Tractor-trailer Simulation And The Assessment Of Training Scenarios For City-driving: Skill Building In The Area Of Left And Right Turns

James Whitmire
University of Central Florida

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TRACTOR-TRAILER SIMULATION AND THE ASSESSMENT OF TRAINING SCENARIOS FOR CITY-DRIVING: SKILL BUILDING IN THE AREA OF LEFT AND RIGHT TURNS

by

JAMES WHITMIRE II
B.A. University of Central Florida, 2002

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Modeling and Simulation in the College of Arts and Sciences at the University of Central Florida Orlando, Florida

Spring Term
2004
ABSTRACT

A simulated inner-city training scenario was found to increase skills in the area of turning when compared with a simulated off-track training scenario. To answer this question, two groups of ten participants (5 women and 5 men) were tested using three scripted scenarios focusing on left and right turns. The first training scenario (control group) is an off-track training scenario, which consists of a large asphalt lot and the use of orange cones; the second training scenario (experimental group) is an inner-city training scenario without the presence of vehicular traffic; and the third scenario (test scenario) is an inner-city scenario with the presence of vehicular traffic. A subject matter expert, who is also a former driver and trainer, evaluated and scored all participants on four critical turns (2 left and 2 rights). The apparatus used for this study was the V-sim non-motion simulator from General Electric (GE). A 2 x 4 factorial analysis was utilized to examine conditional differences as well as gender differences. While there were no gender differences, the results for overall turns were significant, F(1, 16) = 7.14, p = .017, $\eta^2 = 3.09$. The mean for the control group was (M = 20.50, SD = 9.59) with the experimental group at, (M = 31.10, SD = 7.26).
My master’s thesis is dedicated to my dear mother and father whose support throughout my lifetime has been instrumental in my academic achievements.
ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. Peter Kincaid, who supported me throughout the graduate program. I would also like to thank Ron Tarr for his insights and contributions and Talleah Allen who tolerated my continuous interruption in the simulation lab. In addition, I would like to acknowledge Road Master Truck Driving School for the seven instructional modules that were crucial in developing a baseline for testing subjects. Also, a special thanks to all the folks at the Institute for Simulation and Training that supported me through the last year-and-a-half.
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INTRODUCTION

The purpose of this research is to focus on simulation-based training in the area of scenario development and its potential role for improving the overall instruction of student truck drivers. In today’s trucking schools, there is a shortage of equipment, which results in half of the students standing idly by while the other half practice basic maneuvers on large asphalt lots. In fact, due to high attrition rates in the trucking industry and the demand for new drivers, trucking schools are now turning to simulation as an alternative method to train tomorrow’s driving force. Simulation is the only possible way to expose student drivers to as close as possible real-life driving situations without endangering the motoring public at large. Perhaps, one of the most difficult challenges for student drivers is learning how to execute left and right turns. Simply stated, it is the author’s assertion that simulation can better prepare student drivers in the skill of executing left and right turns compared to traditional methods. To accomplish this task, three simulation scenarios focusing on left and right turns were scripted. The first training scenario (control group) is an off-track training scenario, which consists of a large asphalt lot and the use of orange cones. The second training scenario (experimental group) is an inner-city training scenario without the presence of vehicular traffic. The third scenario, an inner-city scenario with the presence of vehicular traffic was designed to test the control and experimental groups.

Also, does the operation of truck simulators present more difficulty for women than men? To answer these questions two groups of ten participants (10 women and 10
men) were tested. A subject matter expert, who is also a former driver and trainer, evaluated and scored all participants on four critical turns (2 left and 2 rights). A 2 x 4 factorial analysis was utilized to examine all research questions. The outcome of this study clearly suggests training in an inner-city situation (experimental group) without the presence of vehicular traffic is superior to the conventional approach (control group) of training on a large asphalt lot and better prepares a driver for training in city situations with the presence of vehicular traffic.

While this study showed an impressive advantage in favor of the inner-city training scenario over the off-track scenario, there were no interactions or main effects pertaining to gender on any turn or overall. The fact that gender was not an issue is in itself noteworthy. It is the assertion of this researcher that women can operate trucks as well as men. In fact, in certain stressful circumstances, they may even out-perform men. Overall, women seem to be less aggressive and more often than not cooler heads will prevail. The potential benefits of this research pertaining to truck driving simulators as a training tool for student drivers are better utilization of the trainee’s time, development of quality scenarios for truck simulators, and most important, a better trained driver.
The trucking industry employs over nine million people and approaches annual revenues of half a trillion dollars. In fact, according to Truckinfo.net, there are over 360,000 companies related to the trucking industry and at least 3.3 million truck drivers in the United States with total annual revenues of 255.55 billion dollars. Furthermore, truck driving can be a very dangerous profession. In fact, 457,000 trucks were involved in accidents in the year 2000 of which 4,930 involved a fatality. An interesting note on those statistics is 68% of fatal accidents involving trucks begin with the automobile (Trucking Odds & Ends, 2003). In order to make our roads safer and better prepare drivers for crisis situations, the trucking industry is now taking advantage of the latest technologies (i.e., simulation).

