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Introduction of the VIVA+ Vulnerable Road User Models

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



**Human Modeling and
Simulation in
Automotive Engineering**



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



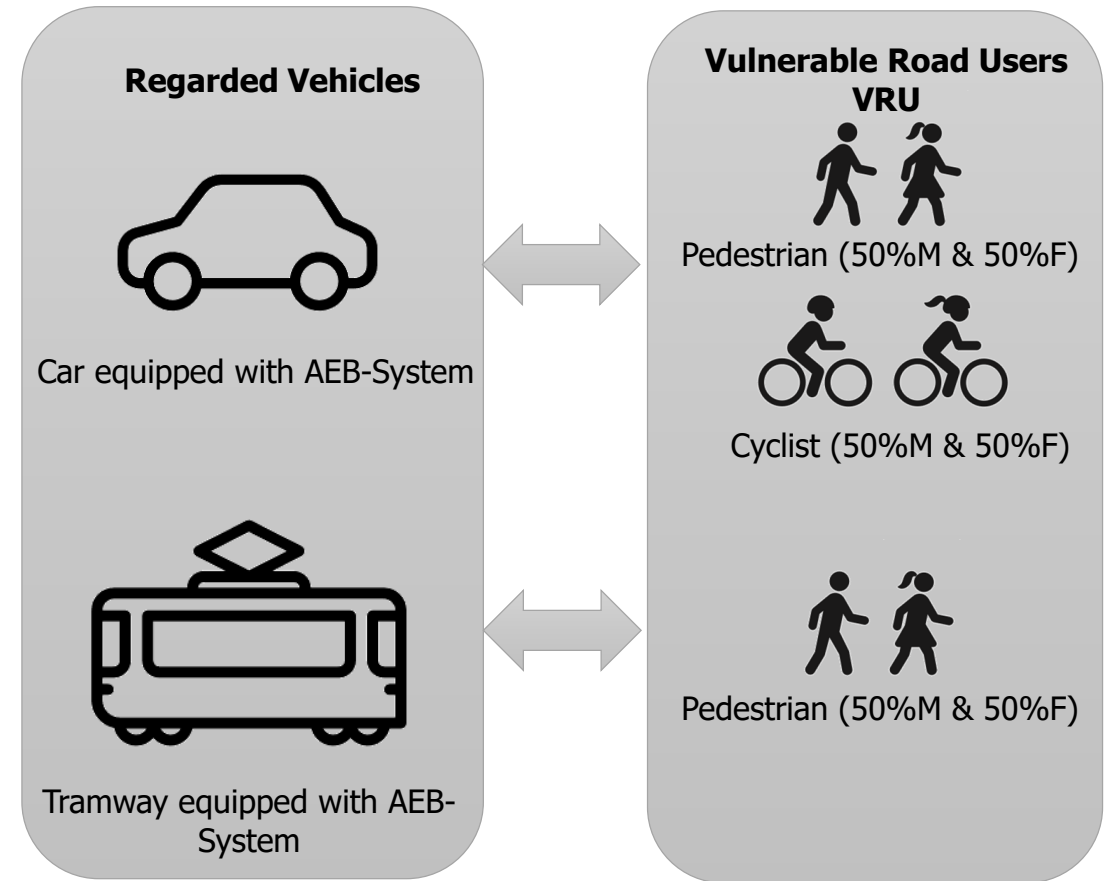
Public transport users



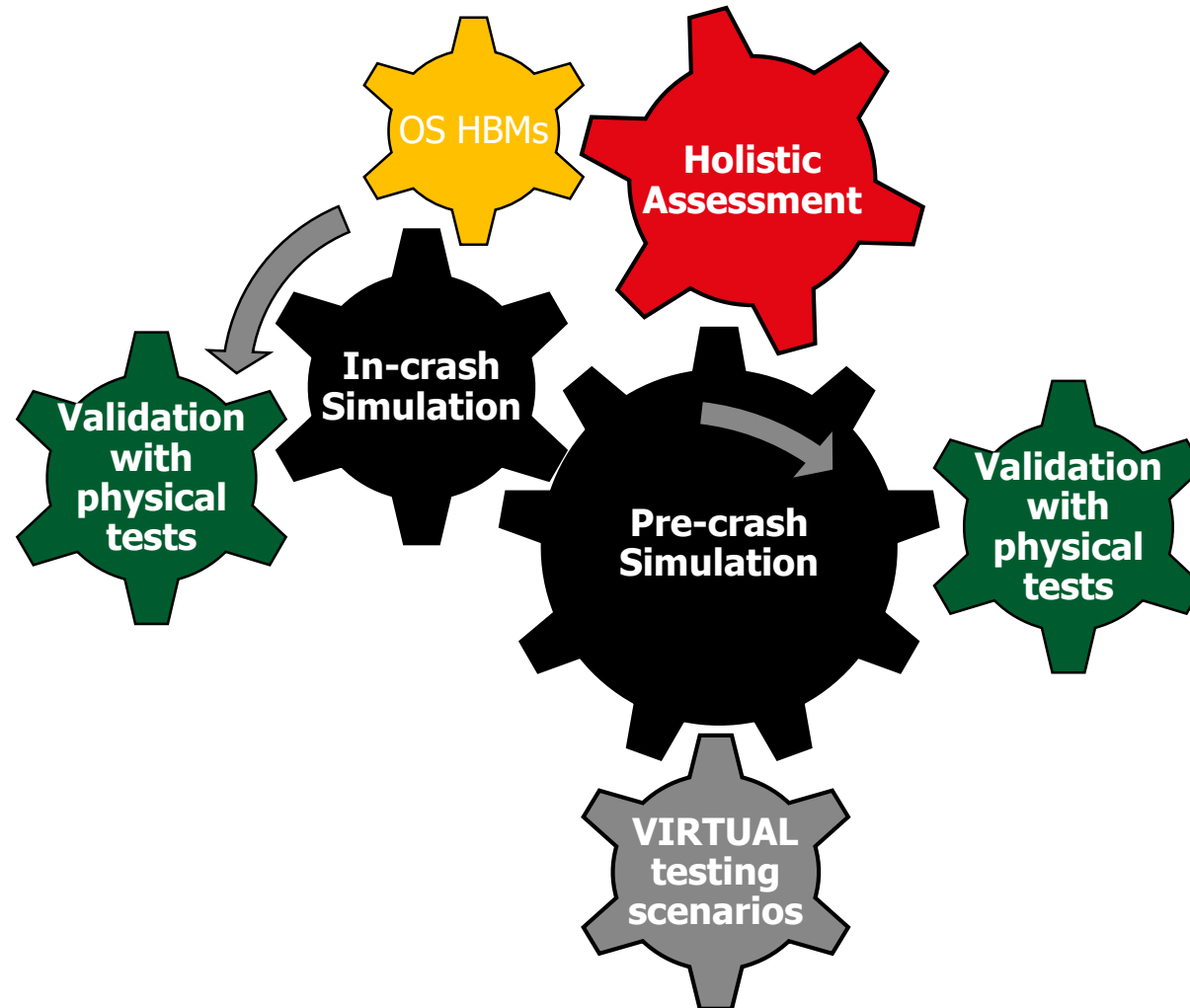
Aim of VRU assessment in VIRTUAL

- Demonstration of integrated VT chain for **VRUs outside the vehicle**, subjected to potential **future impact scenarios**.
- Holistic assessment considering **accident avoidance and injury mitigation**.

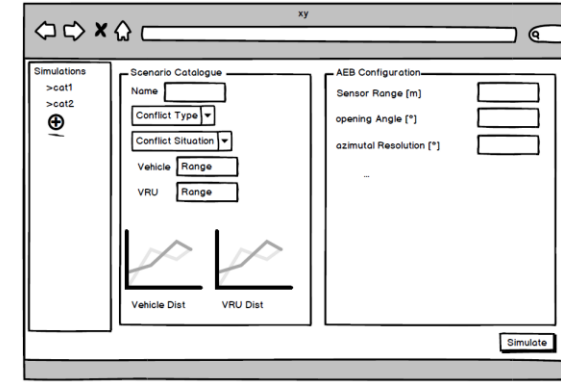
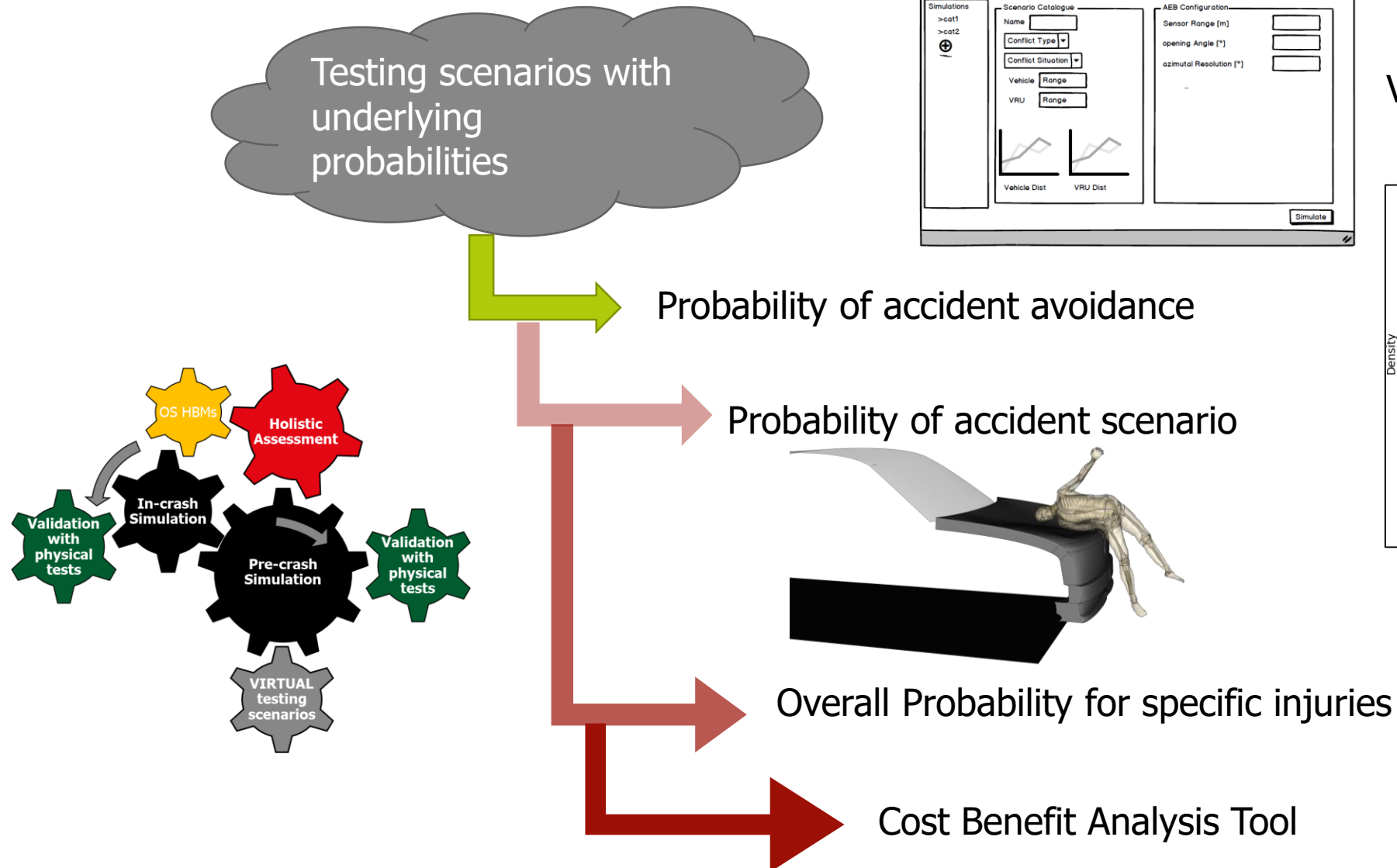
→ **Virtual Assessment protocols with all tools openly available**



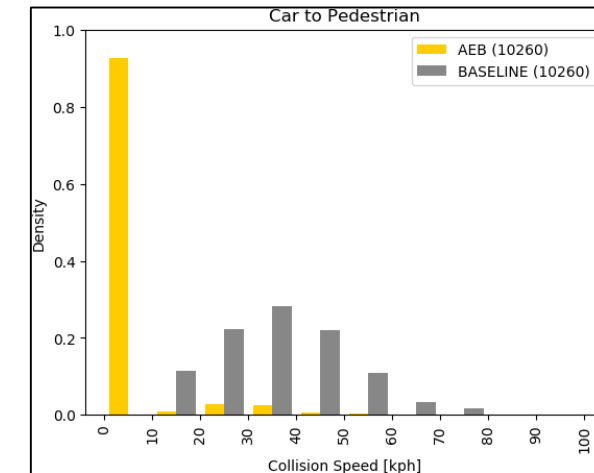
How are VIVA+ VRU models going to be used?



