Development of the THOR-5F advanced frontal small female dummy FE model

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I. INTRODUCTION

Development and implementation of sophisticated and more human-like anthropometric test devices (ATDs), commonly known as 'crash test dummies' or 'dummies', to evaluate vehicle performance is ongoing. The Test device for Human Occupant Restraint (THOR) is an advanced frontal ATD that incorporates improved biofidelic features. It has significantly expanded instrumentation, enabling engineers to investigate injury pathways not included in the design of the HIII family of dummies currently being used in various regulations. The THOR dummy concept was initiated in early 1980. Recently, the THOR 5th percentile small female ATD hardware has been under development, as a possible successor to the HIII 5th percentile crash test dummy.

This study highlights the development of the THOR-5F ATD finite element (FE) model. Although this dummy FE model is evaluated for a variety of biofidelity loading conditions, which it is necessary for the hardware to fulfil, the current paper is limited to a selected biofidelity loading condition in the thorax region of the THOR-5F FE model.

II. METHODS

The THOR-5F is an advanced frontal ATD with complex features and measurement capabilities. It can have a total of 174 data channels and extensive biofidelity requirements. The THOR-5F FE model incorporates all the complex features and instrumentation with a great level of detail. Concurrent development of the THOR-5F FE model, along with associated hardware, has allowed developers to ensure that the latest hardware changes are represented. The geometry, material modelling and structural connectivity are realized in the most physical way in the THOR-5F model development efforts.

Fig. 1 shows the THOR-5F FE model representation and also a sectional view of the model to present the interior features. The THOR-5F FE model has a total of over 600,000 elements. The initial time-step size for the model is 0.7 micro-second for computational efficiency, which is in line with common industry practices.

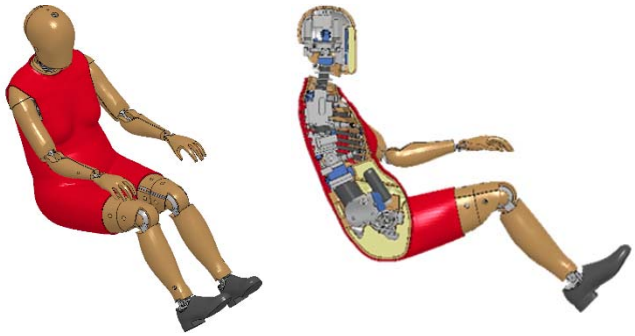

Fig. 1. THOR-5F FE model.

The THOR-5F FE model is preliminarily evaluated against more than 20 biofidelity test validations, from head to toe, for functionality evaluation. The current paper presents initial results for the thorax probe impact biofidelity test validation, as preliminary functionality and performance check. The THOR-5F thorax consists of a complex structure involving rib cage, flesh and spine box.

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The THOR-5F thorax has a number of sensors, ranging from Infra-Red Telescoping Rod for the Assessment of Chest Compression (IRTRACC), load-cells, accelerometers, and angular rate sensors (ARS) for injury prediction capabilities. The most important sensor from the thorax injury perspective is the chest compression measurement, which is carried out using the IRTRACC and used to measure how much the sternum compresses relative to the spine of the dummy.

One of the thorax biofidelity evaluations requires the thorax probe impact as shown in Fig. 2. The model is in a seated position, without any back support, with legs horizontal and arms raised to be horizontal to the ground. The probe impacts the model such that the centreline is at the mid-line of the sternum, at rib number 3.

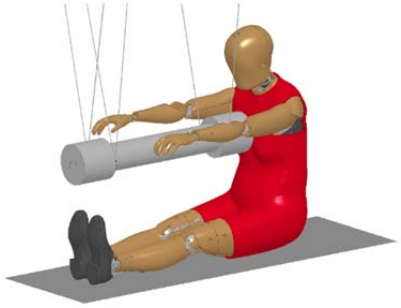

Fig. 2. THOR-5F Thorax Probe Impact Model Set-up.

III. INITIAL FINDINGS

The comparison of the FE model response to the biofidelity corridors is presented in Fig. 3. The corridors are derived from cadaver test data by Neathery *et al.* and scaled down to be used for the small female anthropometry. In the model, the force is measured as the contact force between model and probe, and the compression is the average deflection from the right and left IRTRACC displacement sensors.

Fig. 3. Thorax probe impact response against biofidelity corridors.

IV. DISCUSSION

The limitation of the biofidelity corridors is that they have been derived from scaling down of the cadaver data from the 50th percentile anthropometric representation. The other limiting factor for the current response is the materials, which are derived from the best possible sources, as hardware is being developed concurrently. More material and hardware testing is planned to further enhance the model in the most physical way. All the hardware complexities of the structure, and instrumentation of the dummies, are reasonably captured using the best possible features in the FE solver. It is concluded from the current study that a very detailed THOR-5F dummy FE model has been developed and evaluated for functionality and preliminary performance.

V. REFERENCES

[1] Neathery, R., 18th STAPP Conference, 1974.