Presentation of the CoHerent Project IWG-DPPS

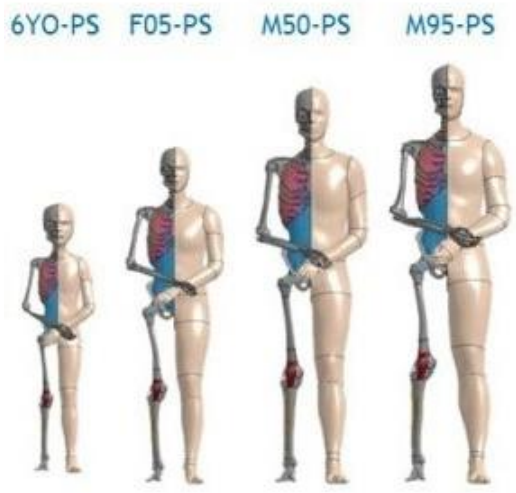
Corina Klug, Florian Feist, Wolfgang Sinz, James Ellway, Michiel van Ratingen

19.04.2018

Source: Corina Klug, Florian Feist, Wolfgang Sinz, James Ellway, Michiel van Ratingen: „A Procedure to compare kinematics of Human Body Models for pedestrian assessments", presented at SAE Government/Industry Meeting
January 25th, 2018

Motivation – Application of Human Body Models

- Improving safety assessment with HBMs:
- Influence of body size
- Addressing multiple scenarios
- Additional injury predictors

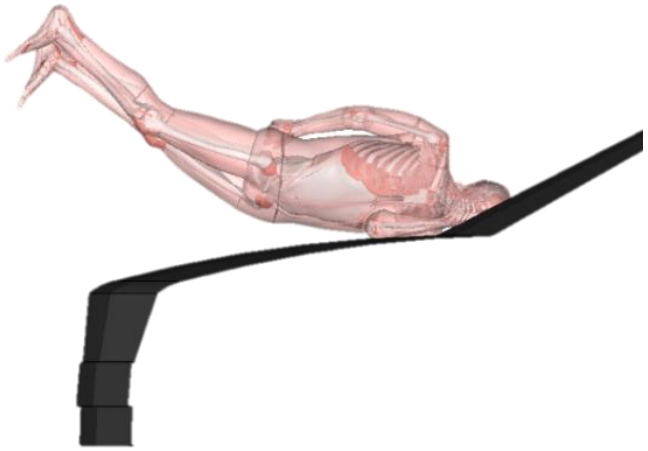


http://www.elemance.com

Biomechanical Research

Product Development

Standards and NCAPs



ENHANCE PEDESTRIAN SAFETY WITH IMPROVED ASSESMENT METHOD

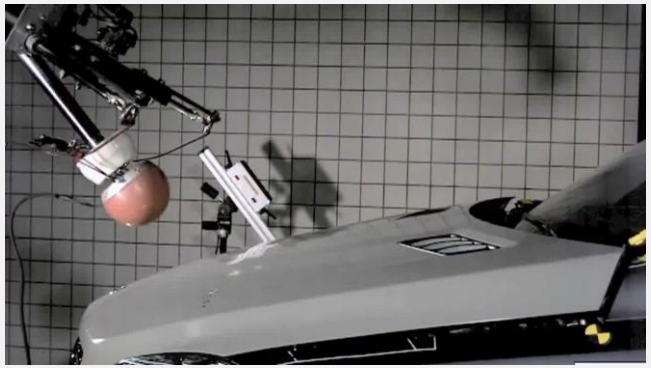
Euro NCAP Assessment of Deployable Systems - A Hybrid Approach

Simulation with HBMs

COMPARABILITY!!!

- Head Contact Time
- Head Impact Location
- Deflection due to body loading

Sub-system Tests



Head Injury Criterion

Rating

FOR SAFER CARS
EURO NCAP
www.euroncap.com

Challenges

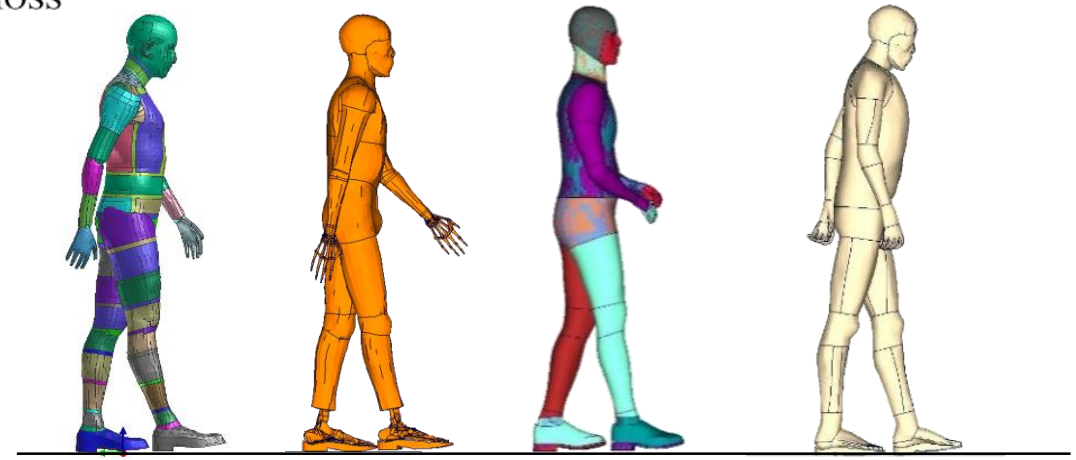
- Variety of HBMs based on different anthropometry and validated with different PMHS tests
- Variety of Versions of HBMs (in-house modifications & revisions)
- Variety of Solvers
- Variety of Initial Positions
- Variety of Simulation Settings

VIRTUAL PERFORMANCE SOLUTION

LS-DYNA

Altair RADIOSS

ABAQUS



Source: ACEA, 2016

Objectives

- **AIM: Harmonization of Pedestrian Simulations with Human Body Models**

- How are kinematics affected by varying simulation setups?

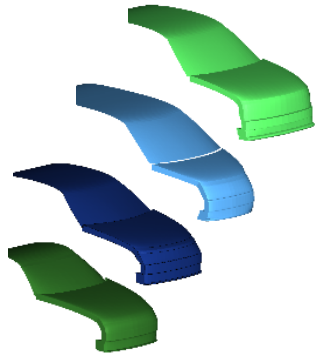
- How are kinematics affected by varying pedestrian models?

- How to ensure that pedestrian assessment simulations with different HBMs render consistent results?

