

Slides based on presentation originally prepared for the
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Felix Ressi*, Bernd Schneider, Desiree Kofler, Vishnuvel Kannan, Corina Klug
Graz University of Technology, Austria



Devon C. Hartlen, Duane S. Cronin
University of Waterloo, Ontario, Canada

*Presenter

Development of a Robust Human Body Model Qualification Methodology: Ensuring Biofidelity for Occupant Protection Assessments in Virtual Testing



Felix Ressi, Bernd Schneider, Desiree Kofler, Vishnuvel Kannan, Corina Klug
Graz University of Technology, Austria



Devon C. Hartlen, Duane S. Cronin
University of Waterloo, Ontario, Canada

Motivation

- Virtual methods are increasingly important in vehicle safety assessment
- Human body models (HBMs) enable new kinds of analyses (tissue level, consider human diversity...)

Current gap:

- HBMs lack standardised qualification

Major challenge: variability

- No direct “well-defined” physical counterpart
- Inherent biological variability in PMHS tests

Main goals

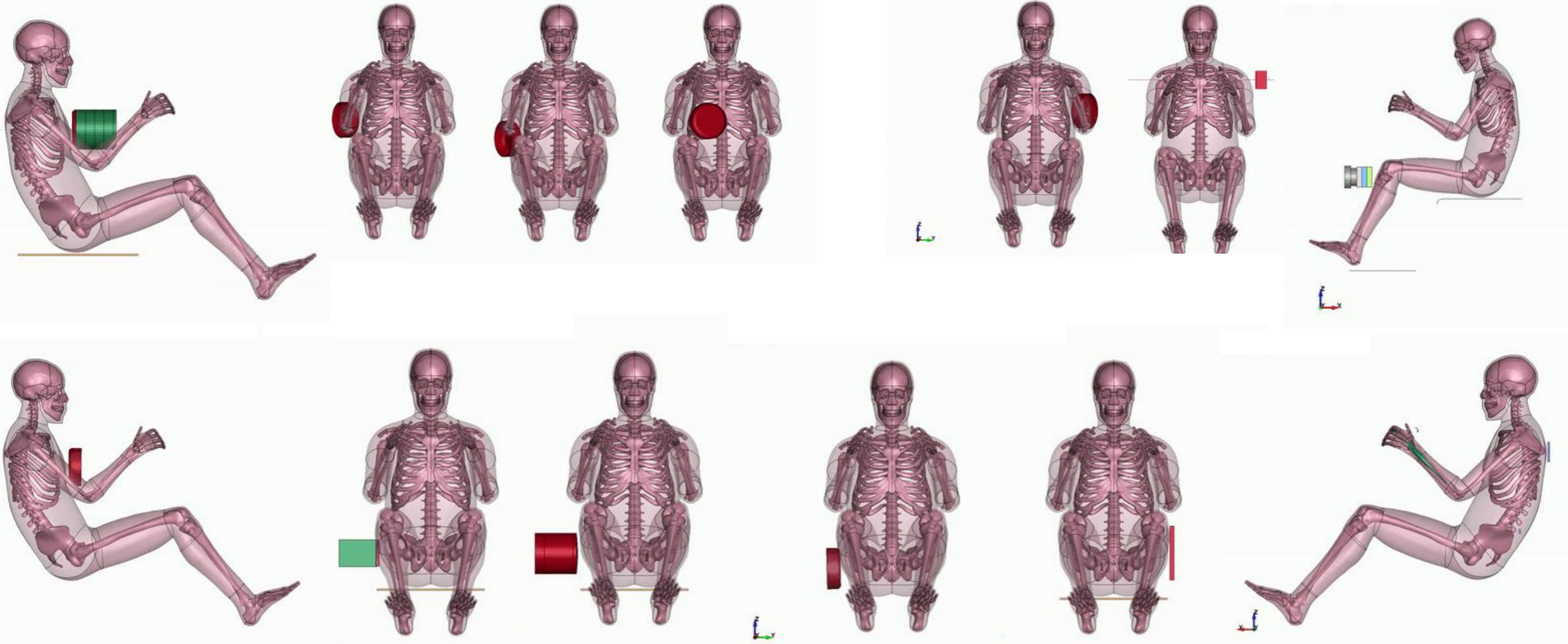
- Create **HBM-neutral validation setups** (far-side and frontal)
 - Publicly available, easy to use, adjustable to any HBM with minimal effort
 - Facilitate translation of the (LS-Dyna) models to other FE solvers
- Enable **harmonised post-processing** and **biofidelity scoring**
- Feed the collected insights into a Euro NCAP **technical bulletin** for HBM qualification for frontal and far-side occupant simulations

HBM-neutral simulation setups

- Based on 19 publications
- HBM provided by user
- Step-by-step guide
- HBM positioning
 - Initial *orientation* modified by parameters
 - Further *positioning* is part of simulation
- Goal is not perfect replication, but reproducibility and future integration of hashing



