INTRODUCTION

Ejection from high-performance aircraft can result in accelerations up to 18 times the force of gravity and have been reported to cause spinal injury in as many as 30% of cases.

Existing spinal injury evaluation standards rely solely on measured seat acceleration and may be inadequate to truly predict spinal injury risks.

Advancements in Finite Element (FE) modeling related to the human body provides an alternative means to evaluate these loading scenarios and provide additional data to support traditional Post Mortem Human Subjects (PMHS) research.

Before these human body models can be effectively used as injury prediction tools, the model response and boundary condition (fixture/restraint) models must be validated.

The objective of this study was to develop and validate an experimental seat and restraint system model in a FE software, previously used in vertical loading PMHS research, for future use with FE human body models.

MATERIALS & METHODS

Vertical drop tower testing was conducted at Wright-Patterson Air Force Base using a Hybrid III 50th Automotive Anthropometric Test Device (ATD) to minimize occupant response variability.

The experimental setup was recreated in LS-PrePost and ran in LS-DYNA V11.0.

An open source LSTC Hybrid III 50th automotive ATD FE model placed in the seat.

CAD from the original seat design was simplified and meshed using Hypermesh.

Load cells were placed under the seat pan for comparison to recorded data.

A parachute harness model was constructed using the belt routing tool in LS-PrePost.

Retractor elements were incorporated into the harness to allow for pre-tensioning.

1D elements were added to the shoulder attachments and routed through the seat to the fixture floor.

Lap belt was added to match the experimental setup.

Recorded acceleration data (20 G peak) from testing was prescribed to the fixture carriage using boundary prescribed motion.

Initial velocity was prescribed to the entire model to simulate the free fall of the physical test.

Final model positioning was achieved using the dummy positioning tool in LS-PrePost and aligned to scan data collected during testing using a Hexagon Romer Absolute arm.

RESULTS & DISCUSSION

Table 1: Primary variables considered for optimizing model response to experimental data

<table>
<thead>
<tr>
<th>Model Parameter</th>
<th>Model Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restraint contact friction</td>
<td>Resultant seat load</td>
</tr>
<tr>
<td>1D belt element stiffness</td>
<td>Shoulder belt force</td>
</tr>
<tr>
<td>Harness retractor pretension</td>
<td>Pelvis, chest and head</td>
</tr>
<tr>
<td>Pelvis foam stiffness</td>
<td>2-axis accelerations</td>
</tr>
</tbody>
</table>

Figure 4: (a) Final model position and (b) prescribed pulse

Figure 5: Time history comparison of model response to experimental data

CONCLUSIONS & FUTURE WORK

• All data for comparison achieved an average NRMSD value less than 15%.

• Plateauing of the shoulder belt forces in the simulation was observed that was not observed during testing, which should be explored further.

• Differences in peak belt load were observed in both the experimental setup and simulation results, which could have been a result of slight asymmetry in the restraint model and physical restraint system on the ATD.

• Next steps will evaluate the current setup using additional experimental data available (6G, 10G and 15G) followed by incorporation with the GHBMC and THUMS human body models for comparison to PMHS response data.

REFERENCES CITED