According to Woong-Sung, Jung-Ha & Jun-Hee (2003), driving simulators are devices that immerse the operator in a realistic driving environment through feedback of visual, audio and tactile modalities. Likewise, Amico, Bruzzone & Guha (2001) suggest that possible accidents or large financial losses during the operation of complex man-machine systems can be devastating and in these circumstances simulation can prove to be invaluable. In addition, due to advances in computing technology simulation has become an efficient tool for investigation, design, research, training and logistics. Moreover, according to Pierowicz, Robin & Gawron (2001), simulators have been fruitfully engaged within the military arena and commercial airline business for over 30 years. If amply established, simulation technology may complement the training, testing, and licensing of commercial motor vehicle (CMV) drivers. Consequently, universities
throughout the United States as well as the world have invested in driver simulators to carry out research and training.

One university that has invested in this technology is the University of Central Florida (UCF). UCF is rapidly becoming a premier research institute in the area of simulation with focuses on driving simulators. UCF is home to four levels of driving simulators, the first is a desk-top simulator for basic training and scenario development. The second is the mid-level non-motion simulator. The third is the Patrol Sim which provides training for police and emergency personnel and finally, the fourth is the Mark II, a full-motion truck simulator by GE which is housed in the College of Engineering.
UCF TRUCK SIMULATORS

Desk Top Simulator

The desk-top simulator (Figure 1) consists of a standard 19-inch monitor and utilizes Windows 2000 platform. The steering, fuel pedal and gas pedal are a WingMan Formula GP by Logitech. The computer is a Pentium 4 using G force 3 and Direct X to generate the graphics. This simulator is used as a development station for scripting scenarios which can be loaded to the Patrol Sim, mid-level simulator, or the full-motion simulator. Also, the desk-top can be used as a training tool for enhancing situational awareness for student drivers. While the Patrol Sim as well as the full-motion simulator are discussed in this section of the paper, the mid-level simulator is addressed in the materials section.

Figure 1: Desk-Top Simulator
**Patrol Simulator**

The Patrol Sim simulator (Figure 2) offers law enforcement agencies a high-fidelity, interactive training experience that helps save lives. The three-channel, three-monitor immersive driving environment combine the look and feel of a real squad car with the most advanced technology on the market (GE Driver Development, 2003). The Patrol Sim is proving to be a valuable training tool with limitless research possibilities.

![Figure 2: Patrol Simulator](image-url)
**Full Motion Simulator**

The Mark II Motion-Based Driver Training Simulator (Figure 3) combines a fully operational truck cab with the latest digital simulation technology to create life-like training scenarios that improve driving behavior and skills (GE Driver Development, 2003). Some of the research areas include driver training, human factors and traffic engineering. Recent research projects include evaluation of a prototype (Safety Warning System) to enhance driver safety while another project focuses on minimum acceptable gaps for a left turn from a minor road at a stop controlled intersection (Klee, 2003).

![Figure 3: Full-Motion Simulator](Image)
SIMULATOR SUBSYSTEMS

Each truck driving simulator incorporates various subsystems that provide support to the simulation. The truck simulator hardware (i.e., pedals, steering wheel, etc.) supplies a full array of sensory signals and stimuli to the operator. The software controls all feedback systems (Freeman, Watson, Papelis, et al., 2000). While there are many subsystems, some of the most obvious include the visual, audio, force feedback, vehicle type, and scenario control. All of these systems work together, to create an illusion that the driver is actually in control of a real truck (Johansson & Nordin, 2002).

Visual System

Notably, the feedback from the visual system is a crucial factor, determining success as well as the realism of a driving simulator, affecting the driver’s response to strategically react to scripted events (Xiaopeng, Hung, & Swekuang, 2000). Since visual cues are a major element in the operation truck simulators, the need for high quality graphics in the visual system is indispensable in order for the operator to experience a realistic driving experience and respond to the driving surroundings in a pragmatic way (Woong-Sung, Jung-Ha, Jun-Hee, et al., 1999). In fact, simulating a realistic virtual environment on a visual screen depends on dynamics such as transport delay, frame rate, display size, and resolution. Some of the visual effects supplied are full-field-of-view rearview mirrors, rain, snow, fog, and many different traffic configurations depending on the needs of the research.
**Sound System**

Another important attribute of a truck simulator is the sound system. While not as critical as the visual system, the ability for the driver to immerse him/herself into the simulation would be incomplete. Some of the main audio feedbacks include engine noise (RPM), gear shifting and various road noises.

**Force Feedback**

The force feedback on the mid-level non-motion simulator utilized in this research project consists of an actual truck steering wheel, shifter, turn signal, and fuel, brake, and clutch pedals. The steering wheel is the most sophisticated force feedback element of the above mentioned items. In fact, most mid-level driving simulators focus on steering realism and feedback. Steering resistance differs with truck speed, steering position and topography (Xiaopeng, Hung & Carolina, 2000). The steering on the mid-range simulator provides realistic feedback to the driver if the truck tires bumps a curb or if a flat tire is triggered by a scripted event.
SCENARIO DEVELOPMENT

Validation

Validation of a simulator is gauged through the overall practicality or realism. That is, in this case how well the simulator imitates the actual driving of a tractor-trailer. According to Reymond and Kemeny (2000), the concept of simulator validation can be divided into the following categories:

- Physical validity: Comparing the rendered motion cues in the simulator with the real-world counterparts.
- Perceptual validity: Comparing the operator’s discernment of the motion in a simulator with real-world circumstances.
- Relative Behavior Validity: Measuring the driver’s response, for example, to road or traffic conditions in the simulated environment.
- Absolute Behavior Validity: Does the driver react the same way in a simulated event as he or she would in a similar real-world driving situation.

