THOMO

NEWSLETTER

Development of a Finite Element Model of the Human Thorax and Upper Extremities

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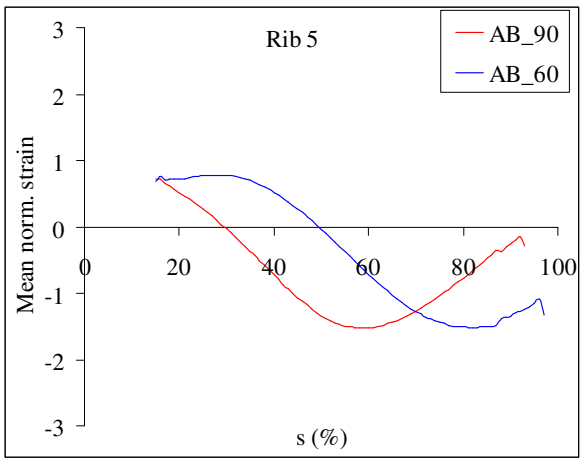
WP2 Human Mechanical Properties

The work package 2 concerns the gathering of existing data and acquisition of new biomechanical data.

Analysis of rib strain profiles (CEESAR)

Corridors of rib strain profiles in side and oblique impact tests for airbag and impactor test conditions were built, based on 24 THOMO and existing dynamic tests, with the ribcage fully instrumented with strain gages. The results, showing the effect of angle, loading type (distributed and rigid impact) and rib level, have been disseminated through a publication in the Journal of Stapp Car Crash Conference in November 2011. Here after an example of strain profile in side and oblique impact, in airbag test conditions.



Caption: in red and blue colors, respectively pure side and forward oblique impact.

In this Issue :

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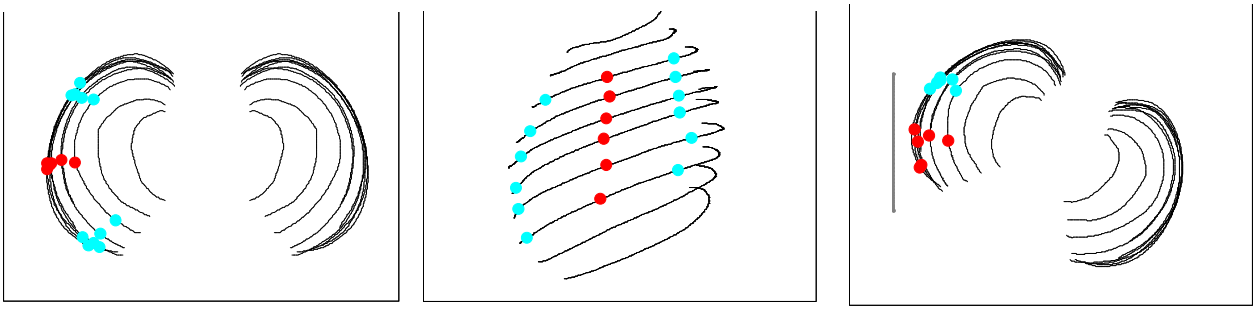
(…) Analysis of rib strain profiles (CEESAR)

The typical points of the strain profiles are drawn on the GHBM* thorax model on the figure here after.



