Astrid Linder

Project VIRTUAL In Brief

Event: VIRTUAL-OSCCAR workshop
Location: On-line
Date: 8/09/2020

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

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VIRTUAL: Open Access Virtual Testing Protocols for Enhanced Road User Safety

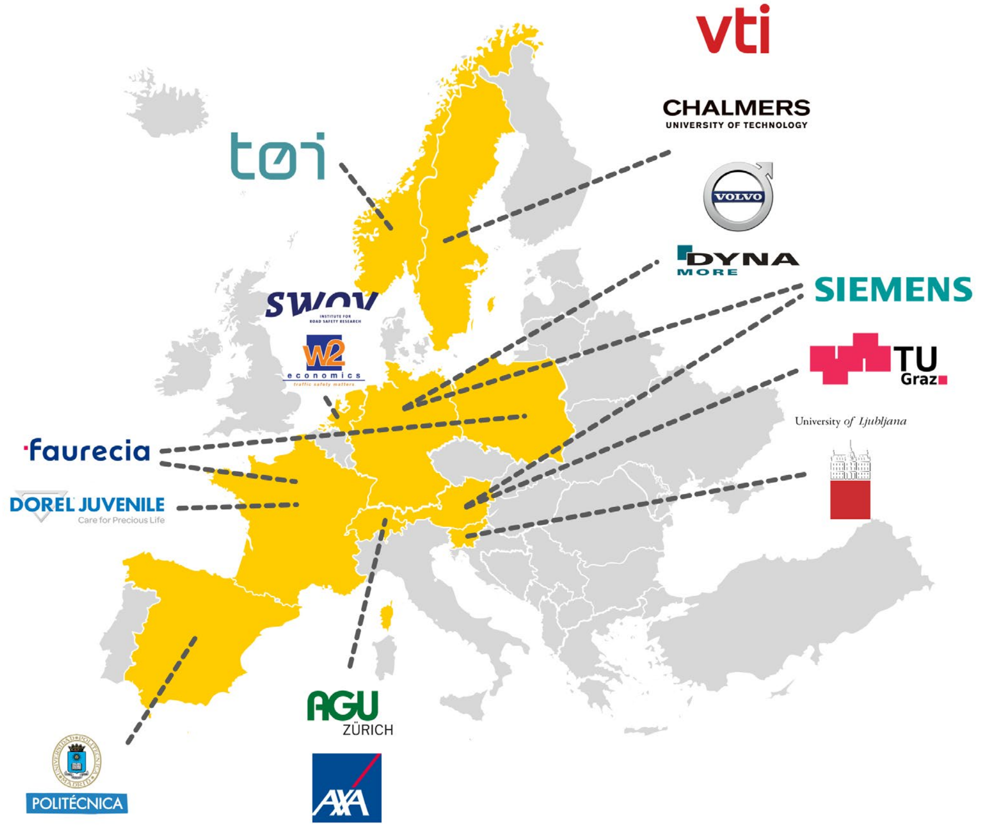
- Duration: 48 Months, started 1 June 2018
- Funding: € 6.99 Million
- Partners: 15
- Countries: 9
- www.projectvirtual.eu

Aims:

Reduce loss of life and health in road crashes for all road users.

Share and foster knowledge: Open Source (OS).

Identify protective innovations: Virtual Testing, OS-HBM 50F and 50M.



European Commission

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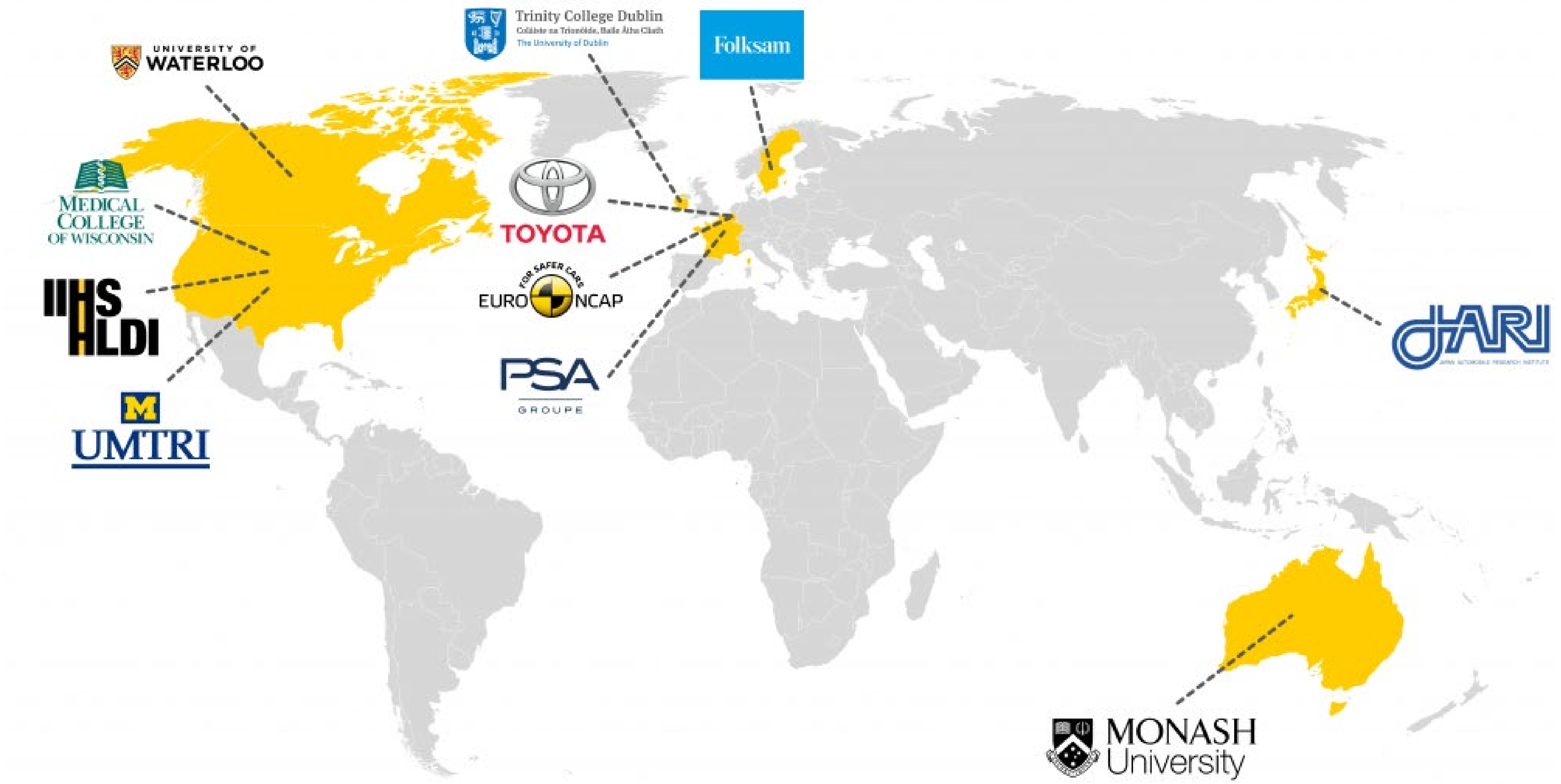
International collaboration



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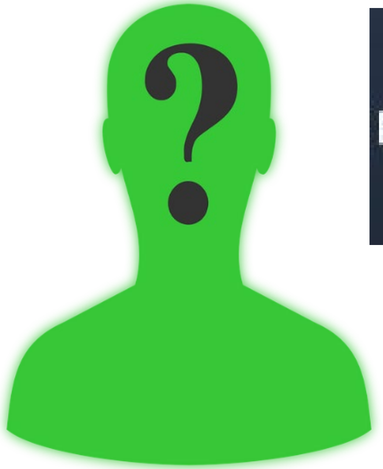
Vision: By 2030, injury protection performances of new cars will be assessed for both women and men!

Benefits:

- Inclusive crash safety assessment
- Best performing innovations identified
- Improved safety for everyone



www.euroncap.com

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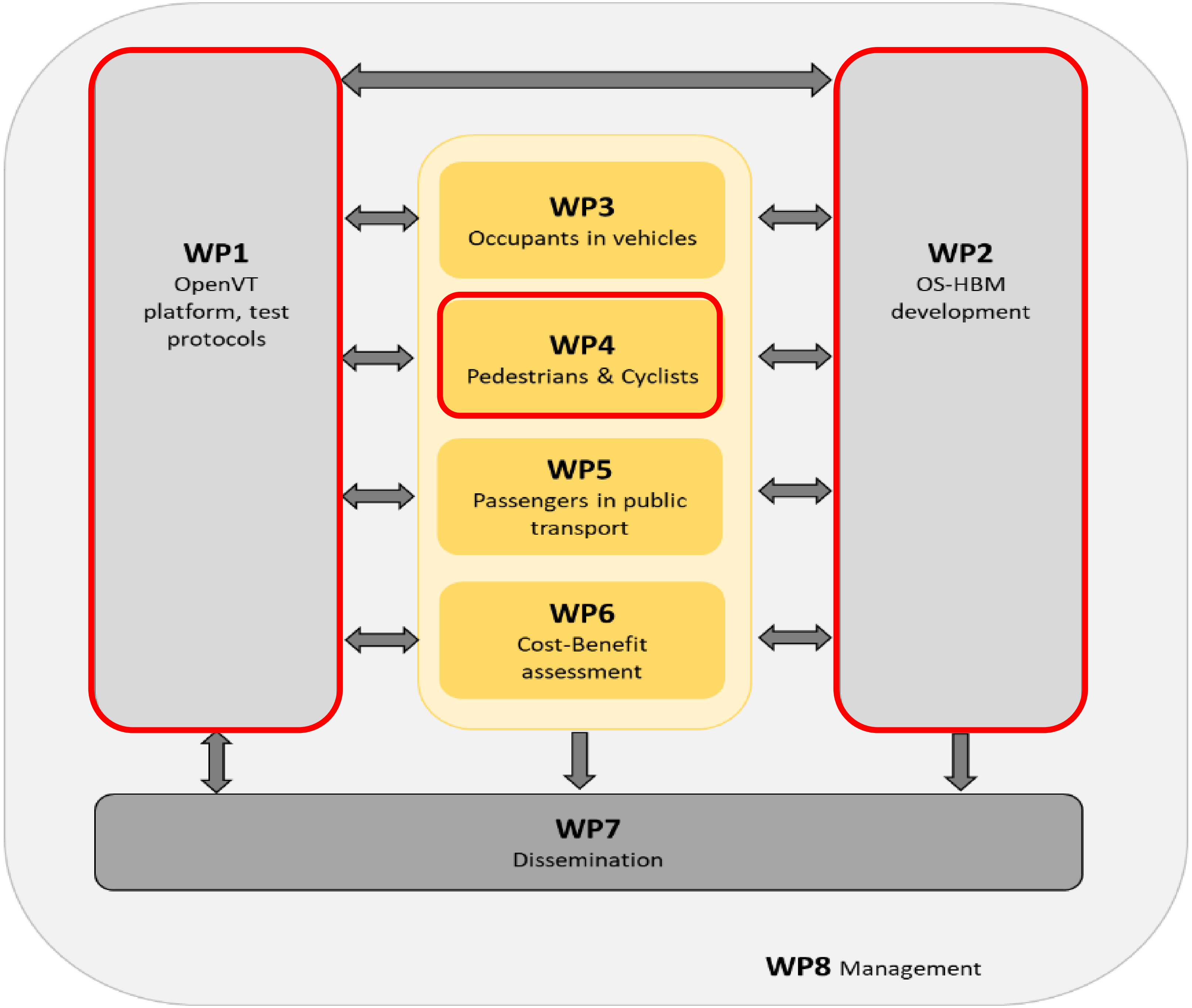
WP1
OpenVT platform, test protocols
WP3
Occupants in vehicles
WP4
Pedestrians & Cyclists
WP5
Passengers in public transport
WP6
Cost-Benefit assessment
WP2
OS-HBM development
WP7
Dissemination
WP8 Management


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Contact:
Astrid Linder
Astrid.linder@vti.se
+46 708 286468

For more information:
www.projectvirtual.eu

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Arne Keller

www.projectvirtual.eu

The OpenVT platform

Event: workshop OSCCAR-VIRTUAL
Location: online
Date: 2020/09/08

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

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VIRTUAL: Open Source in road safety testing

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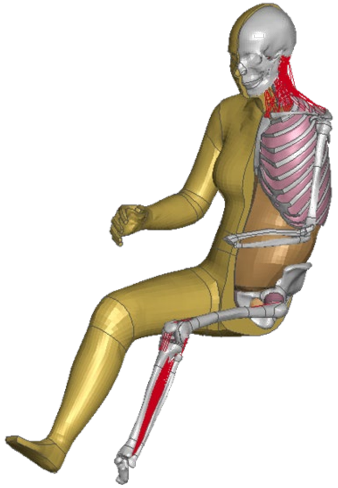
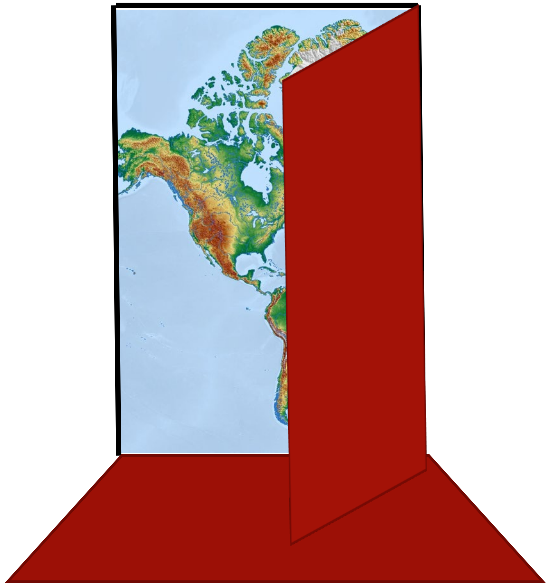
LGPLv3
Free Software
Free as in Freedom

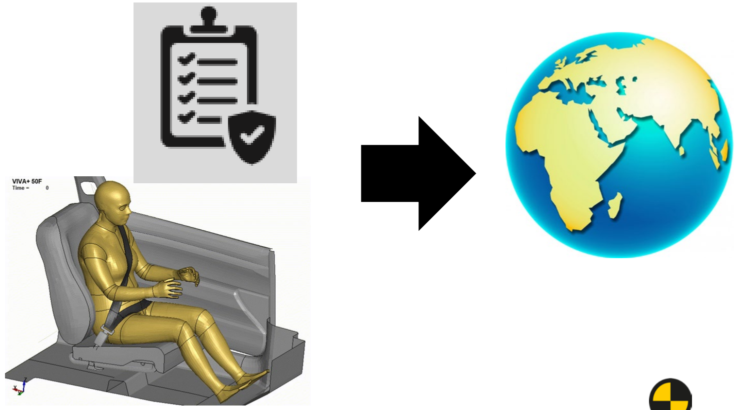


The OpenVT platform

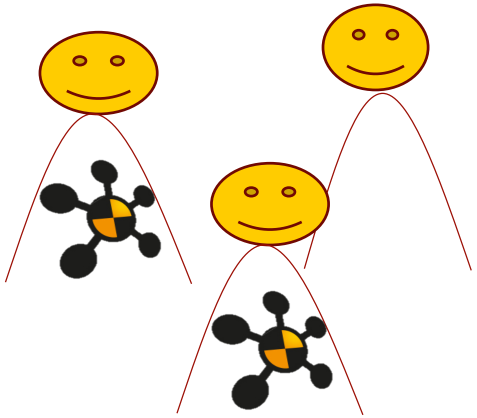


The OpenVT platform

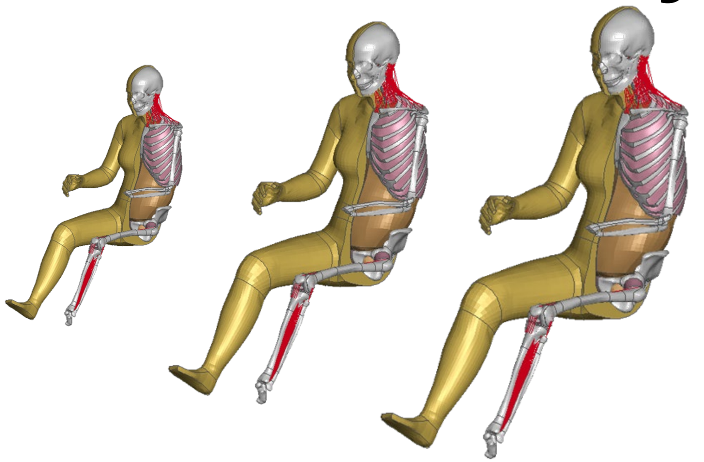
- Dissemination



- Development + collaboration



- Sustainability



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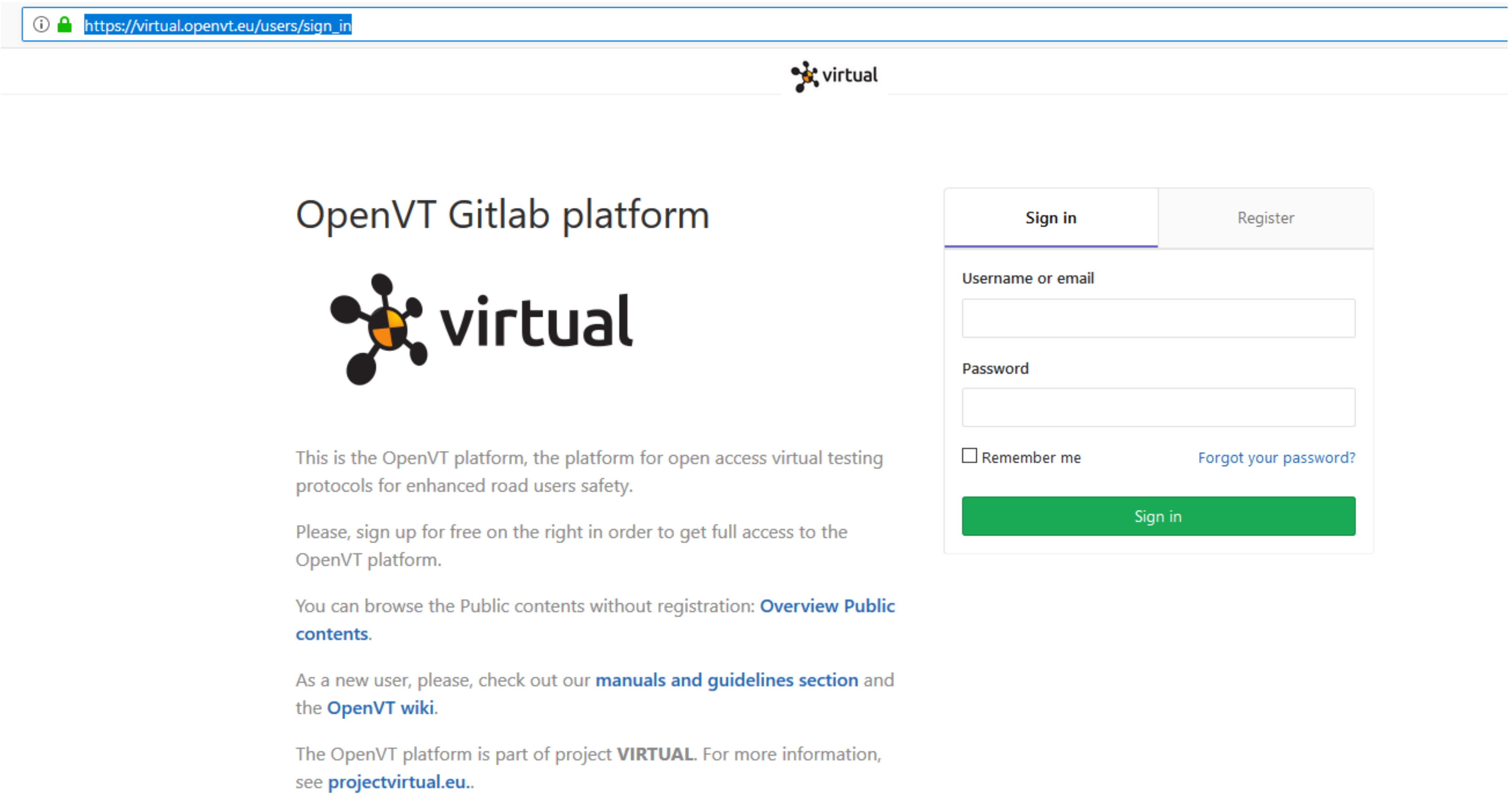
Gitlab server: https://virtual.openvt.eu



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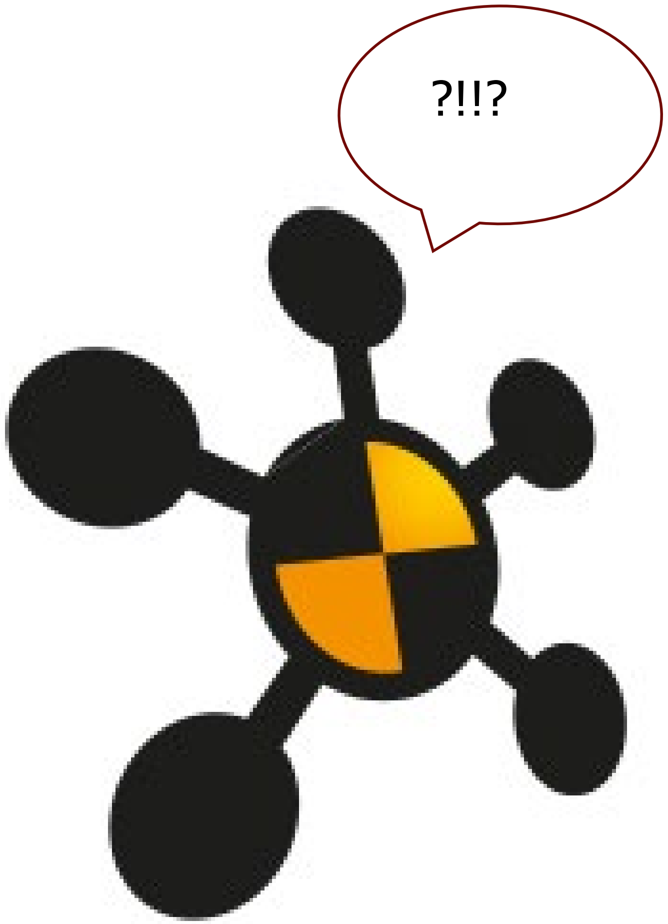
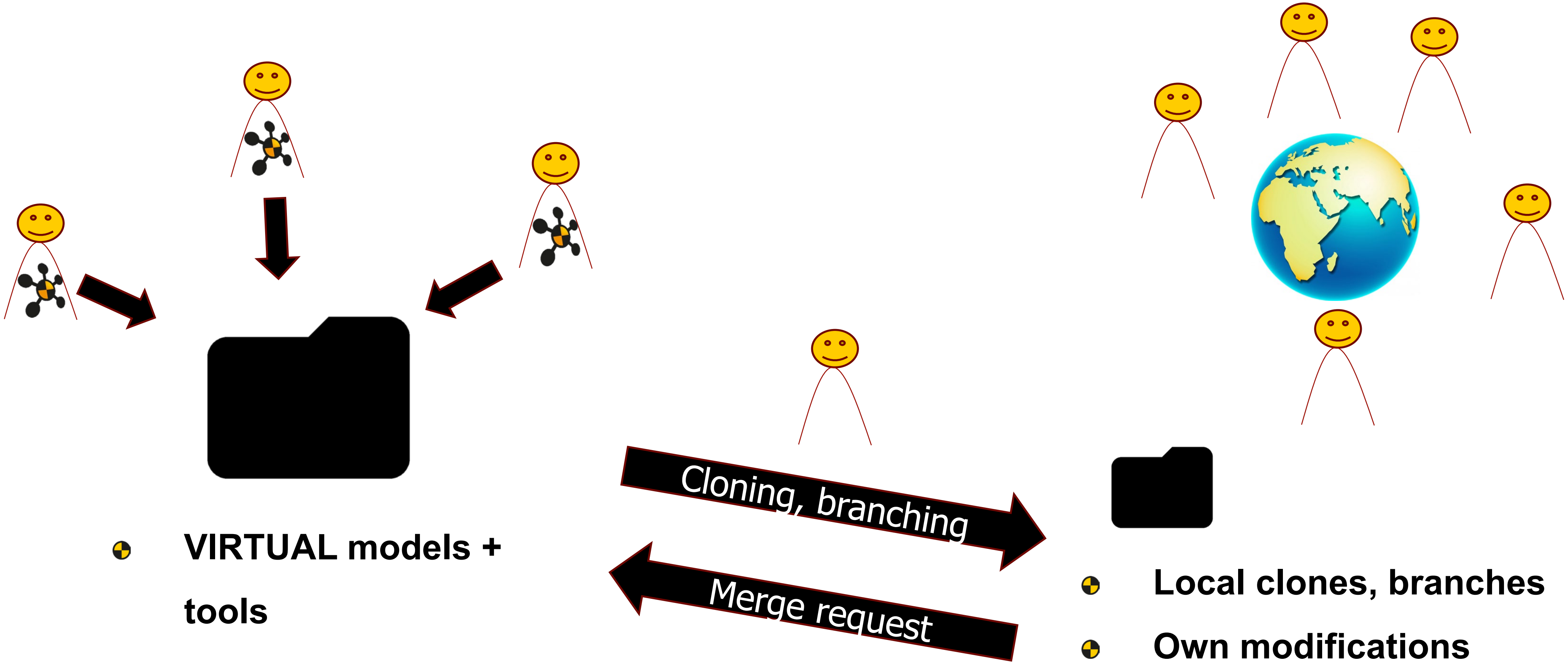
Public contents on OpenVT:

- **Online**
  - Original VIVA model
  - Cost-benefit analysis tool
- **Coming soon**
  - First release of VIVA+ models
  - Pre-crash assessment tool VRUs
  - Post processing tool and templates
  - Validated car seat model
  - Generic child seat model

And beyond VIRTUAL?



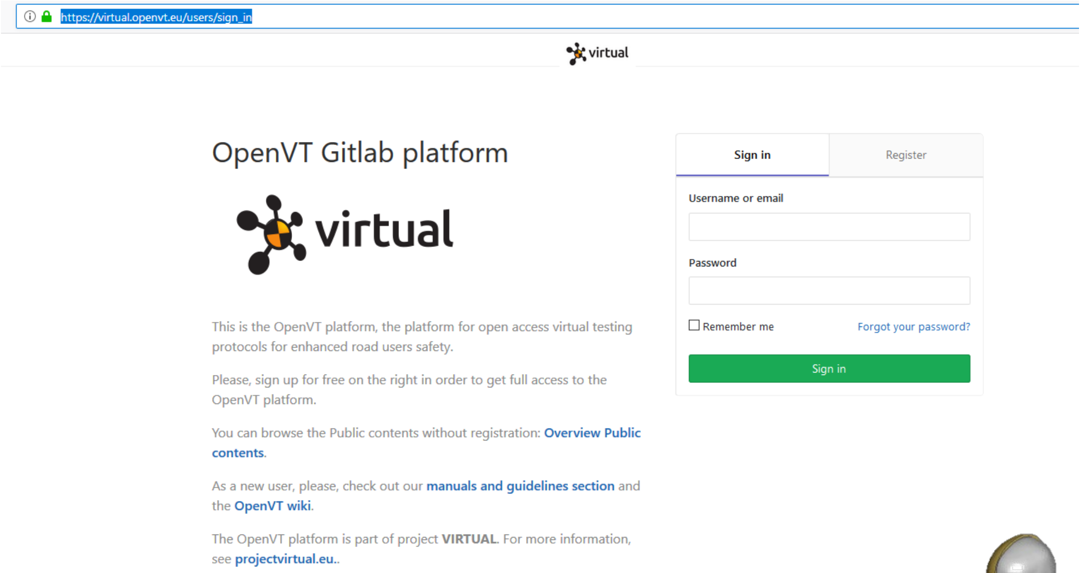
Open Source: include user community

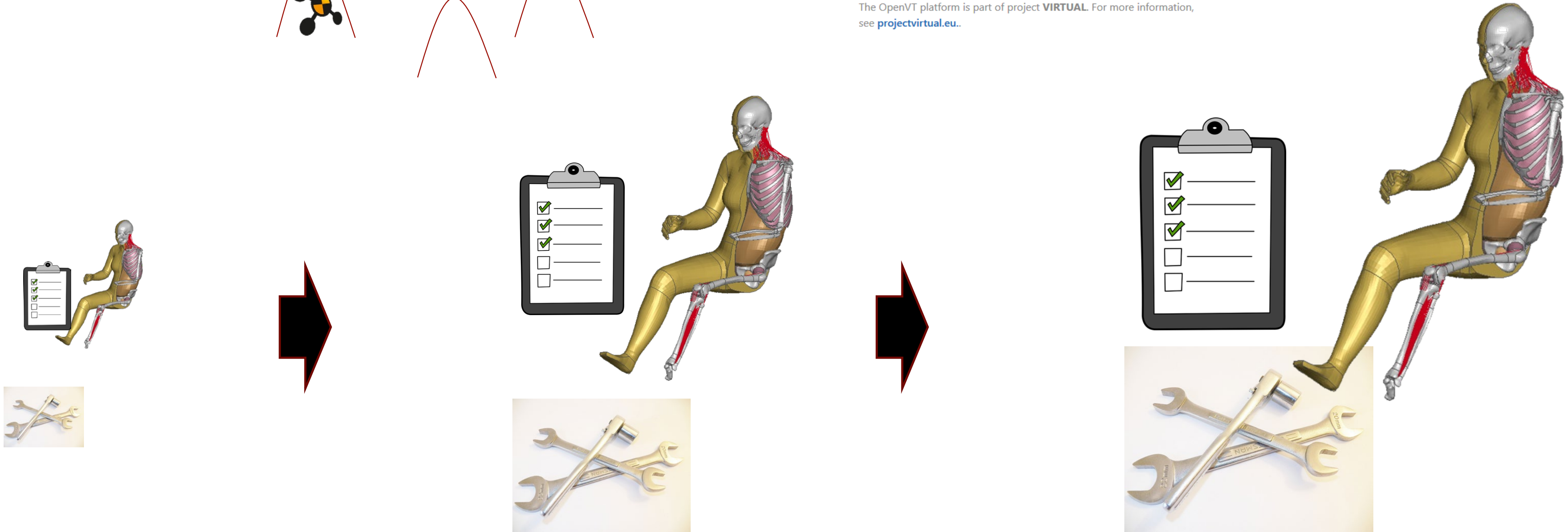


- **VIRTUAL models + tools**

- **Local clones, branches**
- **Own modifications**

You are invited to participate!





