Simulation as a Tool for Enhancing Commercial Driver Skills and Recertification: Follow-On to the Virtual Check Ride System

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Ronald W. Tarr
Program Director
Simulation and Performance Technology
Center for Advanced Transportation Simulation Systems (CATSS)
University of Central Florida

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Disclaimer

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16. Abstract

The Virtual Check-Ride System (VCRS) is a scientifically validated virtual alternative to the traditional Commercial Driver License test. The VCRS combines computer-based training (CBT) with simulation to create a valid replication of the current CDL process. The CBT portion includes multiple choice tests with questions on general knowledge, air brakes, and combination vehicles, and a virtual pre-trip (VPT) walk around inspection. The VPT guides the driver around the truck and requires the driver to identify the key inspection points based on CDL requirements. The third portion of the system consists of a simulation-based driving skills test. A truck simulator is used and the driver is required to perform the driving maneuvers required by the CDL test. The system has effectively replicated the on-pad and off-pad driving scenarios. These scenarios have undergone detailed scientific examination and provide a valid virtual alternative to the actual driving scenarios required by the CDL test. This blend of technology has proven to be a valid alternative to the traditional CDL test and has the potential to meet challenges facing the transportation community such as more objective driver testing, performance-based renewals and reduction of fraudulent licenses. This system is dynamic and adaptable to varying organizations and has been shown to also offer a tailored remediation capability and an alternative to annual driver training. Since both the CBT and the simulation scenarios have been independently validated, organizations can choose which aspects of the system best fit their needs. The VCRS has advanced and is evolving into a highly sensitive diagnostic and remediation system for the transportation community, both industry and industry training wide applications.

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This research was made possible by the Florida Department of Transportation. In addition, we would like to recognize the hard work and the team members' contributions that made the Virtual Check Ride a viable and important research tool.

Back Row: James Whitmire, Scott Tanner, Chris Evans, Ron Tarr, Alpesh Makwana, Doug LaCroix, Front Row: Carol Jones, Lisa Hernandez, Nancy Molina, Tzywei Cheng, Simone Basilio, Kamini Gupta, Rae Hanson

Dedication

This paper is dedicated to Talleah Allen whose tireless work and endless enthusiasm for technology and safety throughout the trucking industry has inspired us all.

Executive Summary

Florida and the U.S. Department of Transportation (DOT) have identified operator performance and safety as major objectives in addressing the trucking needs of the state and nation. The trucking issues we encounter with Commercial Motor Vehicles (CMV's) are the severity of accidents, potential terrorist threats, rising fuel costs, and tight budgets. These issues demand that today's drivers operate at their highest possible safety and performance levels. One of several concerns surrounds the recertification of driving skills. Another is how to create a cost-effective method to identify fraudulent Commercial Drivers Licenses (CDL's). An additional issue is those drivers who have been grandfathered into the 1992 CDL program from the previous program without any actual driver performance assessment.

One of the major factors inhibiting solving these problems is the complexity of the predicament and the administrative time required to conduct a CDL test in the traditional fashion. Although current U.S. DOT regulations preclude the use of simulation in the initial testing for the CDL, the regulations allow for the use of simulation for supplemental training and testing. This report details the cumulative research effort of the Virtual Check Ride System (VCRS), which includes the development of the application and its exhaustive validation efforts. The findings to date support the VCRS as a valid diagnostic and remediation system for representing the skills required for the CDL.

Our initial approach to creating the VCRS focused on gaining a strong needs-assessment by working closely with several subject matter experts (SME's) from the Florida Trucking Association, Florida Motor Carrier Compliance, Frito-Lay, and Roadmaster. Once we identified the needs we turned to well tested traditional methods to meet our objectives for a simulated alternative to the CDL. The VCRS can be divided into three sections that combine computer-based training (CBT) with simulation to create a valid replication of the current CDL process. The first section, the VCRS's CBT segment of the examination includes a multiple-choice test with questions on general knowledge, air brakes, and combination vehicles. Furthermore, the CBT consists of 55 CDL test questions randomly selected from a data base of 500 actual CDL test questions and includes an after action review (AAR) for student learning. The next section includes a pre-trip inspection using virtual technology. This feature guides the driver around the truck and requires the driver to identify the key inspection points based on CDL requirements. The third section of the system consists of a simulation-based driving skills test. A truck simulator is used and the driver is required to perform the driving maneuvers demanded by the CDL test. The section effectively replicates the on-pad and off-pad driving skills required for the CDL exam.

These test simulations have undergone detailed scientific validation and provide a suitable virtual alternative to the actual driving skills required by the CDL test. This blend of technology, in extensive field trials, has proven to be a compelling alternative to the traditional CDL test and has the potential to meet challenges facing the transportation community such as more objective driver testing, performance-based renewals and reduction of fraudulent licenses. Since both the CBT and the simulation scenarios have been independently validated, organizations can choose which aspects of the system best fit their needs.

The overall goal of our research was to explore and validate the application of computer-based and simulation-based technology for the commercial driving community that provides a valid, low cost process of determining drivers' skills and commercial vehicle knowledge. Research and development processes included various simulators and learning technologies to improve driver/operator safety and performance in the trucking and transportation communities, in various configurations. This report

covers some of that initial research but mostly describes the follow-on research that has expanded the VCRS from a test to a broader capability that includes remediation and additional validation in other jurisdictions, e.g., Schneider National in Green Bay, WI. This resulted in the Virtual Check Ride (VCR) becoming the VCRS or Virtual Check Ride System, which includes test reports, recommendations for remediation on specific items and details on part identification. With the completion of this phase of research, the VCRS is now being considered by several training and education activities for incorporation into their programs as well as by the Federal Motor Carrier Safety Administration and Florida DMV for use as a tool to assist in certification of 3rd party CDL examiners and as a tool for CDL remediation and renewal.

Table of Contents

Disclaimer ii
Acknowledgement iv
Dedication v
Executive Summary vi
List of Figures x
List of Tables xi
Chapter One: Introduction 1
    Virtual Check Ride System 2
    Virtual Check Ride Remediation 4
Chapter Two: Transportation Trends 6
    The Large Truck Crash Causation Study 6
    Driver Behavior-Based Model 6
    Driver Recognition Factor 6
    Driver Decision Factor 7
    Top Ten Crash Types 7
Chapter Three: Research Approach 8
    Content Fidelity 10
    Reliability 10
    Simulation Fidelity 10
Chapter Four: Research Method 11
    Data Collection Methods 11
    Dependent Measures 11
    Participants 11
    Virtual CDL Testing Methods 12
Chapter Five: Research Outcomes 14
    Introduction to Research Outcomes 14
    Knowledge Tests 14
    Straight Line Backing 15
    Alley Dock 16
    First Street Intersection 17
    Tenth Street Intersection 20
    Seventh Street Intersection 22
    H Street Intersection 24
    Fifth Street Intersection 26
    F & Fifth Street Intersection 28
    First & F Street Intersection 30
Chapter Six: Findings and Conclusions 33
    Frito-Lay 34
    Expanded Project Goals and Objectives 34
    England Briefing and Demonstration 34
    Large Truck Study: Advanced Scenarios 35
    Future Direction: Mid-Florida Tech 38
References 40
Appendix A: Participant Instructions 41
Appendix B: Informed Consent 42
Appendix C: Demographic Survey 43

Appendix D: Pre-Simulation Sickness 44
Appendix E: Brake Test 45
Appendix F: Off-Road Score Sheet 46
Appendix G: City Score Sheet 47
Appendix H: Urban Score Sheet 49
Appendix I: Freeway Score Sheet 50
Appendix J: Rural Score Sheet 51
Appendix K: Post-Experimental Questionnaire 52
Appendix L: Post-Simulation Sickness 53
Appendix M: Student Survey 54

List of Figures

Figure 1: Test Selection 3
Figure 2: VCRS Part Identification 3
Figure 3: VCRS Simulated Driving Scenario 4
Figure 4: CDL Remediation 5
Figure 5: ADDIE Model 8
Figure 6: Advanced Performance Technology Model 9
Figure 7: Motor Coach 34
Figure 8: Advanced Scenario 35
Figure 9: Scenario Outline 36
Figure 10: Pre-trip Outline 36
Figure 11: Exit Procedures 37
Figure 12: Potential Hazards 37
Figure 13: VCRS Test Site at Mid-Florida Tech 38

List of Tables

Table 1: Skill Classifications 5
Table 2: Computer-Based Performance 14
Table 3: Straight Line Back 15
Table 4: Alley Dock 16
Table 5: First Street Intersection 17
Table 6: Tenth Street Intersection 20
Table 7: Seventh Street Intersection 22
Table 8: H Street Intersection 24
Table 9: Fifth Street Intersection 26
Table 10: F & Fifth Street Intersection 28
Table 11: First & F Street Intersection 30

Chapter One: Introduction

Florida and the U.S. Department of Transportation (DOT) have identified operator performance and safety as major objectives in addressing the trucking needs of the state and nation. The trucking issues we encounter with Commercial Motor Vehicles (CMV's) are the severity of accidents, potential terrorist threats, rising fuel costs, and tight budgets. These issues demand that today's drivers operate at their highest possible safety and performance levels. One of several concerns surrounds the recertification of driving skills. Another is how to create a cost-effective method to identify fraudulent Commercial Drivers Licenses (CDL's). An additional issue is those drivers who have been grandfathered into the 1992 CDL program from the previous program without any actual driver performance assessment.

One of the major factors inhibiting solving these problems is the complexity of the predicament and the administrative time required to conduct a CDL test in the traditional fashion. Although current U.S. DOT regulations preclude the use of simulation in the initial testing for the CDL, the regulations allow for the use of simulation for supplemental training and testing. This report details the cumulative research effort of the Virtual Check Ride System (VCRS), which includes the development of the application and its exhaustive validation efforts. The findings to date support the VCRS as a valid diagnostic and remediation system for representing the skills required for the CDL.

The current CDL examination consists of a multiple-choice knowledge test, a walk-around pre-trip inspection of a tractor and trailer, and a basic skills driving test. The required components of the knowledge tests, which all CDL examinees must take, are: General Knowledge, Air Brake Knowledge, and Combination Vehicles Knowledge. The walk around consists of 105 inspection points and is conducted on a driving range. The basic skills test includes a set of fundamental maneuvers that include shifting, backing, parking, and coupling and uncoupling the trailer. It also includes a road test which is comprised of normal street driving, highway driving, and some extreme driving conditions, such as stopping on a hill. The entire CDL test can take 1-2 days to complete.

Some of the benefits of using simulation technology are that simulations provide the opportunity for drivers to experience dangerous or lethal consequences as a result of their decisions (Tarr, 2004). For example, the driver who has never driven on snow and ice can use a simulator to experience these driving conditions without injury to him or damage to the vehicle. Additionally, the driving scenario could provide a realistic "fish-tail" situation where the driver must be able to regain control of the vehicle without "jack-knifing."