Holistic Assessment



VIRTUAL precrash tool



VIVA+ VRU models - Requirements

- **Representative Anthropometry**



Anthropometry

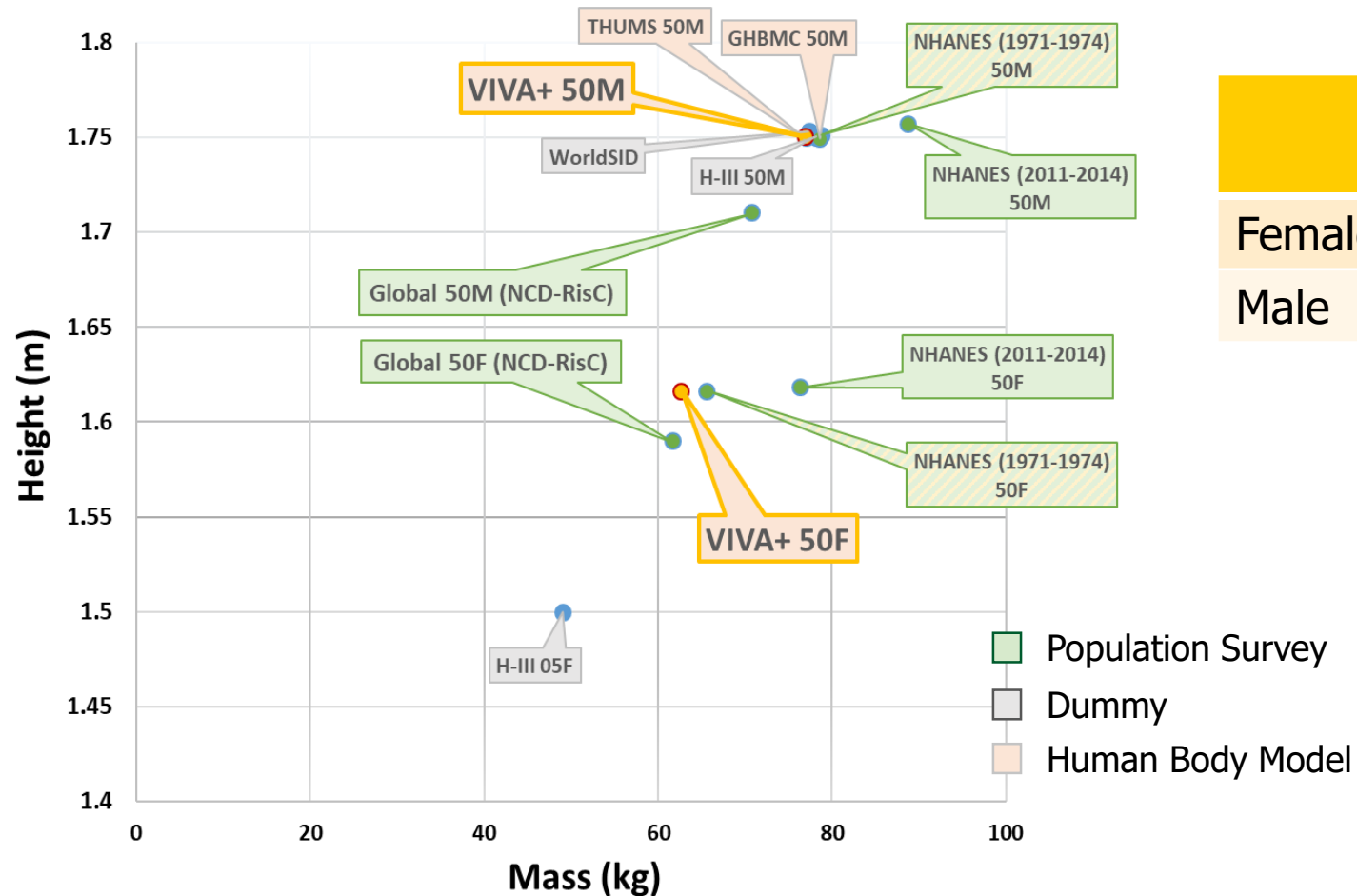
Technical Report Documentation Page		
1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle DEVELOPMENT OF ANTHROPOMETRICALLY BASED DESIGN SPECIFICATIONS FOR AN ADVANCED ADULT ANTHROPOMORPHIC DUMMY FAMILY, Volume 1	5. Report Date December 1983	6. Performing Organization 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	10. Work Unit No. (TRAIS)
9. Performing Organization Name and Address The University of Michigan Transportation Research Institute 2901 Baxter Road Ann Arbor, Michigan 48109	11. Contract or Grant No. DTNH22-80-C-07502	13. Type of Report and Period Covered FINAL REPORT Oct. 1980 - Dec. 1983
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590	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 ²]	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]



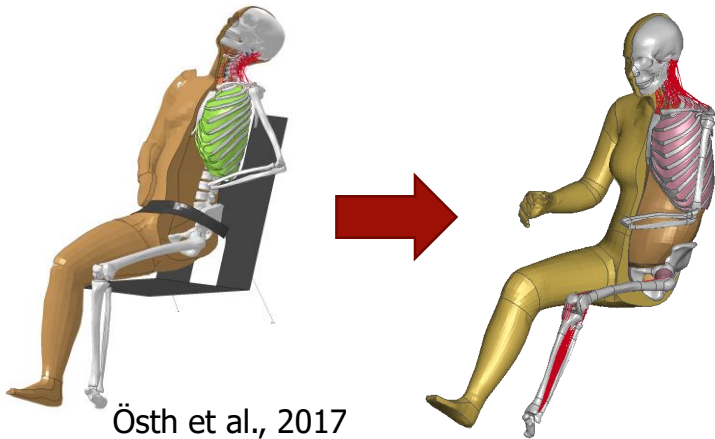
VIVA+ VRU models - Requirements

- **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+

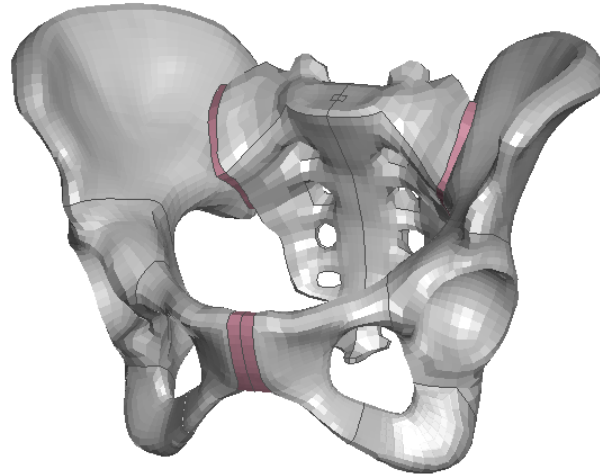


Östh et al., 2017

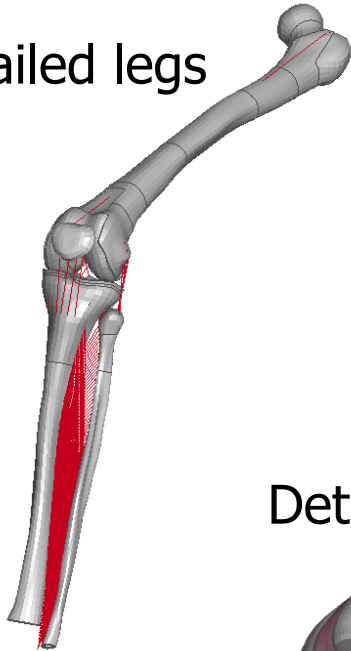


From VIVA to VIVA+

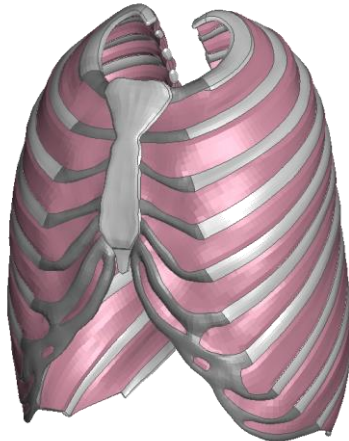
Detailed pelvis



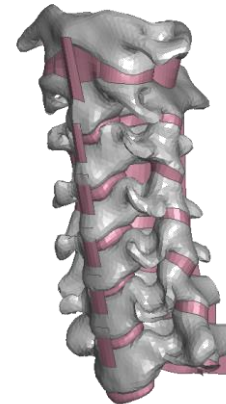
Detailed legs



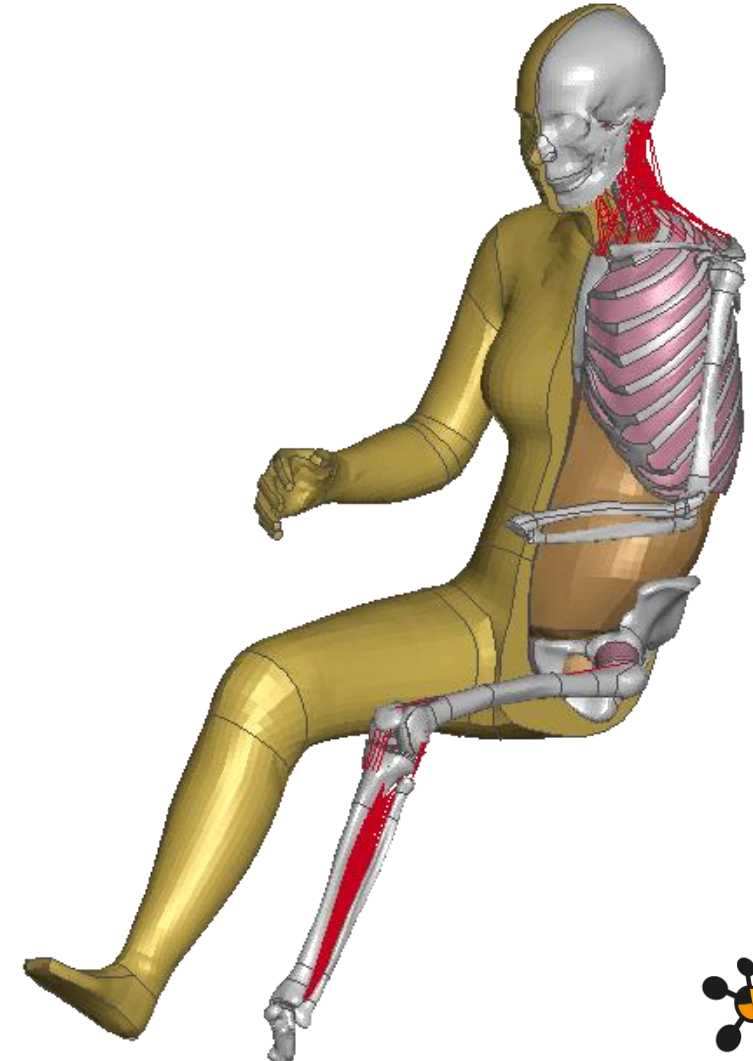
Detailed rib cage



Detailed cervical spine*



**carry over from VIVA*

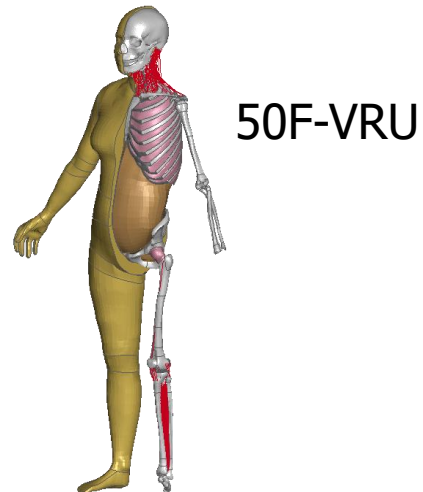
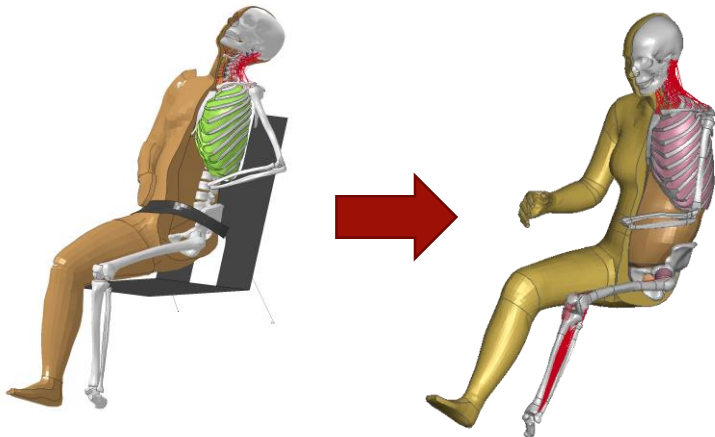


