Simulation as a Tool for Enhancing Commercial Driver Skills: A Systematic Approach to Tailored Training

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Abstract

To report on the establishment of a Research and Development program for Performance Enhancement using valid applications of High Quality Simulation and Advanced Learning Technologies for the Commercial Driving community. This project is one element of a larger research and education initiative sponsored by both the US Federal and State Departments of Transportation. It is focused on enhancing the performance of transportation operators and other personnel by diagnosis of performance deficiencies and the tailored training and remediation by advanced simulation and learning technology applications.

This expanded performance system included a revised version of the ***VCR*** into a diagnostic tool that assesses and prescribes tailored approaches to remediation, Continuing Education and additional Specialized Skills training for such topics as safety, dangerous situations, security awareness, hazardous materials, etc. It also expands the target audience, to include small commercial vehicles and emergency vehicles, such as ambulance and police drivers, transit operators, such as city and school bus personnel. This multi-modal approach has the potential to be a significant boost to the cost effective and strengthening of the CDL program by adding a consistency and enhanced stability across the entire commercial driving community. It is a follow on to the successful validation of the ***Virtual Check Ride*** research previously reported at DSC EU 2004.

INTRODUCTION

This paper reports the findings of a research program and several studies within that program that focus on human performance outcomes based on interventions by various driving simulators and applications of advanced learning technology. The program overall is entitled the Virtual Check Ride System (VCRS). The purpose of the VCRS is enhancing the performance of transportation operators and other personnel by diagnosis of performance deficiencies and the tailored training and remediation by advanced simulation and learning technology applications. This performance enhancement is measured by comparison of scores resulting from completion of the Virtual Check Ride (VCR), a simulator-based, virtual equivlent of the Commercial Drivers License (CDL) test, previously validated and report at the DSC 2004 (Europe) conference.

The expanded performance system or VCRS includes a revised/updated version of the ***VCR***, an enhanced diagnostic tool that assesses skills and knowledge in more detail and a matrix that prescribes tailored approaches for remediation of identified deficit skills. It is designed in a modular format so that Continuing Education and additional Specialized Skills training for such topics as safety, dangerous situations, security awareness, hazardous materials, or company unique needs, can be added to better meet the needs of the commercial community. The research also expands the target audience, to include small commercial vehicles and emergency vehicles, such as ambulance and police drivers, transit operators, such as city and school bus personnel.

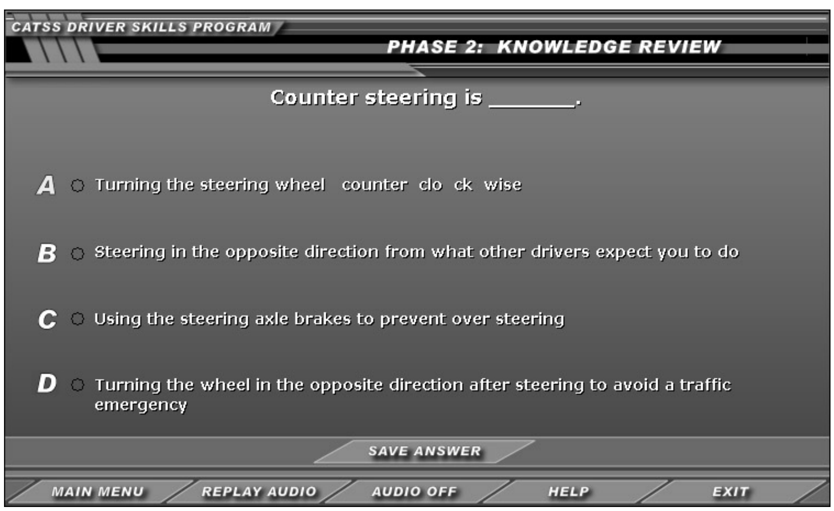
Another objective of the program was to examine human performance across four different levels of driving simulators to determine what type of skills can be successfully achieved on each level of fidelity of the various driving simulators.

Each level of simulator has a definite set of functions and features that accommodate various tasks that can be performed on it. By identifying which level of driving simulator is the best fit according to the skill, knowledge, and attitude task element, we could prescribe appropriate level of simulator for diagnostic, testing, pre-hire, remediation, safety issues and advanced driving skills in a more cost effective manner.