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Contact:
Arne Keller
AGU Zürich
Winkelriedstrasse 27
8006 Zürich, Switzerland
keller@agu.ch

For more information:
www.projectvirtual.eu

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VIRTUAL - OSCCAR Workshop: WP2 – Open VIVA+ models

Event: VIRTUAL-OSCCAR Workshop
Location: Online
Date: 8/9/2020

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

Specific project aims related to the adult HBM development

- **Openly** provide average **female** and **male** open source (OS) HBM's for virtual testing.
- The models will represent **erect** and **seated** adults and will include postural control functions for human-like pre-crash response.
- Reach a higher degree of biofidelity and assessment capability of the OS-HBM's by focusing detailed OS-HBM development to the following test cases
  - *CASE 1: Identify high performance safety concepts with regards to protection against **whiplash injuries** among others.*
  - *CASE 2: Provide enhanced integrated safety assessments for the **protection of VRUs** (pedestrians and cyclists)*
  - *CASE 3: Fall initiating of standing occupants in public transport*
- The OS-HBMs will also be prepared for further development in other test cases that need to be addressed in future projects.

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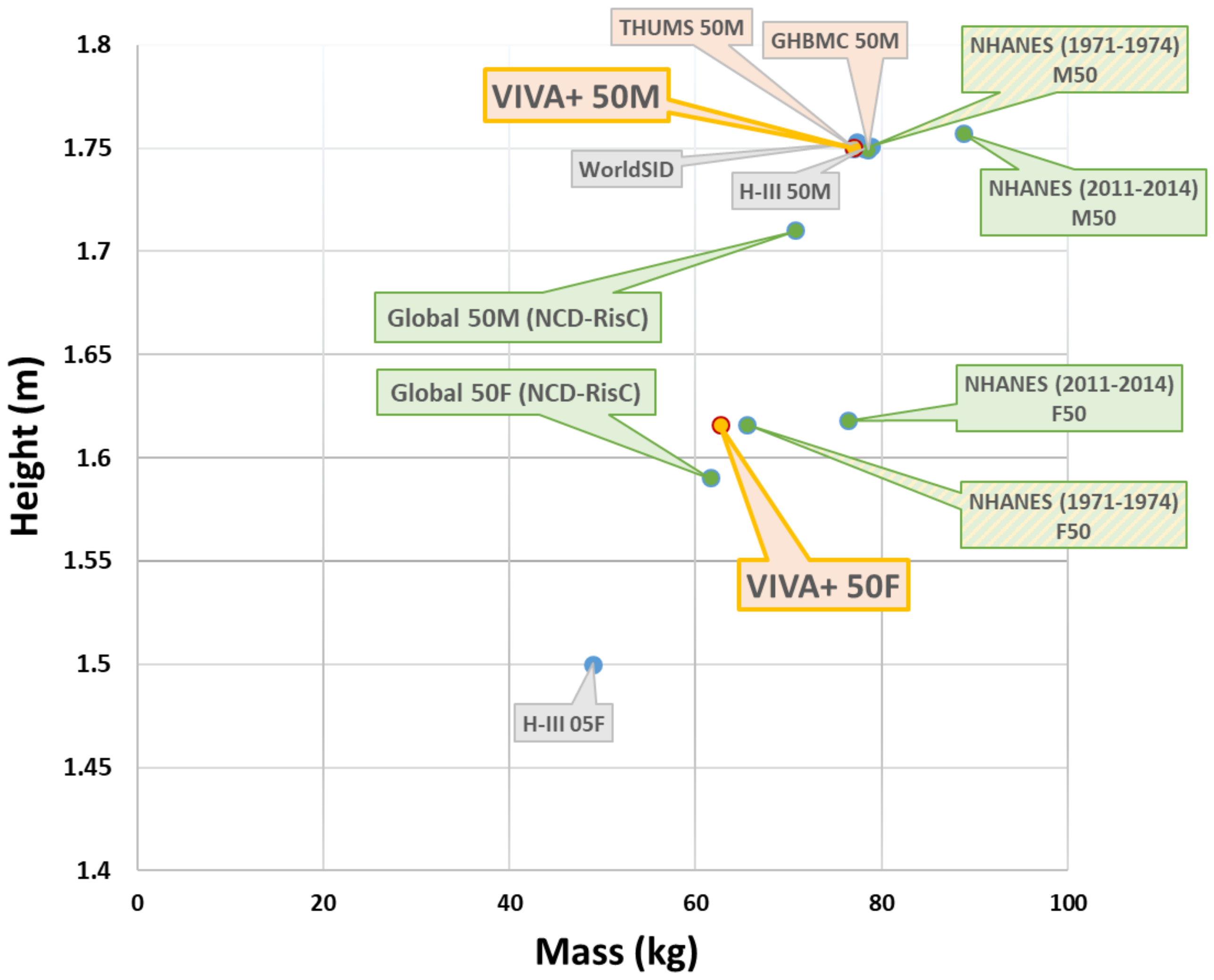
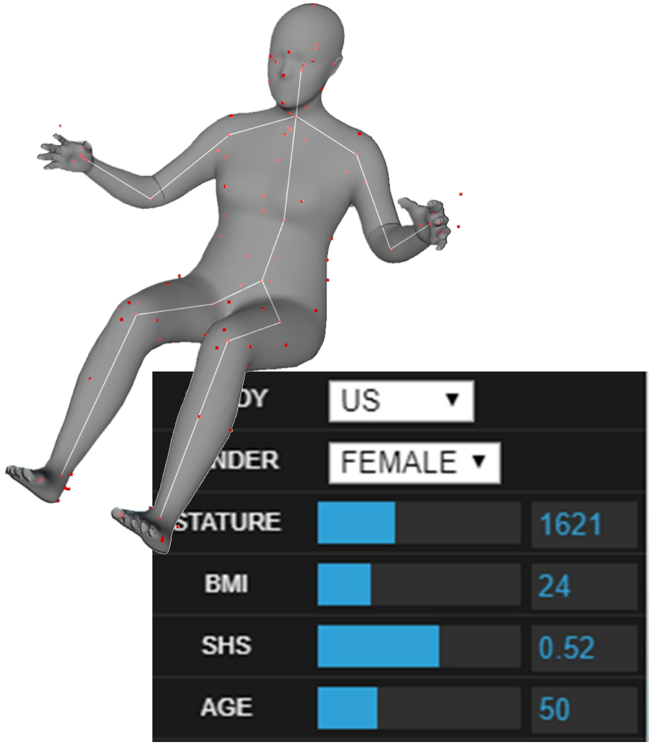
Definition of male and female averages



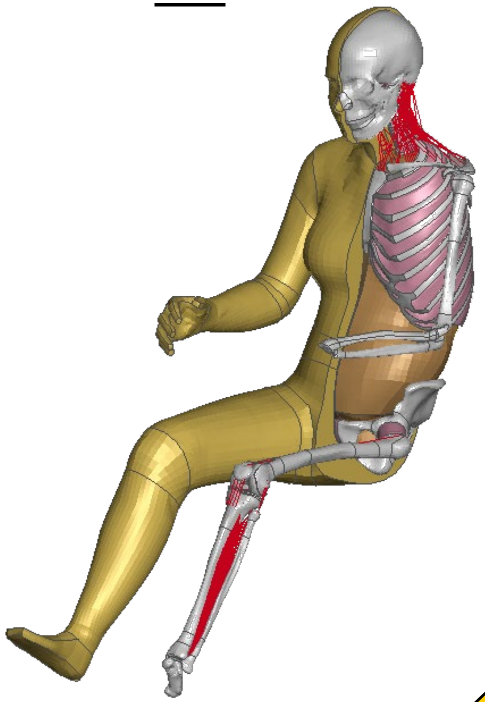
	Mass [kg]	Height [m]	BMI [kg/m]	Age [years]
Female	62	1.62	24	50
Male	77	1.75	25	50

Development of the VIVA+ HBMs

Acquire **averaged** anatomical data

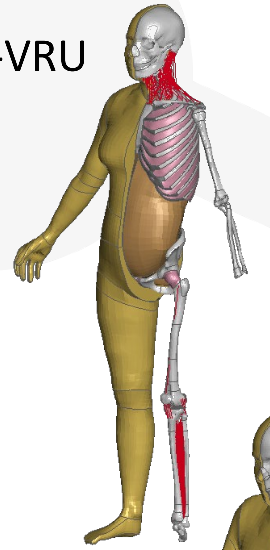


Create FE **base** **F50** model

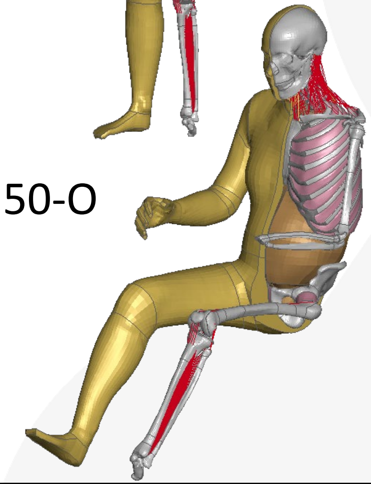


Create **derivate** models

F50-VRU



M50-O



Validate models

End users' issues

- Robustness
- Positioning
- New load cases
- New solvers
- Scaling/Morphing

One model to update/enhancement

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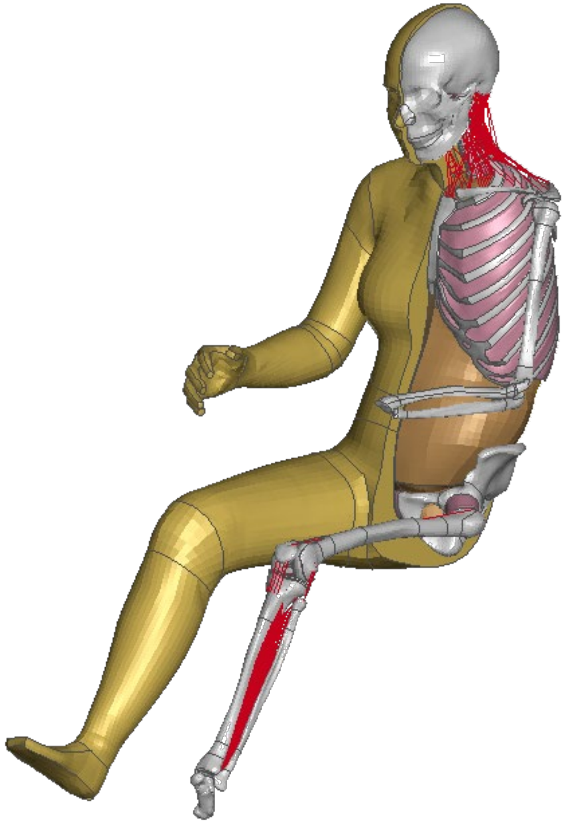
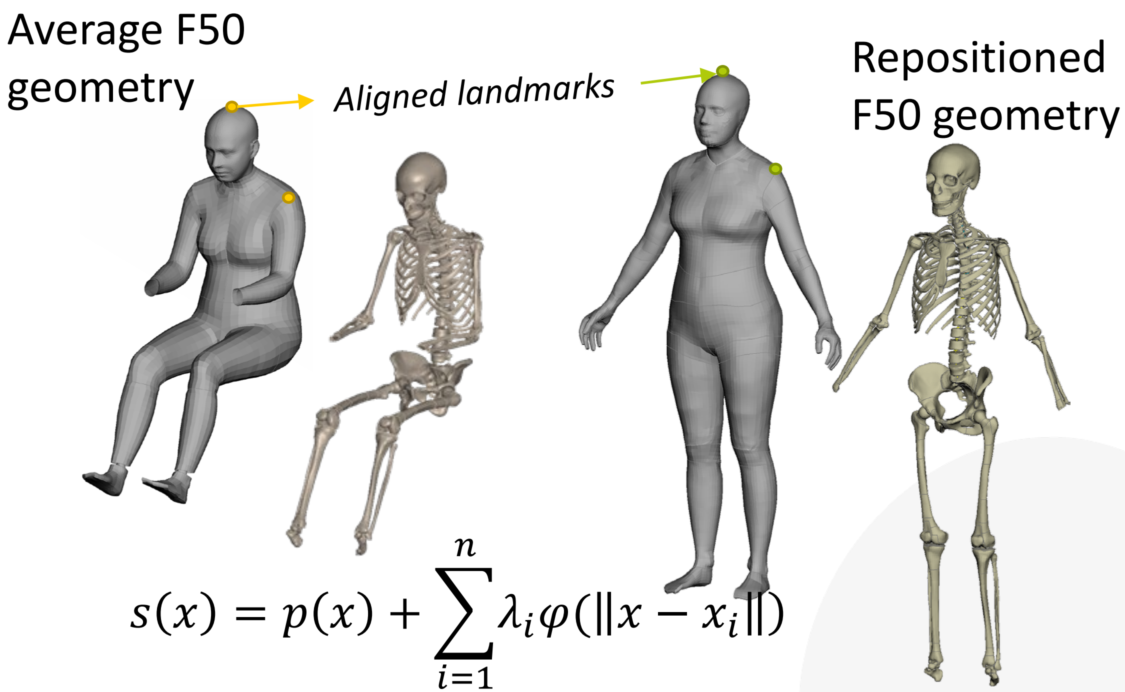
Development of the VIVA+ HBMs
- The VRU derivatives



Non-linear mesh morphing using Radial Basis Function with Thin-Plate-Splines



$$s(x) = p(x) + \sum_{i=1}^{n} \lambda_i \varphi(\|x - x_i\|)$$

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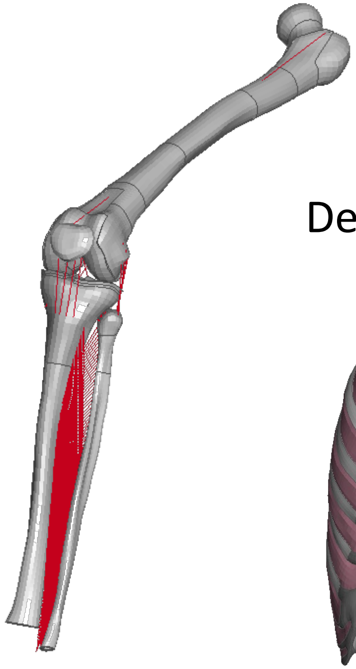
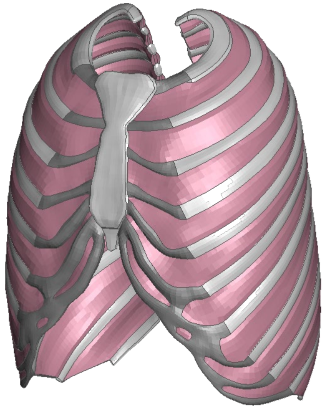
HBM development in VIRTUAL project – Base F50 model

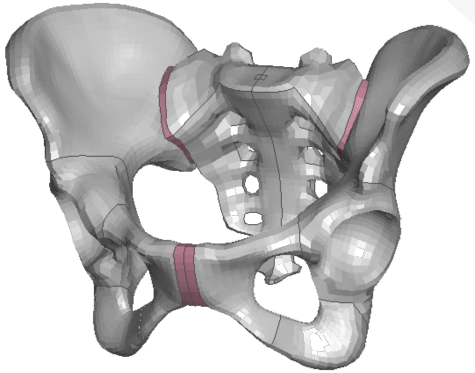
Detailed legs



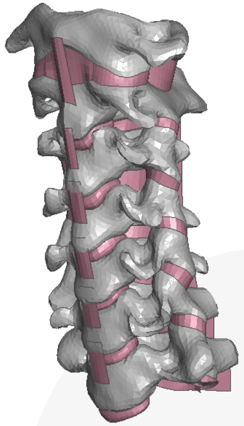
Detailed rib cage

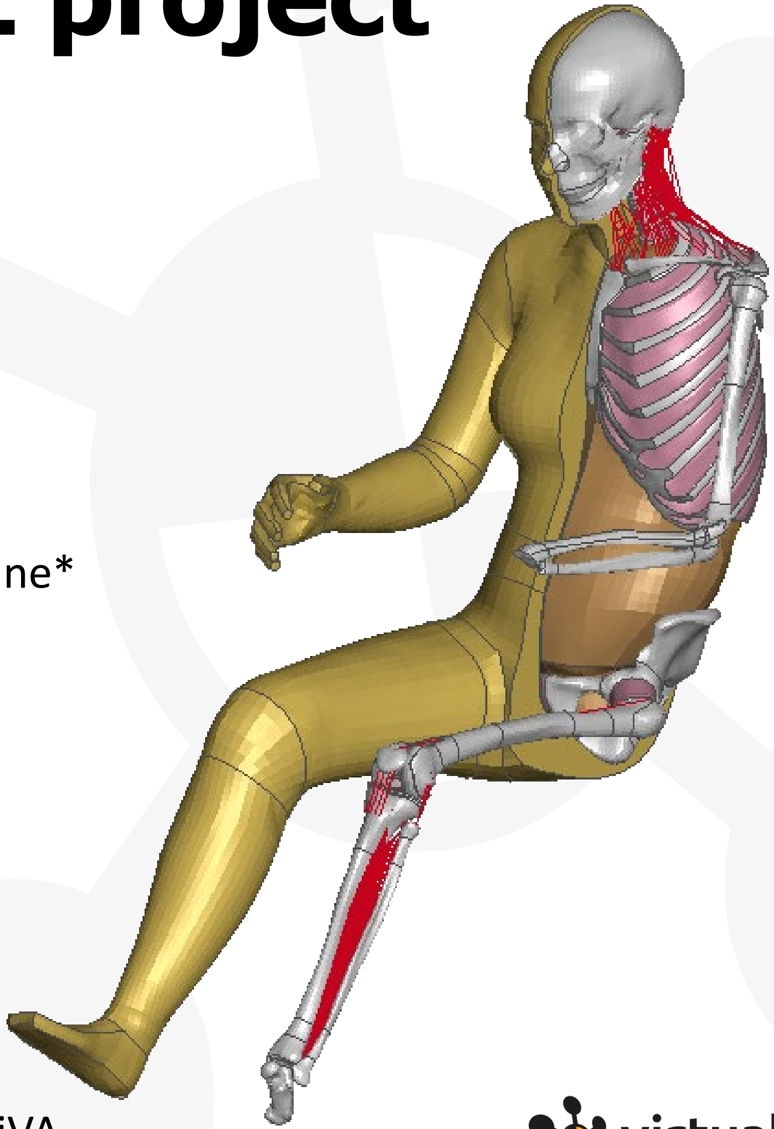


Detailed pelvis



Detailed cervical spine*





← *Strain based injury criteria* →

*carry over form ViVA

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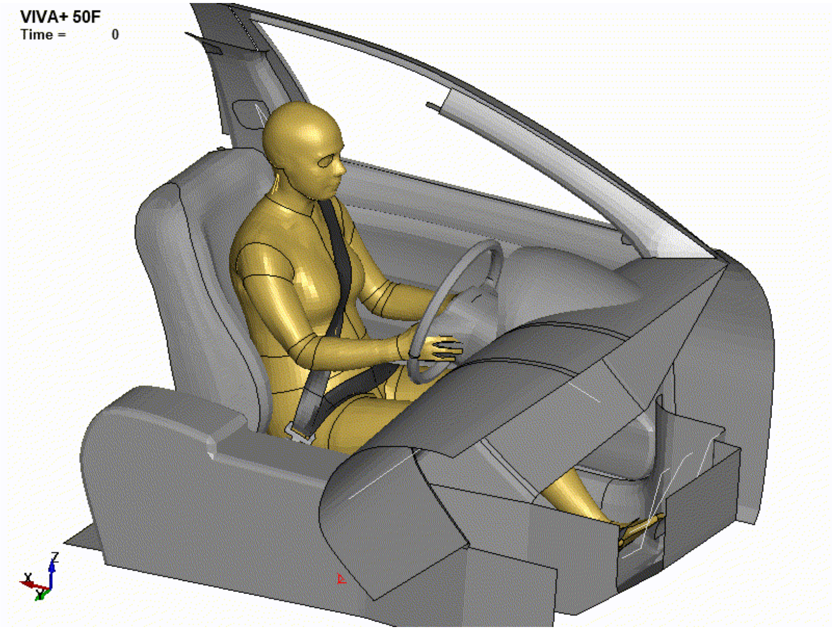
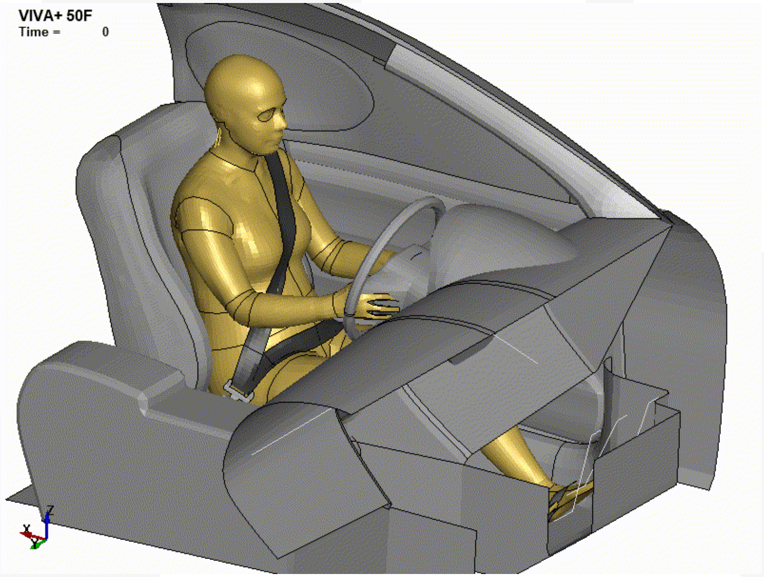
HBM development in VIRTUAL project - Base F50 model robustness

DV=70kph



DV=70kph

$V_{intrusion}$=56kph



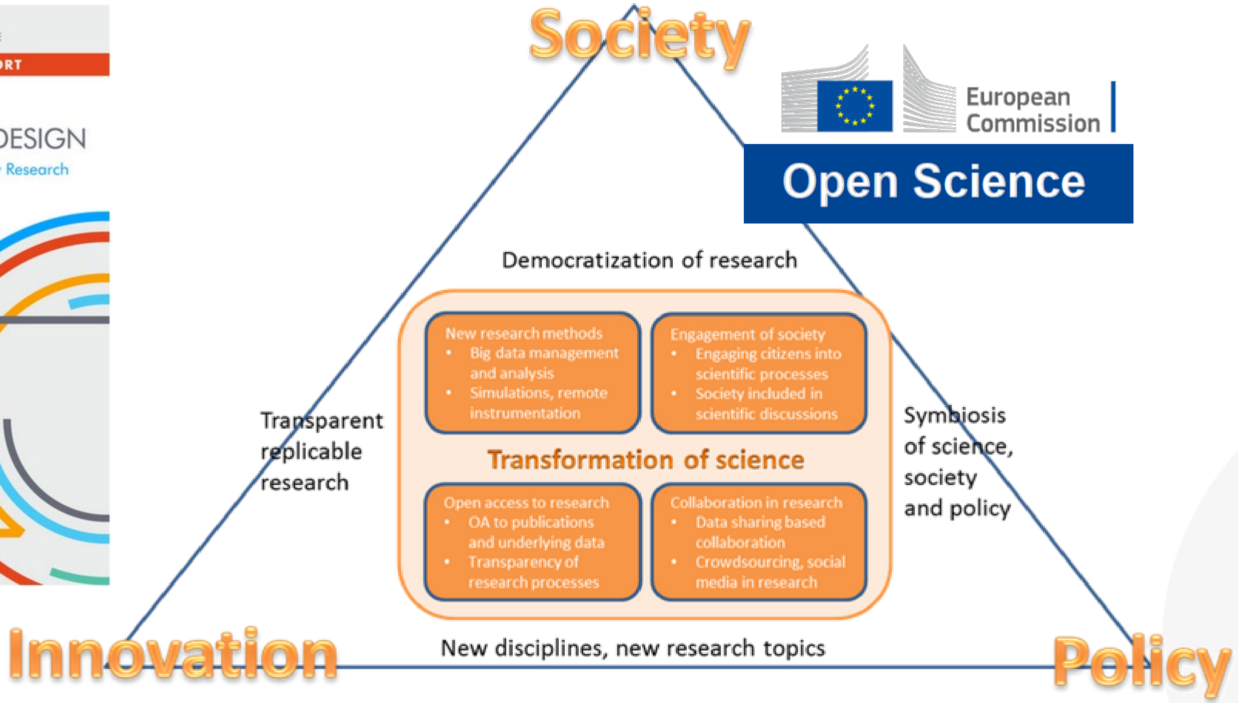
VIVA+ and Open Science

United Nations
Educational, Scientific and
Cultural Organization

Organisation
des Nations Unies
pour l'éducation,
la science et la culture

Organización
de las Naciones Unidas
para la Educación,
la Ciencia y la Cultura

WORLD SCIENCE DAY
FOR PEACE AND DEVELOPMENT
2019
OPEN SCIENCE, LEAVING NO ONE BEHIND



Open Science is the practice of science in such a way that

- others can **collaborate** and **contribute**
- where **research data** and **research processes**
  - are freely available
  - under terms that enable
    - **reuse**
    - **redistribution**
    - **reproduction**

FOSTER EU Open Science Initiative

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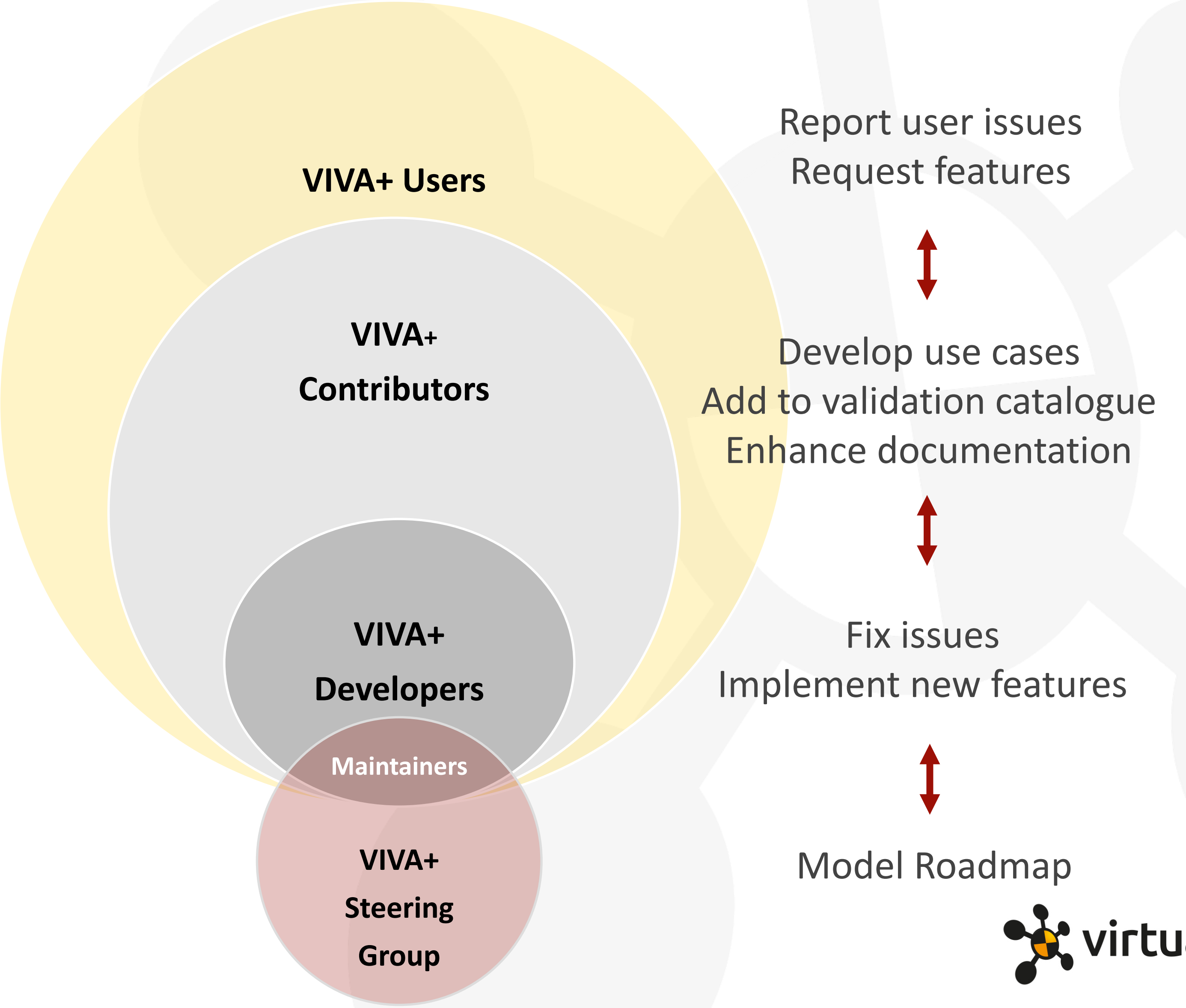
VIVA+ and Open Science

- **Open Source License**
  - LGPL (v3)
- **Open Repository**
  - Git version control
- **Open Development**
  - ‘Develop-in-the-open’ enabled by Gitlab collaboration tools
- **Open and Reproducible Analysis**
  - Python-based *Dynasaur* library
  - computational notebooks (Jupyter)

EVERYONE CAN CONTRIBUTE!



