

# Validation Procedure for a Vehicle Environment Model to be used for HBM-based Virtual Testing as developed in OSCCAR

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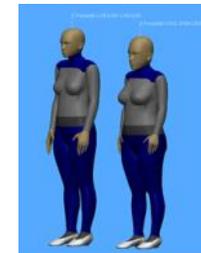
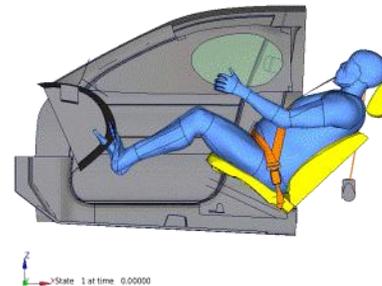
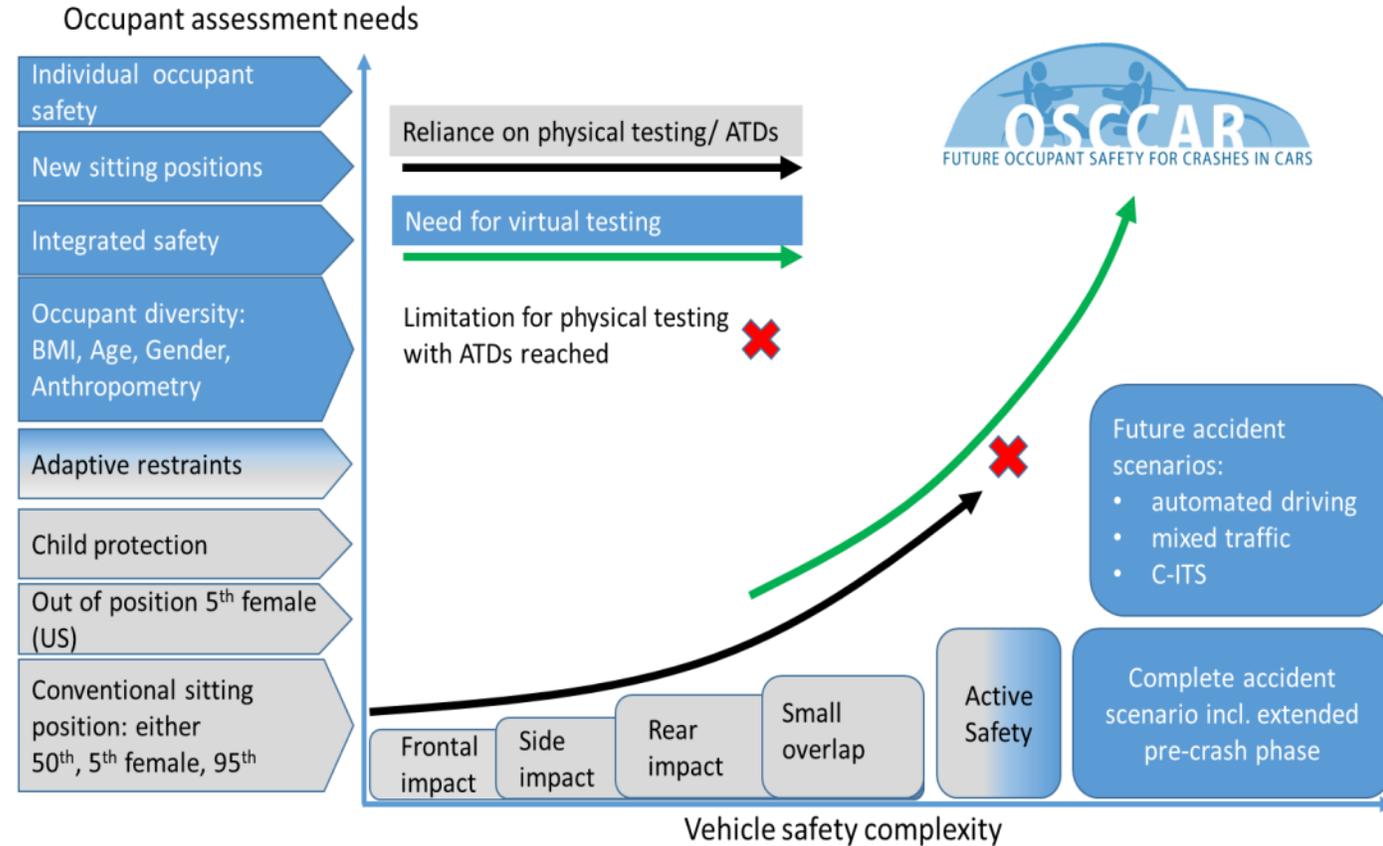
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# “Full Virtual Testing” approach with HBMs

