Presentation of EU Horizon 2020 project ”OSCCAR”

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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 GERMANY AUTOMOTIVE GMBH

NETHERLANDS

- SIEMENS DIGITAL INDUSTRIES SOFTWARE

SPAIN

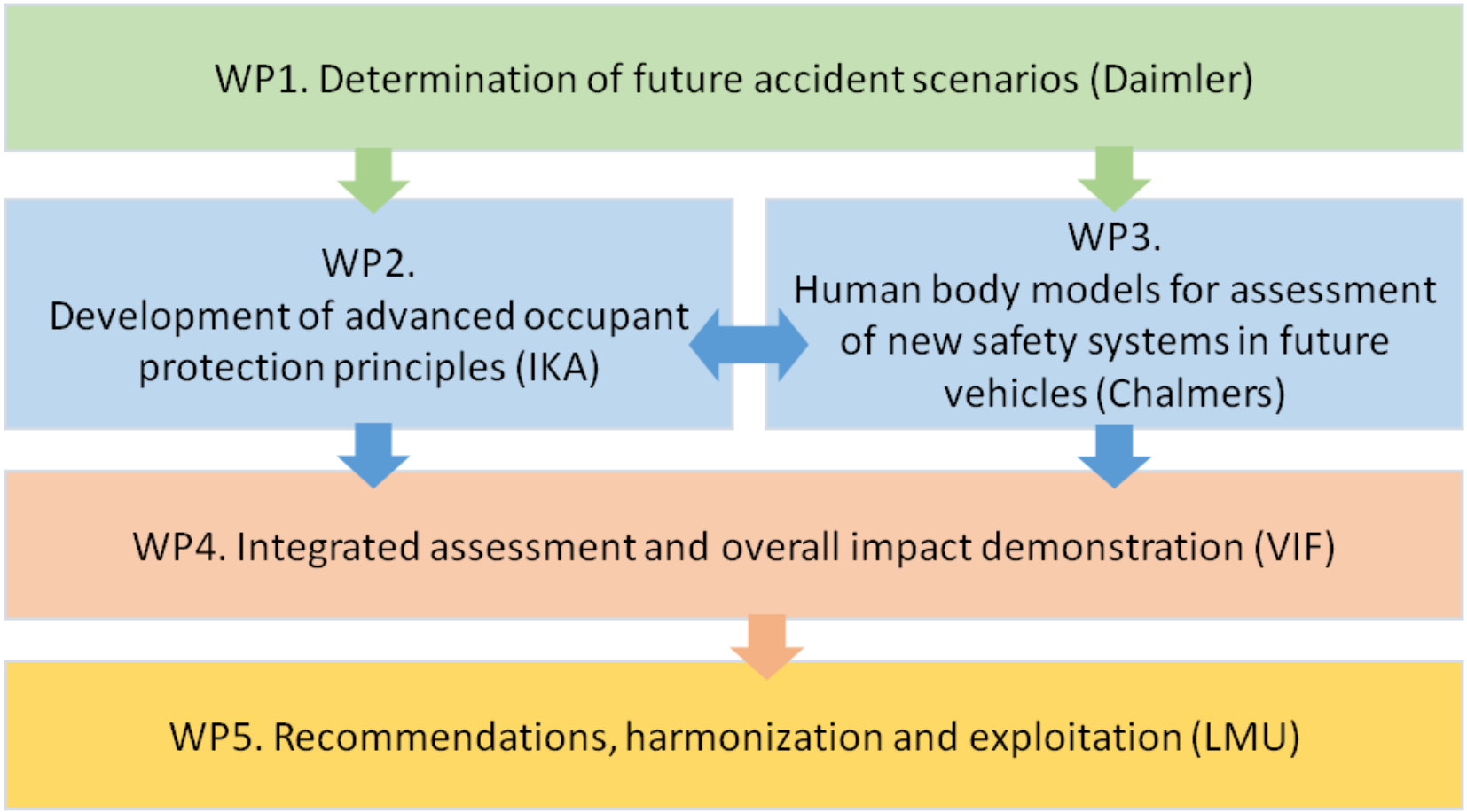
- IDIADA AUTOMOTIVE TECHNOLOGY SA

SWEDEN

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

WP	WP Title	Lead beneficiary	Person-months
1	Determination of future accident scenarios	DAIMLER	85
2	Development of advanced occupant protection principles	RWTH	175
3	Human Body Models for assessment of new safety systems in future vehicles	CHALMERS	240
4	Development of robust and efficient crash simulation tools for integrated assessment & overall impact demonstration	VIF	93
5	Standardization of virtual testing	LMU	50
6	Project Communication, dissemination and exploitation	VIF	32
7	Project Management	VIF	34
8	Ethics requirements	VIF	
Total			**710**

OSCCAR main aims



Brief description of WP1

Objectives:

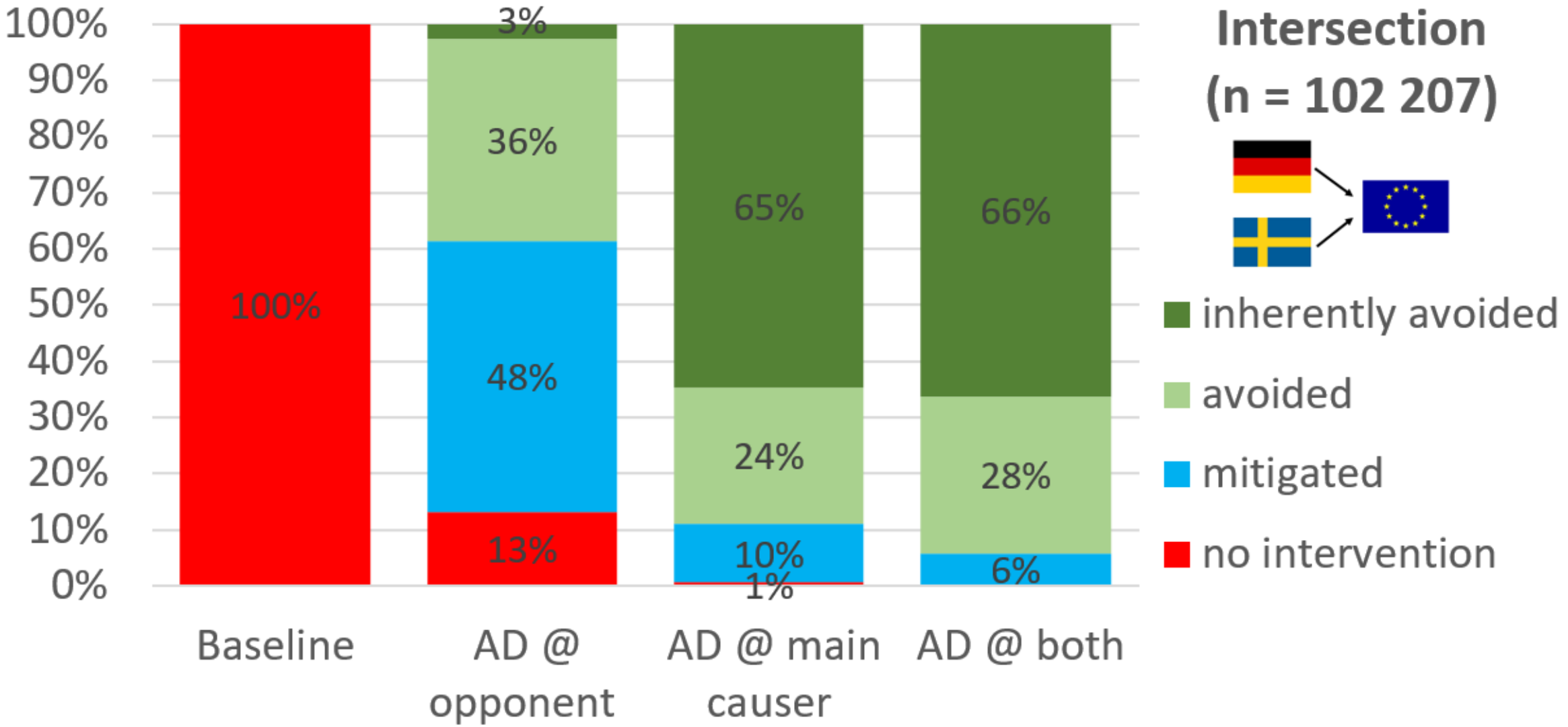
To apply **accident research** and to combine it with **future trend analysis** and insights from other real-world data to derive an **outlook to future remaining accident scenarios**

- Assessment methodology to use real-world crash data for future predictions
- Crash configuration specification & analysis for HAV interiors and seating positions
- OSCCAR pulses – harmonized, future relevant crash pulses for selected crash configurations
- Traffic-based simulation method to obtain and evaluate AD crashes in future mixed traffic in openPASS / COVISE

Deliverables:

- D1.1 - Remaining accidents, crash configurations and crash pulses for virtual assessments
- D1.2 - OpenPASS-based tool to assess AD - use case motorway traffic
- D1.3 - Discussion of validity & robustness of work presented in D1.1 and D1.2