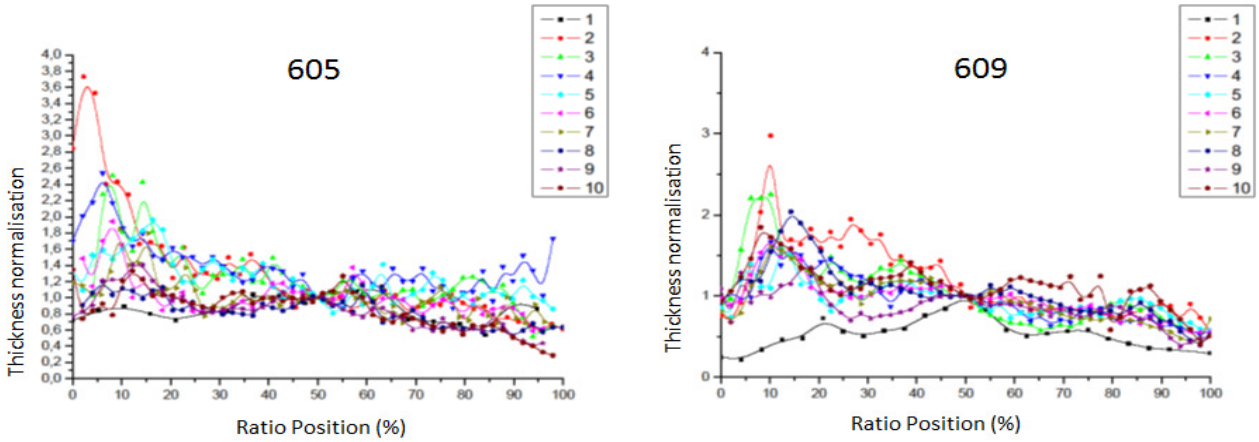
Caption: Typical zero-strain and maximum strain location drawn on the GHBM thorax model, in pure side impact test conditions for the two left figures (upper and side views), and in oblique impactor test conditions (right figure). The red points correspond to the maximum rib strain (and also to the rib fracture location). The blue points correspond to the zero-strain location.

In 2010 and 2011, six dynamic tests on small females (mean weight of 43 kg) were performed in side and oblique impactor conditions, at a 4.3 m/s speed. The analysis regarding the mechanical behavior is in progress and will be used for the validation of the small female model.

Local geometrical rib properties (UVHC)

The complete local geometrical rib properties have been acquired on two post-mortem human subjects, using a µ-CT scan device. This dataset has been complemented with the acquisition of the geometrical properties of a rib sample on the sixteen remaining specimens, including six small females. The data analysis has allowed the definition of trends regarding the cortical bone thickness distribution, which has been compared with those of the reference GHBM model.

Cortical thickness distribution along each rib



Caption: cortical thickness distribution along each rib from 1 to 10 for two specimens (605 and 609)

*GHBM for Global Human Body Model

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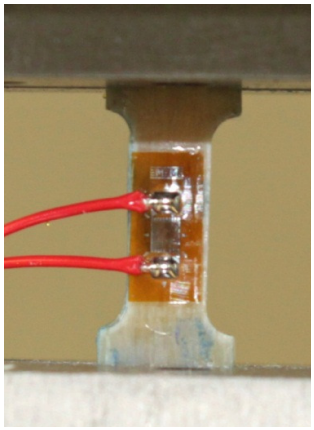
(…) Local geometrical rib properties (UVHC)

Scaling factors for the local geometrical properties have been also determined, with help of data coming from the literature, which regard the cross-section and cortical bone thickness for the small female and the large male. These parameters will be implemented in the 5th percentile female and 95th percentile male thorax models.

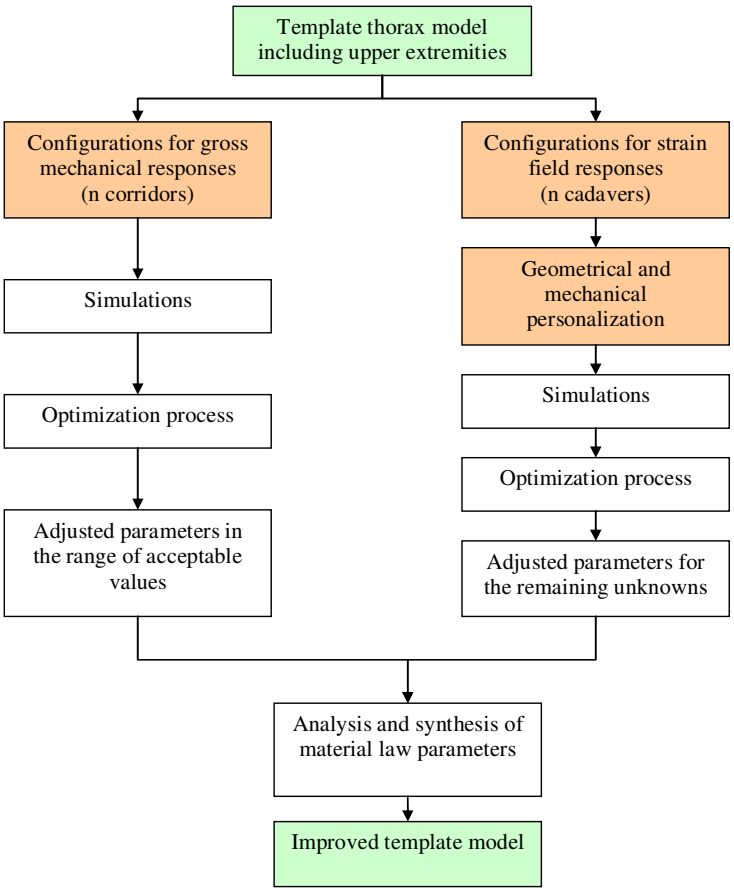
In order to personalize the models at a tissue level, the ribs of each specimen (n=18) were tested in tensile tests, with a specific protocol, including the use of a strain gage glued on the coupons. The results show that the cortical bone can be considered as a fragile material, with properties comparable with published results in similar test conditions. Significant differences were found between the internal and external table.



