Investigation of Potential Mitigation of Driver Injury in Heavy Truck Frontal and Rollover Crashes

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TRB IRSC 2017
June 12-15, 2017 – San Francisco, CA
Acknowledgments

- David W. Eby (Director, ATLAS Center)
- Robert Wunderlich (Associate Director, ATLAS Center)
- DOS for use of COE truck cabin FE model developed by TTI.
- Jingwen Hu (UMTRI) for assistance with FE computer simulations.
- Akram Abu-Odeh (TTI) for assistance with TruckSim.
Background

- Approximately 340,000 medium/heavy trucks involved in traffic crashes per year in U.S.
- 600 fatalities; 20,000 injuries to truck drivers
- Aggregate cost of crashes to society is $3.1 billion

- No existing standards for truck cab crashworthiness or occupant protection in heavy truck crashes (although being discussed)
- Need of additional characterization of crash-injury, current heavy truck crashworthiness, potential benefits of crashworthy structures in heavy truck cabs
Objectives

TTI and UMTRI proposed jointly effort devoted to collect & develop required information by:

- analyzing available crash & travel datasets;
- identify heavy truck crashes frequencies & costs;
- estimate benefits of crashworthy structures in heavy trucks to reduce death, injury, & societal costs of heavy truck crashes.
Methodology – Big Picture

FE Computer Simulations
- Frontal Impact (Wall)
- Rollover Scenario
- Parametric Variation
- Seatbelt Properties
- ATD Injury Criteria

Heavy Truck + ATD + Seatbelt + Airbag
Step 1.

Develop Heavy Truck Cabin Model
FE Computer Model – Heavy Truck

Current FE Computer Model

Need for Occupant Compartment Interior
Heavy Truck Cabin Model

FE Model of Cab-Over-Engine Cabin*

* Developed by TTI under project funded by Department of State

Morphed Conventional Cab*

* As of Peterbilt 387
Step 2.

Develop Heavy Truck Interior Compartment
Heavy Truck Interior Compartment

Cloud Point Scans*
* Developed by UMTRI for Peterbilt 387
Heavy Truck Interior Compartment

Models developed applying mesh grid over cloud points
Step 3.

Inclusion of ATD
ATD Inclusion and Pre-Positioning

Existing LSTC Hybrid
III 50% Male ATD
Step 4.
Addition of Passive Restraint Systems
Seatbelt Model

Original
*Developed by LSTC for Passenger Car

Modified
*To fit Heavy Truck Geometry

Original

Modified
Seatbelt Model

Modified
*To fit Heavy Truck Geometry

<table>
<thead>
<tr>
<th>Event</th>
<th>Action</th>
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<tbody>
<tr>
<td>1 ms</td>
<td>Retractor sensor fires — enters locked mode</td>
</tr>
<tr>
<td>10 ms</td>
<td>Pretensioner sensor fires — enters locked mode</td>
</tr>
<tr>
<td>1.8 kN tension reached</td>
<td>Pretensioner disengages — retractor active</td>
</tr>
<tr>
<td>4 kN tension reached</td>
<td>Load limiter 1 engages (load limit case 1 only)</td>
</tr>
<tr>
<td>8 kN tension reached</td>
<td>Load limiter 2 engages (load limit case 2 only)</td>
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</tbody>
</table>
Airbag Model

Airbag - *Developed by NCAC

Folded

Deployed

NCAC

Heavy Truck
Step 5.
Crash Scenarios Simulation
Methodology
Step 5a.

Frontal Simulation Setup
Step 5a. Frontal Simulation: Crash Pulse

An existing FE model of Tractor Trailer employed to develop frontal crash pulse

Resulting impact Delta-V used as crash pulse for simplified method

Crash pulse applied to cab mount location of new cabin model

Various combinations of inputs given to develop frontal simulations
Parametric Simulations of Frontal Impacts

- Baseline
- No Pretensioner
- 4 kN Load Limiter
- 8 kN Load Limiter
- Lowered D-Ring
Step 5b.

Rollover Scenario
Rollover Event

Evasive maneuver to the left followed by overcorrecting maneuver to the right (Chinni et al., 2007)

TruckSim Rollover Event

60 mph
Application of Rollover Maneuver to Truck Cabin
Simplified ATD

Without Mesh

With Mesh
LSTC 50th% Fast H-III Dummy (Version_2.0, Early-July 2012)
Time = 0
Future Research

- Rollover crash scenario did not analyze occupant behavior after contact with the ground. Significant occupant injury can occur after impact with the ground; therefore, a rollover simulation should be developed to analyze occupant injury criteria during collision with the ground;

- Conduct rollover simulations with detailed ATD FE model;

- Validation of interior component material modelling for accurate deformation response of truck cabin interior;

- Analysis and development of additional restraint systems (side curtain airbag system, four and five point seatbelt) to further prevent injury in heavy truck crashes;
Questions?

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