APPROACH

Our research began with a review and analysis of “critical skills and knowledge” areas, based on Federal & State programs and results of compliance reviews. These took two forms, one being those traditional causes of crashes and fatalities from longitudinal records and second examination of potential new issues, based on increase challenges such as hazardous material and increased security risks from terrorism. These were developed in coordination with our partners at Florida DOT’s Motor Carrier Compliance Office, members of the Florida Trucking Association and local driving community representatives. From this analysis the study team established criteria and measures of success for proper assessment of performance needed to assess such skills and knowledge elements. The task also included research on a knowledge management system, that consisted of the analysis of data requirements, utility and maintainability as well as ease of integration with other software tools such as Photo Shop, Director, and other multi media tools and with performance data from the L3 ISIM simulators. The research was accomplished in a series of mini developmental trials, using accepted best practice knowledge garnered from the literature as well as actual applied research application conducted during the initial validation studies for the ***VCRS.***

This program builds on several projects and activities done previously in support of CATSS mission objectives. The primary foundation for this new study effort is the research to develop and validate the VCR, initial findings reported at I/ITSEC Conference (Allen & Tarr, 2003; Tarr, Dec 2004). Another such project consisted of research into methods of certification of training for transportation applications using simulation as the training medium. (Tarr, June 2002) Another is an on going effort to look at alternative methods of visualizing roads and intersections, both to facilitate planning and situational awareness (CATSS & AT&T). It also builds on the community experience with the several demonstrations of the VCR that CATSS has sponsored using the L3 Isim VS 2000 at 4 major conferences as well as using the existing Mark II simulator located in the CATSS Lab in the new Engineering Building, that has raised the awareness of the ground transportation community to think of new ways to solve old problems. This program includes examination of the broader applications of advanced learning technology methods, such as the world wide web and CD Rom based training, integrated into a performance enhancement systems that marries simulation and learning technology in a seamless fashion.



We believed that the use of blended evaluation and assessment techniques, using experience from the "***Virtual Check Ride***" and expanding the use of computer based simulation and learning technology, would provide a valid profile of a drivers skill, knowledge and ability that would then be matched to performance requirements and learning options to allow enhancement of their ability to a satisfactory manner. Likewise this process can be used to establish a driver profile that could be used for long term diagnostic purposes to help manage identification of potential problems or indicators of bad habits that might lead to problems or allow better management of safety programs.

METHODS

Armed with the set of critical requirements, the research team next converted these into diagnostic assessments using the computer based assessment and simulation scenario assessment techniques developed during the design of the VCR, expanded to meet the broader skills and knowledge requirements. At the same time, in a parallel effort, the team identified existing training programs that could be used as remediation or new training to provide the skills and knowledge the drivers lack. Several alternative techniques were determined that can achieve the enhanced needs in a minimal amount of time, depending on drivers needs and opportunities for training. For example, E-Treads is a web based program that provides some skills training, but is only available over the WWW. While other applications are CD Rom based or conducted in the traditional workshop format. For actual driving skills alternative approaches we considered current operational or “live” systems, training systems, simulation systems, part task systems, and other technology based initiatives. High quality motion and non motion based simulation training and advanced learning technologies potentially useful to the truck driver training and operational community were examined for their utility and remediation capability.

Equipped with these prototype assessments and training prescription, we began the validation process. This Virtual Check Ride System (***VCRS***) included a blend of technologies that best met the mix of utility and technology, to meet the needs of the drivers. This was the focus of the validation; to assess the quality and utility of the mix and achievement of desired outcome. In conjunction with our Industry partners, such as Roadmaster Driving School, Florida Power and Light and other Florida Trucking Association representatives, the formal process of validation was conducted, utilizing both the Mark 2 fixed facility at UCF-CATSS and the mobile capability out of the UCF-IST simulation facility. This validation used the model developed previously under research sponsored by CATSS, (Tarr, Development and Integration of Certification Standards for Transportation Training Simulation Systems, June 2002) as well as elements and techniques used for the ***VCR*** validation. Oversight and review by selected SMEs who are qualified CDL examiners and experienced transportation experts was continuous.

Individual drivers were randomly selected to be placed into one of the four different simulators. Conditions and performance data were collected and compared. The same VCRS program was used cross-platform, thus all drivers navigated through the same scenarios, even though they did not use the same level of simulator. Drivers/students began by taking the VCRS diagnostic assessment which generated a report on their achievement on the 3 major areas as well as topics or skills that they were deficient in. This report was then used to develop a training remediation profile as to the lesssons or simulator scenarios they needed to complete to fix the shortfall. At the completion of the remediation they were then retested to ensure they had successfully reached the proper level of performance.

For our simulator types research, we hypothesized that the full motion-based 270 degree FOV realistic truck cab driving simulator would have the highest performance outcomes of all the driving simulators. The second hypothesis was that the drivers who completed the driving exercises on a non motion-based simulator with 180 degree FOV and with moderate steering and visual feedback would perform better than those who used lower level simulators for the same task. Hypothesis three involved the VS Truck Sim (which is an accurate representation of a heavy truck cab including air brakes, but lacking the 180 degree FOV). We predicted drivers would not perform as well due to the lack of pherifial visual support even though the physicality of the cab was present. Hypothesis four focuses on the use of the single channel PC and Rabbit driving simulators. It is predicted that the lower the level of simulator, the lower the level in human performance outcomes.

