Update and Correlation of the Open-Access LS-DYNA Toyota Auris Seat Model for Rear-End Impacts

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I. INTRODUCTION

Virtual testing of rear-end impact scenarios using anthropomorphic test devices (ATDs) and human body models is gaining importance for research and future development of safer cars. In such scenarios, the seat characteristics largely determine the occupant kinematics and injury risks, making the accuracy of the virtual seat model critical for drawing valid conclusions.

Open-access finite element (FE) seat models are available, e.g. [1-2], and provide valuable resources for the research community. However, these models have primarily been validated under localised impactor loading or quasi-static conditions. Validation under dynamic rear-end impact loading, representative of real-world rear-end impacts, is limited. Hence, their applicability for rear-end impact virtual testing applications, such as accident reconstruction, is limited. The objective of this short communication is to present the update and rear-end impact correlation of the open-access OpenVT LS-DYNA automotive driver seat model representing a Toyota Auris seat [1]. The updated model will subsequently be shared openly via the OpenVT platform [3].

II. METHODS

Physical Testing

Six passenger and three driver Toyota Auris seats (car model year 2008–2012) were acquired from the second-hand market. All seats were placed at mid fore-aft position. The passenger seats were fixed in height, and the driver seats were placed in mid-height position. Laser scanning of seat frames and cushions was conducted to document geometric features and to identify discrepancies relative to the existing FE model [1]. Rear-end impact sled tests were performed at two impact severities: 16 km/h (three passenger seats); and 24 km/h (three passenger and three driver seats). An unbelted THOR-50M ATD was used as an instrumented loading device to provide repeatable and FE-reproducible anthropomorphic loading of the seats. ATD loads and kinematics were recorded, seat-back deflections versus time were measured at five positions by string potentiometers, and marker-based video tracking captured global kinematics. Hardness testing of selected metallic seat-frame components was conducted to support material identification.

FE Modelling

The seat frame was updated by aligning and adding missing geometric frame features (e.g. sheet metal flanges) identified in laser scans. Sheet-metal thicknesses and materials were revised. Seat cushions were re-meshed to improve geometric alignment and element quality. A generic in-house foam material model, with representative properties (~33% softer), was assigned. Upholstery was remodelled to account for initial pre-stress due to tight wrapping. A THOR-50M FE model (Humanetics v1.9.2) was positioned to match the physical test set-ups. Simulations corresponding to the physical test severities were performed. Key responses to match in both 16 km/h and 24 km/h test conditions were lower seat structure and seat-back deformation angles, seat-back lower cross member X-displacement (X direction is fore-aft, Z is up-down), ATD head, T1, and pelvis X- and Z-accelerations, head trajectory, head and pelvis Y-rotational velocity, and head X- and Z-displacement (ramping). Initial values for ATD to seat friction coefficients and seat wrapping tightness were based on engineering knowledge but slightly tuned to match the physical sled tests. The recliner mechanism response was calibrated to achieve good agreement with the measured global seat response since the mesh size (5–7 mm) required simplified representation. The simulations were performed in LS-DYNA, v12.2.1.

III. INITIAL FINDINGS

Although there are different components in the driver and passenger lower seat structures, ATD

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measurements and seat kinematics were similar for all six 24 km/h physical sled tests. Therefore, the same FE seat model will currently be used to model both driver and passenger seats. For the 24 km/h test, some of the key responses are plotted in Fig. 1, together with curves from the original model. Qualitatively, the initial predictions with the updated and calibrated FE seat model showed good agreement to the physical test results.