EU weighted results for OSCCAR L4/L5 urban AD

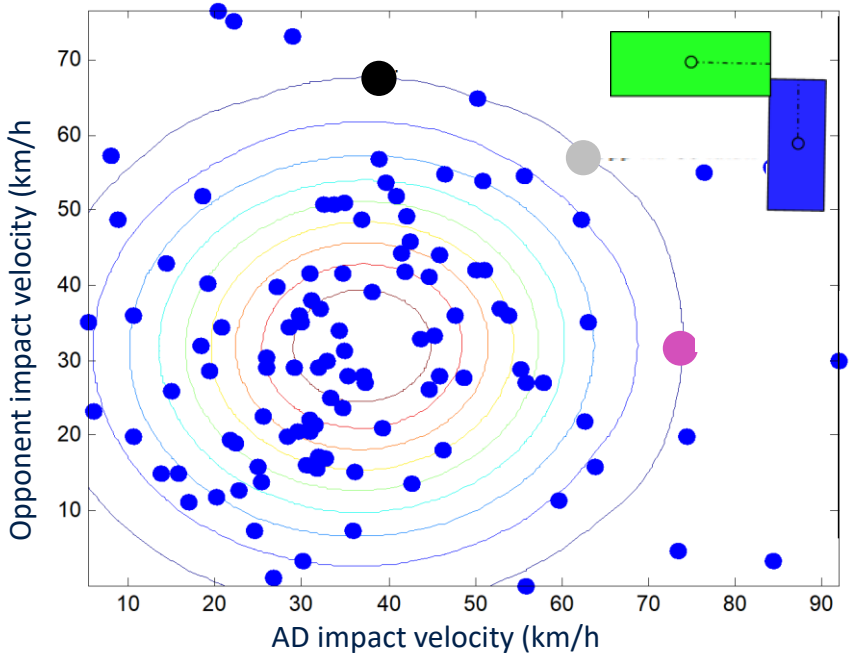


Crash configurations - OSCCAR pulses SCP & LTAP/OD

- For AD vehicles in urban areas, two crash configurations were identified and evaluated
- Aim: reveal new challenges for occupant safety in AD vehicles
- Generic pulses were derived and are publicly available

SCP 1 (N = 106)

- AD 37km/h Opponent 68km/h
- AD 63km/h Opponent 58km/h
- AD 74km/h Opponent 33km/h



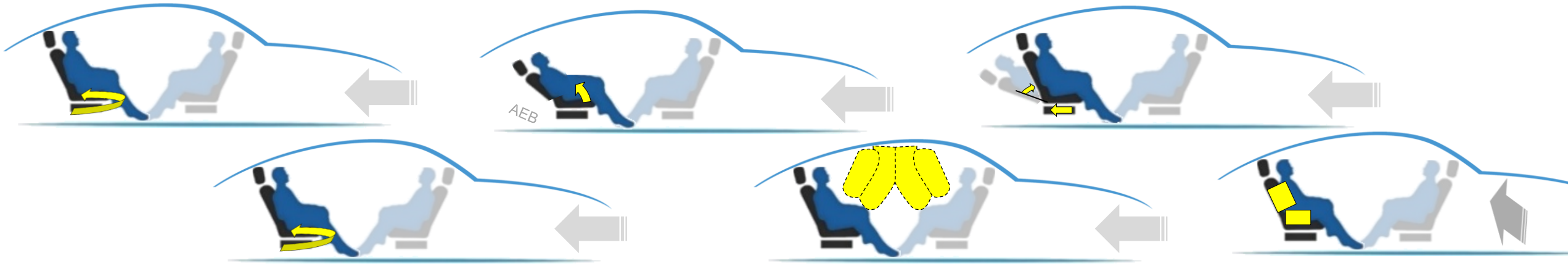
Östling et al., (2019) "Predicted crash configurations for Autonomous Driving vehicles in mixed German traffic for the evaluation of occupant restraint system"

Brief description of WP2

- Objectives
  - Defining future occupant positions and postures in HAV
  - Defining future test cases
  - Development and demonstration of protection principles (pre-crash & in-crash phase) for these test cases

Protection Principles

#1 Pre-Rotated Seat	#2 Seat Inertia *(seat rotation initiated by braking pulse)*	#3 Reclined Occupant - Pelvis & Lumbar Aspects	#4 Mushroom Airbag	#5 Active Seat Backrest	#6 Far-Side Load Case



Protection Principle 3 - Reclined occupant

- Working Group 3:
  - **Autoliv**, Mercedes-Benz, Toyota, Volvo Cars, Volkswagen, ZF
- Avoiding submarining:
  - Increased pelvis loading from the lap belt
  - Increased lumbar spine loading due to unfavourable kinematics
- Protection Principle:
  - Restraint system: Seat load limiter, forward positioned seat belt anchor points, lap belt pretensioning, etc.
  - Seat integrated: Crush element, energy absorption in x / xz direction
- Initial sitting postures

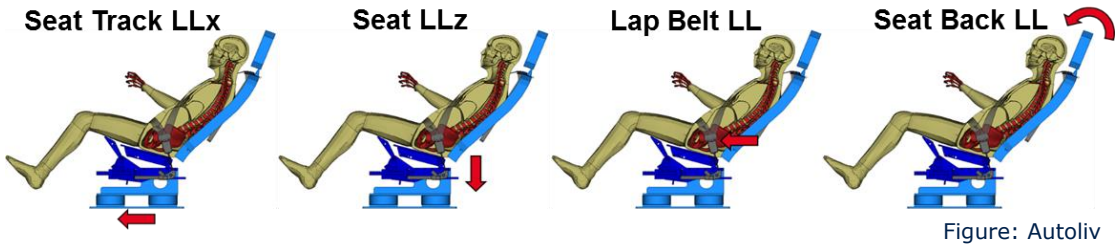


Figure: Autoliv

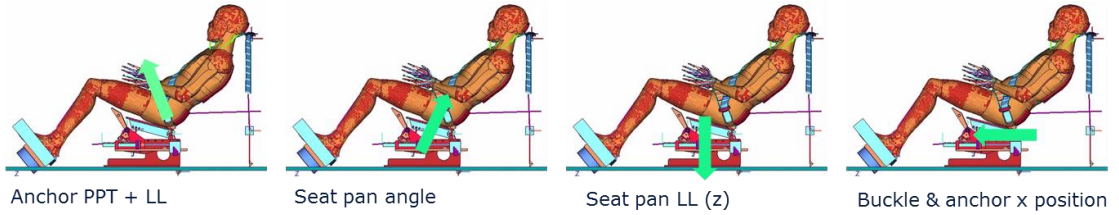


Figure: Volkswagen

Figure: Mercedes-Benz

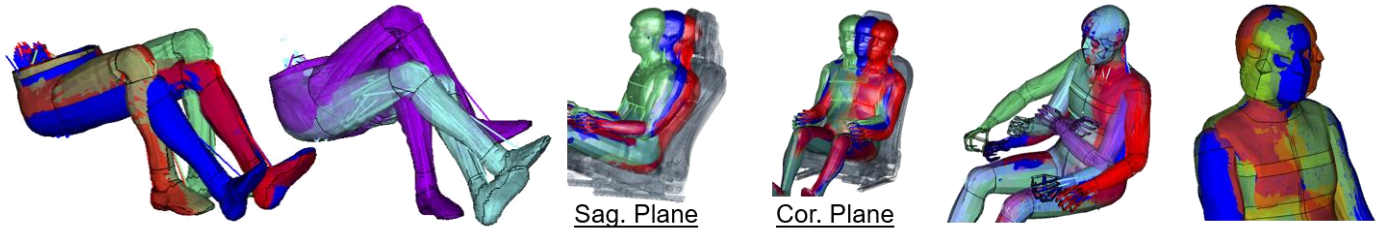


Figure: Volvo Cars

Protection Principle 3 - Reclined occupant

- Demonstrator test case is on a reclined seating position
- Three sled test series at BASt with THOR-50M dummy:
- Validation of sled and environment model in three codes:
  - LS-Dyna, VPS & Madymo

