Commercial Motor Vehicle Driving Simulator Validation Study: Phase II

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Project Background

- NTSB recommendation to encourage development/use of simulator-based training for heavy truck operators
- Findings from prior research studies:
  - Dueker (1995)
  - Stock (2001) and Dugan (2008)
- Commercial availability of high-fidelity, “full mission” truck driving simulators at steadily decreasing prices.
- Simulators successfully implemented as part of CMV driver training programs in Europe
Research Objectives

1. Examine the effectiveness of a driving simulator for entry-level commercial motor vehicle (CMV) driver training and testing.

2. Determine how different entry-level training methods compare in terms of skills acquisition and transfer of training.

3. Investigate the relationship between type of training method and actual job performance.

4. Evaluate the advanced capabilities of the simulator for testing emergency maneuvers and extreme conditions utilizing various vehicle configurations.
Project Setting

● Commercial Transportation Program at Delaware Technical and Community College (DTCC), Georgetown DE

● Virginia Tech Transportation Institute (VTTI) researchers

● FAAC Model TT-2000-V7 3 DOF Simulator.

● Project Period: Aug 2006 – Mar 2010
FAAC, Inc., Model TT-2000-V7
Driving Simulator

Exterior view

Interior view
FAAC, Inc., Model TT-2000-V7 Driving Simulator
Research Design

● Compare the research results of four different types of training methods:
  – Long certified conventional behind-the-wheel (BTW) training, termed *long conventional group* (104hrs/44hrs).
  – Long certified simulator-based training (2/3 with simulator,1/3 BTW), termed *simulator group*.
  – Informal training (e.g., drivers trained by friends or family members), termed *no formal training group*.
  – Short, CDL-focused truck driver training school, termed *CDL-focused group*.

● Longitudinal Follow-up

● Advanced Capability Study (ACS)
Performance Metrics

- Department of Motor Vehicle (DMV)
  - Knowledge, Road and Range Test Scores

- Delaware Technical and Community College (DTCC)
  - Road and Range Test Scores

- Simulator
  - Road and Range Test Scores

- Longitudinal Follow-up
  - 4 to 5 month driver assessment
  - 12-month CDLIS driving records
## Participants

<table>
<thead>
<tr>
<th>Training Group</th>
<th>Number of participants</th>
<th>Mean Age</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>33</td>
<td>34</td>
<td>31 male, 2 female</td>
</tr>
<tr>
<td>Simulator</td>
<td>32</td>
<td>35</td>
<td>31 male, 1 female</td>
</tr>
<tr>
<td>Informal</td>
<td>9</td>
<td>40</td>
<td>9 male, 0 female</td>
</tr>
<tr>
<td>CDL-focused</td>
<td>33</td>
<td>35</td>
<td>30 male, 3 female</td>
</tr>
</tbody>
</table>
Does the training method affect DMV road/range test performance?

<table>
<thead>
<tr>
<th>Group</th>
<th>DMV Road Test</th>
<th>DMV Range Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional (n=33)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulator (n=30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informal (n=9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDL-Focused (n=23)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DMV Test Findings

- The mean DMV road and range test scores were above 90 percent, regardless of group membership.
- The ANOVA for the DMV road test found no significant group differences between groups $F(3, 91) = 1.94, p = 0.13$.
- The ANOVA for the adjusted DMV range test found a significant effect for group, $F(3, 94) = 6.44, p = .0005$.
  - The conventional training group (97.6 percent) scored significantly higher than the CDL-focused (88.4 percent) and informal training group (86.6 percent).
  - There was no difference indicated between the conventional and simulator (93.6 percent) training groups.
Results from DTCC & Simulator Road Tests

![Bar chart comparing test scores for DTCC Road Test and Simulator Road Test across different test modes: Conventional, Simulator, Informal, and CDL Focused. The chart shows the mean test scores for each test mode, with error bars indicating variability.](chart.png)
Findings

- Significant group differences in DTCC road test scores, $F(2, 78) = 109.39, p < 0.0001$
- Significant group differences in simulator road test scores, $F(2, 78) = 41.31, p < 0.0001$
- Conventional and simulator training groups had significantly greater scores on the DTCC road test
- Conventional and simulator training groups scored significantly higher on the Simulator road test
Comparison of Simulator and BTW Testing

- Final scores on BTW and simulator road and range tests were compared
- BTW road test scores were significantly greater than the simulator road test scores
- BTW range test scores were greater than the equivalent simulator range test scores
- Simulator-based testing for CMV drivers does not appear feasible with current levels of simulator technology
Findings: Research Objective 1

- BTW and Simulator trained participants do not differ significantly in test performance
- Use of simulators in entry level training appears feasible
- Students trained in a PTDI-certified program, on average, scored better than the drivers that did not undergo a certified training program in most of these tests
- Simulator-based testing for CMV drivers not feasible with current simulator technology
Longitudinal Effects of Training Method on Driver Performance

- Does training method affect performance on retests 4–5 months after they start working as a commercial driver where a CDL is required?
- How does different entry-level training methods compare in terms of skills acquisition and transfer of training?
- Does training method affect safety performance on the job (e.g., incident rates, number of violations, number of crashes, supervisor ratings) after 4 and 12 months on the job?
### Status of Participants for Follow-up Testing