The effects of simulations are revealed not by tests of knowledge but by tests of transfer and application (Thomas and Hooper 1991). Transfer refers to the driver's ability to apply his/her driving simulation experience in a new situation. It is believed that VCRS, given some scenario changes according to situations, will be used to evaluate driver's

skills while exposing him/her to extreme or unfamiliar driving situations. We believe the ability to use the VCRS in this fashion will increase both perceptual fidelity and manipulative fidelity.

In conducting the study that resulted in the VCRS and its subsequent validation, several considerations were determined to be critical: mirroring the United States Federal Regulation; understanding the issues of the trucking community and what it considered to be critical success measures; a robust sample size; and finally, driver performance, with the technology being clearly a means to that end.

The overall goal of our research was to explore and validate the application of computer-based and simulation-based technology for the commercial driving community that provides a valid, low cost process of determining drivers' skills and commercial vehicle knowledge. Research and development processes included various simulators and learning technologies to improve driver/operator safety and performance in the trucking and transportation communities. This report covers some of that initial research but mostly describes the follow-on research that has expanded the VCRS from a test to a broader capability that includes remediation and additional validation in other jurisdictions, e.g., Schneider National in Green Bay, WI. This resulted in the Virtual Check Ride becoming the VCRS or Virtual Check Ride System, which includes test reports, recommendations for remediation on specific items and details on part identification. With the completion of this phase of research, the VCRS is now being considered by several training and education activities for incorporation into their programs as well as by the Federal Motor Carrier Safety Administration and Florida DMV for use as a tool to assist in certification of 3rd party CDL examiners and as a tool for CDL remediation and renewal.

Virtual Check Ride System

The VCRS computer-based training (CBT) section reflects the requirements set forth by the CDL testing process for the class A, B, and C driver's license. However, the main component of VCRS consists of the class A driver's examination which consists of two tests: the knowledge test and the virtual pre-trip inspection. When individuals sit down at the computer to take the test, they start with the knowledge test and then move through the three different sections as they would in the actual CDL test. The CBT system tracks the scores for each section and provides a percentage for each section as well as an overall score. Each student must score 80% or higher in order to move on to the virtual pre-trip inspection. Should the overall score of 80% not be achieved, the individual must retake the sections of the knowledge test where deficiencies were noted. Upon completion of the knowledge test, the driver will progress to the virtual pre-trip inspection.

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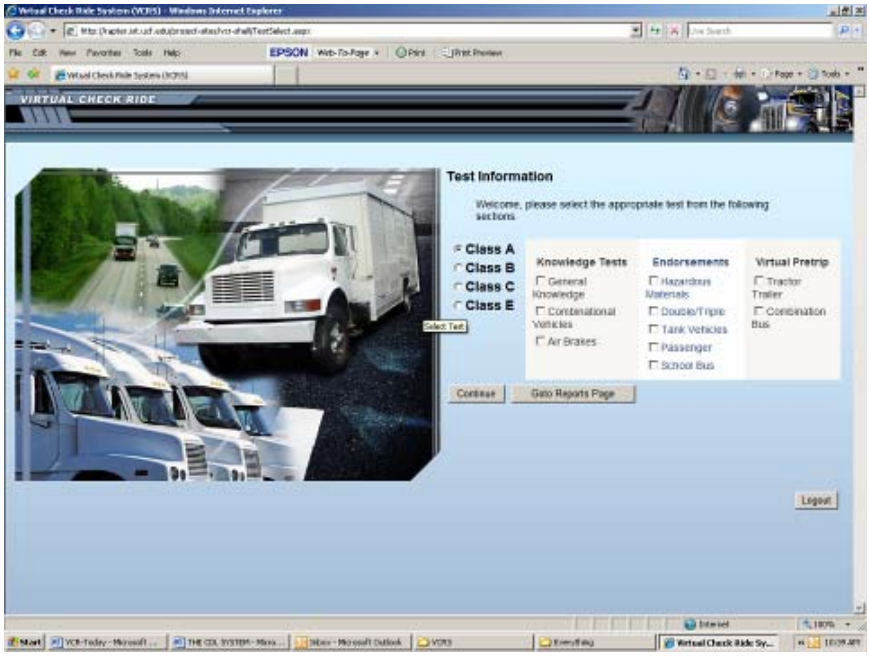


Figure 1: Test Selection

The virtual pre-trip inspection is a test that assesses the driver's knowledge on the location and name of certain parts on the tractor and trailer. After the part identification is addressed, a series of questions on possible defects pertaining to that particular part are presented to the driver. The test asks the driver to match 117 tractor and trailer parts with the correct name. To pass the virtual pre-trip inspection, a driver must identify a minimum of 83 tractor-trailer parts. Should the driver not identify at least 83 parts, a report will be generated that identifies the parts that were not identified correctly and the resulting report can be used as a study guide to help him/her focus on areas of concern.

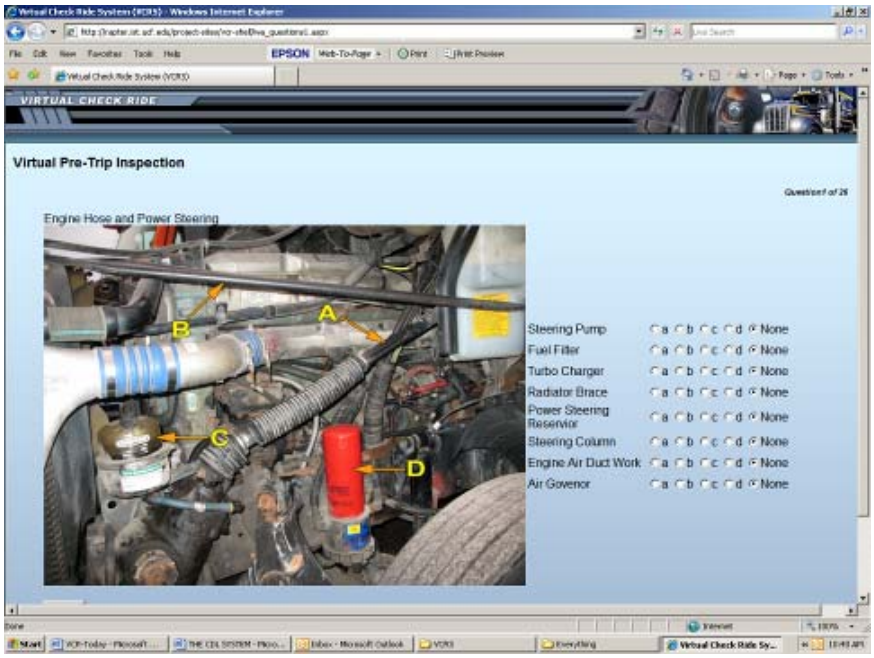


Figure 2: VCRS Part Identification

Upon completion, the drivers will move on to the previously validated simulated driving scenarios and their performance will be assessed by third party examiners. The third party examiners will perform their duties as they would in an actual truck and the driver will be asked to drive though the different types of driving conditions mandated by the CDL process. The different areas are on-pad driving maneuvers and off-pad driving skills. The off-pad portion includes urban driving, city driving and rural driving. The third party examiners will assess the drivers as they would in an actual real world driving environment and pass or fail the drivers. Should the drivers fail, they will have to re-do the entire simulated driving scenarios at a later time.

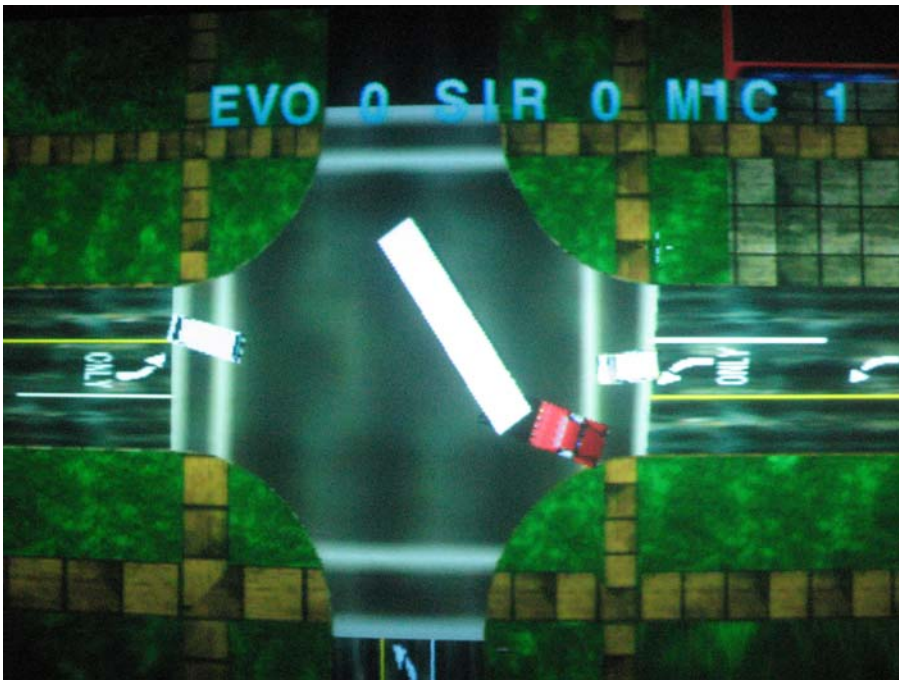


Figure 3: VCRS Simulated Driving Scenario

Virtual Check Ride Remediation

The current CDL driver's manual questions are designed to test drivers in the several areas; however, at the conclusion of the test, no feedback is given to the potential CDL driver. The VCRS diagnostic and remediation system identifies weaknesses in certain areas by asking questions and takes the driver through web-based links to the specific spot in the CDL manual that may address the driver's weakness. The twenty-four skill areas are addressed in the following table one.

Table 1: Twenty-Four Skill Areas

Vehicle Inspection	Basic Control of Your Vehicle	Shifting Gears	Seeing
Communicating	Space Management	Controlling Your Speed	Seeing Hazards
Distracted Driving	Aggressive Drivers/Road Rage	Night Driving	Driving in Fog
Winter Driving	Hot Weather Driving	Railroad-highway Crossings	Mountain Driving
Driving Emergencies	Antilock Braking Systems	Skid Control and Recovery	Accident Procedures
Fires	Alcohol, Other Drugs, and Driving	Staying Alert and Fit to Drive	Hazardous Materials Rules

The following figure illustrates the user interface for CDL remediation. It gives the driver feedback on question he or she missed and what sill area she or he is weak in. The section titles are hyperlinked to the appropriate topics in the CDL manual. In addition, further remediation is being developed to address skill areas by directing the driver to appropriate training modules.