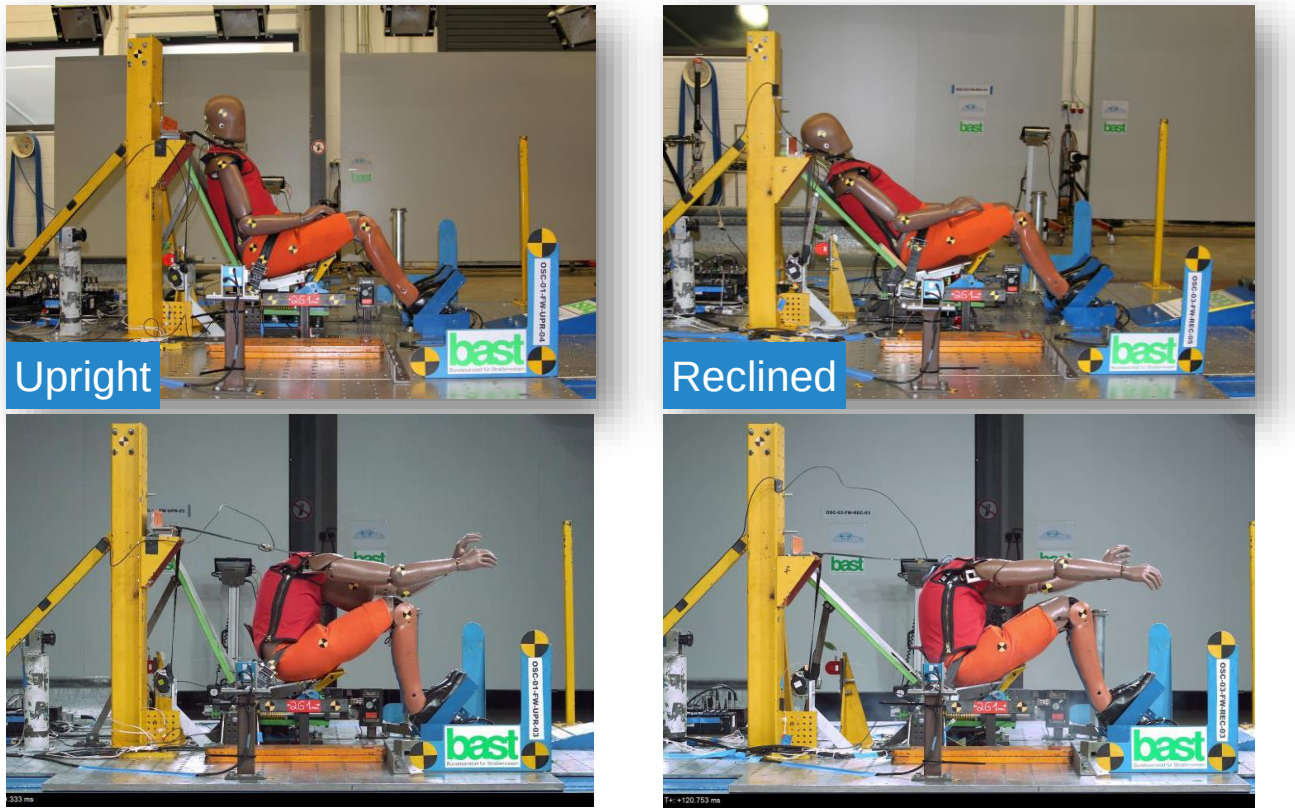
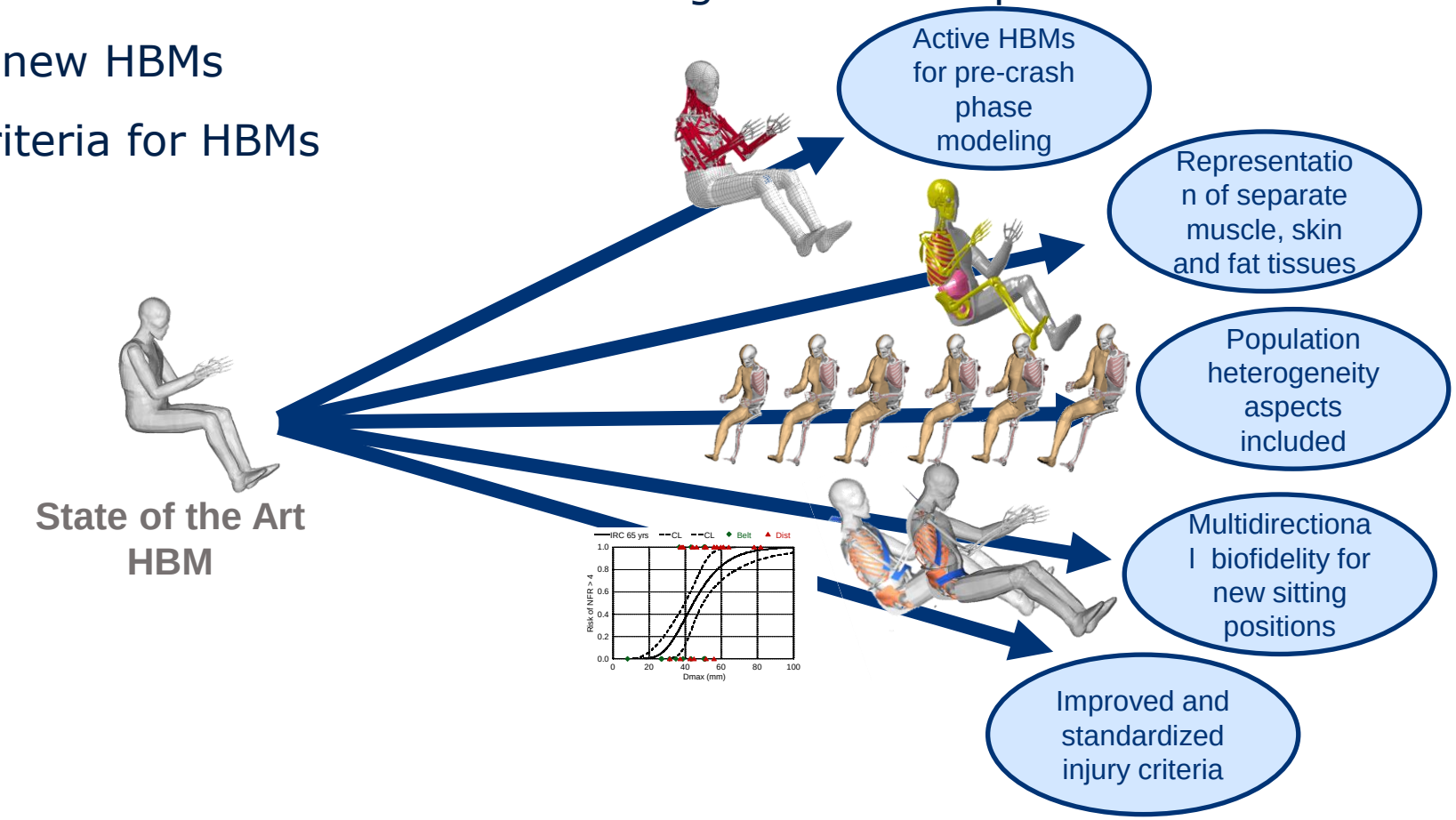


Figure: BASt

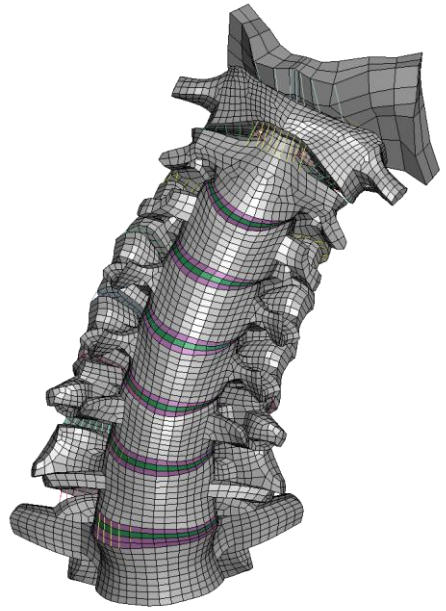
Brief description of WP2

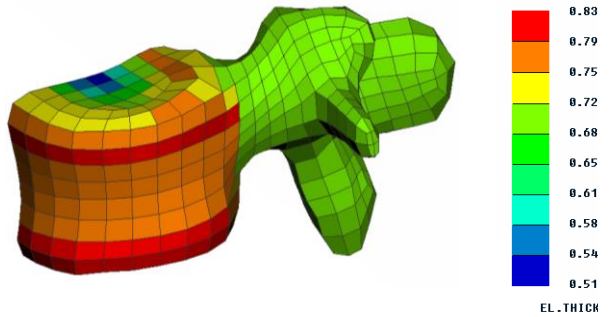
- Provide Human Body Models (HBMs) for the design of superior restraints
  - Develop sub-models and methods to be used in the developments of HBMs
  - Analyse biomechanical data and make this and models of original test setup available
  - Improve existing or develop new HBMs
  - Provide harmonized injury criteria for HBMs

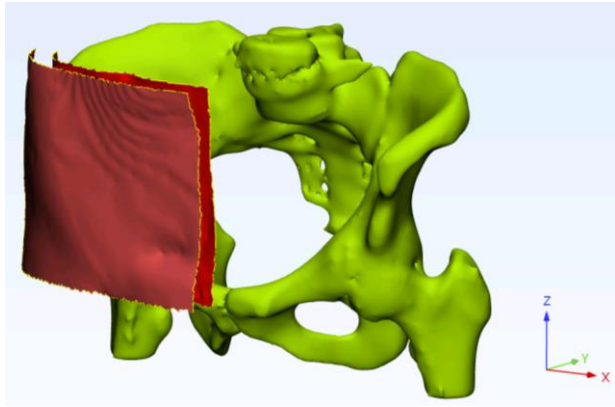


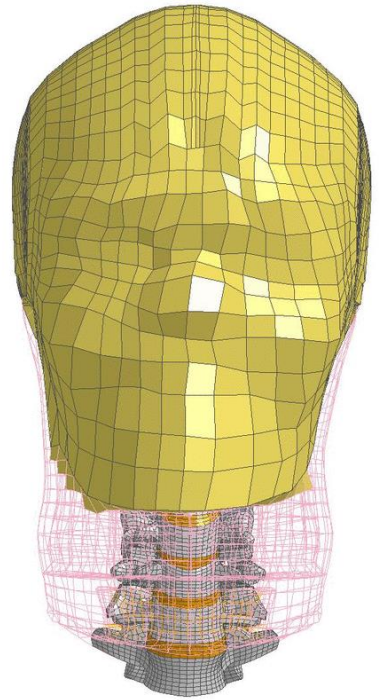
Some results in WP2

- Material modelling soft tissues
  - Skin LS-DYNA + VPS
  - Fat LS-DYNA + VPS
  - Advanced muscle LS-DYNA + VPS
  - Simplified muscle LS-DYNA + VPS
  - Ligaments LS-DYNA + VPS
- Advanced FE-models for HBMs
  - Neck
  - Lumbar spine