Procedure for Kinematic Comparison of HBMs needed, applicable for
- **varying HBMs** in
- **varying codes**

Method

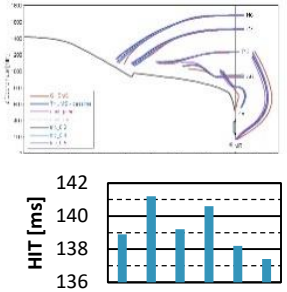
Generic Vehicle Models



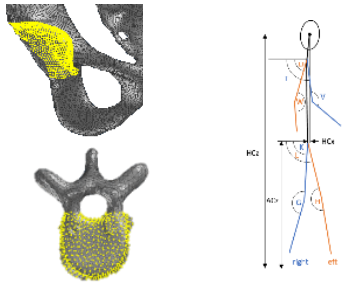
- Representative
- Transferrable to other solvers

Harmonised Simulation Setup

Sensitivity Study

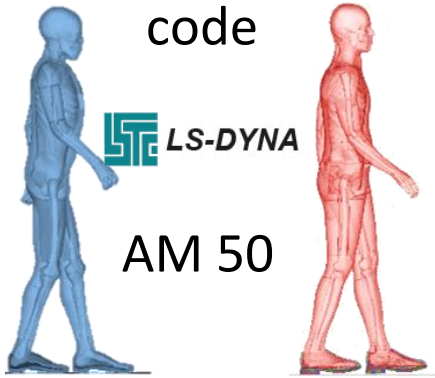


Simulation Protocol



Comparison of HBMs

Two HBMs in one code



AM 50

THUMS v 4.02

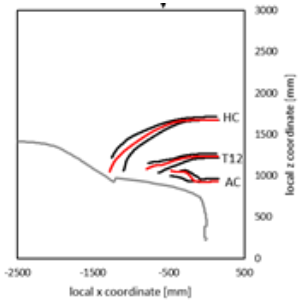
GHBMC PS v1.4.3

Application on more models in 4 codes

Certification Procedure for Euro NCAP

Harmonised Postprocessing

Corridors



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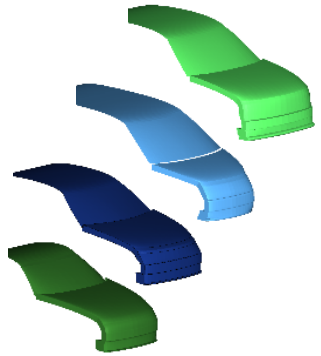

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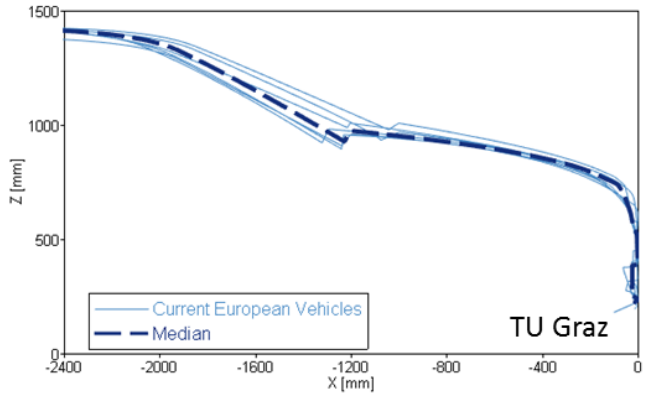

