Development of a Small Rear Facing Child Restraint System Virtual Surrogate to Evaluate CRS-to-Vehicle Interaction and Fitment

Richard Steven Hanna[1,2], Aditya Belwadi[1]

[1]Center for Injury Research and Prevention, The Children's Hospital of Philadelphia
[2]Drexel University, Philadelphia, PA

Abstract

Child restraint systems (CRS) are the leading technology in providing safety and restraint to child occupants in automotive vehicles. Their success at reducing injury in motor vehicle crashes hinges largely upon their proper installation as well as their interface with the vehicle seat. To this degree, it is immensely important that vehicle manufacturers have an accurate means of producing seat design specifications capable of accommodating the large and varied CRS market in terms of safety, comfort and aesthetic appeal. However, to date there is no standardized method (the current recommended practice, SAE J1819, is archaic and inaccurate) of obtaining accurate geometries and volume representative of the current CRS market along with various combinations of rear-facing, forward-facing, and booster seats. Additionally, modern CRS designs have changed considerably to include greater side impact protection as well as design changes to enhance ease of installation. This study looks to correct the lack of accurate industry standardization and give a means of quantifying CRS geometry so vehicle manufacturers have access to true and current volumes thereby enhancing accuracy, fit and safety to the end consumer.

In the current study, three-dimensional digital reconstruction of 22 CRS (rear-facing only CRS (RFCRS), convertible and combination) was accomplished by novel usage of the Microsoft Kinect for Windows sensor. In combination with 18 OEM drawings (made available due to the unique pre-competitive advantage of the Center for Child Injury Prevention Studies (CCHIPS)), a total of 40 child seats were compiled to represent 72 rear facing CRS in the current US market (as of April 2014). Digitized scans of CRSs were imported and combined into finite element (FE) models using ReconstructMe (PROFACTOR GmbH, Austria). The drawings were then edited for noise, extraneous data and assembled in the rear-facing configuration using Hypermesh 12.0 (Altair Inc., MI). Average vehicle seat-back (110°) and seat-pan angles (13.5°) were used (Reed et al. 2004) and the smallest configuration was developed in alignment with SAE J211 right-hand co-ordinate system. The models were "shrink wrapped" to generate an overall volume and to protect critical CRS designs thus generating the smallest rear facing virtual surrogate model.

A finite element (FE) model and surface data set (iges) of the "virtual surrogate" was made available to both vehicle and CRS manufacturers for virtual fitment evaluations in their respective design environment based on a pre-approved material transfer agreement. Based on

both physical installations of the CRSs involved and virtual evaluation, the surrogate was found to accurately depict the volume and fitment of modern rear facing CRSs

The use of virtual surrogates by vehicle manufacturers will be hugely beneficial over the outdated and rudimentary standards currently set in place. By alleviating manufacturers of the challenge of keeping seats and occupant space compatible with CRS, proper vehicle seat design can be applied early on to ensure optimal CRS-to-vehicle fitment. Proper fitment will promote ease of installation by the CRS consumer and improved protection and safety for the CRS occupant.