Application of Active HBMs

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Implementation and application of Extended Hill-type Muscle Model (EHTM) in Active THUMS-D

- Implementation and Verification of Extended Hill Type Muscle (EHTM) material (Kleinbach et al., 2017, Wochner et al., 2020) in A-THUMS-D (Active HBM developed at Mercedes-Benz)
  - Right arm sub-model (Figure 1) was created and constrained appropriately to replicate experiments of Kistemaker et al., 2006.
  - 8 muscle elements were implemented to actuate the elbow joint, see results in Figure 2.
- After successful simulations the EHTM was used to implement all muscles in the A-THUMS-D

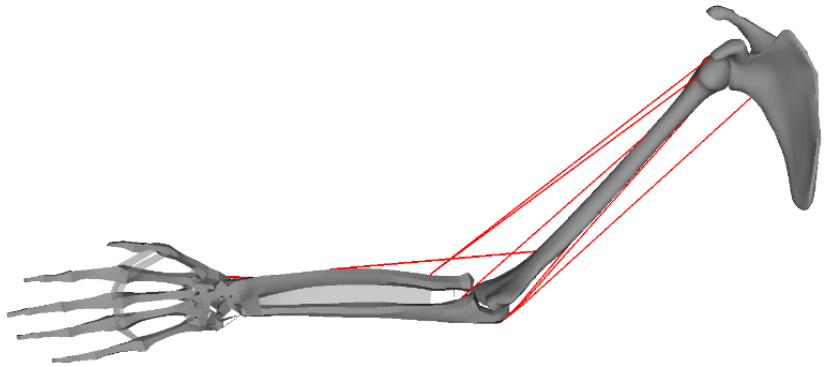


Figure 1: A-THUMS-D Arm Model with FE Muscles (red)

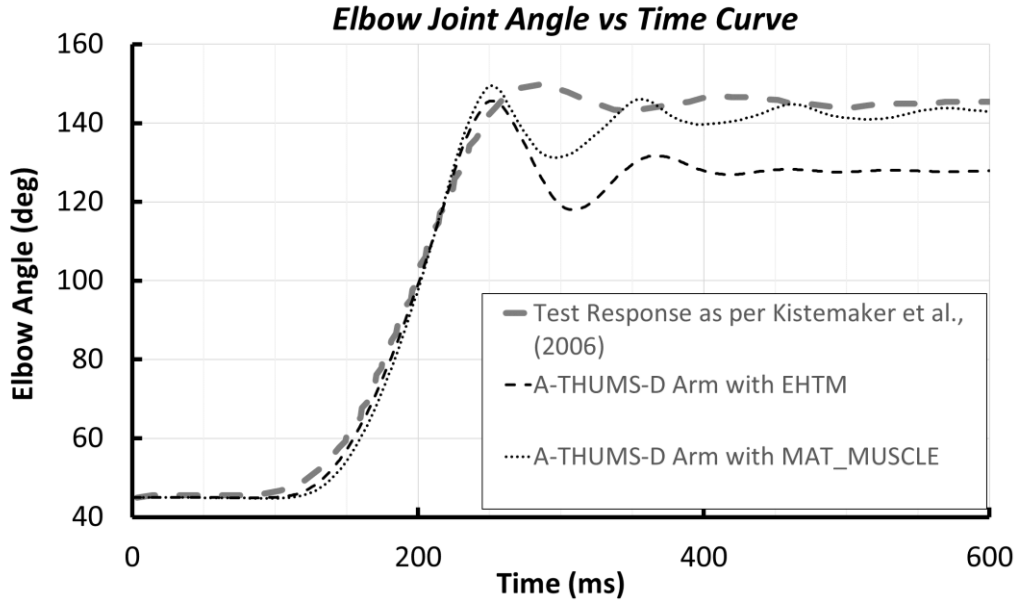


Figure 2: Overlay of A-THUMS-D Arm model kinematics with test data from Kistemaker et al., 2006

Application of Extended Hill-type Muscle Model (EHTM) based muscle model for pre-rotated seat concept in D2.4

- Highway Pilot Scenario for Pre-rotated seat concept for integrated safety assessment
  - pre-crash simulation with A-THUMS-D 3.3.6 with active musculature
  - transition to THUMS-TUC 2020 HBM for simulation of the in-crash phase
  - 3 evaluations performed with the following configuration
    - Case 1: Seat & Occupant in standard position
    - Case 2: Seat and occupant in 30° inwardly-rotated position but no precrash rotation of seat to standard position
    - Case 3: Seat and occupant in 30° inwardly-rotated position. Seat rotates back to 0° position in pre-crash phase (rotation speed = 85.7°/s)