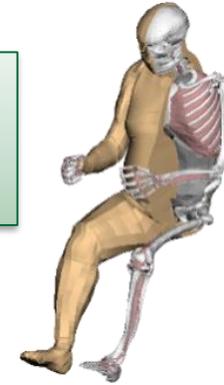
## Motivation for Virtual Testing

- 1.) **Replace existing RT** (real testing) based procedures/ regulations by VT (virtual testing) → with focus on **saving costs and test effort** (no new tests/ requirements)
- 2.) **Extent the scope of protection** by adding test conditions using existing test tools (ATDs) and procedures by combined real and virtual testing (hybrid approach/grid approach) → First Euro NCAP Far-Side Pilot
- 3.) **HBMs in a VT process** to address the limitation of ATDs → **EU-Project OSCCAR**: HBMs for new seating postures, user diversity (small vs. tall, male vs. female, Western vs. Asian), obesity,...



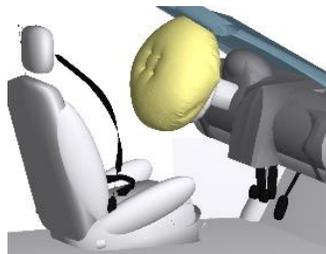
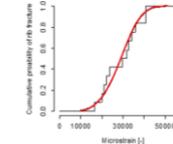
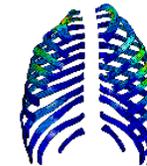
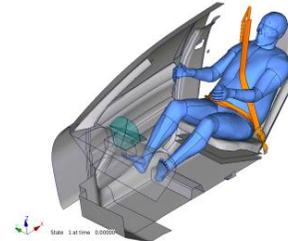
# What is needed for a Virtual testing procedure with Human Models?

**Human Body Model  
(certified for New  
Load case)**



## HBM based Safety Assessment Simulation Procedure

Full Virtual Testing with HBM in new load case



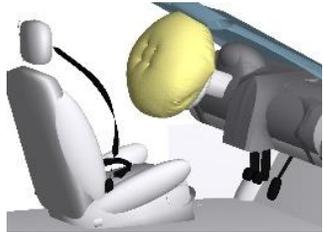
**Vehicle Environment  
Model certified/approved  
for VT**

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

# OSCCAR HBM based Full Virtual Testing procedure

## Phase 1: Vehicle Model Development

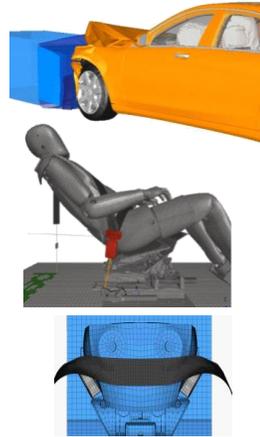
Vehicle Environment Simulation Model development by OEM



Code-specific **quality requirements** (numerical correctness, discretization, convergence, element quality, control settings etc.)  
**Model calibration** based on previous models, test data (e.g. material data base) and validation tests

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

## Phase 2: Vehicle Model Certification (Validation check)



Validation Simulations performed by (OEM)

Simulation data

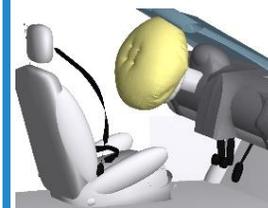
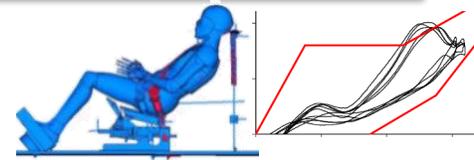
Objective Acceptance Criteria

