Investigation of Rear Seat Occupant Safety During High-Speed Frontal Crashes Using GHBMC M50-O

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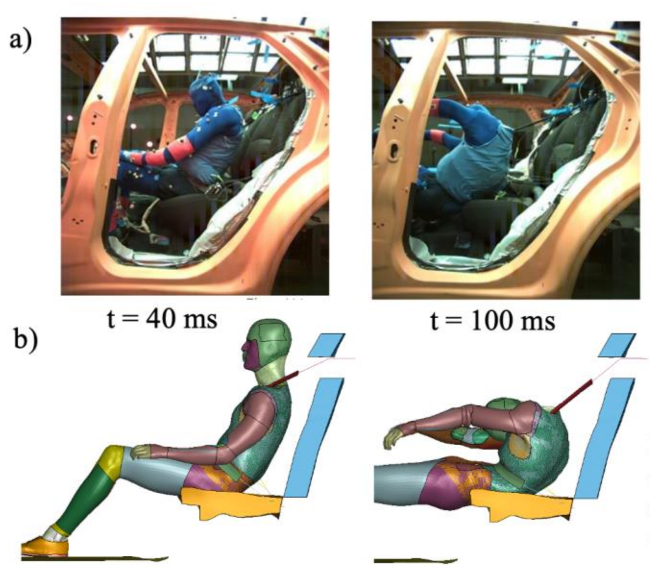
Front seats in cars have traditionally been the focus of government crash test regulations and safety innovations because of their vicinity to instrument panel. However, with safety developments in modern vehicles and restraint systems, the front seats have become much safer than the rear seats for certain occupants and specific crash types. This poses a problem, as rear-seated occupants are still at risk of injury or death, and the rise of autonomous driving systems (ADS) could increase rear-seat occupancy and injury risks. The objective of this study is to investigate the safety performance of current vehicle rear seats using human body models. The study involved evaluating rear-seat models of four vehicles, using Global Human Body model Consortium (GHBMC) male 50th percentile occupant (M50-O) positioned in each seat model, applying frontal New Car Assessment Program (NCAP) crash pulses to each vehicle, and assessing injury likelihood. The results showed reasonable comparison with the test data. The seats with advanced restraints and/or a steep seat pan angle have the potential to lower the injury risk.

The rear-seat models of four vehicles, developed based on their geometry reconstructed using a three-dimensional (3D) digitizer scan, were utilized in frontal crash simulations using scaled sled pulses. Seat foam material parameters were extracted from individual seat testing [1]. Finite Element (FE) model of GHBMC M50-O was positioned and settled in all the seat models and based on the available PMHS test data, the restraint system type and occupant pre-crash posture were modified. Each car underwent frontal New Car Assessment Program (NCAP) crash pulses. The seat models vary in restraint type, advanced restraints (e.g., pretensioners, load limiters) and conventional restraint, and in seat pan angle and seat stiffness, which could influence the injury risk. The time histories of the PMHS tests and GHBMC response signals were compared to assess submarining risks. Figure 1a) and 1b) shows PMHS test data and rear seated GHBMC M50-O simulations during a frontal crash at 40 *ms* and 100 *ms*, respectively. Figure 1c) compares the pelvis acceleration between test and simulation results, which show reasonable agreement.



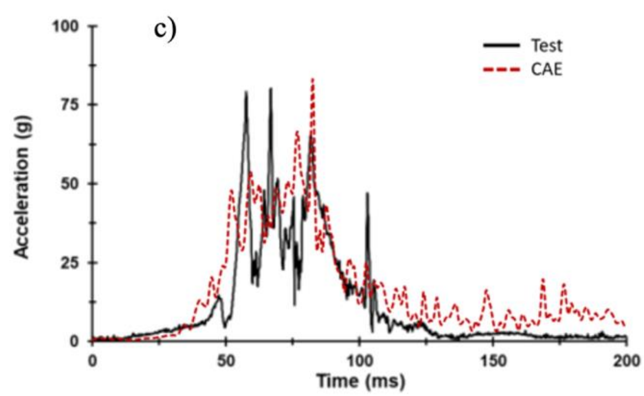


Figure 1. a) Rear Seat-A PMHS test results, b) GHBMC M50-O simulations during the frontal crash at t = 40 ms and t = 100 ms, respectively. c) Shows the comparison of Test and CAE pelvis acceleration.

In this study, several rear seats were evaluated in terms of occupant safety during a frontal crash using GHBMC M50-O. By using only, the exterior surface of the rear seat and compression test data of the seat cushion, we were able to use simplified seat models in our simulations. With seat-A (Fig 1), NCAP85 sled test produced severe submarining and the PMHS came completely off the seat bottom before the lumbar spine slammed against the anterior edge of the seat. Simulation results showed reasonable agreement with the test data. Restraint type was not indicative of whether the GHBMC or PMHS would submarine as many other factors in the rear seat environments of these vehicles likely contribute. Our study has important implications for the design of rear seats, particularly as the rise of autonomous driving systems is expected to increase rear-seat occupancy. We believe that the results presented in this study could be used to optimize the rear seat in future studies and improve the protection of rear-seat occupants. This study found that advanced restraint systems and steep seat pan angles have the potential to reduce the risks of occupant injuries. While the human body model has been validated in previous studies, it has limitations and may not fully capture the variability of human response in high-speed impacts. Therefore, further studies using other human body models or incorporating additional crash scenarios would be valuable for developing a comprehensive understanding of rear-seat safety.

References:

1. Meng, Y., Yates, K., and Untaroiu, C., "Numerical Investigation of the Performance of Current Vehicle Rear Seats Using Finite Element Analysis," SAE Int. J. Trans. Safety 10(2):377-401, 2022, https://doi.org/10.4271/09-10-02-0014.