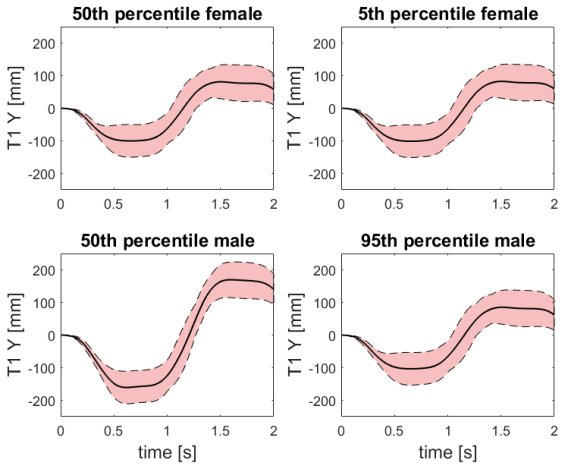






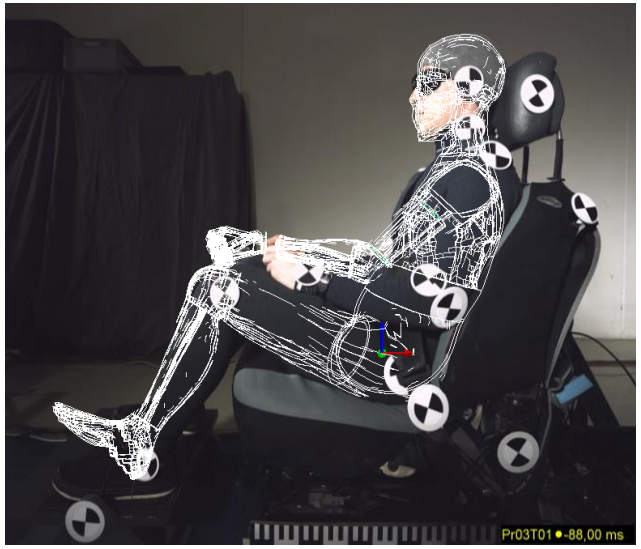
Some results in WP2

- Validation data for Active HBM
  - Test data analyzed and shared via https://zenodo.org/x
  - Models of original test environments generated and shared via
  - https://openvt.eu/osccar/precrash_seat_models/x
  - Advanced statistical analysis of volunteer data – validation data for Active HBMs of any sex, stature and age



Examples of results from statistical analyses of volunteer data

- Effect of AHBM positions on response in pre-crash simulations – a guide for future volunteer test and use of data

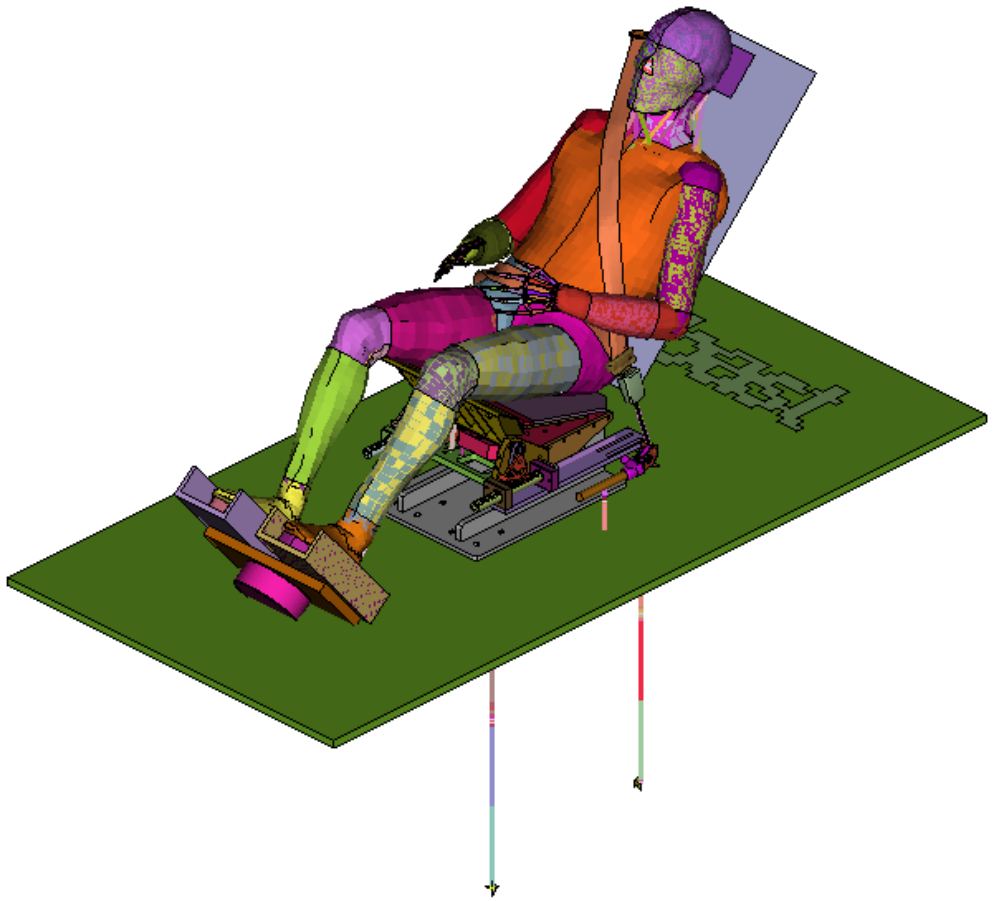


Achievements and results WP4
Homologation testcase - Combining OSCCAR results

Pre-Crash Pulse
WP 2

In-Crash Pulse
WP 1

Validated environment model in 3 codes
WP 2



Open source tool for HBM positioning
WP 4

Harmonized landmark definitions
WP 5

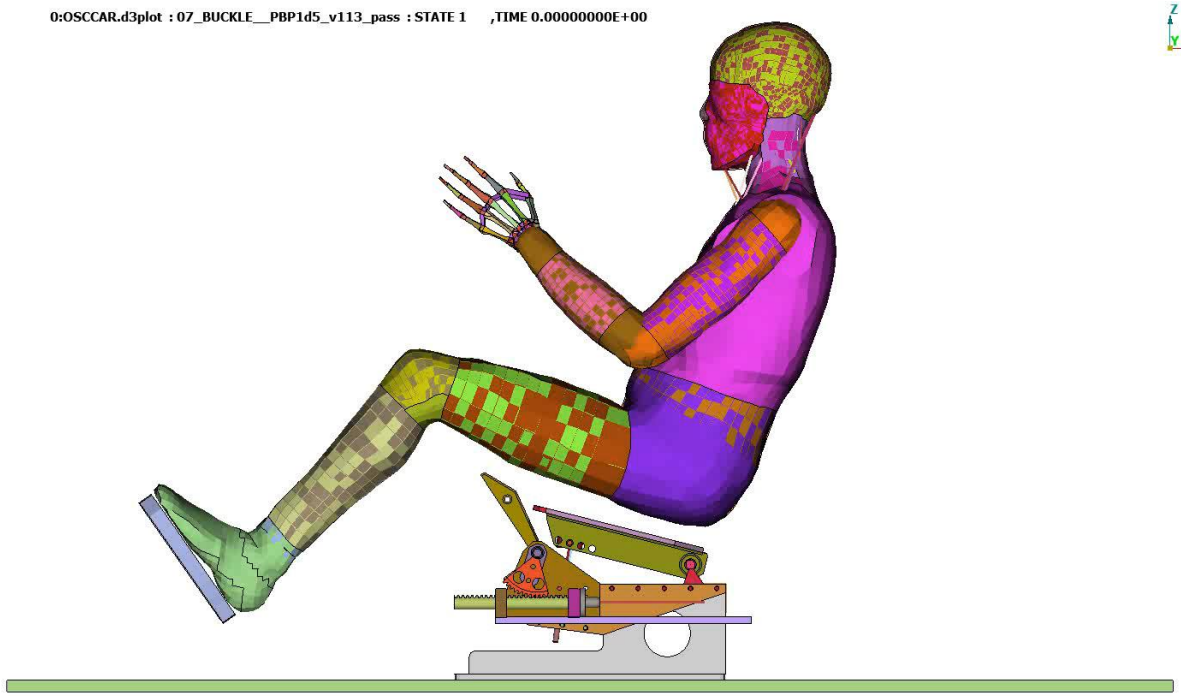
Harmonized injury indicators / risk
WP 3

Harmonized post processing
WP 4

Achievements and results WP4
Tools for handling HBMs – Transition

Enhancement of Dynasaur

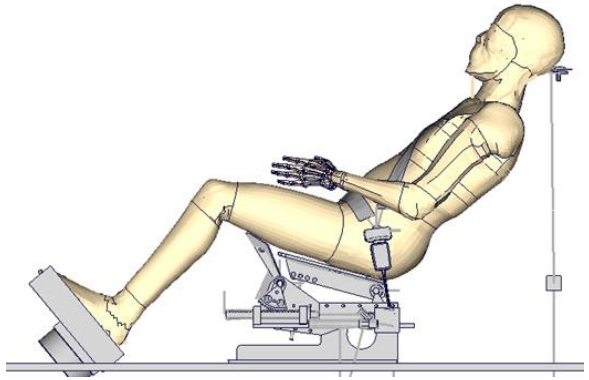
- Open source tool “DynaSaur” (by TU Graz – available under GPL v3 license) is enhanced
  - https://gitlab.com/VSI-TUGraz/Dynasaur
- Postprocessing can be done without using the GUI
  - .csv file is created based on simulation output files for selected output
- Routine for Madymo results
- Routine for selected VPS result files
- Numerical quality check criteria
- Rib injury criteria (incl. OSCCAR update)