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Contact:

Johan Iraeus,
johan.iraeus@chalmers.se

Jobin John

jobin.john@chalmers.se

For more information:
www.projectvirtual.eu

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Klug, Leo, Schachner

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VIRTUAL-
Vulnerable Road User Protection

VIRTUAL – OSCCAR Workshop: Progress in Virtual Testing for automotive applications
Date: 08/09/2020

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

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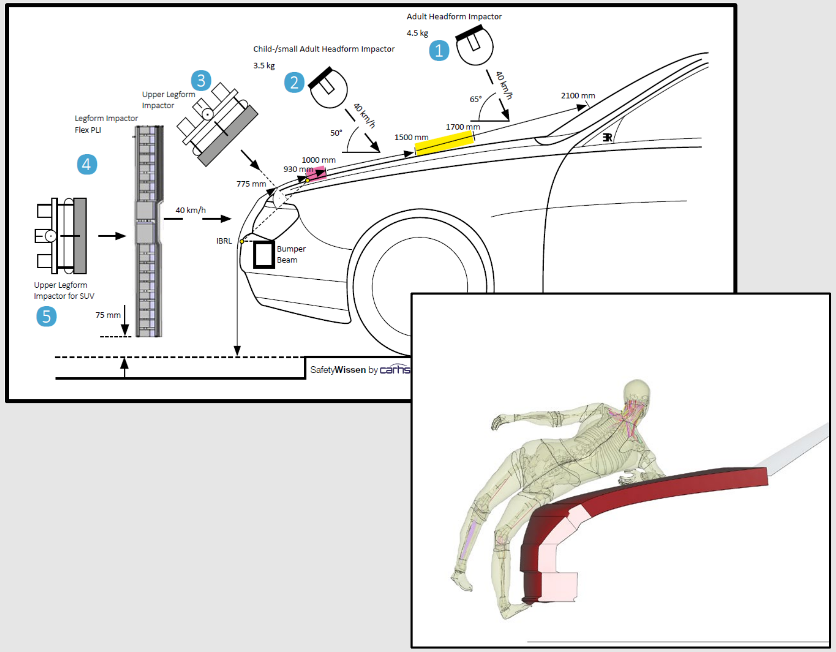
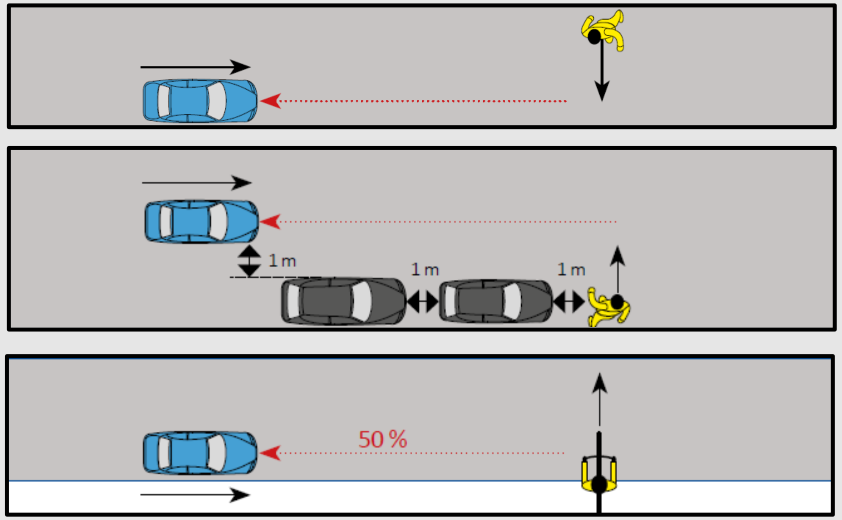
VRU Assessment

Passive Safety



Active Safety



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Standardized virtual testing protocol

OpenVT Gitlab platform

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Open Source Tools

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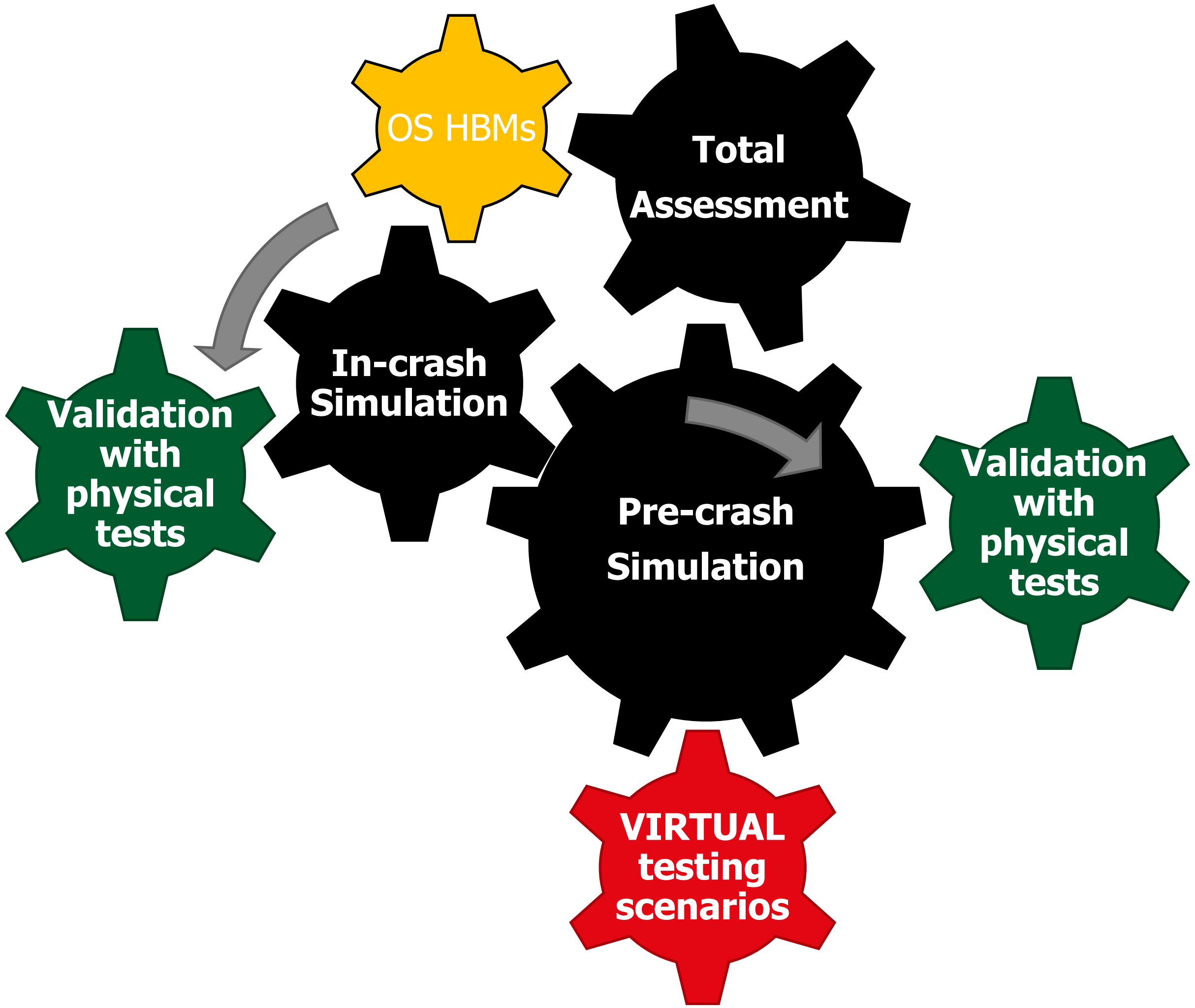
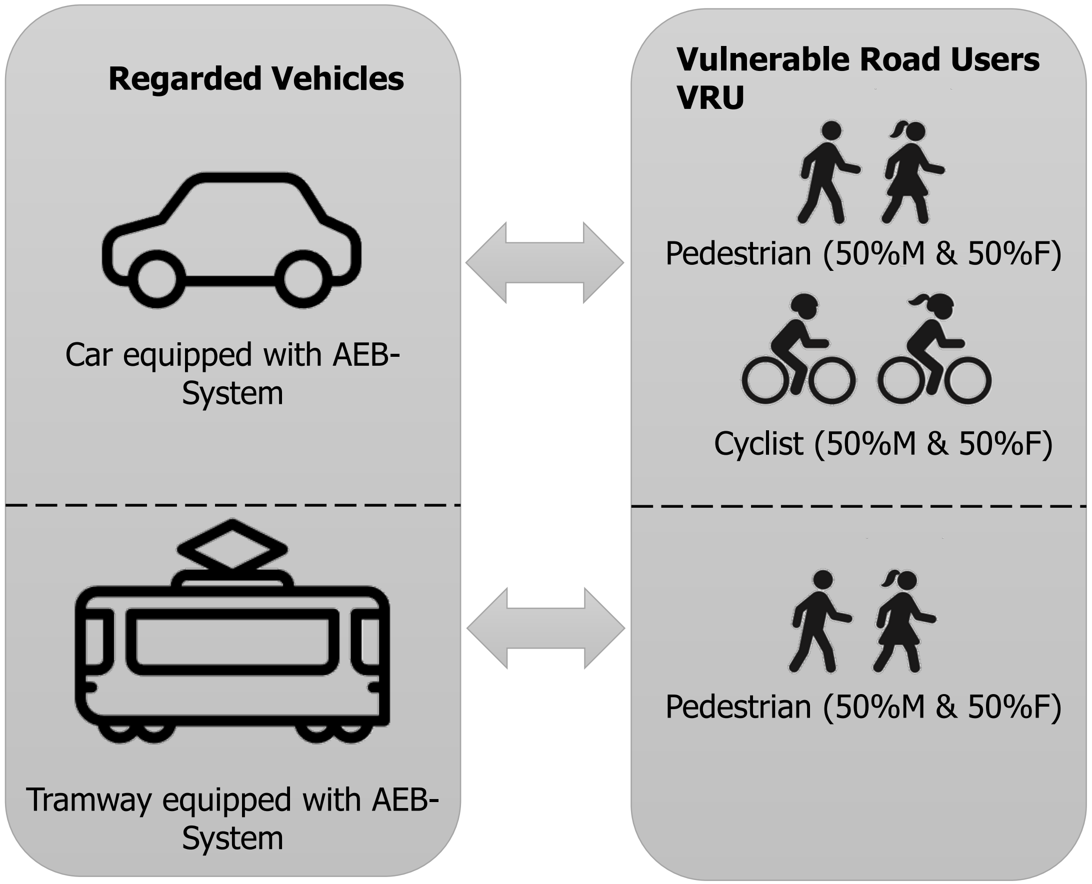
Integrated VRU Assessment – VISAFE VRU





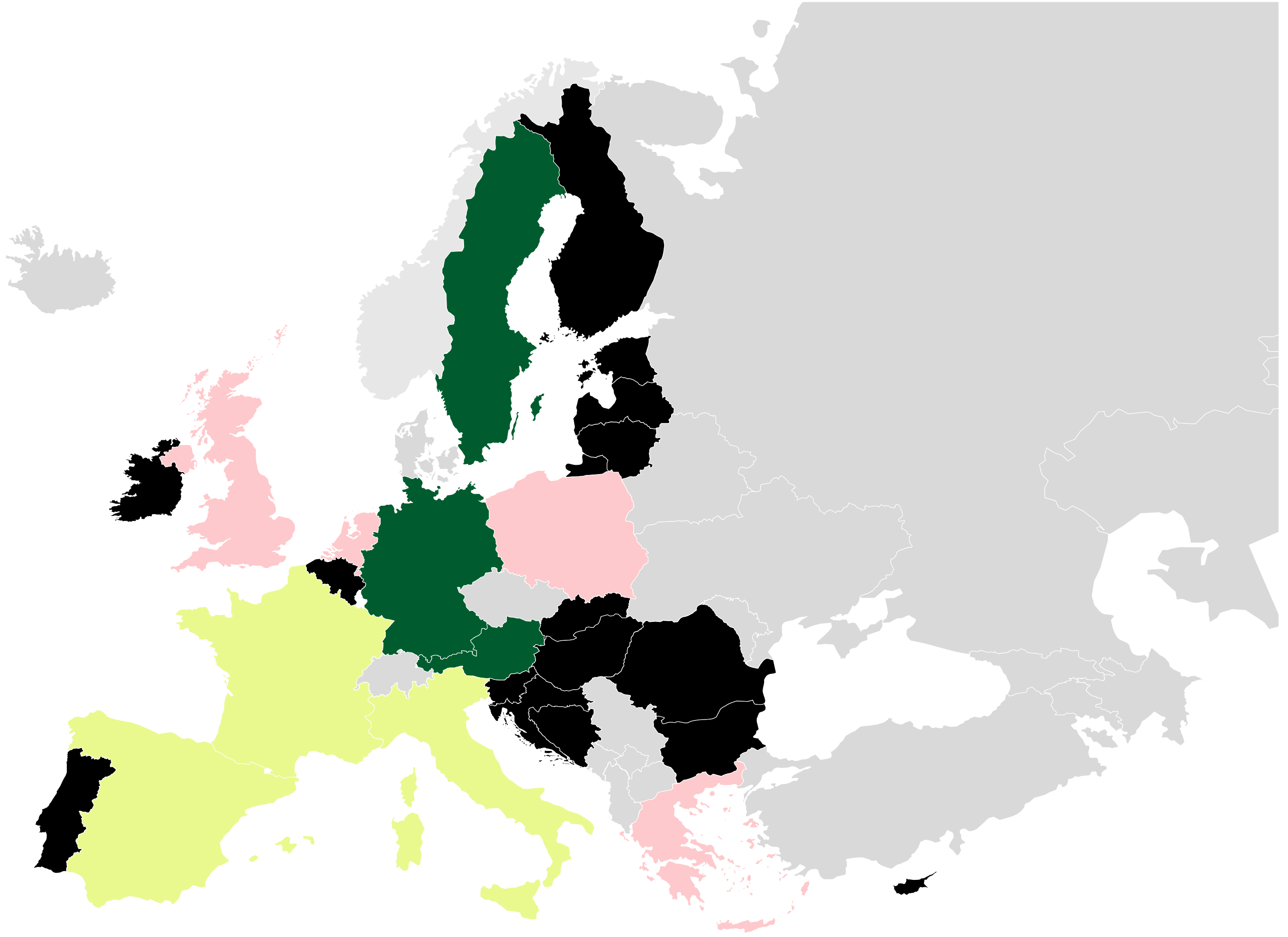
Input Data - Accident Databases

In-Depth Databases

- V_PAD V_CAD
- GIDAS
- CEDATU
- Safer Wheels
- IGLAD

Macroscopic Databases

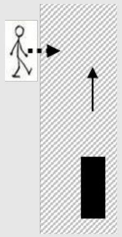
- STRADA
- CARE
- SWOV Data
- Tram Data
- Statistic Austria



Overall more than **4 Million pedestrian and cyclist** accidents in the analysed sample

Catalogue of VIRTUAL Testing Scenarios

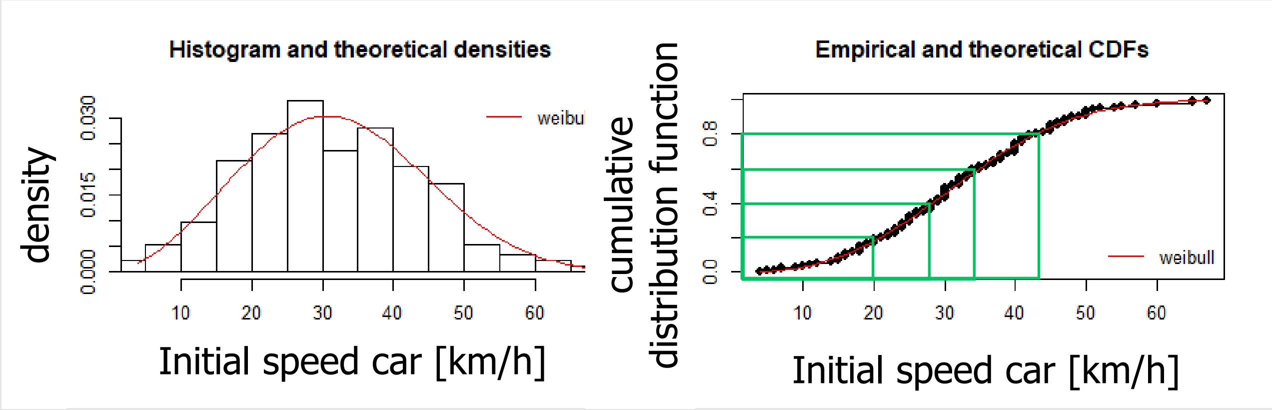
Conflict situations



Classification based on moving patterns

p(conflict scenario)

Probabilities for motion sequence parameters



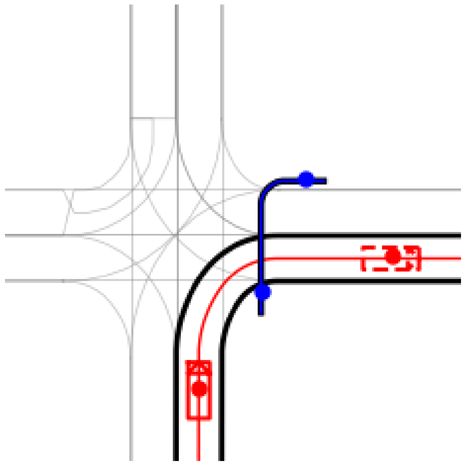
p($v_{vehicle}$, $v_{VRU,...}$) or each conflict situation

Catalogue of virtual test scenarios with related probability

p(SCPPL, $v_{vehicle}$, $v_{VRU,...}$)

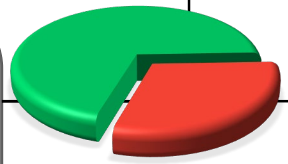
Method to Determine Future Accident Scenarios

Catalogue of virtual testing scenarios between vehicle and VRU with probabilities for each scenario



Generic AEB System

Precrash Simulation with virtual **Precrash Tool** (using openPASS as Simulation platform)



Avoidable scenarios

Unavoidable scenarios = collisions

Collision scenarios (impact location, velocity,..)

Future accident scenarios for In-Crash simulation

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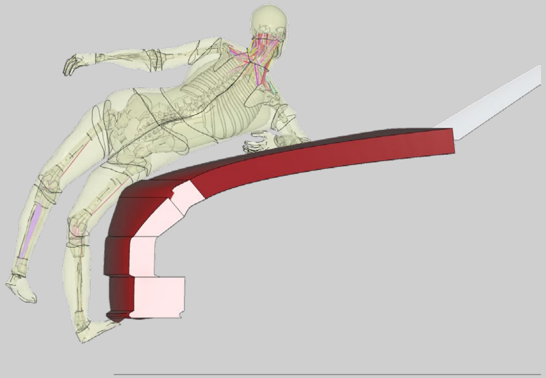
In-Crash Simulation

Validated Models

Vehicle Model

OS-HBMs (VIVA+)

In-Crash Simulation



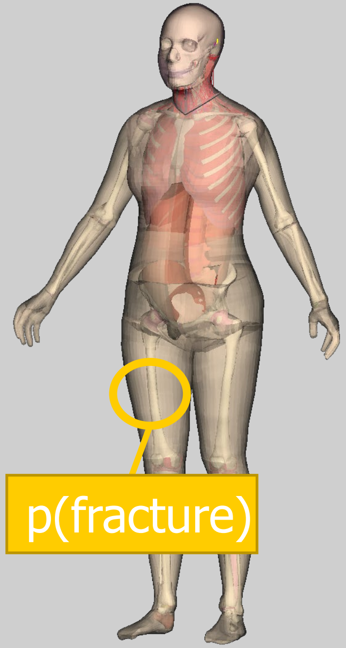
Post processing of HBM Results

DYNASAUR

MUTANT ANALYSIS TOOL

Injury probability

p(injury)



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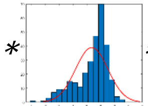
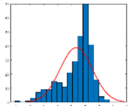
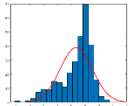
Integrated Assessment

1.) Virtual Testing Scenario

$p(VT\_scenario)$

for SCPRSD

$=p(SCPRSD) \,*$  $*$  $*$ 

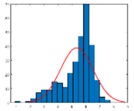
v_{veh} v_{ped} ...

2.) Precrash Simulation with **specific AEB system**

VT Scenario ID	$p\ (VT\_scen)$	Impact Location	V_ col [km/h]
1	1%	40%	10
2	2%	-	-
..	...	..	..
n	p	X%	v

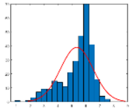
3.) Collision scenarios

$$p(collision\_scenario_x) = \sum_{i=1}^{m} p\begin{pmatrix} VT\_Scenario, v_{collision_1}, \\ location\_impact_1 \end{pmatrix}$$



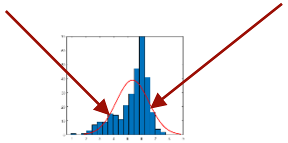
$v_{collision}$

$location\_impact_1$



$v_{collision}$

$location\_impact_j$



$location\_impact$

4.) In-crash Simulation with ViVA+ Models

Collison Scen ID	$p\ (col\_scen)$	$p\ (injury)$ e.g. $femur\ fract.$
1	10%	50%
2	5%	0%
..	...	..
n	p	X%

5.) Overall Assessment

$$p(femur\_fracture)_{total} = \sum_{x=1}^{k} (p(femur_{fracture} | scenario_x) * p(collision\_scenario_x))$$

Where can I read more?

- Leo, C., Klug, C., Ohlin, M., Bos, N., Davidse, R. and Linder, A. (2019), "Analysis of Swedish and Dutch accident data on cyclist injuries in cyclist-car collisions", *Traffic Injury Prevention*, Vol. 20 No. sup2, S160-S162. doi: 10.1080/15389588.2019.1679551.
- Leo, C., Klug, C., Ohlin, M. and Linder, A. (2019), "Analysis of pedestrian injuries in pedestrian-car collisions with focus on age and gender", *2019 IRCOBI Conference Proceedings, Florence, Italy, 11.-13.9.*, IRCOBI, pp. 256–257, available at: http://www.ircobi.org/wordpress/downloads/irc19/pdf-files/40.pdf.
- Schachner, M., Sinz, W., Thomson, R. and Klug, C. (2020), "Development and evaluation of collision scenarios involving pedestrians and AEB-equipped vehicles to demonstrate the efficiency of an enhanced open-source simulation framework", *Accident Analysis and Prevention, accepted*.