Test data

Hardware Validation Tests (performed or witnessed by NCAP/Technical Service)



## HBM Certification / Validation Requirements for New Load Case



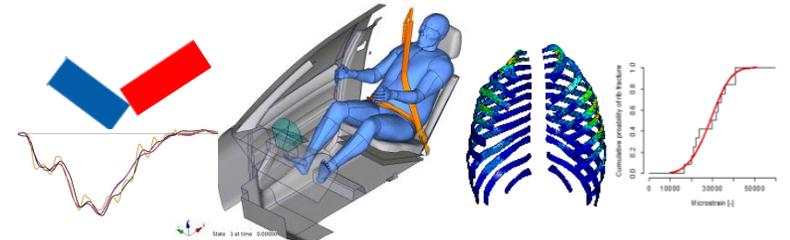
Vehicle Environment Model certified /admitted for VT

## Human Body Model (certified for New Loadcase)



## Phase 3: Safety Assessment Simulation

Full Virtual Testing with HBM in new load case:



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

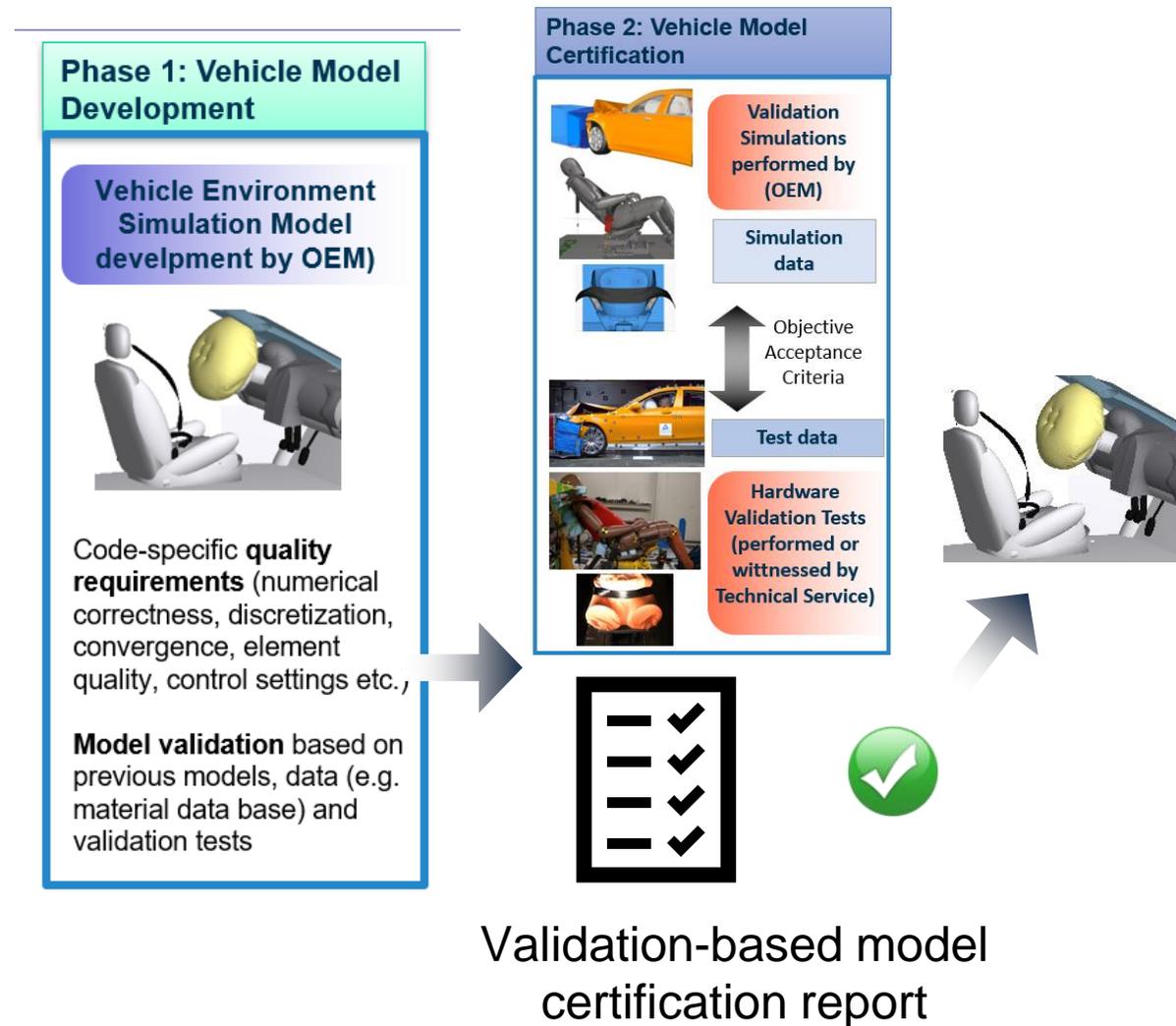
# Workflow of validation-based procedure (responsibilities of involved parties)

