Truck Ergonomics: Field and Laboratory Research

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Biosciences Truck Ergo

Driver posture prediction
Package optimization
Driver vision analysis
Driver motion simulation
Ingress/egress

...
Posture Prediction for Design

Truck cabs are designed using virtual (CAD) mockups and computer manikins (digital human models) to represent drivers.

Cascade model predicts driver posture as a function of cab layout and driver characteristics.

Major partners: Navistar and PACCAR.
Package Optimization

Statistical design tools that replace the current SAE standards for cab layout

New methods for stochastic simulation to optimize designs with multiple constraints.
The Virtual Driver

Integration of a cognitive/perceptual model with the a physical model (HUMOSIM Framework) to simulate military convoy driving with a secondary task.

Helen Fuller, PhD (2010)
(with Omer Tsimhoni and Yili Liu)
Seated Reach and Force Exertion

Modeling reach difficulty, kinematics (including pedal operation), and force exertion capability

with Komatsu, HUMOSIM Lab, US Army (ARC) support
Direct Field of View

Methods for quantifying and grading direct field of view based on crash considerations

with Dan Blower and Mike Flannagan
Driver Vision Analysis

Field of view in truck mirrors *as used* based on field measurement.
Ingress/Egress Safety

- ~15,000 lost-time slip/fall injuries to truck drivers each year in the U.S.
- One large U.S. fleet reports direct losses >US$20M each year due to slips/falls on and around trucks
- ~50% of falls happen on the tractor, mostly on egress
Risk Factors

- Weather conditions: ice, snow, rain
- Footwear
- Driver physique, strength, fatigue, coordination, training, risk-taking
- **Step and handhold configurations**
  - obese
  - sandals
  - facing outward
  - one hand
NIOSH Study

Three-year grant from U.S. National Institute for Occupational Safety and Health (2007-2010)

- Field studies of truck geometry and I/E
- Laboratory study with motion capture
- Development of design guidelines and assessment procedures
Overall Goals

*Design guidelines for I/E systems:* What characteristics make a system more safe?

*Assessment techniques:* Differentiate between systems using simulations with digital human models.
Measurements

Truck dimensions obtained with FARO Arm (16 vehicles) and manual measurements (~40 vehicles)
PhotoModeler

15 to 20 photos of each vehicle taken with a calibrated camera used to create 3D models
Components: Steps

Tank
Box
Integrated
Smooth
Grate
Perforated
Components: Handholds

Map Pocket

Diagonal

Internal
Video Study

33 drivers videotaped getting in and out 3 times
Interviews

107 drivers interviewed about their experiences with I/E
• median age 46 years, median experience 12 years
• 4 women
• 13% owner/operator

Results:
Previously slipped or fallen: 8% ingress, 21% egress
Of those who slipped or fell: 47% injured
Features associated with slip/fall:
  Steps: 57%
  Handholds: 7%
  Ground: 20%
Fall or injury from trailer (including hooking up): 7%
## Covert Observation

<table>
<thead>
<tr>
<th>Egress</th>
<th>Video (N=33 x 3)</th>
<th>Covert (N=250)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facing Truck</td>
<td>68%</td>
<td>47%</td>
</tr>
<tr>
<td>Facing Out</td>
<td>18%</td>
<td><strong>46%</strong>*</td>
</tr>
<tr>
<td>Switch</td>
<td>14%</td>
<td>7%</td>
</tr>
</tbody>
</table>

* Driver jumped from first or second step in 4.4% of egresses
* No supporting hands in 10% of egresses
† Object in one or both hands 14% of the time (10% left hand)

Data collection at truck stops on I-94, the major Chicago-Detroit and Chicago-Canada route
Injury Data

A local less-than-truckload fleet with long haul and pick-up and delivery drivers has provided access to their injury data for one year.

Results:

Of 1052 injury incidents, 190 (19%) resulted from a slip or fall (S&F)

Among S&F, 31% involved the tractor, 26% the trailer.

Of the tractor incidents, 20% ingress, 64% egress

Of trailer incidents, 10% ingress, 28% egress (remainder inside the trailer)
Laboratory Study

- gather subjective responses to a wide range of truck step configurations
- record whole-body motions and reaction forces

Force plates and load cells
Adjustable steps and handholds
Driver Motion Capture

Experienced driver in the lab with motion capture targets

Quantitative tracking data
Analysis with AnyBody
Anthropometric Challenge

Approximately half of drivers are obese -- many are very large, but small-stature men (obese or not) are an increasing percentage of drivers.

About 5% of Class 7 & 8 drivers are women
Future Work in Truck Ergo

Anthropometric modeling of seated body shape

Expanded work on ingress/egress, including tarping and other load/trailer activities

Dynamic driver posture and its effect on exterior vision

Cognitive and physical aspects of driver distraction

Driver health vs seat and cab design
For More Info

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