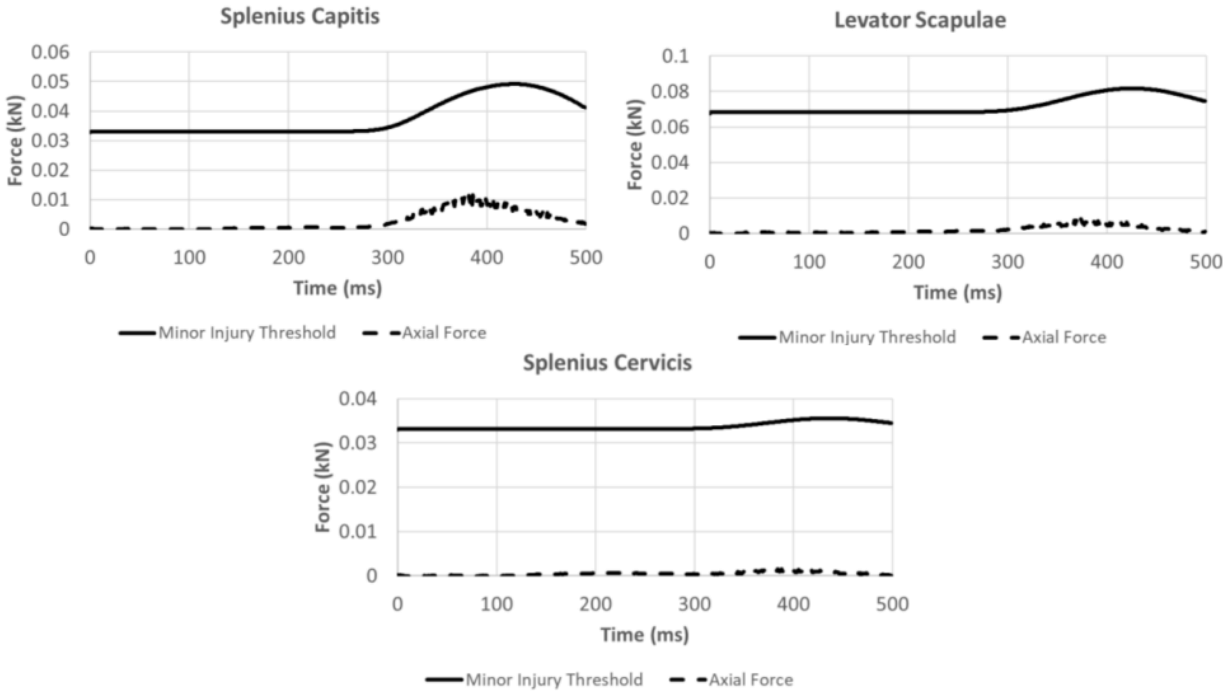
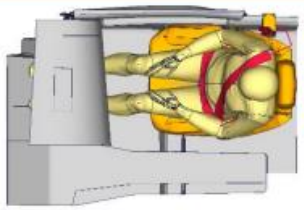
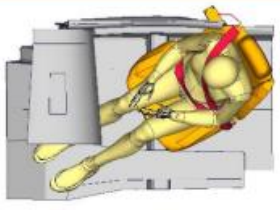
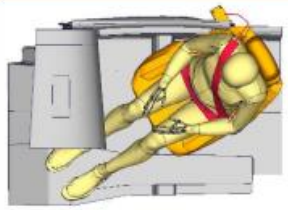
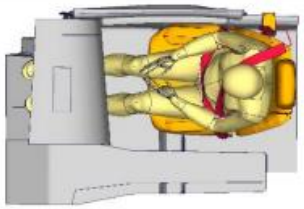
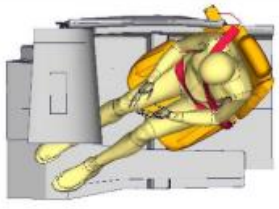
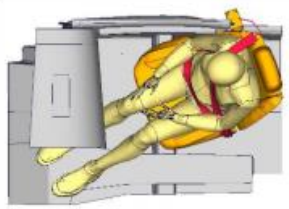
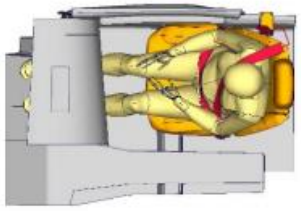
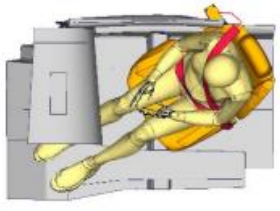
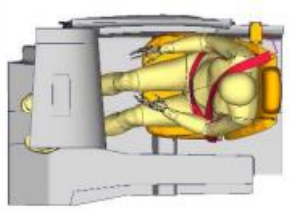
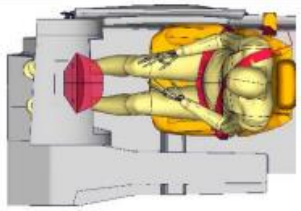
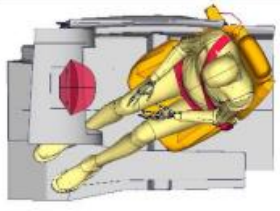
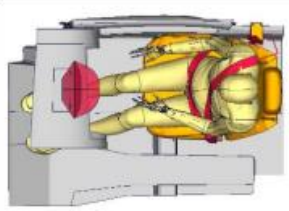