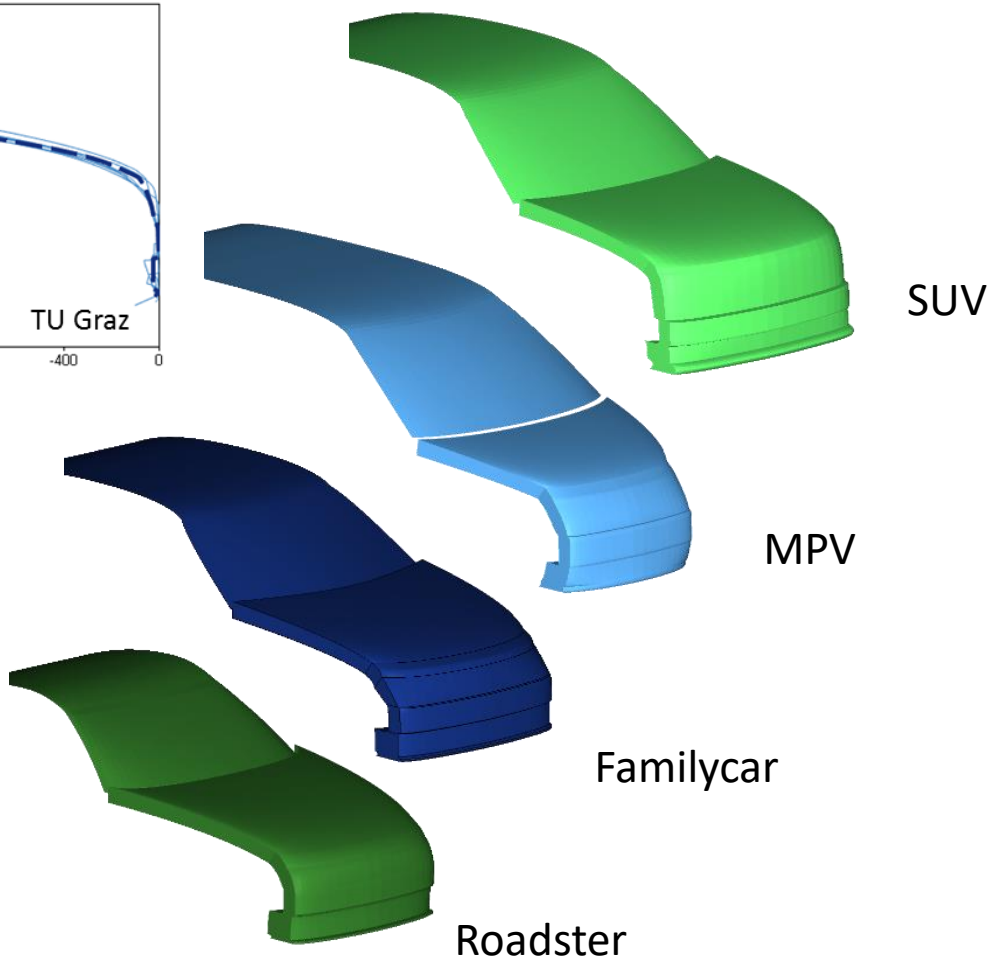

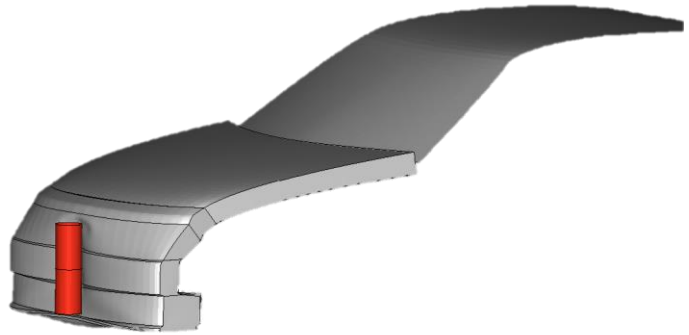

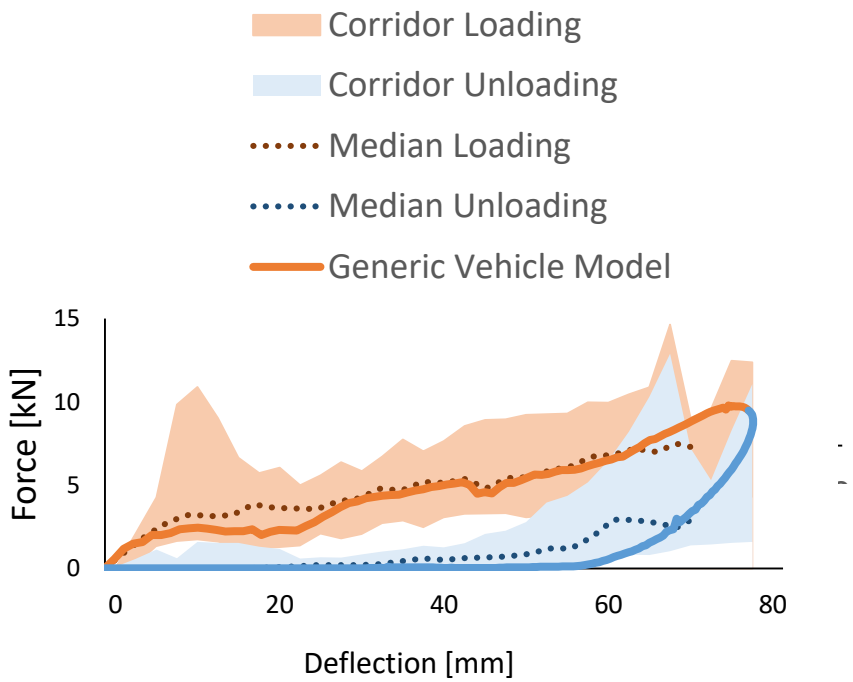

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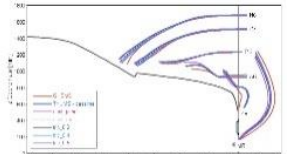

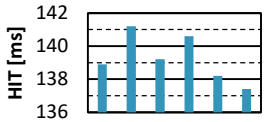

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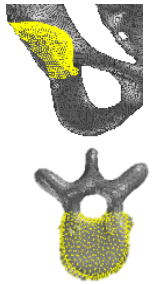

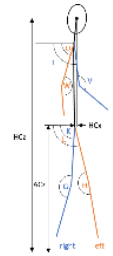

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THUMS v 4.02

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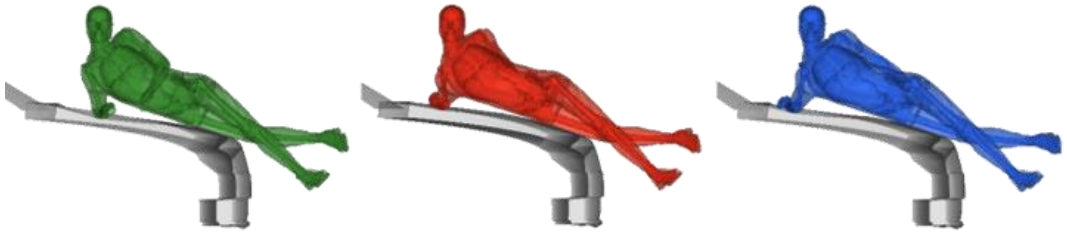
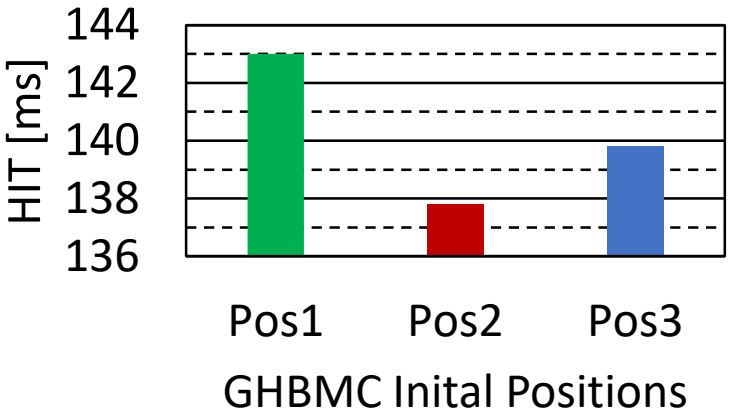
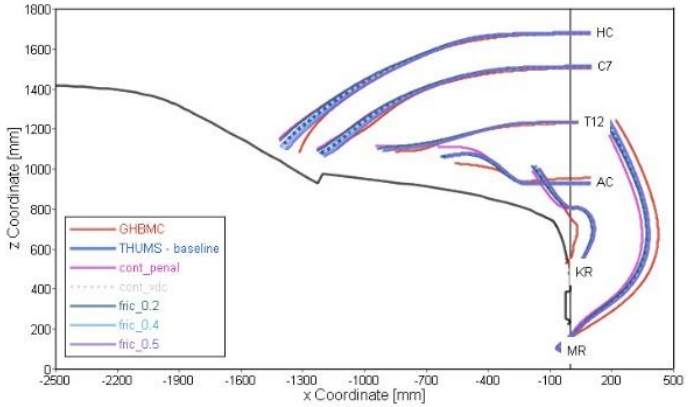
Sensitivity Study

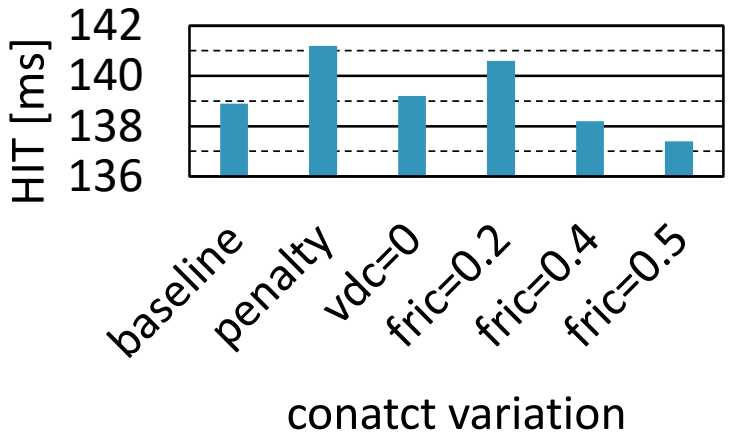
- effect of arm posture: up to 4% in HIT [1]





- effect of contact setting: up to 3% in HIT [1]





Proper protocol for virtual testing needed

Method

Generic Vehicle Models

- Representative
- Transferrable to other solvers

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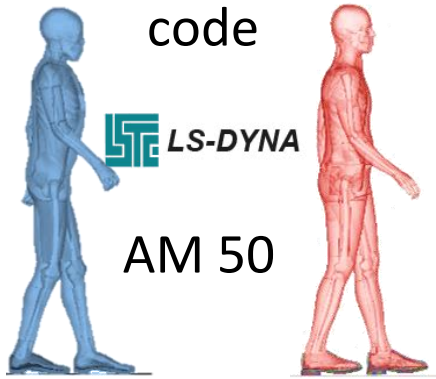
Sensitivity Study