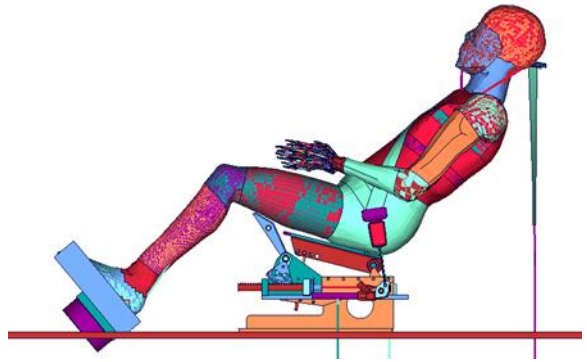
Achievements and results WP4
Homologation testcase

Simcenter AHM v3.1

THUMS TUC v2020.01 VPS

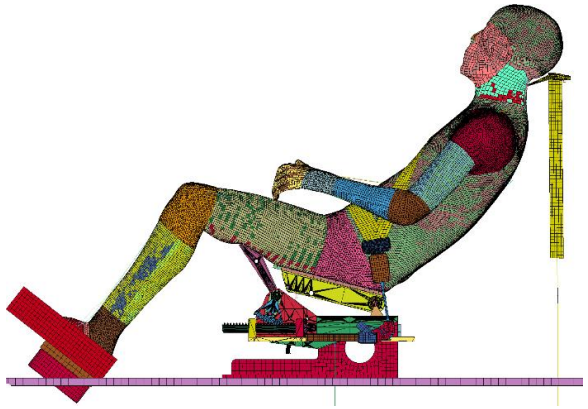


THUMS TUC v2020.01 LS-Dyna

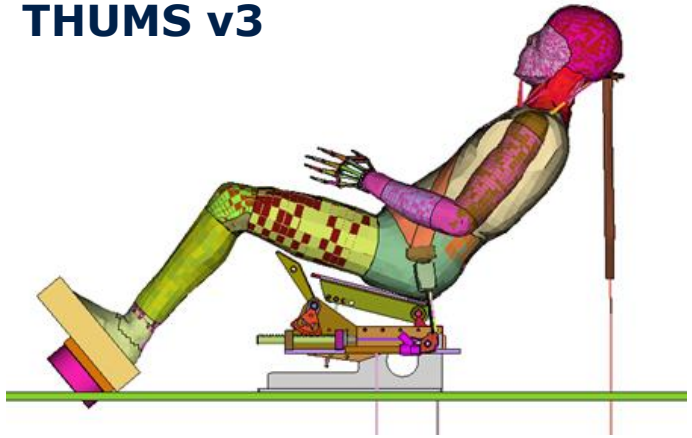


SAFER HBM v9

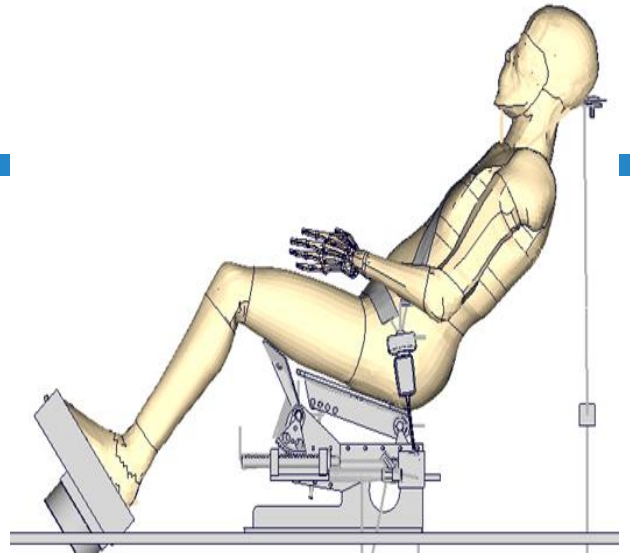
THUMS v6.1



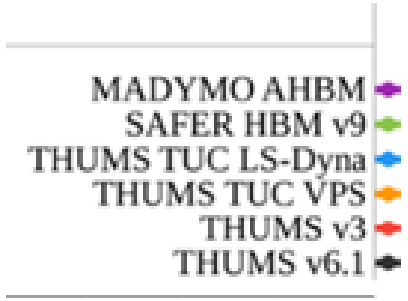
THUMS v3

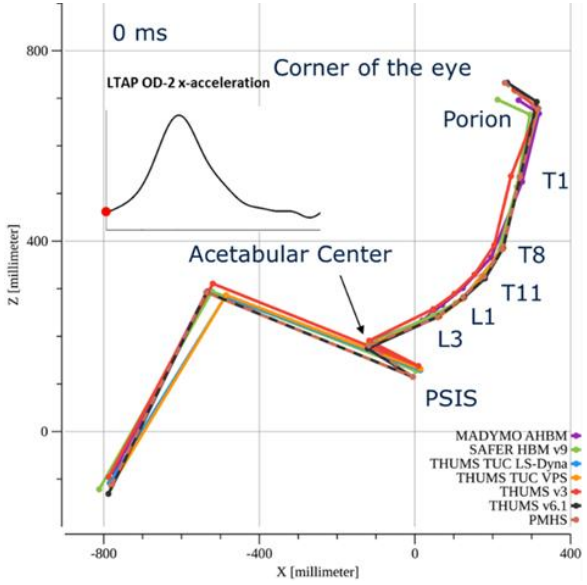


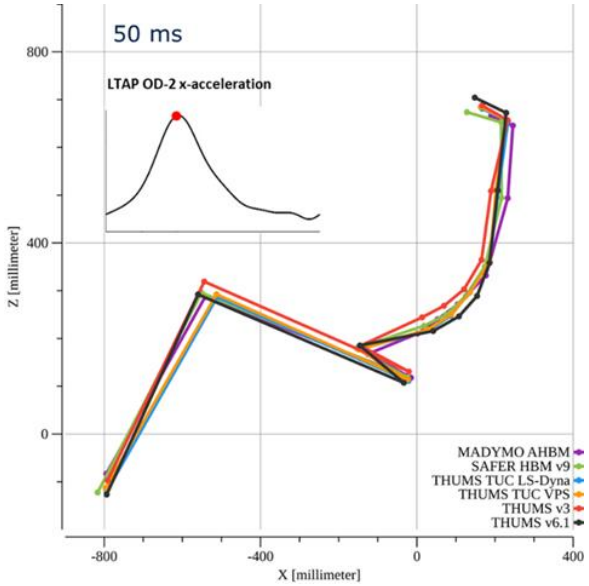
Achievements and results WP4
Homologation testcase

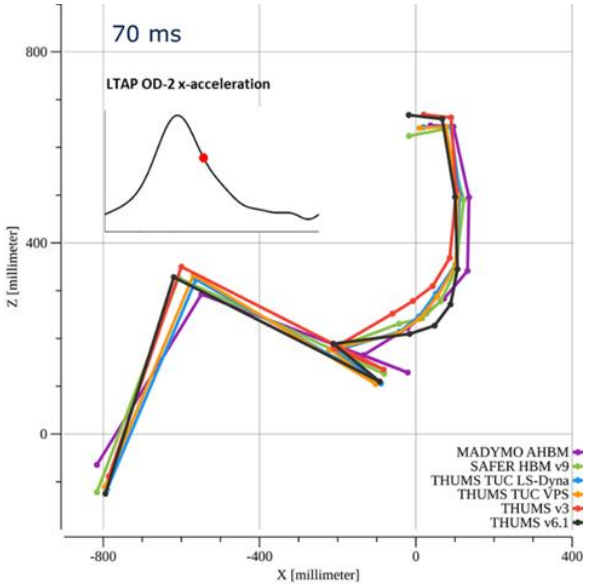


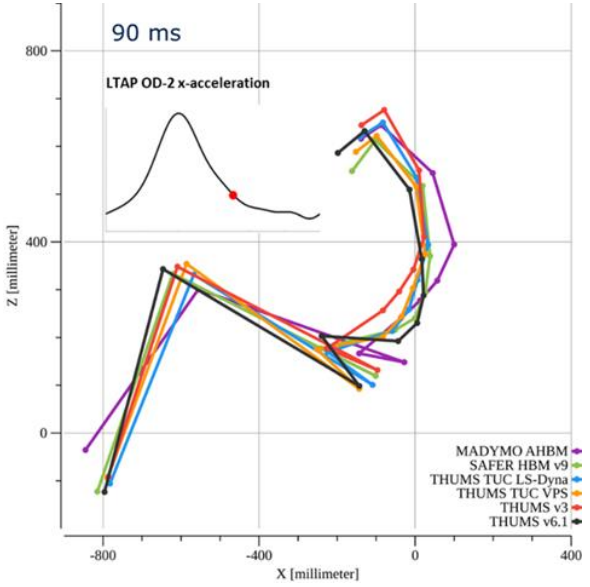
- Kinematic depiction by anatomical landmarks