Setup overview: Impactor setup animations

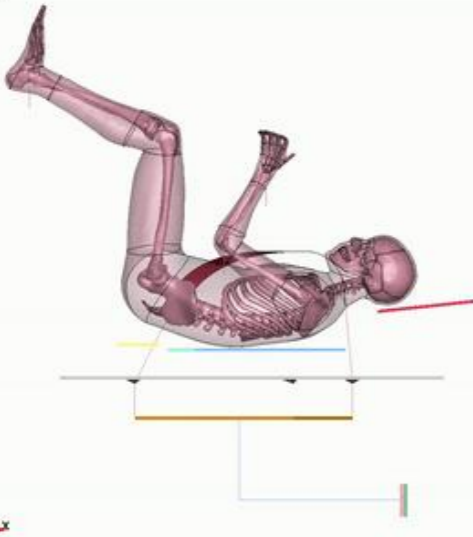


Setup overview: Tabletop setup animations

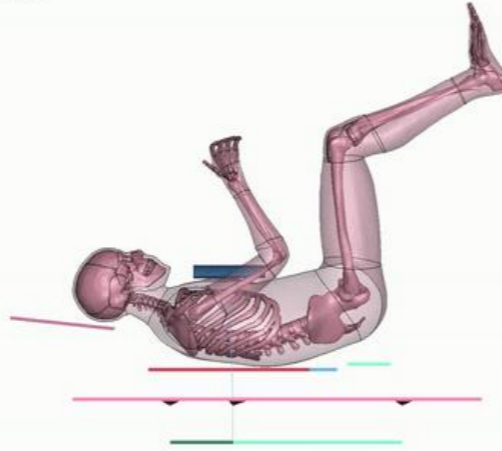
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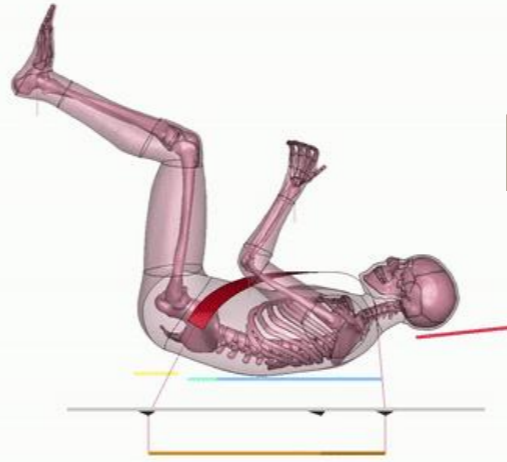
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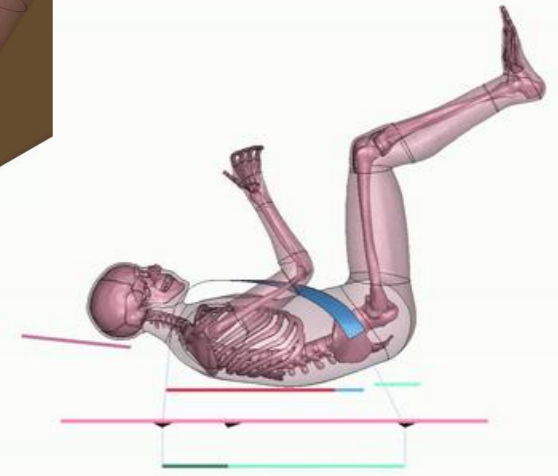