Simulation Protocol

Comparison of HBMs

Two HBMs in one code



AM 50

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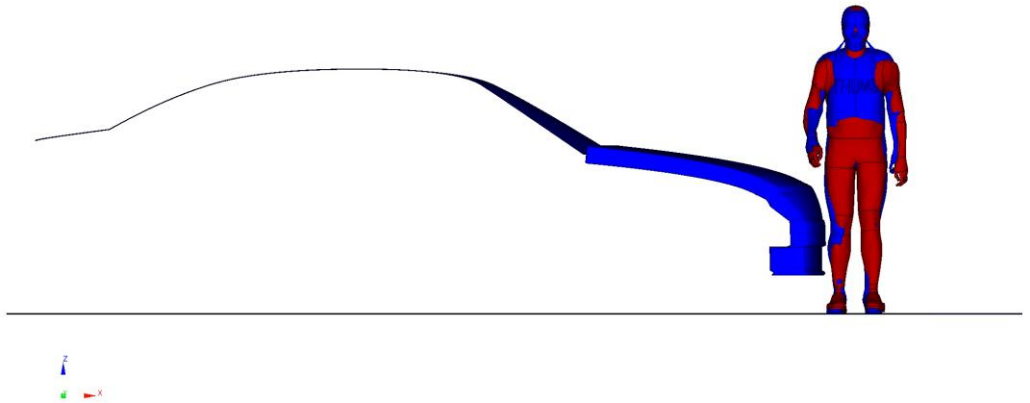
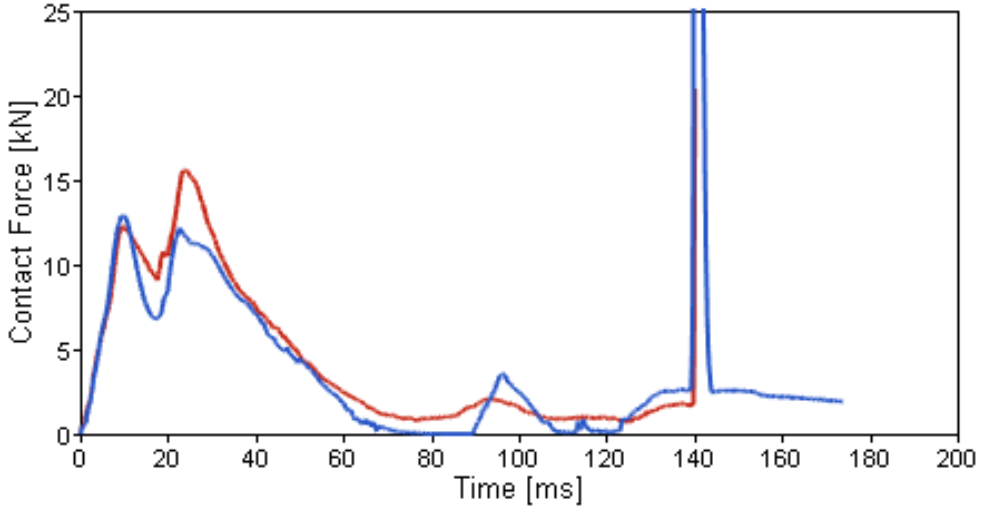
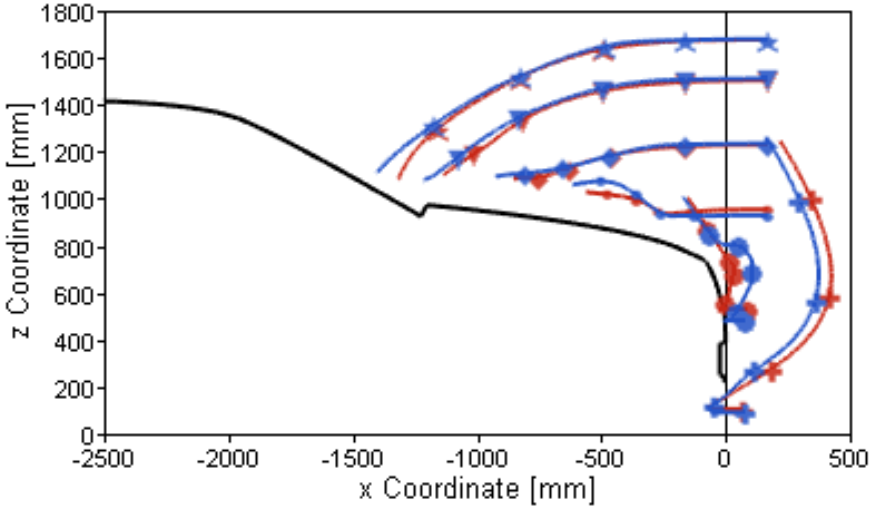
Comparison of two HBMs

- THUMS v4.02 and GHBMC PS v1.4.3 in LS-DYNA show very comparable kinematics

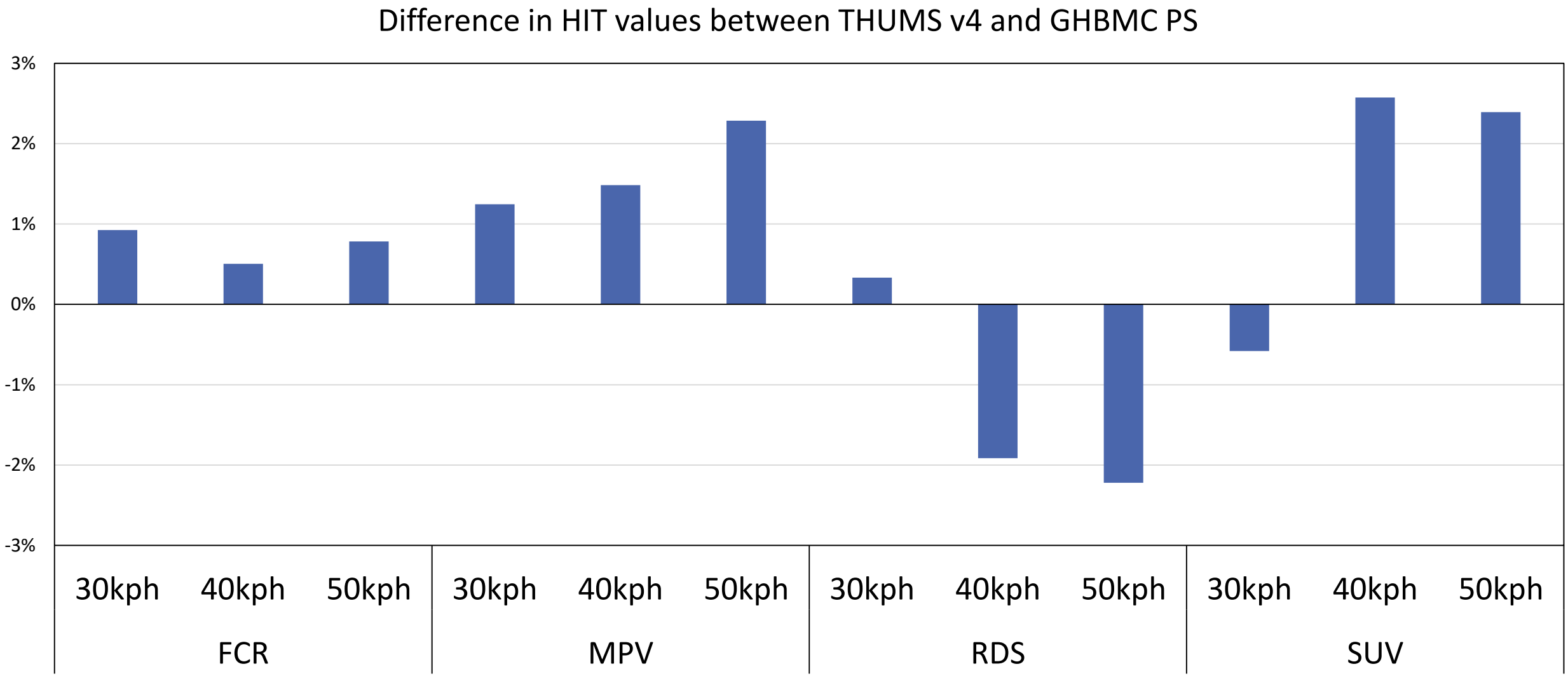
- Difference in HIT for “Family car” impact at 40 kph = 0.7 ms