Caption: Rib coupon in tensile test

WP3 Model Validation

The work package 3 is dedicated to the development of the GHBM thorax model (see flow chart). The first approach was to validate the model in several sub-system configurations. The second one was to personalize the model in several cases for which the geometrical properties are known (from the WP2), and for which the test results are known and the boundary conditions well defined. An optimization process was used to stress the range of acceptable values for the soft tissues. Indeed, the data acquired in the WP2 have allowed defining the geometrical and mechanical properties of the ribcage with a good accuracy.



Caption: flow chart of the WP3

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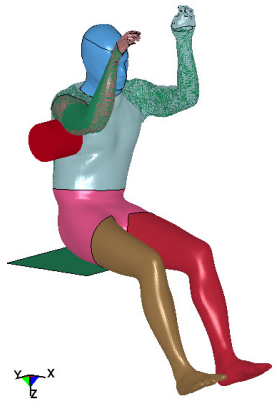
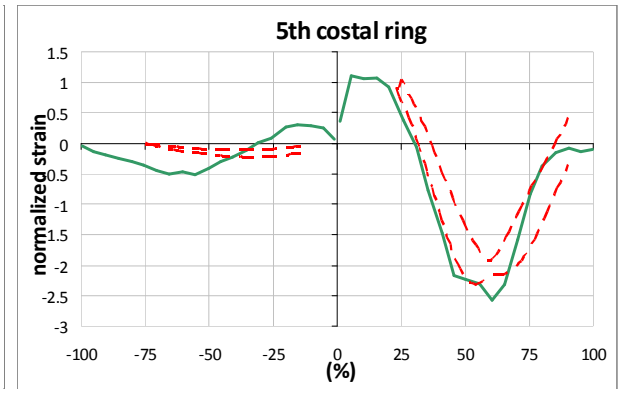
(…) WP3 Model Validation

In order to show the ability of the GHBM thorax model to reproduce the injury mechanisms, specifically regarding the rib fractures, two test configurations were chosen in side and oblique impact, for which strain field corridors were built for each costal ring, based on THOMO and existing tests.

The approach was to compare the rib strain fields from the thorax model with strain field corridors built for that purpose. In a first step, the position of the arms of the reference model was modified to match the real test conditions. In a second step, simulations were performed and the strain outputs were post-processed and compared with existing corridors. Here after an example of results in pure side impact on the 5th costal ring. The results show that the GHBM results are in good agreement with the targets, even then on the opposite side, the strains seems higher as expected.