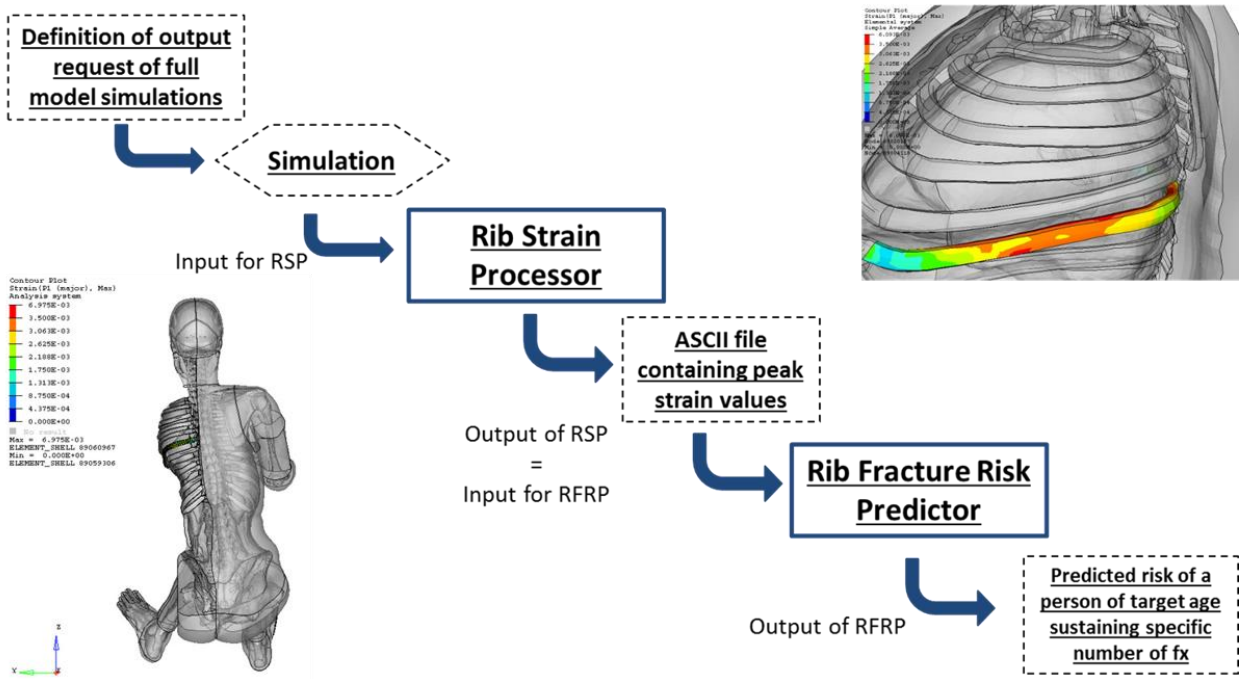


Main objectives WP5

- Make recommendations for substantial use of virtual testing for complex testing scenarios
  - To complete proposal for Virtual Testing procedure
  - To provide elements of harmonised model preparation (pre-processing)
  - The validation of occupant environment models
  - To address the challenges specific for the validation of HBMs
  - To show which result assessment can be harmonised (post-processing)
  - To make recommendations for use of Injury Criteria (AIS2)

Achievements and main results WP5

- Harmonisation in Rib fracture risk estimation
  - First definition of excluded rib cortical bone elements
  - Outer surface for strain extraction instead of mid-surface
  - Weibull risk curve instead of step-function
  - Strain-time gradient 0.4 as indicator for element removal (filtering)
  - Highlighted need for further multi-level model validation



Example TUC tool

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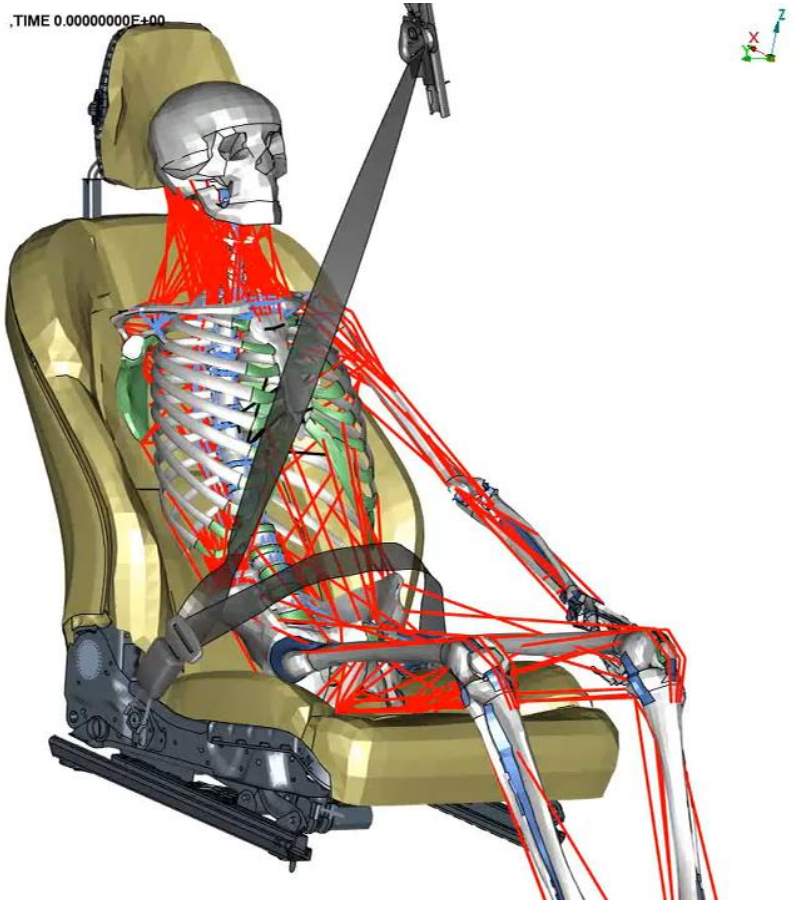
www.osccarproject.eu

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

Protection Principle 5 - Active Seat Backrest

- Working Group 5:
  - **ika/fka**, Bosch, Siemens, Volvo Cars, ZF
- Motivation:
  - Reclined forward-facing: Submarining tendency, unfavourable head neck kinematics due to increased distance to airbag
  - Reclined rearward-facing: Ramping & a reduced effective restraint area of the backrest leading to higher occupant displacements
- Protection Principle:
  - Occupant repositioning from a reclined seating position to an upright position prior to a crash
  - Backrest is actively rotated/upraised
  - Electric Reversible Retractor and optimised seat base energy absorption



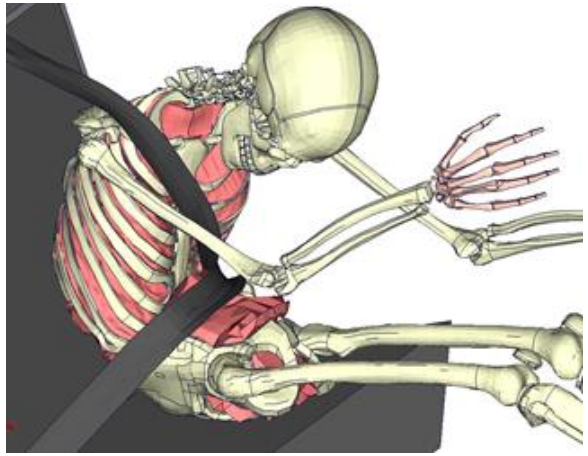
Video: Volvo Cars

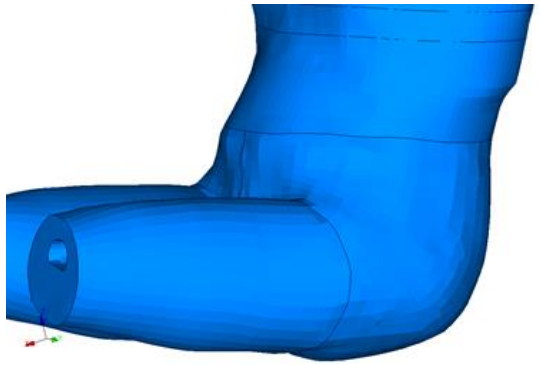
Challenges in WP2

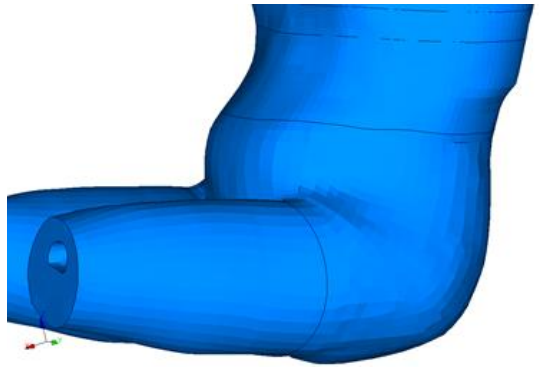
- Repositioning of the occupant into a conventional or “safer” seating configuration prior to a crash
- Considering occupant variety
- Considering omnidirectional occupant loading