Development Process

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



Morphing to
other postures



Development Process

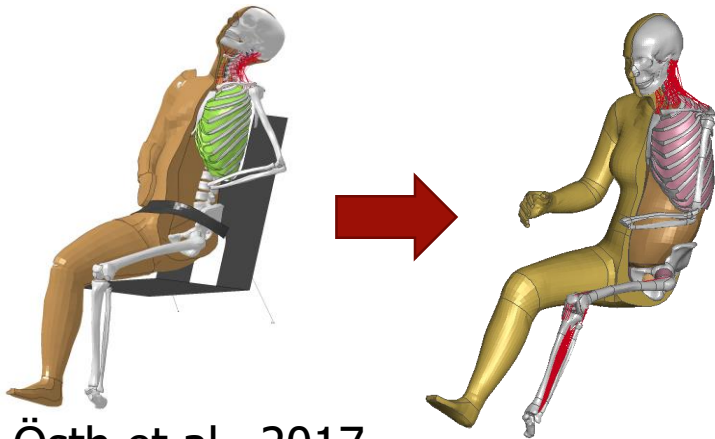
Enhance VIVA
50F Model –
Transition from
VIVA to VIVA+



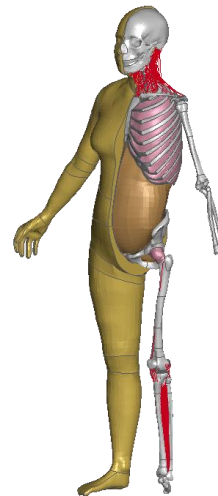
Morphing to
other postures



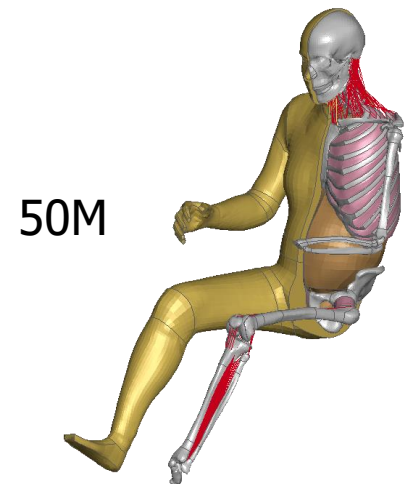
Morphing to
other
anthropometries
(50M)



Östh et al., 2017



50F-VRU



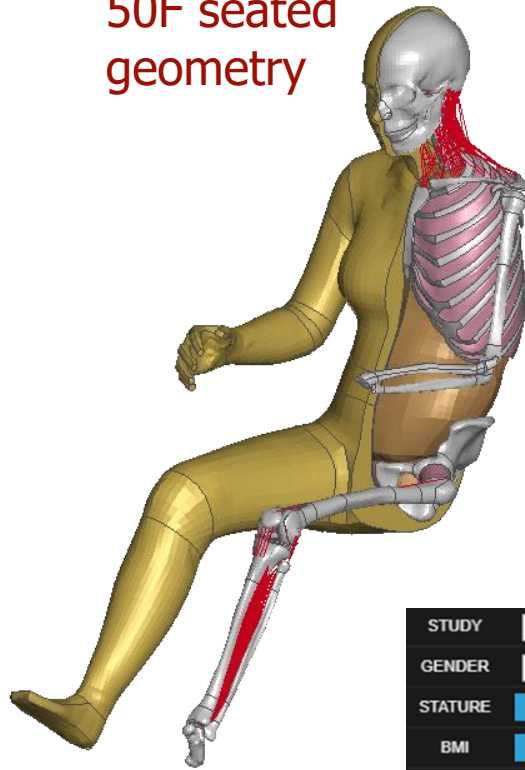
50M



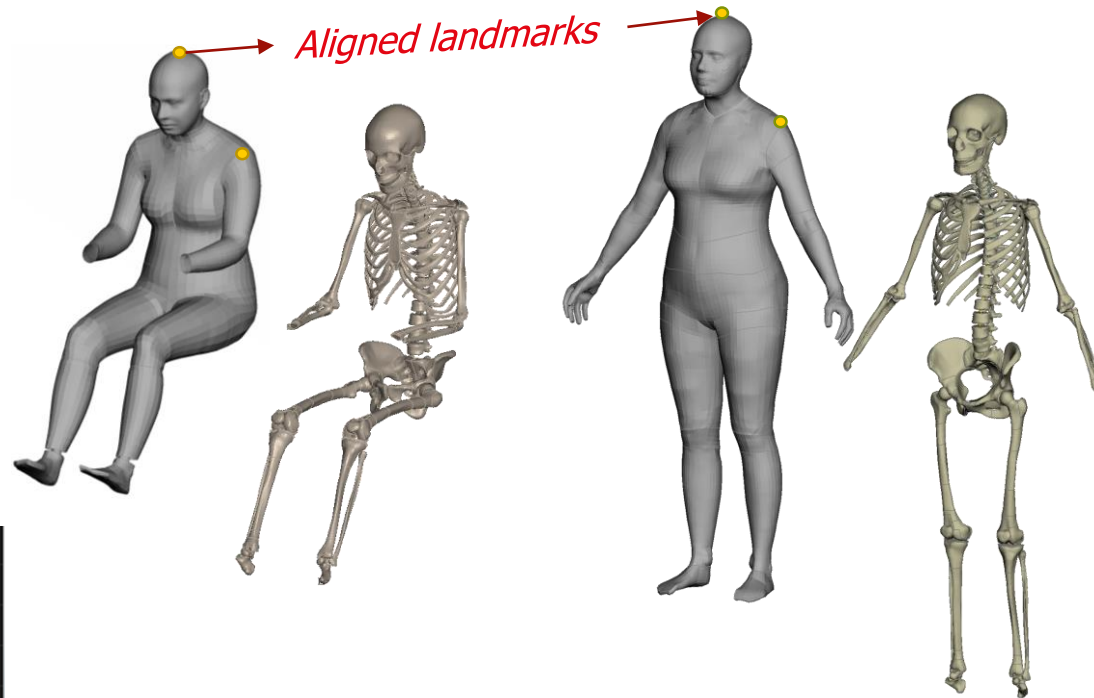
VIVA+ HBM Development

Derivative models through morphing

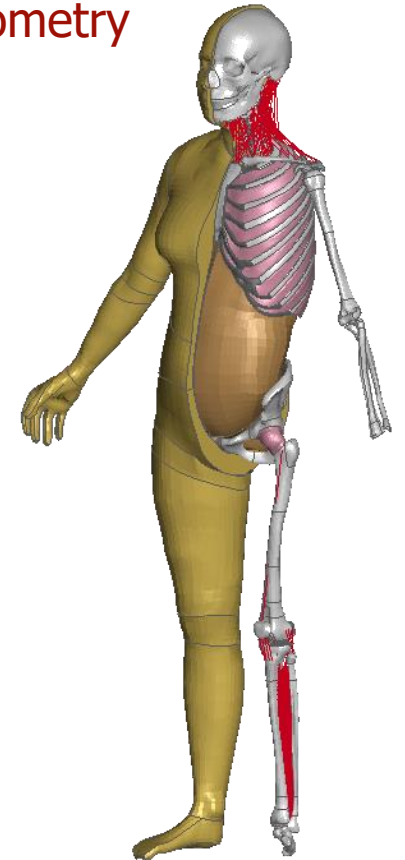
50F seated geometry



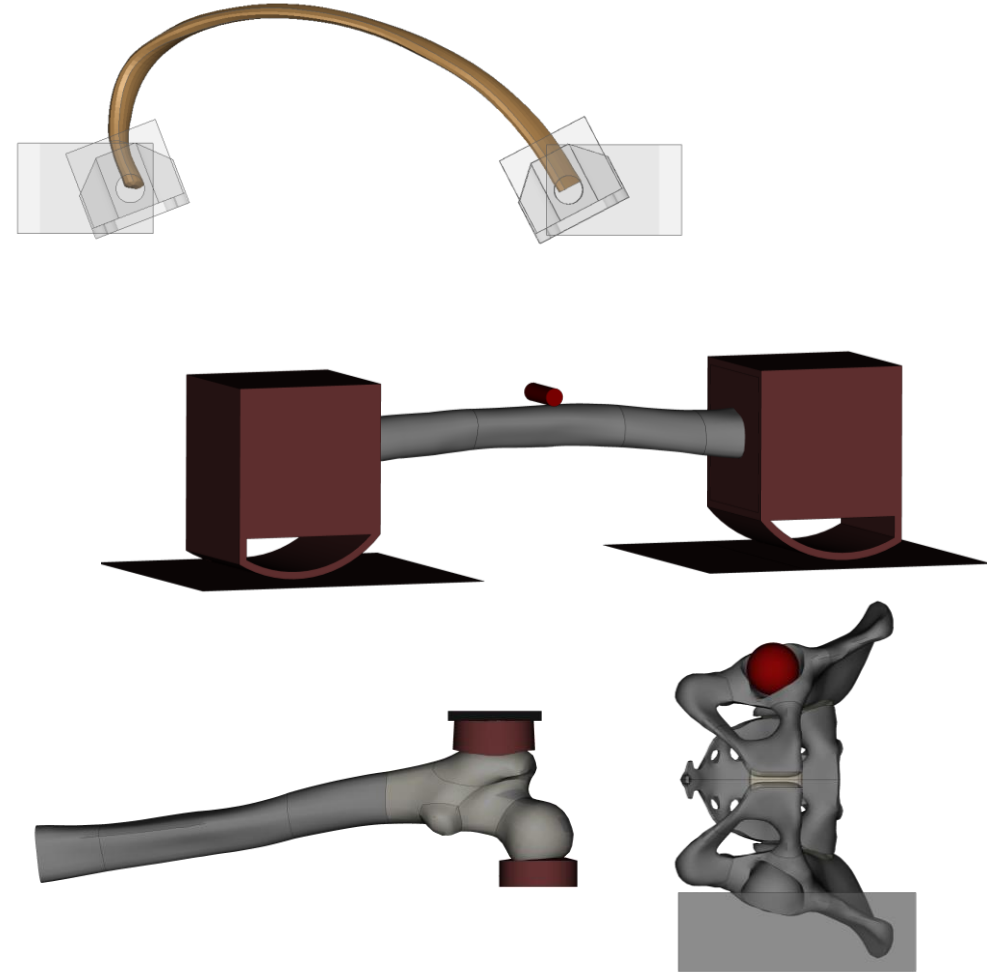
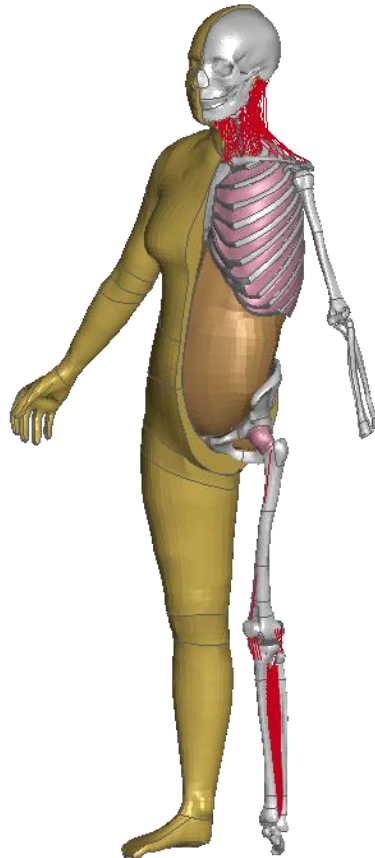
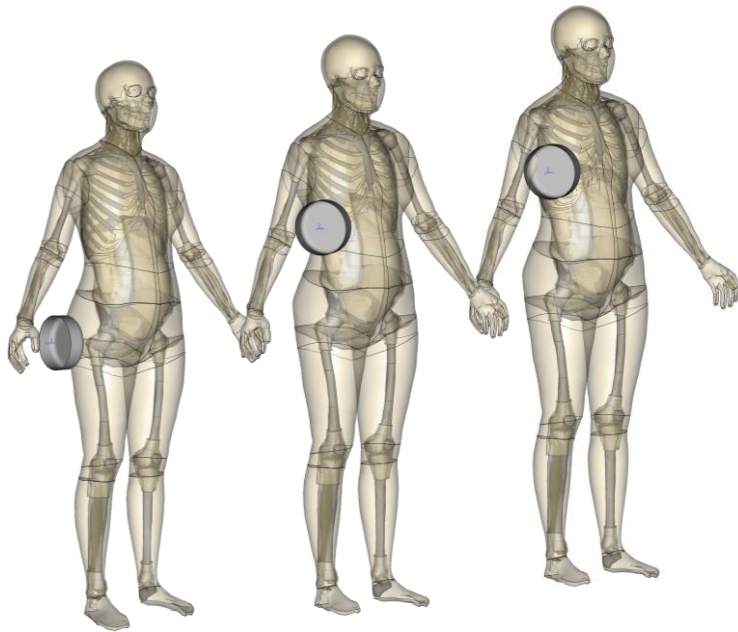
STUDY	US
GENDER	FEMALE
STATURE	1621
BMI	24
SHS	0.52
AGE	50