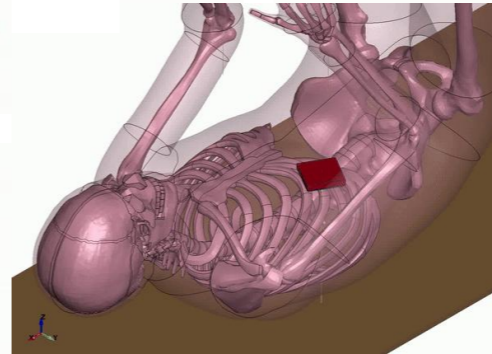
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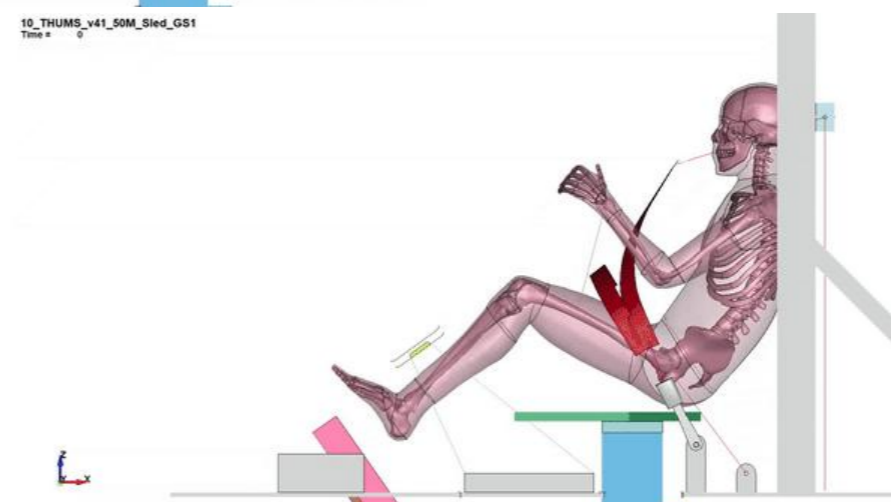
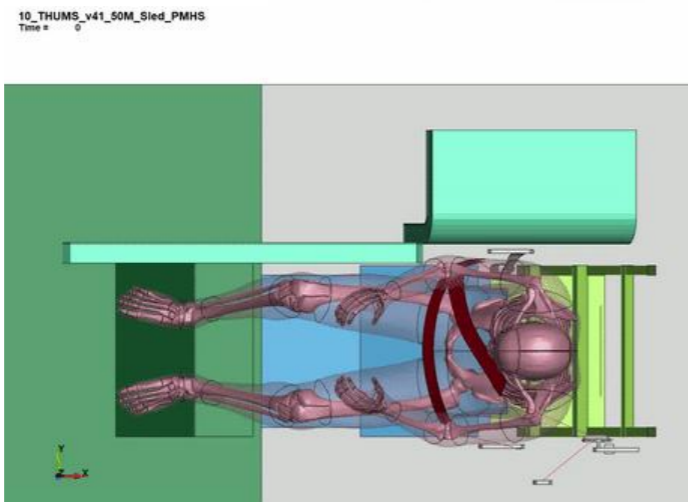
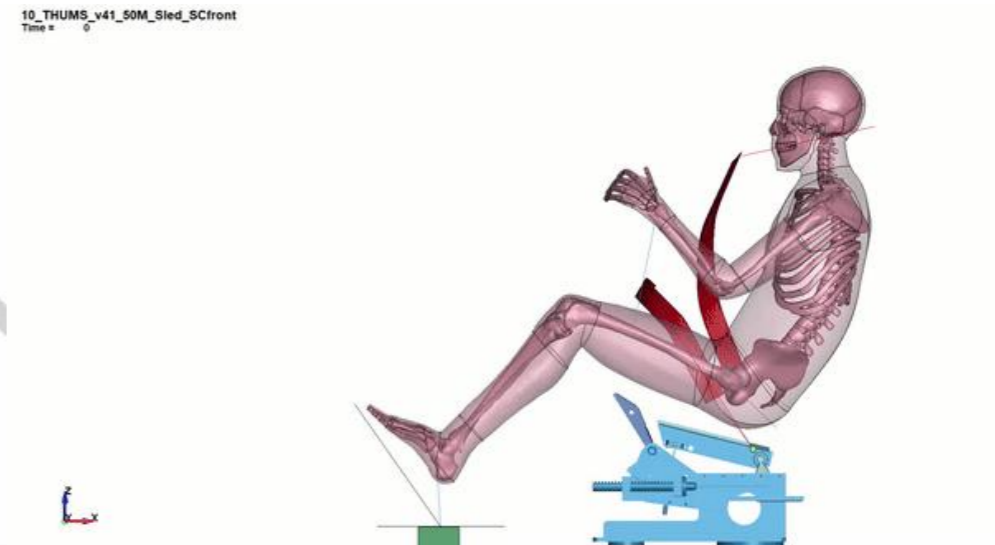
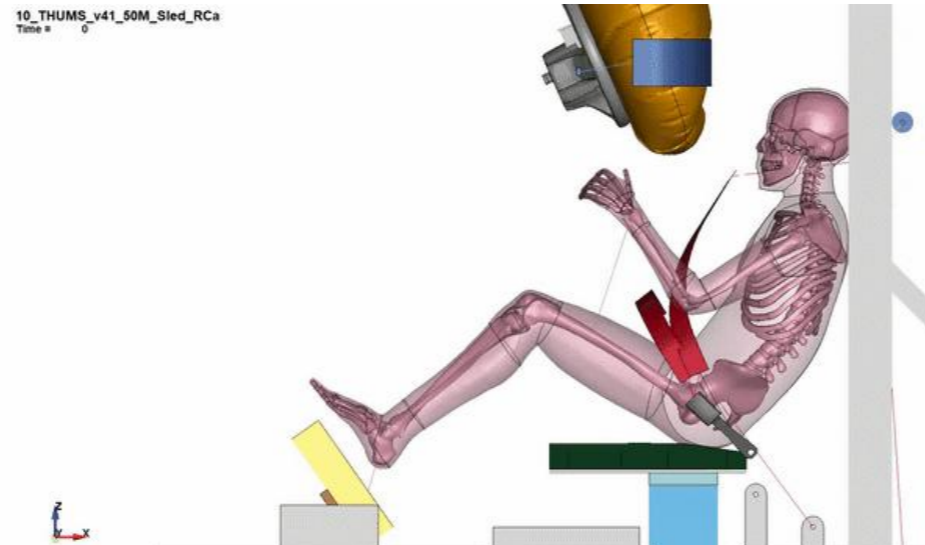
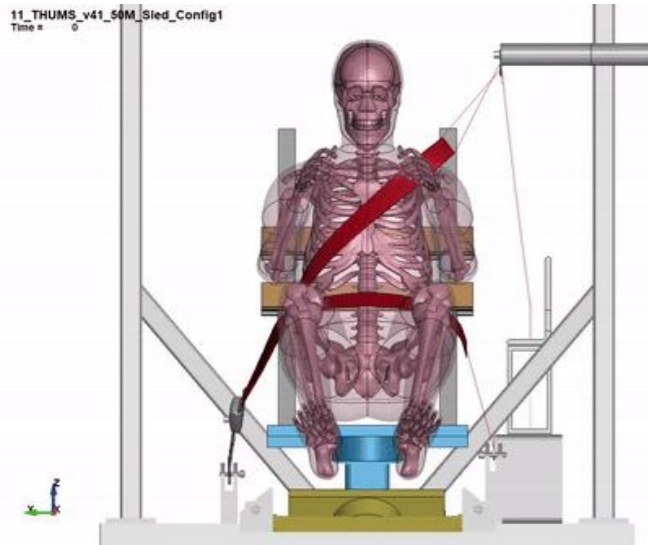
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08_THUMS_v41_50M_Hub
Time = 0