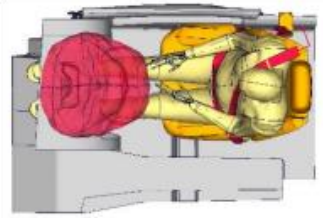
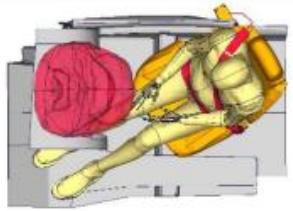
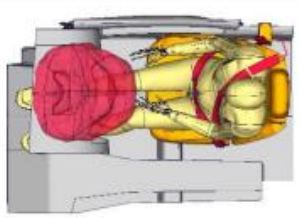
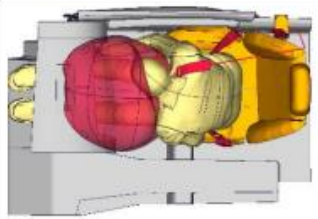
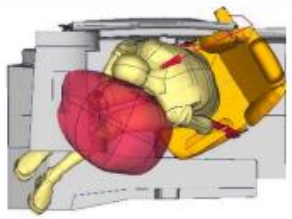
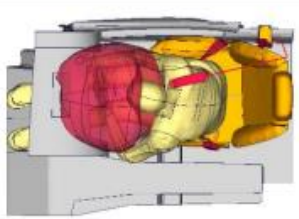
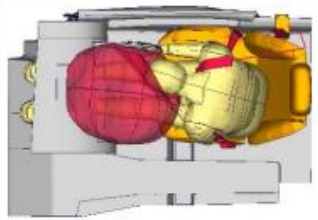
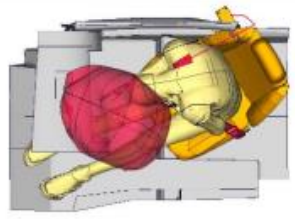
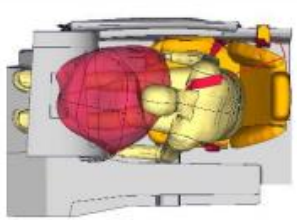
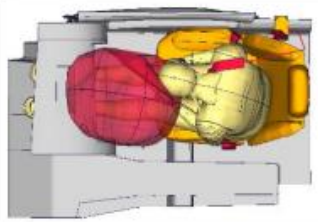
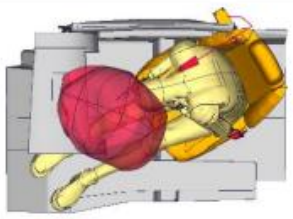
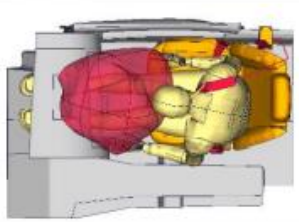