50F standing geometry



VIVA+ HBM Validation load cases



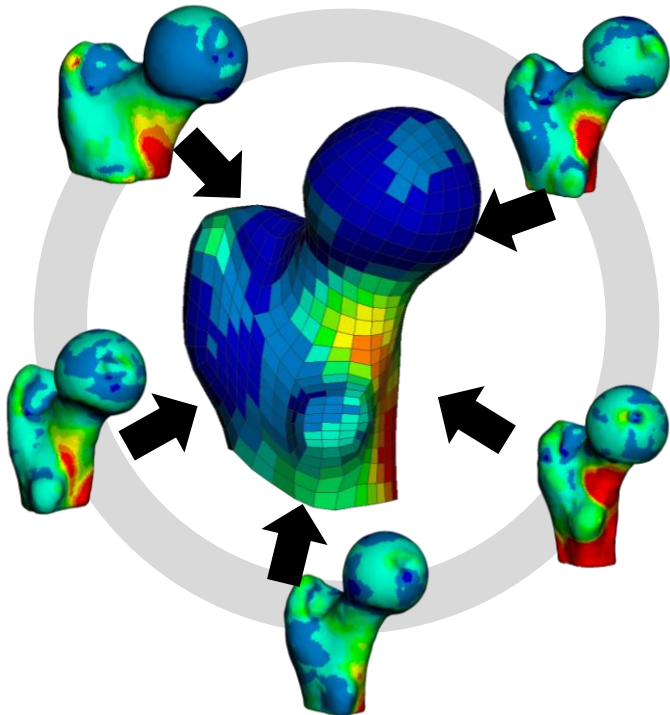
work in progress...



Example - Femur Development

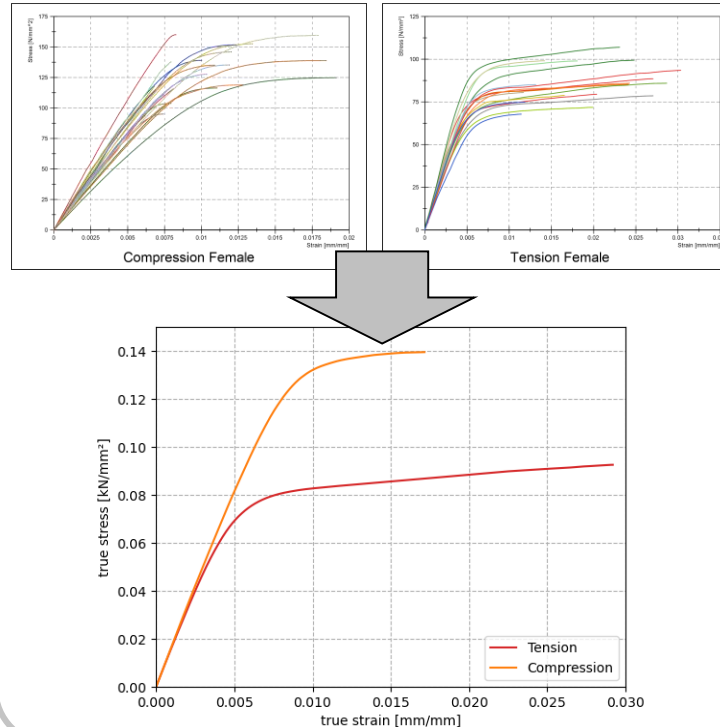
cortical thickness for head

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



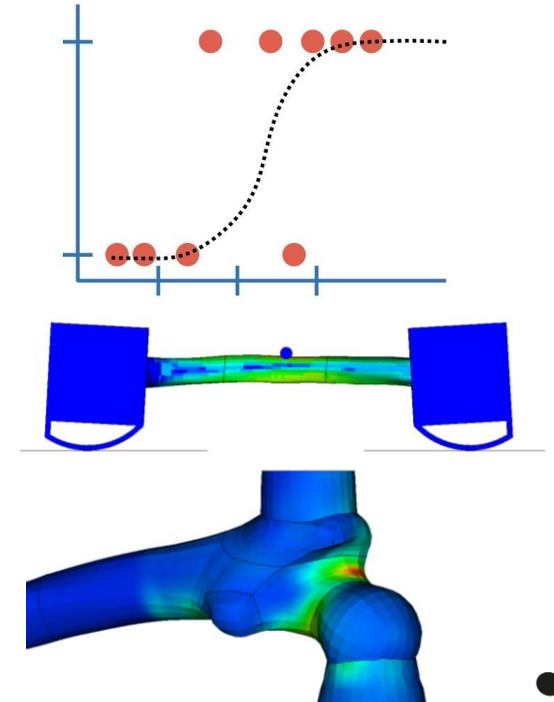
material data for cortical bone

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

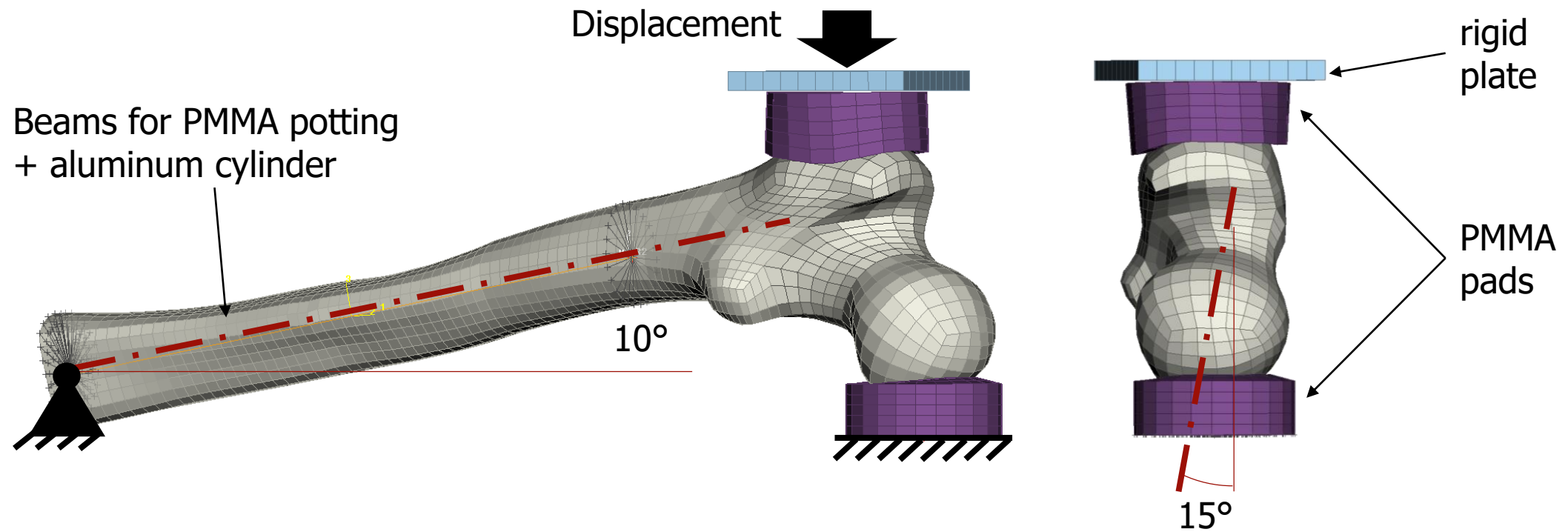


create injury risk curve

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



Femur Neck Validation

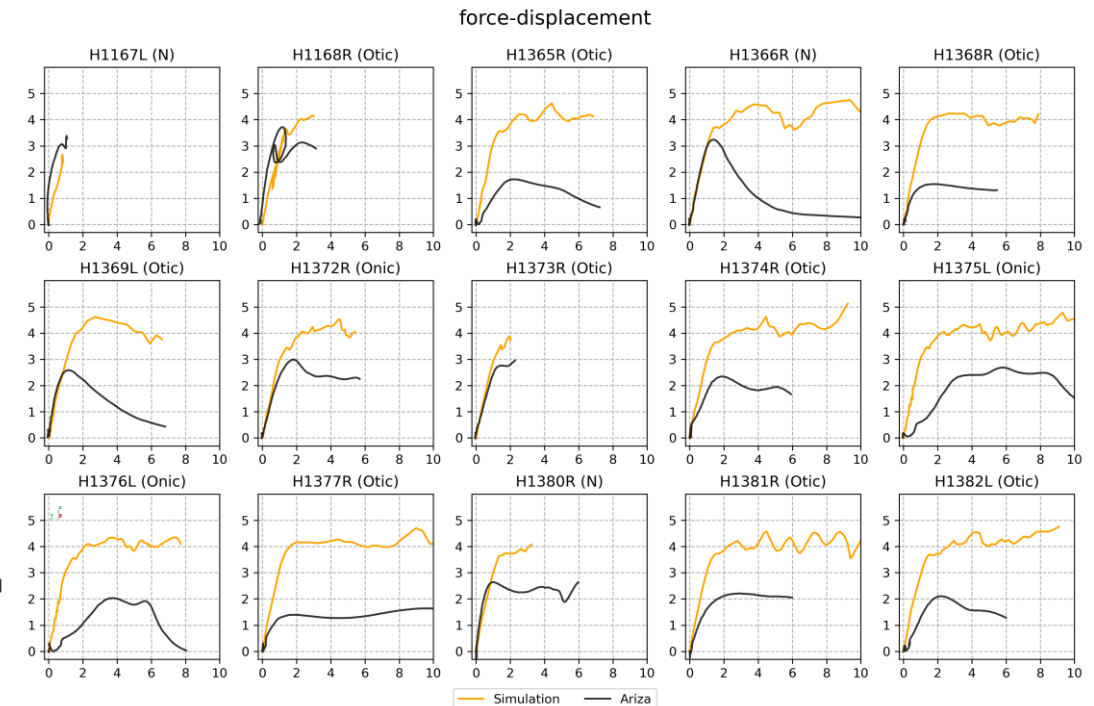
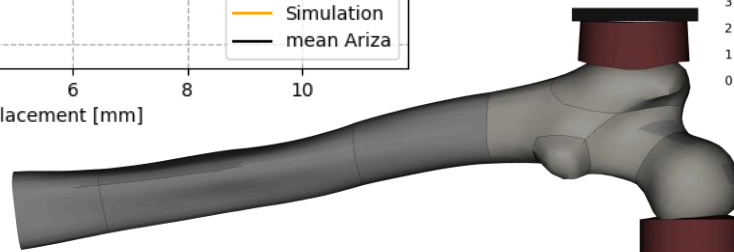
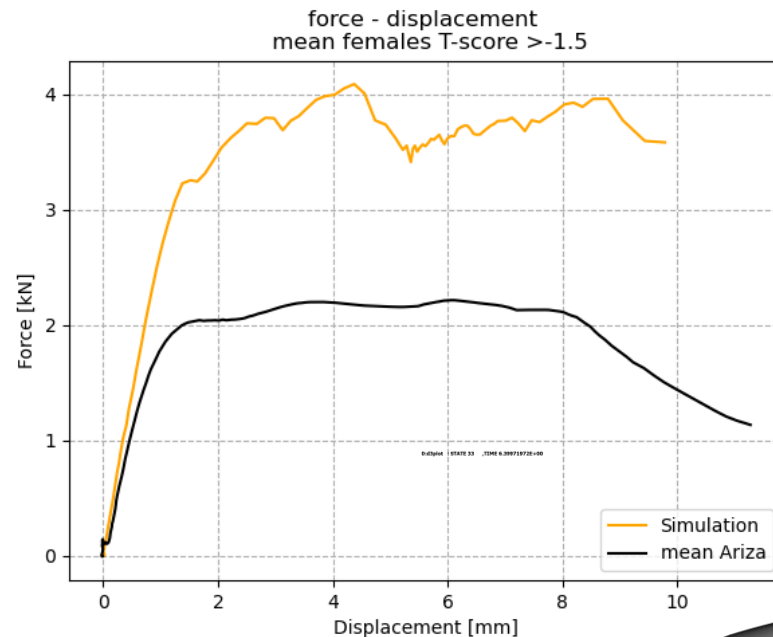