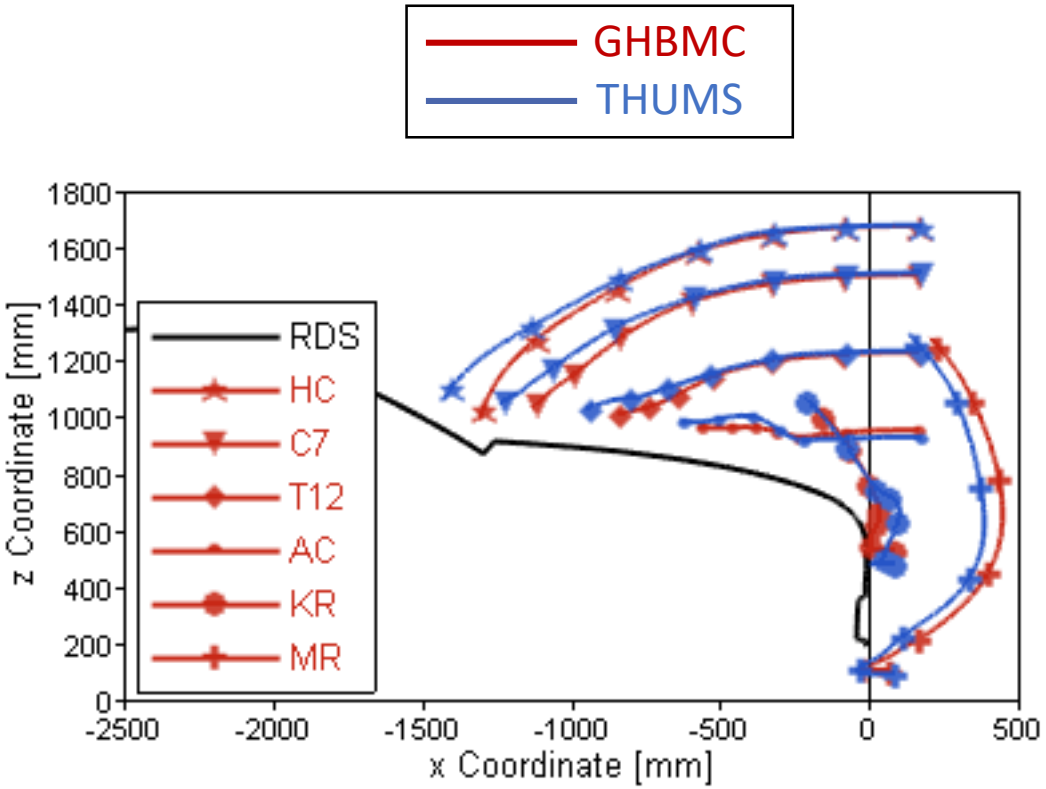


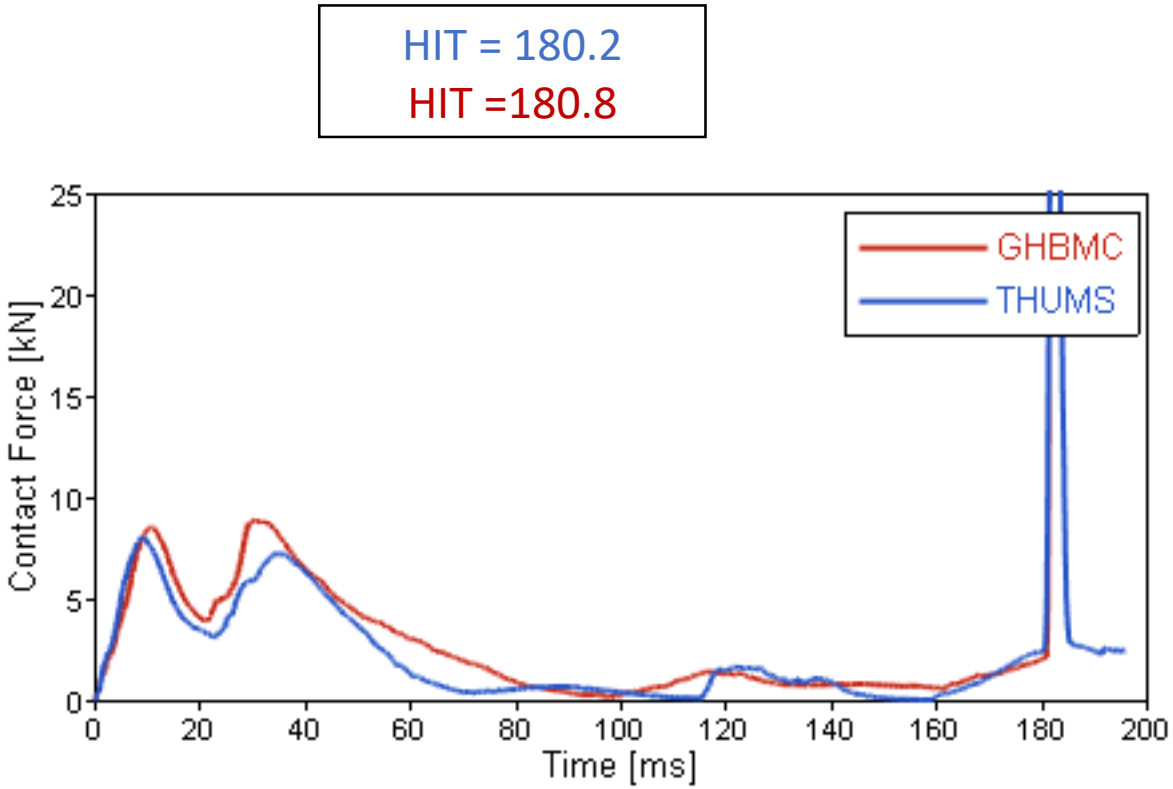
Comparison of two HBMs – Difference in Head Impact Time