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Contact:
corina.klug@tugraz.at
christoph.leo@tugraz.at
schachner@tugraz.at

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Publication plan

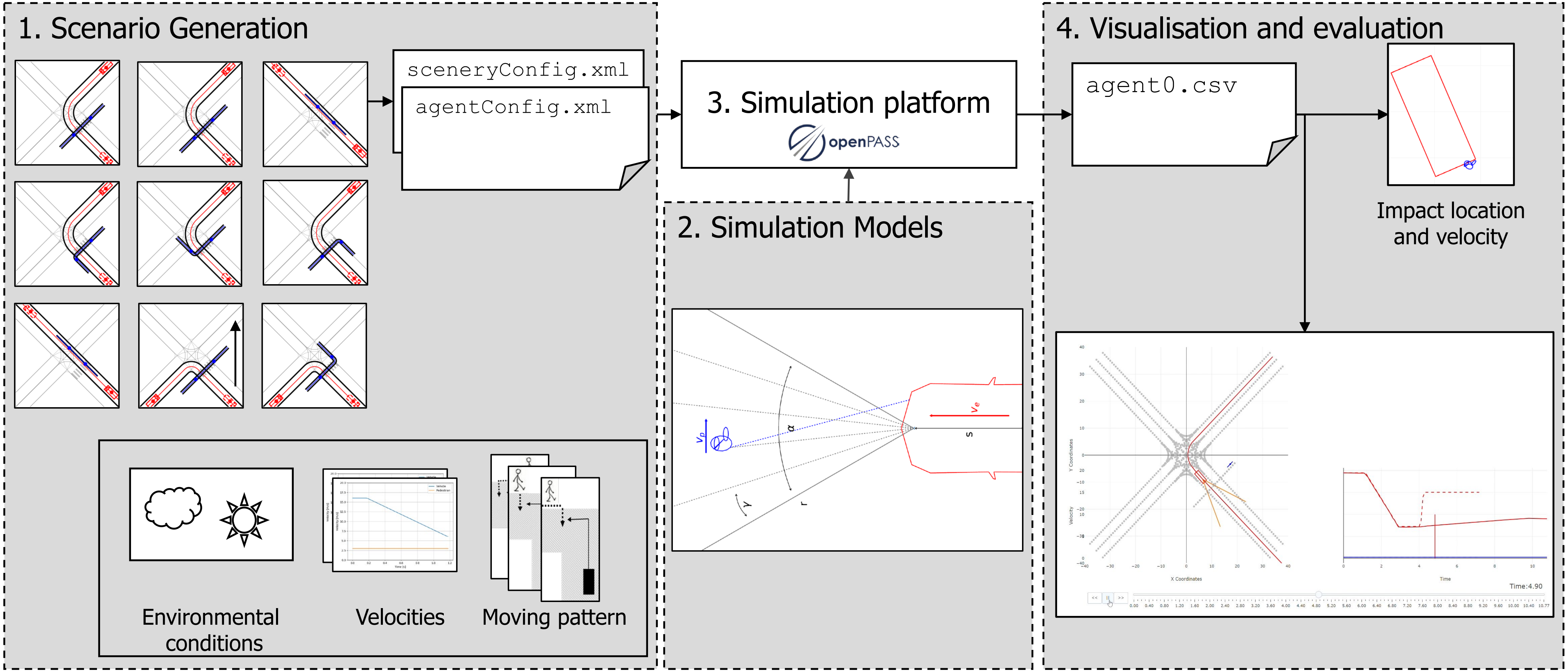
- Paper with overall probabilities for all conflict situations – baseline vs. conceptual AEB
  - Corina Klug, Christoph Leo, Martin Schachner, Ellen Grumert, Maria Rizzi, Ragnhild Davidse, Astrid Linder: Future pedestrian and cyclist accident scenarios – how will autonomous emergency braking systems of passenger cars affect the impact conditions in accidents with pedestrians and cyclists?
- Paper on accident analysis for trams + AEB simulations (effectivity of AEB for pedestrian accident avoidance)
  - Philipp Heinzl, Peter Klager, Martin Schachner, Christoph Leo, Maria Rizzi, Corina Klug: Relevance and scenarios of tram - pedestrian accidents – What data is available and how can accidents be avoided?
- Effect of gender on injuries → Frontiers Bioengineering and Biotechnology - Understanding Age and Sex-Related Differences in the Biomechanics of Road Traffic Associated Injuries Through Population Diversity Analyses

virtual

Status of Pedestrian Model

virtual

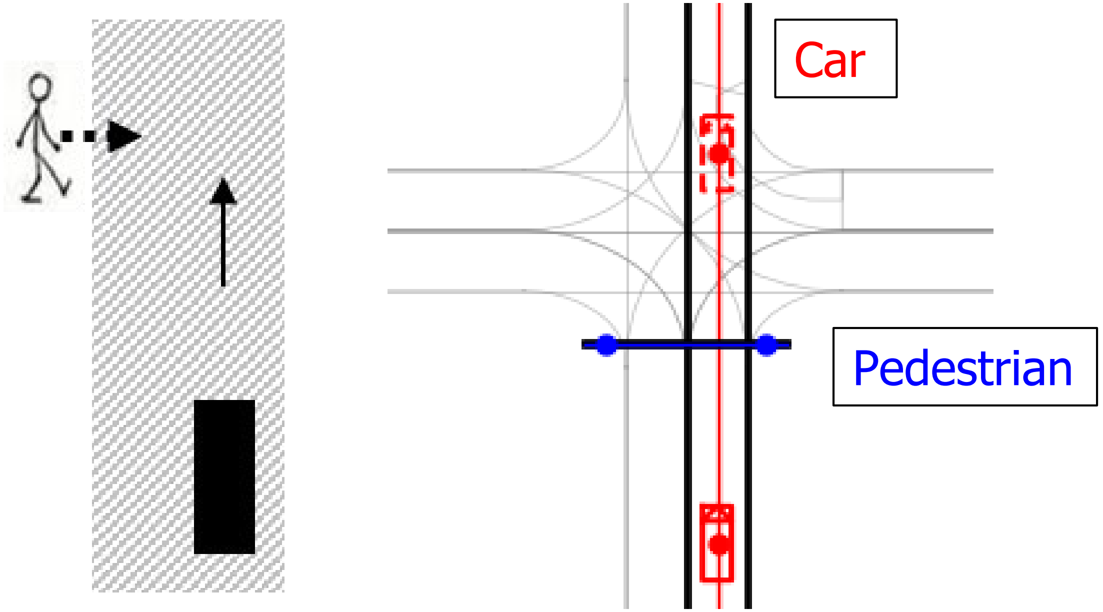
virtual Precrash Tool



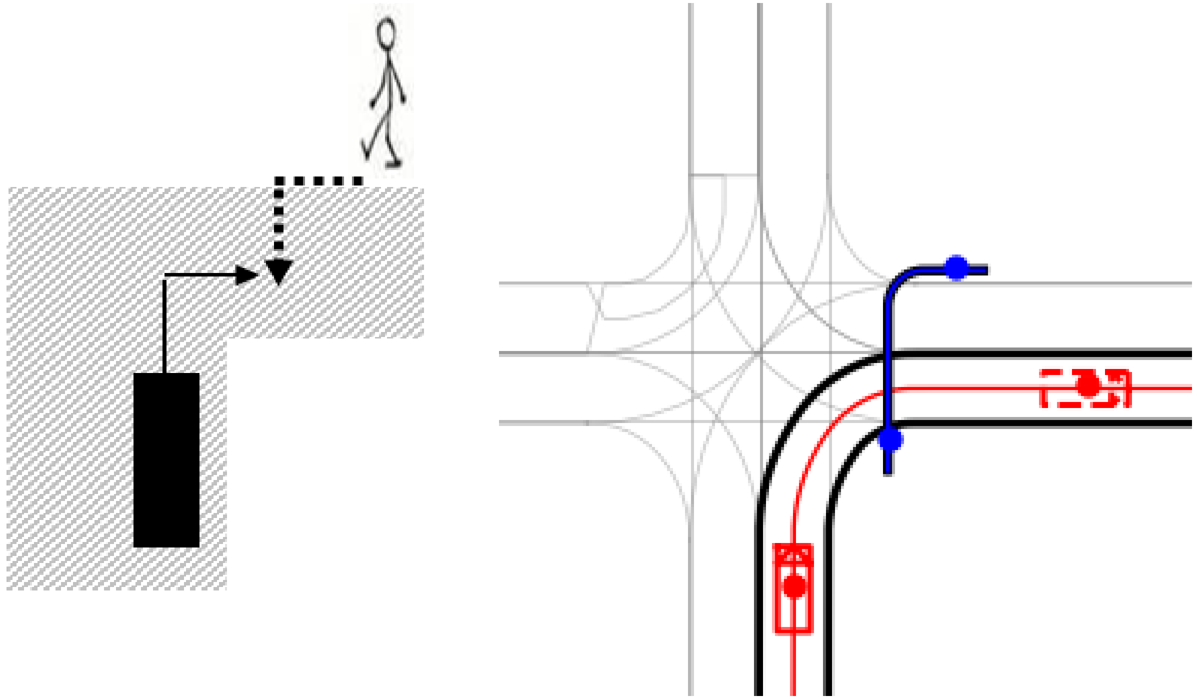
virtual

Scenario Generation

SCPPL

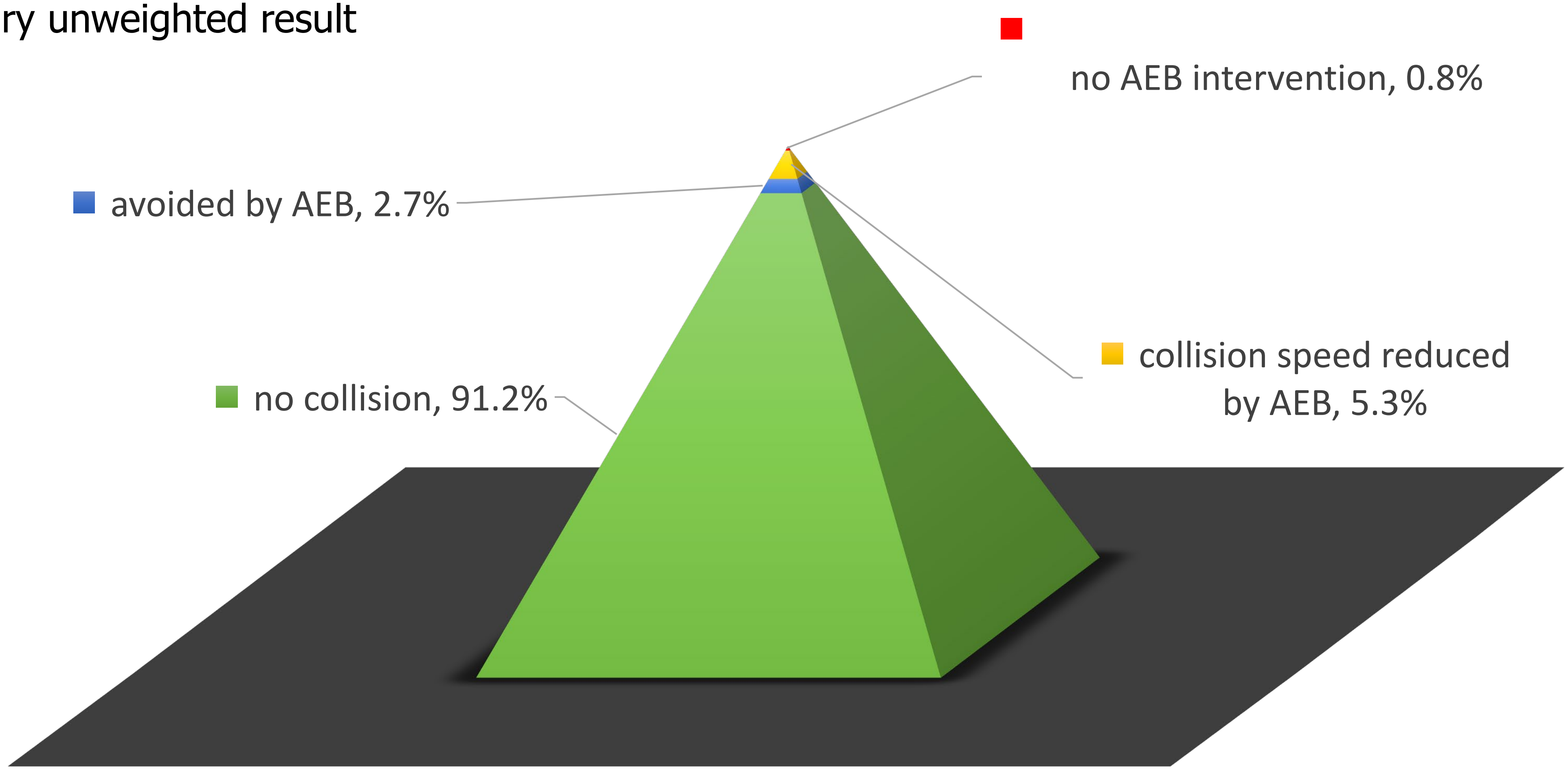


RT/ODRD



Future Accident Scenarios

Preliminary unweighted result



OSCCAR

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

OSCCAR-Virtual Pre-Ircobi workshop - Sept. 8th, 2020

Progress in Virtual Testing for automotive applications

Werner Leitgeb, Christian Mayer, Johan Iraeus, Lennart Nölle, Jason Fice, Andre Eggers
www.osccarproject.eu

OSCCAR has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768947.

Agenda

Update on OSCCAR 14:45 - 15:30

Results and future work incl. Q&A

- **Short intro + status** (Werner Leitgeb)
- Biomechanical alignment/ injury evaluation

  (Christian Mayer, Johan Iraeus, Lennart Nölle, Jason Fice)
- Virtual testing (Andre Eggers)

OSCCAR Project

OSCCAR
FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

PROJECT PARTNERS

AUSTRIA
- TECHNISCHE UNIVERSITÄT GRAZ
- VIRTUAL VEHICLE RESEARCH GMBH

BELGIUM
- SIEMENS INDUSTRY SOFTWARE NV
- TOYOTA MOTOR EUROPE

CHINA
- TSINGHUA UNIVERSITY
- CHINA AUTOMOTIVE TECHNOLOGY AND RESEARCH CENTER

FRANCE
- ESI GROUP
- UNIVERSITE DE STRASBOURG

GERMANY
- BUNDESANSTALT FUER STRASSENWESEN
- ROBERT BOSCH GMBH
- LUDWIG-MAXIMILIANS-UNIVERSITAET MUENCHEN
- MERCEDES-BENZ AG
- RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN
- UNIVERSITAET STUTTGART
- VOLKSWAGEN AG
- ZF GROUP, PASSIVE SAFETY SYSTEMS, TRW AUTOMOTIVE GMBH

NETHERLANDS
- SIEMENS DIGITAL INDUSTRIES SOFTWARE

SPAIN
- IDIADA AUTOMOTIVE TECHNOLOGY SA

SWEDEN
- AUTOLIV DEVELOPMENT AB
- CHALMERS TEKNISKA HOEGSKOLA AB
- VOLVO PERSONVAGNAR AB

PROJECT COORDINATOR: virtual vehicle

PROJECT FACTS

PROJECT COORDINATOR: WERNER LEITGEB

INSTITUTION: VIRTUAL VEHICLE RESEARCH GMBH

EMAIL: OSCCAR@V2C2.AT

WEBSITE: WWW.OSCCARPROJECT.EU

START: JUNE 2018 **DURATION:** 36 months

PARTICIPATING ORGANISATIONS: 21

Follow us on Twitter
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OSCCAR has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768947.

WWW.OSCCARPROJECT.EU

OSCCAR – Main Objectives

The EU Horizon 2020 research project **"OSCCAR - Future Occupant Safety for Crashes in Cars"** - develops a novel, simulation-based approach to safeguard occupants involved in future vehicle accidents

- Understanding future accident scenarios involving passenger cars
- Demonstration of **new advanced occupant protection** principles and concepts addressing future desired sitting positions made possible by HAVs
- Contribution to the development of **diverse**, **omnidirectional**, **biofidelic** and **robust HBMs**
- Establishment of an integrated, virtual assessment framework for complex scenarios as needed for the development of advanced protection systems for all occupants
- Contribution to the **standardization of virtual testing procedures** and promotion of HBMs acceptance in order to pave the way for virtual testing-based homologation

Occupant protection principles – HBM application

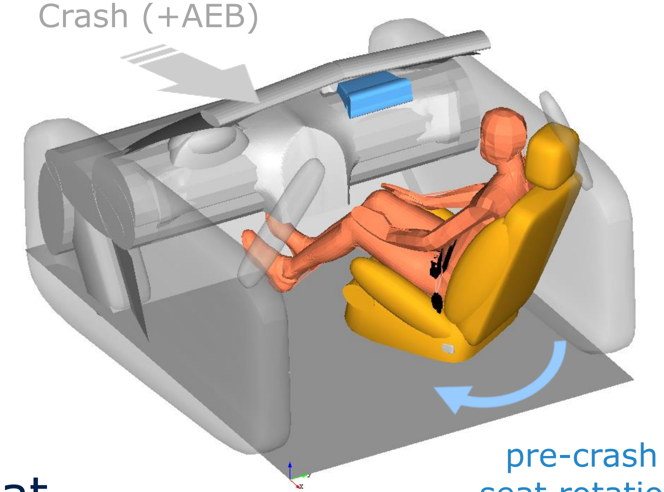
- Occupant protection principles:
  - Conception and investigation of advanced occupant protection principles for sitting positions and postures related to automated driving:
    - Restraints to be adapted towards new boundary conditions
    - Repositioning of the occupant into a conventional seating configuration prior to a crash
  - Considering aspects like occupant variety and omnidirectional occupant loading by use of HBMs
  - Virtual investigation of protection principles and hardware demonstration of selected cases

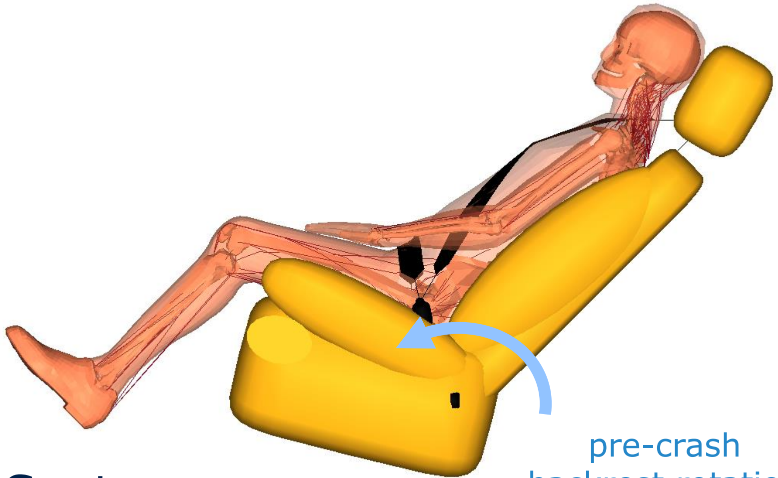
Protection Principles

#1 Swivel Seat	#2 Inertia Seat	#3 Anti Submarining	#4 Mushroom Airbag	#5 Reclined Seat	#6 Far Side

Occupant protection principles – HBM application

- Occupant protection principles - Repositioning of the occupant:





Swivel Seat

- Use Cases & Principle:
  - Occupant sitting slightly rotated, pointing away from the driving direction
  - The seat will be rotated around z-axis towards direction of crash during pre-crash phase
  - Active (defined rotation-time curve) and passive (inertia driven) rotations are considered

Related publication: [Becker et al. IRCOBI 2020]

Reclined Seat

- Use Cases & Principle:
  - Occupant sitting in a relaxed seating position with a reclined backrest angle
  - Prior to the crash the backrest rotates to an upright angle to raise the occupant into a "normal" sitting posture

Related publication: [Östh et al. IRCOBI 2020]

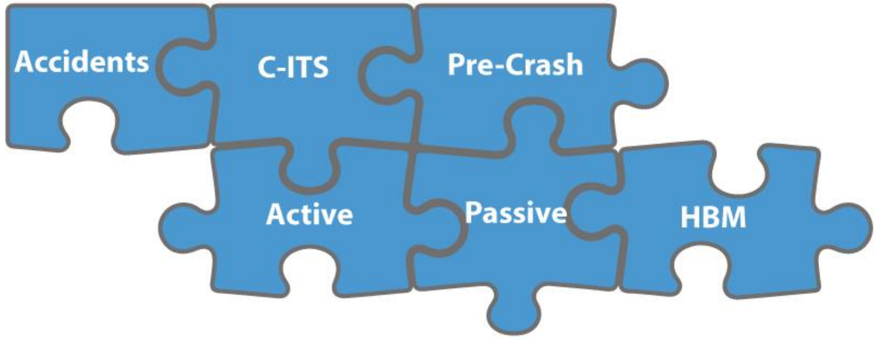
OSCCAR – Integrated and comparable assessment

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

Integrated, continuous and comparable assessment

- Common simulation "input" criteria that allow for comparing results
- Software tool for reproducible HBM seating procedure in development
- Comparable and common assessment using the OSCCAR enhanced open source software tool "DynaSaur"
- Enabling standardized solver output processing for different solvers used within OSCCAR

Fully Integrated Assessment Tool Chain



DYNASAUR https://gitlab.com/VSI-TUGraz/Dynasaur

OSCCAR – Virtual Testing I

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

Virtual Testing requirements

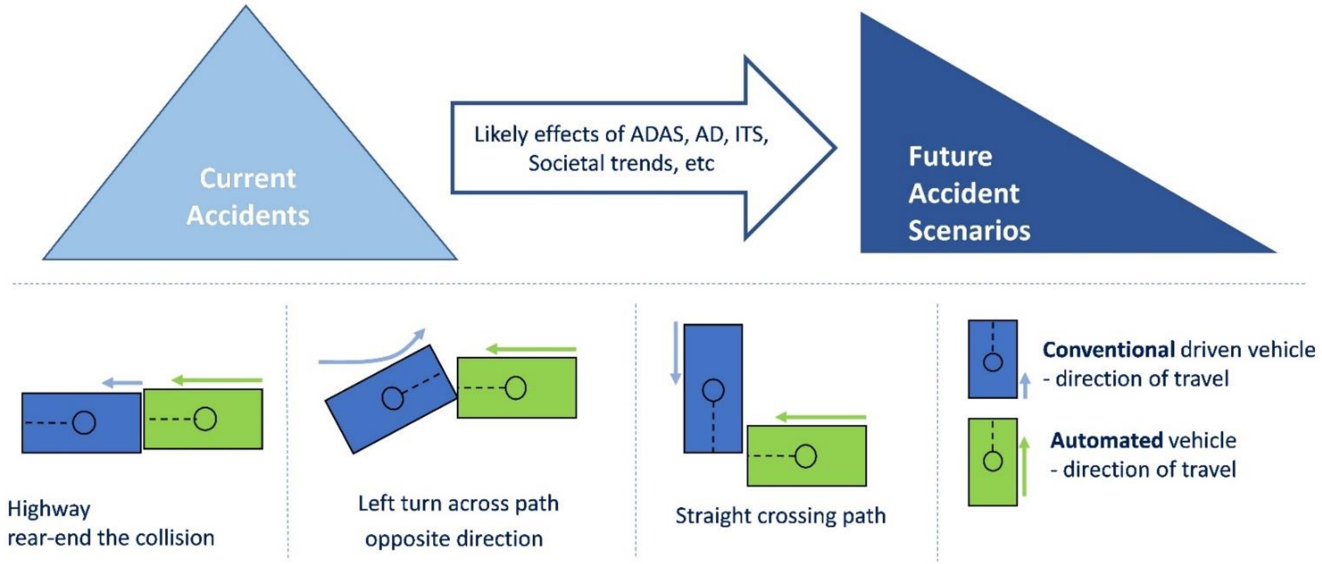
Harmonization of Virtual Testing

- Development of virtual testing and assessment procedures
- First proposal of a procedure for virtual environment validation published

  Eggers et al., Validation procedure for simulation models in a virtual testing and evaluation process of highly automated vehicles, VDI-Tagung Fahrzeugsicherheit 2019
- Harmonization efforts
- Homologation Test Case Demonstration

OSCCAR – Virtual Testing II

- Providing the bigger picture on complete story for virtual testing needs
  - Generic load-cases of future relevant accident scenarios
  - Methodology to estimate generic crash pulses for novel crash configurations, based on state-of-the-art FE vehicle crash models



Harmonization of Virtual Testing

Harmonization of virtual testing
Virtual testing basic needs

Glossary and definition of relevant terms: “What is and what is needed for a valid model”

Verification:	Assessment of accuracy of computational model solving the mathematical problem.
Validation:	Assessment of the degree to which a computational model is an accurate representation of physics being modelled.
Calibration:	The process of modifying (parameters of) a model or tool to reach a performance target defined beforehand.
Certification:	The process of official approval that a model and its associated data are acceptable for a specific purpose. Purpose describes the use in an existing procedure, e.g. consumer rating or legislation with Virtual Testing.

developed in cooperation with Thumbs User Community TUC

OSCCAR – Virtual Testing IV

Homologation Test Case Demonstration

- OSCCAR demo case for an exemplary procedure for future virtual approval using HBMs
  - Extrapolation of hardware test based validity to new, "virtual only" Test Case
  - Focus on reclined, forward facing occupant position
- Demonstration of a method that delivers comparable results, the basis for credibility and acceptability
- Continuous virtual assessment of the pre- and in-crash phase

Agenda

Update on OSCCAR 14:45 - 15:30

Results and future work incl. Q&A

- Short intro + status (Werner Leitgeb)
- **Biomechanical alignment/ injury evaluation**




Christian Mayer, Johan Iraeus, Lennart Nölle, Jason Fice

- Virtual testing (Andre Eggers)

Alignment of Rib Strain Injury Risk Assessment

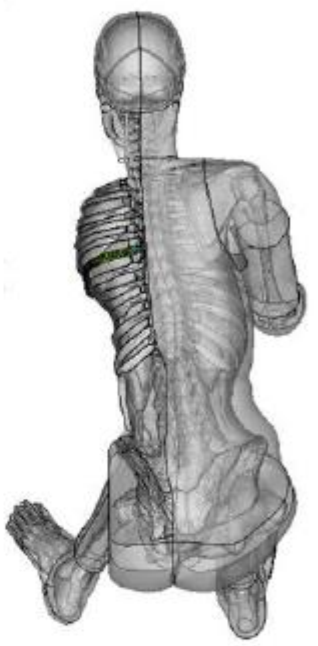
Johan Iraeus (Chalmers University of Technology)

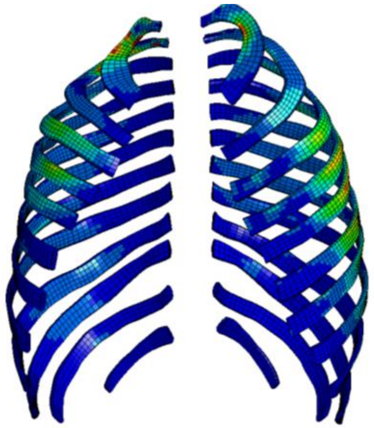
OSCCAR has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 768947.

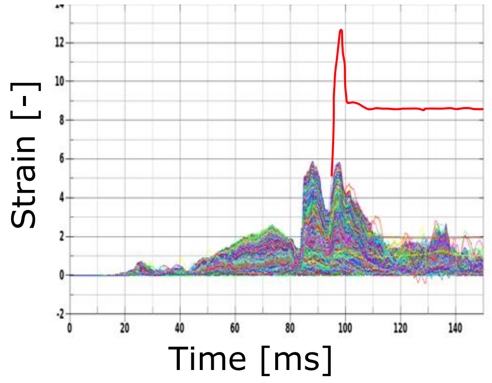
Alignment of Rib Strain Injury Risk Assessment

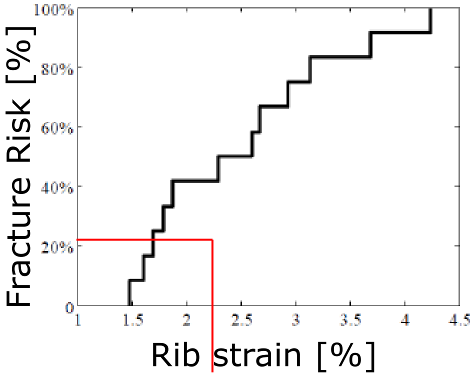
- Goal: Provide guidelines for robust strain based HBM rib injury risk assessment
- An overview of strain-based rib injury risk assessment

Use a robust HBM validated with respect to rib strain → Extract rib strains → Post process signals → Convert strain to fracture risk → Compute overall ribcage risk









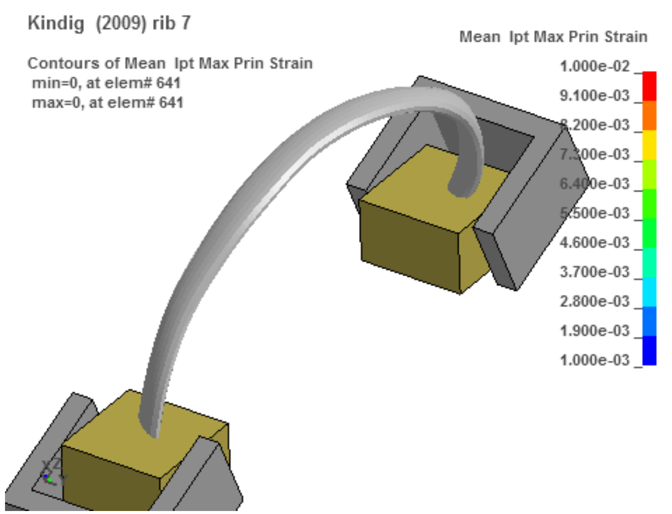
$$\Pr(X = k) = \sum_{A \in F_k} \prod_{i \in A} p_i \prod_{j \in A^c} (1 - p_j)$$

Forman, J. L., et al. (2012). Predicting rib fracture risk with whole-body finite element models: development and preliminary evaluation of a probabilistic analytical framework. the 56th annual AAAM Scientific Conference, Seattle, Washington, Association for the Advancement of Automotive Medicine.

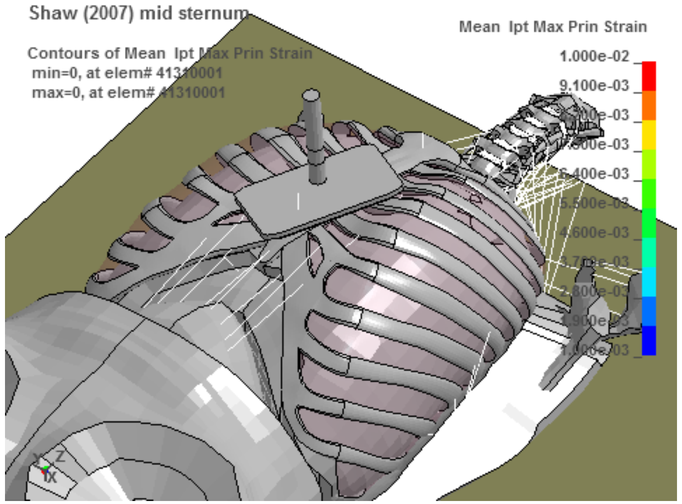
Alignment of Rib Strain Injury Risk Assessment

- Goal: Provide guidelines for robust strain based HBM rib injury risk assessment
- Method: Identified need for validation of HBMs on strain level + HBM modelling guidelines to reduce numerical noise (e.g. CPU dependency),

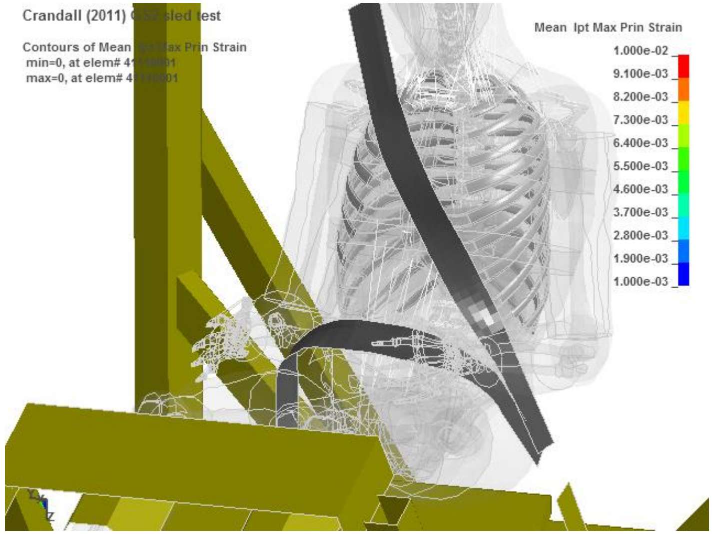
Single rib level (Kindig 2009)



Ribcage level (Shaw et al. 2007)



Full HBM level (Shaw et al. 2009)



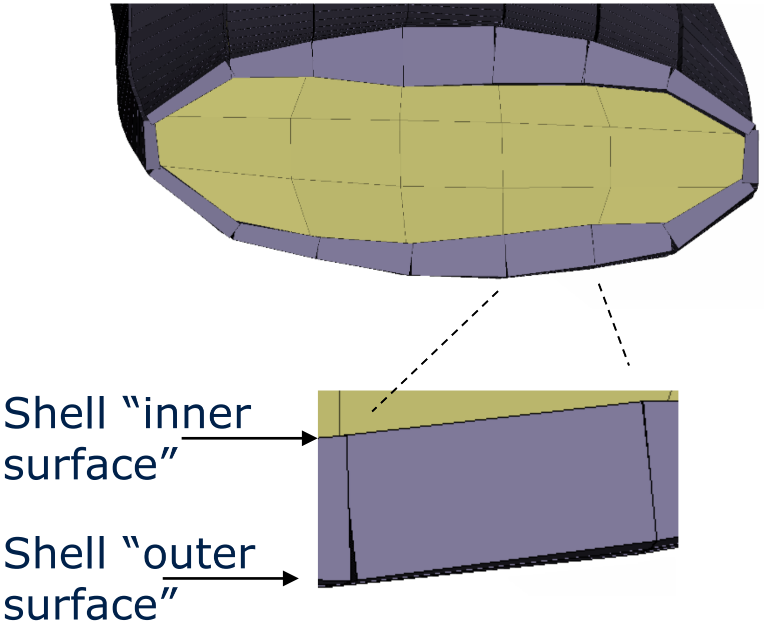
Iraeus, J. and B. Pipkorn (2019). Development and Validation of a Generic Finite Element Ribcage to be used for Strain-based Fracture Prediction. 2019 International IRCOBI Conference, Athens, Greece.