Figure 4: CDL Remediation

Chapter Two: Transportation Trends

The Large Truck Crash Causation Study

The Large Truck Crash Causation Study (LTCCS) was undertaken jointly by the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA). The LTCCS is based on a nationally representative sample of nearly 1,000 injury and fatal crashes involving large trucks that occurred between April 2001 and December 2003. The data collected provide a detailed description of the physical events of each crash, along with an unprecedented amount of information about all the vehicles and drivers, weather and roadway conditions, and trucking companies involved in the crashes.

Driver Behavior-Based Model

The American Transportation Research Institute (ATRI) undertook this research to develop an overall driver performance-based model for predicting future crash involvement based on prior driver history. ATRI's research team included North Dakota State University Upper Great Plains Transportation Institute (NDSU/UGPTI) and the Commercial Vehicle Safety Alliance (CVSA). Several available subsets of driver-specific data were used by the research team to design and test the model. The model includes specific violations discovered during roadside inspections, driver traffic conviction information, and past accident involvement. A secondary component of the research identifies effective enforcement actions to counteract the identified problem driving behaviors/events. The analysis shows that eight separate moving violations were significant with an associated crash likelihood increase between 21 and 325 percent. Four driver violations were associated with a crash likelihood increase between 18 and 56 percent. Twelve convictions were significant with an associated crash likelihood increase between 24 and 100 percent. Furthermore, drivers who have had a previous crash are 87 percent more likely to have a future crash. According to the states identified as having more traffic enforcement and fewer crashes, successful enforcement strategies for addressing problem driver behaviors are those that exhibit one or more of the following components: creating aggressive driving apprehension programs/initiatives; focusing on both CMV and non-CMV driver behavior patterns; conducting highly visible enforcement activities; using a performance-based approach to identify specific crash types, driver behaviors and locations; and conducting covert enforcement activities. According to the LTCCS the top two critical reasons in a sample of 78,000 truck crashes were driver recognition factor (accounting for 29% or 22,000 crashes) and driver decision factor (accounting for 38% or 30,000 crashes.)

Driver Recognition Factor

- Inattention (i.e., daydreaming) at 5,000 crashes or 6%

- Internal distraction at 3,000 crashes or 3%
- External distraction at 2,000 crashes or 3%
- Inadequate surveillance at 9,000 crashes or 12%
- Unknown at 4,000 or 5%

Driver Decision Factor

- Too fast for conditions at 7,000 crashes or 9%
- Misjudgment of gap or others speed at 2,000 or 3%
- Following too closely at 3,000 or 4%
- False assumption of others action at 1,000 or 2%
- Illegal maneuver at 4,000 or 5%
- Inadequate evasion action at 1,000or 1%
- Aggressive driving at 1,000 or 1%
- Too fast for turn or curve at 9,000 or 12%

Top Ten Crash Types

- Rear-end at 231 crashes or 24%
- Roadside departure at 158 crashes or 16%
- Sideswipe, same direction at 111 crashes or 12%
- Turn across or into path at 94 crashes or 10%
- Intersecting vehicles, straight
- Rollover
- Hit object in road
- Sideswipe, opposite direction
- Head-on

Note: This was out of 963 crashes

Chapter Three: Research Approach

Our initial steps in creating the VCRS focused on gaining a strong needs-assessment and working closely with several subject matter experts to identify and define the problems at large. Once we identified the needs we turned to the traditional systems approach for creating our objectives and a simulated alternative to the CDL. The objectives closely matched the CDL exam requirements. The systems approach at first glance appeared to offer exactly what we were looking for. The system is defined as a set of concepts or parts (objectives) that must work together to perform a particular function (performance and skills enhancement). There are two main characteristics of a systems approach:

- A systems approach is as scientific as it is empirical and must be able to be replicated
- A systems approach separates skills and knowledge into manageable parts

The ADDIE model is a systems approach training model. This model is an empirical process for designing training that is both efficient and replicable. The ADDIE model first breaks things down (skills and knowledge) into manageable parts (objectives). These objectives form the basis of the instruction, both in terms of content and assessment, ensuring accomplishment of the goals. Implementation and evaluation are both guided by the objectives, making the process a controlled system.

Figure 5: ADDIE Model

However, shortly after adopting this model, we realized that our system was more complex than what the ADDIE model could support. We needed something along the lines of the ADDIE model but something that also supported human performance. Thus we paired it with the theory of human performance technology (HPT). HPT aims to improve performance in the workplace or in learning situations by determining gaps in performance and designing cost-effective and efficient technology interventions. By marrying the two we created a hybrid model called the Advanced Performance Technology © model. Our model uses a systematic approach, but takes a broader view; i.e., it is not limited to training as the only intervention.

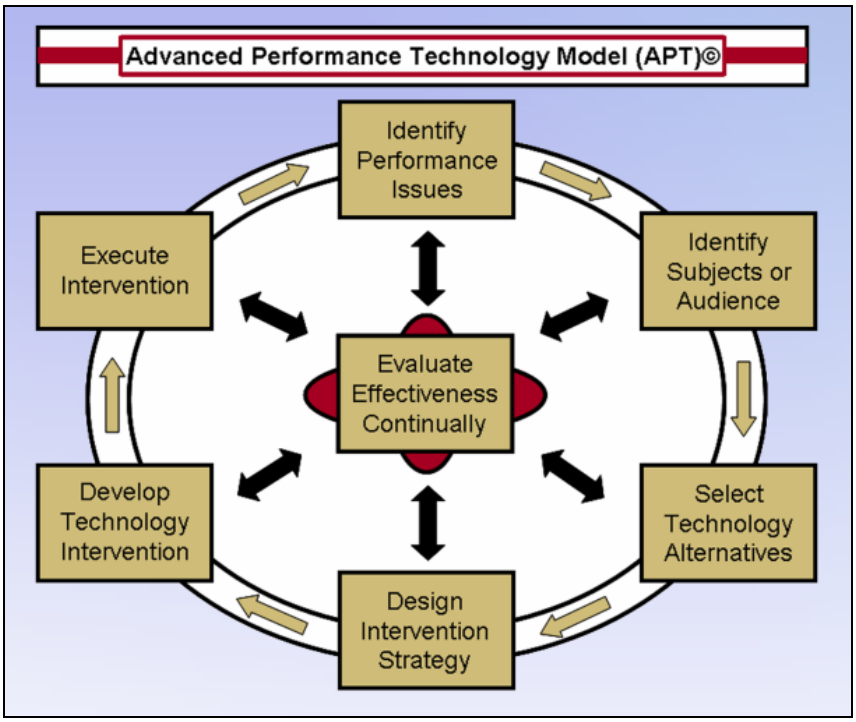


Figure 6: Advanced Performance Technology Model

Once we identified the needs we turned to well tested traditional methods to meet our objectives for a simulated alternative to the CDL. Consequently, the VCRS can be divided into three sections that combine CBT with simulation to create a valid replication of the current CDL process. The first section, the VCRS's CBT segment of the examination includes a multiple-choice test with questions on general knowledge, air brakes, and combination vehicles. Furthermore, the CBT consists of 55 CDL test questions randomly selected from a data base of 500 actual CDL test questions and includes an after action review (AAR) for student learning. The next section includes a pre-trip inspection using virtual technology. This feature guides the driver around the truck and requires the driver to identify the key inspection points based on CDL requirements. The third section of the system consists of a simulation-based driving skills test. A truck simulator is used and the driver is required to perform the driving maneuvers demanded by the CDL test. The section effectively replicates the on-pad and off-pad driving skills required for the CDL exam. After conducting extensive testing on a VCRS prototype, we launched the VCRS validation experiment.

The VCRS validation experiment is a quasi-experimental design (Allen & Tarr, 2003), due to the fact that we do not have a normal control group, but are comparing it to previous cohorts of drivers, considered to be equivalent except for our intervention. Our subject matter experts (SMEs) consisted of the training specialists and third-party examiners from the organizations where the validation experiment took place; therefore, we opted to use them for the data collection process. Because they are knowledgeable about the CDL and CDL examining system, we felt secure in their abilities to evaluate the driver. Furthermore, having the experiment on-site made scheduling of drivers easier and was therefore more convenient for all parties involved. The SMEs were trained in the

operation of the VCRS systems and their skills in driver-assessment proved critical for maintaining a consistent data collection process.

Content Fidelity

The Virtual Check Ride Knowledge Test items consist of the CDL required driver knowledge items. They are said to have content validity after highly qualified subject matter experts reviewed and agreed that each test item is testing some element of knowledge that is necessary for safe operation of a commercial vehicle. These were compared to the existing test items used for the actual CDL test. The content was determined to be valid.

Reliability

Reliability indicates system consistency and dependability. The assessments used in both the VCRS and the road test simulation must be reliable and valid if they are to properly support driver assessment. Likewise, the reliability was acceptable by determining through 500 participant assessments and the comparison of the resultant AAR's.

Simulation Fidelity

Simulation fidelity (Sanders, 1994) is generally defined as the level of realism that the simulator presents to participants. Overall, this includes, physical characteristics, visual display accuracy, spatial algorithmic values, kinesthetic, and event validity (predicted responses). In addition, simulators have many different configurations and manufactures (e.g., from fixed- base with motion to mobile without motion). Scenario development capabilities and limitations vary from simulator to simulator; thus, the simulated driving scenarios built for each simulator must be carefully analyzed and verified prior to development.

Chapter Four: Research Method

Data Collection Methods

Data collection was carried out by appointed staff members of FLETC. All FLETC staff members were trained by RAPTER team members for data collection and the proper procedures to handle data. In addition, the RAPTER team monitored data collection through periodic visits and the use of appropriate questions imbedded into the dependent measure in order to control for integrity.

Dependent Measures

- Experimental Introduction Letter (Appendix A)
- Informed Consent Form (Appendix B)
- Demographic Survey (Appendix C)
- Pre-Simulation Sickness Form (Appendix D)
- Brake Test Form (Appendix E)
- CDL 2-Off-Road Scenario Score sheet (Appendix F)
- CDL 4-City Scenario Score sheet (Appendix G)
- CDL 3-Urban Scenario Score sheet (Appendix H)
- CDL 3B-Freeway Scenario Score sheet (Appendix I)
- CDL 2B-Rural Scenario Score sheet (Appendix J)
- Post-Simulator Questions (Appendix K)
- Post-Sim Sickness Form (Appendix L)
- CDL Survey Form (Appendix M)

Participants

Validation of the Virtual Check Ride System has been an iterative process that has included data collection from many different sponsors within the trucking industry. Over 500 participants have contributed their time to the validation process. The following trucking companies participated:

- Schenck Distributor
- Rinker Concrete
- Roadmaster Truck Diving School
- Frito-Lay
- Schneider International
- American Coach Lines
- Mid-Florida Tech
- Commercial Carrier Corporation

The RAPTER team has begun to work with the trucking industry, specifically within the domain of driver training, implementing the VCRS as a diagnostic and remediation tool to better train drivers for the truck driving profession. This process included best practices outreach for the transportation community, to include papers such as those presented at the North American Driving Simulation Conference, the European Driving Simulation Conference and the Interservice/Industry Education, Training and Simulation Conference. We also coordinate continuously with the Florida Motor Carrier Compliance Office (primary sponsor) personnel as well as special members such as Florida Highway Patrol Enforcement, FTA members, and FDOT Division of Licensing. We did this to ensure both proper understanding of CDL needs and practical issues of administering the Virtual Check Ride System.