Comparison of two HBMs – Maximum Difference in Trajectories

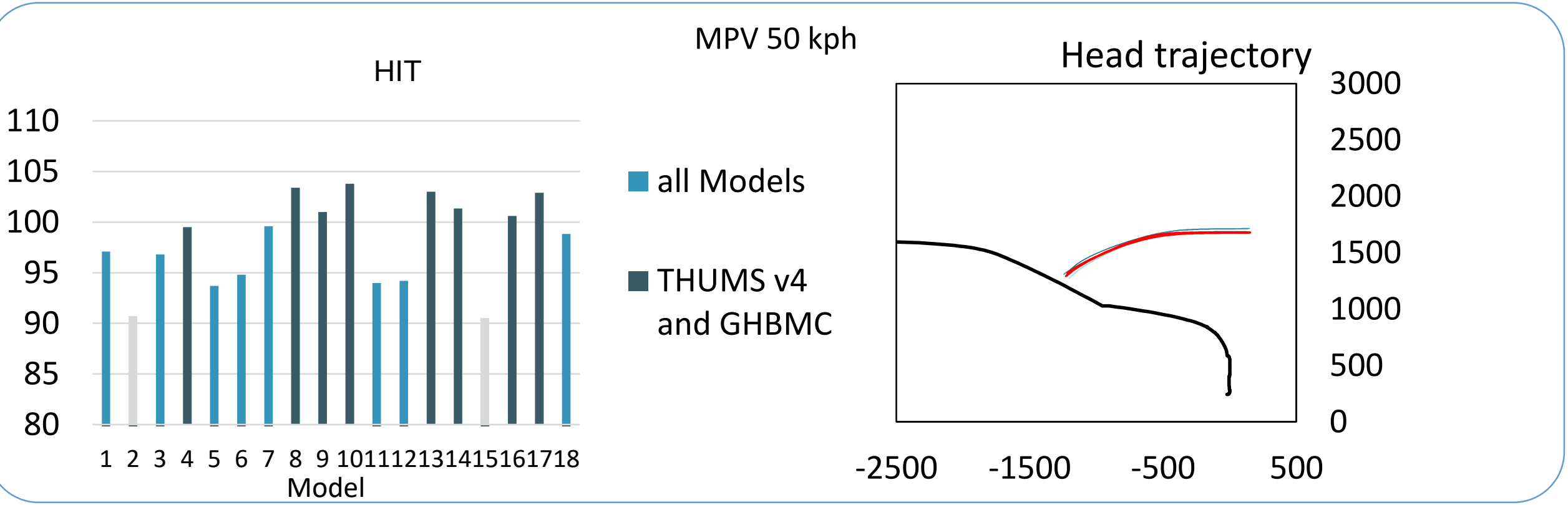
Max. difference of location of head COG in “Roadster” impact at 30 kph – 4% of path length





Application to Various HBMs in Multiple Codes

Harmonized protocol was applied with varying models in multiple codes on different platforms at several institutions



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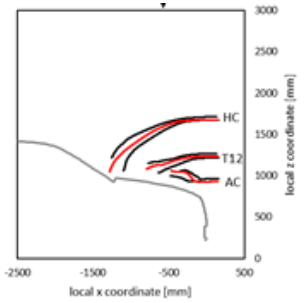
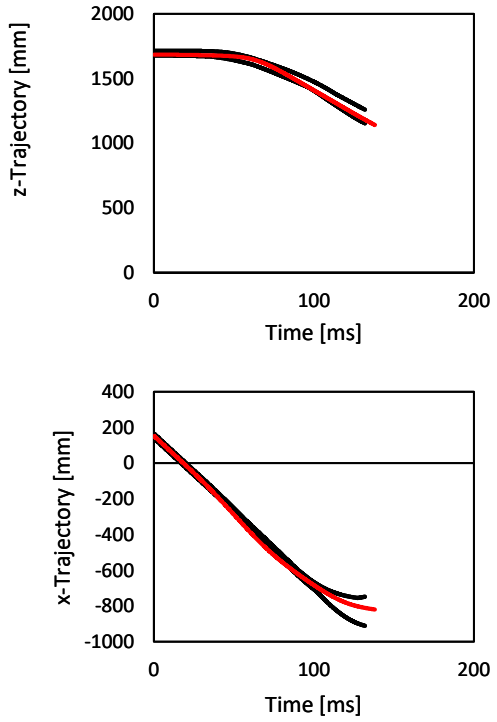
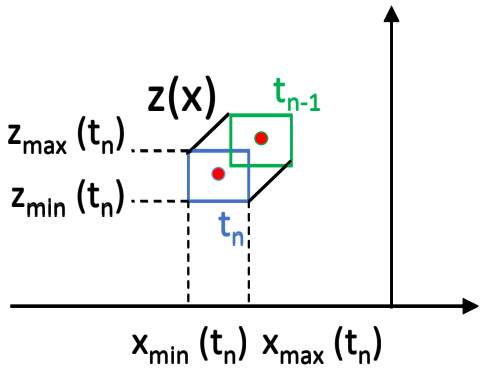


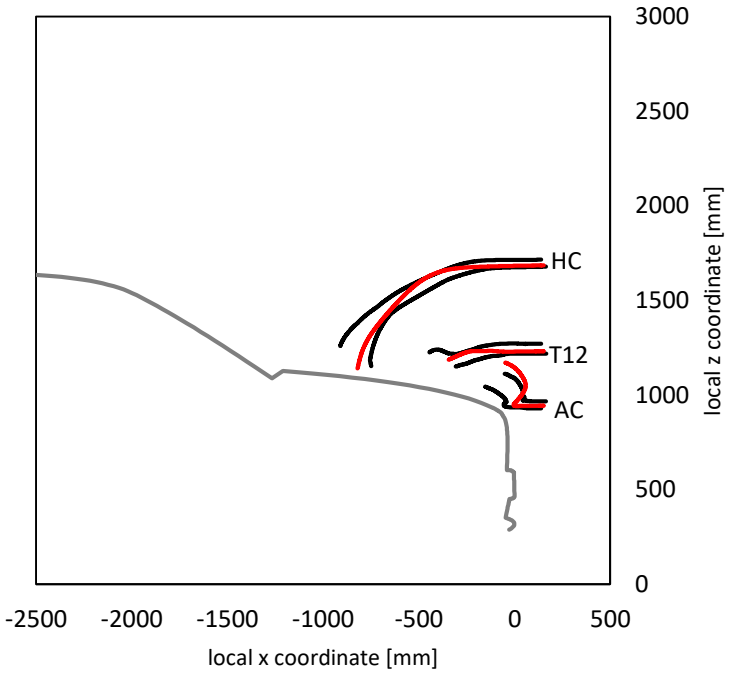
Certification Procedure for Euro NCAP - Trajectories

- Results from all parties were collated and analysed
- Outliers were identified and eliminated - corridors were created from „consistent“ results
- Trajectory is considered time dependent as timing is essential for evaluation





