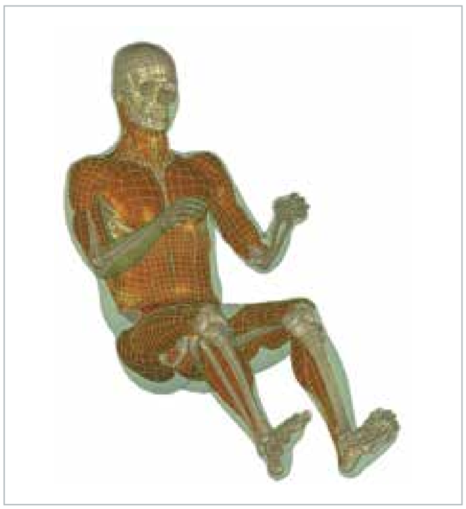
Using HyperWorks to Develop Human Body Models for Vehicle Crash Simulation



Virginia Tech
Wake Forest University
School of Biomedical Engineering and Sciences

Key Highlights

Industry: University/Research, Automotive

Challenge: Develop highly detailed, finite-element human body models for vehicle crash simulation

Altair Solution: Utilize HyperMesh, HyperMorph, and RADIOSS for model development & validation

Benefits: Computational human body model simulation can enable assessment of more real world injury scenarios to allow for improved engineering design to prevent potential human injury resulting from vehicle collision

Background

Wake Forest Baptist Medical Center is a leading research university in biomedical sciences and bioengineering that provides students and faculty with outstanding opportunities for personal and professional growth. The Center of Injury Biomechanics (CIB) in the School of Medicine at Wake Forest Baptist investigates injury mechanisms following trauma resulting from vehicle crash to develop a greater understanding of human tolerance to injury and to engineer enhanced safety countermeasures. Since 2006, Drs. Joel Stitzel and Scott Gayzik of the CIB have been principle investigators for the Global Human Body Modeling Consortium(GHBMC), an international consortium of automakers and suppliers working with research universities and government agencies to advance human body modeling technologies for crash simulation.

Develop highly detailed, finite-element human body models for vehicle crash simulation

Computational modeling is a growing component of injury biomechanics and trauma research. Detailed mathematical modeling of the human body can enable computational analysis of real-world injury scenarios to allow for engineering improvements to help prevent potential human injury. The first step in developing the necessary detailed models is to mathematically quantify fundamental human body organs, skeletal members, and body extremities that are subject to trauma. The resulting medical image data must accurately represent a range of vehicle occupants: adults (male & female), children (3-6 years old), and infants. Next, the human body data must be discretized to generate

