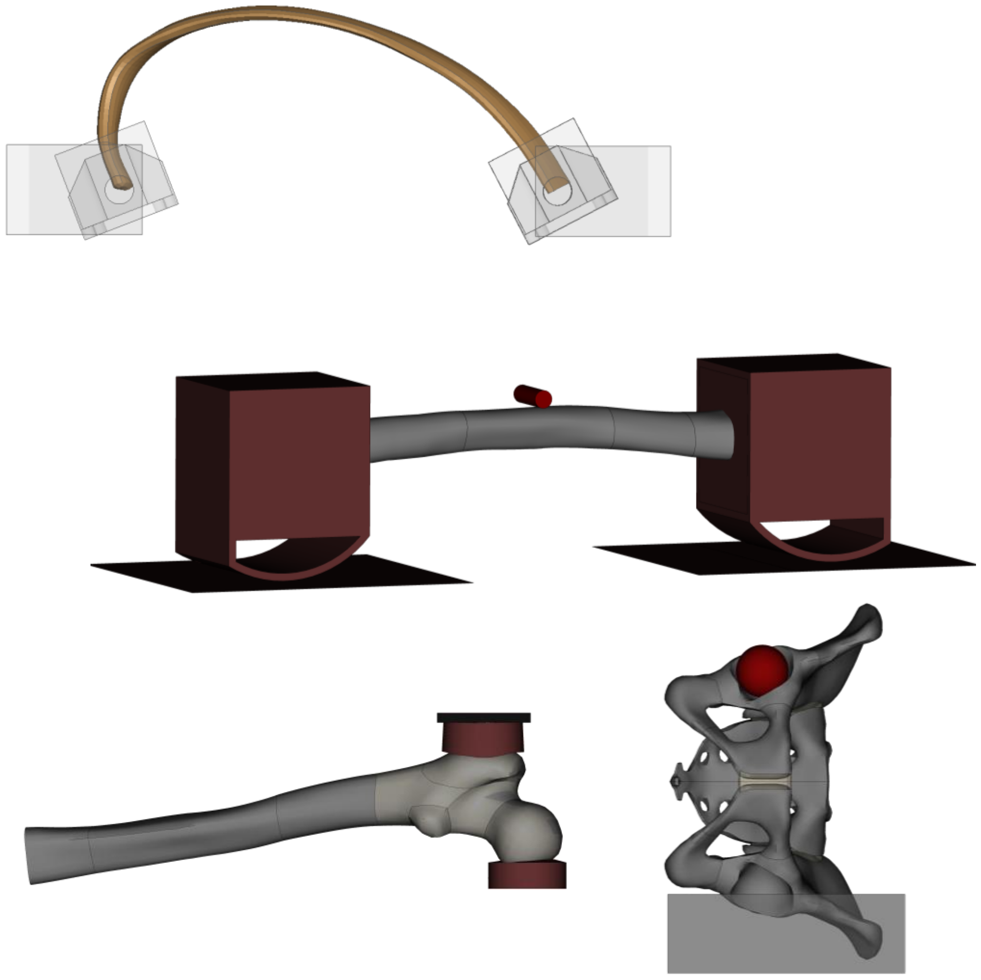
Derivative models through morphing



VIVA+ HBM Validation load cases





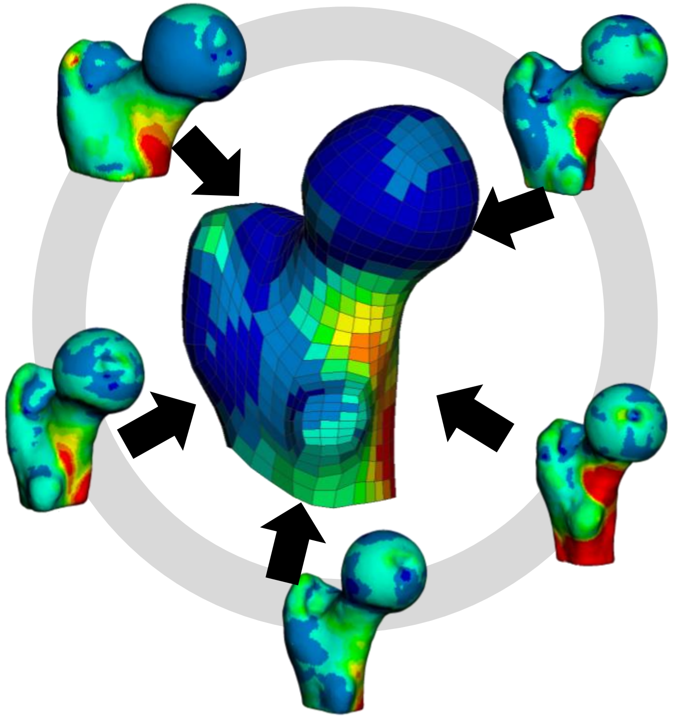


work in progress...

Example - Femur Development

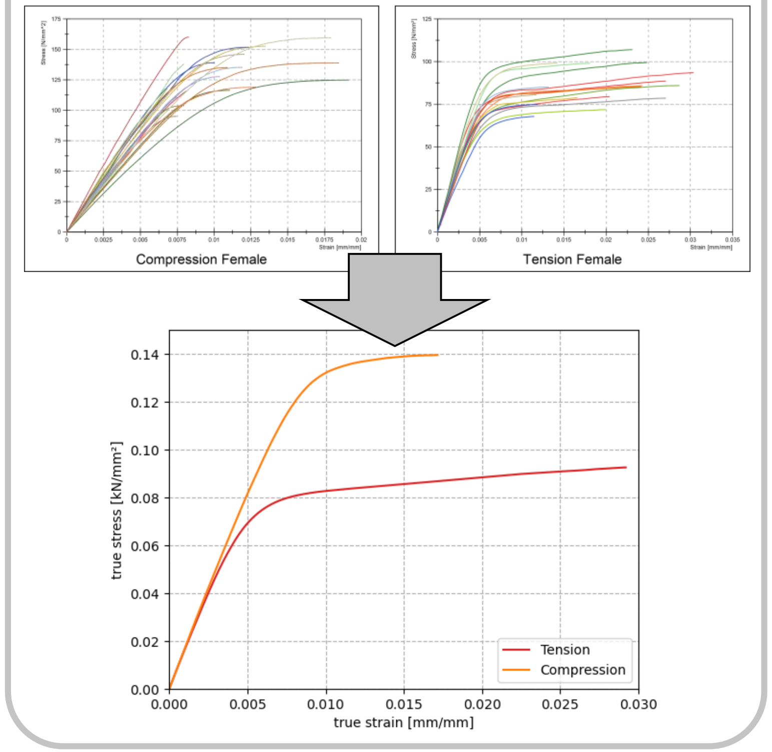
cortical thickness for head

- definition of landmarks
- morphing of samples
- projecting thickness to target geometry
- calculate average



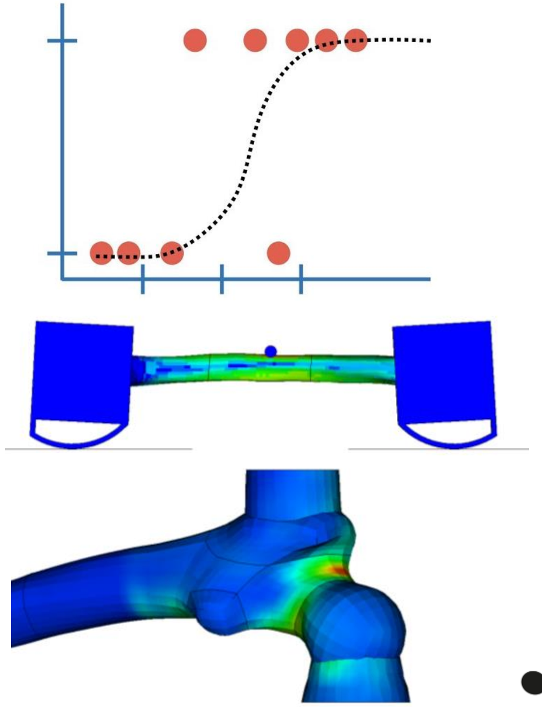
material data for cortical bone

- create average strain-stress-curves from experimental data (Mirzaali et al, 2016)
- calibrate material properties
- validate femur model

