

CALIBRATION AND VALIDATION OF A FINITE ELEMENT MODEL OF THOR-K ANTHROPOMORPHIC TEST DEVICE FOR AEROSPACE SAFETY APPLICATIONS

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BACKGROUND

The THOR anthropomorphic test device (ATD) has been developed and continuously improved by the National Highway Traffic Safety Administration to provide automotive manufacturers an advanced tool that can be used to assess the injury risk of vehicle occupants in crash tests. Recently, a series of modifications were completed to improve the biofidelity of THOR ATD [1]. The updated THOR Modification Kit (THOR-K) ATD was employed at Wright-Patterson Air Base in 22 impact tests in three configurations: vertical, lateral, and spinal [2]. Although a computational finite element (FE) model of the THOR had been previously developed [3], updates to the model were needed to incorporate the recent changes in the modification kit. The main goal of this study was to develop and validate a FE model of the THOR-K ATD.

METHODS

The CAD drawings of the THOR-K ATD were reviewed and FE models were developed for the updated parts. For example, the head-skin geometry was found to change significantly, so its model was re-meshed (Fig. 1a). A protocol was developed to calibrate each component identified as key to the kinematic and kinetic response of the THOR-K head/neck ATD FE model (Fig. 1b). The available ATD tests were divided in two groups: a) calibration tests where the unknown material parameters of deformable parts (e.g., head skin, pelvis foam) were optimized to match the data and b) validation tests where the model response was only compared with test data by calculating their score using CORrelation and Analysis (CORA) rating system. Finally, the whole ATD model was validated under horizontal-, vertical-, and lateral-loading conditions against data recorded in the Wright Patterson tests [2].

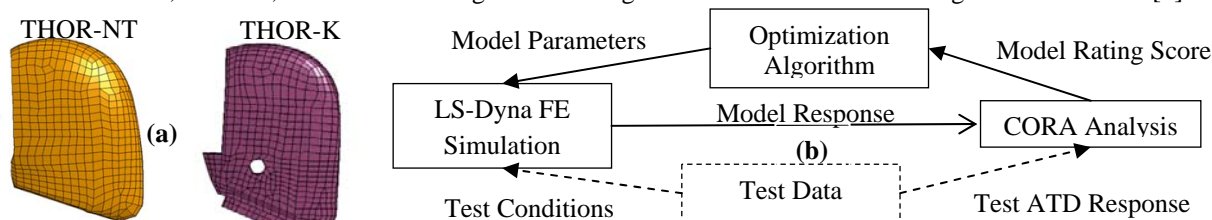


Fig. 1. (a) Geometry/mesh update (e.g., head skin), (b) Material properties update /model calibration.

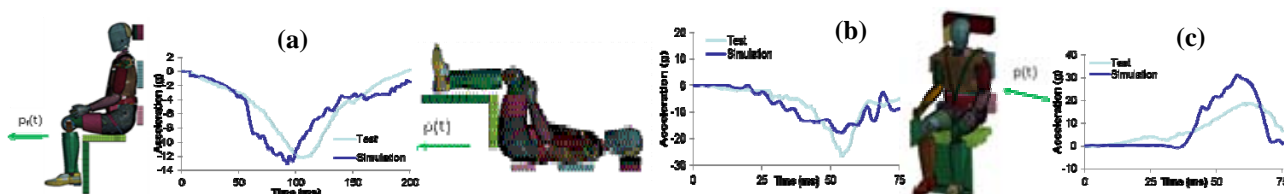


Fig. 2. The FE model of THOR-K dummy in the Wright Patterson test set-ups and test vs. simulation comparison in time histories of pelvis acceleration (preliminary results) (a) horizontal loading, (b) vertical loading, (c) lateral loading.

RESULTS AND DISCUSSION

Overall, the final THOR-K ATD model developed in this study is shown to respond similarly to the ATD in all validation tests. This good performance indicates that the optimization performed during calibration by using the CORA score as objective function is not test specific. Therefore confidence is provided in the ATD model for use in predicting response in test conditions not performed in this study such those observed in the spacecraft landing. Comparison studies with ATD and human models may also be performed to contribute to future changes in THOR ATD design in an effort to improve its biofidelity, which has been traditionally based on post-mortem human subject testing and designer experience.

REFERENCES

[1] Ridella AS, Parent DP. (2011) *ESV Conf* 11-0312, [2] Newby N, Somers JT, Caldwell EE, et al. (2013) *Stapp Car Crash J*, [3] Untaroiu CD, et al. (2009) *ESV Conf* 09-0272, [4] Putnam J, Somers J, Untaroiu CD. (2013), *Traffic Inj Prev* (under review)