HUMAN RESPONSE TO A FRONTAL SLED DECELERATION TEST FOR THE VALIDATION OF A CAR OCCUPANT MATHEMATICAL MODEL

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Introduction

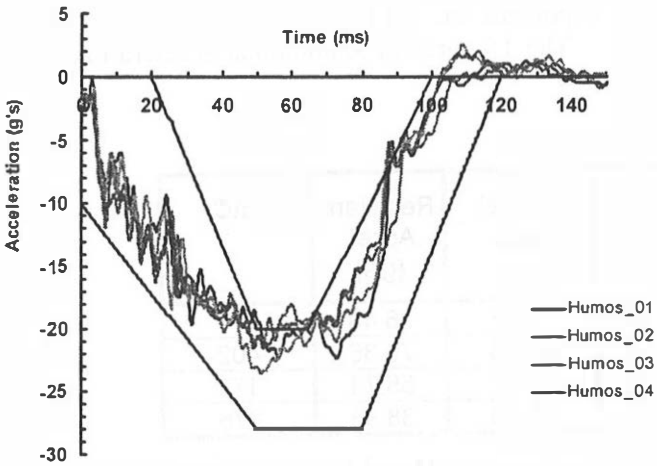
The general objective of the HUMOS European research program (HUman MOdel for Safety) is the development of a new finite element model of a seated car occupant, validated for car crash conditions and aiming at the optimization of vehicle design. The project is composed of 6 main work packages ; Global specifications, Geometry acquisition, Biomaterial behavior characterization, Post Mortem Human Subject (PMHS) experimental data, Whole model validation.

The paper presents the information on the response (kinematics, acceleration) of the PMHS in a frontal sled deceleration test.

During the last decades, a great amount of work has been made with the view of characterizing the human dynamic behavior. Number of experiments has been carried out in order to obtain global information on the human behavior. Unfortunately, the lack of coherence between the different studies, together with the difficulties encountered to clearly identify and/or reproduce the used boundary conditions render the exploitation of those results difficult to achieve.

Methodology

An experimental protocol was set up according to the needs expressed by the HUMOS consortium. For the mathematical modeling, the boundary conditions were simplified. No steering wheel, no knee bolster and no airbag were mounted. A catapult is used to simulate impact. The deceleration pulse is close to the ONU/ECE/R44 regulation (Child Restraint System, Figure 1).



Test	Velocity (km/h)	Max. Decel. (g's)
HUMOS_01	48.80	-21.92
HUMOS_02	48.10	-21.26
HUMOS_03	49.80	-23.56
HUMOS_04	48.10	-21.21

Figure 1 : Test velocity and deceleration conditions

The PMHS are unembalmed coming from the department of anatomy of medical university of Lyon. They are examined for HIV or other infectious diseases, anatomic abnormality or signs of very long decubitus. They are seated on a rigid seat and restrained by separated shoulder and lap belt. The shoulder belt is equipped with a load limiter. Each foot is fixed on a separated rigid toe-pan. The hands are suspended to in a position corresponding to the natural posture for driver.

Two high-speed 16-mm cameras (1000 frames/sec) filmed the motion and a total of 61 channels of data are recorded during the test. Accelerometers are located on the head, the thorax, the upper and lower extremities. Force sensors are located on the belt, the toe-pan and the seat. Initial position of the PMHS and of the seat as well as sensor location is recorded using a 3D measuring system. Anthropometry of the PMHS is collected. After the test, the PMHS is autopsied for injury survey.

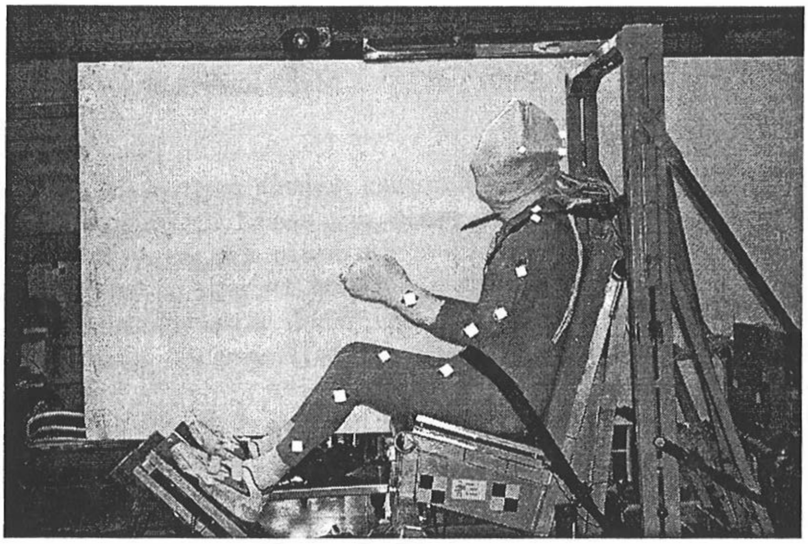


Figure 2 : Test set up

Results:

Four tests have been carried out. The results consist of the kinematics of the PMHS obtained from the analysis of the high-speed films and the dynamics coming from the sensor.