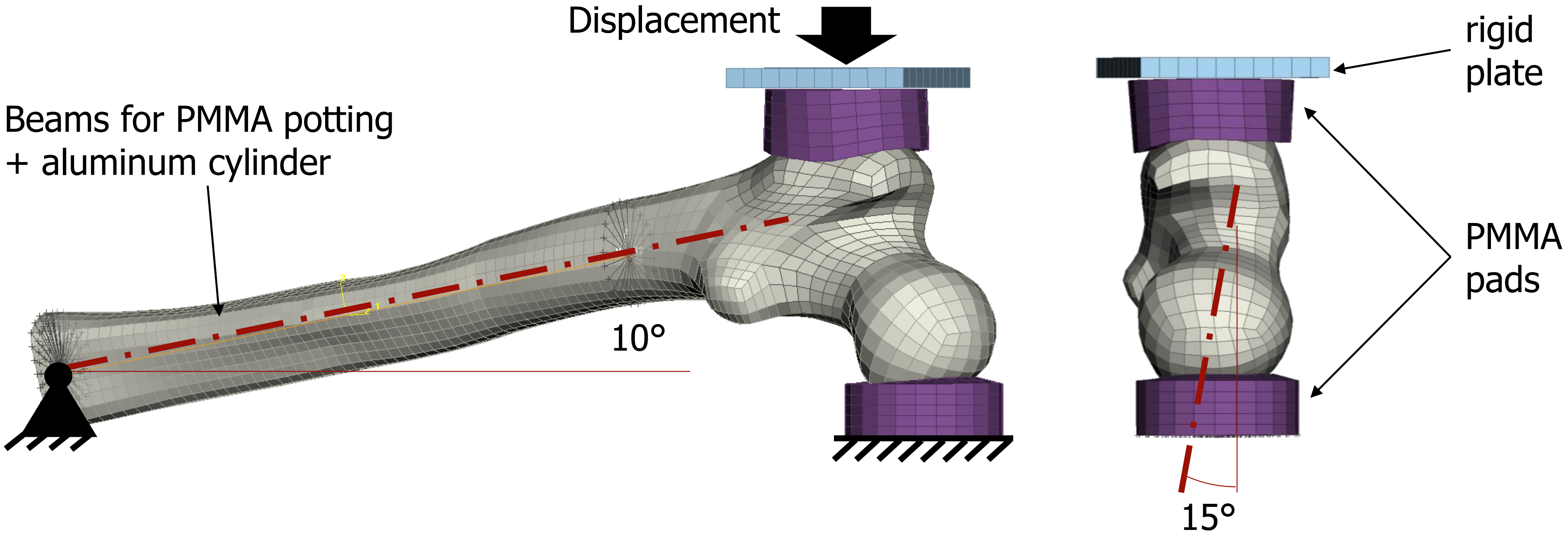


create injury risk curve

- **strain-based risk curve for midshaft and proximal femur**



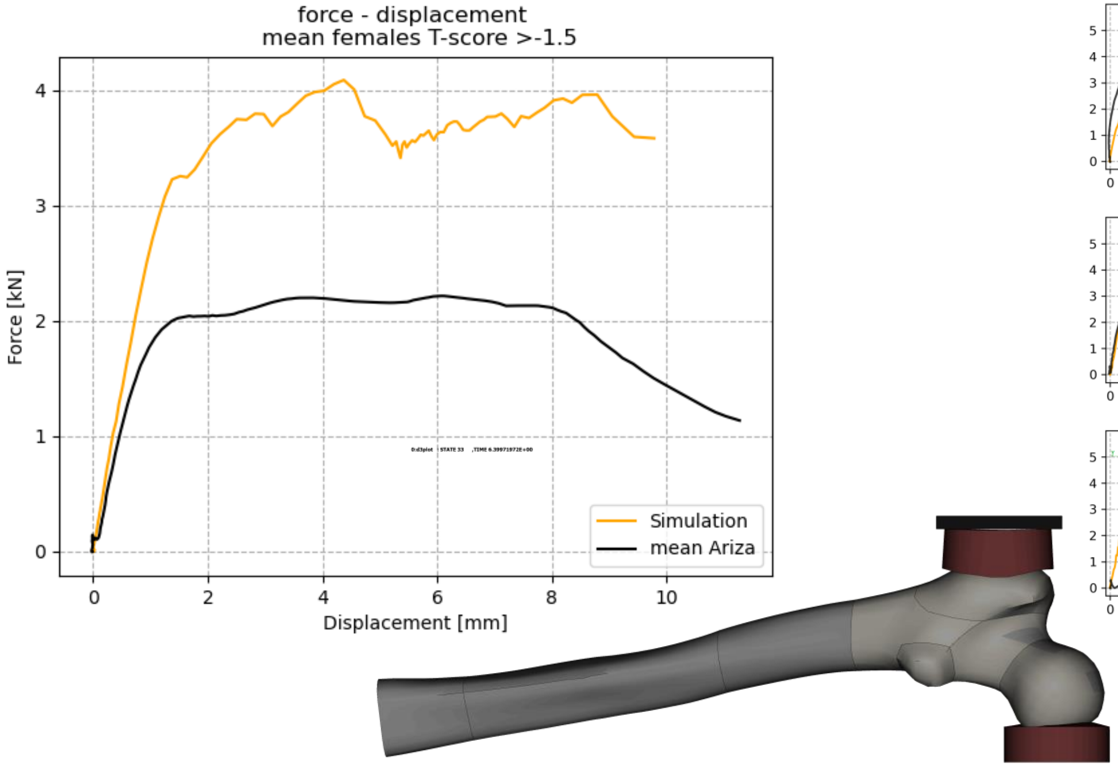
Femur Neck Validation

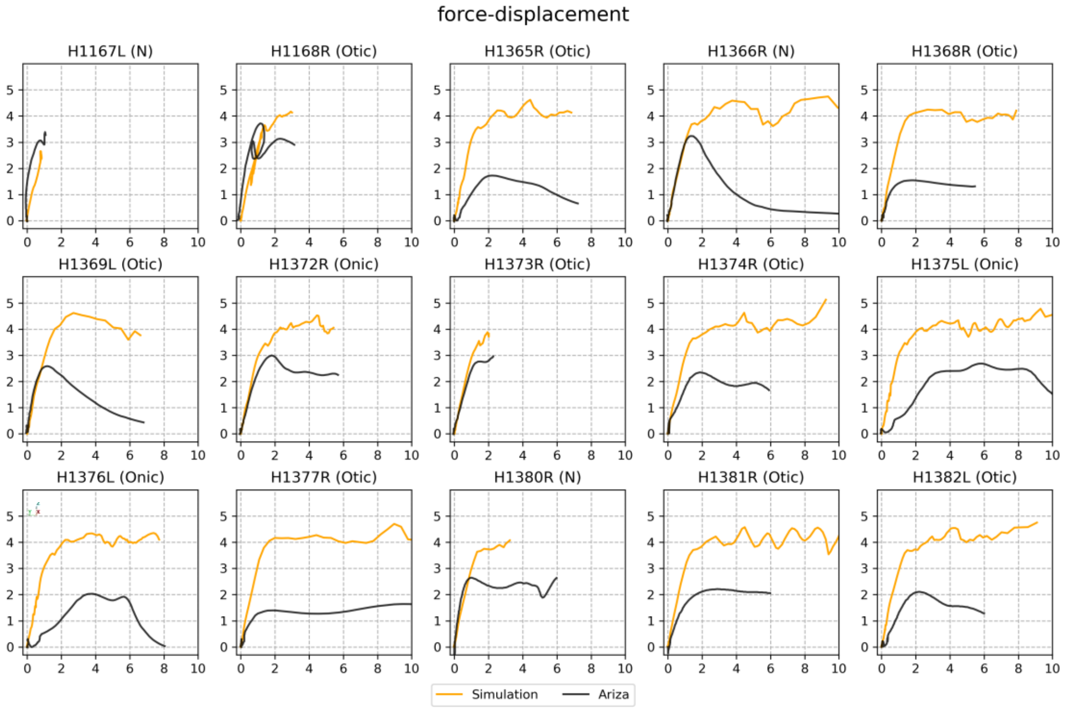


Test setup used in Ariza et al. (2015)[4]