## Phase 1 (OEM internal) model development

At the end of Phase 1 vehicle model should be ready for VT → Model status should be frozen

## Different options for the workflow/time sequence and responsibilities of stakeholders for Phase 2:

**Option A.)** Phase 2 “Vehicle environment validation check” is based on **validation report** provided by vehicle manufacturer including validation test results and simulation results (tuned to validation tests)  
→ Model admitted to VT based on OEM validation report



# Workflow of validation-based procedure (responsibilities of involved parties)

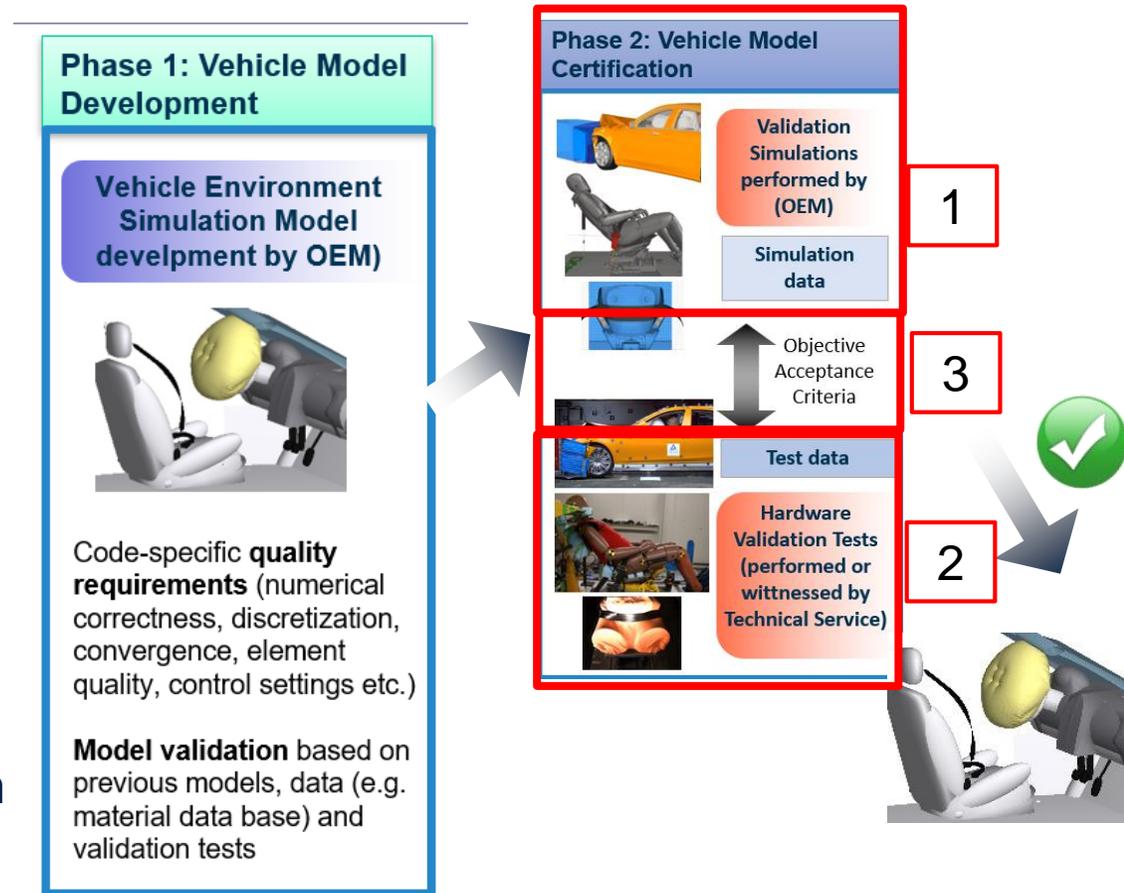
**Option B.)** Phase 2 “Vehicle environment validation check” is based on validation testing carried out (or witnessed) by technical service/NCAP:

1<sup>st</sup> step: OEM provides detailed simulation results for all validation load cases

2<sup>nd</sup> step: Technical service or NCAP lab carries out (all or selected) validation tests (or witnessed tests)

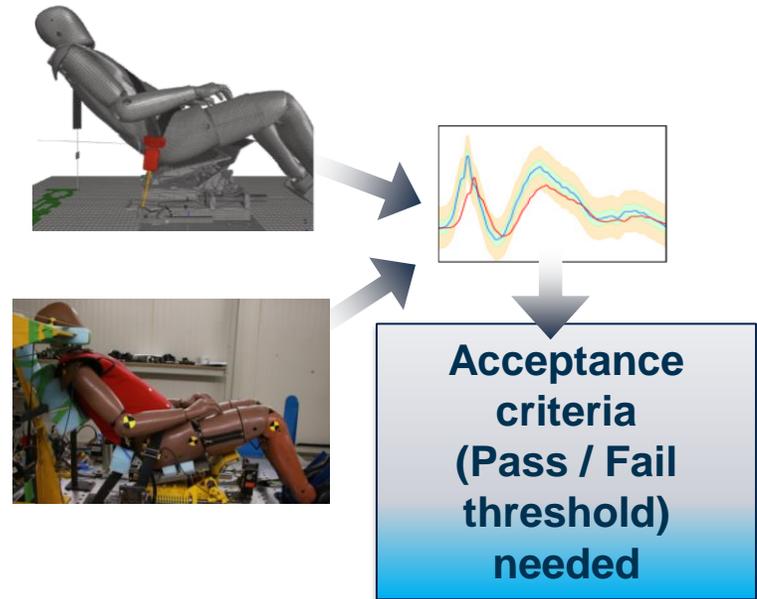
3<sup>rd</sup> step: Based on objective acceptance criteria vehicle model is certified for use in Phase 3 (HBM based VT safety assessment)

→ Option B could be done on a case-by-case decision depending on trust or a selected (sub-)set of validation load cases



# Objective procedure needed to assess the correlation of simulation and test data

- Option B will provide more trust in simulation model and VT based assessment
  - However, reliable validation acceptance criteria are needed **considering test scatter in real test!**
- Pass/Fail criteria to distinguish valid and non-valid model response
- **Demanding** enough to assure the trustworthy and reliable validation of vehicle environment
  - **Achievable** thresholds to make sure validation can be fulfilled, if no RT based alternative is available

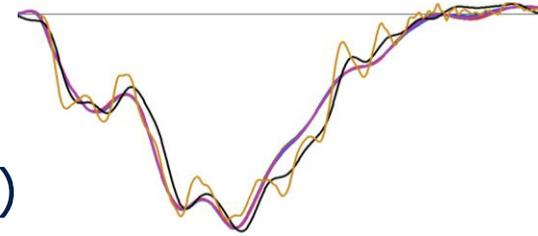


- CORA or ISO rating?
- Overall model rating or individual thresholds per channel?
- Weighing factors based on test scatter?