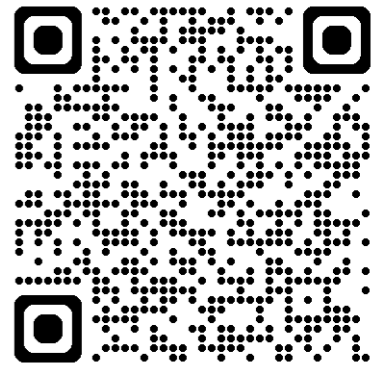
Setup overview: Sled setup animations



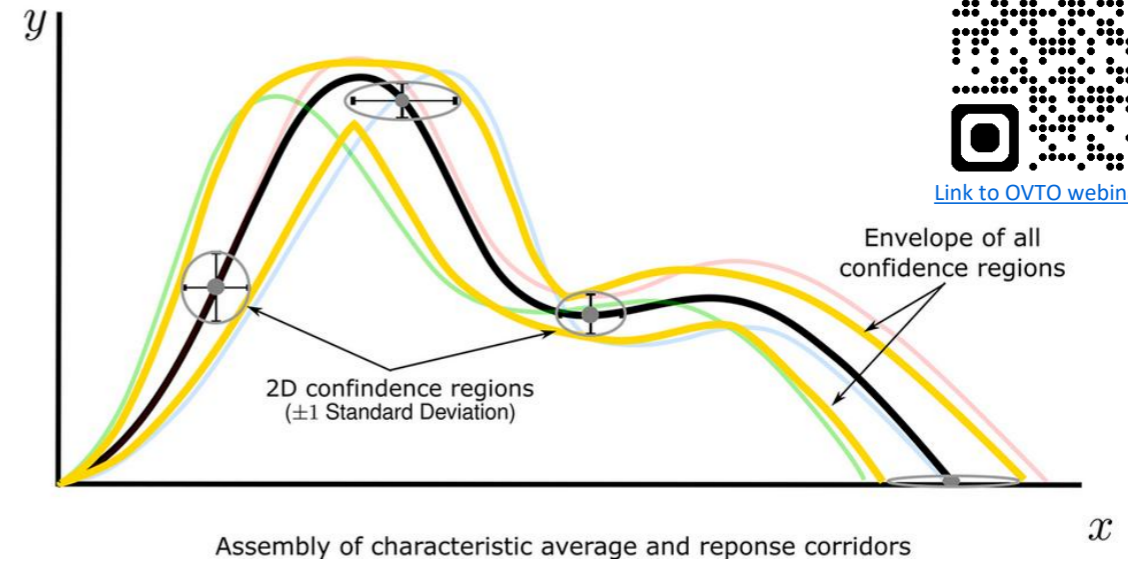
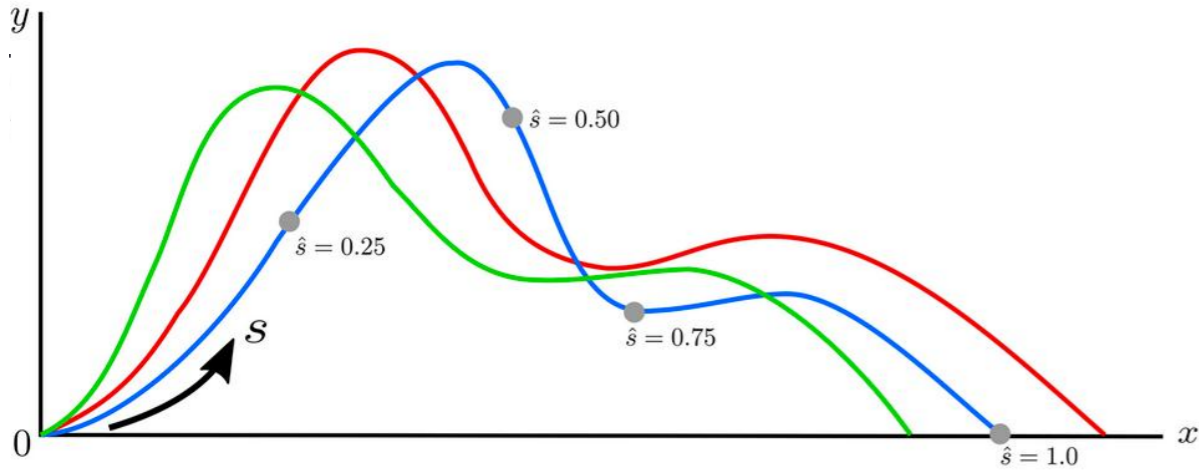
Assessment notebooks

- Jupyter notebooks using Dynasaur library
- Read simulation results and compare against PMHS data
 - Direct import of results works for LS-Dyna
 - ESI/Keysight is working on “compatibility layer” for Dynasaur. Until then, assessment via csv input (pre-processed by user) is possible.
- Plausibility check
- Calculate two **scores** for responses of interest