One of the major elements of the final report has been consideration of ease of execution and cost-benefit of the VCRS in providing a useful application. The VCRS in the follow-on phase has been expanded into its diagnostic and training role and will be used as a major element of the continual expansion of the larger Center for Advanced Transportation Systems Simulation (CATSS) research agenda, focusing on the utility of simulation and advanced learning technology to enhance performance of all ground transportation personnel, such as transit and bus personnel.

As previously reported, the objective of VCRS was to determine the validity of an alternative to the CDL process. After extensive research, the VCRS now has evolved into a CDL alternative, a comprehensive diagnostic tool, a training addition to standard lecture formats, a tool to remediate in selected modules as needed or required, and into an over-all system. With the approved extension, the development and validation has expanded into other jurisdictions to ensure the generalizability of the VCRS to other geographic, traffic and audience situations. The initial testing was done in cooperation with Frito-Lay, our first validation sponsor, and involved travel to depots in Perry, Georgia and Greenville, South Carolina. After successful testing there we moved much farther north to Green Bay, Wisconsin. We have just finished testing the VCRS with Schneider Trucking Company (based in Green Bay). The testing ran from December of 2006 through February of 2007. Once this test was completed, we began further revisions and modifications, and we plan to do a complete re-validation of the system using Schneider and other local partnership subjects including a minimum of two different regions. We are also converting modules of the English version of the VCRS into Spanish.

Virtual CDL Testing Methods

A virtual CDL test or VCRS was designed to mirror the actual US Federal Department of Transportation CDL test and its three major components. In addition, the VCRS includes a formal AAR and feedback element designed to provide a suitable diagnostic process for evaluating and validating a driver's driving skills and general CDL required knowledge. The VCRS simulation scenarios provide CDL drivers with immersed interactions with

other moving vehicles, extreme weather, traffic conditions, freeway driving, inter-city driving, and rural driving conditions. Instructor controls include changing various variables such as terrain, road surface, weather, traffic conditions, tire blow-outs, and wind direction. The benefit of having an instructor controlling the road and weather conditions is the ability to test the driver in multiple situations during a real time simulation ride.

Chapter Five: Research Outcomes

Introduction to Research Outcomes

The following pages represent the findings from the VCRS validation process. Within each table under the first column labeled significant are particular research topics. The second and third column refers to whether the statistical findings are significant or not significant. This gives the reader a quick understanding of relevancy to a particular research area. Following the tables, at the beginning of each paragraph, is the corresponding research question followed by the statistical findings. Above each table, in italics, is the name of the company from which the participants volunteered and their level of skill (Experienced, Novice Group 1, and Novice Group 2). The experienced group has a mean of 15 years driving experience, Novice Group 1 has two weeks of experience, and Novice Group 2 has one week of experience.

Knowledge Tests

Experienced was Frito-Lay, Novice Group 1 Roadmaster, and Novice Group 2 Schneider

Table 2: Knowledge Tests

Significant	*Yes*	*No*
General Knowledge	X	
Commercial Vehicle	X	
Virtual Pre-Trip	X	

General Knowledge

Is there a relationship between the amount of experience for the general knowledge test as it relates to novice and experienced truck drivers? The mean changes in performance are 83.12 (SD = 9.0), n = 50; 89.91 (SD = 7.22), n = 23; 76.55 (SD = 9.71), n = 47; pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,117) = 17.88$, $p = .01$. The effect size was strong, $N^2 = .23$. Follow-up tests were conducted and the Tukey HSD procedure was used. The results of this analysis indicate that there is a significant difference between all three groups (both of the novice groups as well as the experienced group).

Commercial Vehicle

Is there a relationship between the amount of experience for the Commercial Vehicle Test as it relates to novice and experienced truck drivers? The mean changes in performance are 84.80 (SD = 14.88), n = 50; 85.65 (SD = 14.09), n = 23; 72.00 (SD = 16.53), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 10.18$, $p = .01$. The effect size was moderate, $N^2 = .15$. Follow-up tests were conducted and the Games-Howell procedure

was used. The results of this analysis indicate that there is a significant difference with both novice groups outperforming the experienced group.

Pre-Trip Inspection

The research question for steering technique: Is there a difference in the outcome of the Pre-Trip Inspection between the amount of experience for novice and experienced truck drivers? The mean changes in performance are 85.19 (SD = 8.88), n = 50; 93.07 (SD = 3.45), n = 19; 79.57 (SD = 4.80), n = 47 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,113) = 28.04$, $p = .01$. The effect size was strong, $N^2 = .33$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant difference between all three groups.

Straight Line Backing

Table 3: Straight Line Back

Significant	*Yes*	*No*
Straight Line Backing Maneuver: Smooth		X
Straight Line Backing Maneuver: Idle Back		X
Straight Line Backing Maneuver: Used Mirrors		X
Straight Line Backing Maneuver: Cones Hit	X	

Straight Line Backing Maneuver: Smooth

Is there a relationship between the smooth execution of the straight line backing maneuver for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 50; 1.00 (SD = 0.00), n = 26; 0.98 (SD = 0.15), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,119) = .824$, $p = .441$, therefore no follow-up analysis was necessary.

Straight Line Backing Maneuver: Idle Back

Is there a relationship between backing the truck in the idle position of the straight line backing maneuver for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 50; 0.96 (SD = 0.20), n = 26; 0.98 (SD = 0.15), n = 45 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,118) = .840$, $p = .434$, therefore no follow-up analysis was necessary.

Straight Line Backing Maneuver: Used Mirrors

There are no changes in the means. All groups scored the maximum possible points. There is no significance between means.

Straight Line Backing Maneuver: Cones Hit

Is there a difference in the percentage of cones hit while executing the Straight Line Back Maneuver comparing novice and experienced truck drivers? The mean changes in performance are 0.52 (SD = 0.61), n = 50; 0.19 (SD = 0.40), n = 26; 0.13 (SD = 0.55), n = 47 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,118) = 6.55$, $p = .05$. The effect size was, $N^2 = .1$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant with the experienced group outperforming both novice groups.

Alley Dock

Table 4: Alley Dock

Significant	*Yes*	*No*
Alley Dock Maneuver: Smooth	X	
Alley Dock Maneuver: Idle Back		X
Alley Dock Maneuver: Used Mirror		X
Alley Dock Maneuver: Success	X	
Alley Dock Maneuver: Flush to Dock	X	

Alley Dock Maneuver: Smooth

Is there a relationship between the smooth execution of the alley dock for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 50; 1.00 (SD = 0.00), n = 26; 0.88 (SD = 0.34), n = 32 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,105) = 14.32$, $p = .01$. The effect size was, $N^2 = .09$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in Novice Group 2 as compared to the Experienced and Novice Group 1 participants.

Alley Dock Maneuver: Idle Back

Is there a relationship between the amount of experience and using the proper idling technique during the Alley Dock Maneuver for novice and experienced truck drivers? The mean changes in performance are 0.98 (SD = 0.14), n = 50; 1.00 (SD = 0.00), n = 26; 0.91 (SD = 0.30), n = 32 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,105) = 2.17$, $p = .119$. The analysis was not significant therefore follow-up analysis was not necessary.

Alley Dock Maneuver: Used Mirrors

Is there a relationship between the use of mirrors during the Alley Dock Maneuver for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 50; 1.00 (SD = 0.00), n = 26; 0.91 (SD = 0.30), n = 32 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,105) = 3.82$, $p = .05$. The effect size was, $N^2 = .068$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in Novice Group 2 as compared to both the Experienced and Novice Group 1 pertaining to the use of mirrors.

Alley Dock Maneuver: Success

Is there a relationship between the successful execution of the Alley Dock Maneuver between novice and experienced truck drivers? The mean changes in performance are 0.66 (SD = 0.48), n = 50; 0.20 (SD = 0.40), n = 26; 0.25 (SD = 0.44), n = 32 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,105) = 12.72$, $p = .01$. The effect size was strong, $N^2 = .195$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that the experienced group significantly outperformed both novice groups.

Alley Dock Maneuver: Flush To Dock

Is there a relationship between the amount of experience for the driver correctly positioning the back of the truck flush to the dock for novice and experienced truck drivers? The mean changes in performance are 0.66 (SD = 0.48), n = 50; 0.15 (SD = 0.37, n = 26; 0.20 (SD = 0.40), n = 32 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,105) = 17.23$, $p = .01$. The effect size was strong, $N^2 = .247$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in this performance measure pertaining to the both novice groups as compared the experienced group.

First Street Intersection

Table 5: First Street Intersection

Significant	*Yes*	*No*
First Street Intersection: Traffic Check	X	
First Street Intersection: Used Both Hands	X	
First Street Intersection: Deceleration	X	
First Street Intersection: Initiated Turn Signal	X	
First Street Intersection: Maintain Lane	X	
First Street Intersection: Ran Over Curb	X	
First Street Intersection: Cancel Signal	X	
First Street Intersection: Fully in Lane after Turn	X	

First Street Intersection: Traffic Check

Is there a relationship between the amount of experience and the proper execution of a traffic check at the First Street Intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 24; 0.85 (SD = 0.36), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,111) = 7.59$, $p < .05$. The effect size was, $N^2 = .099$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper execution of a traffic check for novice group 2 as compared to experienced group and novice group 1.

First Street Intersection: Used Both Hands

Is there a relationship between the amount of experience and the use of both hands for novice and experienced truck drivers? The mean changes in performance are 0.71 (SD = 0.46), n = 49; 0.92 (SD = 0.28), n = 24; 1.00 (SD = 0.00), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,111) = 9.01$, $p < .01$. The effect size was, $N^2 = .14$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the use of both hands in the experienced group as compared to both novice groups.

First Street Intersection: Deceleration

Is there a relationship between the amount of experience and the proper deceleration when approaching an intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 24; 0.80 (SD = 0.40), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,111) = 8.62$, $p < .01$. The effect size was, $N^2 = .134$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper use of deceleration in novice group 2 as compared to the experienced as well as the novice group 1.

First Street Intersection: Initiated Turn Signal

Is there a relationship between the amount of experience and proper initiation of the turn signal while approaching the intersection for novice and experienced truck drivers? The mean changes in performance are 0.96 (SD = 0.20), n = 49; 0.88 (SD = 0.34), n = 24; 0.46 (SD = 0.51), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,111) = 22.09$, $p < .01$. The effect size was strong, $N^2 = .28$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the initiation of a turn signal for novice group 2 as compared to the experienced and novice group 1.