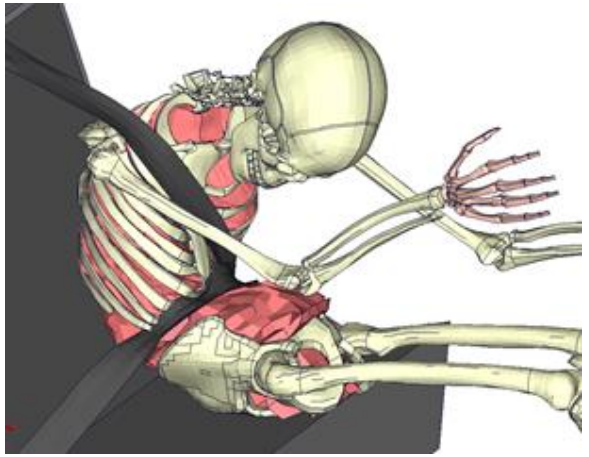
Task 3.1 - Improved HBMs for injury risk prediction

- Assess the effect of soft tissue thickness and updated soft tissue models
  - Integration of fat and skin material models and abdomen fat geometry update
  - Application to a generic crash at 7.8 m/s
  - Variation in submarining risk, depending on loading/boundary conditions and thickness and material models used



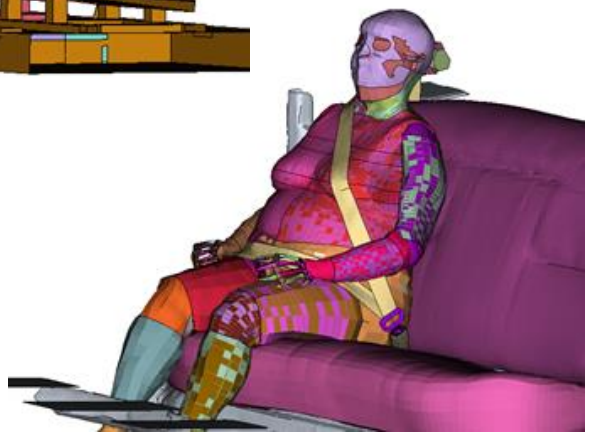


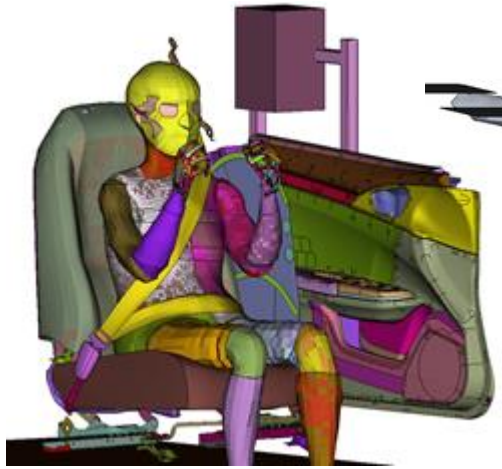


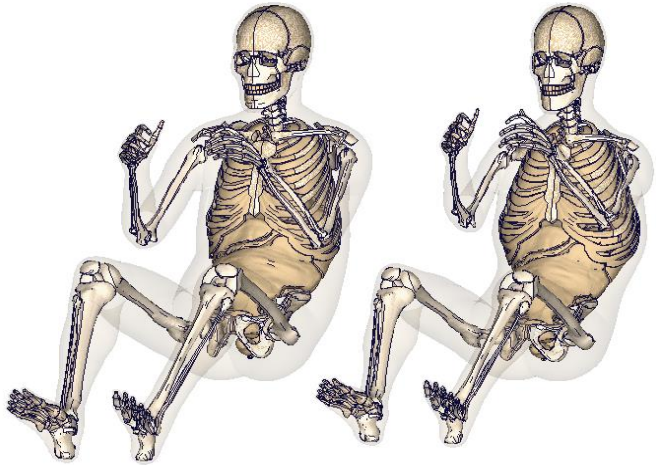


Task 3.1 - Improved HBMs for injury risk prediction

- Representation of diversity using HBMs
  - Morphed SAFER HBM to match Age, Sex, Stature and Weight of PMHSs used in past tests
  - Apply boundary conditions from test
  - Compare responses to assess the quality of morphing tools
- Special HBMs were developed for selected markets





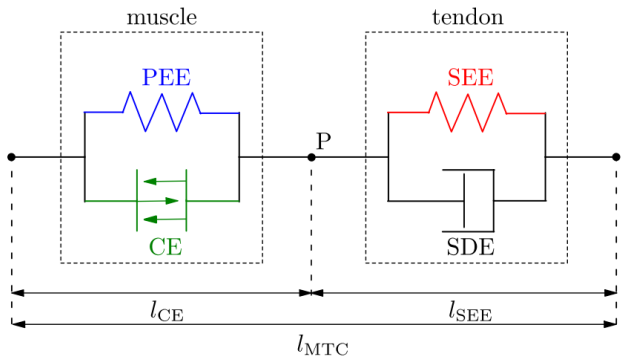


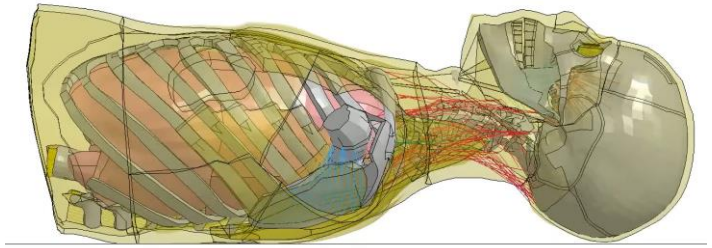
THUMS V4

Asian 50th Male

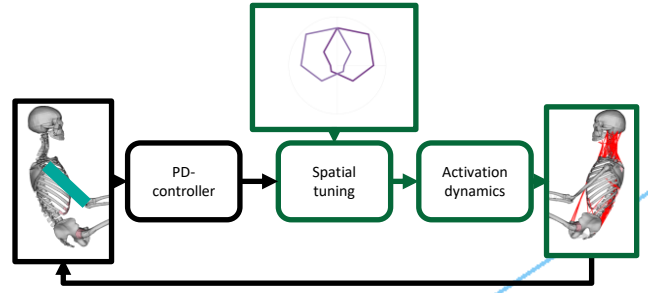
Task 3.2 - Improved HBMs for pre-crash simulations

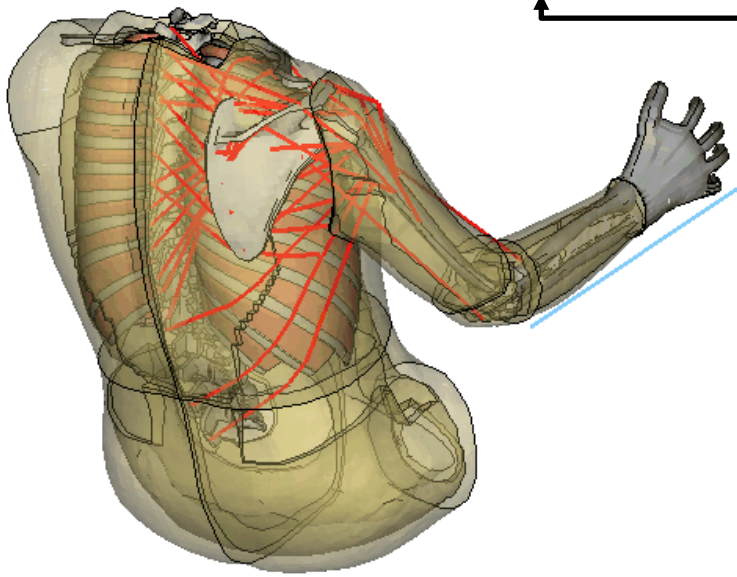
- Model developments
  - Stability and evaluations of integrated muscle controllers
  - Kinematic controllers





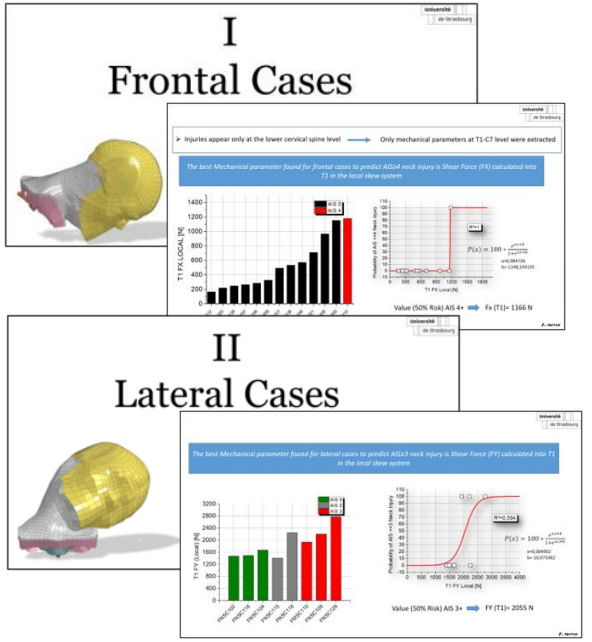
- New shoulder muscle control system
  - Required to model steering wheel interactions
  - Capacity to model antagonist and synergist muscles