<table>
<thead>
<tr>
<th>Training Group</th>
<th>Participants Completed Initial Testing</th>
<th>Participants Eligible for Follow-Up</th>
<th>Participants Screened for Follow-Up</th>
<th>Participants Completed 4-Month Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>33</td>
<td>10</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Simulator</td>
<td>32</td>
<td>15</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Informal</td>
<td>9</td>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>CDL-focused</td>
<td>33</td>
<td>10</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Findings: Research Objectives 2 & 3

- Most of the follow-up test scores were lower than the original scores during the entry-level tests.
- The conventional and simulator groups performed better on the follow-up road tests than the Informal and CDL-focused groups.
- No computation for statistical significance due to limited sample size.
- There was limited data to determine differences in safety records between groups.
Assessing Advanced Capabilities of the Simulator

- Are there differences in driver performance between million mile drivers and non-million mile drivers?
  - Emergency maneuvers with different vehicle configurations
  - Driving under hazardous or extreme road conditions corresponding to their vehicle configuration experience.
## Advanced Capabilities Study

### Participant Demographics

<table>
<thead>
<tr>
<th>Driver Type</th>
<th>Number of Participants</th>
<th>Million Miler Status</th>
<th>Mean Age</th>
<th>Gender</th>
<th>Mean Years Experience</th>
<th>Mean Miles Logged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Trailer</td>
<td>6</td>
<td>Million Miler</td>
<td>51</td>
<td>6 male, 0 female</td>
<td>31.3</td>
<td>2,942,976</td>
</tr>
<tr>
<td>Van Trailer</td>
<td>10</td>
<td>Non-Million Miler</td>
<td>44</td>
<td>9 male, 1 female</td>
<td>7.7</td>
<td>439,100</td>
</tr>
<tr>
<td>Doubles Trailer</td>
<td>6</td>
<td>Million Miler</td>
<td>51</td>
<td>6 male, 0 female</td>
<td>23.0</td>
<td>2,281,976</td>
</tr>
<tr>
<td>Doubles Trailer</td>
<td>10</td>
<td>Non-Million Miler</td>
<td>42</td>
<td>10 male, 0 female</td>
<td>12.0</td>
<td>537,687</td>
</tr>
<tr>
<td>Tanker Trailer</td>
<td>6</td>
<td>Million Miler</td>
<td>51</td>
<td>6 male, 0 female</td>
<td>29.5</td>
<td>2,538,667</td>
</tr>
<tr>
<td>Tanker Trailer</td>
<td>10</td>
<td>Non-Million Miler</td>
<td>42</td>
<td>10 male, 0 female</td>
<td>10.1</td>
<td>402,300</td>
</tr>
</tbody>
</table>
## Simulator’s Advanced Capabilities

<table>
<thead>
<tr>
<th>Emergency Maneuvers</th>
<th>Extreme conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merge Squeeze</td>
<td>Fog</td>
</tr>
<tr>
<td>Lane Cross</td>
<td>Rain</td>
</tr>
<tr>
<td>Tire Blowout</td>
<td>Snow</td>
</tr>
<tr>
<td>Rollovers—Right</td>
<td>Black Ice</td>
</tr>
<tr>
<td>Rollovers—Left</td>
<td>8% Upgrade</td>
</tr>
<tr>
<td>Brake Failure</td>
<td>8% Downgrade (Dry)</td>
</tr>
<tr>
<td>Evasive Maneuver</td>
<td>8% Downgrade (Snow)</td>
</tr>
<tr>
<td>Animal Crossing</td>
<td>Dirt Road</td>
</tr>
<tr>
<td>Blind Entrance</td>
<td>Construction Zone</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>Railroad Crossing</td>
</tr>
<tr>
<td>Tight City Turns</td>
<td>Fog</td>
</tr>
<tr>
<td>Roadway Obstruction</td>
<td>Rain</td>
</tr>
</tbody>
</table>
Findings: Research Objective 4

- Findings indicate that the simulator was able to produce a realistic simulation of many different types of emergency maneuvers and extreme conditions.

- Overall, million milers responded appropriately to the 12 emergency maneuvers and 9 extreme conditions more often than non-million milers.

- Million milers still responded inappropriately or not at all in approximately 30 percent of the emergency events and 32 percent of the extreme conditions encountered.

- Results indicate that all participants could potentially benefit from refresher and defensive driving training using simulators.
Summary of Findings

- Use of simulators in entry level driver training appears feasible.
- Simulator-based testing for CMV drivers does not appear feasible with current levels of simulator technology.
- There were differences between groups on DTCC and Simulator versions of DMV tests, suggesting that more training leads to greater performance on these tests.
Summary of Findings

- No differences in safety records were able to be determined from longitudinal follow-up.
- ACS participants generally rated the scenarios as realistic.
- Million milers responded to simulated events appropriately more often than non-million milers.
Implications for Future Research

- Prospective vs. Retrospective study
- Initial training vs. Experience
  - Post training confounding factors
- Is crash reduction the appropriate surrogate for measuring the safety benefits of training?
Questions?