First Street Intersection: Maintain Lane

Is there a relationship between the amount of experience and maintaining lane before executing an intersection turn for novice and experienced truck drivers? The mean changes in performance are 0.80 (SD = 0.41), n = 49; 1.00 (SD = 0.00), n = 24; 0.56 (SD = 0.50), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,111) = 9.54$, $p < .01$. The effect size was, $N^2 = .14$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant difference in performance for all three groups. Novice group 1, Experienced, and Novice group 2 performed at 100%, 80%, and 56% respectively.

First Street Intersection: Ran Over Curb

Is there a relationship between the amount of experience and the ability to avoid running over a curb for novice and experienced truck drivers? The mean changes in performance are 0.73 (SD = 0.45), n = 49; 1.00 (SD = 0.80), n = 25; 0.17 (SD = 0.38), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,112) = 26.42$, $p < .01$. The effect size was strong, $N^2 = .32$. Follow-up tests were conducted and the Tukey HSD procedure was used. The results of this analysis indicate that there is a significant drop in running the rear wheels over the curb for novice group 2 as compared to both the experienced group as well as novice group 1.

First Street Intersection: Cancel Signal

Is there a relationship between the amount of experience and the proper cancellation of the turn signal for novice and experienced truck drivers? The mean changes in performance are 0.88 (SD = 0.33), n = 49; 0.88 (SD = 0.33), n = 24; 0.44 (SD = 0.50), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,111) = 15.59$, $p < .01$. The effect size was strong, $N^2 = .22$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper cancellation of the turn signal for novice group 2 as compared to the experienced and novice group 1.

First Street Intersection: Fully In Lane After Turn

Is there a relationship between the amount of experience and proper position of the truck after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.76 (SD = 0.43), n = 49; 1.00 (SD = 0.00), n = 24; 0.83 (SD = 0.38), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. The mean changes in performance can be found in the figure below. An ANOVA was significant, $F(2,111) = 3.61$, $p < .05$. The effect size was, $N^2 = .061$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the in the proper position of the truck after

completion of the turn for both the experienced and novice group 2 as compared to novice group 1.

Tenth Street Intersection

Table 6: Tenth Street Intersection

Significant	*Yes*	*No*
Tenth Street Intersection: Traffic Check	X	
Tenth Street Intersection: Used Both Hands	X	
Tenth Street Intersection: Deceleration		X
Tenth Street Intersection: Initiated Turn Signal		X
Tenth Street Intersection: Maintain Lane	X	
Tenth Street Intersection: Cancel Signal	X	
Tenth Street Intersection: Fully in Lane after Turn		X

Tenth Street Intersection: Traffic Check

Is there a relationship between the amount of experience and the proper execution of a traffic check at the Tenth Street Intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 25; 0.83 (SD = 0.38), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,117) = 7.59$, $p = .01$. The effect size was, $N^2 = .115$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper execution of a traffic check for novice group 2 as compared to experienced group and novice group 1.

Tenth Street Intersection: Used Both Hands

Is there a relationship between the amount of experience and the use of both hands for novice and experienced truck drivers? The mean changes in performance are 0.59 (SD = 0.50), n = 49; 0.92 (SD = 0.28), n = 25; 0.98 (SD = 0.16), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,112) = 14.32$, $p = .01$. The effect size was strong, $N^2 = .20$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the use of both hands in the experienced group as compared to both novice groups.

Tenth Street Intersection: Deceleration

Is there a relationship between the amount of experience and the proper deceleration when approaching an intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 25; 0.93 (SD = 0.26), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2

respectively. An ANOVA was not significant, $F(2,112) = 2.85$, $p = .062$. No further analysis was needed.

Tenth Street Intersection: Initiated Turn Signal

Is there a relationship between the amount of experience and initiating a turn signal for novice and experienced truck drivers? The mean changes in performance are 0.98 (SD = 0.14), n = 49; 0.96 (SD = 0.20), n = 25; 1.00 (SD = 0.00), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,112) = .740$, $p = .479$. Follow-up tests were not necessary.

Tenth Street Intersection: Maintain Lane

Is there a relationship between the amount of experience and the ability to maintain lane upon approach of an intersection for novice and experienced truck drivers? The mean changes in performance are 0.92 (SD = 0.28), n = 49; 1.00 (SD = 0.00), n = 25; 0.76 (SD = 0.44), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,112) = 14.32$, $p < .01$. The effect size was, $N^2 = .086$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop the ability to maintain lane for novice group 2 as compared to the experienced and novice group 1.

Tenth Street Intersection: Cancel Signal

Is there a relationship between the amount of experience and the cancellation of the turn signal after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.82 (SD = 0.39), n = 49; 0.84 (SD = 0.37), n = 25; 0.98 (SD = 0.16), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,112) = 2.94$, $p = .057$. The effect size was, $N^2 = .05$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the cancellation of the turn signal between novice group 2 and the experienced group.

Tenth Street Intersection: Fully In Lane After Turn

Is there a relationship between the amount of experience and proper position of the truck after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.80 (SD = 0.41), n = 49; 0.88 (SD = 0.33), n = 25; 0.95 (SD = 0.22), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,112) = 2.43$, $p = .093$.. Follow-up tests were not necessary.

Seventh Street Intersection

Table 7: Seventh Street Intersection

Significant	*Yes*	*No*
Seventh Street Intersection: Traffic Check	X	
Seventh Street Intersection: Used Both Hands	X	
Seventh Street Intersection: Deceleration		X
Seventh Street Intersection: Initiated Turn Signal		X
Seventh Street Intersection: Maintain Lane	X	
Seventh Street Intersection: Cancel Signal		X
Seventh Street Intersection: Fully in Lane after Turn		X

Seventh Street Intersection: Traffic Check

Is there a relationship between the amount of experience and the proper execution of a traffic check at the First Seventh Street Intersection for novice and experienced truck drivers? The mean changes in performance are 0.98 (SD = 0.14), n = 49; 1.00 (SD = 0.00), n = 25; 0.76 (SD = 0.46), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,112) = 9.23$, $p < .01$. The effect size was, $N^2 = 1.41$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper execution of a traffic check for novice group 2 as compared to experienced group and novice group 1.

Seventh Street Intersection: Used Both Hands

Is there a relationship between the amount of experience and the use of both hands for novice and experienced truck drivers? The mean changes in performance are 0.67 (SD = 0.47), n = 49; 0.80 (SD = 0.41), n = 25; 0.98 (SD = 0.16), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,112) = 7.25$, $p = .01$. The effect size was, $N^2 = .115$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the use of both hands in the experienced group as compared to both novice groups.

Seventh Street Intersection: Deceleration

Is there a relationship between the amount of experience and the proper deceleration when approaching an intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 25; 0.93 (SD = 0.26), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,112) = 2.85$, $p = .062$. Therefore, no follow-up tests were necessary

Seventh Street Intersection: Initiated Turn Signal

Is there a relationship between the amount of experience and proper initiation of the turn signal while approaching the intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 25; 1.0 (SD = 0.00), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. All groups scored 100% and therefore there is no significance or need for analysis

Seventh Street Intersection: Maintain Lane

Is there a relationship between the amount of experience and maintaining lane before executing an intersection turn for novice and experienced truck drivers? The mean changes in performance are 0.94 (SD = 0.24), n = 49; 1.00 (SD = 0.00), n = 25; 0.63 (SD = 0.49), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,112) = 9.54$, $p < .01$. The effect size was, $N^2 = .188$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant increase in performance for the experienced and novice group 1 as compared to novice group 2.

Seventh Street Intersection: Cancel Signal

Is there a relationship between the amount of experience and the proper cancellation of the turn signal for novice and experienced truck drivers? The mean changes in performance are 0.84 (SD = 3.73), n = 49; 0.92 (SD = 0.28), n = 25; 0.95 (SD = 0.22), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,111) = 1.672$, $p = .193$. No follow-up analysis was necessary.

Seventh Street Intersection: Fully In Lane After Turn

Is there a relationship between the amount of experience and proper position of the truck after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.84 (SD = 3.73), n = 49; 0.92 (SD = 0.28), n = 25; 0.90 (SD = 0.30), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. The mean changes in performance can be found in the figure below. An ANOVA was not significant, $F(2,112) = .701$, $p = .498$. Follow-up tests were not necessary.

H Street Intersection

Table 8: H Street Intersection

Significant	*Yes*	*No*
H Street Intersection: Traffic Check		X
H Street Intersection: Used Both Hands	X	
H Street Intersection: Deceleration	X	
H Street Intersection: Initiated Turn Signal	X	
H Street Intersection: Maintain Lane	X	
H Street Intersection: Ran Over Curb	X	
H Street Intersection: Cancel Signal	X	
H Street Intersection: Fully in Lane after Turn		X

H Street Intersection: Traffic Check

Is there a relationship between the amount of experience and the proper execution of a traffic check at the H Street Intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 25; 0.93 (SD = 0.26), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,112) = 2.845$, $p = .062$. Follow-up tests were not necessary.

H Street Intersection: Used Both Hands

Is there a relationship between the amount of experience and the use of both hands for novice and experienced truck drivers? The mean changes in performance are 0.59 (SD = 0.50), n = 49; 0.84 (SD = 0.37), n = 25; 0.98 (SD = 0.15), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,117) = 13.08$, $p < .01$. The effect size was strong, $N^2 = .18$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the use of both hands in the experienced group as compared to both novice groups.

H Street Intersection: Deceleration

Is there a relationship between the amount of experience and the proper deceleration when approaching an intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 25; 0.83 (SD = 0.38), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,117) = 7.96$, $p < .01$. The effect size was, $N^2 = .115$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper use of deceleration in novice group 2 as compared to the experienced as well as the novice group 1.

H Street Intersection: Initiated Turn Signal

Is there a relationship between the amount of experience and proper initiation of the turn signal while approaching the intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 25; 0.78 (SD = 0.42), n = 41 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,11) = 20.16$, $p < .01$. The effect size was, $N^2 = .153$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the of a turn signal for novice group 2 as compared to the experienced and novice group 1.

H Street Intersection: Maintain Lane

Is there a relationship between the amount of experience and maintaining lane before entering an intersection for novice and experienced truck drivers? The mean changes in performance are 0.80 (SD = 0.41), n = 49; 0.96 (SD = 0.20), n = 25; 0.61 (SD = 0.49), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,117) = 6.28$, $p < .01$. The effect size was, $N^2 = 096$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant difference in performance for novice group 1 and novice group 2.