Caption: Thorax model in side impact configuration



Caption: Comparison of the strain profiles (model in green line, test corridor in red dotted line)

Personalization of the thorax model (WUT , UWB)

For a better understanding of the influence parameters on the global response (force, deflection) and on the amount of rib fractures, the reference model has been personalized for four medium males and two small females. The personalization regards the global dimensions of the ribcage and also the local geometrical properties, as cross-section and cortical bone thickness. The kriging method was applied for that purpose, considering the thorax model as a baseline model. Despite several difficulties due to the method and the large amount of data (more than 700 hundred control points), the models are built and they are numerically stable and suitable for the next step which will consist to compare the results with the results of each post-mortem human subject test. It is expected that the results will allow for identifying the parameters which influence the mechanical response and injuries. Here after four examples of personalized thorax models (external soft tissues were removed for a better view of the ribcage).

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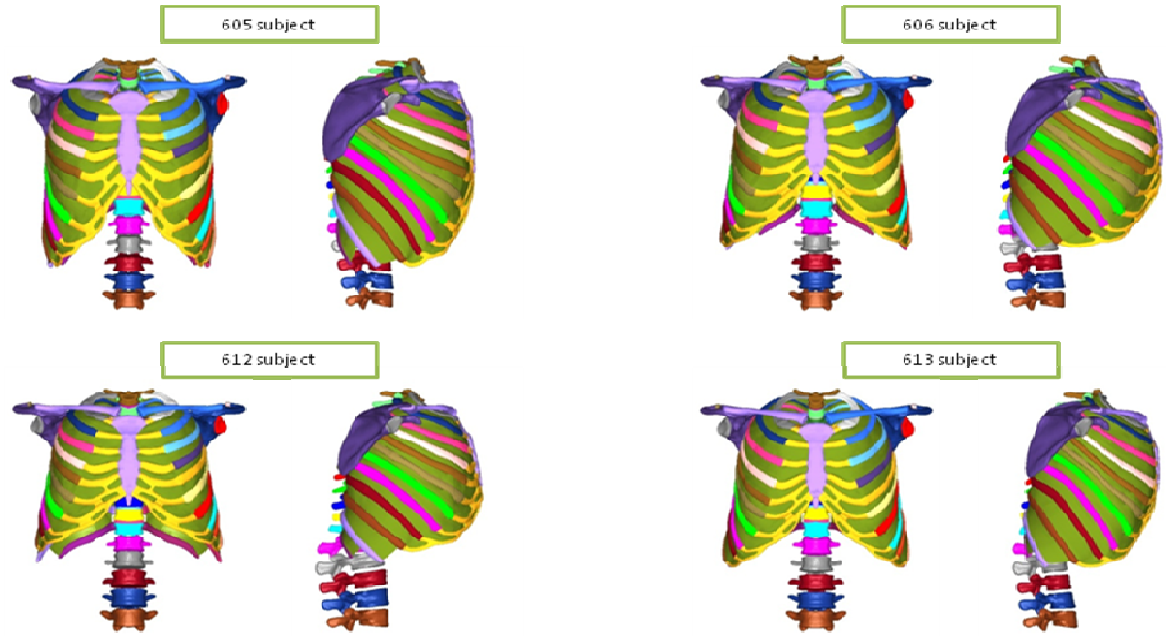
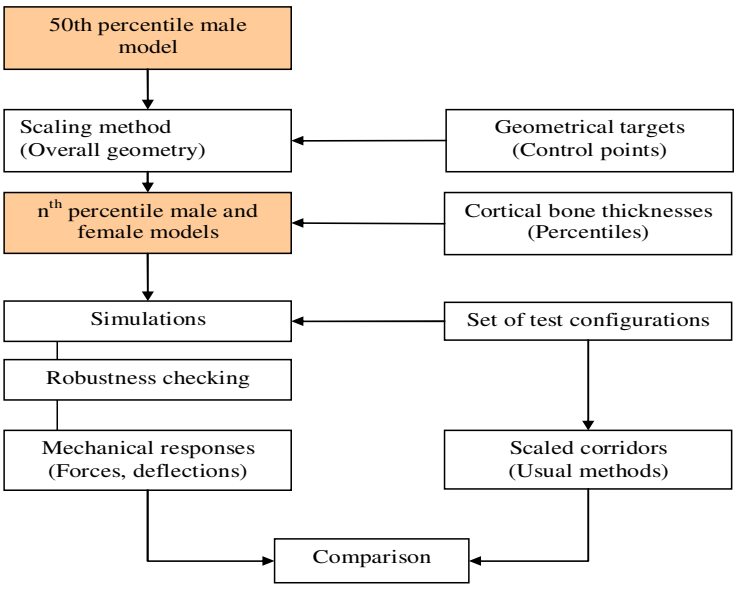
(…) Personalization of the thorax model (WUT , UWB)



Caption: Four personalized models in side and front views (external soft tissues removed)

WP4 Development of the Models Family

The work package 4 concerns the development of a complete family of thorax models. (See flowchart).