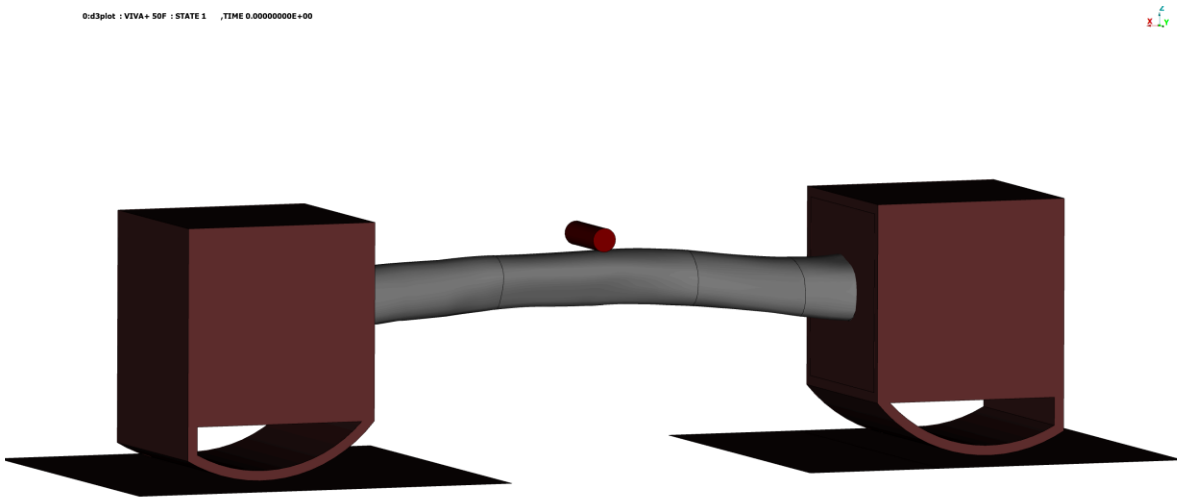
Femur Neck Validation

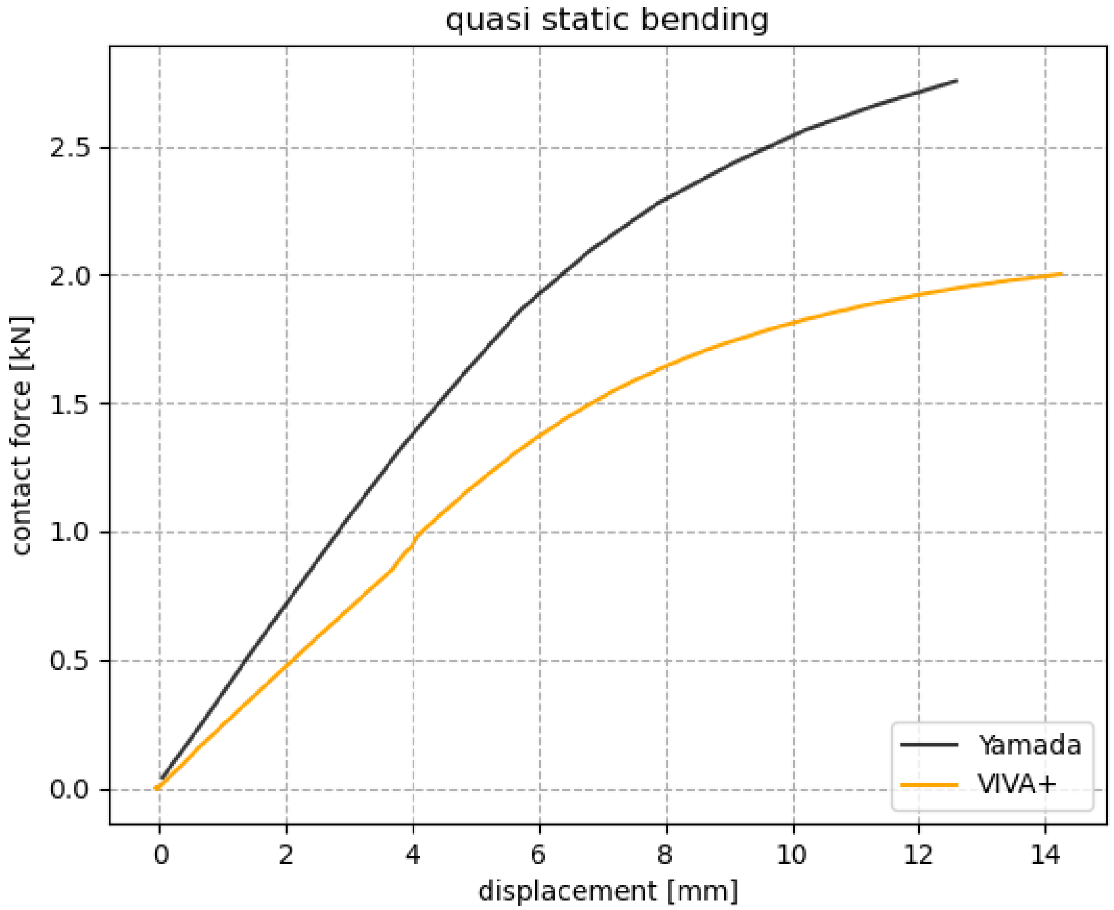
- Individual displacement curves from Ariza et al. (2015)[4] applied to the rigid plate
- A mean displacement of the 5 female specimen with the highest T-Scores was simulated additionally



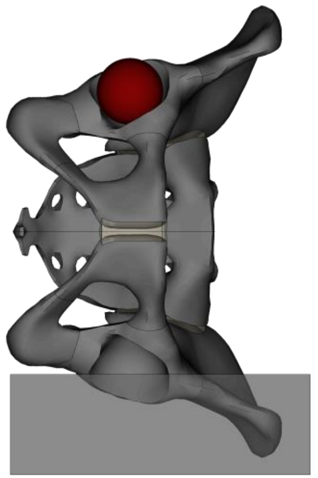


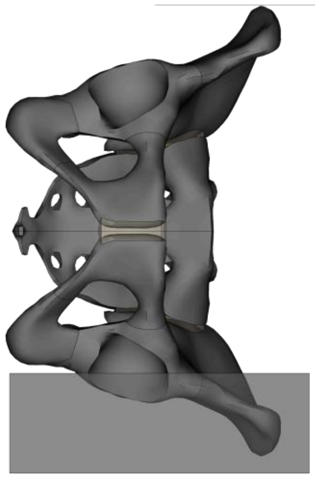
Femur Midshaft Validation – Quasistatic Test