Alignment of Rib Strain Injury Risk Assessment

- Goal: Provide guidelines for robust strain based HBM rib injury risk assessment
- Method: Extract rib strains

Rib cortical bone considered to be brittle
> Use maximum principal strain evaluated at the shell "outer surface"

To be addressed:
- Exclude elements near unphysical stress concentrations in post-processing?



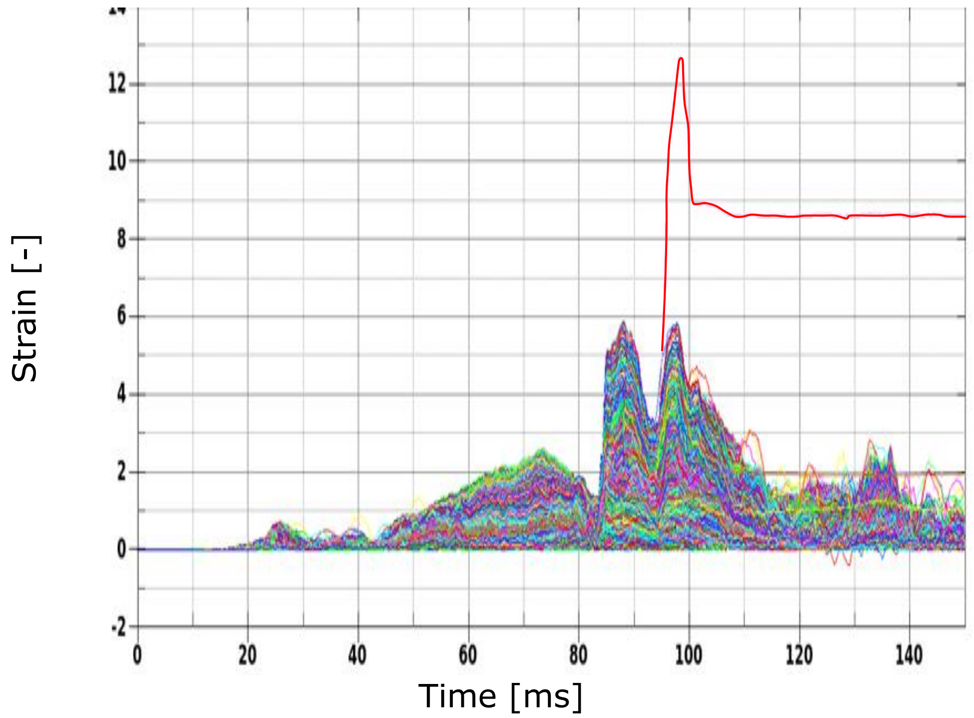
Isa et al., "Assessing Impact Direction in 3-point Bending of Human Femora: Incomplete Butterfly Fractures and Fracture Surfaces", J Forensic Sci, January 2018, Vol. 63, No. 1

Alignment of Rib Strain Injury Risk Assessment

- Goal: Provide guidelines for robust strain based HBM rib injury risk assessment
- Method: Propose result filtering to reduce effects of numerical noise

Tissue based injury criteria are sensitive to numerical noise!

To be addressed:
- (Time gradient) filtering of strain signals?
- Percentiles?



Alignment of Rib Strain Injury Risk Assessment

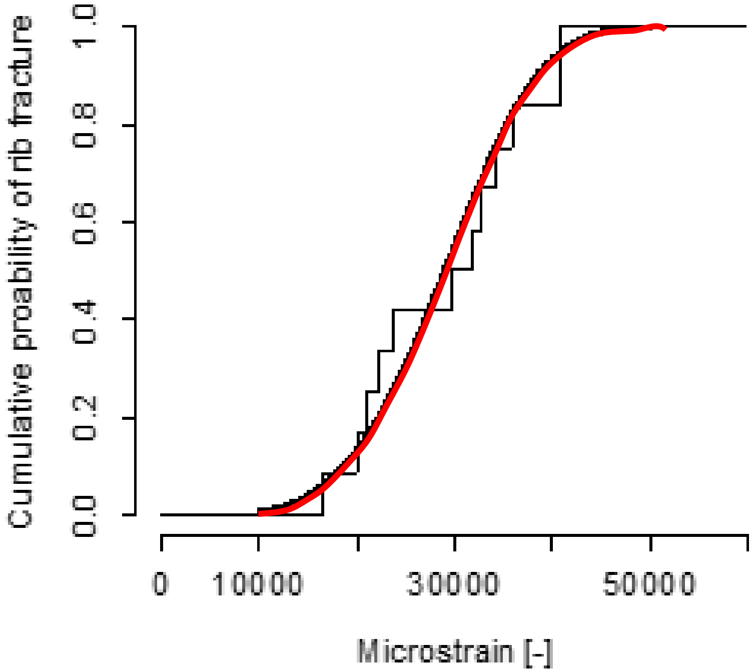
- Goal: Provide guidelines for robust strain based HBM rib injury risk assessment
- Method: Best-practice for model output and post-processing

Smooth Forman (2012) ECDF to remove unrealistic injury risk jumps

Cumulative Weibull distribution:

$$1 - e^{-\left(\frac{x}{\lambda}\right)^k}, \quad x \geq 0$$

X=strain in microstrain
λ=(36578.7 – 165.5*AGE)
k=4.249542



Johan Iraeus & Mats Lindquist (2020) Analysis of minimum pulse shape information needed for accurate chest injury prediction in real life frontal crashes, International Journal of Crashworthiness, DOI: 10.1080/13588265.2020.1769004

OSCCAR
FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

Evaluating injury severity of the Muscle-Tendon-Unit (MTU)

Lennart V. Nölle, Oleksandr V. Martynenko, Syn Schmitt
(IMSB, University of Stuttgart)

OSCCAR
FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

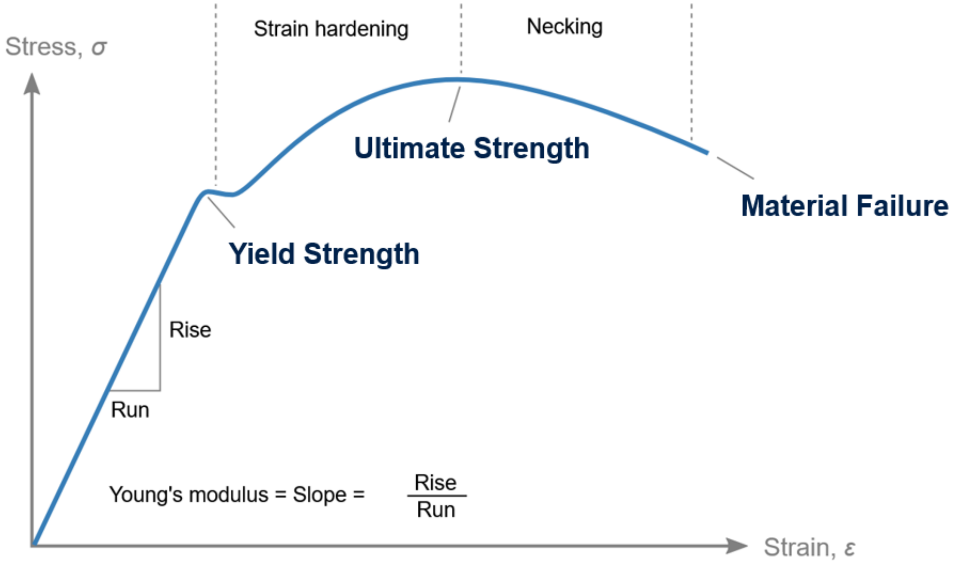
OSCCAR has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 768947.

MTU Injury Criteria - **Introduction**

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

- **Motivation:** Developing a method to evaluate the risk of passengers sustaining minor injuries related to pre-crash safety system functions.
- **MTU** (Muscle-Tendon-Unit) **strain injuries** are the focus of this injury criteria definition because Hill-type muscle models, including the extended Hill-type material (EHTM) developed in USTUTT [1], are defined as 1D truss elements incapable of assessing other types of injury.
- The definition of **three injury thresholds** is done analogous to the generic material deformation stages of a standard engineering stress-strain-curve.

  - ☐ **Minor MTU Injury Threshold**
    Coincides with Yield Strength
  - ☐ **Major MTU Injury Threshold**
    Coincides with Ultimate Strength
  - ☐ **MTU Rupture Threshold**
    Coincides with Material Failure



Modified from: https://upload.wikimedia.org/wikipedia/commons/c/c1/Stress_strain_ductile.svg

MTU Injury Criteria – **Injury Thresholds**

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

- Injury thresholds for the **tendon**, the **passive** and the **active skeletal muscle** were determined from literature and are presented in the table below.

Type of Injury	**Tendon**	**Passive Muscle**	**Active Muscle**
Minor Injury	2% Strain	30% F_{tf}	70% F_{tf}
Major Injury	5% Strain	80% F_{tf}	90% F_{tf}
Rupture	10% Strain	100% F_{tf}	100% F_{tf}
References	[2]	[3,4]	[5]

where F_{tf} is the tensile force needed to pull the muscle to failure [N]

- Literature comparison indicates that the unknown F_{tf} can be estimated based on each muscle's maximum isometric force F_{max} given in anatomical literature sources:

$$\mathbf{F_{tf} = 3F_{max}}$$

MTU Injury Criteria – **Computational Modelling**

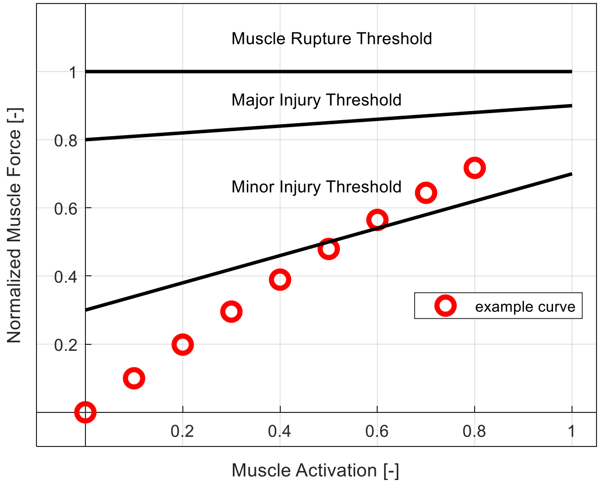
- Activation dependant injury thresholds for the muscle were calculated through linear interpolation between the passive and active threshold extreme values:

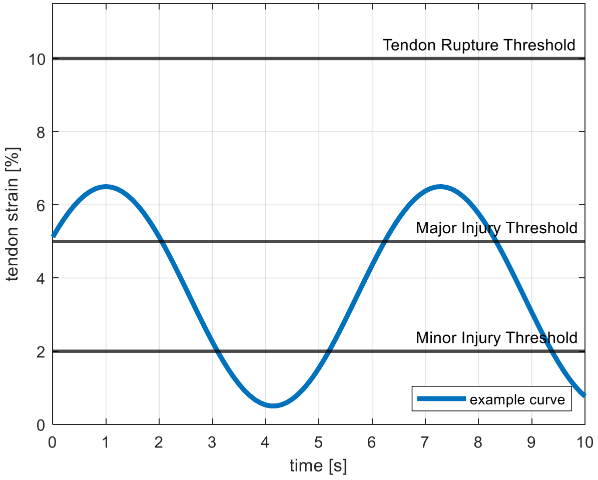
$$F_{thres}(a) = F_{thres,pa} + a\,(F_{thres,ac} - F_{thres,pa})$$

where F_{thres} is the muscle threshold force [N]
$F_{thres,ac}$ is the active muscle injury threshold [N]
$F_{thres,pa}$ is the passive muscle injury threshold [N]
a is the activity level of the muscle 0...1

- Assessment of injury severity is achieved through comparison of resulting muscle forces and tendon strains with the corresponding injury thresholds [6].

Muscle Injury Thresholds





Tendon Injury Thresholds

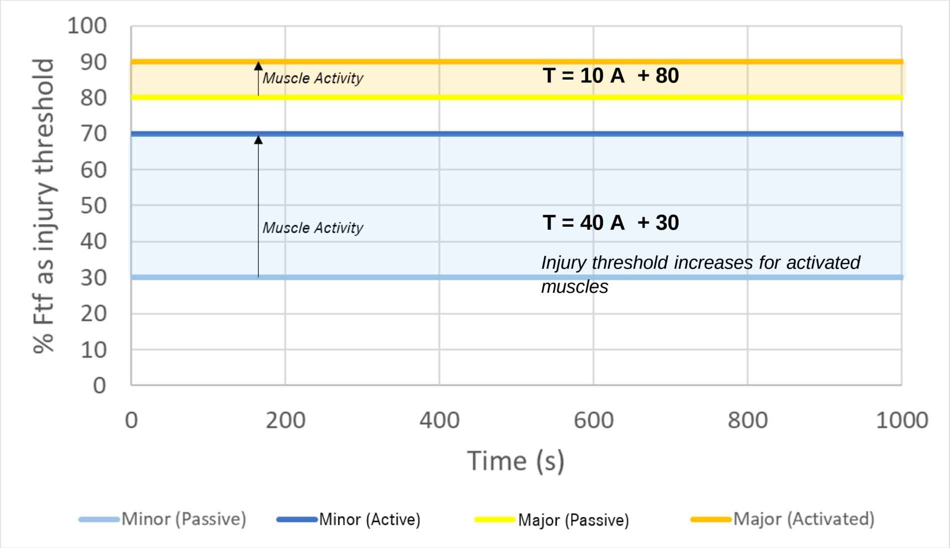
Injury Criteria - Muscles

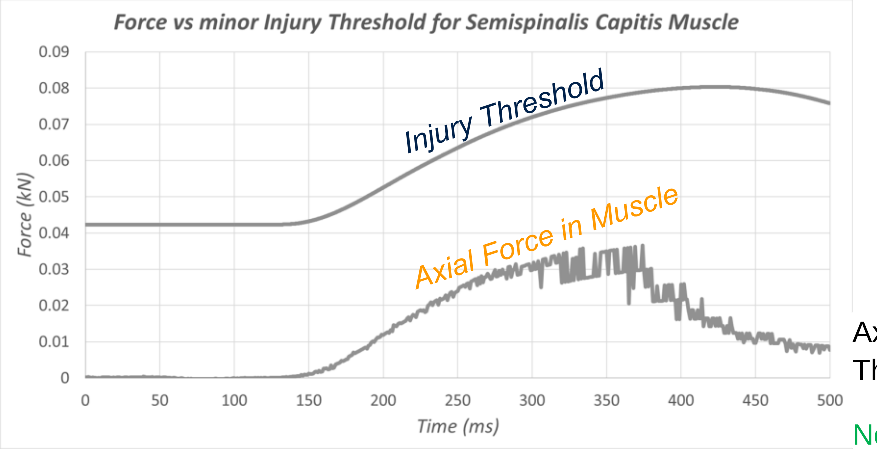
Criterion and Thresholds received from University of Stuttgart

Type of Injury	Tendon	Passive Muscle	Active Muscle
Minor Injury	2% Strain	30% F_{tf}	70% F_{tf}
Major Injury	5% Strain	80% F_{tf}	90% F_{tf}
Rupture	10% Strain	100% F_{tf}	100% F_{tf}
References	Stauber et al.	Noonan et al., Nikolaou et al.	Hasselman et al.

where F_{tf} is the tensile force needed to pull the muscle to failure [N] *(Values available)*

- *Strain based muscle injury in consideration*
- *Only stretching muscles can experience injury*

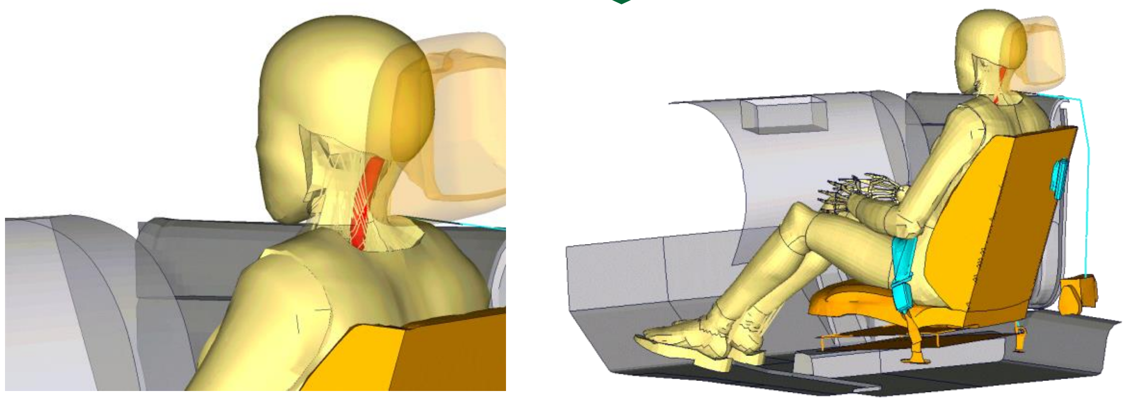




Both injury threshold and force increase with increase in activity level (A) after t=150ms

Axial force < Injury Threshold

No muscle injury!



OSCCAR PP1 Highway Pilot Pre-Crash Phase, with pre-rotated seat

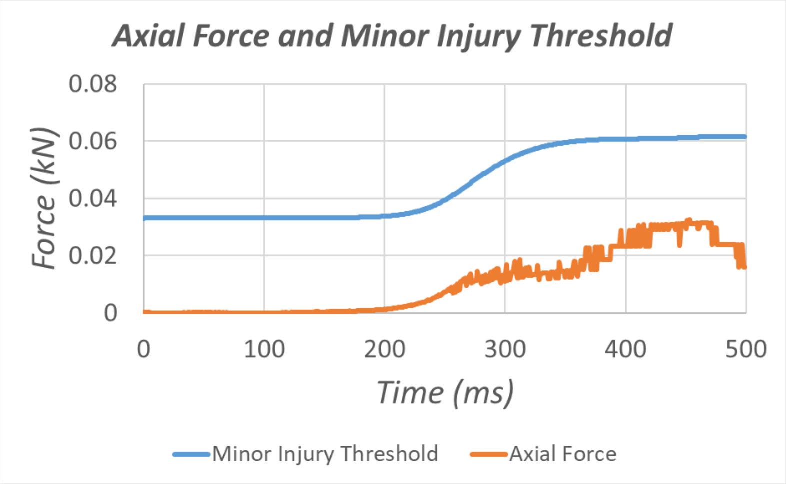
Semispinalis Capitis Muscle Highlighted in **RED**

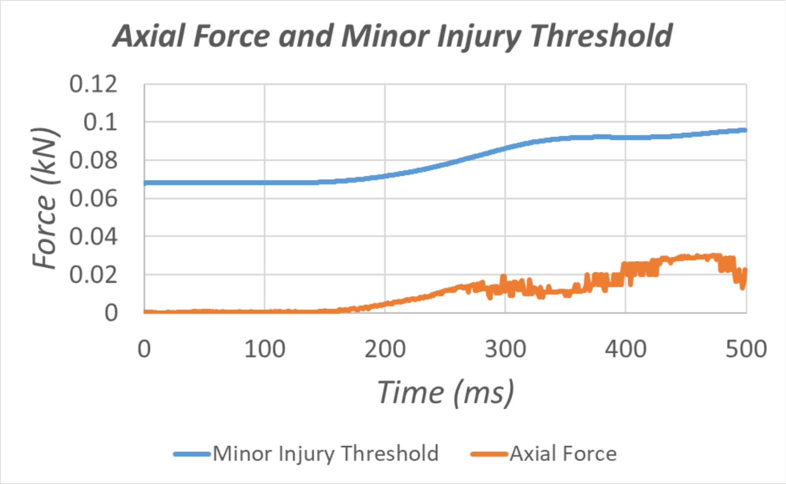
Results for Some Representative Neck Muscles

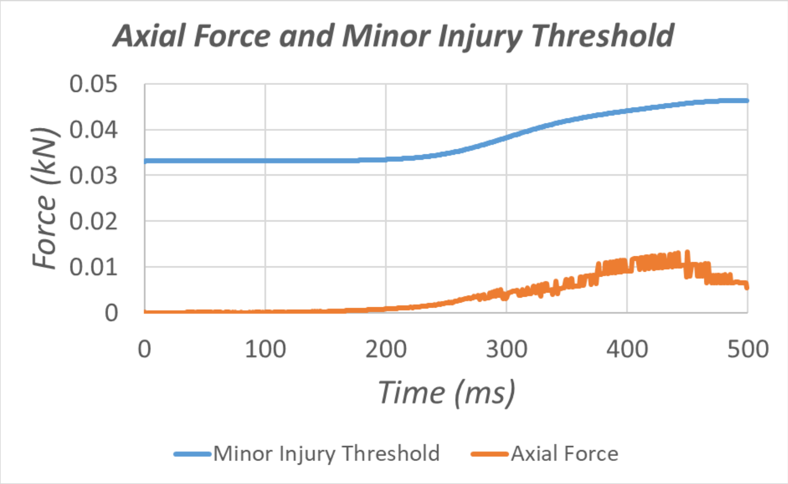
OSCCAR Protection Principle1 Highway Pilot load case with pre-rotated seat

Splenius Capitis | **Levator Scapulae** | **Splenius Cervicis**

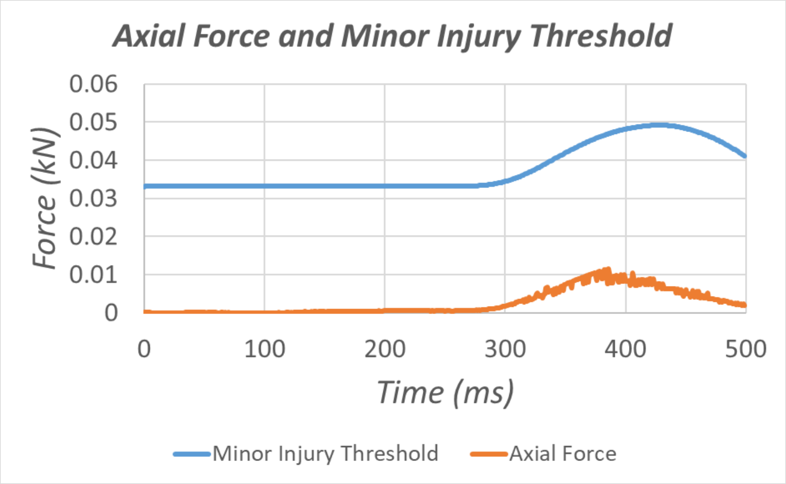
Seat Rotation in 200ms

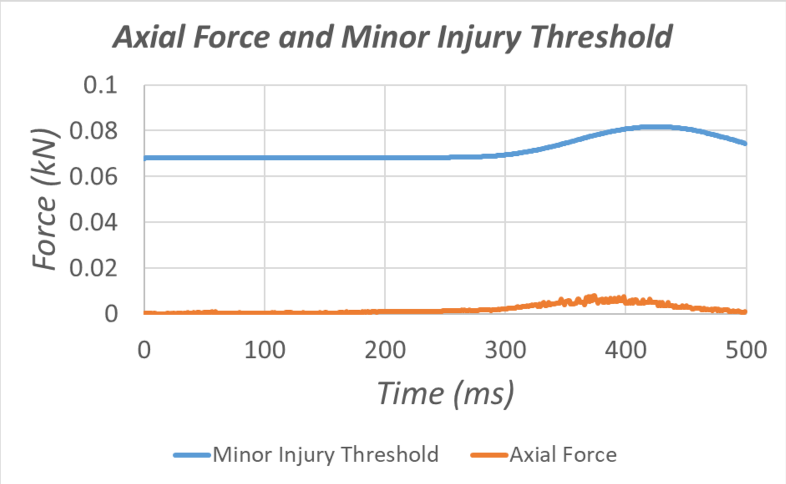


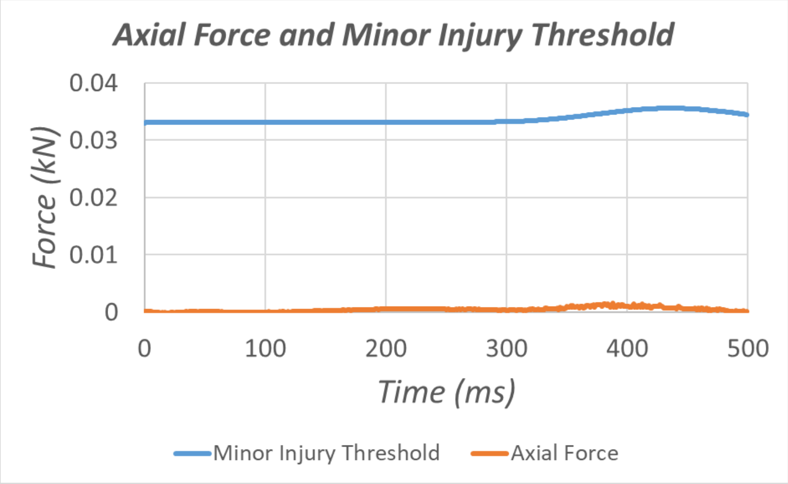




Seat Rotation in 350ms







Control algorithms for population diversity and mobility-impaired people

Lennart V. Nölle, Oleksandr V. Martynenko, Syn Schmitt
(IMSB, University of Stuttgart)

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

OSCCAR has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768947.

Control algorithms for population diversity and mobility-impaired people

Development of control algorithms for three types of persons with reduced mobility:

- **Elderly occupants**
  - Can be characterised with an elongated reaction time, dependent on the age and gender.
  - *Approach:* Introduce a stimulation signal delay [7-9].

https://roadsafetygb.org.uk/wp-content/uploads/2018/01/Older-driver-GEM.jpg

- **Wheelchair-bound occupants**
  - *Approach:* Simulate reduced lower limb control by not stimulating the muscles in specified limbs [10].

https://i.pinimg.com/236x/53/e7/ce/53e7cec0962336db61fa4da17f48912b--small-cars-electric-cars.jpg

- **Occupants** suffering from **neural diseases**
  - *Approach:* Introduce signal noise to the stimulation or modify reflex controller settings to model hyperexcitability of the peripheral motor nerve or a reduced inhibition of the stretch reflex [11,12].

Volunteer pre-crash validation catalogue

Jason Fice (Chalmers University of Technology)

OSCCAR has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768947.