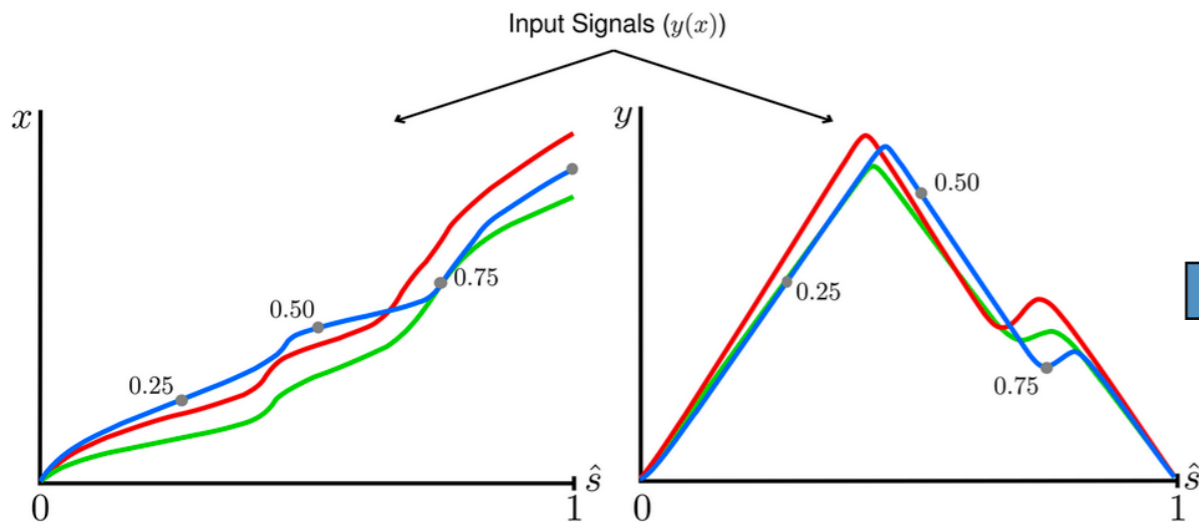
Basis for Scoring Methodology: ARCGen



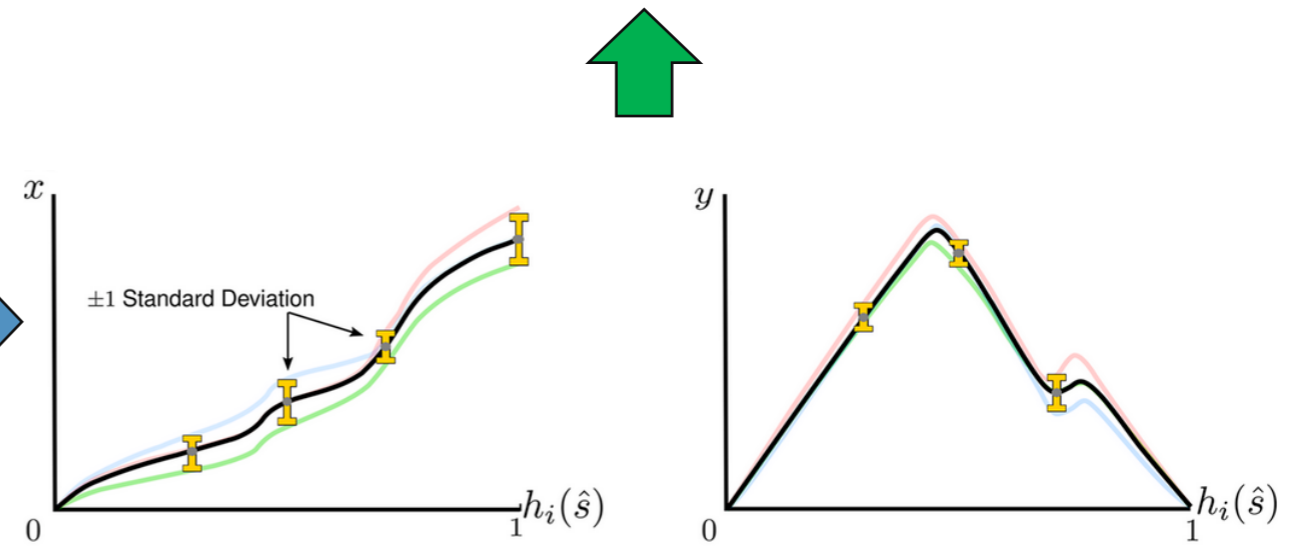
[Link to OVTO webinar by Devon Hartlen](#)



Assembly of characteristic average and response corridors



Re-parameterized Signals ($x_i(\hat{s})$ & $y_i(\hat{s})$)