Keywords: HyperMesh, HyperMorph, RADIOSS, computational modeling, biomechanics

Wake Forest Baptist Medical Center Success Story

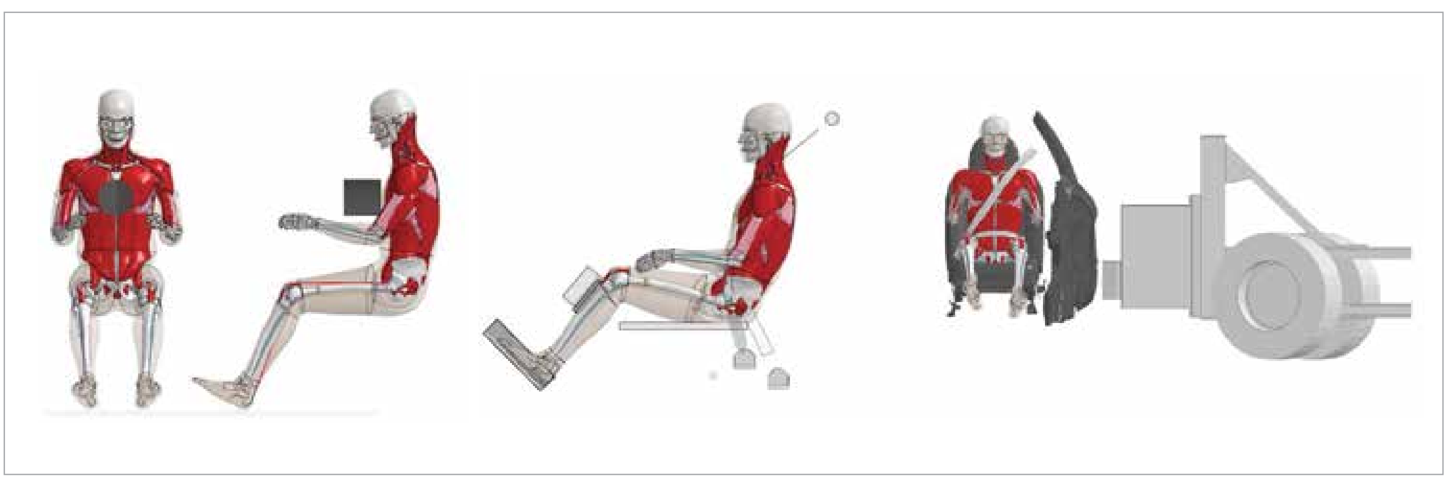
"Advanced meshing and morphing tools are key for enabling the development of human body computational models for injury assessment from vehicle crash events."

Dr. Scott Gayzik
Assistant Professor
Center for Injury Biomechanics

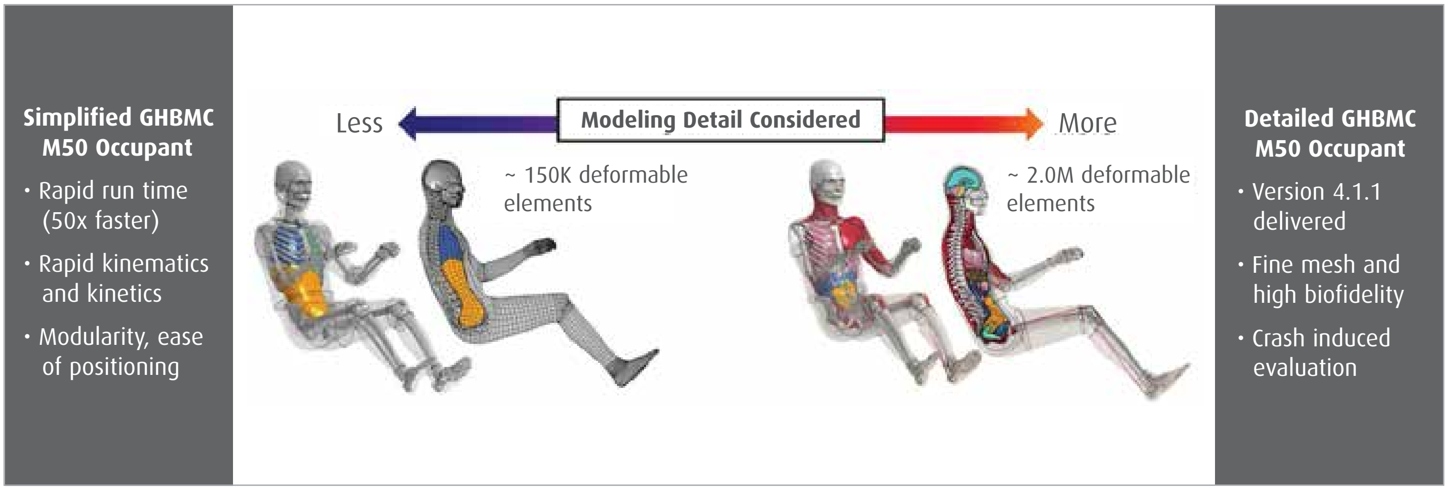
accurate finite element (FE) models of the varied human body systems. FE models of these different body systems must then be integrated to formulate a model of the entire human body. Finally, the entire human body model must be validated in vehicle crashworthiness simulations with occupant and pedestrian impact conditions.