With these points in mind, when constructing scenarios for a test population, the researcher should craft all test points using the same events across all subjects. For example, if scripting a backing exercise, the developer of the scenario should allow one slot for the truck driver to back into, thus reducing confusion as well as possible confounds. Also, for example, when the test participant is driving on a common road and a person walks in front of the car, the space between the person and the car determines
the vehicle’s rate of speed which should elicit a similar response across participants (Johansson & Nordin, 2002). In these examples, the surrounding environments are controlled, which results in cleaner as well as more reliable data.

**Creating a Scenario**

To craft three scenarios for this experiment required sketching out a detailed route for each scenario followed by selecting an appropriate route from a library of scenario road data bases. Afterwards, the appropriate vehicle types are added to the route in order to create the desired training or test scenario for the designed outcome. There are eight vehicle types to select from: Fixed Object (FO), Normal Vehicle Route (NVR), Recorded Vehicle (REC), Dynamic Control Route (DCR), Auto Density Route (ADR), Attached Trailer, Railroad Engine, and Railroad Car. The three scenarios in the study used the FO, NVR, and the ADR. A fixed object can be any stationary object, including parked cars, signs, trees, fences, shrubs and signs. A Normal Vehicle Route consists of a library that enables users to place autonomous (artificial intelligence) vehicles with a click of button. Autonomous vehicles follow a predefined route and, by default, obey the rules of the road, including obeying traffic-control devices and responding to a siren. The last vehicle type used in crafting the scenarios was the Auto Density Route. These are normal vehicle routes that are generated randomly to create traffic density. The next step in creating the scenarios consisted of writing a description of the scenario, selecting the appropriate road data base, positioning the Owncab (the driver’s vehicle) using x and y coordinate system, and finally adding all scenario vehicles.
**Off-Track Training Scenario (Control Group)**

For this scenario, the road data base was entitled “Warehouse” (Figure 4) and included a large building placed at the end of a large asphalt lot. A figure eight was built in this lot using 92 fixed objects (80 orange cones and 12 orange signs with black arrows). At each right or left turn the driver was directed by the arrows in which direction to turn (right or left).

![Figure 4: Off-Track Training Scenario](image)
**Inner-City-Scenario with No Traffic (Experimental Group)**

The second training scenario (Figure 5) consisted of 26 vehicles, all of which are fixed objects (orange signs with black arrows). This scenario consisted of 8 rights and 5 left turns and took approximately ten minutes to complete.

![Figure 5: Inner-City Training Scenario](image-url)
Inner-City Scenario with Traffic (Test scenario)

The only difference between this scenario and the inner-city scenario with no traffic was the addition of 46 vehicles, which included 13 orange signs with black arrows, 10 ADR vehicles, 22 NVR vehicles and one 4-way stop sign. All ADR’s had logic statements (e.g., If-Vehicle-19-Location-Not in Zone-1.0 / Then Set-Owncab-Collision-Equal to-False) included in order to reduce collision errors with the Owncab. All left and right turns were the same and time to complete the scenario was approximately one to two minutes longer due to traffic.
METHODS

Participants

Twenty participants from the University of Central Florida and the Institute for Simulation and Technology participated in the experiment (10 males and 10 females). Their ages ranged between 22 and 57 with a mean age of 30.5 years. The participants included four undergraduate and ten graduate students with six participants listing themselves as others. The lowest computer usage was 20 hours per week while the highest was 70 hours per week. Participants were recruited at the Institute for Simulation and Training at the University of Central Florida through word of mouth. They were placed on a list and participated as they became available for testing.

Materials and Apparatus

Paper materials covered the informed consent, demographic survey, pre-simulation sickness questionnaire, post-training multiple-choice questions, post-simulation sickness questionnaires, subjective questionnaires and finally a score sheet for the grading of four critical turns throughout the test scenario. The next instrument included a collection of seven short video sessions delivered through a computer-based format on basic truck driving. These seven video clips came from Roadmaster Truck Driving School with the shortest lasting 55 seconds and the longest at 2 minutes and 34 seconds.
Perhaps the most important piece of equipment was the TranSim VS™ truck-driving simulator (Figure 6). This is a mid-range non-motion truck-driving simulator with a six by six-foot print developed by GE. In basic mode, it can accurately simulate the behavior of approximately 240 engines, 140 transmissions, 33 axle ratios, and 300 tire sizes, along with road conditions and various grades. Trainees and drivers learn the proper way to shift a variety of transmissions over different grades, pulling an assortment of loads—all from the safety and convenience of the classroom (GE driver development, 2003).

