Virtual Occupant Simulation in Vehicle Crash –
From Dummy-Considerations to Human Modeling

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The requirements concerning safety in car crash are increasing considerably over the last 25 years. Since the mid-eighties of the last century crash simulations with virtual models have almost completely replaced the real full car crash tests even including dummies. These improvements were resulting in further requirements concerning the occupant modeling. Initially mainly rigid dummy simulation models which could be handled with some ease were used due to limits in computer power. However, their application and possibilities were then strongly limited due to the inherent simplifications in modeling.

Since the mid-nineties – supported by the fast developments in computer hardware and modeling plus simulation software – the developments went towards complete and detailed modeling of the classical hardware dummies using finite element (FE) technology. The initial goal were a) to make these models usable for multi purposes, b) to make them simple to handle and c) to make them applicable for many load cases without general modifications. To achieve this the automotive industry and the main suppliers involving the simulation software providers and consulting firms made enormous efforts, to develop ready-to-go deformable occupant simulation models which are able to deliver good predictions – as far as possible with hardware dummies. These simulation models can then be taken e.g. for seat and belt design, combined with airbag construction and design as well as for the complete interior of an automotive including knee airbags and tubular head airbags.

With increasing maturity of the virtual dummy models the desire emerged to develop further towards human models. Toyota Motor Corporation, Japan was working on such models since 2000 proposing the THUMS – Total HUman Model for Safety - model family and had made the offer to the interested experts to use the models and to improve the models on their own. However, human modeling is raising many new questions. These are starting with the ethically highly problematic mining of “material”-data for the corresponding body parts and continuing with the extremely difficult modeling of body parts, muscles, sinews etc. simply considering the geometry and the internal connections to the surrounding. Further difficulties are the up to now unknown passive-active behavior of muscles and sinews and their corresponding modeling. However, some first models are available with highly resolved details which are very impressive. These models can be used for first investigations even in car simulations.

Within the lecture starting with a general overview over occupant simulation first actual models for hardware dummies will be presented. Then the view will be on the difficulties concerning developments and validation of the models. The second strong focus will be on the current available human models, their validation possibilities and some first applications in realistic type simulations.

Finally the view will be on the acting persons in the development of such models and on the role of science – mathematics, mechanics, software development, computer environment - within this process.