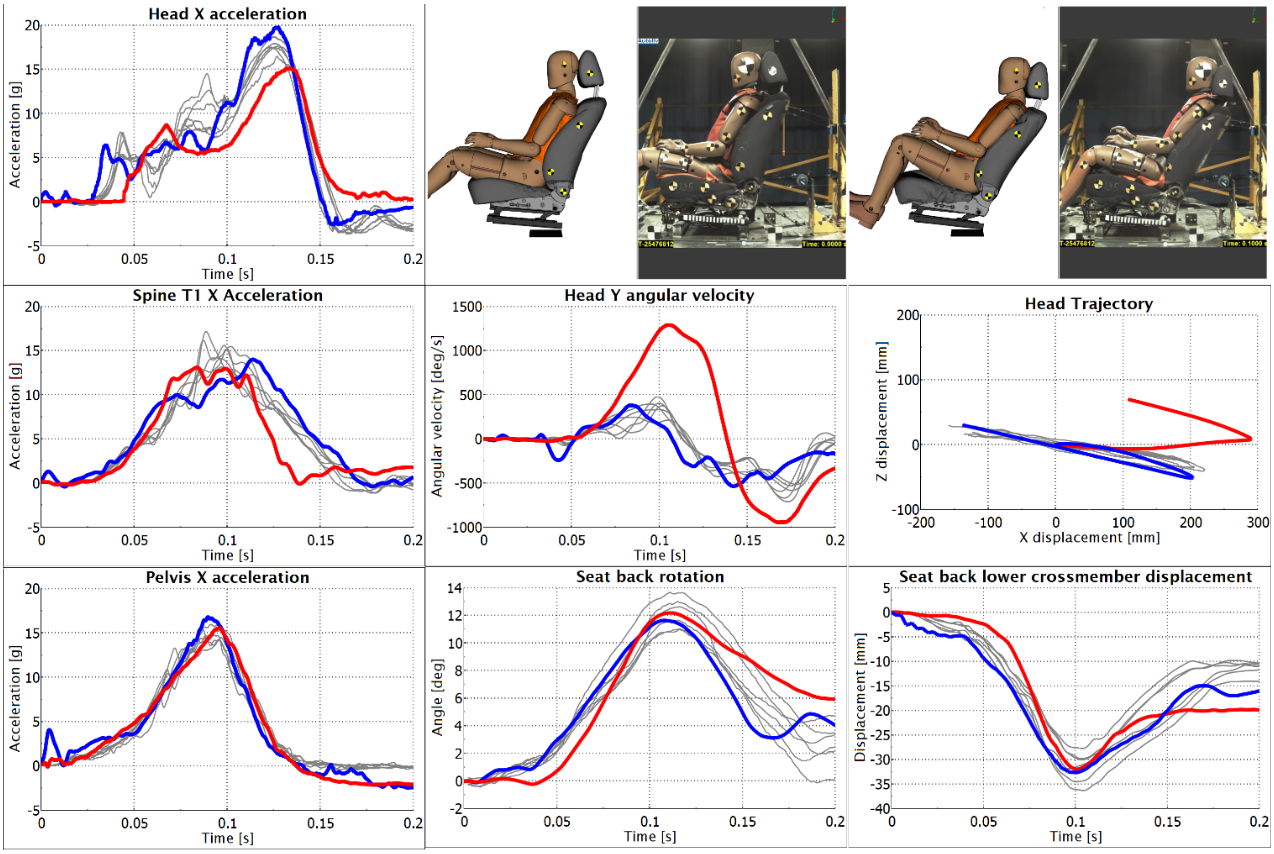

Fig. 1. Key responses: Gray – Physical sled tests; Red – Original seat model [1]; Blue – updated seat model. Side-by-side figures: simulation and tests at 0.0 s (left), and at 0.1 s (right). Test condition: 24 km/h.

IV. DISCUSSION

Initial results indicate that the updated open-access Toyota Auris seat model qualitatively exhibits good correlation with physical test results, in particular for ATD head and pelvis kinematics and seat deformation. The improvement from the original model highlights the importance of geometric consistency and appropriate modelling of foam for rear-end impact simulations.

In this study the THOR-50M was used as an instrumented loading device, with a vetted FE-representation, to correlate structural response of the seat. The purpose was not to assess injury risk or rear-end impact biofidelity of the ATD, but to provide a repeatable and well correlated loading condition for seat model correlation.

Continued work will focus on updating the lower seat structures to further improve rear-end impact responses, but also to extend the correlation to frontal impacts, based on additional reference data from frontal impact ATD physical testing. Once finalised, the updated FE seat will be provided for public use via the OpenVT platform [3] to support rear-end impact virtual testing, accident reconstructions, and further studies.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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