Figure 6: Mid-Level Simulator from GE
Procedure

The participants were brought into the simulation lab and were asked to fill out an informed consent (Appendix A). They were then required to fill out a demographic survey (Appendix B). Next, they filled out a pre-screen simulation sickness questionnaire (Appendix C). Afterwards, the participants watched a 13-minute and 50-second collection of 7 video clips. Video clip 1 lasted 0:55 and covered starting the engine. Video clip 2 lasted 1:08 and was entitled “Moving Off” followed by clip 3, “Off Tracking” which lasted 2:34. The fourth and fifth video clips covered right turns and lasted 3:35. Clip number 6 covered left turns and ran 1:57 and the last clip was 1:16 and addressed stopping. These clips are part of a 41 disc system owned by Roadmaster for the training of new drivers. To complete the training system by Roadmaster takes in excess of 100 hours.

Next, the participants were randomized in to one of two groups depending on the outcome of a coin toss. The two simulation training sessions consisted of an off-track scenario (control group) or an inner-city driving scenario (experimental group) without the presence of vehicular traffic. The off-track scenario consisted of an asphalt lot and several orange cones designed into a figure eight. The participants were required to practice turning in this scenario for 10 minutes. The inner-city driving scenario without vehicular traffic also lasted 10 minutes. While this scenario did not include traffic, it did include stop signs, buildings, and traffic lights.
After the participants completed the training session they were asked to take a 16-question multiple-choice test (Appendix D) in order to establish a baseline understanding. All participants were required to score 75% or higher to be counted in the results. Next, all participants were tested on the inner-city driving scenario with the presence of vehicular traffic on four critical turns (2 right turns and 2 left turns). The test session also lasted ten minutes. The right turns were scored on signal, ease to the left before the turn, proper speed, tractor either too far or not far enough into the intersection, rear tandem tires run over the curb, rear tandem tires too far from the curb, and proper position of the truck after the turn. The left turns were scored in a similar fashion; signal, ease to the right before the turn, proper speed, tractor either too far or not far enough into the intersection, rear tandems run into the inner lane and proper position of the truck after the turn. All turns had independent characteristics; right turn 1 was a Button Hook turn, right turn 2 was a Jughandle turn, left turn 1 went from a four lane to a two lane, and left turn 2 went from a two lane road to a two lane road. Score sheets and weights can be found in Appendix G. All turns were scored by a subject matter expert, a former driver and trainer.

**Right Turn 1 (Button Hook)**

The proper execution of the first turn (Figure 7) is as follows: signal, slow down to 15 mph or slower, bring the truck as far to the left as possible without coming out of the lane in order to gain every inch possible, move the tractor in to the intersection and crank the steering wheel hard right causing the rear wheels to round the curb, bringing the tractor completely back in to the proper lane and cancel signal. This is the most desirable of the right turns because the driver is not required to come out of his/her lane.
Figure 7: Right Turn 1

**Right Turn 2 (Jughandle Turn)**

The proper execution of the second turn (Figure 8) is as follows: signal, slow down to 15 mph or slower, bring the tractor out of the lane but not into incoming traffic while the rear of the truck stays in the turning lane to prevent traffic from getting in between the truck and the curb, move the tractor to the center of the intersection and crank the steering wheel hard right causing the rear wheels to round the curb, bring the tractor completely back in to the proper lane and cancel the signal. This is the most difficult of the right turns because the driver is required to come out of his/her lane.
Left Turn 1

The proper execution of the first left turn (Figure 9) is as follows: signal, slow down to 15 mph or slower, bring the truck as far to the right as possible without coming out of the lane in order to gain every inch possible, move the tractor into the intersection and crank the steering wheel hard left causing the rear wheels to avoid tracking into the inner lane, bring the tractor completely into the proper lane and cancel signal.
The proper execution of the second left turn is (Figure 10) as follows: signal, slow down to 15 mph or slower, bring the truck as far to the right as possible without coming out of the lane in order to gain every inch possible, move the tractor into the intersection and crank the steering wheel hard left causing the rear wheels to avoid tracking into the inner lane, bring the tractor completely into the proper lane and cancel signal.
After the training session, all participants were required to fill out a post simulation sickness questionnaire (Appendix E); followed by a subjective survey found in Appendix F. The participants were then asked how they were feeling and if they were not adversely affected by the simulator, they were then free to leave.
RESULTS

The quantitative results for the 2 x 4 factorial analyses yielded the following results. There were no gender effects for combined turns as well as individual turns (between-subject effects can be found in Appendix H). However, overall conditional effects are significant. Participants trained in the inner-city training scenario without the presence of vehicular traffic (experimental group) out-performed those trained in the off-track scenario (control group) when tested in the inner-city scenario with the presence of vehicular traffic (test session). Descriptive statistics are illustrated in the table below.

Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Turns</th>
<th>Condition</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Turn 1</td>
<td>Inner-City</td>
<td>6.30</td>
<td>2.58</td>
</tr>
<tr>
<td></td>
<td>Off-Track</td>
<td>4.50</td>
<td>1.08</td>
</tr>
<tr>
<td>Right Turn 2</td>
<td>Inner-City</td>
<td>7.60</td>
<td>3.06</td>
</tr>
<tr>
<td></td>
<td>Off-Track</td>
<td>4.90</td>
<td>.99</td>
</tr>
<tr>
<td>Left Turn 1</td>
<td>Inner-City</td>
<td>10.10</td>
<td>3.25</td>
</tr>
<tr>
<td></td>
<td>Off-Track</td>
<td>5.90</td>
<td>4.77</td>
</tr>
<tr>
<td>Left Turn 2</td>
<td>Inner-City</td>
<td>7.10</td>
<td>4.01</td>
</tr>
<tr>
<td></td>
<td>Off-Track</td>
<td>5.20</td>
<td>4.34</td>
</tr>
</tbody>
</table>

Note: N = 10
The test session results for all turns combined were statistically significant, $F(1, 16) = 7.14$, $p = .017$, $\eta^2 = 3.09$. The overall differences in the training sessions are illustrated in the Figure 11. The mean for the control group ($M = 20.50$, $SD = 9.59$) with the experimental group at, ($M = 31.10$, $SD = 7.26$).

![Figure 11: Overall Training Scores](image)

The multiple-choice test (Figure 12) served as a baseline as well as a training tool. The questions were designed to measure learning captured from the instructional modules as well as the simulated training sessions. A minimum score of 75% was required on this test to be counted in the study.
Subjective responses (Figure 13) yielded the following results. Interestingly, participants overall felt they did not do well and moreover they strongly agreed that truck driving is difficult. This is a correct interpretation as the off-track (control group) averaged 20 out of the possible 48 points possible while the inner-city (experimental group) averaged 30 points out of the possible 48 points possible.
Possible symptoms of non-motion simulators include nausea, disorientation, and ocular problems, such as eyestrain, blurred vision and eye fatigue. In a fixed-based simulator, the driver remains in a fixed position while the vision system senses motion. The disparity between sensory cues may result in simulation sickness (Casali, 1986). The results from the post-simulation sickness (Figure 14) questionnaire are illustrated below.

**Figure 14: Simulation Sickness**
DISCUSSION AND CONCLUSION

When drivers are trained in today’s truck driving schools the conventional sequence of teaching is classroom instruction, followed by driving maneuvers on a large asphalt lot and finally driving on the public roads. Often, there is a shortage of equipment as well as instructors which leaves students standing idly by while the other students practice off-track maneuvers on asphalt lots or take turns driving while the other students ride in the sleeper compartment during road trips.

The mid-level simulator is a logical step in filling this gap and better preparing drivers to meet the challenges and demands of the road. With simulation, it is possible to script various driving situations that build skills required for the operation of these complex machines. Instead of having students standing around they could be honing their skills with the aid of simulation. In fact, without simulation, there is absolutely no way to prepare a driver for his/her first experience in the motoring public. The outcome of this study clearly suggests training in an inner-city situation without the presence of vehicular traffic is superior to the conventional approach of training on a large asphalt lot and better prepares a driver for inner-city situations with the presence of vehicular traffic.

While this study showed an impressive advantage in favor of the inner-city training scenario over the off-track scenario, there were no interactions or main effects pertaining to gender on any turn or overall. The fact that gender was not an issue in itself is noteworthy. There are abundant stereotypes surrounding the trucking profession. For instance, the scene in the popular movie “Thelma and Louise” portrays truck drivers as incompetent. Likewise, women and men alike grow up with attitudes towards driving
trucks that are very different. Men often think of driving trucks as a Burt Reynolds type of profession while women are generally intimidated by the whole affair. Perhaps truck driving simulators could act as an instrumental intermediate step for bringing women into the trucking profession. It is the assertion of this author that women can operate trucks as well as men. In fact, in certain circumstances may even out-perform men. For example, women seem to be less aggressive and often cooler heads will prevail. The truck simulator gives the potential driver the opportunity to accustom him/herself with the size of the steering wheel, the clutch pedal, shifting procedures, size of the truck and the space required to successfully turn around corners. The simulator provides a safe place for the student to say to him or herself, “I can do this,” and furthermore, reduces anxiety and fear.

The limitations of this study can be examined using Kirkpatrick’s four-level approach to the evaluation of training programs. Level (1) measures satisfaction and can be demonstrated through the qualitative results of the subjective questionnaires. Ten attributes were measured on a 1 to 5 scale with 5 being the highest. The overall mean was a 3.92 which translates to a 78.4% satisfaction on all items measured. Level (2) assesses the amount of information learned. This is demonstrated by the quantitative results which illustrate an impressive advantage over the inner-city training scenario as compared to the off-track scenario. Level (3) evaluates behavior such as risk-taking, strategy, and planning as it relates to on-the-job performance and is commonly referred to as transfer of training (Kirkpatrick, 1996). The first aspect to consider when evaluating this study is the impressive outcome, especially considering the sample size, which produced an
obvious transfer of training. Indeed, there was significant learning for the group that trained in the inner-city scenario as opposed to the off-track training scenario. The second factor or obvious next step is to apply this training approach in cooperation with truck driving schools where actual student drivers can participate and outcomes can be measured through surveys, interviews and statistical analysis. Level (4) measures results from the business point of view in terms of increased sales, productivity, profits and lowered turnover rates (Kirkpatrick, 1996). While this is the most difficult level to measure, both productivity and increased profits have been well documented using flight simulation within the airline industry. However, those objectives were not designed into this experiment, and therefore the impact is not known and the generalization is weak at best.