Figure 3 Muscle forces with minor injury thresholds in Case 3 for selected neck muscles based on NölleEtAl2020

Application of Extended Hill-type Muscle Model (EHTM) based muscle model for pre-rotated seat concept in D2.4 *cont..*

Time (ms)	Case 1	Case 2	Case 3
-500			
-200			
0			
	end of pre-crash phase		
0			
	data transferred to THUMS-TUC HBM		

20			
100			
160			
180			

The axial forces in the muscles were well below the threshold for minor injury risk, which was the case for all of the load cases. The active pre-crash seat rotation is thus not expected to be critical for the muscles of the occupant.

Applicability of AHBMs for a pre-crash safety system and implementation of minor injury evaluation

- Translatability of EHTM (VPS & LS-Dyna) and applicability of Muscle Injury (MADYMO, LS-Dyna & VPS) was established in this PP

Summary:

- VPS and LS-Dyna models are more aligned to each other than to the MADYMO model.
- Despite the different codes, occupant models and partly different model settings, the comparison of the simulation results shows an acceptable agreement.
- The current evaluations demonstrate that it is possible to conduct a muscle injury prediction with the approach developed in the project.

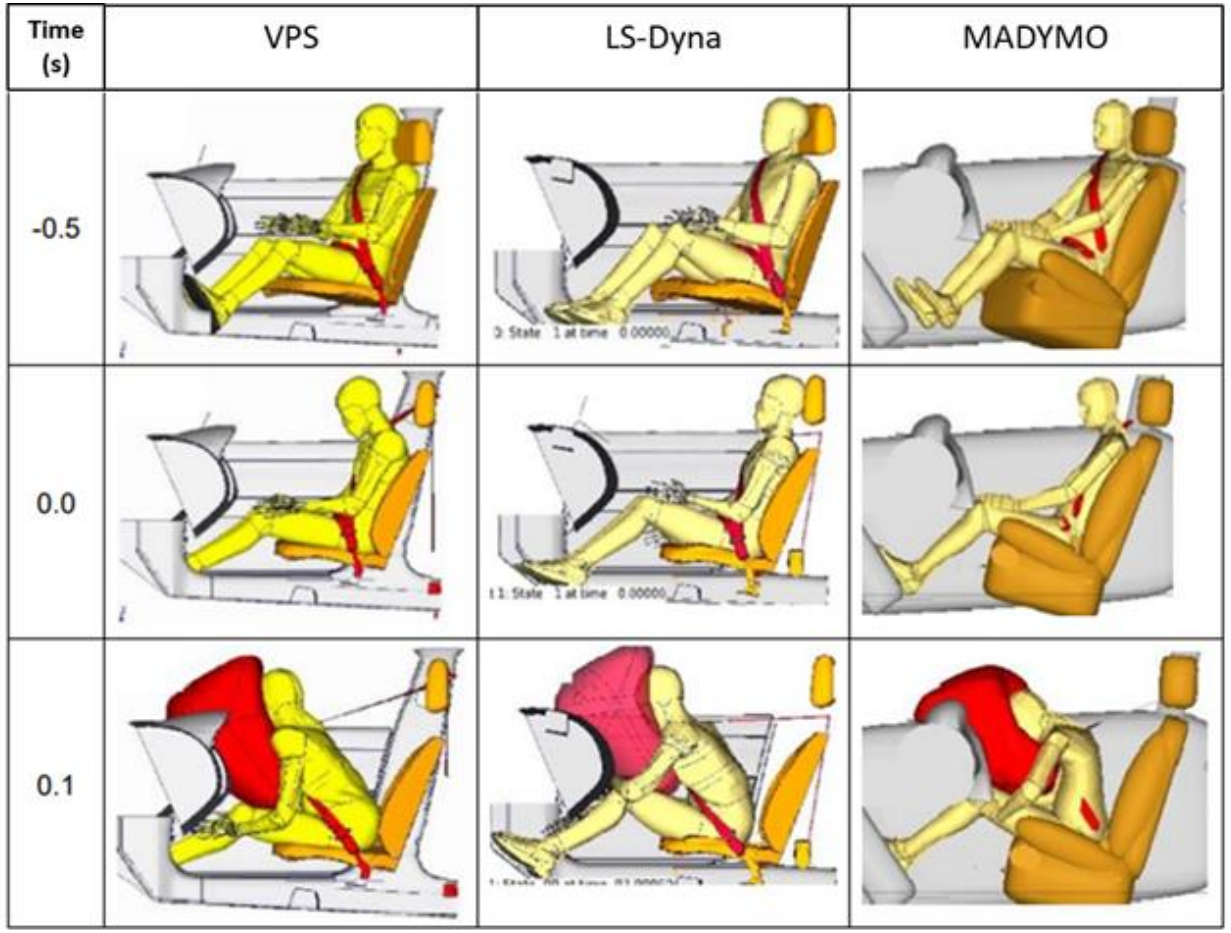


Figure 6 Comparison of occupant motion - side view