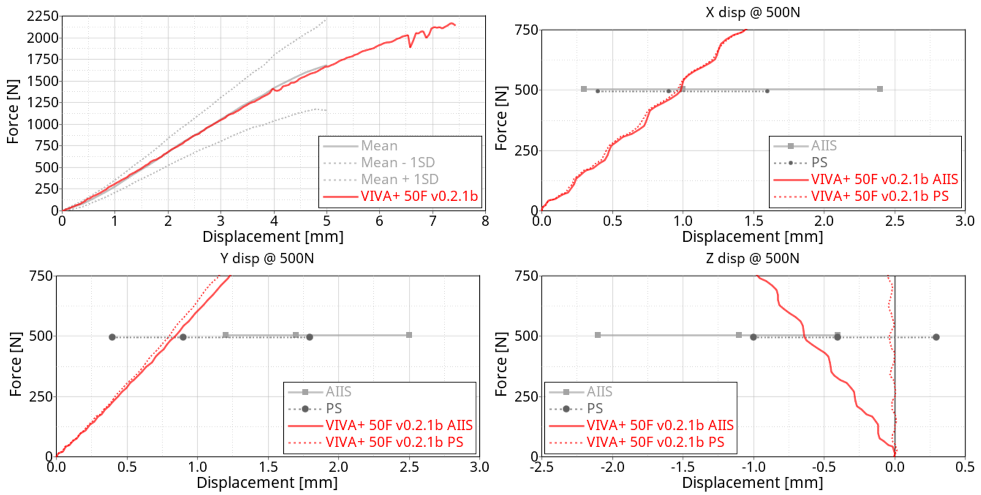


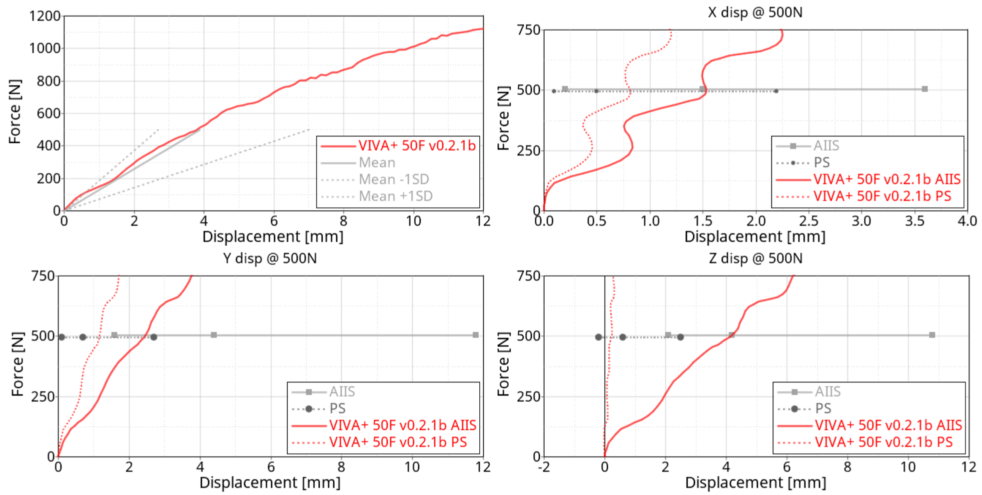


Pelvis Validation – Static Guillemot et al., 1998



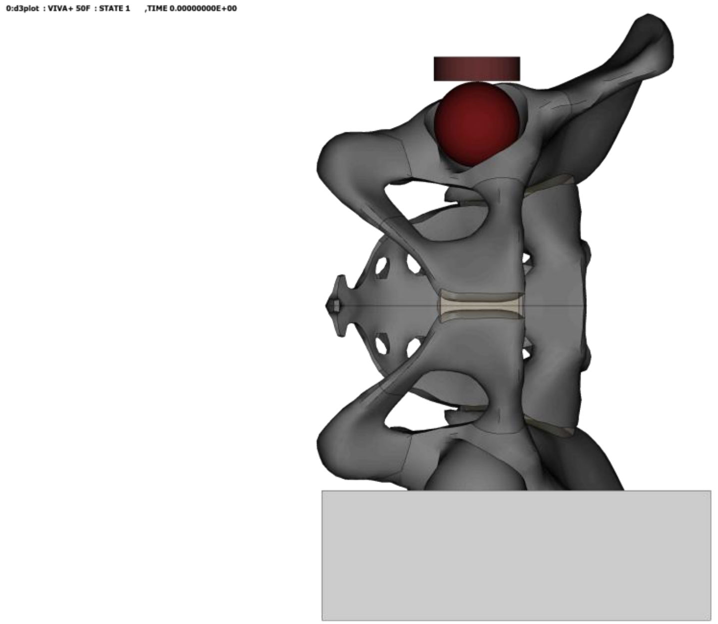


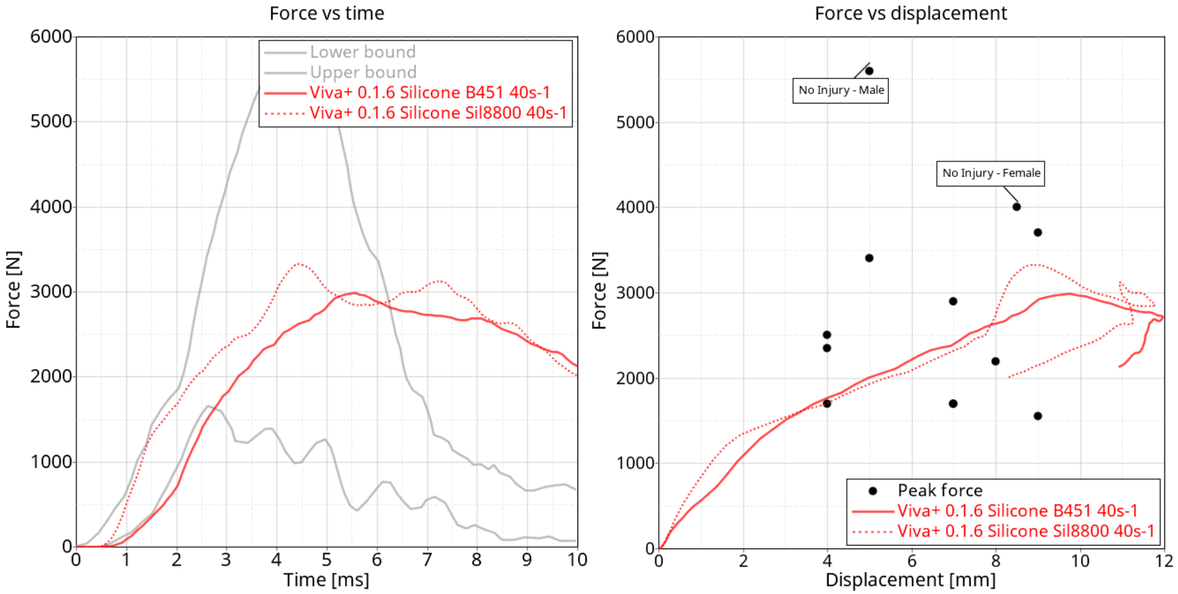




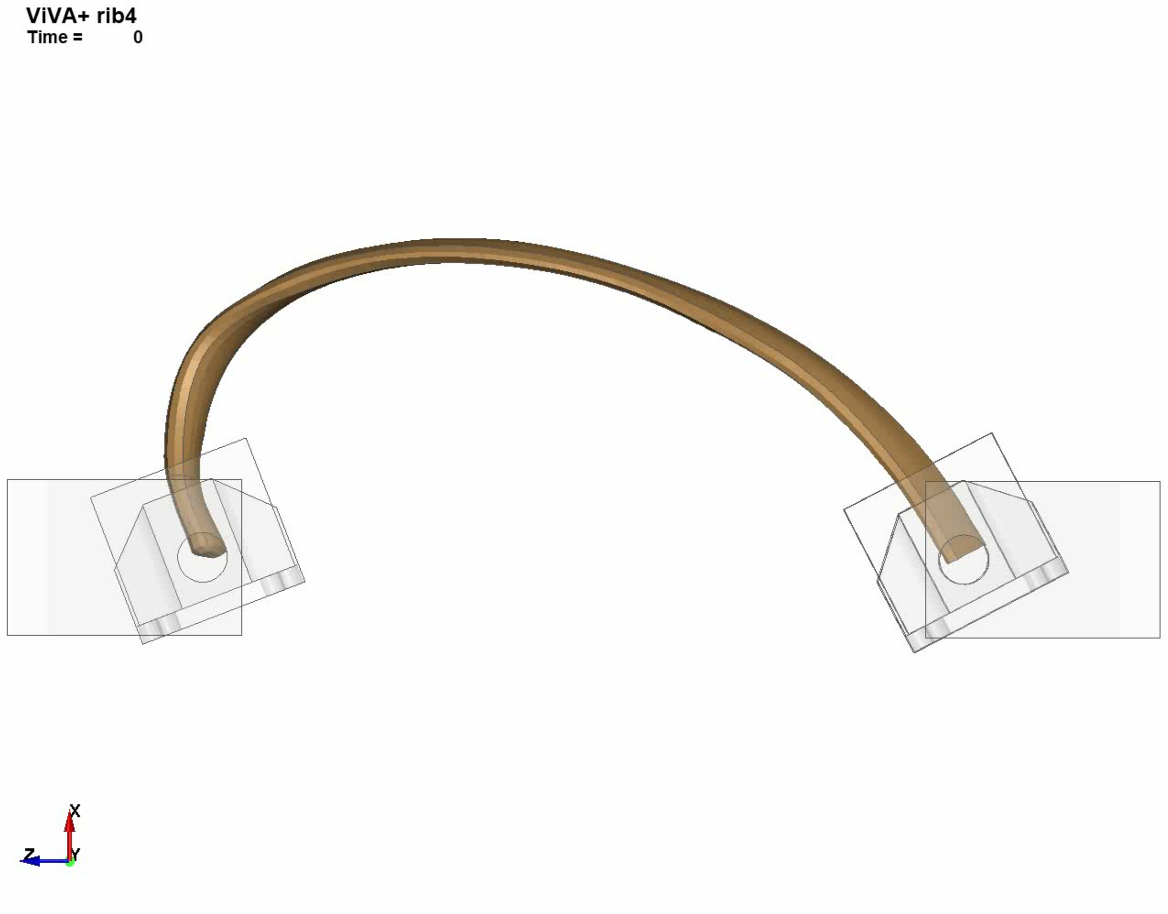
Pelvis Validation – Dynamic acetabulum loading