In conclusion, as simulation moves into the trucking industry the need for well-scripted scenarios as well as high-quality simulators such as the simulators provided by GE will be crucial. Hopefully, the outcome of this scenario testing is a first step in the development of a training package for truck driving schools as they bring simulation in to their instructional techniques. While this study did not evaluate student truck drivers per se, the results did demonstrate that simulation can produce learning; moreover, naive subjects can learn the skill of turning tractor-trailers when given appropriate training.
**Informed Consent**

Please read this consent document carefully before you decide to participate in this study.

**Project title:** "Assessment of Training Scenarios for Tractor-Trailer Drivers"

**Purpose of the research study:** The purpose of this study is to evaluate training scenarios for Tractor-Trailer Drivers.

**What you will be asked to do in the study:** Short demonstration with interactive courseware on off tracking, left and right turns. Then, a training session on either the off-road or city driving without vehicles on a midlevel simulator. Then take the test scenario! Finally, fill out a questionnaire.

**Time required:** One up to 1 & 1/2 hours.

**Risks:** A small percentage of people experience simulation sickness, in one study 1.75% of the participants experienced nausea, 11% experienced oculomotor difficulty (eyestrain, difficulty focusing and blurred vision) and 8.7% suffered disorientation (vertigo and dizziness).

**Benefits / Compensation:** There is no compensation or other direct benefit to you for participation.

**Confidentiality:** Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file in my faculty supervisor’s office. When the study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

**Voluntary participation:** Your participation in this study is voluntary. There is no penalty for not participating.

**Right to withdraw from the study:** You have the right to withdraw from the study at any time without consequence.

**Whom to contact if you have questions about the study:** James Whitmire II, 407-823-1375 Ron Tarr 407-823-1300

**Whom to contact about your rights in the study:** UCFIRB Office, University of Central Florida Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 207, Orlando, FL 32826. The phone number is (407) 823-2901.

___________________________________________
I have read the procedure described above.

Participant Date I voluntarily agree to participate in the procedure.
APPENDIX B

DEMOGRAPHIC SURVEY
Demographic Survey

1) Sex: Male____ Female____

2) Age ____

3) Have you operated a driving simulator or any other type of simulator before?
   Yes____ If yes, please describe___________________________
   No____

4) How would you classify yourself?
   Undergraduate______ Graduate______ Post Bac_______ Other______

5) What is your Major? __________

6) Have you ever operated a tractor-trailer? Yes____ No_____

7) Do you have a driver’s license? Yes____ No____

8) Have you ever used a desktop driving simulator? Yes____ No____

9) Do you play video games? Yes____ No____

   If Yes, answer # 10 and # 11. If No, skip to 12.

10) If Yes, how often? For example, one hour a month or a week? __________

11) At what age did you start playing video games? ________________

12) If you use a computer, how many hours per week? ________________

13) Do you have 20/20 eyesight?

   Yes____

   No____

   If No, what is your eyesight, (for example 20/10 or 20/30)? ______

14) Do you trailer a boat or any other type of trailer vehicle behind a truck or car?

   Yes____  No____
APPENDIX C

SIMULATOR SICKNESS PRE-SCREENING QUESTIONNAIRE
Simulator Sickness Pre-Screening Questionnaire

This study will require you to drive in a simulator. In the past, some participants have felt uneasy after participating studies using the simulator. To help identify people who might be prone to this feeling, we would like to ask the following questions.

1. Do you or have you had a history of migraine headaches?
   □ Yes  □ No
   If yes, please describe: ________________________________

2. Do you or have you had a history of claustrophobia?
   □ Yes  □ No
   If yes, please describe: ________________________________

3. Do you or have you had a history of motion sickness?
   □ Yes  □ No
   If yes, please describe: ________________________________

4. If you are a female, are you or is there a possibility that you might be pregnant?
   □ Yes  □ No

5. Do you have any health problems which affect driving?
   □ Yes  □ No
   If yes, please describe: ________________________________

6. Have you ever experienced heart problems or suffered a heart attack?
   □ Yes  □ No
   If yes, please describe: ________________________________

7. Have you ever suffered from a stroke, tumor, head trauma, or serious infection?
   □ Yes  □ No
   If yes, please describe: ________________________________

8. Have you ever suffered from epileptic seizures?
   □ Yes  □ No
   If yes, please describe: ________________________________

9. Have you ever experienced shortness of breath/chronic med.?
   □ Yes  □ No
   If yes, please describe: ________________________________

10. Have you ever had therapy for respiratory disorders/asthma?
☐ Yes  ☐ No
If yes, please describe: _______________________________________

11. Have you ever experienced inner ear problems, dizziness, vertigo, or balance problems?
☐ Yes  ☐ No
If yes, please describe: _______________________________________

12. Do you have Diabetes for which insulin is required?
☐ Yes  ☐ No
If yes, please describe: _______________________________________