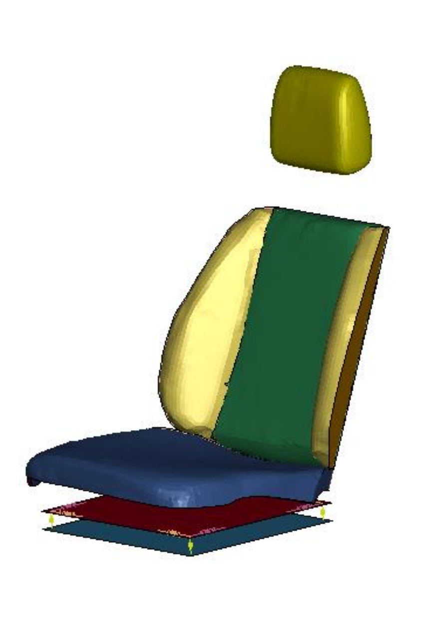
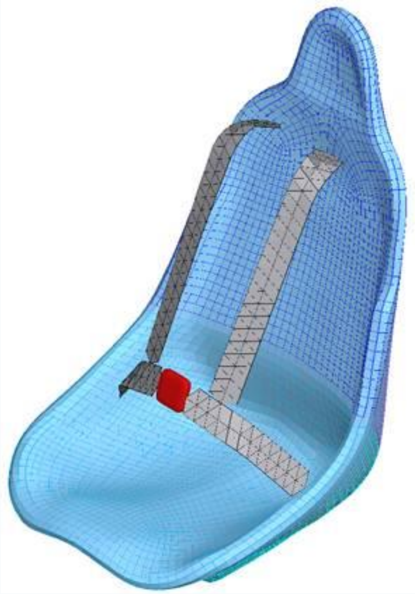
Volunteer pre-crash validation catalogue

- Goal: Provide a set of volunteer data to validate HBMs for pre-crash manoeuvres
- Method: Identified 25 volunteer experiments. Choose reproducible datasets suitable for HBM validation.

Frontal Acceleration (Braking)	Lateral Acceleration (Lane-change)	Combination
Chalmers Autobraking test series (Östh, J., et al., (2013). Stapp.; Ólafsdóttir, J. M., et al., (2013) IRCOBI) 	Siemens / TNO Robot test vehicle (Van Rooij, L., et al., (2013). Stapp) 	ViF / TU Graz OM4IS 2 
ViF / TU Graz Precooni (In preparation) 	Chalmers Lane-change test series (Ghaffari, G., et al., (2018), IRCOBI; Ghaffari, G., et al., (2019) Traffic Inj Prev.) 	Chalmers Lane-change test series 
ViF / TU Graz OM4IS 2 (Huber, P., et al., (2015). IRCOBI; Huber, P., et al., (2014) IRCOBI; Kirschbichler, S., et al., (2014), IRCOBI) 	ViF / TU Graz OM4IS 2 	

Volunteer pre-crash validation catalogue

- Seat and/or environment models are an important part of "well defined boundary conditions"

Chalmers	ViF / TU Graz	Siemens
• 2012/2016 Volvo V60 seat/belt model was developed. 	• OM4IS II and Precooni use seat based on the structure of 2012 Mercedes-Benz S-Class. 	• A rigid racing seat was used (RCI Poly Highback Seat 8000S). 

Agenda

Update on OSCCAR 14:45 - 15:30

Results and future work incl. Q&A

- Short intro + status (Werner Leitgeb)
- Biomechanical alignment/ injury evaluation

  (Christian Mayer, Johan Iraeus, Lennart Nölle, Jason Fice)

- **Virtual testing** (Andre Eggers, BASt)

Full Virtual Testing approach with HBMs

Vehicle interior model certification procedure

Andre Eggers (BASt), Christian Mayer (Mercedes-Benz), Steffen Peldschus (LMU Munich)

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

OSCCAR has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 768947.

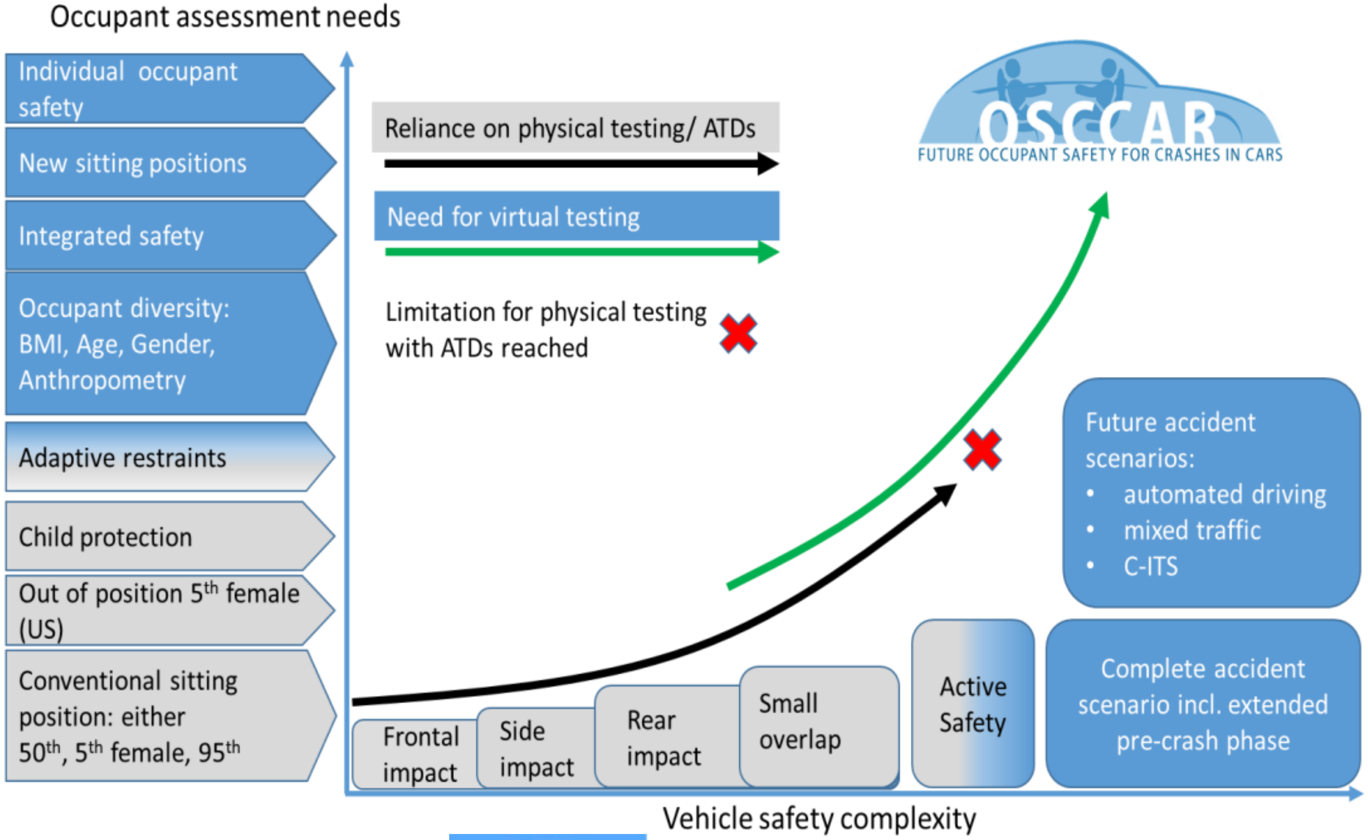
"Full Virtual Testing" approach with HBMs - no fallback option for RT

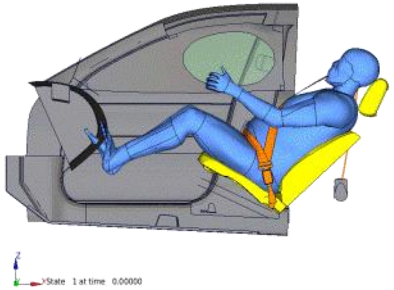
Motivation for Virtual Testing

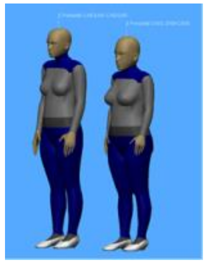
1.) **Replace existing RT** (real testing) based procedures **by VT** (virtual testing) → e.g. EU-Project IMVITER) with focus on **saving costs** (no new tests/requirements)

2.) **Extent the scope of protection** by adding test conditions using existing test tools (ATDs/impactors) by combined real and virtual testing (hybrid approach/grid approach)

3.) Use of **HBMs in a VT process** to address the limitation of ATDs → **OSCCAR**: HBMs to address new seating postures, user diversity (small vs. tall, male vs. female, Western vs. Asian), obesity,…



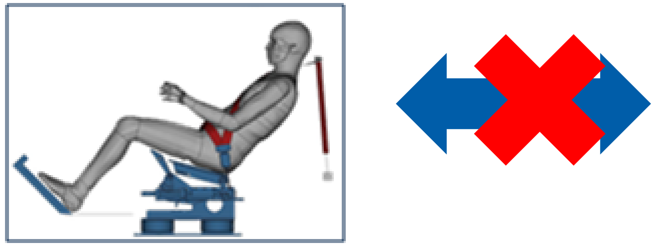




OSCCAR “Full Virtual Testing” approach with HBMs - vehicle interior model certification procedure

Why do we need vehicle interior certification procedure?

- ➢ No possibility to check validation of vehicle model by real tests in assessment/type approval test setup (No real test tool existing corresponding to HBM)



No corresponding real test for interior model validation

- ➢ No combined VT/RT hybrid approach
- ➢ No RT fall back option if validation fails

“Full Virtual Testing” approach with HBMs - no fallback option for RT

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

HBM Certification requirements for new load cases

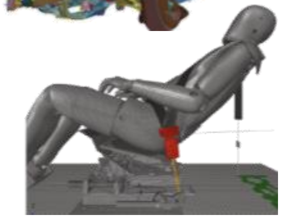
Human Body Model (certifed for new loadcase)

Phase 1: Vehicle Model Development

Vehicle (interior) model development

- Code-specific quality requirements
- Model validation based on internal experience, tests and data

Phase 2: Vehicle Model Certification



Simulations (Carried out by OEM)

Simulation data

Objective correlation procedure

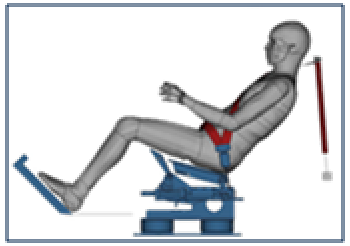
Real test data

Validation Tests (by accredited lab)

Certified Vehicle Interior Model

Phase 3: Homologation / Assessment

Virtual Testing of new load case



- Test/Assessment Tool: HBM
- Standardized virtual test procedure
- HBM based assessment criteria

“Full Virtual Testing” approach with HBMs - no fallback option for RT

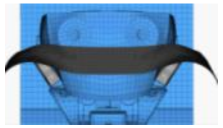
Phase 2: Model Certification

Vehicle interior model Simulations carried out by (OEM)

Simulation data

Objective correlation procedure

Test data



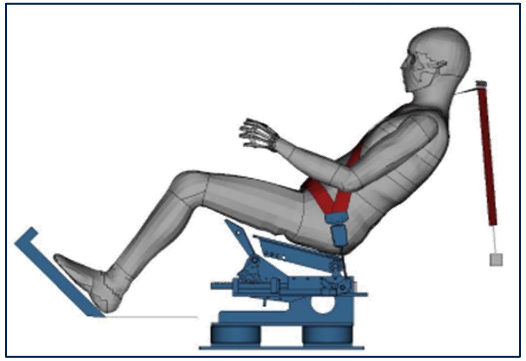
Validation Tests (carried out or witnessed by accredited lab)

Validation based vehicle interior model certification procedure:

- Defined set of **validation load cases** (crash test, sled test, impactor tests in representative of new loading condition) including suitable **validation tool** (standard ATD, modified/simplified ATD, impactor,..)
- Based on **objective correlation procedure** vehicle interior model is certified for use in Phase
- Selection of relevant validation measurements
- Definition of objective metrics threshold considering acceptable scatter in real test and vehicle components

Application to OSCCAR Homologation Test Case Demonstration

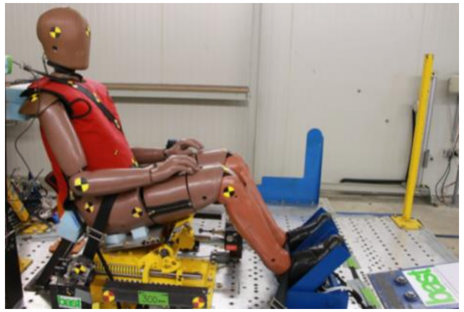
- Frontal impact
- Reclined seat (48° / 60°)
- Average occupant (50%ile) incl. soft tissue layer variation



Proposed **interior validation load cases** for the OSSCAR homologation scenario:

- **Sled tests** with 50 km/h full-frontal pulse
- **Validation tool: THOR-50M** (in upright and reclined seating position)

➢ Sled tests have been performed and used for interior model validation in different codes



Next steps / further work in OSCCAR:

- Comparison of THOR and HBM simulations in validation load cases
  - Discuss possible **limitations of sled validation load cases and THOR as validation tool**

- Evaluate objective metrics (e.g. Cora / ISO) and thresholds considering variation in dummy response, vehicle components and test scatter (More sled tests with THOR planned to evaluate load case specific **real test variation of relevant validation signals)**

- Evaluate validation procedure based on further THOR sled tests
  - Draft proposal procedure for vehicle interior certification

OSCCAR – downloads, results

OSCCAR public deliverables and downloads:

http://osccarproject.eu/media/

OSCCAR @ Ircobi 2020:

Östh et al.: Evaluation of Kinematics and Restraint Interaction when Repositioning a Driver from a Reclined to an Upright Position Prior to Frontal Impact using Active Human Body Model Simulations

Becker et al.: Occupant Safety in Highly Automated Vehicles Challenges of Rotating Seats in Future Crash Scenarios

Mroz et al.: Effect of Seat and Seat Belt characteristics on the Lumbar Spine and Pelvis Loading of the SAFER Human Body Model in reclined Postures

Nölle et al.: Defining Injury Criteria for the Muscle-Tendon-Unit

OSCCAR

FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

Contact:

Werner Leitgeb

werner.leitgeb@v2c2.at

www.osccarproject.eu

Christian Mayer

christian.c.mayer@daimler.com

Johan Iraeus

johan.iraeus@chalmers.se

Jason Fice

jason.fice@chalmers.se

Lennart Nölle

lennart.noelle@imsb.uni-stuttgart.de

Andre Eggers

eggers@bast.de

OSCCAR has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768947.


FOR SAFER CARS
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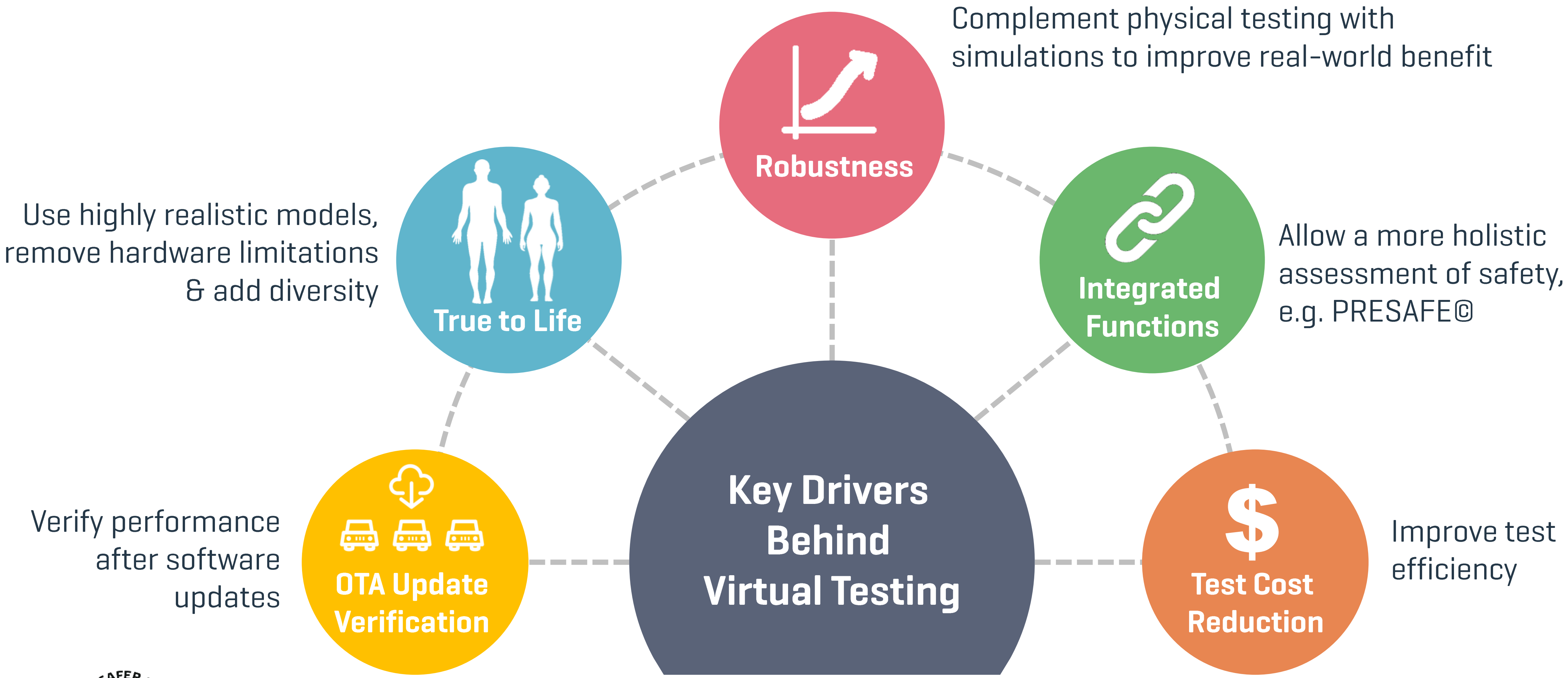
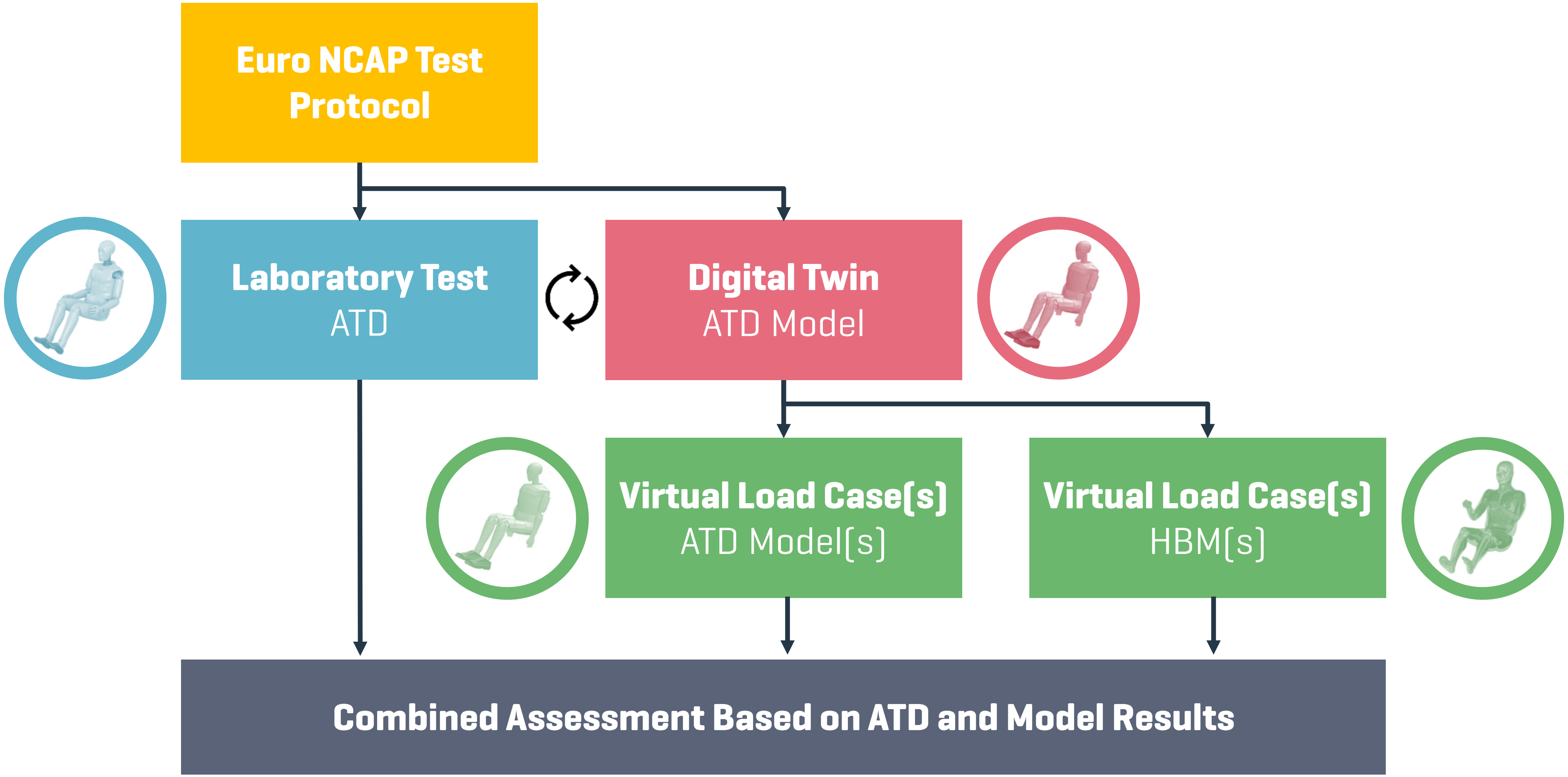
Contents

EURO NCAP FOR SAFER CARS

Why Virtual Testing?



Virtual Testing Principle



Aims of Euro NCAP VTC WG

- Develop "Far-side impact" pilot case
  - Task 1: Vehicle Model Control
  - Task 2: Validation Testing
  - Task 3: Virtual Load Case(s) Definition
  - Task 4: Data Handling & Management, Communication
  - Task 5: Scoring and Rating Process
  - Task 6: Virtual Occupant Specification & Certification

- Scope limitations
  - Passive safety countermeasures only, no integrated systems
  - No HBM development or new biomechanical research

Far-Side Impact Pilot

Far Side Test and Assessment Protocol v2

- Acceleration based sled rig with BIW (mounted at 75°)
- WorldSID mid-sized male ATD (sleeveless suit)
- AE-MDB and Pole impact pulse

Relevant Virtual Load Case Variations*

- Delta v
- Vehicle variants (mass, EV, vehicle body): crash pulse
- Anthropometry: occupant sizes, gender & posture
- Seating position

**Based on review of accident data*

Added Measurements for Validation

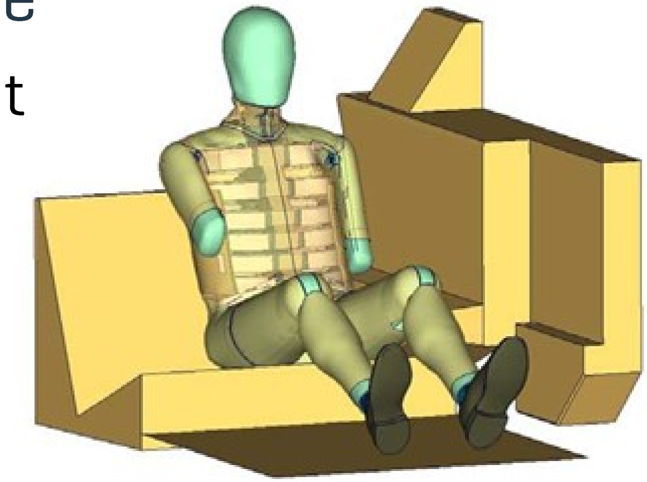
- Pre-test: reference points of seat, belt anchorages, WorldSID position scan, etc.
- During test: Dummy (head) position, seat back position over time, relative airbag position (additional stills and video)

EURO NCAP FOR SAFER CARS

Human Test Tool Definition – ATD Model

- Variation in ATD model response
  - Different code and code version
  - Different model supplier (commercially available, in-house developed)
  - Different model version (often linked to vehicle programme)

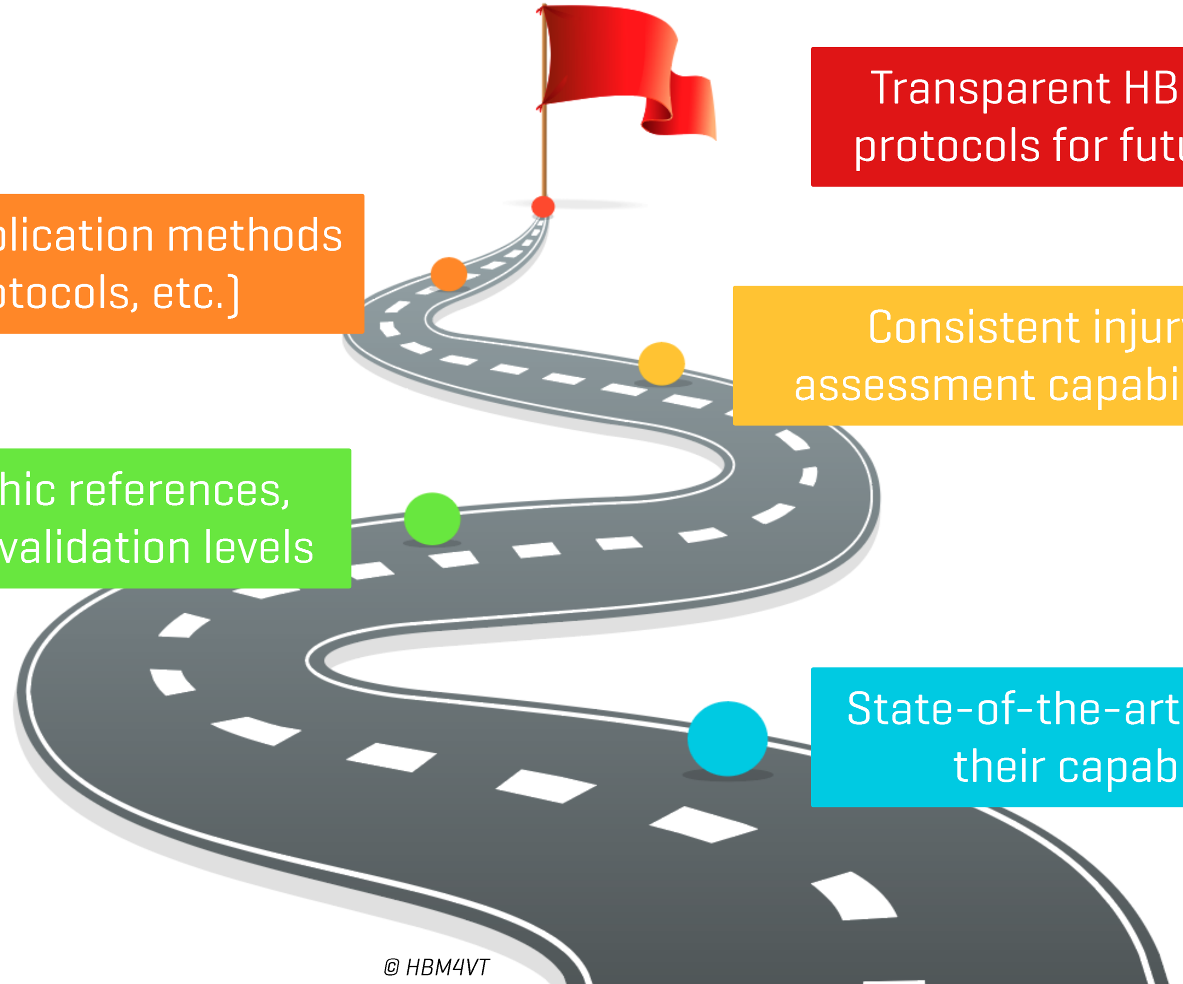
- Model “certification” catalogue for quality assurance
  - Includes near and far-side load cases, simplified restraint interaction
  - Model acceptance based on correlation requirements
  - Declared by manufacturer and/or supplier



© Dynamore

Human Test Tool Definition - HBM

- “HBM4VT” - A framework of international experts to develop a roadmap for HBM application in virtual testing



Quality Control & Checks

Occupant Model

Supplier/OEM runs simulations
Euro NCAP verifies

"Certification Acceptance Criteria"

Vehicle Environment Model

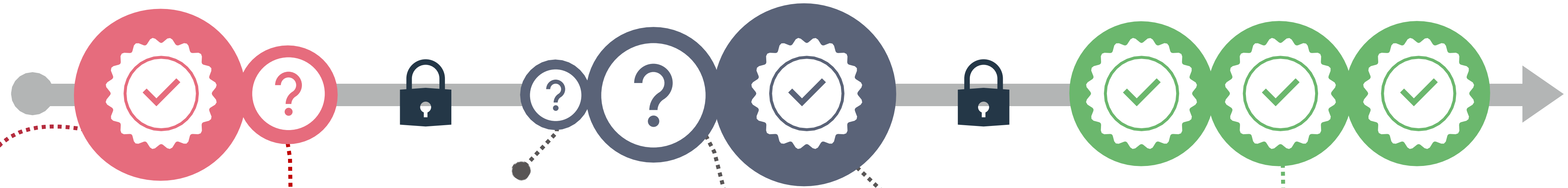
OEM/systems integrator runs simulations
Euro NCAP verifies

"Validation Acceptance Criteria"

Assessment Model(s)

OEM/systems integrator runs simulations
Euro NCAP verifies & rates

"Assessment Criteria"



Certification Catalogue
Standardized load cases
near and far side,
simplified restraint loading

Additional Certification
Manufacturer-specific certification
load case(s) (if needed)

Material Validation
Unique materials

Component Validation
Restraint specific

System Validation
Vehicle specific geometry,
restraint and materials

Prescribed Load Cases
Variations in boundary conditions, pulse,
seating position, etc.