Head trajectory



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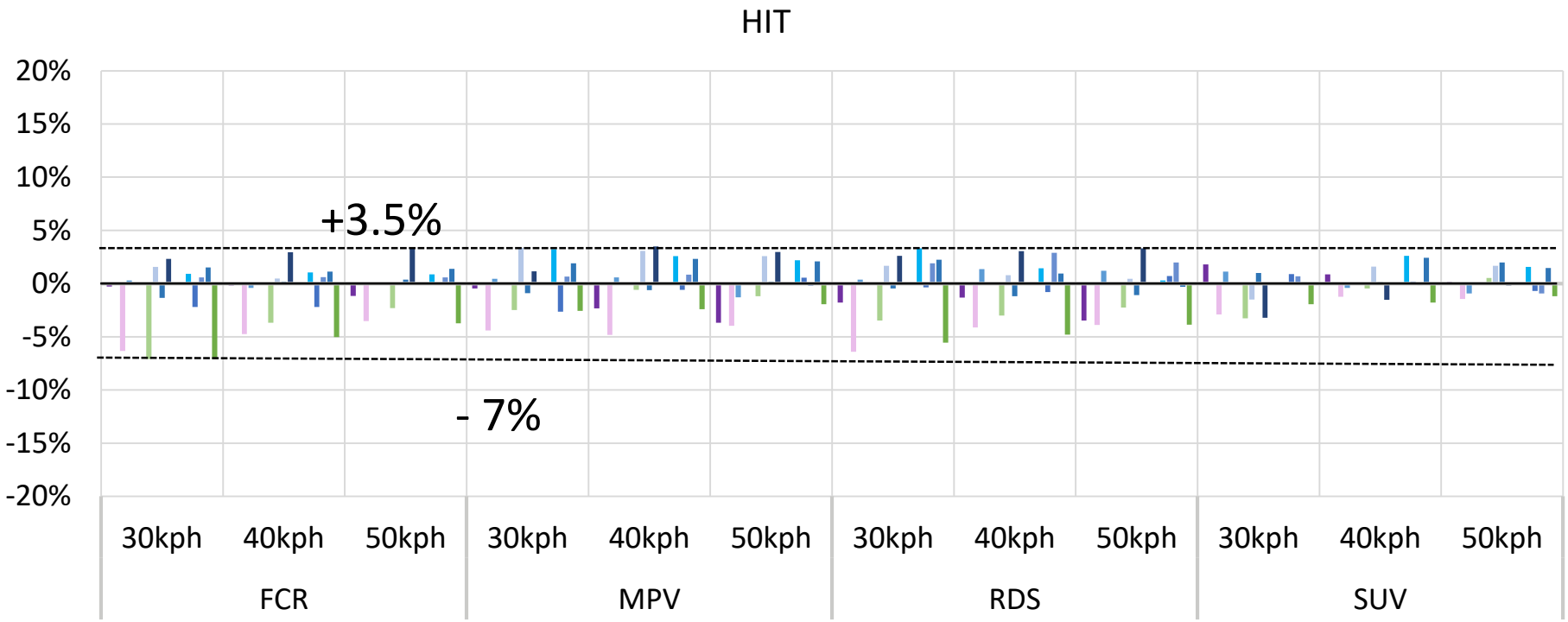
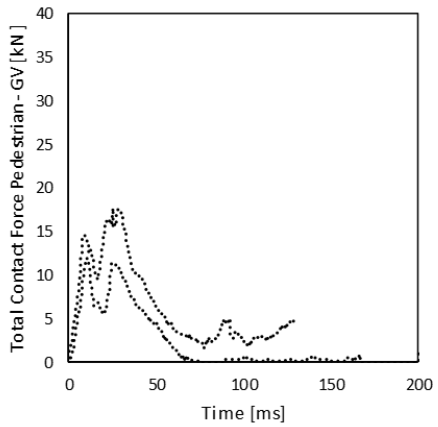


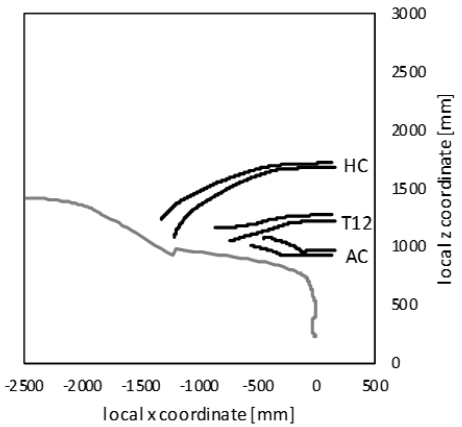
Median of all consistent results

Certification Report

FCR 40 kph

FCR 40 kph				
Pedestrian Model	submitted by	Date		
e.g. THUMS	Manufacture XY	2017-10-10	check	value
All required data provided?			OK	
FE Surfaces getting in contact do not cross each other			OK	visual check
Surfaces getting in contact do not get trapped one in the other (sticky nodes)			OK	visual check
Contact force (between HBM and vehicle) is zero at simulation start			OK	0
Total energy remains constant within a 15% tolerance			OK	0.0%
Hourglass energy <= 10% of the total energy			OK	0.0%
Contact energy at the simulation start <= 1% of the total energy			OK	0.0%
Artificial energy (contact energy and hourglass energy) <= 15% of the total energy			OK	0.0%
Artificial mass increase for moving parts <= 3%			OK	0.10%
Trajectories are within corridor			OK	max. 0mm 0ms
HIT is within tolerance			OK	-0.9% (HIT=136.9ms)
Contact Force is within corridor (monitoring only!)				max. 0kN 0ms
Time step does not fall and stays excessively low (monitoring only)				t_min= 4E-04





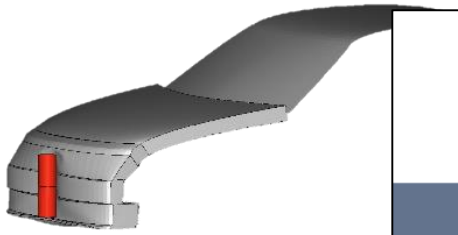
Templates are available on Euro NCAP website as „Certification Pack“
https://www.euroncap.com/en/for-engineers/supporting-information/

Euro NCAP Procedure for Virtual Pedestrian Safety Assessment

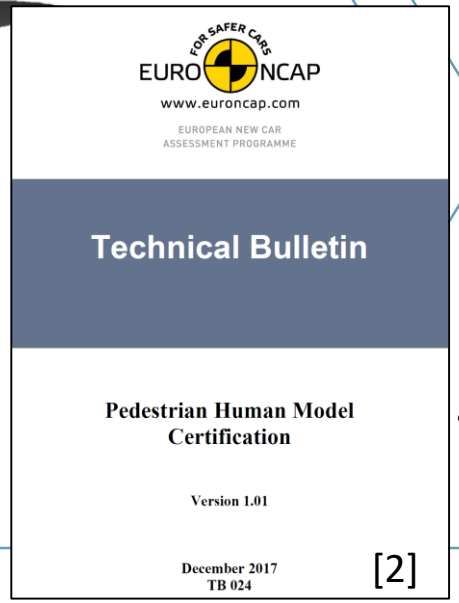
With consistent settings and unchanged HBM