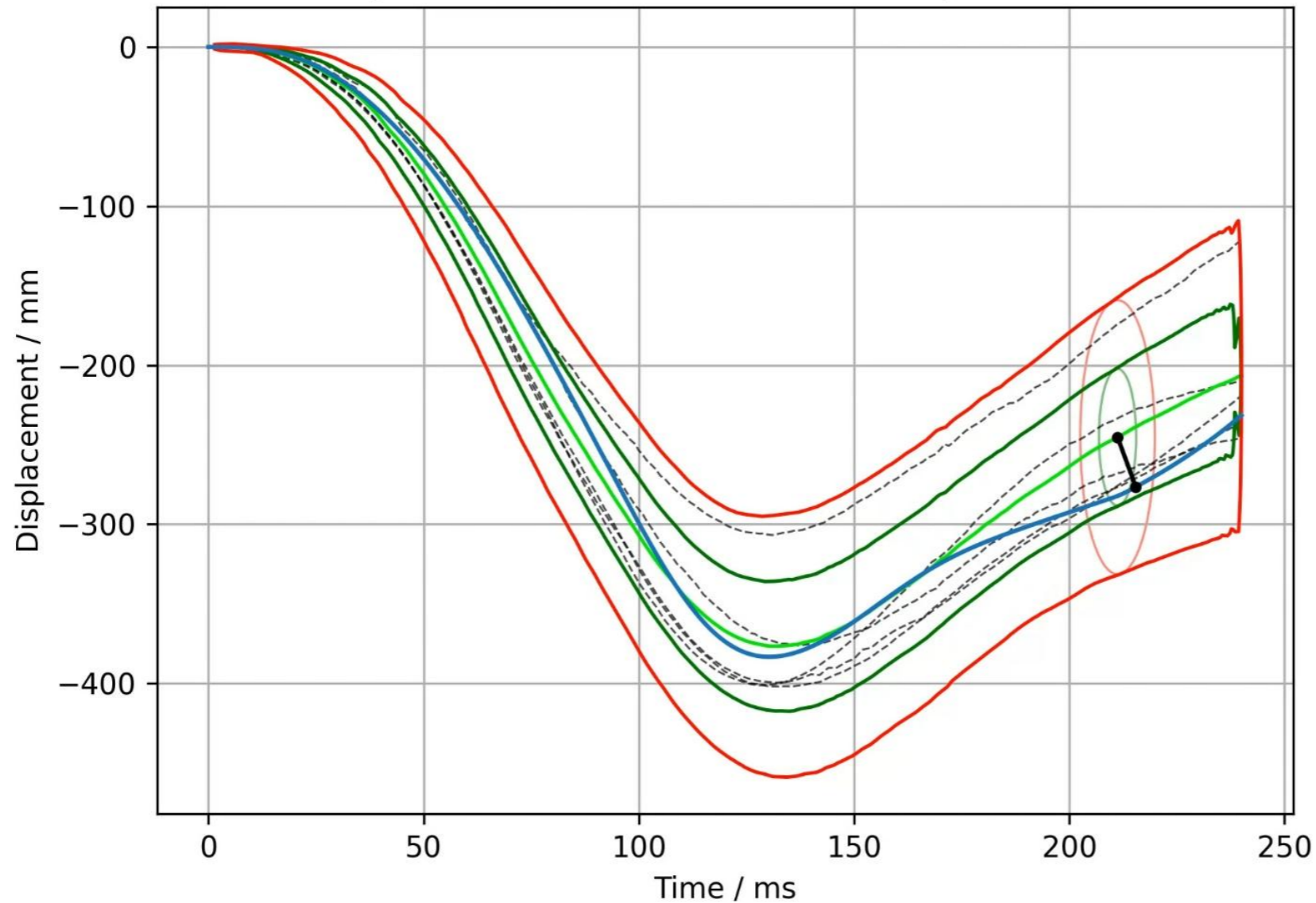


Compute mean and standard deviation at each warped arc-length

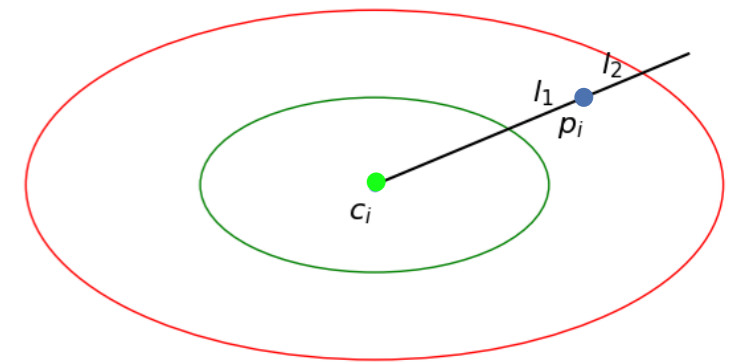
Ellipse Score example: Shaw et al. 2009 (Gold Standard 2)