Test setup used in Ariza et al. (2015)^[4]

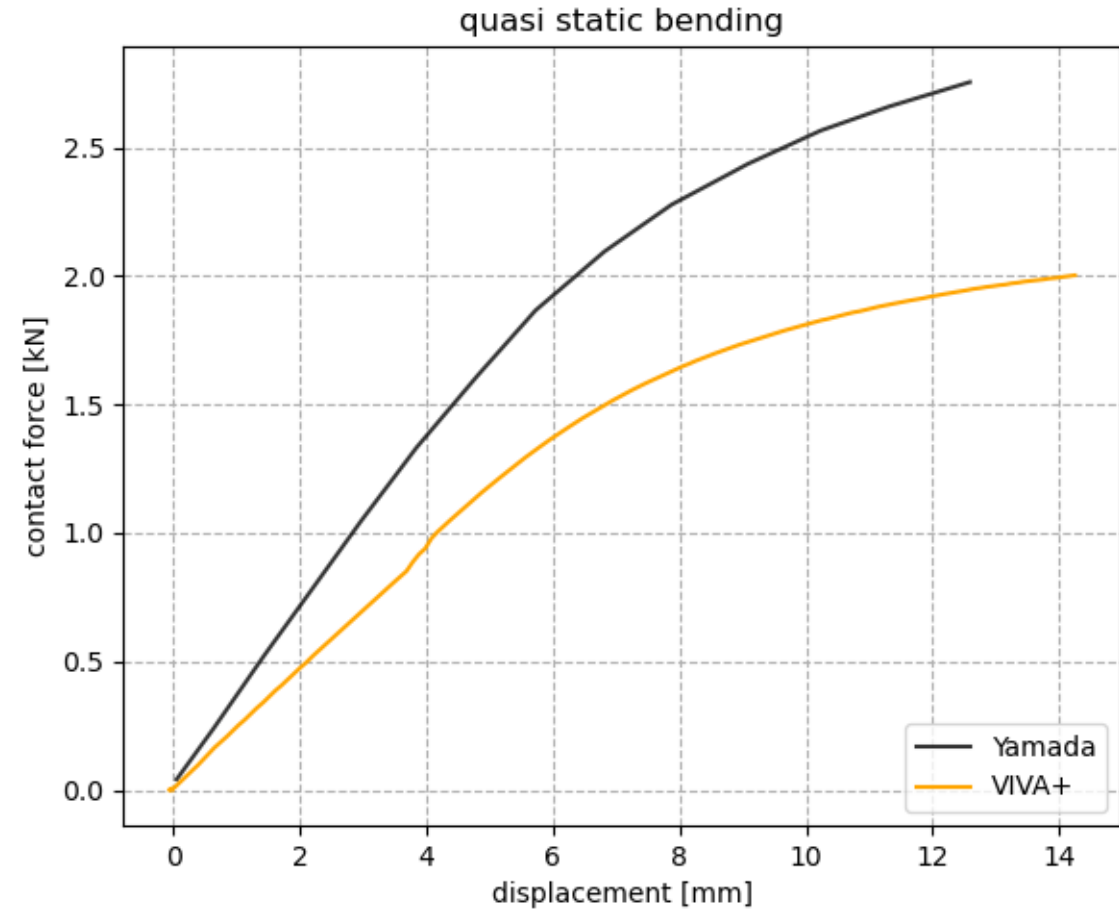
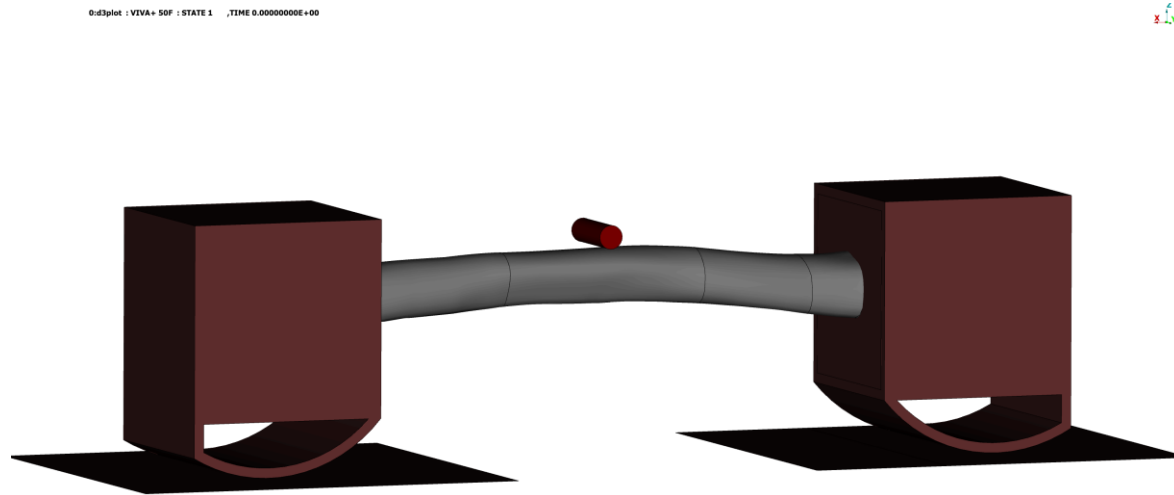


Femur Neck Validation

- 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



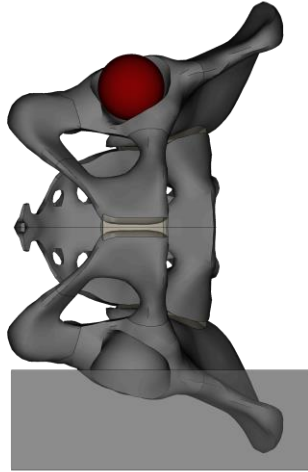
Femur Midshaft Validation – Quasistatic Test



Pelvis Validation – Static

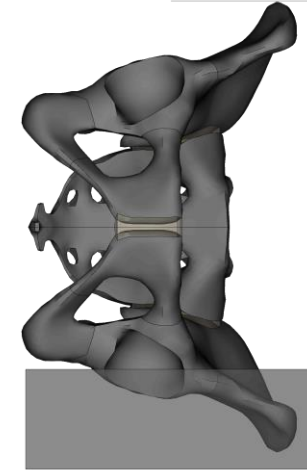
Guillemot et al., 1998

0:00plot : VIVA+ 50F : STATE 1 : TIME 0.00000000E+00

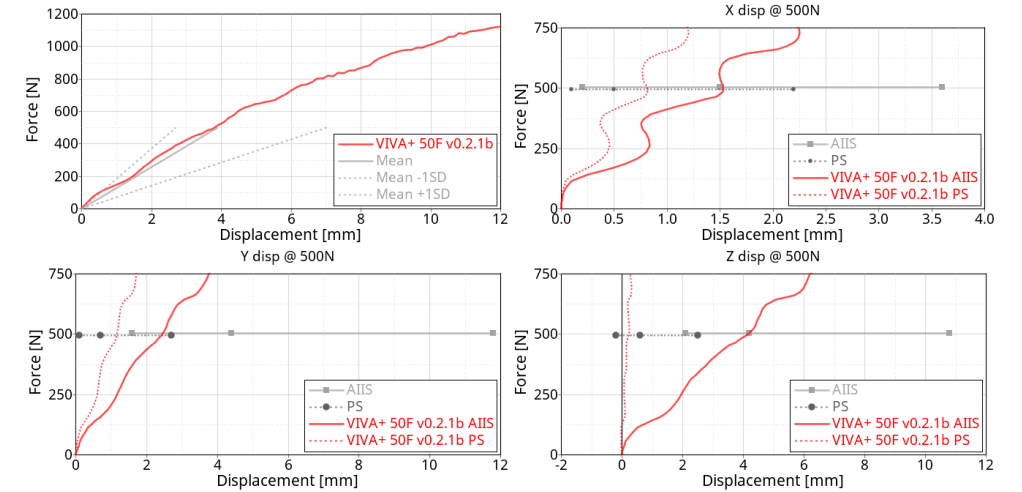
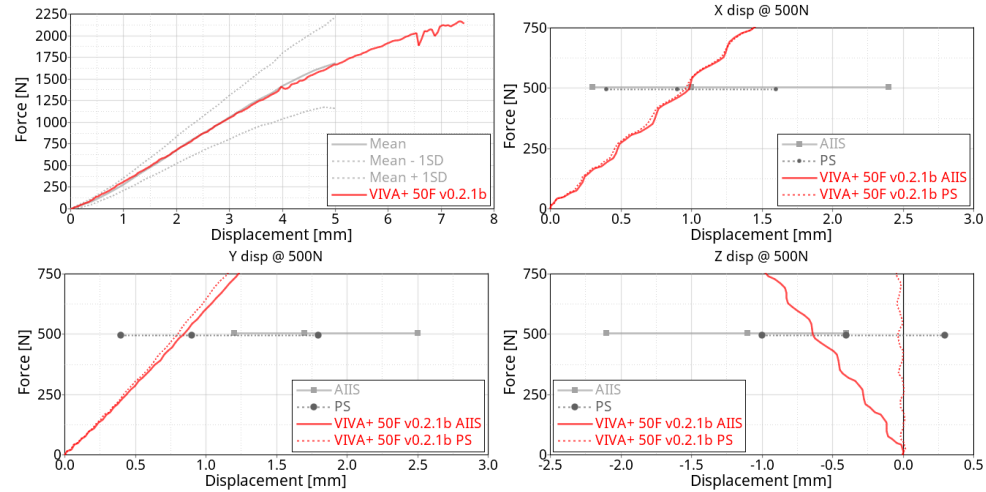