Utilize HyperWorks tools for FE model development & validation

The GHBMC has applied Altair HyperMesh and its HyperMorph module to develop detailed finite element models based upon extensive scanned data of human body organs, tissues, and skeletal systems. The data was developed under the direction of established GHBMC Centers of Expertise (COE) at selected universities. Each of these Centers had responsibility for CAD and finite element modeling of specific regions of the human body. An additional COE was established to integrate data and finite element models from each subsystem into a full body model. The GHBMC selected the Wake Forest University CIB to complete the extensive integration work requited for the Total Human Body COE. Five other COEs were established at leading international university biomedical research centers to complete the required work for the head, neck, thorax, abdomen, and lower extremity body regions. Altair has made available the entire HyperWorks suite of CAE tools to enable the finite element and crashworthiness analysis-related work for each COE. HyperMesh was applied for finite element modeling of human body CAD data, while RADIOSS was applied for vehicle crash simulation validation. The work of the full body modeling COE is particularly demanding in that it must integrate detailed finite element models from each of the five body region specific COEs. This integration work has proved to be challenging at the interface of the head and neck regions where small elements (5-mm in edge length) are



M50 occupant model with 2.2 million elements and 1.3 million nodes



Process to scale down dummy models and increase simulation efficiency has been developed

needed to insure good element continuity and quality. Similar challenges occur at the interface of the pelvis with the lower extremities where larger elements (10-mm in edge length) can be applied to enable a total finite element model of reasonable size.

50th Percentile Male Occupant Finite Element Model Developed and Validated

A 50th percentile male vehicle occupant (M50) model has been developed that consists of 2.2 million elements, 1.3 million nodes, and weighs 76.9 kg. The GHBMC M50 model, through extensive simulation work at all COE collaborating universities, has been validated for 38% of all crash-induced injuries. These include skull and facial bone fracture, intervertebral disk injury, rib fracture, liver and spleen injury, pelvis and hip fracture, and leg fracture. The model is detailed enough for simulating 80% of all crash-induced injuries, and has been validated on RADIOSS, LS-Dyna, and PamCrash simulation platforms. Full vehicle, frontal barrier validation studies at Wake Forest University consisted of 18 simulation cases: 9 frontal, 8 lateral, and 1 roll-over.

One significant challenge of the GHBMC is to develop a method that effectively extends the modeling features of the M50 model to other occupant dummy sizes used for crashworthiness assessment. A modeling scaling approach has been applied by the Wake Forest Baptist team to rapidly develop other sized models. Their work leveraged the large amount of existing data for the M50 development, including external anthropometry and medical imaging data. Homologous surface landmarks from the M50 data were placed on corresponding locations for a target M95 (male 95th percentile) model. Thin plate splines were used to morph the surfaces. Similar efforts were used to apply HyperMorph, Altair's manipulation tool included within HyperMesh, to develop additional M50 finite element model variants.

Another significant objective of the implementation of the full human body model is to increase simulation efficiency by using reduced-size models. Reduced-size models have been developed using 150,000 deformable elements and enable simulation run times that are 50% faster than corresponding detailed models. The simplified models enable rapid kinematic evaluation of an impact event and allow for easy positioning of the occupant finite element model in a vehicle interior. The Wake Forest Baptist COE has completed the development work on a M50-based simplified model. "Advanced meshing and morphing tools are key for enabling the development of human body computational models for injury assessment from vehicle crash events" recalls Dr. Scott Gayzik, Assistant Professor, for the Center for Injury Biomechanics.

Future efforts of the GHBMC will focus on developing simplified and detailed full-body models for male 5th and 95th percentile size. Development of corresponding models for female 5th, 50th, and 95th percentile size are also planned. Simplified and detailed models for standing pedestrians will also be developed.

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