H Street Intersection: Ran Over Curb

Is there a relationship between the amount of experience and the ability to avoid running over a curb for novice and experienced truck drivers? The mean changes in performance are 0.71 (SD = 0.46), n = 49; 0.64 (SD = 0.49), n = 25; 0.09 (SD = 0.29), n = 45 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 30.14$, $p < .01$. The effect size was strong, $N^2 = .34$. Follow-up tests were conducted and the Tukey HSD procedure was used. The results of this analysis indicate that there is a significant drop in running the rear wheels over the curb for novice group 2 as compared to both the experienced group as well as novice group 1.

H Street Intersection: Cancel Signal

Is there a relationship between the amount of experience and the proper cancellation of the turn signal for novice and experienced truck drivers? The mean changes in performance are 0.86 (SD = 3.54), n = 49; 0.96 (SD = 0.20), n = 25; 0.74 (SD = 0.44), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,117) = 3.09$, $p < .05$. The effect size was strong, $N^2 = .05$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper cancellation of the turn signal for novice group 2 as compared to novice group 1.

H Street Intersection: Fully In Lane after Turn

Is there a relationship between the amount of experience and proper position of the truck after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.67 (SD = 0.47), n = 49; 1.00 (SD = 0.00), n = 25; 0.96 (SD = 1.43), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,111) = 3.61$, $p < .05$. The effect size was, $N^2 = .061$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is not a significant difference between groups.

Fifth Street Intersection

Table 9: Fifth Street Intersection

Significant	*Yes*	*No*
Fifth Street Intersection: Traffic Check		X
Fifth Street Intersection: Used Both Hands	X	
Fifth Street Intersection: Deceleration		X
Fifth Street Intersection: Initiated Turn Signal		X
Fifth Street Intersection: Maintain Lane	X	
Fifth Street Intersection: Cancel Signal	X	
Fifth Street Intersection: Fully in Lane after Turn	X	

Fifth Street Intersection: Traffic Check

Is there a relationship between the amount of experience and the proper execution of a traffic check at the First Street Intersection for novice and experienced truck drivers? The mean changes in performance are 0.98 (SD = 0.14), n = 49; 1.00 (SD = 0.00), n = 24; 0.93 (SD = 0.25), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,116) = 1.25$, $p = .290$. Follow-up tests were conducted and showed no difference between groups.

Fifth Street Intersection: Used Both Hands

Is there a relationship between the amount of experience and the use of both hands for novice and experienced truck drivers The mean changes in performance are 0.61 (SD = 0.49), n = 49; 0.92 (SD = 0.28), n = 24; 1.00 (SD = 0.00), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 16.48$, $p < .01$. The effect size was strong, $N^2 = .221$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the use of both hands in the experienced group as compared to both novice groups.

Fifth Street Intersection: Deceleration

Is there a relationship between the amount of experience and the proper deceleration when approaching an intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 24; 0.91 (SD = 0.29), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 3.39$, $p < .05$. The effect size was, $N^2 = .055$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis confirm that there, in fact, is no significant difference between groups.

Fifth Street Intersection: Initiated Turn Signal

Is there a relationship between the amount of experience and proper initiation of the turn signal while approaching the intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 0.88 (SD = 0.34), n = 24; 1.00 (SD = 0.00), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 6.615$, $p < .01$. The effect size was strong, $N^2 = .10$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate there is no significant difference between groups.

Fifth Street Intersection: Maintain Lane

Is there a relationship between the amount of experience and maintaining lane before entering before executing an intersection turn for novice and experienced truck drivers? The mean changes in performance are 0.92 (SD = 0.28), n = 49; 1.00 (SD = 0.00), n = 24; 0.65 (SD = 0.48), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 10.40$, $p < .01$. The effect size was, $N^2 = .152$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant increase in performance novice group 1 and the experienced group as compared to novice group 2.

Fifth Street Intersection: Cancel Signal

Is there a relationship between the amount of experience and the proper cancellation of the turn signal for novice and experienced truck drivers? The mean changes in performance are 0.96 (SD = 0.20), n = 49; 0.88 (SD = 0.34), n = 24; 0.96 (SD = 0.21), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,116) = 1.18$, $p = .31$. Follow-up tests were not necessary.

Fifth Street Intersection: Fully In Lane After Turn

Is there a relationship between the amount of experience and proper position of the truck after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.59 (SD = 0.50), n = 49; 1.00 (SD = 0.00), n = 24; 0.87 (SD = 0.34), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 11.11$, $p < .01$. The effect size was, $N^2 = .161$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant difference in performance for the proper position of the truck after completion of the turn for all groups.

F & Fifth Street Intersection

Table 10: F & Fifth Street Intersection

Significant	*Yes*	*No*
F Fifth: Used Both Hands		X
F Fifth: Deceleration	X	
F Fifth: Initiated Turn Signal		X
F Fifth: Maintain Lane	X	
F Fifth: Ran over Curb	X	
F Fifth: Cancel Signal		X
F Fifth: Fully in Lane after Turn	X	

F & Fifth Street Intersection: Used Both Hands

Is there a relationship between the amount of experience and the use of both hands for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 24; 0.93 (SD = 0.25), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,116) = 2.48$, $p = .088$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis confirm that there is no significant difference in performance between groups.

F & Fifth Street Intersection: Deceleration

Is there a relationship between the amount of experience and the proper deceleration when approaching an intersection for novice and experienced truck drivers? The mean changes in performance are 0.96 (SD = 0.20), n = 49; 1.00 (SD = 0.00), n = 24; 0.85 (SD = 0.36), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 3.43$, $p < .05$. The effect size was, $N^2 = .056$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the proper use of deceleration in novice group 2 as compared to novice group 1.

F & Fifth Street Intersection: Initiated Turn Signal

Is there a relationship between the amount of experience and proper initiation of the turn signal while approaching the intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 24; 1.00 (SD = 0.00), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. There is no difference in means; therefore, follow up tests were not required.

F & Fifth Street Intersection: Maintain Lane

Is there a relationship between the amount of experience and maintaining lane before entering an intersection to execute a turn for novice and experienced truck drivers? The mean changes in performance are 0.94 (SD = 0.24), n = 49; 1.00 (SD = 0.00), n = 24; 0.50 (SD = 0.51), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 24.32$, $p < .01$. The effect size was, $N^2 = .29$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant increase in performance for novice group 1 and the experienced group as compared to novice group 2.

F & Fifth Street Intersection: Ran Over Curb

Is there a relationship between the amount of experience and the ability to avoid running over a curb for novice and experienced truck drivers? The mean changes in performance are 0.37 (SD = 0.49), n = 49; 0.75 (SD = 0.44), n = 24; 0.48 (SD = 0.51), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 5.03$, $p < .01$. The effect size was, $N^2 = .08$. Follow-up tests were conducted and the Tukey HSD procedure was used. The results of this analysis indicate that there is an increase in performance for novice group 1 as compared to the experienced group.

F & Fifth Street Intersection: Cancel Signal

Is there a relationship between the amount of experience and the proper cancellation of the turn signal for novice and experienced truck drivers? The mean changes in performance are 0.86 (SD = 0.35), n = 49; 0.96 (SD = 0.20), n = 24; 0.91 (SD = 0.29), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,116) = .981$, $p = .378$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this confirm that there are no significant differences in performance in all groups.

F & Fifth Street Intersection: Fully In Lane After Turn

Is there a relationship between the amount of experience and proper position of the truck after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.80 (SD = 0.41), n = 49; 1.00 (SD = 0.00), n = 24; 0.48 (SD = 0.51),

n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 14.67$, $p < .01$. The effect size was, $N^2 = .20$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant difference between all three groups. Novice group 1 out performed the experienced group and the experienced group out performed novice group.

First & F Street Intersection

Table 11: First & F Street Intersection

Significant	Yes	No
First F: Traffic Check	X	
First F: Used Both Hands	X	
First F: Deceleration	X	
First F: Initiated Turn Signal		X
First F: Maintain Lane	X	
First F: Ran Over Curb	X	
First F: Cancel Signal		X
First F: Fully in Lane after Turn	X	

First F: Traffic Check

Is there a relationship between the amount of experience and the proper execution of a traffic check at the First Street Intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 24; 0.87 (SD = 0.34), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 5.37$, $p < .05$. The effect size was, $N^2 = .084$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in performance for novice group 2 in the proper execution of a traffic check as compared to the experienced group and novice group 1.

First F: Used Both Hands

Is there a relationship between the amount of experience and the use of both hands for novice and experienced truck drivers? The mean changes in performance are 0.63 (SD = 0.49), n = 49; 0.71 (SD = 0.46), n = 24; 0.98 (SD = 0.15), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 10.02$, $p < .01$. The effect size was, $N^2 = .14$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant increase in performance for novice group 2 pertaining to the use of both hands as compared novice group 1 and the experienced group.

First F: Deceleration

Is there a relationship between the amount of experience and the proper deceleration when approaching an intersection for novice and experienced truck drivers? The mean changes in performance are 1.00 (SD = 0.00), n = 49; 1.00 (SD = 0.00), n = 24; 0.87 (SD = 0.34), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 5.33$, $p < .01$. The effect size was, $N^2 = .084$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in performance for the proper use of deceleration in novice group 2 as compared to the experienced as well as novice group 1.

First F: Initiated Turn Signal

Is there a relationship between the amount of experience and proper initiation of the turn signal while approaching the intersection for novice and experienced truck drivers? The mean changes in performance are 0.96 (SD = 0.20), n = 49; 0.96 (SD = 0.20), n = 25; 0.98 (SD = 0.15), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was not significant, $F(2,116) = .159$, $p = .853$. Follow-up tests were not necessary.

First F: Maintain Lane

Is there a relationship between the amount of experience and maintaining the lane before executing an intersection turn for novice and experienced truck drivers? The mean changes in performance are 0.90 (SD = 0.31), n = 49; 1.00 (SD = 0.00), n = 24; 0.54 (SD = 0.50), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 16.08$, $p < .01$. The effect size was, $N^2 = .21$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in performance for novice group 2 as compared to both the experienced and novice group 1.

First F: Ran Over Curb

Is there a relationship between the amount of experience and the ability to avoid running over a curb for novice and experienced truck drivers? The mean changes in performance are 0.86 (SD = 0.35), n = 49; 0.83 (SD = 0.38), n = 24; 0.15 (SD = 0.36), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 52.13$, $p < .01$. The effect size was strong, $N^2 = .47$. Follow-up tests were conducted and the Tukey HSD procedure was used. The results of this analysis indicate that there is a significant drop in performance for running the rear wheels over the curb for novice group 2 as compared to both the experienced group as well as novice group 1.

First F: Cancel Signal

Is there a relationship between the amount of experience and the proper cancellation of the turn signal for novice and experienced truck drivers? The mean changes in performance are 0.88 (SD = 0.33), n = 49; 0.88 (SD = 0.34), n = 24; 0.93 (SD = 0.25), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = .517$, $p < .01$. Follow-up tests were not necessary.