X

0:00plot : VIVA+ 50F : STATE 1 : TIME 0.00000000E+00



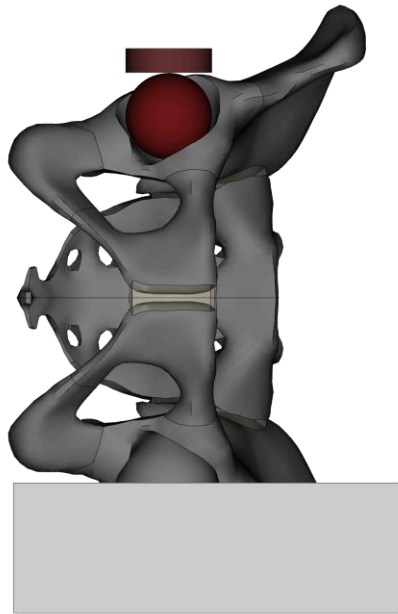
X



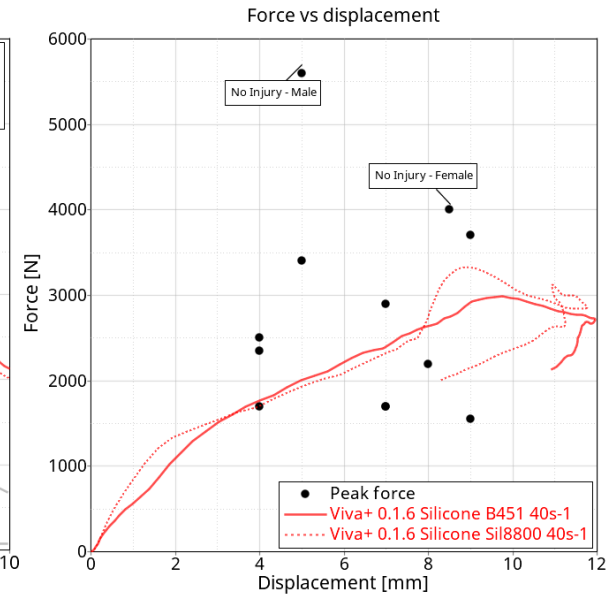
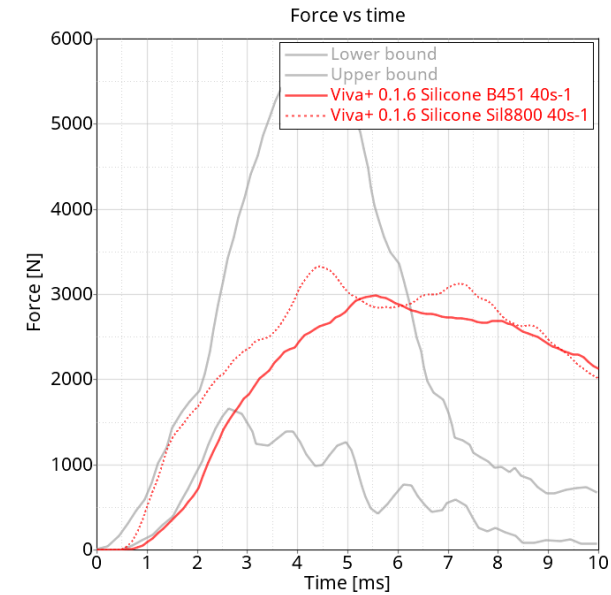
Pelvis Validation – Dynamic acetabulum loading

Guillemot et al., 1998

0:d3plot : VIVA+ SOF : STATE 1 ,TIME 0.00000000E+00

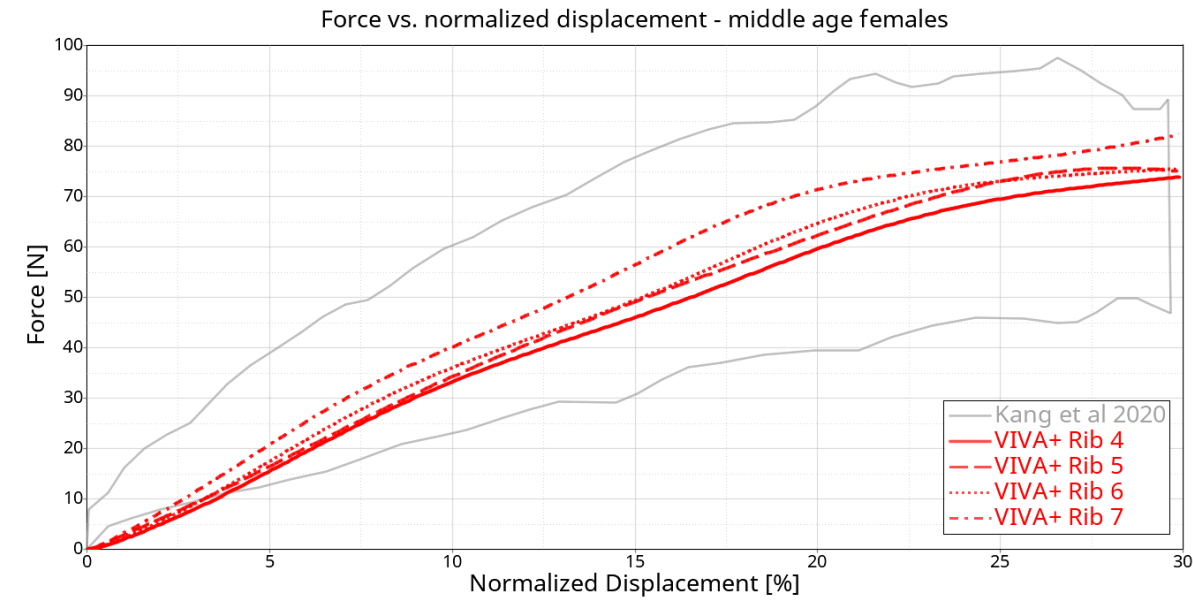
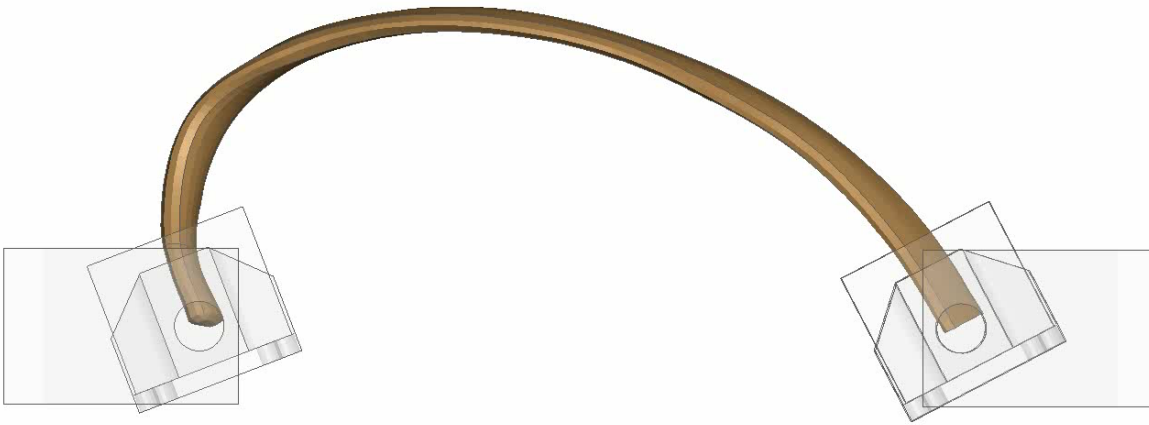


x, z
y



Single Rib Validation - anterior posterior bending

VIVA+ rib4
Time = 0

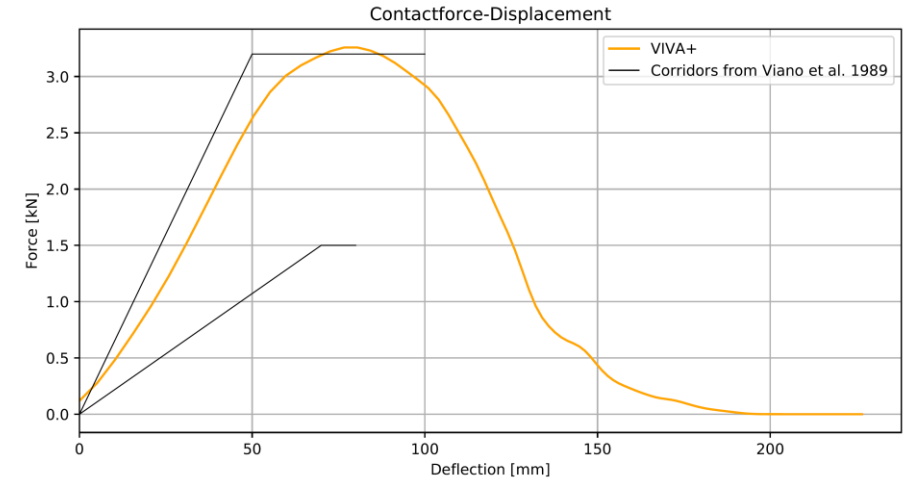
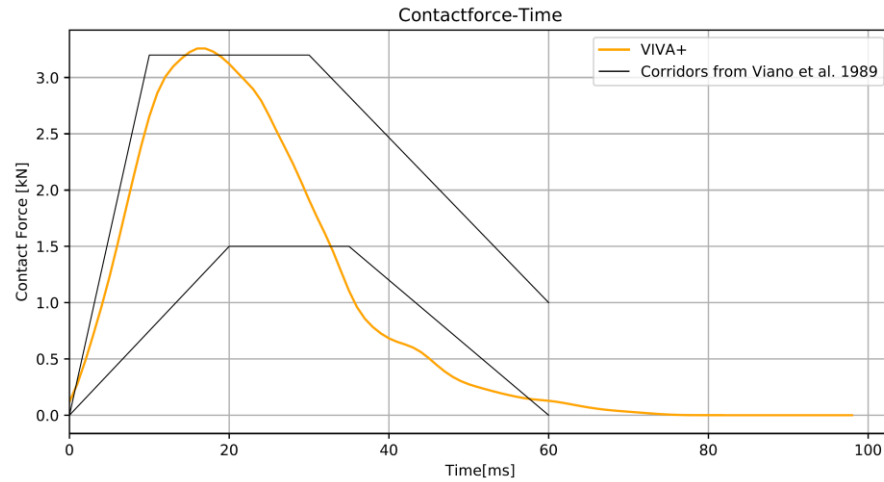


Kang, Y.-S., et al. (2020).

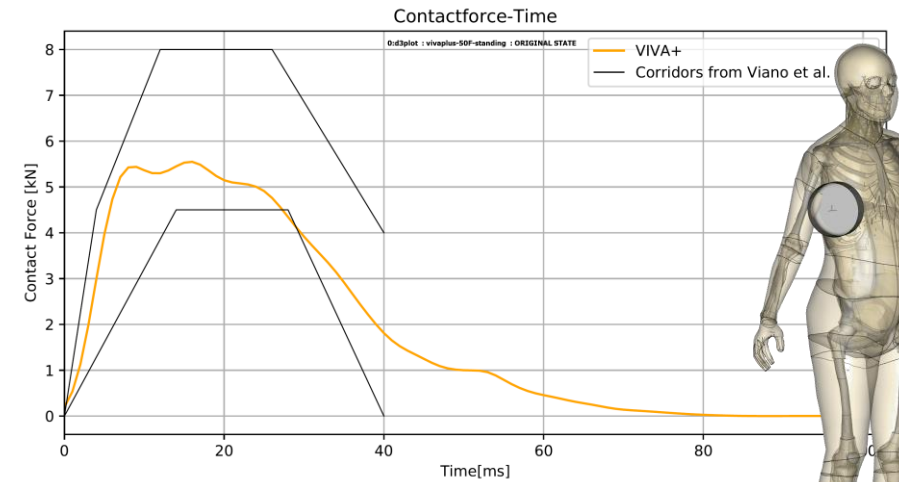
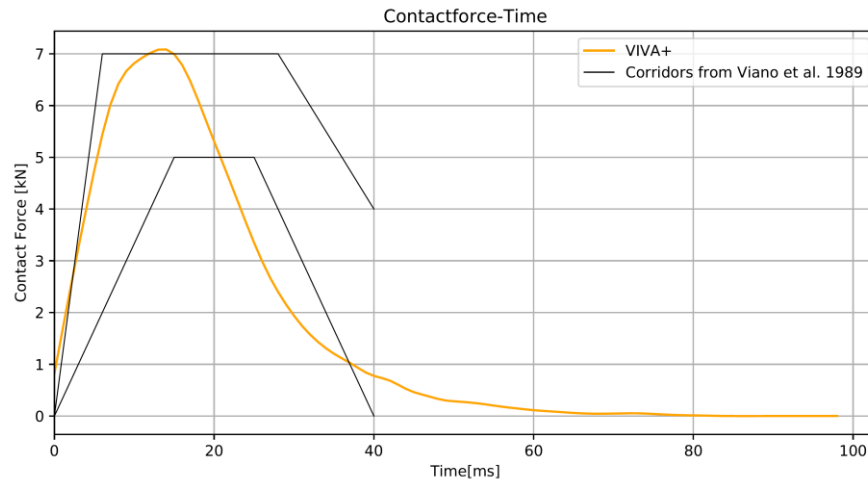