Gold Standard 2

Objective Metric Score - Head X-Displacement



$$\text{Score} = \frac{l_2}{l_1 + l_2}$$

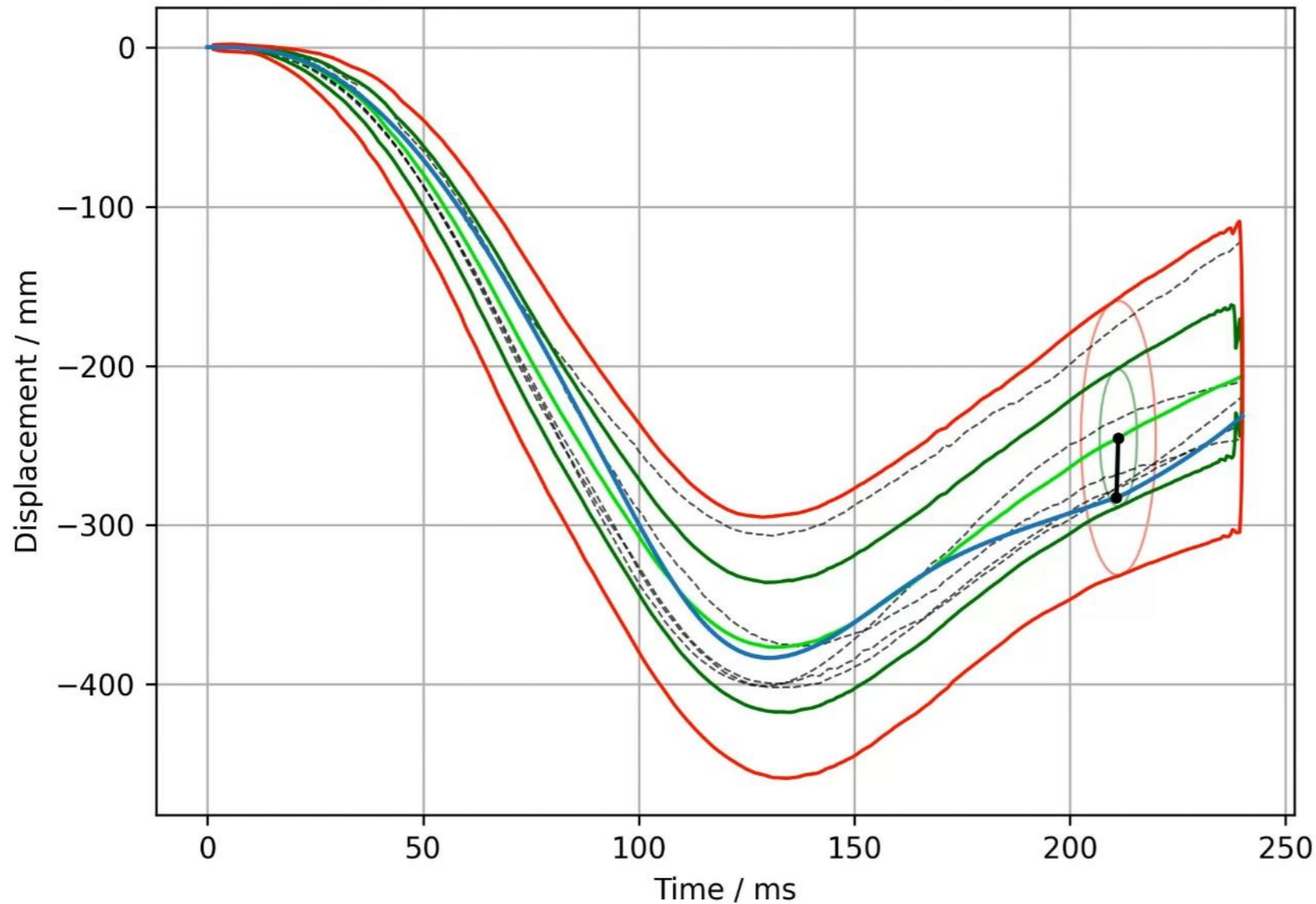


- Experiment
- ARCGen characteristic average
- ARCGen 1.0 SD corridor
- ARCGen 2.0 SD corridor
- HBM simulation

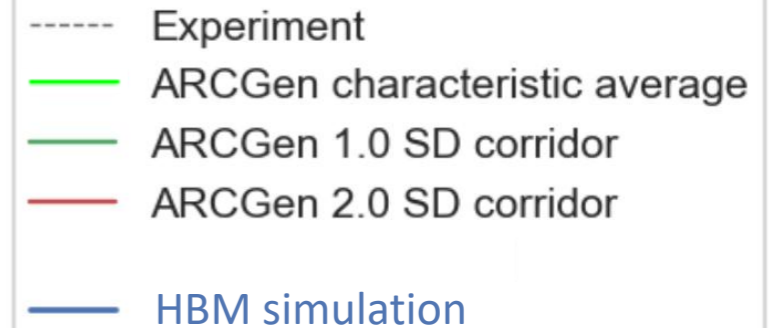
DALW Score example: Shaw et al. 2009 (Gold Standard 2)

Gold Standard 2

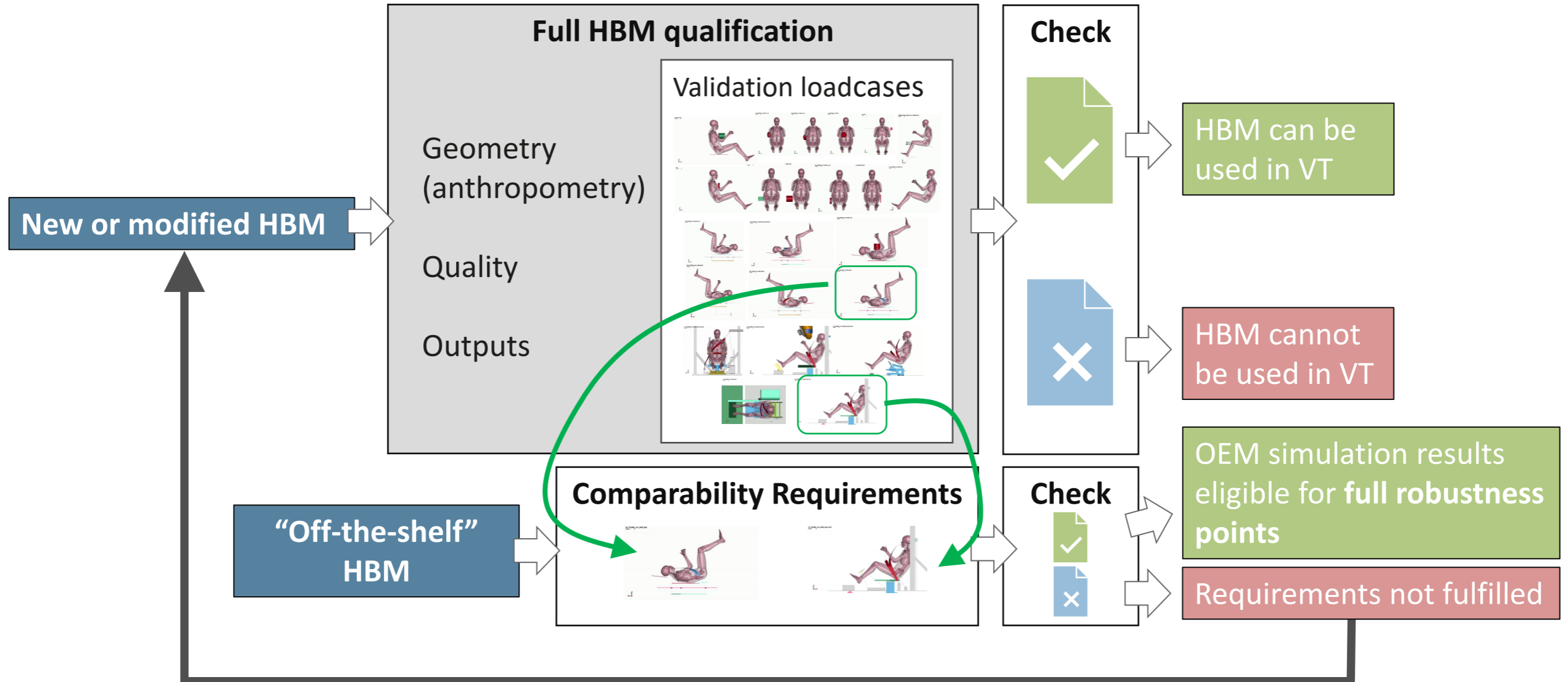
Objective Metric Score - Head X-Displacement