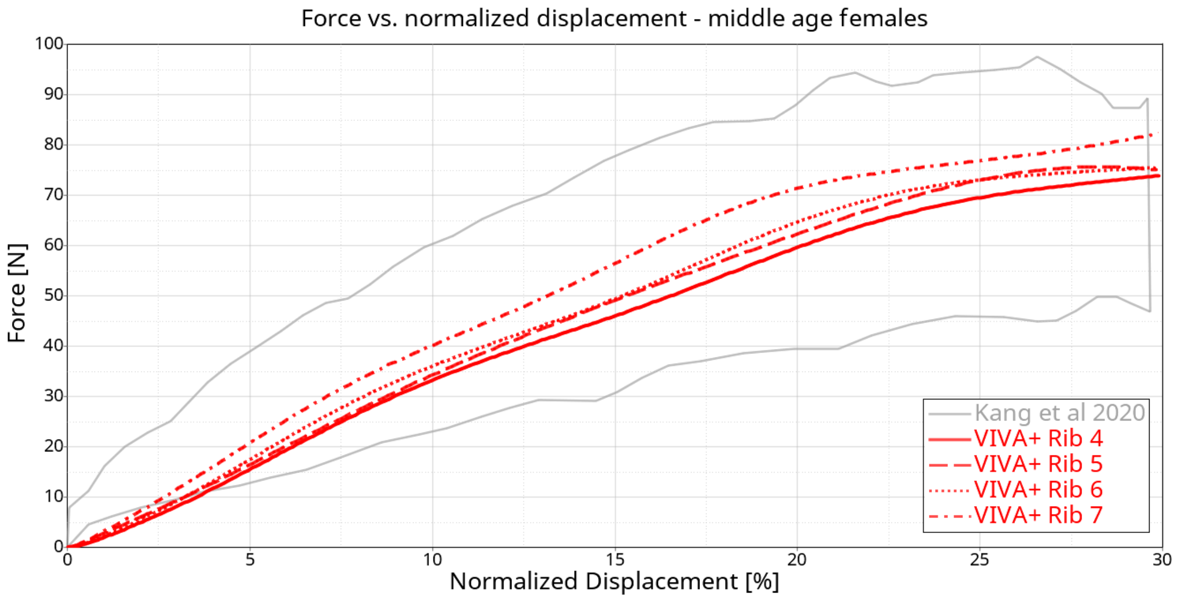
Guillemot et al., 1998





Single Rib Validation - anterior posterior bending

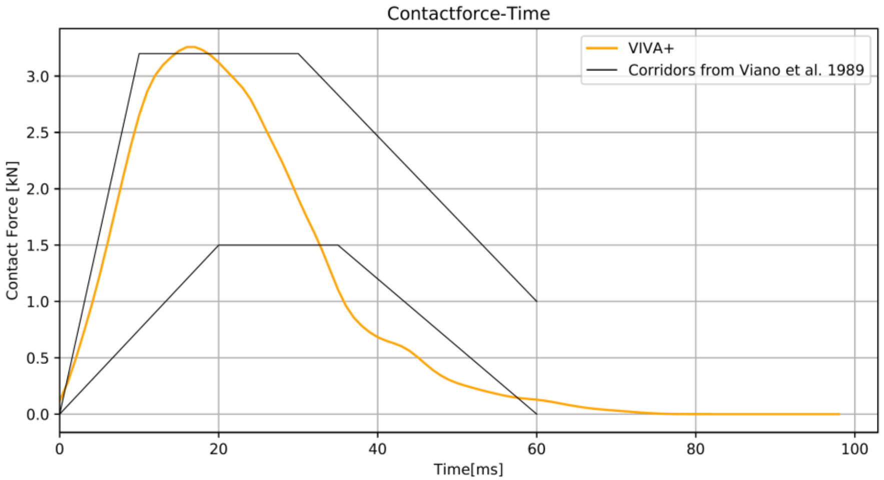


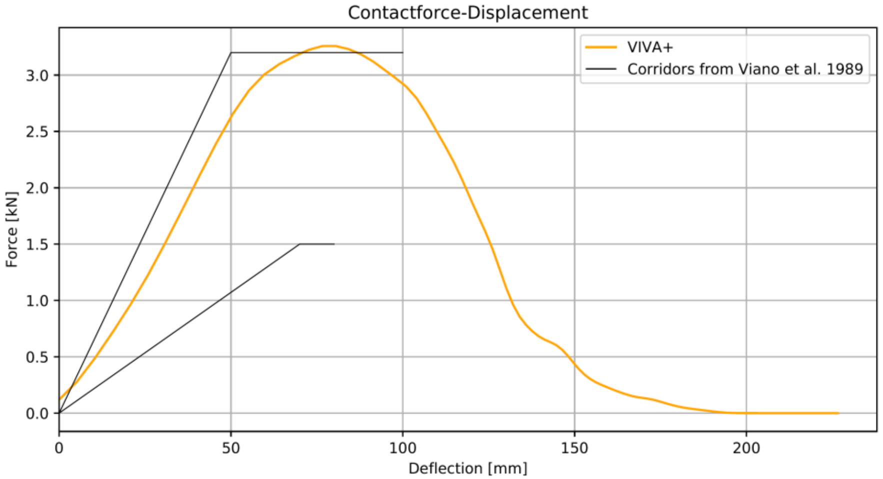


Kang, Y.-S., et al. (2020).