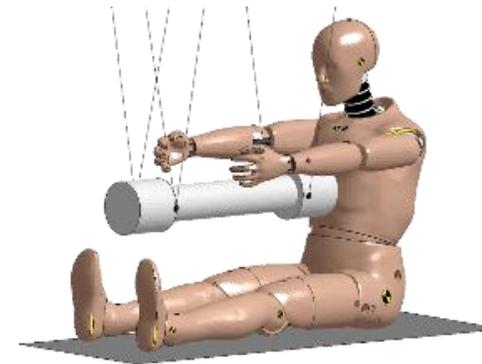
## How to consider test scatter in validation procedure?

Three main sources of test scatter:

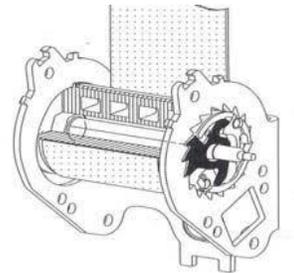
(1) Scatter in real test procedure  
(pulse, dummy positioning, belt routing,...)



(2) Variation in validation device  
(hardware dummy/tool variation)



(3) Variation in vehicle components



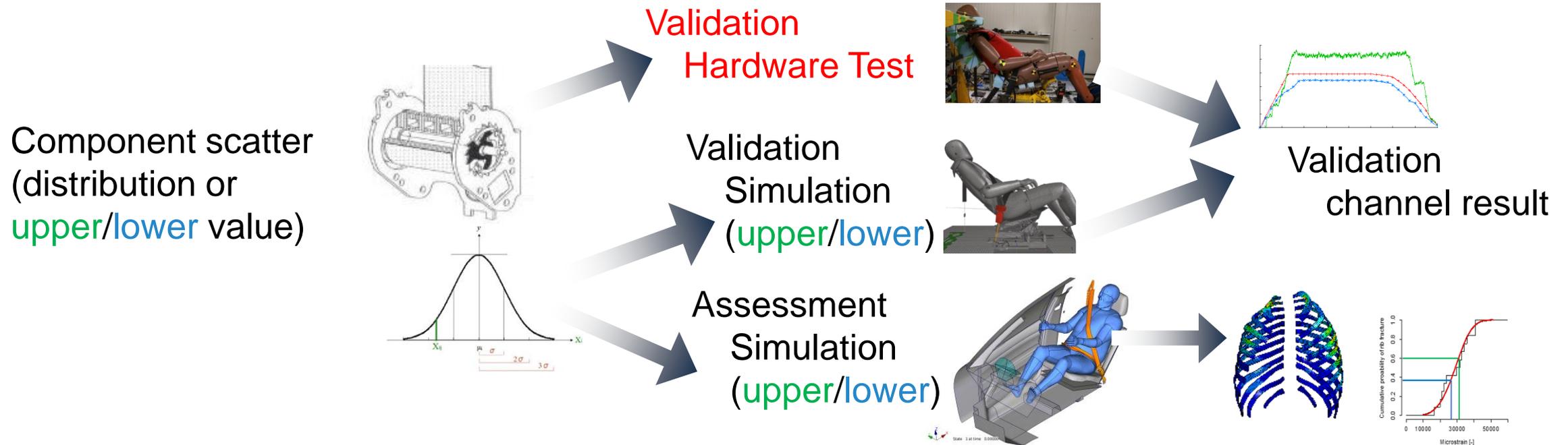
## Proposals how to consider scatter in hardware test procedure (1) and validation device (2):

- Identify and quantify scatter in RT validation load cases
    - R&R tests (validation load cases, similar load cases)
    - ATD certification tests
    - Consider relevance of validation channels (supported by CAE studies)
- based on these findings select channels and define acceptance criteria (**general global requirements** and/or **individually for each validation channel**)

### Motivation for an acceptance criterion for each individual validation channel:

→ For a validation channel with high RT scatter the deterministic simulation output cannot be more predictive than only one corresponding hardware validation test