**Dynamic
Arc-Length
Warping
Score**



Qualification overview



Conclusions

- ✓ HBM-neutral setups for LS-Dyna and VPS are publically available
- ✓ Assessment scripts enabling plausibility check against physical tests
- ✓ Integrated biofidelity scoring taking human variability into account
- ✓ Euro NCAP technical bulletin CP 550 “Qualification Procedure for HBMs”

Outlook for next Euro NCAP protocol update (2029)

- Improve definition of average male anthropometry
- Update qualification to include small female, average female
- Integrate traceability (hashing of HBM, boundary condition models and results)
- Critical review of contribution/added value of all loadcases
- Review scoring methodology
- Increase biofidelity requirements
- Integrate harmonised strain-based (rib fracture) assessment

Acknowledgements

We would like to acknowledge and thank all **HBM4VT participants** for their valuable feedback and contributions to this project and the **QualiPro HBM4VT sponsors** for funding the work on the public setups and methodology:

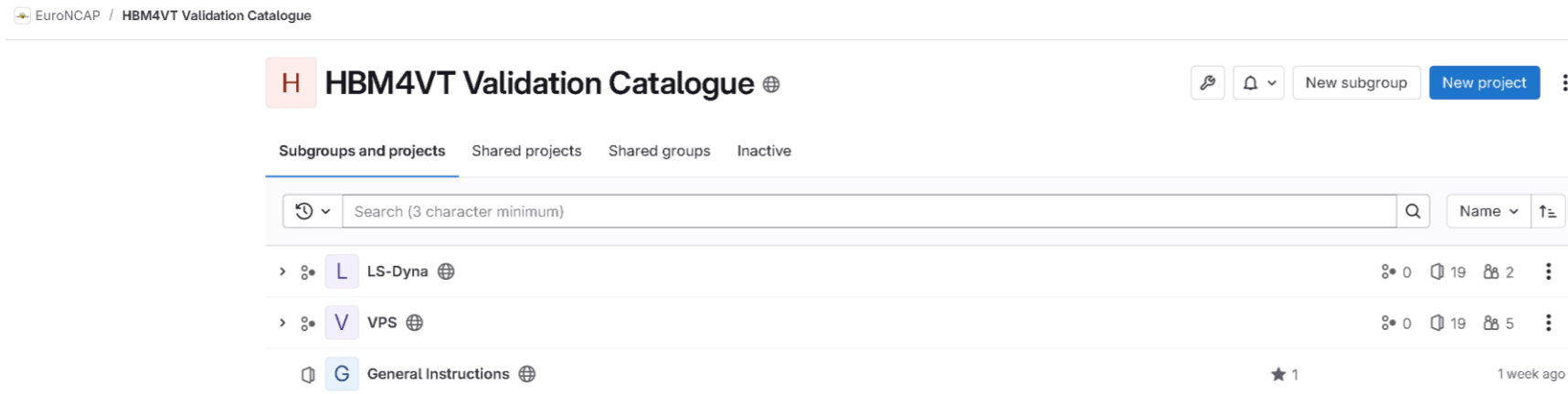
- DYNAmore
- GHBMC
- Elemance
- Humanetics
- Autoliv
- Volvo
- Toyota Motor Europe

Disclaimer:

All claims expressed in this presentation are solely those of the presenter and do not necessarily represent those of all HBM4VT participants.

Data availability

- Received simulation data is not publically available
- Check out the HBM4VT validation setups on openvt.eu:
<https://openvt.eu/EuroNCAP/hbm4vt-validation-catalogue>



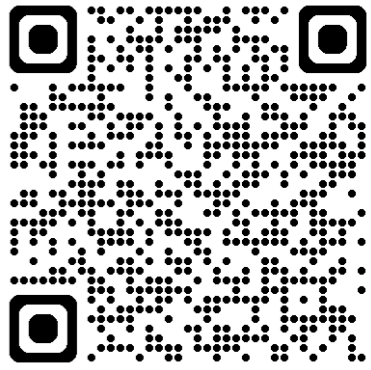
The screenshot shows the 'HBM4VT Validation Catalogue' page on the openvt.eu platform. The page title is 'HBM4VT Validation Catalogue' with a globe icon. Below the title, there are tabs for 'Subgroups and projects', 'Shared projects', 'Shared groups', and 'Inactive'. A search bar is present with the text 'Search (3 character minimum)'. Below the search bar, there are three entries:

- LS-Dyna (with a globe icon, 0 likes, 19 views, and 2 shares)
- VPS (with a globe icon, 0 likes, 19 views, and 5 shares)
- General Instructions (with a globe icon, 1 star, and '1 week ago')



Anyone can use these models: Would you fulfil comparability requirements?

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ARCGen by Devon Hartlen](#)



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<https://openvt.eu/EuroNCAP/hbm4vt-validation-catalogue>