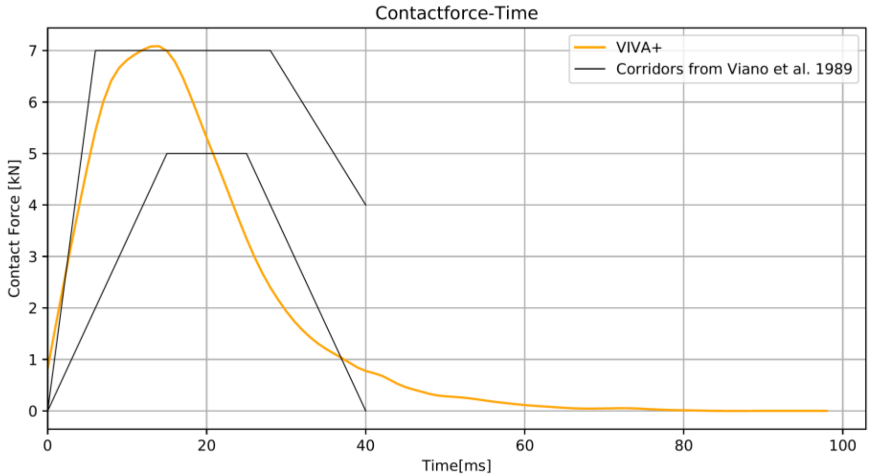
Blunt Body Impacts - Thorax Viano, 1989

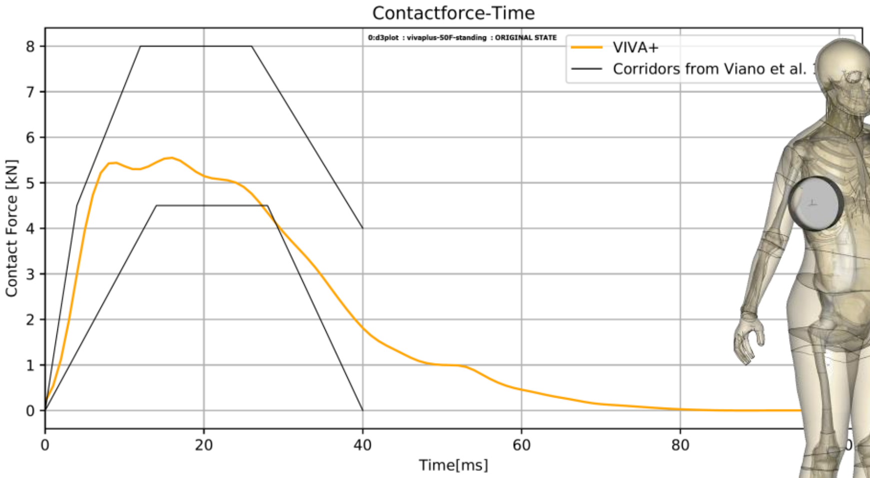
5.2 m/s

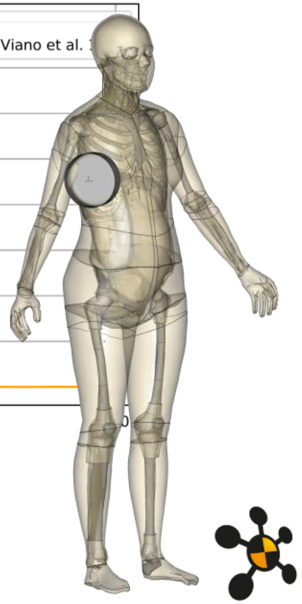




9.5 m/s

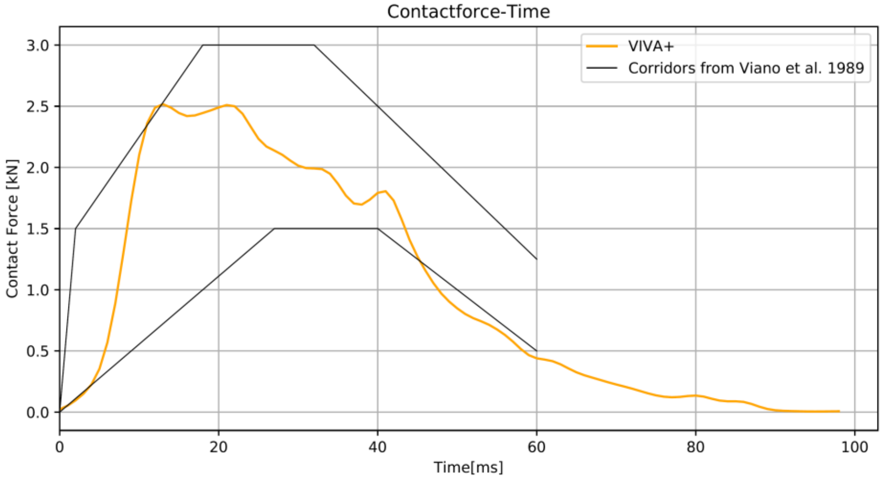


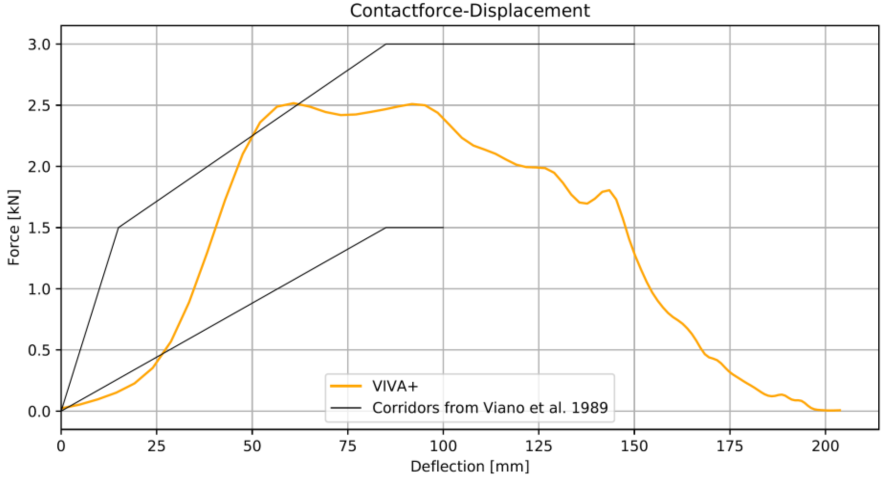




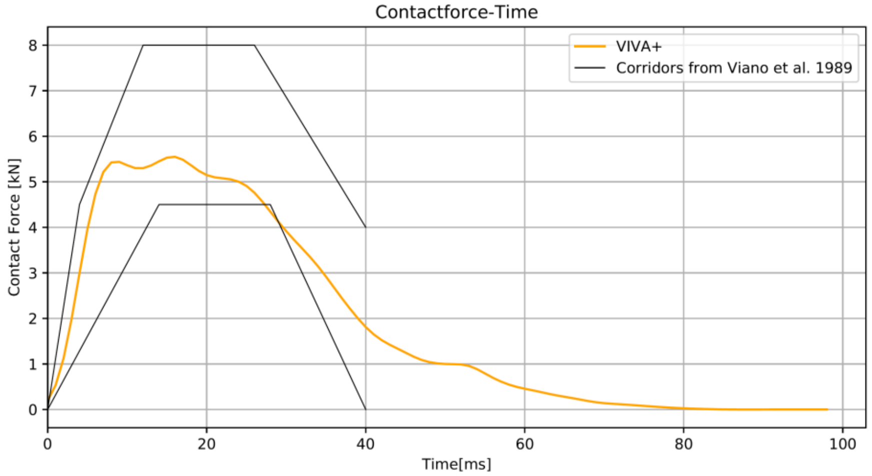
Blunt Body Impacts - Abdomen Viano, 1989