Caption: flow chart of the WP4

Development of the 5th percentile female and 95th percentile male thorax models (UWB , WUT)

Two families of thorax models (the small females and the large males) have been developed and are numerically stable. Their characteristics depend on the anthropometric databases. The comparison of the force-deflection curves in frontal and side impact with scaled corridors coming from the 50th percentile male are in progress. The results obtained on a set of six small female post-mortem human subjects will be also used to this end.

Publications

INFATS 9th International Forum of Automotive Traffic Safety. December 3-5, 2011. Changsha, CHINA.
- "Influence of the material definition on the biomechanical response of a simplified human torso FE model". D.Gierczycka, C.Rzymkowski and J.Toczyski (WUT)

55th Stapp Car Crash Conference, November 7-9, 2011, Dearborn, MI USA
- "Study of the rib fracture mechanisms based on the rib strain profiles in side and forward oblique impact". Tipahine Leport, Pascal Baudrit, Pascal Potier (CEESAR), Xavier Trosseille, Erwan Lecuyer (LAB PSA Peugeot-Citroën RENAULT), Guy Vallancien (University René Descartes, Paris)

NHTSA 39th International Workshop on Human Subjects for Biomechanical Research, November 6, 2011. Detroit, USA.
- "Numerical Anthropometry Comparison between the THOMO PMHS and GHBMc Model". O. Mayeur, J. Delattre, M. Kindig, R. Delille,F. Chaâri, D. Lesueur, P. Drazetic,P. Baudrit. (Univ Lille Nord de France; UVHC. LAMIH; CNRS; UVA; CEESAR)

ISN Workshop on Biomechanical Experiments on Human Subjects. September 13, 2011. Cracow, Poland
- "Selected problems in numerical modeling of human 50th percentile male model". D. Gierczycka-Zbrozek, J. Toczyski (WUT)

1st International THOMO Workshop. April 7. 2011 Valenciennes, FRANCE
-"THOMO project presentation "-Pascal BAUDRIT, CEESAR, France
-"Study of the mechanical ribcage behaviour through the analysis of PMHS strain profiles in side and oblique impact." - Pascal BAUDRIT, Tiphaine LEPORT, CEESAR, France
-"From medical imaging at different scales to thorax geometrical characterization" – Olivier MAYEUR, Fahmi CHAARI, University of Valenciennes, France
-"Scaling modelling methodology used for thorax model "- Tomasz DZIEWONSKI and Michal PEDZISZ, University of Warsaw, Poland
-"Methodology for model validation"- Magdalena JANSOVA, University of West Bohemia, Czech Republic
-"Stabilisation process and robustness analyses of simplified scaled GHBMC reference 50tile male thorax model "- Jacek TOCZYSKI, University of Warsaw, Poland
-"Reconditioning and instrumentation of PMHS" - Pascal POTIER, CEESAR, France

Agenda:

5th Steering Committee: 9-10 June 2011, at WUT in Warsaw, Poland.
6th Steering Committee: 26-27 January 2012, at UWB in Plzen, Czech Republic.
7th Steering Committee: 21-22 June 2012, at CEESAR in Nanterre, France.

Organizations

CEESAR, Centre Européen d'Etudes de Sécurité et d'Analyse des Risques, FR
UVHC, Université de Valenciennes et du Hainaut Cambrésis, FR
UWB, University of West Bohemia, CZ
WUT, Warsaw University of Technology,PL

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SEVENTH FRAMEWORK PROGRAMME

Website http:// www.thomo.eu