Blunt Body Impacts - Thorax Viano, 1989

5.2
m/s

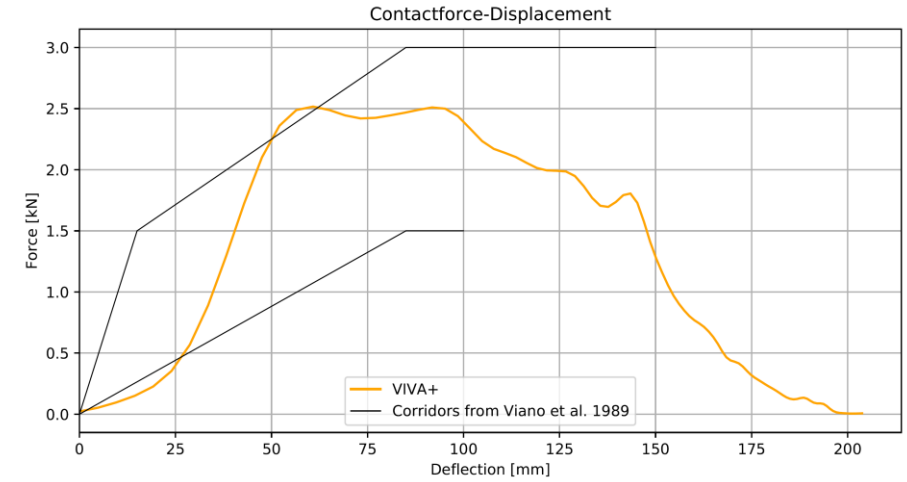
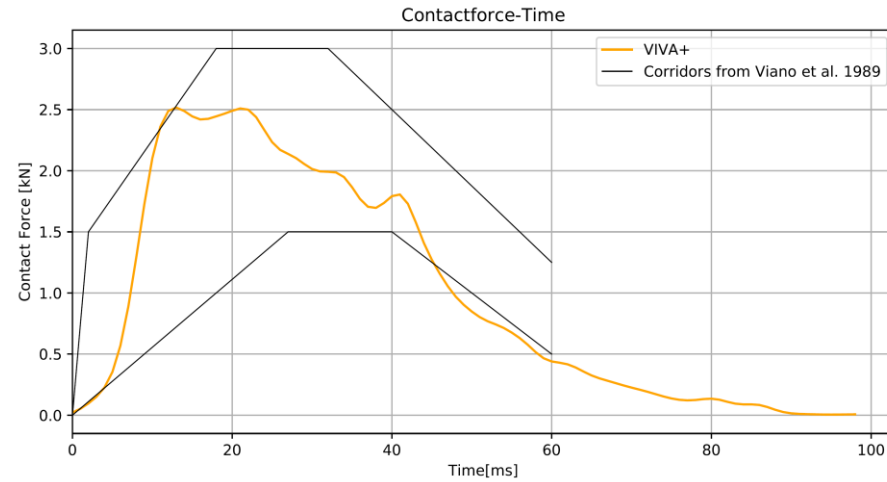


9.5
m/s

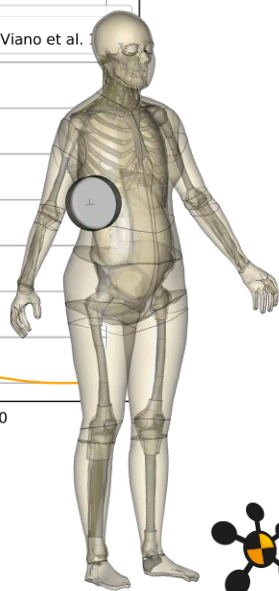
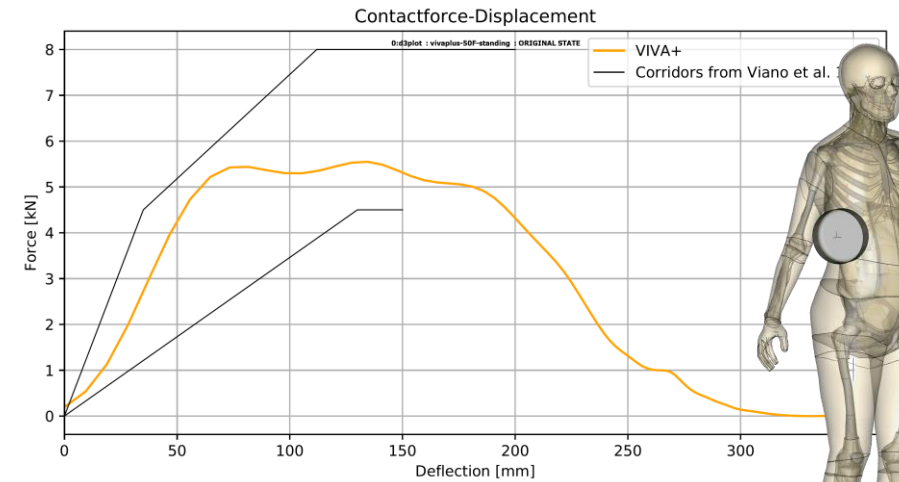
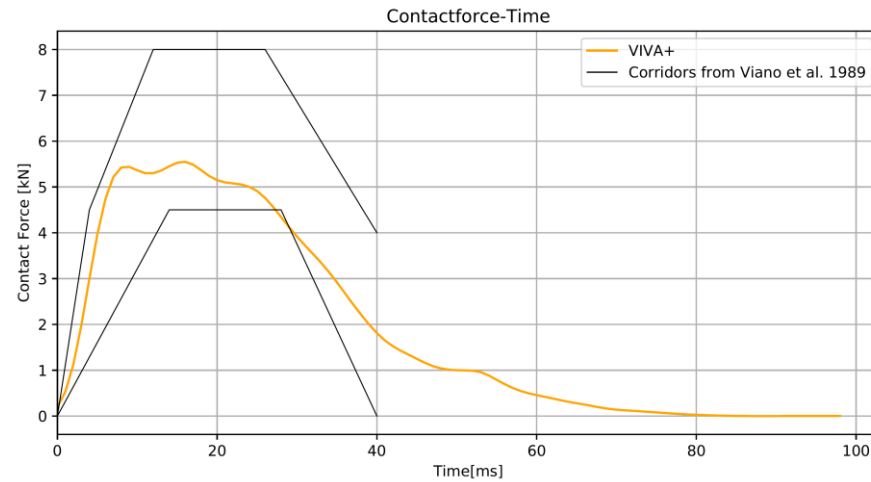


Blunt Body Impacts - Abdomen Viano, 1989

4.8
m/s



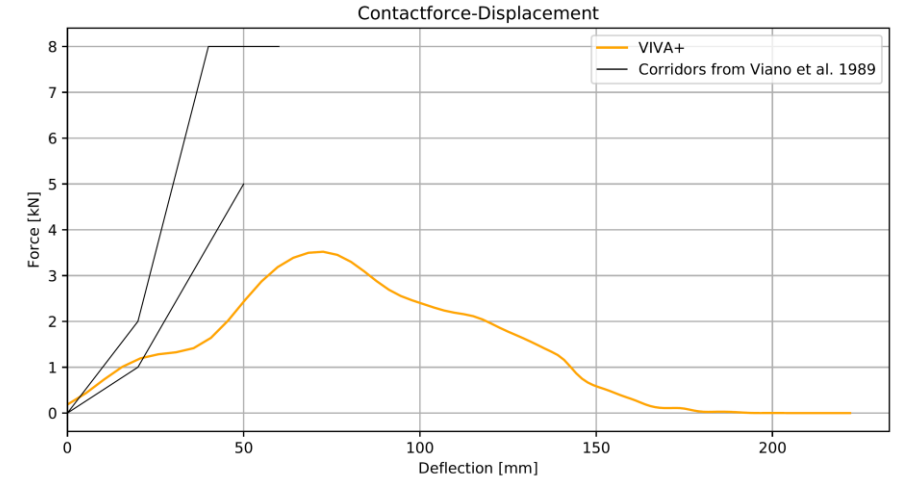
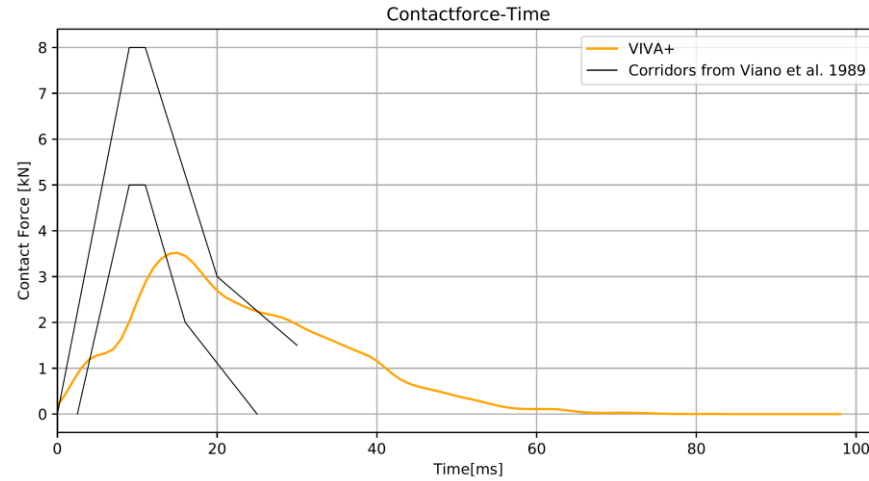
9.4
m/s



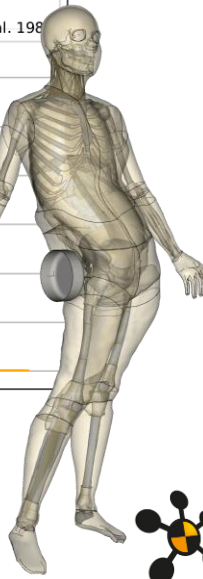
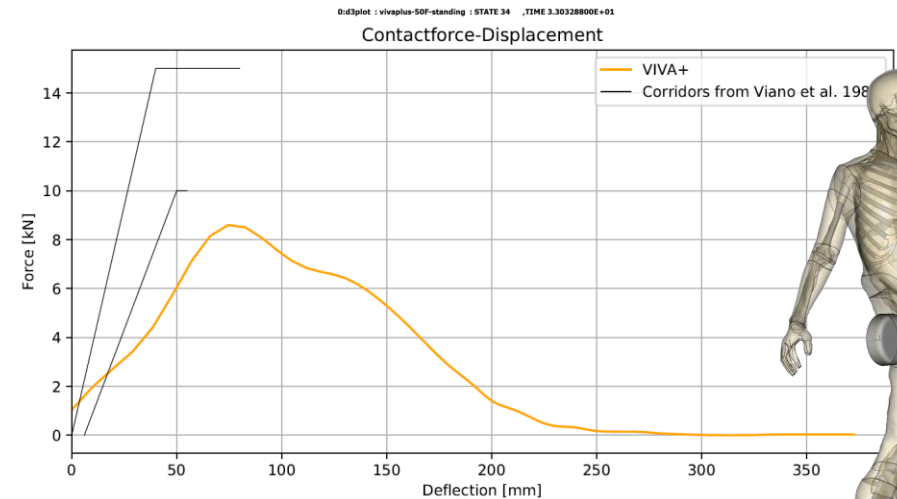
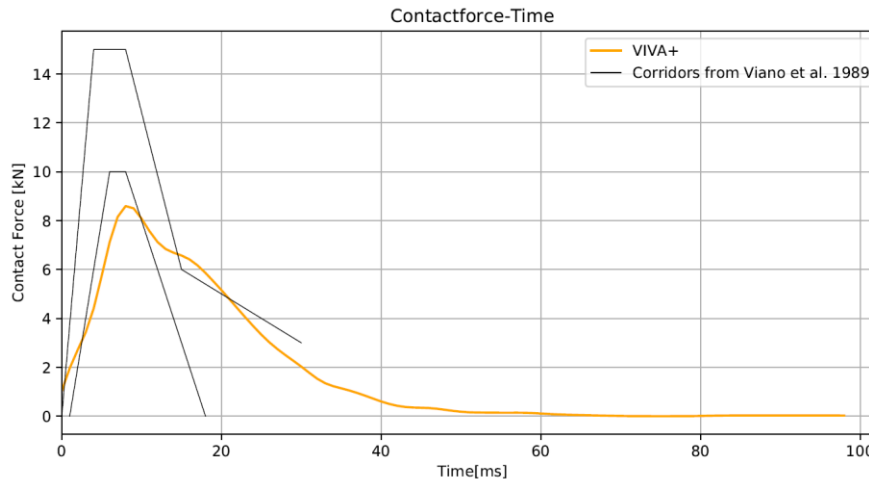
Blunt Body Impacts – Hip