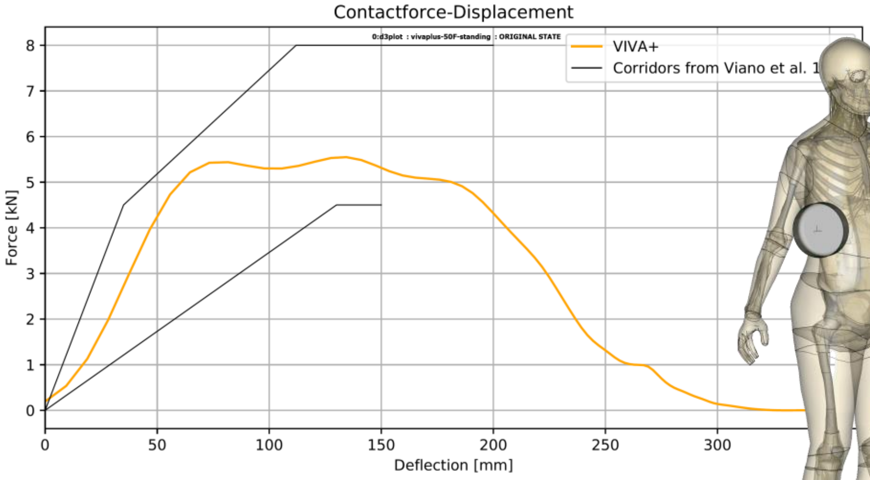
4.8 m/s

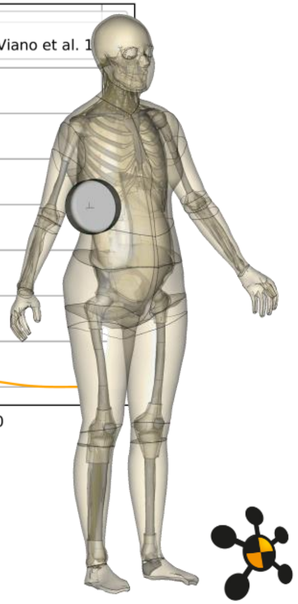




9.4 m/s

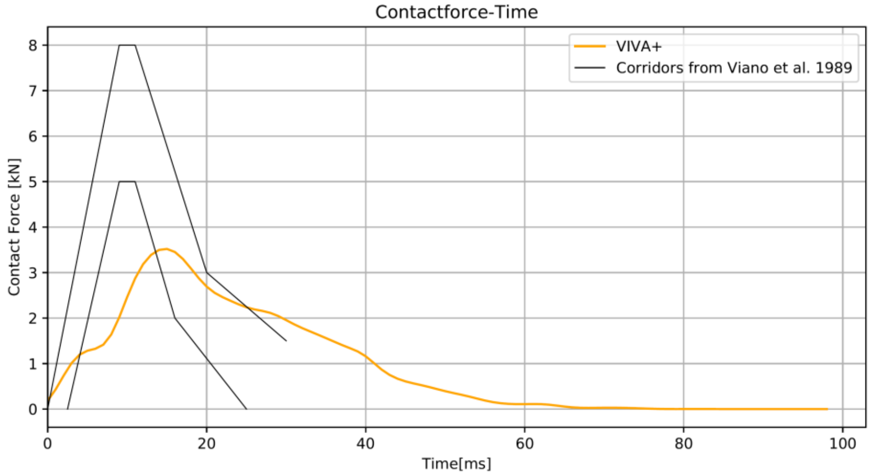


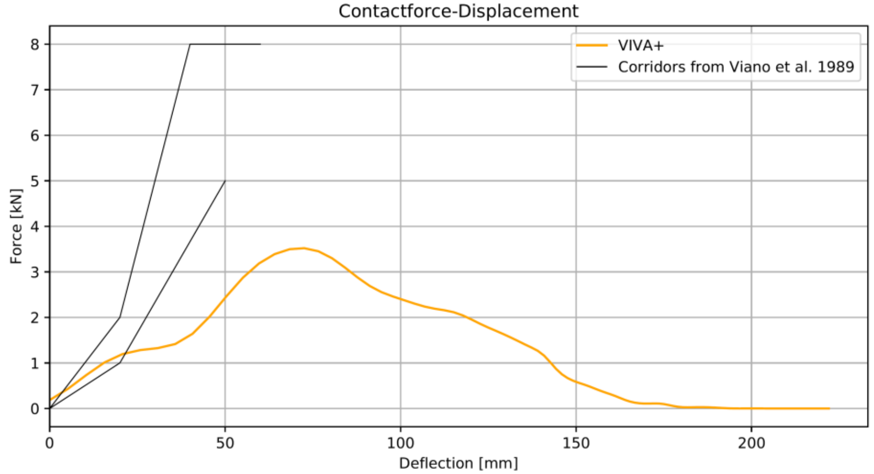




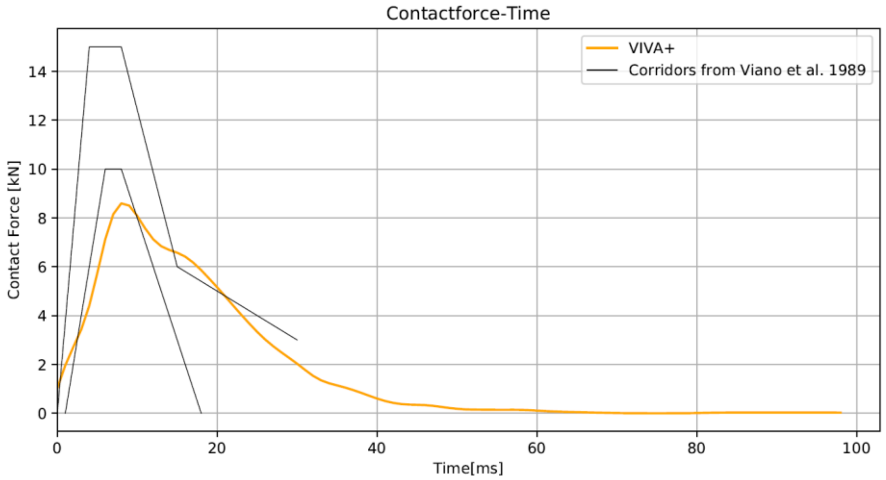
Blunt Body Impacts – Hip Viano, 1989

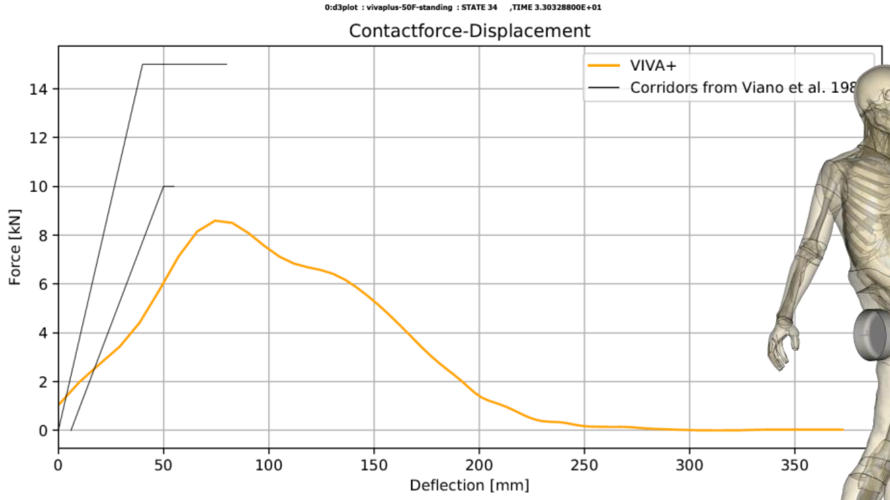
5.2 m/s

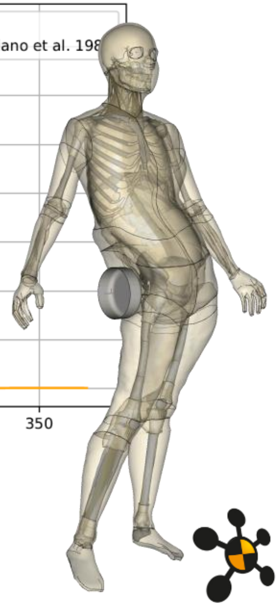




9.8 m/s







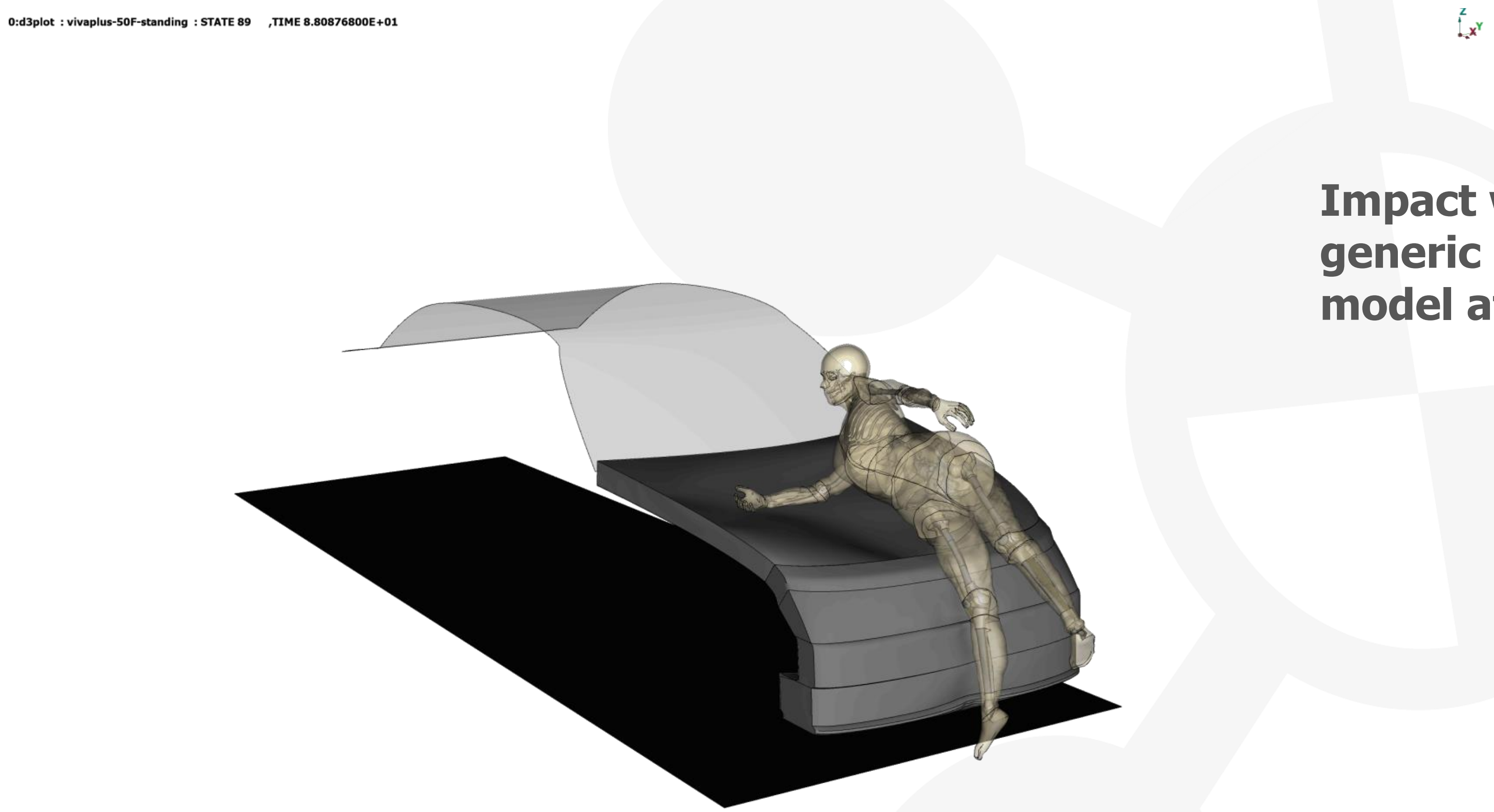
Viano, 1989

VIVA+ HBM Validation cases

- All validation loadcases and related auxiliaries on OpenVT platform
  - certification loadcases in VIRTUAL protocols