Pedestrian models and setup has to be certified according to TB 024 before being used in deployable bonnet simulations

Check Generic Vehicle Models

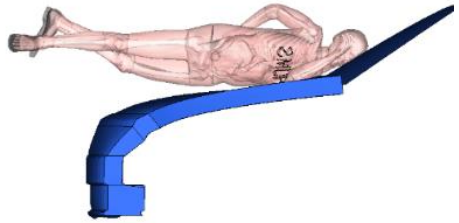


Impactor vs. GV Models



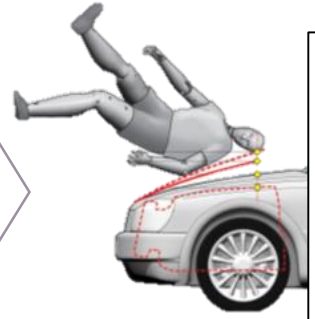
[2]

Certification of HBM

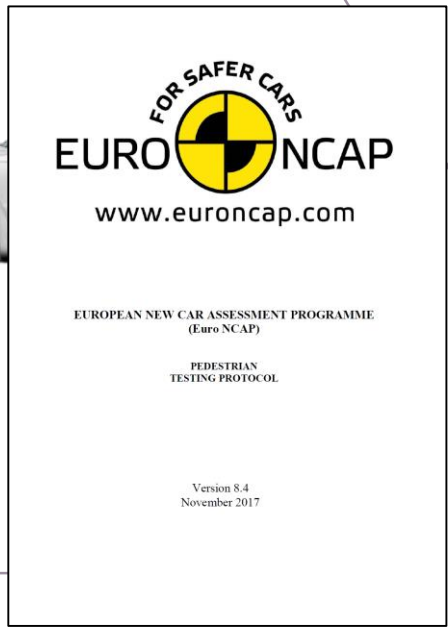


HBM vs. GV Models
4 vehicle shapes,
30, 40 and 50 km/h

Assessment of Deployable System



HBM vs. full FE vehicle model



Discussion and Limitations

- Certification procedure does not replace the validation of HBMs – it qualifies model and setup for safety assessment to allow HBM to be used as a “virtual test device”

- Although GHBMC and THUMS are validated with differing PMHS tests, and do not have the exact same geometry, the response was very similar
  - This wasn’t true for some other pedestrian models

- Only kinematics were compared, no injury metrics

- Contact force corridors were derived for guidance only

- Corridors currently only available for 50th percentile male

Conclusions

- Inconsistent boundary conditions can lead to larger differences in terms of HIT than differences observed between the two HBMs in one code
- When setup was harmonized, THUMS v4.02 and GHBMC v1.4.3 led to very comparable results – an important outcome for the Euro NCAP assessment
- Application of HBMs for pedestrian assessment is not straightforward - challenges have to be addressed
- Procedure developed to ensure consistency between Human Body Models has been adopted by Euro NCAP as of Jan 2018

Acknowledgement

- The project CoHerent was funded by Euro NCAP.
- The authors would like to thank ACEA for provision of data for GV models and financial support of the project.
- We acknowledge that Elemance LLC is the exclusive distributor of the Global Human Body Model Consortium-owned GHBMC-Model.
- We acknowledge that Toyota Motor Corporation and Toyota Central R&D labs, Inc., are the owners of the licensed Total Human Body Model for Safety.
- The authors would like to acknowledge the use of HPC resources provided by the ZID of Graz University of Technology.
- We would like to thank all participants of the CoHerent project for their contribution to the project (TASS, SUBARU, Nissan, JLR, HongIK University, Daimler, BMW, JARI, WFU, Audi, Honda, ESI, Simulia, Dassault Systemes, Altair).

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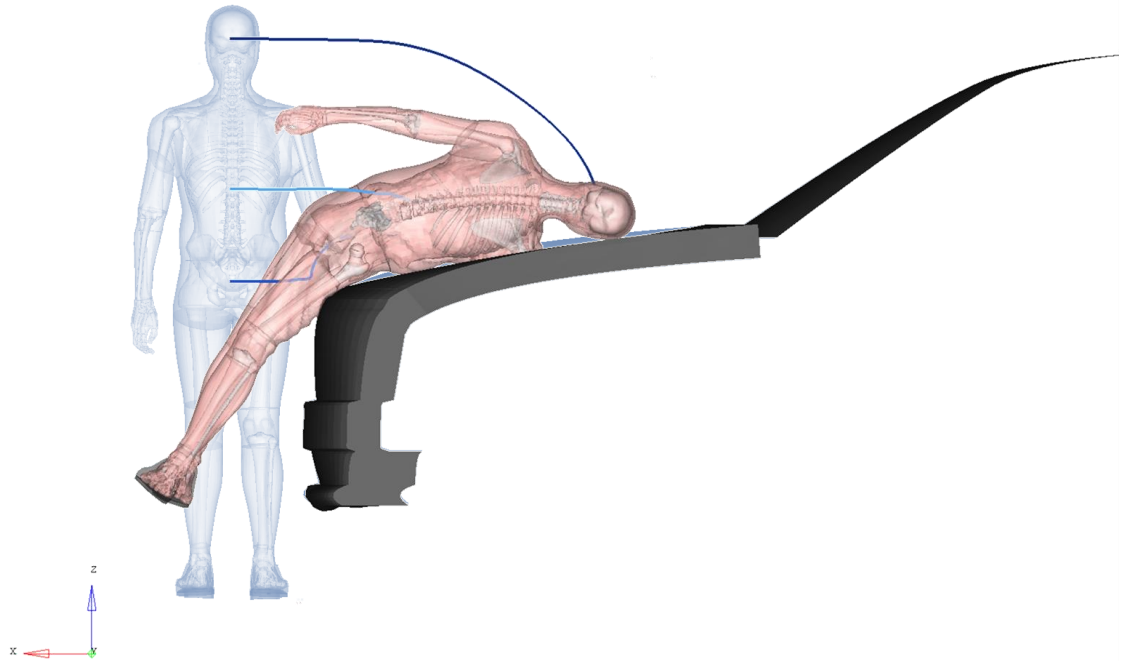

References:

1. Klug C, Feist F, Raffler M, Sinz W, Ellway J, Petit P, van Ratingen, M. “Development of a Procedure to Compare Kinematics of Human Body Models for Pedestrian Simulations”. In: *2017 IRCOBI Conference Proceedings*; 2017.
2. Euro NCAP. “TB024 - Pedestrian HBM Certification” https://cdn.euroncap.com/media/34544/tb-024-pedestrian-human-model-certification-v101.pdf
3. Klug C, Feist F, Raffler M, Sinz W, Ellway J, van Ratingen, M. : „A Procedure to compare kinematics of Human Body Models for pedestrian assessments”, presented at SAE Government/Industry Meeting, January 25th, 2018