First F: Fully In Lane After Turn

Is there a relationship between the amount of experience and proper position of the truck after completion of the turn for novice and experienced truck drivers? The mean changes in performance are 0.61 (SD = 0.49), n = 49; 1.00 (SD = 0.00), n = 24; 0.70 (SD = 0.47), n = 46 pertaining to Experienced, Novice Group 1, and Novice Group 2 respectively. An ANOVA was significant, $F(2,116) = 6.72$, $p < .01$. The effect size was, $N^2 = .061$. Follow-up tests were conducted and the Games-Howell procedure was used. The results of this analysis indicate that there is a significant drop in the in the proper position of the truck after completion of the turn for both the experienced and novice group 2 as compared to novice group 1.

Chapter Six: Findings and Conclusions

The overall goal of our research was to explore and validate the application of computer-based and simulation-based technology for the commercial driving community that provides a valid, low cost process of determining drivers' skills and commercial vehicle knowledge. Research and development processes included various simulators and learning technologies to improve driver/operator safety and performance in the trucking and transportation communities. With the completion of this research, the VCRS is now being considered by several training and education activities for incorporation into their programs as well as by the Federal Motor Carrier Safety Administration and Florida DMV for use as a tool to assist in certification of 3rd party CDL examiners and as a tool for CDL remediation and renewal.

The primary benefit of this research was to formally demonstrate and document the potential utility of computer-based simulation for cost-effective CDL re-certification. Throughout the VCRS development process, we conducted on-site validations at Roadmaster, Frito-Lay, Schenck Distributors Incorporation, Commercial Carrier Corporation, Watkins Motor Lines Incorporation and Schneider International. All data collection was carried out by instructors from various companies. The data collection process included extensive communications and logistical strategies along with a personalized management plan and support for each partnership. Observations conducted while various groups of subjects completed the simulated driving test of the VCRS supports that using simulation can add value for those drivers who are preparing for their CDL re-certification; both novice and experienced drivers. The validation process has involved establishing partnerships with several agencies and creating management plans for onsite data collection. Establishing and maintaining a positive relationship with the truck driving industry has taken a great deal of effort considering the challenges of weather, time and delivery driver schedule handicaps. However, with presentations, briefings, site visits, personal personnel support and procedural observations, we successfully brought several organizations on board for the validation study and a collective partnership for the overall VCRS research.

The conclusions from our research indicate that the VCRS is a valid diagnostic, remediation, and training system application that efficiently tests the knowledge and skills required to pass the current CDL test. There were two main areas of testing that were measured: Simulation and CBT. The Simulation portion of the exam follows the CDL computer-based test by utilizing different truck driving simulators to replicate the actual CDL process. The ultimate goal of this is to validate the truck driving CDL simulator in comparison to that of the actual real-world truck driving CDL process. The CBT portion of the experiment measures the knowledge base of the drivers, in particular: general knowledge, combination vehicles, hazardous materials, and air-breaks, and a walk-around inspection. These are the key testing areas of the actual CDL test but in a computer-based, randomly generated format. The goal of having the CDL test in computer-based format is to establish a cost-effective way for the re-certification process.

Frito-Lay

There was an unexpected finding that centered on braking techniques, as a result of using the VCRS at Frito-Lay. Upon investigation with Frito-Lay, we found that there was a braking deficiency with their drivers which correlated with what our test found. Apparently, they had a high number of minor incidents due to improper braking, and upon the completion of our study, they implemented a four-hour refresher course on air brakes and have decreased their accident rate significantly. Overall, the novice drivers tended to do better than the expert drivers on the general knowledge section, but this was due to the fact that the novice drivers had just completed their CDL a week before and the material was fresh in their minds.

Expanded Project Goals and Objectives

With the latest iteration of the VCRS, we will continue testing using several different classes of CDL users, to include transit and motor coach personnel. In addition, our motor coach and bus programs are expanding with our safety inspector project that is looking at the enforcement side of the equation.

Figure 7: Motor Coach

England Briefing and Demonstration

The UK has undergone several changes in transportation research since 1996. The Transportation Research Laboratory (TRL) used to be the primary agency involved in simulation research. However, due to changes, they are now owned by the Transportation Research Foundation (TRF). This foundation runs more like a university in that it has four main directors, a chief research scientist, and over 500 employees. Dr. Parkes is one of the chief research scientists. He has a background in Psychology and is currently in charge of a large-scale investigative focused on truck driving skills. He and his team have

recently completed a large-scale study consisting of 600 participants. TRF developed a study that focuses on the skills associated with obtaining a commercial truck drivers license in the UK. They utilized a blended learning approach in their study that consisted of a CBT portion and a full motion simulator. The CBT section randomly chooses 35 questions that test a driver on general knowledge and other skills. They then move the participants from the CBT section to the full-motion simulator that tests the driver's skills. The participants are tested on basic driving skills as well as braking, accident prevention, situational awareness, loading (hazardous materials), basic road traffic regulations, ergonomic principles, and what to do in emergency situations. Dr. Parkes is looking for collaboration between universities to assist them in their validation effort. The UK is facing many of the same problems that the US is facing when dealing with commercial truck drivers.

Large Truck Study: Advanced Scenarios

The following figures are images from ten advanced training modules that will be incorporated into the remediation segment of the VCRS. This is an on-going endeavor and as we test the validity of each scenario through subject matter experts as well as experienced truck drivers, we will expand our remediation base. As the reader can notice from the figures below, all of our scenarios are story-boarded after front-end analysis is finished. Front-end analysis for this set of scenarios is based on the materials found in the chapter on transportation trends within this report.

Sky view of suburban scenario area.

City setting scenario with the driver starting at 1st ave. heading towards Greggs Sporting Goods in the Mall plaza off 3rd avenue.

Approx dist. 4 miles

Drive Time: 15 min

Figure 8: Advanced Scenario

Outline to scenario:

Scenario name: IST_truck
Database: Suburban
Advanced scenario

Instructor notes:

1. Explain to student the environment in which they will be driving:

   This is an advanced suburban scenario. Driver you have a 50ft cab with a heavy load You are driving approx. .4 miles to the mall area.

2. Explain to the student what you are looking for in their drive.

CONTROL OF SPEED AND DIRECTION BY KNOWING:

total weight of vehicle
length of grade
steepness of grade
road conditions/weather

****Hazards turn into emergencies****

You will be graded on safely completing the scenario and avoiding committing the top violations that have been shown to most often result in accidents.

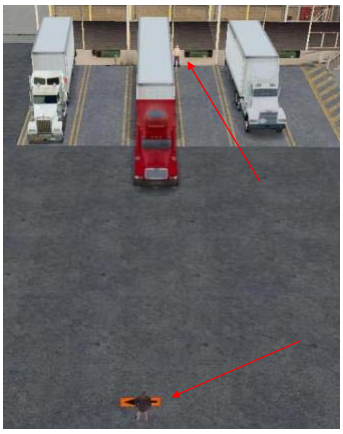
- Improper turning
- Improper or erratic lane changes
- Failure to yield right of way
- Failure to keep in proper lane
- Failure to obey warning lights
- Following too closely
- Excessive Speed

Figure 9: Scenario Outline

Before the driver leaves for a trip. All proper areas should be inspected.

•Tires, wheels and rims
•Brakes
•Lights and reflectors
•Electrical connections to trailer
•Trailer coupling devices
•Cargo securement devices
•Clearance of trailer (viewed from the driver rear mirror)

Figure 10: Pre-trip Outline



Warehouse employee located behind the truck directing the driver. Driver needs to adjust mirrors while checking clearance. All around the vehicle needs to be checked and adjustments made before the driver leaves the warehouse .

- Execution of turn:
  Improper turn violation ☐
- Speed management:
  Improper speed violation ☐
- Failure to keep a safe distance:
  Following too closely violation ☐
- Obey traffic control devices:
  Failure to obey traffic sign violation ☐

Figure 11: Exit Procedures

As the driver clears the entrance to the parking area, the driver will see the Gregg Sports store and will parallel park in front of the store directed by the arrows. When parking the driver needs to avoid having to back out of a situation. Try to park so driver can pull forward to get out. Employees of Gregg sports are waiting outside for your arrival.

Potential Hazards:

•Parked vehicles
•Pedestrians
•Children
•Distracted pedestrians (cell phone users, parents with small children, etc.)
•Other delivery trucks
•Drivers in a hurry

Figure 12: Potential Hazards

Future Direction: Mid-Florida Tech

With our completion of this phase of research, the VCRS is now being considered by several training and education activities for incorporation into their programs. One such activity for the Virtual Check Ride includes the RAPTER research team's recent preliminary talks with Mid-Florida Tech, an Orange County Schools organization that is chartered to conduct semester-long courses on commercial truck driving and to establish a long term working relationship in terms of research and implementation of advanced technologies such as the VCRS. The initial goals set forth by this collaboration consist of implementation of the VCRS into the curriculum employed for the CDL licensure program now taught at Mid-Florida Tech. Mid-Florida Tech is one of the most technically advanced training centers in the State of Florida and is accredited by the Commission of the Council on Occupational Education (COE),the Southern Association of Colleges and Schools Commission on Middle and Post Secondary Schools (SACS) and the Commission on International and Trans-Regional Accreditation (CITA). Our long term goal is to create a research arm at this technology school for transfer of training studies. The picture below represents the initial effort by the RAPTER research team to implement the Virtual Check Ride System. Mid-Florida Tech provided five computers and classroom space and we have started collecting preliminary data.

Figure 13: VCRS Test Site at Mid-Florida Tech

Another potential follow-on application will be with the Florida DMV as well as the Federal Motor Carrier Safety Administration, who are looking at the VCRS for use as a

tool to assist in certification of third- party CDL examiners and as a tool for CDL remediation and renewal. Overall, the research and development conducted within this program has met the intended objectives of the project. In addition, it has met as the goals of the FDOT Research Center in terms of its resulting in techniques and applications that will not only be useful to the community but will be sustained by other agencies and continue providing improvements to the safety of the driving community.

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Appendix A: Participant Instructions

Dear Participant:

The University of Central Florida, Center for Advanced Transportation Systems Simulation (CATSS) and the Institute for Simulation and Training (IST) are conducting research and development using simulators and computer-based technologies for diagnostic, testing, and training in response to the need to improve safety and performance in the trucking and transportation systems communities.

The Virtual Check Ride (VCRS), was developed in response to the need to develop a cost effective diagnostic and commercial drivers license (CDL) validation system. The VCRS addresses transportation safety and security by focusing on the enhancement of operator's skills through the deployment of driver training simulation and advanced learning technology interventions. This is accomplished by using computer-based CDL general knowledge evaluations and computer-based table-top simulators, full motion simulators and non-motion simulators.