- Interactive Jupyter Notebooks to visualise validation results
  - including quality checks

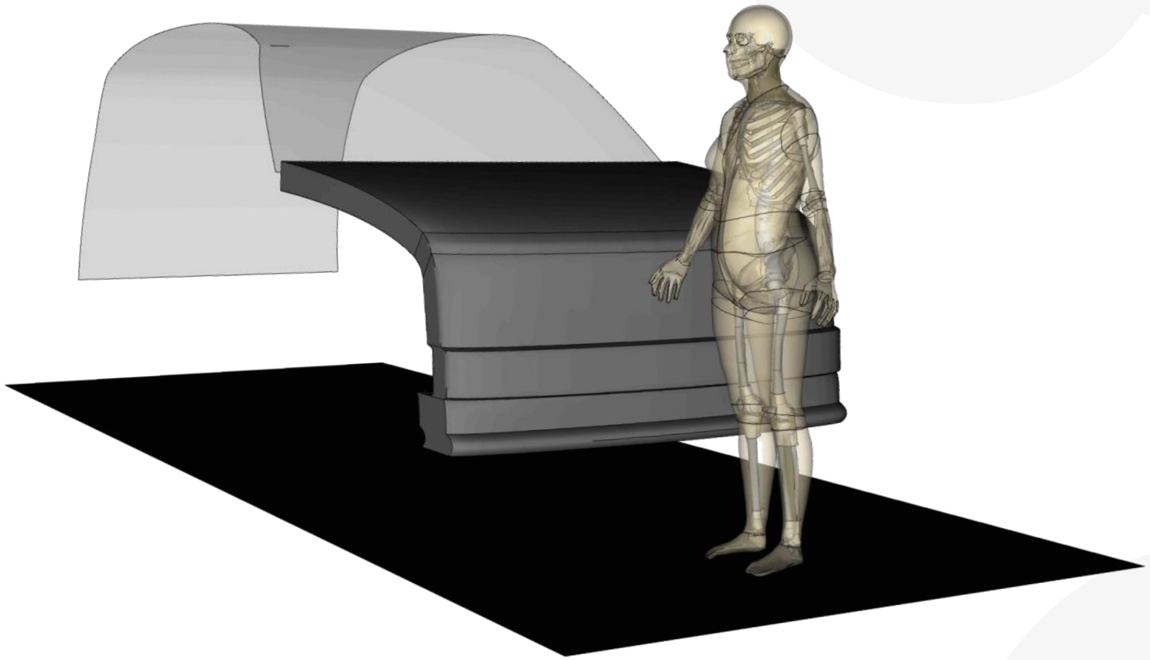
Robustness Checks



Impact with generic familycar model at 50km/h

200 ms in 24 hours with 20 CPUs

Robustness Checks



Impact with generic SUV model at 50km/h

Roadmap of VIVA+

Model Development

VIRTUAL-Internal Evaluation in different use cases

Model validation and continuous improvement within VIRTUAL

External Evaluation of beta - users

External Evaluation & Contributions

Start: Jun 2018

Apr 2020

Sep. 2020

Sep. 2021

Apr. 2022

VIVA+: Open Science

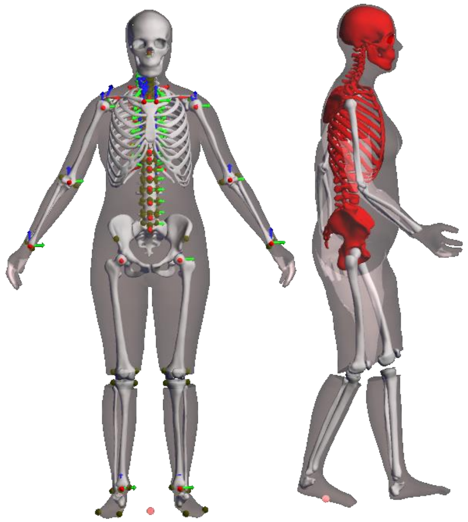
Open Model Development and Maintenance

LGPL 3
Free Software
Free as in Freedom

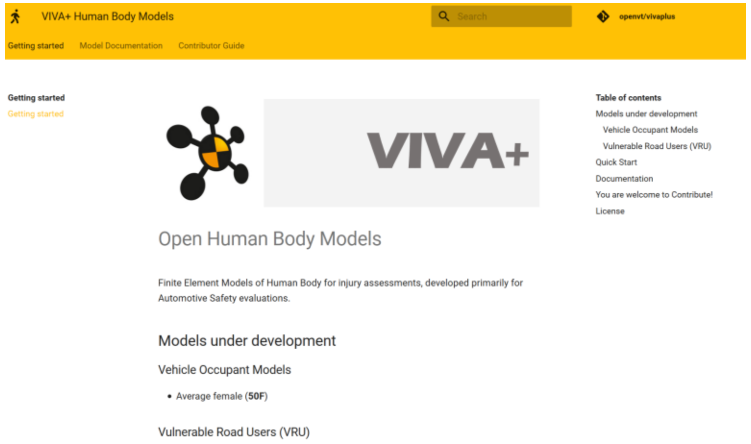
Open Tools

jupyter

PIPER

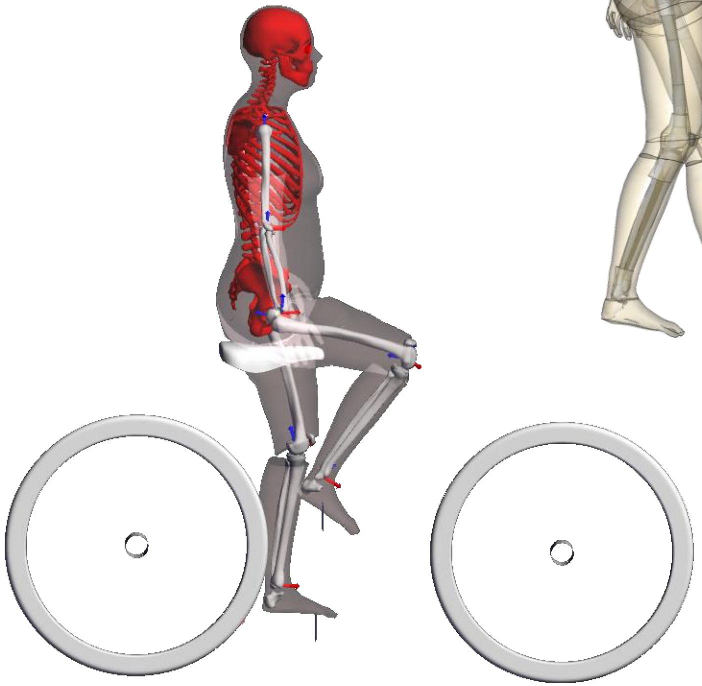


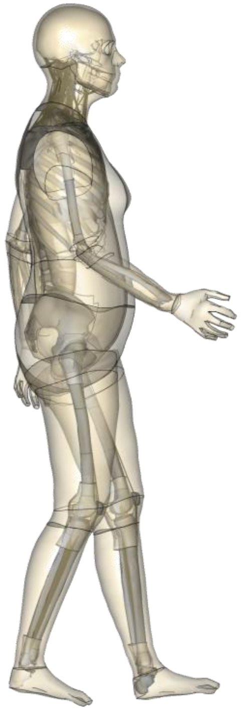
Open Documentation



Next steps

- **Further validations & improvements**
  - **more tests with females PMHS needed!**
- **Development of virtual testing protocols**
  - **Positioning to „standard postures"**
  - **Standardised bicyclist simulations**
  - **Demonstration of continuous tool chain**





VIVA+ Human Body Models

virtual

Outside VIRTUAL

??

Everyone is welcome to contribute!

OpenVT (*virtual.openvt.eu*)

OpenVT Gitlab platform

virtual

This is the OpenVT platform, the platform for open access virtual testing protocols for enhanced road users safety.

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