13. Have you been diagnosed with a serious or terminal illness?
☐ Yes  ☐ No
If yes, please describe: _______________________________________

14. Have you ever been diagnosed with a mood problem or a psychiatric disorder?
☐ Yes  ☐ No
If yes, please describe: _______________________________________

15. Are you currently taking any medications?
☐ Yes  ☐ No
If yes, please describe: _______________________________________

16. Do you have trouble climbing a flight of stairs easily?
☐ Yes  ☐ No
If yes, please describe: _______________________________________

17. Do you have normal (n) or corrected (c) to normal vision (e.g., glasses, contacts)?
☐ Yes  ☐ No
If yes, please describe: _______________________________________
APPENDIX D

POST TRAINING QUESTIONNAIRES
Post Training Questionnaires

Read the following multiple choice questions and circle the best answer.

1) Which of the following is NOT a key point of off-tracking?
   a) The distance between the kingpin and the rear trailer axle.
   b) The amount of sideways drag created during the turn.
   c) The sharpness of the turn at the intersection.
   d) The amount of tread on the rear trailer axle.

2) When approaching a turn when should the driver stop the truck?
   a) To prepare for a button hook turn.
   b) To prepare for a jug handle turn.
   c) When you reach a speed of 15 mph or more.
   d) When truck stalls out.

3) When the trailer tires don’t follow the same path as the tractor tires, this is referred to as what?
   a) Back tracking.
   b) Off tracking.
   c) On tracking.
   d) Side tracking.

4) Which right hand turning maneuver is most desirable?
   a) Buttonhook.
   b) Crossing.
   c) Jug Handle.
   d) Straight Entry.

5) Which of the following is a common mistake in making a right hand turns?
   a) Approaching the intersection too fast.
   b) Shifting in the middle of the turn.
   c) Not downshifting before the turn.
   d) All of the above.

6) What is the proper way to make a jug handle turn?
   a) Pull into the oncoming lane.
   b) Adjust your speed.
   c) Watch the right hand mirror.
   d) All of the above.
7) The sharpness of the turn is a critical factor when deciding whether to make a jug handle or button hook turn?
   a) True.
   b) False.

8) Left hand turns have a longer radius.
   a) True.
   b) False.

9) When making a left hand turn, get as far left as possible in the lane.
   a) True.
   b) False.

10) Hitting a car with the trailer when making a turn is referred to as a low speed tracking accident.
    a) True.
    b) False.

11) When making a right hand turn what is the proper position of the truck immediately before the turn?
    a) As far left as possible in the correct lane in order to gain every inch to make a successful turn.
    b) Centered in the correct lane.
    c) As close to the curb as possible.
    d) It depends on what time of day it is.

12) A driver should always signal before a turn.
    a) True
    b) False

13) What is the proper position of the truck after a turn?
    a) In the correct lane with the blinker on.
    b) Approaching the correct lane with the blinker on.
    c) Approaching the correct lane with the blinker off.
    d) In the correct lane with the blinker off.

14) On a right turn, what is a possible explanation if your rear tires run over a curb?
    a) You took your tractor too far out into the intersection before turning.
    b) You did not take your tractor far enough into the intersection before turning.
    c) The curb sticks too far out in the street.
    d) The road is too skinny.
15) When making a right hand turn what is the correct range of speed? Pick the best answer.
   a) **Below 15mph.**
   b) **Above 15mph.**
   c) The speed of light.
   d) Faster than the speed of light.

16) The position of the tractor determines what during a turn?
   a) Weather your rear tires run over the curb.
   b) Weather your rear tires are too far from the curb.
   c) A successful turn.
   d) **All of the above.**
Post-Experiment Simulator Induced Discomfort Questionnaire

There is a small risk associated with driving in the simulator environment. The driver may experience feelings of dizziness and increased body temperature, which are symptoms of a temporary condition called 'Simulator Induced Discomfort' (SID).

To verify the extent of SID occurrence, we are tracking the severity of any discomfort felt by those who drive in the driving environment simulator.

Sex:
☐ Male
☐ Female

Age: ______

Are you wearing prescription glasses or contact lenses?
☐ Yes
  ☐ Glasses
  ☐ Contact lenses
☐ No

What is your exposure to the driving environment simulator?
☐ First time
☐ Second time
☐ More than two times

During this most recent experience in the driving environment simulator, did you experience any feelings of discomfort?