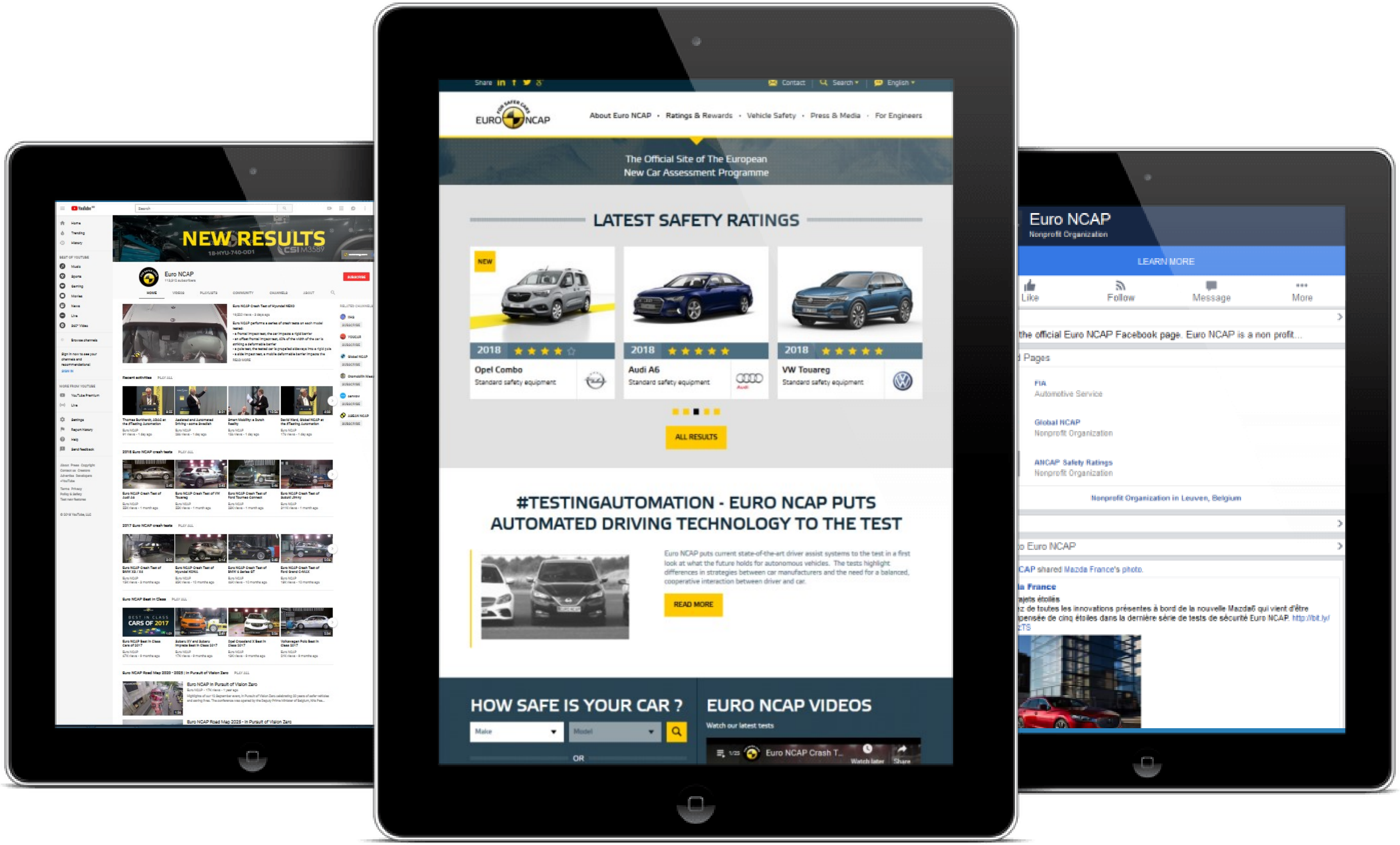
EURO NCAP FOR SAFER CARS

OSCCAR FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

virtual

Closing Remarks

- Virtual testing offers many opportunities for enhanced safety assessment, but there are important challenges to overcome
- Industry, academia and Euro NCAP have joined forces to develop a feasible methodology, applicable to the evaluation of crash protection systems
- First application and test case is far-side impact – if successful, other applications like frontal impact and pedestrian safety will be considered
- Model (quality) control is fundamental in achieving trust in the process and has been the focus of the WG so far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IIHS research: virtual testing for out-of-position occupants in low severity rear impacts

Virtual workshop

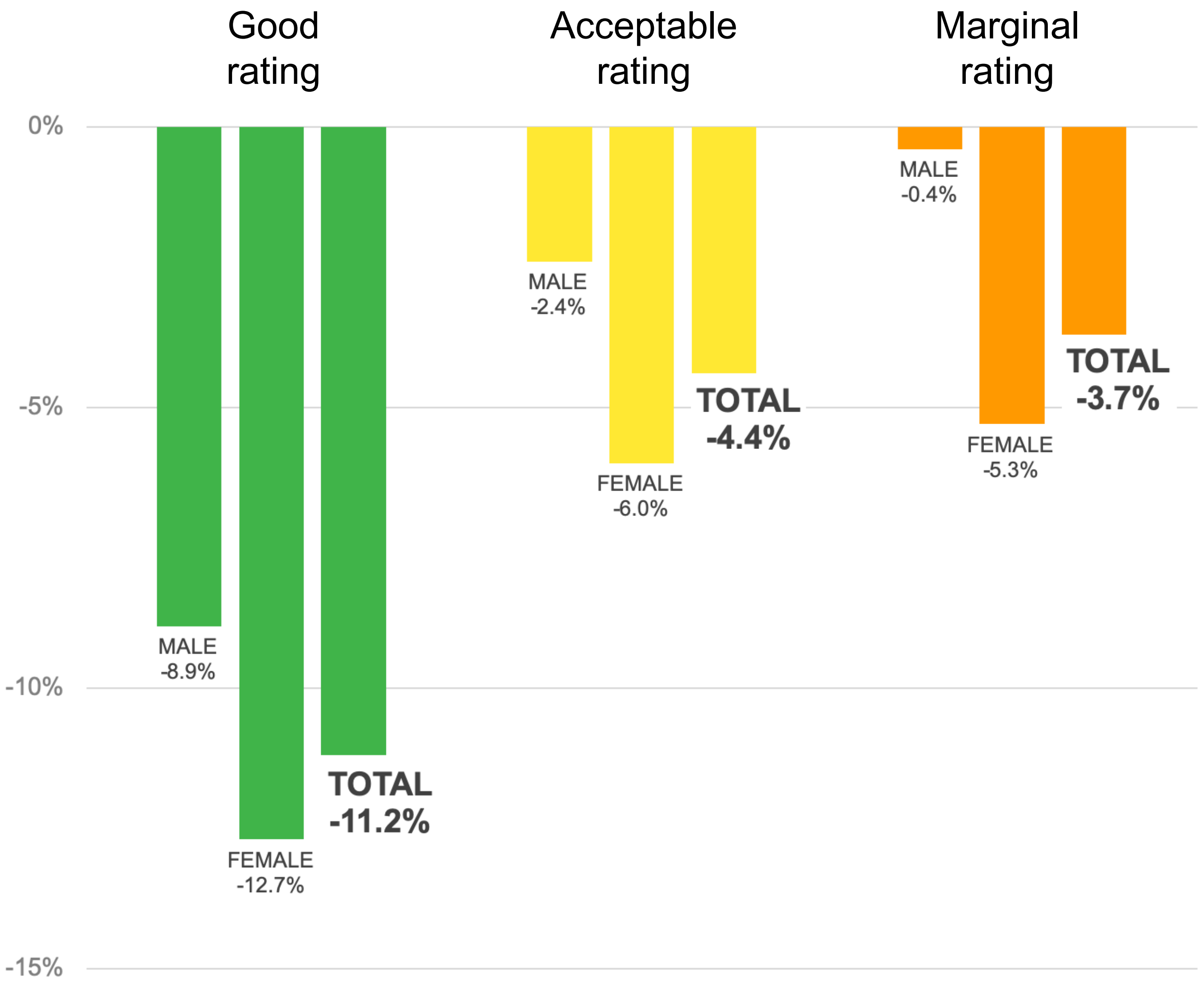
September 8, 2020

Marcy Edwards
Research Engineer

Background

IIHS whiplash evaluation

Percent reduction in injury claim rates vs. poor-rated seats

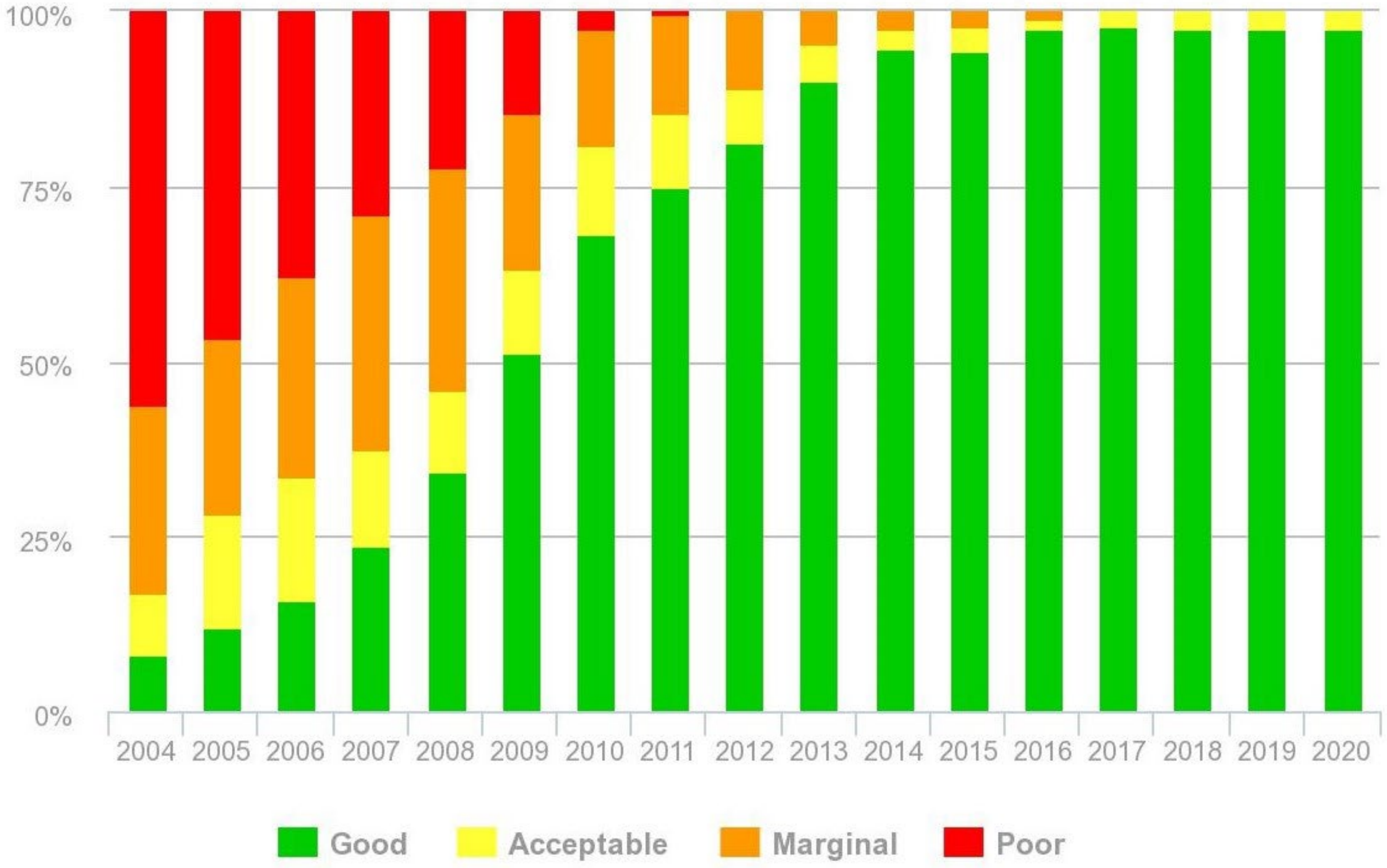


IIHS HLDI

IIHS whiplash evaluation

Percent of ratings by model year,
as of August 30, 2020

- Nearly all modern vehicles earn **GOOD** ratings.



IIHS whiplash research goals

IIHS whiplash research goals

Continue to reduce whiplash injury in low severity rear impacts

Active safety technology

- Autonomous emergency braking
- Driver assist features

Robust seat and restraint designs that can protect many occupants

- Different crash severities
- Varied occupant positions
- Range of occupant sizes and sex

Passive IIHS whiplash safety research goals

Continue to reduce whiplash injury in low severity rear impacts

Active safety technology

Robust seat and restraint designs that can protect many occupants

Automatic emergency braking

Driver assist features

Different crash severities

Varied occupant positions

Range of occupant sizes and sex

Research questions and goals

Encouraging robust seat and restraint designs that can protect many occupants

Different crash severities

- Researching the addition of higher severity physical tests (Euro NCAP 24 km/h and JNCAP pulse)

Varied occupant positions

- Realistic out-of-position scenarios
- Alternate positions that can be achieved with the physical BioRID dummy
- Feasibility of evaluating alternate positions with BioRID models
- Can human body models represent human occupant out-off-position scenarios better than dummy models?

Range of occupant sizes and sex

- Do alternate size or female dummy models improve the correlation of test results to real world data?
- Do human body models offer more options for evaluating a variety of occupant sizes?

2021 Research questions and goals

Encouraging robust seat and restraint designs that can protect many occupants

Different crash severities

- Researching the addition of higher severity physical tests (Euro NCAP 24 km/h and JNCAP pulse)

Alternate occupant positions

- Realistic out-of-position scenarios
- Alternate positions can be achieved with the physical BioRID dummy
- Feasibility of evaluating alternate positions with BioRID models
- Can human body models represent human occupant out-off-position scenarios better than dummy models?

Range of occupant sizes and sex

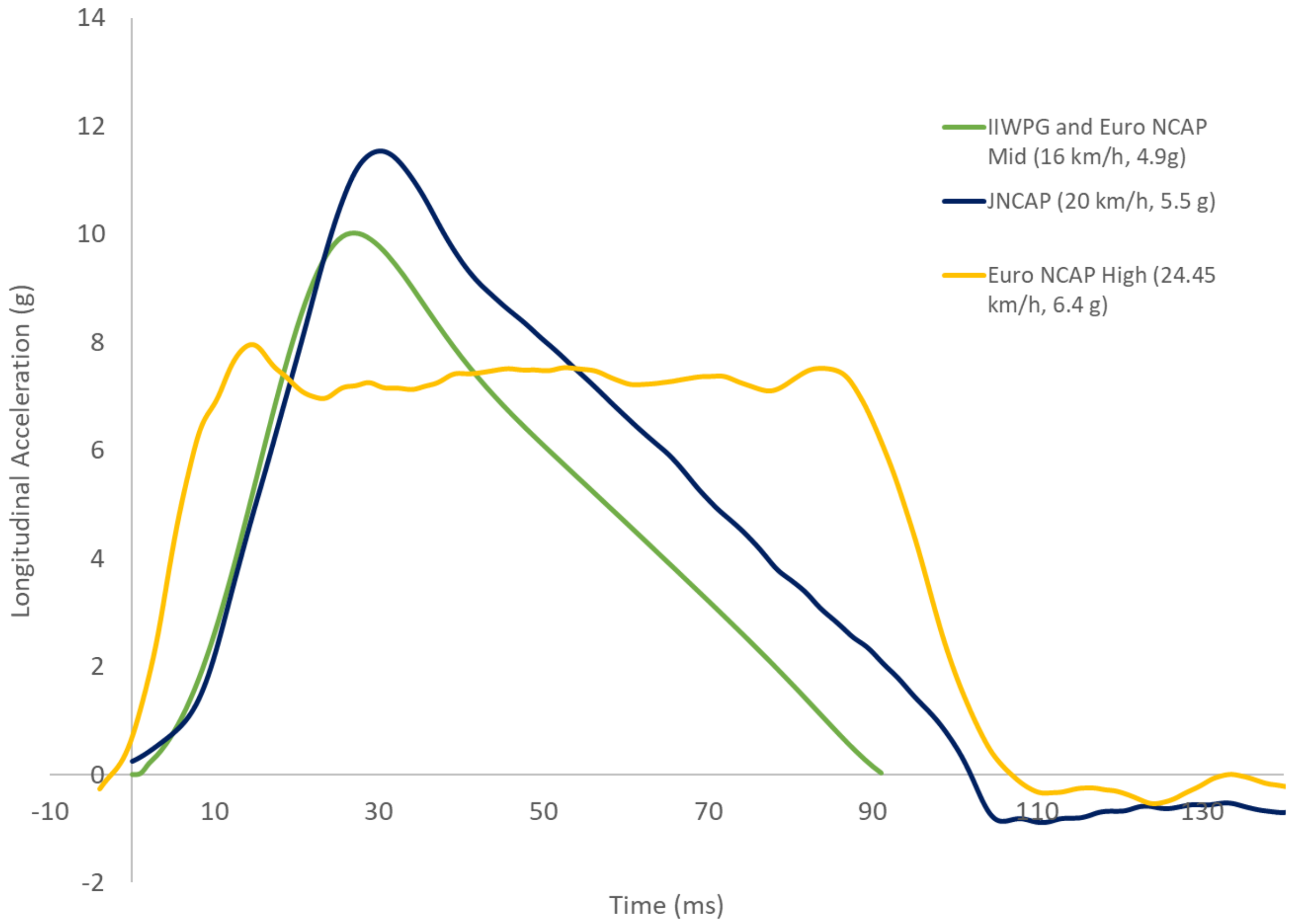
- Do alternate size dummy models improve the correlation of test results to real world data?
- Do human body models offer more options for evaluating a variety of occupant sizes?

Researching different crash severities

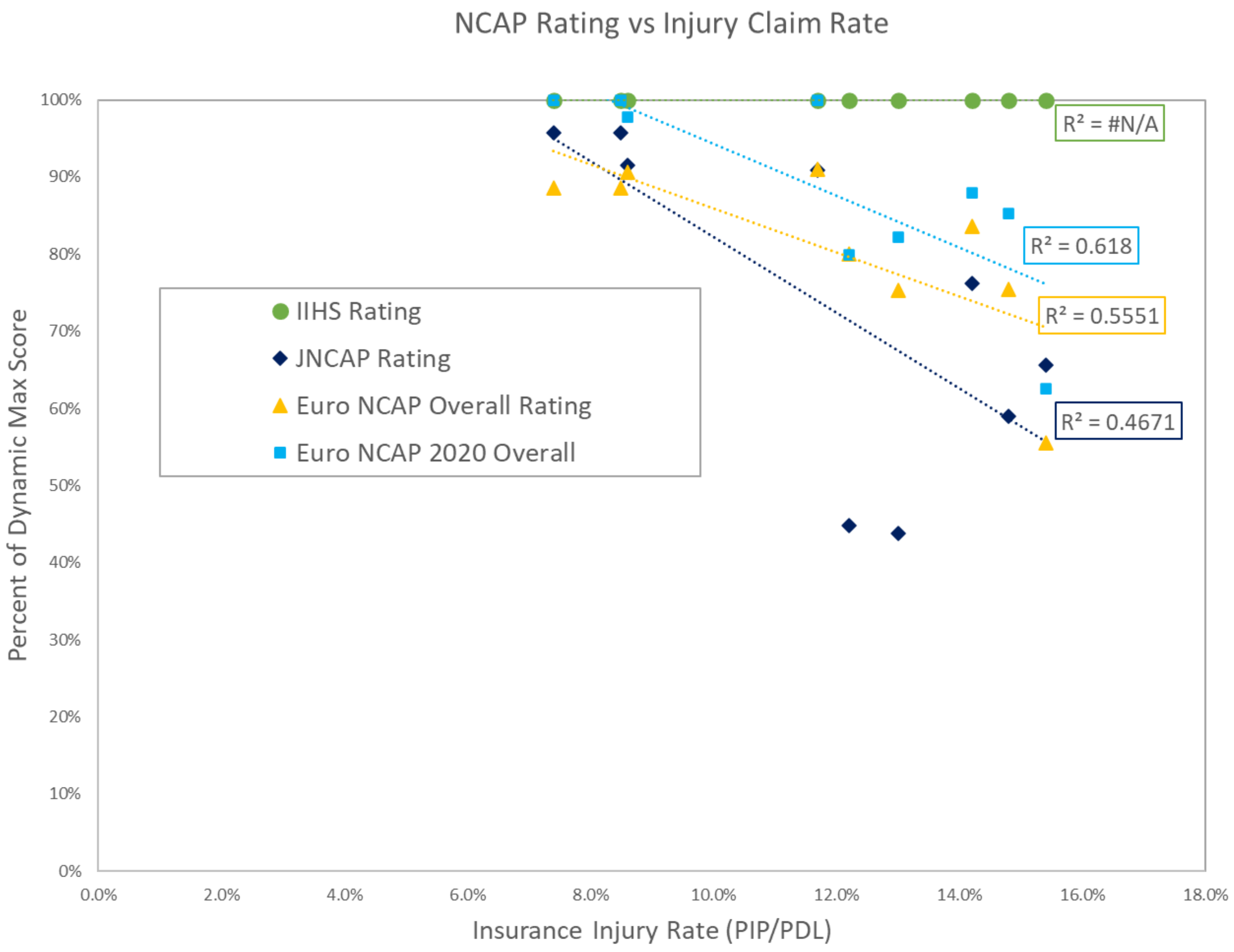
Different crash severities

We have completed IIWPG, EuroNCAP high pulse and JNCAP pulse tests for eight midsize cars:

- ✓ 2018 Nissan Altima
- ✓ 2018 Ford Fusion
- ✓ 2018 VW Passat
- ✓ 2017 Toyota Camry
- ✓ 2017 Honda Accord
- ✓ 2018 Hyundai Sonata
- ✓ 2018 Mazda 6
- ✓ 2019 Subaru Legacy/Outback



Different crash severities



Next Step

Midsize SUVs

Researching assessment of alternate occupant positions

IIHS HLDI

Alternate occupant position research phases

Phase 1

- Identify real world out-of-position scenarios from naturalistic driver data

Phase 2

- Investigate using physical BioRID dummy in alternate seating positions
- Research BioRID biofidelity in these positions

Phase 3

- Research the feasibility of evaluating these alternate seating positions with the BioRID computational models

Real world out-of-position scenarios

How do current driving behaviors affect interactions with the modern generation of seats and head restraints?

For common locations and scenarios for low severity rear impacts:

↓

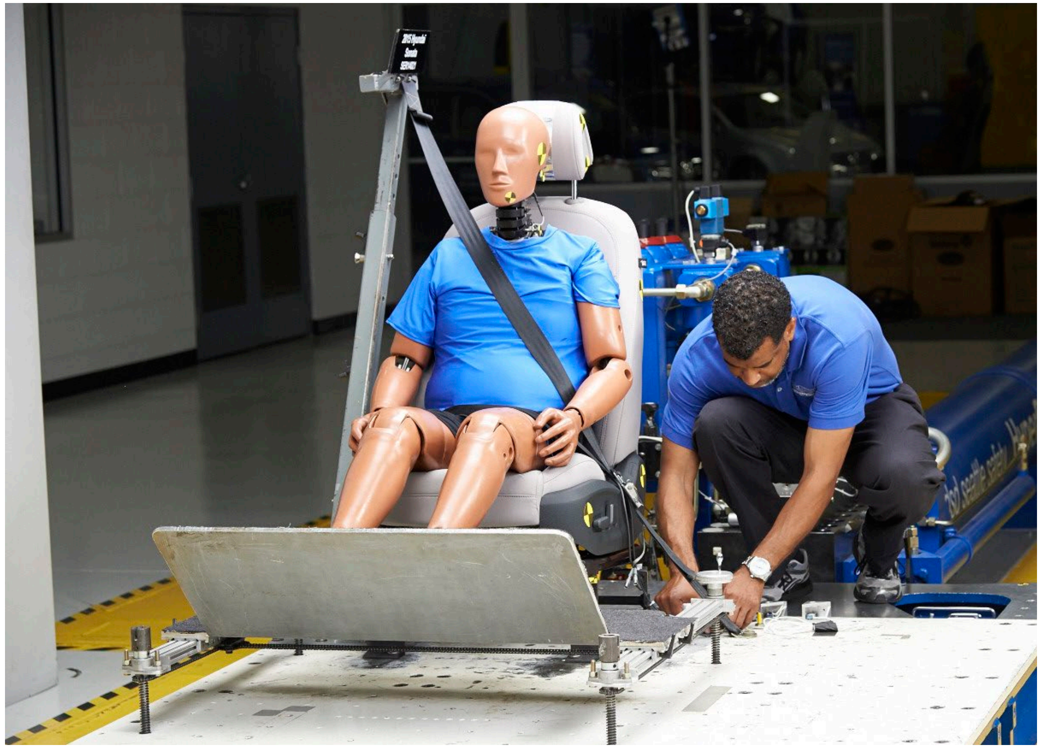
Use naturalistic data to observe occupant behaviors at these locations (e.g. looking down at phone)

↓

Categorize how these behaviors affect occupant position relative to seat and head restraint

BioRID physical dummy out-of-position

- Choose a position where the physical dummy can be used to validate the simulation



BioRID and seat computational models

Can we develop a process to use seat and dummy models to reliably predict BioRID dummy response for an out-of-position scenario in an automaker developed seat model?

- Verify that the BioRID model can represent the physical BioRID dummy for the out-of-position load case
- Develop a method for assessing the fidelity of the automaker seat model
- Compare simulation responses to the hardware response for the out-of-position condition

Verify that the BioRID model can represent the physical BioRID dummy for the out-of-position load case

a. Using generic, simplified seat, compare physical BioRID dummy responses to simulation response for the out-of-position condition	Kinematic response	
	Dummy injury metrics	

Develop a method for assessing the fidelity of the automaker seat model

a. Compare simulation results and hardware results for existing in-position physical rear impacts test

	Seat kinematic response
	Dummy/surrogate kinematic response
	Dummy injury metrics

Compare simulation responses to the hardware response for the out-of-position condition

a. Simulation response vs hardware response for the out-of-position condition

- Seat kinematic response
- Dummy kinematic response
- Dummy injury metrics

IIHS HLDI

Computational modeling research goals

- Understand the fidelity of the BioRID models for non-standard seating positions
- Understand the resources required for this evaluation method for automakers and the hurdles they may encounter in supporting this evaluation method
- Identify challenges in the workflow related to data sharing with automakers, validating models and robustness of model results
- Develop an understanding of the analysis tools and resources required to assess model results and compare them to hardware results
- Define a process and metrics for validating an automaker seat model using a current hardware test
- Gain understanding about the robustness of model results by comparing the dummy and seat responses

IIHS hopes to collaborate with automakers and modeling experts to achieve these goals

Summary

IIHS Whiplash research goals for 2021

- Assess alternate crash severities for correlation with insurance injury claim rate data
- Identify realistic out-of-position scenarios
- Verify that the BioRID physical dummy and computational model can represent out-of-position scenarios
- Develop a method for assessing the fidelity of automaker seat models
- Assess whether FE simulation can provide accurate and meaningful representation of the physical dummy and seat response for the out-of-position load case

Insurance Institute for Highway Safety
Highway Loss Data Institute

More information at iihs.org and on our social channels:

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IIHS

Marcy Edwards

Research Engineer
medwards@iihs.org

iihs.org

Royalty-free THUMS

DATE: 08.09.2020
VIRTUAL - OSCCAR workshop

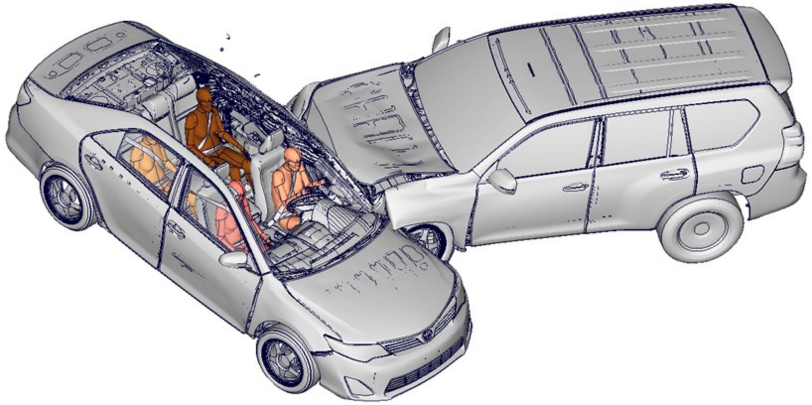
Tjark Kreuzinger (TOYOTA MOTOR EUROPE)
Yuichi Kitagawa (TOYOTA MOTOR CORPORATION)

CONTENTS

1. About Royalty-free

Background:

- THUMS is now widely used for vehicle safety research.
- Future updates should be made based on user needs.
- Royalty-free license may bring further expansion and evolution of THUMS.



