# Challenges in Using a Finite Element Human Body Model in Different Crash Codes

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## I. INTRODUCTION

In recent years Finite-Element (FE) Human Body Models (HBMs) considerably gained in importance not only for the evaluation of occupants' passive safety systems, but also in the field of pedestrian protection. HBMs are characterised as complementing conventional dummy models when limits of crash tests or simulations with dummies are reached. The advancement and enormous improvements of passive safety systems demand tools which are more accurate in terms of biofidelity and injury risk prediction, like HBMs, for the evaluation of their quality. However, users of HBMs are facing numerous challenges. The complex anatomy of the human body has to be generated using imaging techniques such as CT or MRI and to be represented by suitable meshes for a correct model geometry. In terms of material modelling, choosing adequate constitutive material models and parameters for the different biological tissues demands great experience and knowledge from the users due to the non-linear, anisotropic and viscoelastic characteristics of these tissues [1]. Furthermore, the variety of available models and crash codes impedes harmonised results of crash simulations. Outcomes depend on the model and code used for the simulation [2-4]. Within the project *THUMS User Community* it is aimed to develop an approach which is capable of delivering credible harmonised crash simulation results even when using different crash codes. For this project, the Total Human Model for Safety (THUMS) V3 developed by Toyota Motor Corporation and Toyota R&D Labs is used. Furthermore, a method to compare the kinematics and kinetics of HBMs between the different crash codes as well as between different model evolutions will be developed.

## II. METHODS

Past experiences with translating models from LS-Dyna into VPS and Abaqus were analysed for developing model guidelines to define exact requirements a human model should fulfil to ensure an improved convertibility from one crash code into another, in this case from LS-Dyna to VPS and Abaqus. In a second step, model updates and upgrades were integrated in the original LS-Dyna version of the human model THUMS V3. Model improvements mainly concerned anatomy and mesh quality of the thorax and shoulder region.

As a third action, a multi-stage validation catalogue was developed representing different levels of validation. So far, a basic validation check was conducted to ensure a robust model that can be translated into the other crash codes without major changes and delivers comparable results even if different crash codes are used. Therefore, this first level of validation catalogue consists of six load cases on the component level representing the most crash-relevant body regions and three cases on the full scale level including one pedestrian collision.

## III. INITIAL FINDINGS

Several findings were identified for an improved conversion of Human Body Models from LS-Dyna into VPS and Abaqus. These comprise a unique numbering system as well as a material modelling using materials which are directly translatable into the other codes. The requirements include the definition of stress-strain curves far beyond realistic strain values to avoid differences in extrapolation between codes. The commonly used rubber material model should not contain more than three terms. Appropriate contact definitions removing initial penetrations for all codes were found to be practically unfeasible without iterations. Segment sets as they are often used for the definition of contacts in LS-Dyna are preferred to be avoided for null-shell creation in the other codes.

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Running a simulation of a car-to-pedestrian collision proved to be an adequate demonstrator of the robustness and is seen to be a good benchmark for code-dependency of results.

## IV. DISCUSSION/OUTLOOK

As a next step, the harmonised THUMS models will be checked against a second-stage validation catalogue. In contrast to the already conducted basic validation check ensuring the model robustness and convertibility, purpose of this second-stage catalogue will be to assess and improve the biomechanical quality of the models. Objective criteria are aimed to be developed to define requirements for the performance of the models in simulations and to evaluate the validation results properly. However, several challenges in choosing appropriate reference load cases from literature have been identified and demand further efforts, especially in the area of setting up experiments. In search of a frontal full scale load case involving airbag and belt, no experiment could be identified where all the relevant components, like seat, belt and airbag, can be adequately modelled for simulation with reasonable efforts.

Furthermore, methods to compare the harmonised THUMS models between the different codes are currently identified and developed. Therefore, mesh-independent reference points defined on the basis of CT scans are developed and attached to local structures of the model.

## V. REFERENCES


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