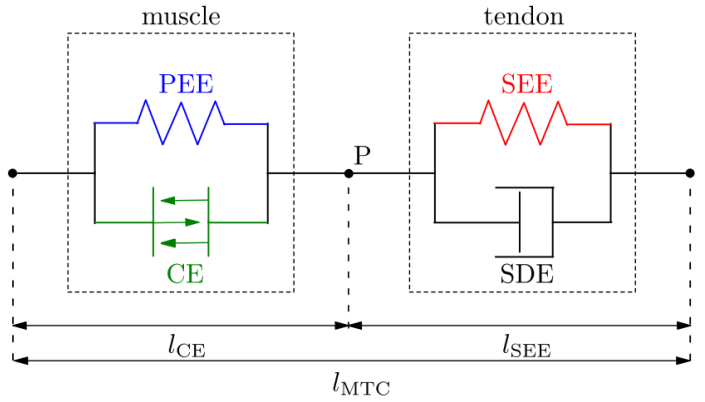




Task 3.3 - Injury prediction in new sitting positions and new crash scenarios

- Injury Criteria
  - Neck injury
    - SUFEHNM* evaluated under an array of accident cases to develop injury criteria
    - First omnidirectional neck injury criteria for HBMs
  - Muscle
    - Strain-based injury criteria; predicts the risk of muscle stretch
    - Based on the extended Hill-type material model**





*SUFEHNM –Strasbourg University Finite Element Head Neck Model

**Kleinbach et al 2017

Overall Objectives of WP4

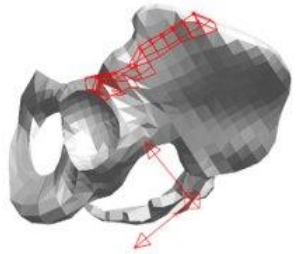
- Develop…
  - a **quality check** method tool for virtual testing with HBMs tool independent software
  - an integrated **assessment tool chain** for crash simulation using **HBMs**
    - for MBS and for FEM simulation
    - using the same general input and assessment method
- Demonstrate…
  - the effectiveness of the new advanced protections system when developed with adequate HBMs

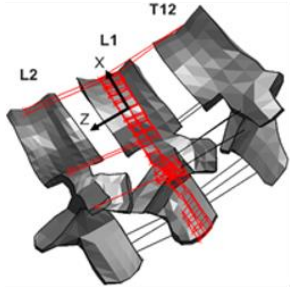
Objectives WP4

- Development of a positioning method for HBMs
- Development of a method / tool to handover HBM kinematic information from pre- to in-crash simulation
- Homologation testcase
  - Partners conduct HBM simulation under harmonized boundary conditions + harmonized assessment
  - Application and enhancement of OSCCAR results

Achievements and results WP4

- Injury indicators
  - Lumbar spine forces / moments
  - ASIS forces

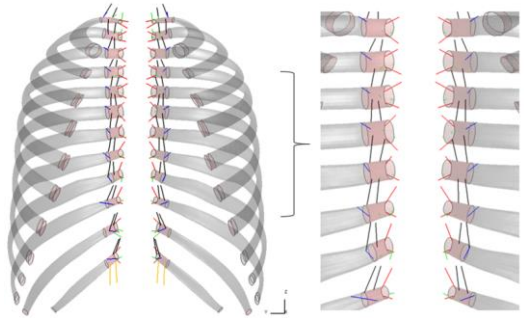




- Injury risk parameters
  - Head injury risk (analysed with SUFEHM)

Model	HIC15	HIC 15 AIS 2+	BRIC	BriC MPS AIS2+	SUFEHM [kPa]	SUFEHM_RISK [%]	A3MS
SAFER HBM v9	102	3%	0.68	75%	6.29	7%	37
Madymo AHM	136	7%	0.72	81%	5.27	6%	40
THUMS TUC LS-Dyna	117	5%	0.51	47%	5.02	6%	37
THUMS v6.1	202	19%	0.82	91%	5.01	6%	47
THUMS v3	108	4%	0.67	74%	4.96	6%	36
THUMS TUC VPS	106	4%	0.60	62%	5.87	6%	37

- Rib strain determination according to OSCCAR Task 3.3

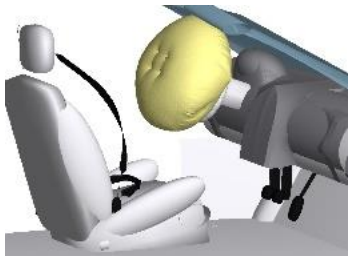


- Harmonized simulation result processing with Dynasaur (https://gitlab.com/VSI-TUGraz/Dynasaur)

Achievements and main results WP5

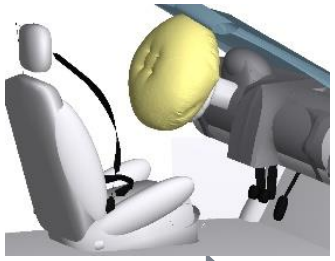
Phase 1: Vehicle Model Development

Vehicle Environment Simulation Model development by OEM)



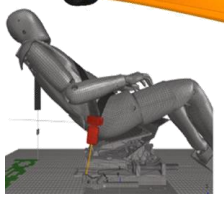
Code-specific **quality requirements** (numerical correctness, discretisation, convergence, element quality, control settings etc.)

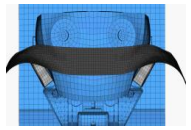
Model calibration/validation based on previous models, data (e.g. material data base) and validation tests



Calibrated Vehicle Environment Model – status frozen (ready for VT)

Phase 2: Vehicle Model Validation





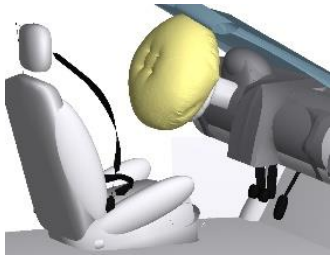
Validation Simulations performed by (OEM)

Simulation data

Objective correlation procedure

Test data

Hardware Validation Tests (performed or witnessed by Technical Service)

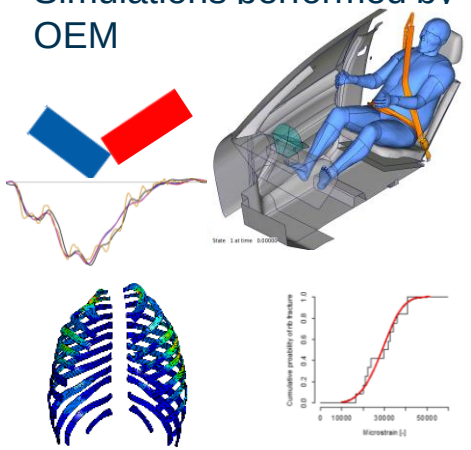


Officially Admitted/ Certified Vehicle Environment Model

Phase 3: Homologation / Assessment

Full Virtual Testing with HBM in new load case:

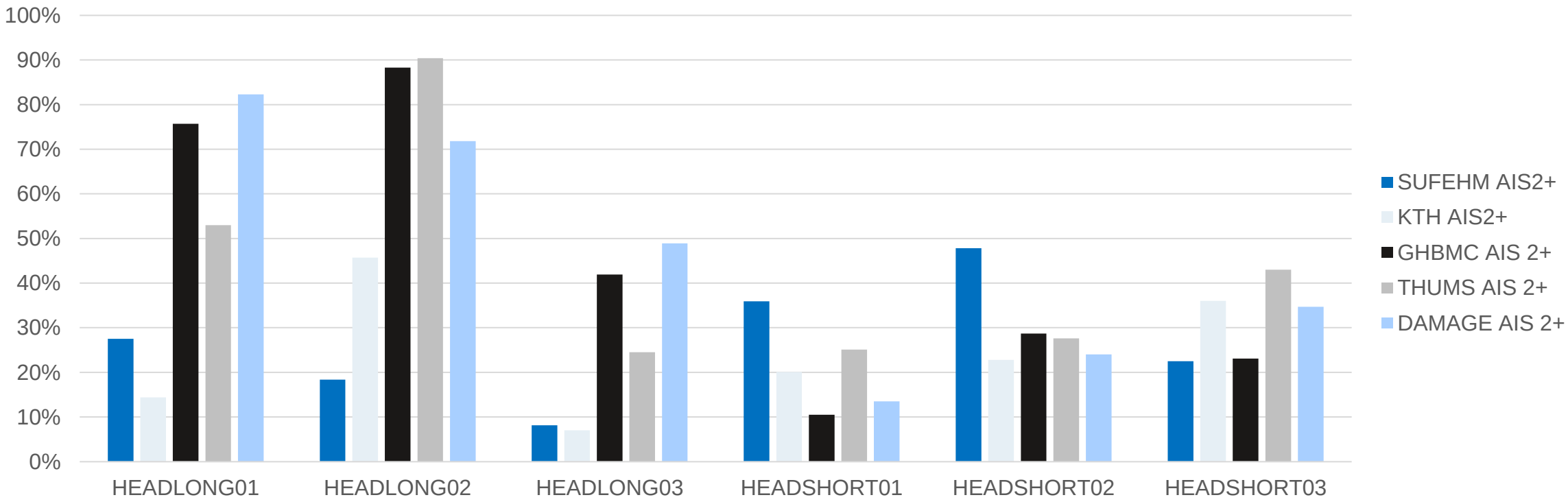
- Simulations performed by OEM



- Test tool: HBM certified for new load case
- Standardised virtual test procedure (Occupant positioning, belt installation,...)
- HBM based assessment criteria (kinematics/injury)

Achievements and main results WP5

- Comparative simulations in brain injury risk estimation
  - Differences observed and recommendations for next steps derived
  - Importance of underlying data



Achievements and main results WP5

- Abdomen/Submarining measurement proposed:
  - Kinematic based on position of lap-belt centre line relative to ASIS
  - Complemented by Section forces through iliac wing