1. About Royalty-free

What models for free from January 2021?

- Version 4 Occupant AM50, AF05, AM95, 3YO, 6YO, 10YO
- Version 4 Pedestrian AM50, AF05, AM95, 3YO, 6YO, 10YO
- Version 5 Occupant AM50, AF05, AM95
- Version 6 Occupant AM50, AF05, AM95

What else?

- Validation Datasets for Each Model
- Other Variation Models for Research Collaboration

1. About Royalty-free

Terms and conditions: (under development)

- Original copyright permanently belongs to TOYOTA.
- User needs to register information such as name and affiliation.
- THUMS can be modified and shared with other registered users but free of charge. (Commercial support is OK.)
- Users are obliged to inform TMC what they share with whom.

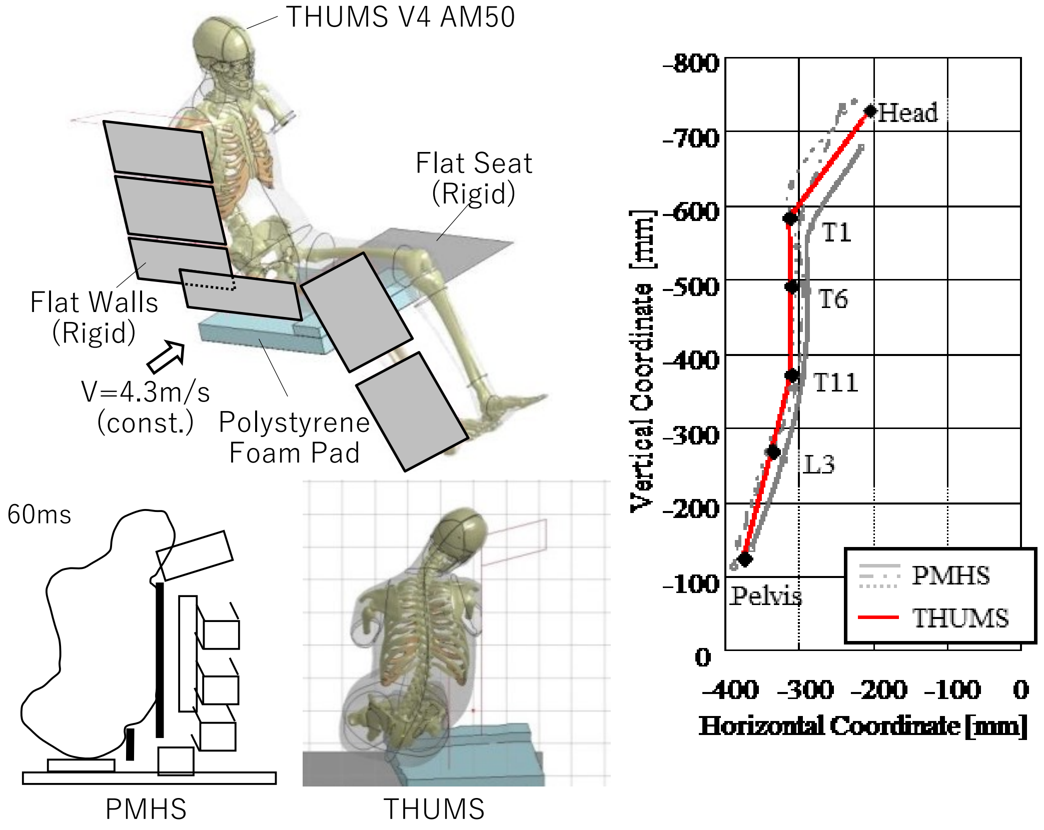
Note: Existing users are recommended to switch to new agreement.

2. Use for Virtual Testing

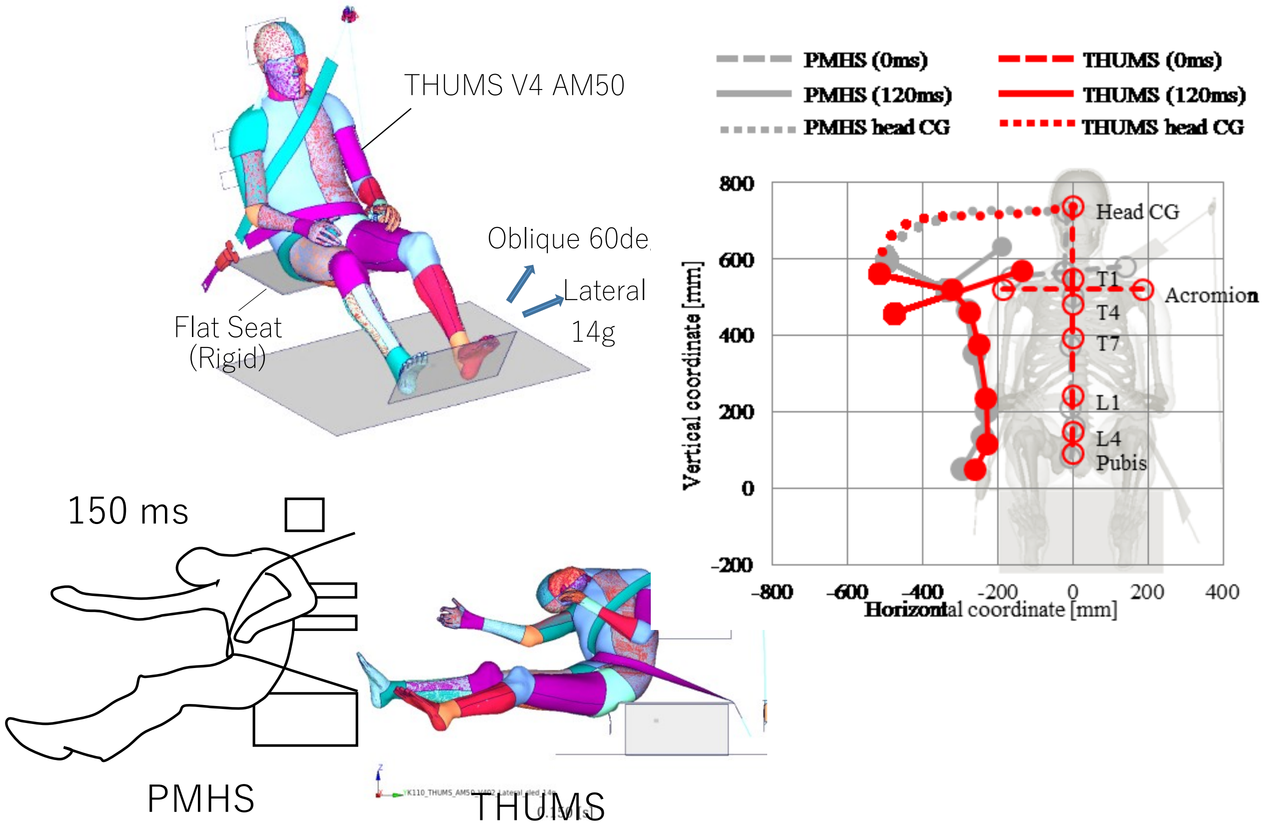
Load Cases	Available THUMS Models		Features
Far-side Impact	V4 OCC	AM50	(Original)
Rear Impact	V4 OCC	AM50, AF50	Cervical Joint Capsules
Frontal Impact	V4 OCC	AM50, AF05, 10YO, 6YO	Aging Effects on Ribs
Pedestrian Impact	V4 PED	AM50, AF05, AM95, 6YO	Walking Postures
Pre-collision	V6 OCC	AM50, AF05, AM95	Muscle Responses
ADS Posture	*V7 OCC*	*AM50, Obese, AF05*	*Abdominal Soft Tissues*

2. Use for Virtual Testing: Far-side Impact

- Previously validated to both near-side and far-side impact tests



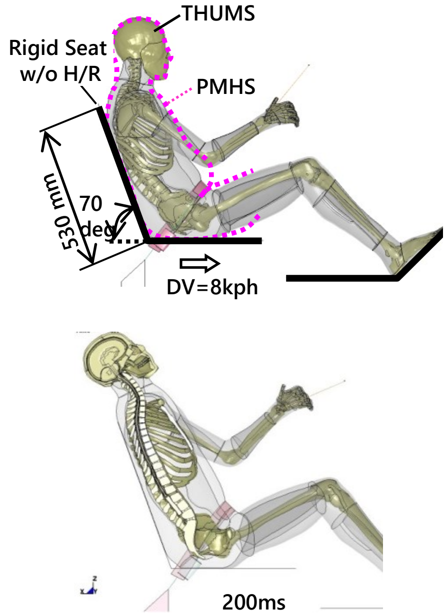
Near-side Impact (Lessley et al. 2010)

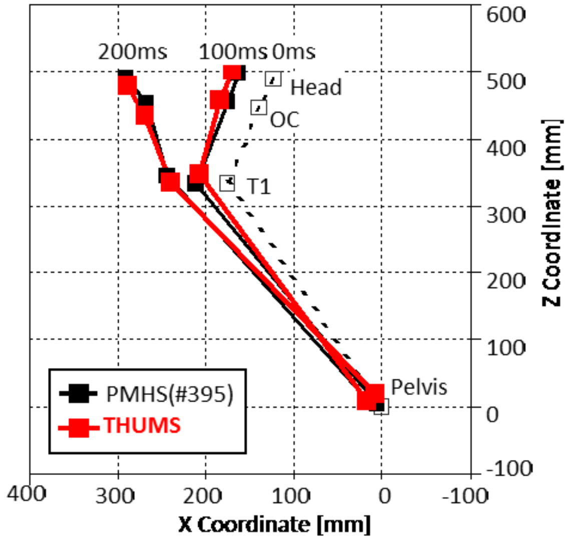


Far-side Impact (Forman et al. 2013)

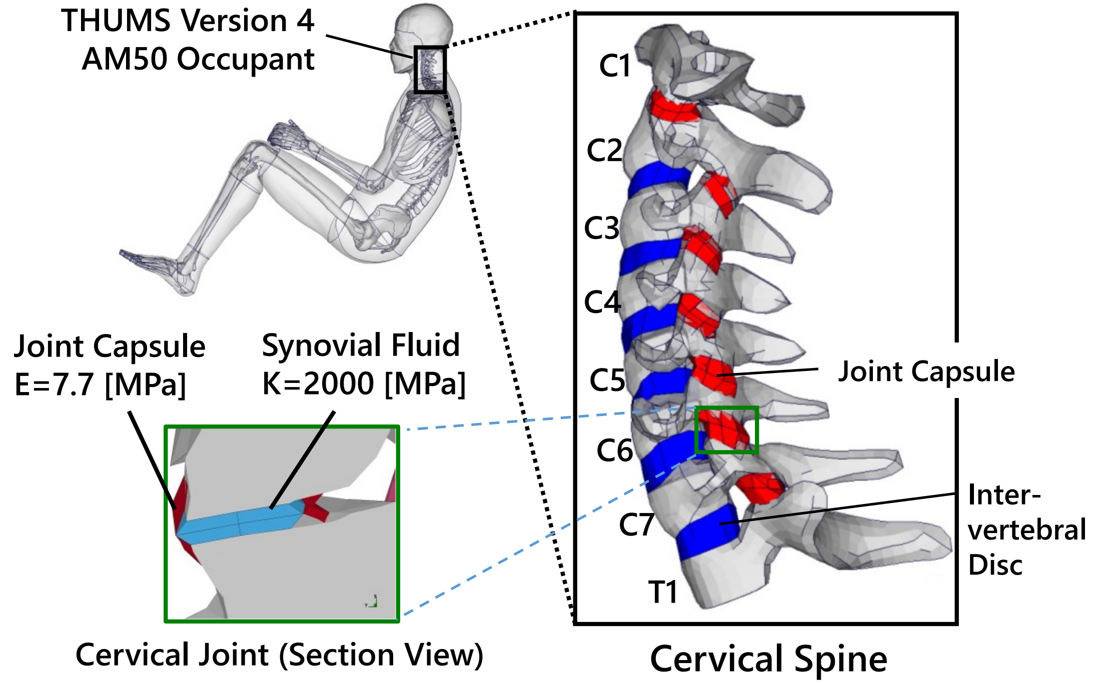
2. Use for Virtual Testing: Rear Impact

- Previously validated to low-speed rear impact tests
- Modeling of cervical joint capsules for both AM50 and AF50





Comparison of Kinematics

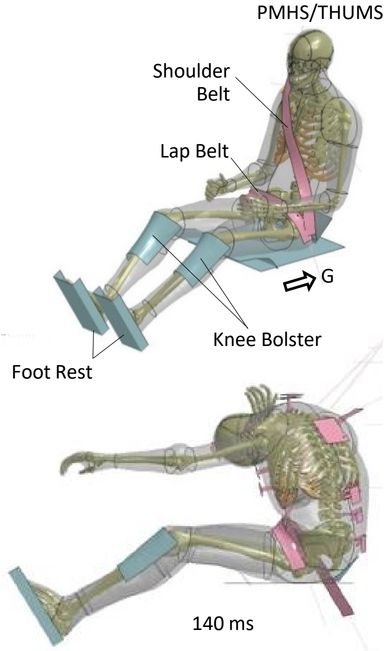


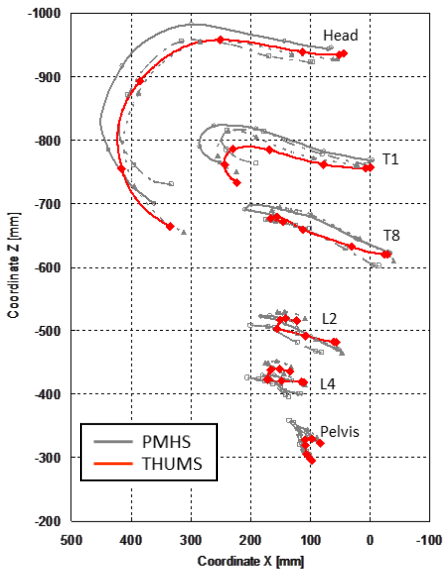
Validation to PMHS Rear Impact Tests
(White et al. 2009)

Modeling of Cervical Joint Capsules

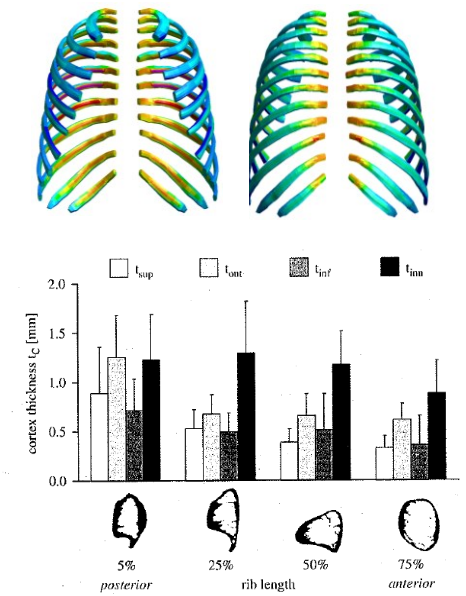
2. Use for Virtual Testing: Frontal Impact

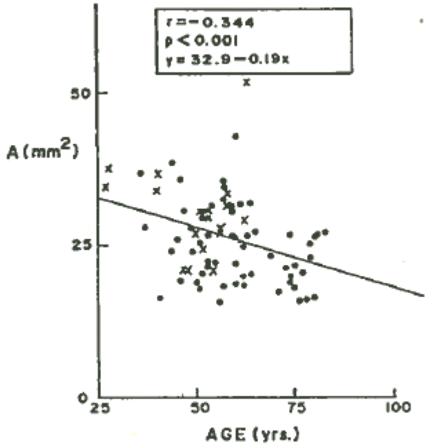
- Previously validated to frontal impact tests
- Realistic rib cortical bone to better predict rib fracture of elderly





Comparison of Trajectories



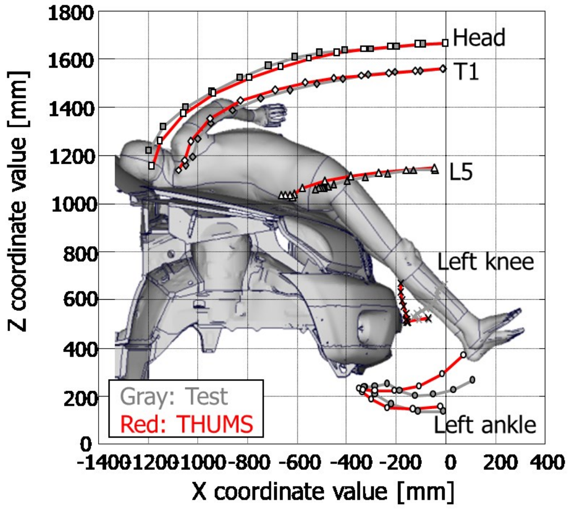


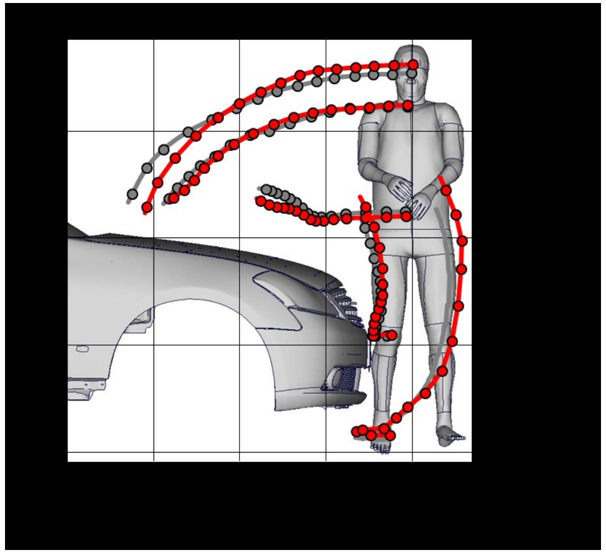
Validation to PMHS Frontal Impact Tests
(Shaw et al. 2009)

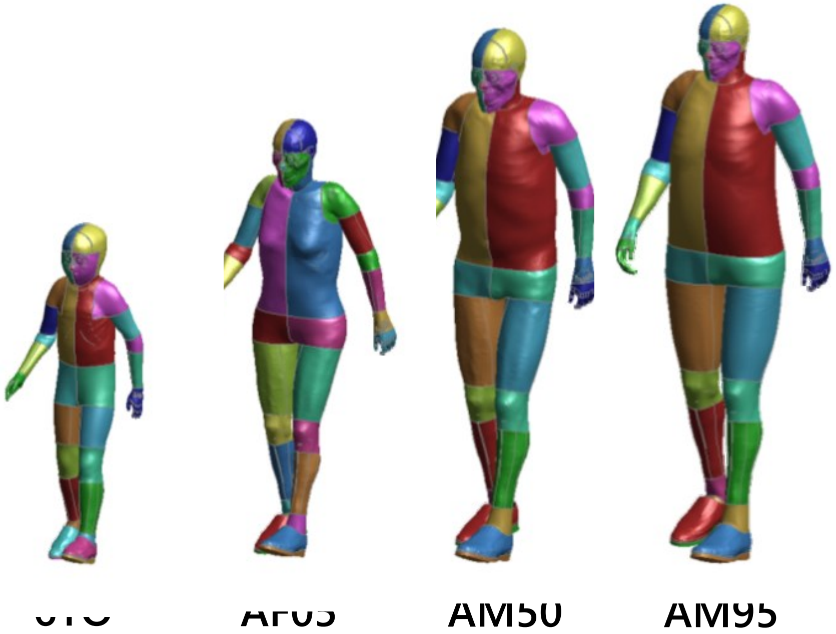
Aging Effect on Rib Cortical Bone
(Mohr et al. 2007, Stein et al. 1976)

2. Use for Virtual Testing: Pedestrian Impact

- Previously validated to pedestrian impact tests
- Different body size models in walking posture for TB024





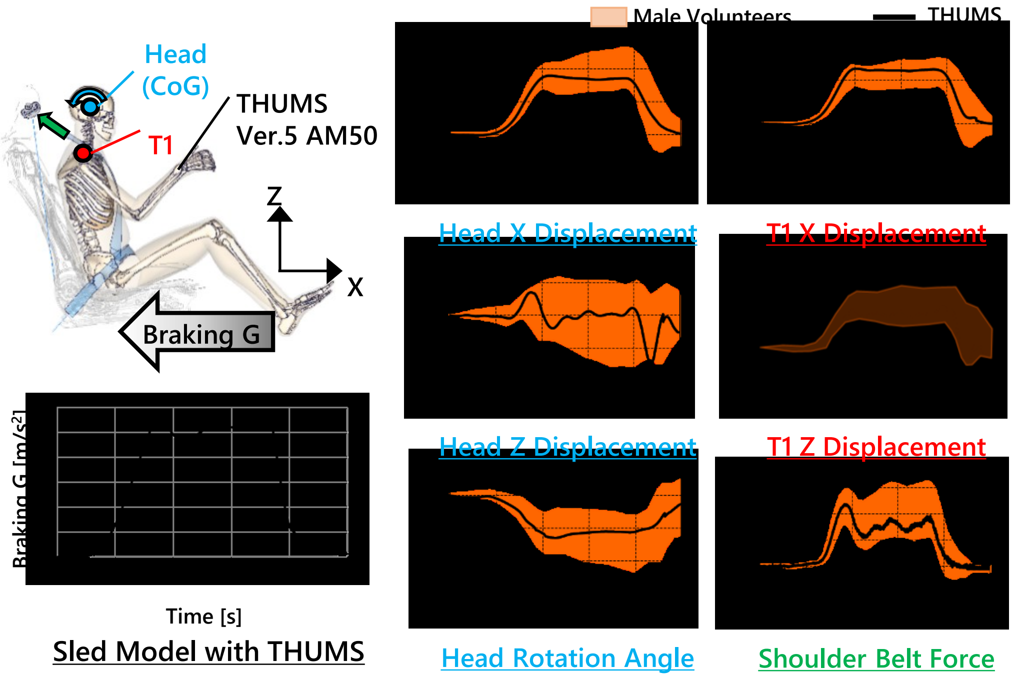


Validation to PMHS Pedestrian Impact Tests
(Schroeder et al. 2008, Subit et al. 2008)

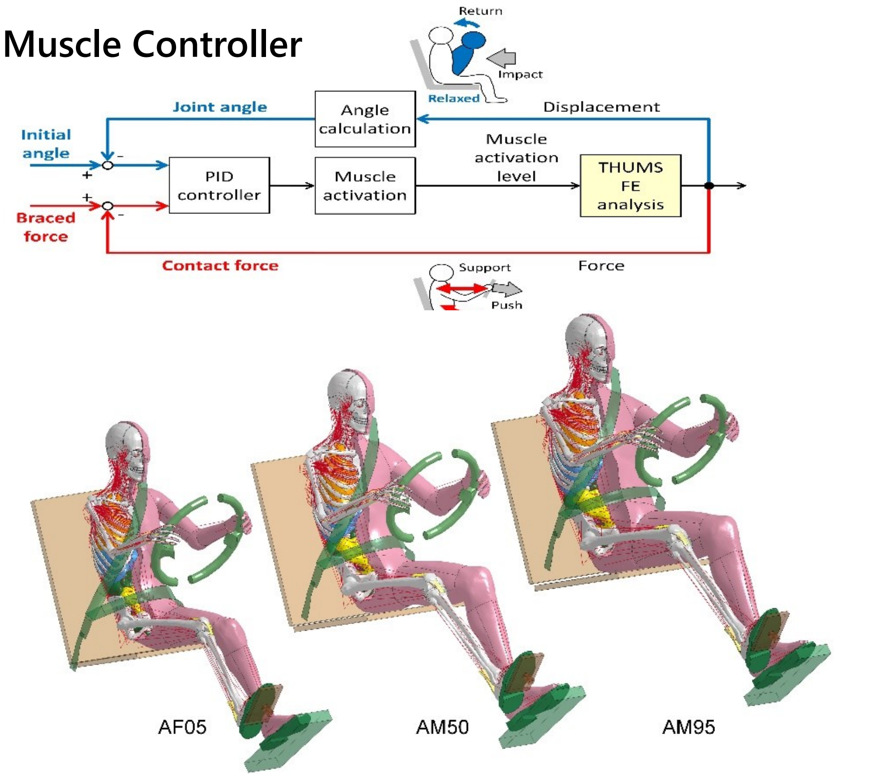
Different Body Size Models
(Euro NCAP TB024)

2. Use for Virtual Testing: Pre-collision

- Previously validated to volunteer kinematics in braking tests
- Both pre-collision and in-collision simulations are executable



Validation to Volunteer Braking Tests
(Ólafsdóttir J M, et al. (2013))

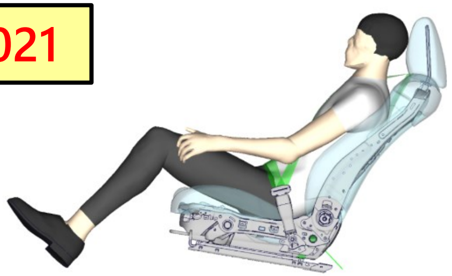


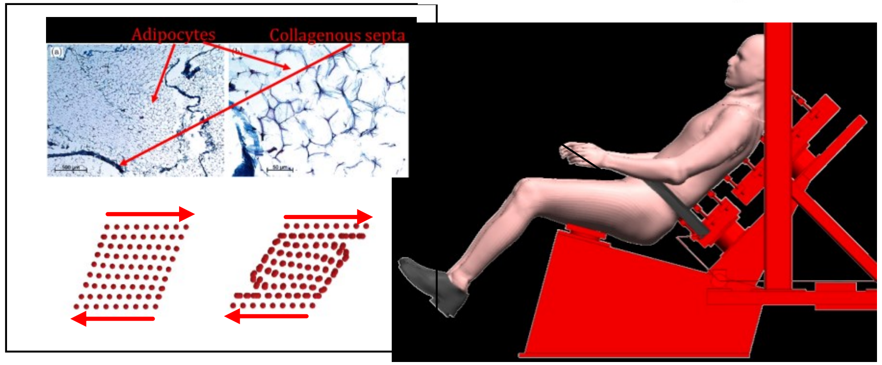
THUMS V6 AF05/AM50/AM95

2. Use for Virtual Testing: ADS Posture

- V7 under development to represent occupant ADS posture
- Modeling of abdominal soft tissue to simulate seatbelt interaction

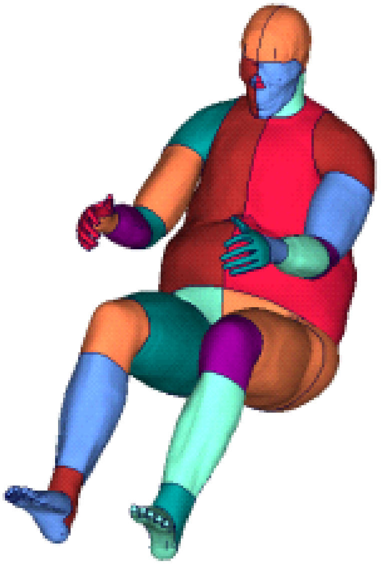
To be completed in 2021





Validation to PMHS Reclined Tests
(CSRC-UVA Research Project)

Small Intestine and Mesentery



Obese Occupant

Modeling of Abdominal Soft Tissue

2. Use for Virtual Testing

- ✓ Availability of Base Models
- ✓ Validation to Test Data
- Certification - TBD
- Encryption - Possible
- Free Access - from 2021

→ *Ready to Use*

3. Future Updates

Versions	Features	Release
V4.1 OCC (AF05, AM95)	Pelvis-Lumbar-Rib Geometry	Jan 2021
V6.1 OCC (AF05, AM95)		
V7 OCC (AM50, AF05, AM95)	Abdominal Soft Tissue	End of 2021

Note:

- *No more updates by Toyota after V4.1, V6.1 and V7*
- *No more supports by Toyota like we did for TB024*

3. Future Updates

MODEL-ORIENTED:

LOAD-SPECIFIC APPLICATION PACKAGES:

STANDARDISATION + HARMONIZATION:

Updates, Next Topics

Pla

Mai
Qu
Release Management

Model Positioning /

Release Management
"Label" needed

Validation Repository /

ent

Handling Test Data

THUMS User Community

Future model updates, application and standardization will be led by THUMS User Community.

Questions?

Further information will be provided by January 2021.