The objective of this validation is to validate a diagnostic and/or retest Virtual Check Ride (VCRS) system that provides a valid, low cost process of determining drivers' skills and commercial vehicle knowledge. We are evaluating and validating the VCRS system not your overall performance. You will participate in the evaluation and validation of the system by completing surveys before and after completion of your participation, completing computer bases (CBT) general knowledge questions and Pre-Trip general knowledge questions. You will then help evaluate and validate the use of driving simulators and driving scenarios in the CDL process. No personal data will be collected. The result of this study will be published by several professional organizations.

Appendix B: Informed Consent

General. Please read this consent document carefully before you decide to participate in this study. Upon completion of your reading it, please sign if you agree to participate.

Project title: Analysis and Verification of a Virtual Check Ride

Privacy Protection: University of Central Florida's Institute for Simulation and Training (IST), a partner with CATSS, maintains a secure records holding area that only those who need to know can access.

Purpose of the research study: To determine if the VCRS is a reliable, valid and cost-effective system that could be used for diagnosing commercial vehicle driving knowledge and skills readiness prior to taking commercial drivers license (CDL) knowledge and driving exams. During this research study, we will also examine the difference between novice and experienced drivers pertaining to Virtual Check Ride Computer Based Training (CBT), the Check Ride on Simulator(s) either a mobile non-motion simulator and/or a stationary full-motion "Road Skills" simulator, against the traditional Commercial Drivers License (CDL) exam standards and requirements.

What you will be asked to do in the study: Fill out a demographic and informative survey and post simulator survey, participate in the Computer Based Training and operate the non-motion simulator and/or the motion simulator. You may also be asked to drive the table-top simulator during this study. You may be asked to video tape your simulator driving participation.

Time required: Up to three hours.

Risks: Possible Simulator sickness (sickness due to the visual effects of the simulator).

Benefits / Compensation: Potential benefits are: Increase your skills and knowledge of CDL rules and driving skills. The impact of reducing accidents and saving lives through the cost effective use of simulation, and an increased understanding of driver performance issues as well as increased employee awareness. There is no monetary compensation.

Confidentiality: Your identity will be kept confidential to the extent provided by law. Your name will not be used in any report nor will you be assigned a numerical identifier. Any data collected will not be used against you or your rights to obtain your commercial vehicle driving license.

Voluntary participation: Your participation in this study is voluntary. There is no penalty for not participating. There is no penalty for declining video taping should you be asked to tape your check ride.

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: Ron Tarr or Talleah Allen at the Institute for Simulation and Training. 3280 Progress Dr., Orlando, FL 32826. The phone number is (407) 882-1300

_____I have read the procedure described above.
_____ I voluntarily agree to participate in the procedure.
_____ I have received a copy of this description.

_____/_____
Participant Date

Appendix C: Demographic Survey

1) Male____ Female____

2) Age ____

3) Have you operated a driving simulator or any other type of simulator before?

   Yes____ No____ If yes, please describe_____

4) Have you ever used a Desktop driving simulator? Yes____ No_____

5) Do you play video games? Yes____ No_____

6) At what age did you start playing video games? _____

7) If you use a computer, how many hours per week? _____

8) If Yes, how often? For example, one hour a month or a week? _____

9) Do you have your CDL? Yes____ No _____ If yes, how long have you had your

   CDL? _____

10) Have you had any major accidents? Yes____ No____ If yes, please

    describe_____

11) Have you had any minor accidents? Yes____ No____ If yes, please

    describe_____

12) How long have you been driving a tractor trailer (total)? _____

13) Do you have 20/20 eyesight? Yes____ No_____

14) If not, is it correctable to 20\20? _____

Appendix D: Pre-Simulation Sickness

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.

- Do you or have you had a history of migraine headaches? ☐ yes ☐ no
  If yes, please describe: _____
- Do you or have you had a history of claustrophobia? ☐ yes ☐ no
  If yes, please describe: _____
- Do you or have you had a history of motion sickness? ☐ yes ☐ no
  If yes, please describe: _____
- If you are a female, are you or is there a possibility that you might be pregnant? ☐ yes ☐ no

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Appendix E: Brake Test

Low Pressure Warning Signal

Build Pressure and then Shut Engine Off___ Turn Electric Power On____ Fan Brake Pedal____ Air Pressure Signal comes on when Pressure reaches 60 PSI_____	Score: _____

Pop Valves

Release parking brakes___ Fan Brake Pedal____ Air Pressure Valves Pop Out when Pressure reaches 20-40 PSI_____	Score: _____

Rate of Air Pressure Build Up

Engine idling___ Air Pressure builds from 85 – 100 PSI in 45 seconds_____

Test Air Leakage

Fully Charged System___ Turn Off Engine_____ Release the service brake____ Time Air Pressure Drop____ Apply 90 PSI to brake pedal____ After Initial Drop air pressure should not drop more than 3-4 PSI in one minute____	Score: _____

Appendix F: Off-Road Score Sheet

Stop Line (Bumper)

Smooth___ Full Stop_____ Attempts 1 2 3

Score: _____

Straight Line Back

Attempt 1:

Smooth___ Used Mirrors____ Idled Back_____ Number of Cones Hit: 1 2 3 or_____

Attempt 2: (Pull Up)

Smooth___ Used Mirrors____ Idled Back_____ Number of Cones Hit: 1 2 3 or_____

Attempt 3: (Pull Up)

Smooth___ Used Mirrors____ Idled Back_____ Number of Cones Hit: 1 2 3 or_____

Score: _____

Right Turn

Smooth___ Attempts 1 2 3

Score: _____

Alley Dock

Attempt 1:

Smooth___ Used Mirrors____ Idled Back_____ Successful_____ Flush to Dock_____

Attempt 2: (Pull Up)

Smooth___ Used Mirrors____ Idled Back_____ Successful_____ Flush to Dock_____

Attempt 3: (Pull Up)

Smooth___ Used Mirrors____ Idled Back_____ Successful_____ Flush to Dock_____

Score: _____

Parallel Park

Attempt 1:

Smooth___ Used Mirrors____ Idled Back_____ Successful_____
Number of Attempts____

Score: _____

Appendix G: City Score Sheet

Right on F Street

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Left on E Street

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Right on 9th Ave.

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Left on D Street

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Right on 8th Ave.

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Left on C Street

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Left on 7th Ave.

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Left on F Street

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Right into Pad

Traffic Check___ Used Signal____ Remain in Lane____ Used both hands_____

Deceleration_____Used Brakes during Turn____ Cancel Signal_____

Fully in Lane after Turn_____ Ran Over Curb_____

Score: _____

Appendix H: Urban Score Sheet

Bridge Clearance on Overpass

Driver remembered Clearance_____	Score: _____

Urban Driving

Traffic Checks___ Spacing____ Maintains Lane_____ Speed____	Score: _____

Curve Left

Traffic Checks___ Speed Entering____ Speed During Curve ____ Maintains Lane _____	Score: _____

Curve Right

Traffic Checks___ Speed Entering____ Speed During Curve ____ Maintains Lane _____	Score: _____

Appendix I: Freeway Score Sheet

Freeway Onramp

Traffic Checks ___ Initiate Signal ____ Cancel Signal _____ Speed Entering____ Maintains Lane _____ Use of Mirrors _____	Score: _____

Lane Changing to Left

Traffic Checks ___ Initiate Signal ____ Cancel Signal _____ Maintains Lane _____ Use of Mirrors _____	Score: _____

Lane Changing to Right

Traffic Checks ___ Initiate Signal ____ Cancel Signal _____ Maintains Lane _____ Use of Mirrors _____	Score: _____

Freeway Off Ramp (exit)

Traffic Checks ___ Initiate Signal____ Cancel Signal _____ Speed Entering____ Use of Mirrors _____	Score: _____

Appendix J: Rural Score Sheet

Railroad Crossing with HWL

Law___ Stops____ Traffic Check____

Score: _____

Drive Upgrade

Keep Right___ Safe Speed____Traffic Check____

Score: _____

Stop/Start on Upgrade

Smooth___ Space Management____ Stop Line____ Full Stop_____ Traffic Check____

Deceleration_____

Score: _____

Drive Down Grade

Right Lane___ Brake Check____ Safe Speed____ Braking_____ Traffic Check____

Score: _____

Stop/Start on Downgrade

Smooth___ Space Management____ Stop Line____ Full Stop_____ Traffic Check____

Deceleration_____

Score: _____

Railroad Crossing without HWL

Law___ Stops____ Traffic Check____

Score: _____

Rural Driving

Traffic Checks___ Spacing____ Maintains Lane_____ Speed____

Score: _____

Appendix K: Post-Experimental Questionnaire

The gauges seemed realistic?					
The simulator, “Virtual Check Ride” could prepare drivers for the CDL exam.					
After completing the simulated driving portion of this assessment, I feel CDL testing using simulators are a realistic alternative to the conventional approach?					
After completing the simulator “Virtual Check Ride”, I feel truck simulators are an efficient training tool?					
The computer-based portion of the assessment was realistic?					
The pre-trip examination was realistic and tested pre-trip items?					
The simulated driving section of this assessment was too long?					
I would recommend “Virtual Check Ride” for those interested in preparing for their CDL or CLD re-certifications.					
The simulated driving section of this assessment was too short?					
The side view mirrors need adjustment?					
The brakes stopped in the right amount of distance?					
Knowledge test questions accurately tested what I need to know to pass my CDL tests.					

NOTE: 5 POINT LIKERT SCALE

Appendix L: Post-Simulation Sickness

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?
- ❑ no
- ❑ glasses
- ❑ contact lenses

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? Please rate your feelings on a five-point scale.

My overall eye strain was:
1----------2----------3----------4----------5
None Low Moderate High Severe

My overall temperature increase was:
1----------2----------3----------4----------5
None Low Moderate High Severe

I experienced dizziness:
1----------2----------3----------4----------5
None Low Moderate High Severe

I developed a headache:
1----------2----------3----------4----------5
None Low Moderate High Severe

I felt nauseous:
1----------2----------3----------4----------5
None Low Moderate High Severe

Appendix M: Student Survey

1. This course helped me learn where systems are located on the vehicle.					
2. The classroom materials prepared me for my commercial truck drivers license (CDL).					
3. After completing the driving portion of this course, I feel I am a safer operator of commercial vehicles					
4. After completing the simulator "Virtual Check Ride", I feel I am ready to complete the on-road driving skills test.					
5. Tables, figures, and enclosures provided sufficient support in preparing me for my CDL or CDL re-certification tests.					
6. Knowledge test questions accurately tested what I need to know to pass my CDL tests.					
7. The course should have more interactivity and simulator time so I can practice applications of theories and driving skills.					
8. I think the simulator ride taught me how to react to safety issues.					
9. I would recommend this course for those interested in preparing for their CDL or CLD re-certifications.					
10. My learning style is "I must do it to fully understand and remember."					

NOTE: 5 POINT LIKERT SCALE