## Proposal how to consider scatter in vehicle components (3) in VT



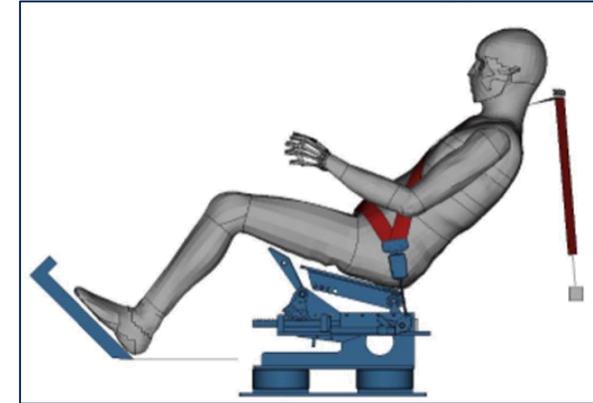
- Upper/lower parameter setting of relevant component parameters in validation model (or stochastic distribution of input) → provide (upper/lower) corridor outputs of validation channels
- Same upper/lower parameters must be used in the vehicle environment model in assessment
- Assessment based on worst case or distribution for each injury parameter or body region

## Need for a validation device (VD) in a VT process

- Real testing device (VD) representing the occupant is needed for vehicle environment validation
- VD only to be used for validation not for (injury) assessment!

## Requirements for a VD:

- VD as a test device should represent the interaction between HBM and restraint systems in validation load case as similar as possible compared to the assessment simulation (including possible new restraint concepts)
- Realistic human-like (HBM-like) occupant kinematics
- Robust, repeatable, reproducible in real testing
- No (advanced) internal instrumentation needed (no injury assessment)
- Corresponding CAE model needed? Or HBM as direct reference?



Comparison for  
Vehicle Environment  
Model Validation



## Can we use a standard ATD (Hybrid III, THOR, World-SID,...) as validation device (VD)?

Standard ATDs might not sufficiently fulfill all requirements to enable a robust vehicle environment validation procedure needed for a HBM based VT process

### ■ Existing simple devices

- High robustness and R&R
- Not biofidelic enough regarding belt/seat to occupant interaction

### ■ Standard ATDs (THOR, Hybrid III for reclined seating?)

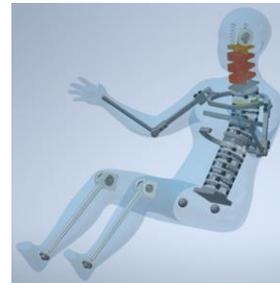
- High complexity resulting in limited R&R
- Exactly corresponding occupant might not be available (for specific load case)
- Also limited biofidelity regarding belt/seat to occupant interaction (in new load cases)

### ■ Development of New VD (example VIVA)

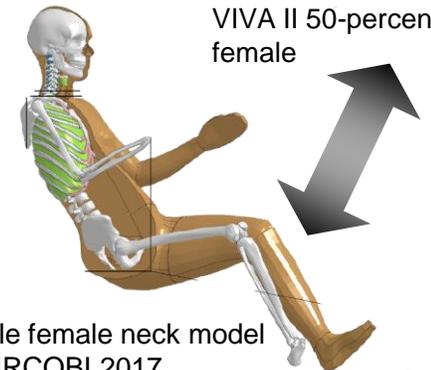
- Conflict between biofidelity and real testing requirements (Robust, R&R, durability) of ATD can be neglected for VD selection/development
- However, new VD for every VT application should be avoided!



Ballast dummy



VIVA II 50-percentile female



50-percentile female neck model  
Östh et al. IRCOBI 2017

- A general process for an HBM-based VT procedure was developed with main focus on a validation-based certification of the vehicle environment simulation model
- Ideas and concepts how to consider RT scatter in this validation procedure were proposed including an objective approach to derive acceptance criteria for individual validation channels
- Requirements were derived for a validation device to be used for validation of the vehicle environment model within a HBM-VT process



# OSCCAR

## FUTURE OCCUPANT SAFETY FOR CRASHES IN CARS

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