Eye Strain:
☐ none ☐ slight ☐ moderate ☐ severe

Temperature Increase:
☐ none ☐ slight ☐ moderate ☐ severe

Dizziness:
☐ none ☐ slight ☐ moderate ☐ severe

Headache:
☐ none ☐ slight ☐ moderate ☐ severe

Nausea:
☐ none ☐ slight ☐ moderate ☐ severe
Subjective Questions (Check appropriate response)

<table>
<thead>
<tr>
<th>Questions</th>
<th>1=Strongly Disagree</th>
<th>2=Somewhat Disagree</th>
<th>3=Neither Agree or Disagree</th>
<th>2=Somewhat Agree</th>
<th>1=Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The simulator was easy to drive.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The graphics were realistic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The graphics were clear.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The simulator conveyed the real world environment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brake pedal was easy to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas pedal was easy to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The simulator is an effective training tool.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The mirrors were helpful.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck driving is difficult.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel I did well.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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APPENDIX G

SCORE SHEETS
### RIGHT TURN 1

<table>
<thead>
<tr>
<th>POSSIBLE POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Ease to the left before the turn.</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Proper Speed</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Tractor either too far or not far enough into intersection.</strong></td>
</tr>
<tr>
<td>4 points</td>
</tr>
<tr>
<td><strong>Rear Tandem Tires Run over Curb</strong></td>
</tr>
<tr>
<td>2 points</td>
</tr>
<tr>
<td><strong>Rear Tandem Tires Too far from the Curb.</strong></td>
</tr>
<tr>
<td>2 points</td>
</tr>
<tr>
<td><strong>Proper position of the Truck after the Turn</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
</tbody>
</table>

### RIGHT TURN 2

<table>
<thead>
<tr>
<th>POSSIBLE POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Ease to the left before the turn.</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Proper Speed</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Tractor either too far or not far enough into intersection.</strong></td>
</tr>
<tr>
<td>4 points</td>
</tr>
<tr>
<td><strong>Rear Tandem Tires Run over Curb</strong></td>
</tr>
<tr>
<td>2 points</td>
</tr>
<tr>
<td><strong>Rear Tandem Tires Too far from the Curb.</strong></td>
</tr>
<tr>
<td>2 points</td>
</tr>
<tr>
<td><strong>Proper position of the Truck after the Turn</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
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</table>

### LEFT TURN 1

<table>
<thead>
<tr>
<th>POSSIBLE POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Ease to the right before the turn.</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Proper Speed</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Tractor either too far or not far enough into intersection.</strong></td>
</tr>
<tr>
<td>5 points</td>
</tr>
<tr>
<td><strong>Rear Tandem Tires Run into inner lane.</strong></td>
</tr>
<tr>
<td>3 points</td>
</tr>
<tr>
<td><strong>Proper position of the Truck after the Turn</strong></td>
</tr>
<tr>
<td>1 point</td>
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</table>

### LEFT TURN 2

<table>
<thead>
<tr>
<th>POSSIBLE POINTS</th>
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</thead>
<tbody>
<tr>
<td><strong>Signal</strong></td>
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<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Ease to the right before the turn.</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Proper Speed</strong></td>
</tr>
<tr>
<td>1 point</td>
</tr>
<tr>
<td><strong>Tractor either too far or not far enough into intersection.</strong></td>
</tr>
<tr>
<td>5 points</td>
</tr>
<tr>
<td><strong>Rear Tandem Tires Run into inner lane.</strong></td>
</tr>
<tr>
<td>3 points</td>
</tr>
<tr>
<td><strong>Proper position of the Truck after the Turn</strong></td>
</tr>
<tr>
<td>1 point</td>
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</table>
APPENDIX H

BETWEEN-SUBJECT EFFECTS
Table 2: Between-Subject Effects

<table>
<thead>
<tr>
<th>Turns</th>
<th>F</th>
<th>P</th>
<th>Eta Squared</th>
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<tbody>
<tr>
<td><strong>Right Turn 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>3.857</td>
<td>.067</td>
<td>.194</td>
</tr>
<tr>
<td>Gender</td>
<td>.048</td>
<td>.830</td>
<td>.003</td>
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<td><strong>Right Turn 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>6.781</td>
<td>.019</td>
<td>.298</td>
</tr>
<tr>
<td>Gender</td>
<td>1.126</td>
<td>.304</td>
<td>.066</td>
</tr>
<tr>
<td><strong>Left Turn 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>5.227</td>
<td>.036</td>
<td>.246</td>
</tr>
<tr>
<td>Gender</td>
<td>.581</td>
<td>.457</td>
<td>.035</td>
</tr>
<tr>
<td><strong>Left Turn 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
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<td>.347</td>
<td>.055</td>
</tr>
<tr>
<td>Gender</td>
<td>.210</td>
<td>.653</td>
<td>.013</td>
</tr>
<tr>
<td><strong>Combined Turns</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
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<td>.017</td>
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</tr>
<tr>
<td>Gender</td>
<td>.206</td>
<td>.656</td>
<td>.013</td>
</tr>
</tbody>
</table>

Note: Condition (Inner-City vs. Off-Track)
APPENDIX I

IRB
September 22, 2003

James Whitmire  
3280 Progress Drive  
Orlando, FL 32826  

Dear Mr. Whitmire:

With reference to your protocol entitled, "Assessment of Training Scenarios for Tractor-Trailer Drivers," I am enclosing for your records the approved, executed document of the UCFIRB Form you had submitted to our office.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur. Further, should there be a need to extend this protocol, a renewal form must be submitted for approval at least one month prior to the anniversary date of the most recent approval and is the responsibility of the investigator (UCF).

Should you have any questions, please do not hesitate to call me at 823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

[Signature]

Chris Grayson  
Institutional Review Board (IRB)

Copies: Mr. Ronald Tarr  
IRB File
REFERENCES


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