Viano, 1989

5.2
m/s



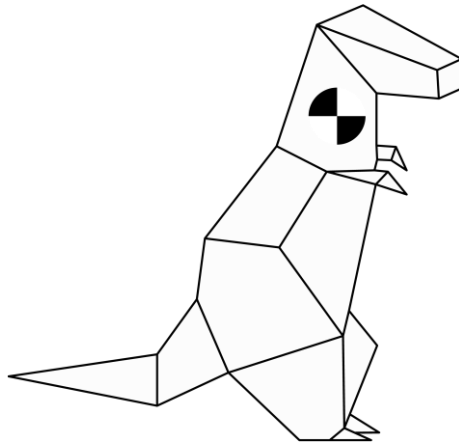
9.8
m/s



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

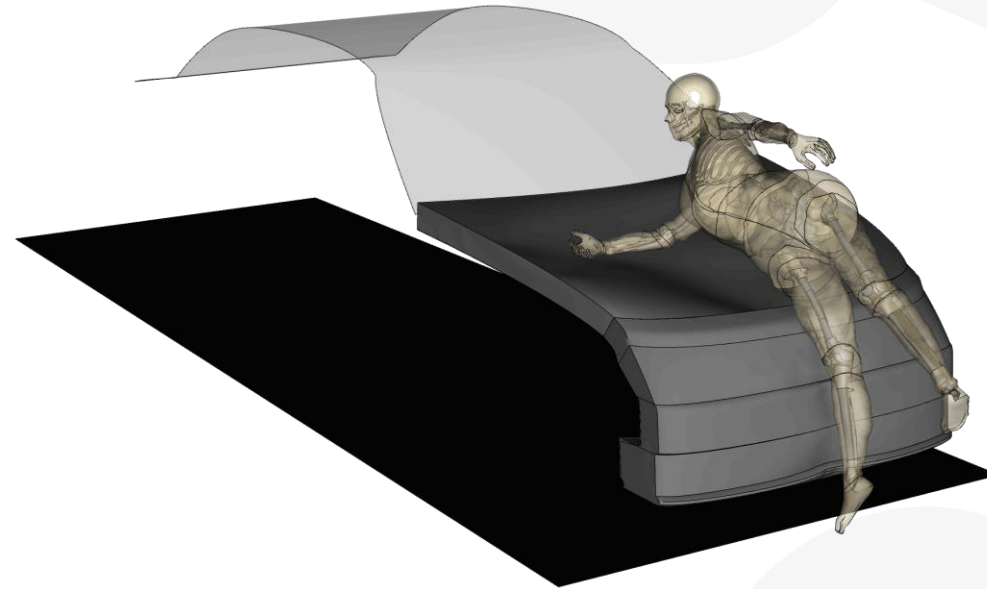


Robustness Checks

0:d3plot : vivaplius-50F-standing : STATE 89 ,TIME 8.80876800E+01



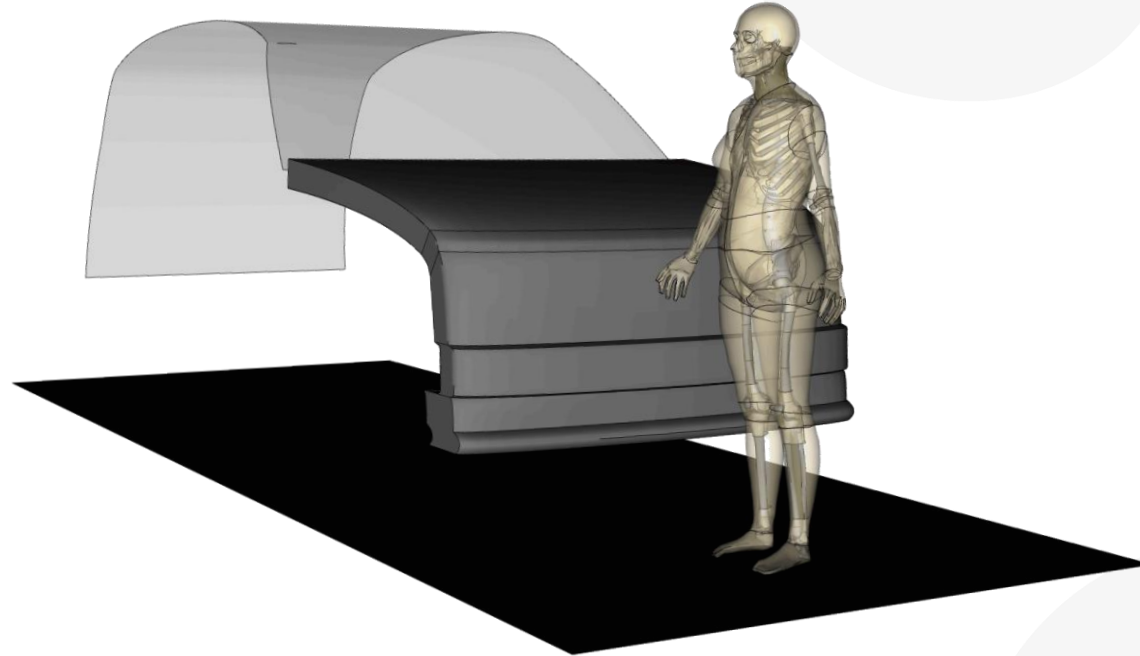
**Impact with
generic familycar
model at 50km/h**



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**

Apr 2020

Sep. 2020

Sep. 2021

Apr. 2022

Start:
Jun
2018

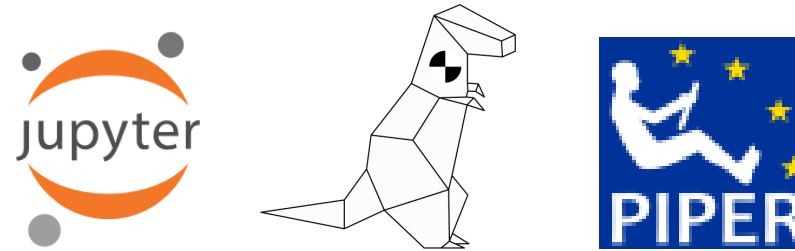


VIVA+: Open Science

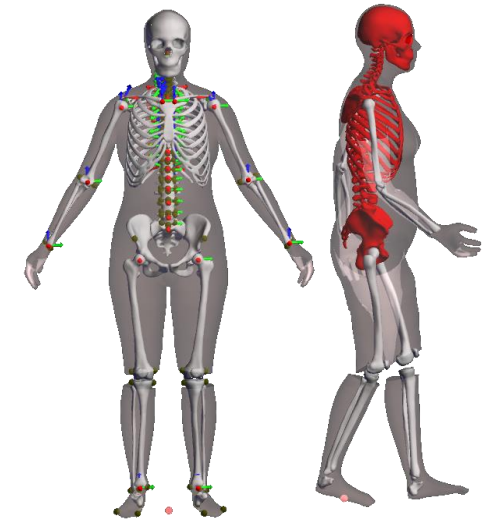
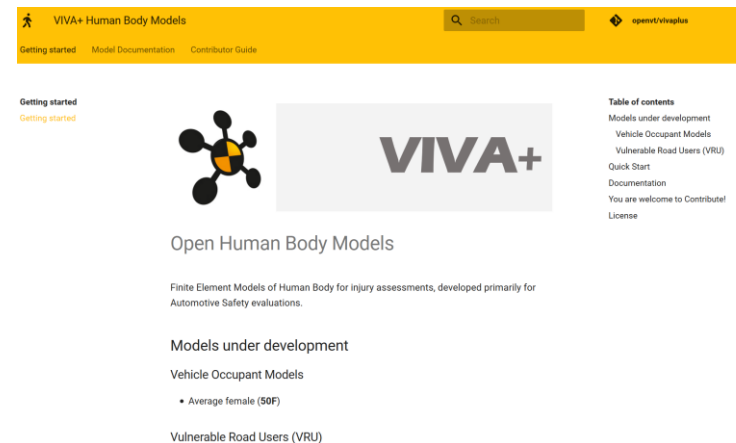
Open Model Development and Maintenance



Open Tools

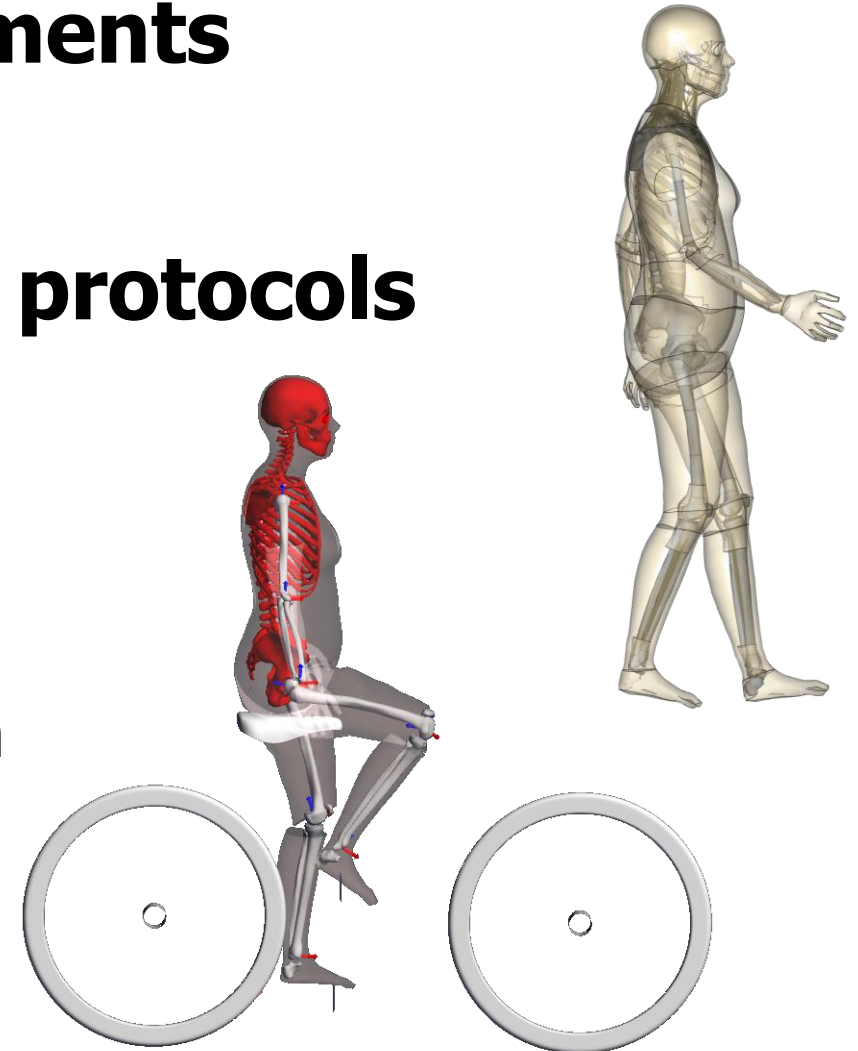


Open Documentation



Next steps

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



VIVA+ Human Body Models



CHALMERS
UNIVERSITY OF TECHNOLOGY



TU
Graz

DYNA
MORE NORDIC



University of Ljubljana

vti



AGU
ZÜRICH

SIEMENS

Outside
VIRTUAL



??

Everyone is welcome to contribute!
OpenVT (virtual.openvt.eu)



OpenVT Gitlab platform



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

Please, sign up for free on the right in order to get full access to the OpenVT platform.

You can browse the Public contents without registration: [Overview Public contents](#).

As a new user, please, check out our [manuals and guidelines section](#) and the [OpenVT wiki](#). There you also find a [FAQ section](#).

The OpenVT platform is part of project **VIRTUAL**. For more information, see projectvirtual.eu.

Sign in	Register
Username or email	
Password	
☐ Remember me	Forgot your password?
Sign in	



Acknowledgement



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

<https://projectvirtual.eu/>

The authors would like to thank Beta CAE for their support. ANSA and META were used within this study.



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