INRETS - LBMC has developed software to calculate the head center gravity acceleration of PMHS. This software uses the data from twelve acceleration channels of the INRETS-LBMC helmet to determine the acceleration, velocity and displacement components and the Head Injury Criterion (HIC). The longitudinal (X) and vertical (Z) components and the resultant acceleration are calculated and the maximal values are reported in Table 1. The T8 vertebra longitudinal acceleration of PMHS tests is given in the figure 3.

Test	X Accel. (g's)	Z Accel. (g's)	Resultant Accel. (g's)	HIC
HUMOS_01	-69.82	87.01	96.48	919
HUMOS_02	-46.56	43.03	75.36	402
HUMOS_03	-35.03	43.64	55.71	173
HUMOS_04	-25.92	31.76	38.93	176

Table 1: Maximal head acceleration and Head Injury Criterion

An injury description is given from the autopsy. For the two first tests, a 6kN shoulder belt load limiter was used (standard belt without airbag), and the PMHS were massively injured. The results are however in accordance with known injury risk curves (Kallieris et al.). After these tests, the HUMOS consortium decided to reduce the load limit. The two last tests were carried out with a 4kN shoulder belt load limiter and the number of rib fractures reduced, as expected.

The PMHS were selected in order to match as close as possible the characteristics of the PMHS which was used for generating geometric data of the model within the HUMOS program. But, of course, exact matching is not possible and some adjustment of the model will be necessary.

The fractures produced during the test modify the mechanical response of the body while the model was not intended, at least in a first step, to simulate the occurrence of injury. This can lead to some difficulties to reproduce the behavior of the PMHS in the tests.

These tests provide information to evaluate the biofidelity of a finite element model of a car occupant, in a relatively simple frontal impact situation with well-known initial and boundary conditions. The protocol used was especially designed for the purpose of model validation.

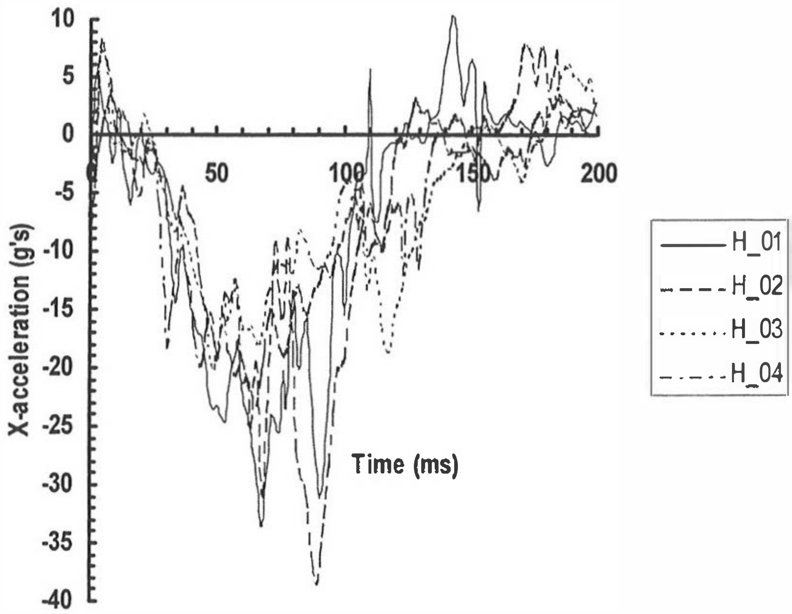


Figure 3 : T8 vertebra longitudinal acceleration

Conclusions

The situation tested is representative of accidents with occupant restrained by a safety belt. For further validation of the model we need to increase the knowledge of the human thorax/shoulder response during loading in frontal impact with airbags. Such an action is planned within the next European Frontal Impact Dummy research program.

Acknowledgements

The authors would like to thank to Gérard GOUTELLE, Pierre LAPELERIE, Michel MARAIS, Sophie SERINDAT, for doing such a fine work in collecting data, photos, measurements, during the INRETS-LBMC experiments.

The HUMOS (HUman MOdel for Safety) project is supported by European Community (DG XII) and co-ordinated by LAB PSA Peugeot Citroën RENAULT (FR). The other partners are ; Volvo (SE), VW (DE), BMW (DE), ISAM GmbH (DE), ESI (FR), TNO (NL), National Technical University of Athens (GR), Bertrand Faure (FR), Chalmers University (SE), ECIA (FR), Heidelberg University, and Marseille University.

Reference

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