However, our hypothesis is not quite as straight forward as that, as we do believe that there are different categories of outcomes, essentially dependent on the primary ingredients of the tasks being psychomotor or cognitive. Essentially a task that is heavily loaded in psychomotor will require a higher fidelity simulator, while a task that is mostly rule based or decision making can be accomplished on a lower end simulator. This of course is also dependent on the conditions or cues that are necessary, e.g. if being able to see hard left or right is required then clearly a single channel simulator will not be sufficient. This is really the focus of our research and methodology, to tease out across our matrix, the empirical elements of performance that are appropriate for each type of system. As the cost effectiveness of simulators is a major concern to users, this information should be critical to decisions by users based on their training needs.

DESCRIPTION OF DRIVING SIMULATORS

Level 1 - PC Simulator. Runs same software as levels 2 and 3 with minor modifications. Single channel, lacks air brakes, and transmission and 180 degree FOV. See Figure 1 below. Joystick steering replaced with a realistic steering system created by IST/UCF design and engineering teams. See Figure 2. Production price = $5,000 current configuration, and $6,000 with realistic steering system.

A real 15" steering wheel and robust gear reduction allows two modes, car and truck. Production
price $1,000. This steering system makes the PC driving simulator seem more realistic. Before, this level of simulator functioned more like a glorified game that the driver had some control of but still felt like a game. See Figure 2 below.

Level 1 - FAAC Rabbit Simulator. The heavy truck cab lacks air brakes, and transmission and 180 degree FOV. The simulator lacks a real feeling steering system for a heavy truck. Although realistic graphics and vehicle dynamics are included, we found the driver longer to become submerged into the driving scenario. List price $25,000. See Figure 3 below.

Level 2 - VS2 Truck Simulator. Accurate representation of heavy truck cab including air brakes, steering feedback, with manual and automatic transmission configurations. Lacks 180 degree FOV. List price $65,000. See Figure 4 below.

Level 3 - Patrol Simulator. Accurate representation of a Crown Victoria. This simulator is generally used for Police and Emergency Response drivers. Can be configured to emulate a heavy truck without air brakes and manual transmission systems. Added plus above the Level 2 simulator used in this study is the display of 180 degree FOV. List price $160,000. See Figure 5 below.

Level 4 - Mark II Truck Driving Simulator. Has a Moog 6-DOF motion base platform, air brakes, manual and automatic transmission configurations, and 270 degree FOV. List price = $500,000. See Figure 6 below.

Each level of simulator has a definite set of tasks that can enhance human performance. Being able to forecast or identify the types of human performance at each level of simulation is important because it provides information to operations managers on how to plan training based on what degree of performance they are trying to address and at what monetary cost. If the cognitive skills can be separated from the psycho-motor skills portion of the human performance, the desktop simulator may indeed be a viable option and at an affordable cost. However, for more advanced human performance, such as emergency procedures like reacting to skids, a higher level of simulation appears to be necessary.

STUDY RESULTS

There are two main areas of testing & remediation that were measured; knowledge of both the general nature and pre-trip inspection was done on the CBT and driving skills for both on pad and on road were done with the simulators. 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, however in a computer based, randomly generated format. The simulator portion of the exam follows the CDL driving test by using a truck driving simulator to replicate the actual driving activities. The ultimate goal of this is to validate the truck driving simulator in comparison to that of the actual real-world truck driving procedures. The goal of having the CDL test in computer based format is to establish a cost-effective way for the remediation and certification.

Content testing related to knowledge and skills necessary for safe driving was validated using 50 subjects from 2 different organizations along with feedback samplings from various truck driving communities. The key participants were Roadmaster, a certified private truck driving school and the Orlando Depot for Frito Lay. Frito Lay provided strictly motor carrier trained and a 50-50 mixture of CDL certified and non-certified subjects. Roadmaster provided certified CDL school trained and CDL licensed subjects that consisted of drivers, instructors and SMEs.

Our results indicated that the tailored remediation worked significantly better than the group paced remediation and took lesson time on the average than was normally spent. The greatest improvement was on the driving scenarios, which we believe was based on the limited practice time students have in the real vehicles and the power of the AAR replay of the simulators. The knowledge remediation was the least effective, and we believe this was because this area is mostly academic and memorization work which is the part where scores are traditionally lower on normal testing. The pre-trip was significant however it appears that identifying the features in the virtual environment may actually be a different type of skill then the way it is done in the real world. It could have something to do with cueing by the actual presence of the truck which effects the transfer of learning from the virtual world to the real. This is an area we will research more in the future.

Our hypothesis on the results of the higher fidelity simulator was indeed supported. Human performance was the highest in the highest level of simulator. However, our findings show that there is no significant difference between the level three (180 degree FOV) and level two (VS Truck Sim with single channel) simulator even though the degrees of freedom and cab reality are a factor. Our third hypothesis was partially supported in that the drivers did not perform well when the FOV was limited, although the comparison to the desktop simulator showed no significant difference with the exception of the steering systems. Hypothesis four, use of single channel PC and Rabbit simulators also known as level I simulators, offered slightly higher human performance than expected. This is important because of the major monetary difference between the different levels of simulators.

CDL Driving Skills-Tasks KSAs	Knowledge Cognitive	Skills Psychomotor	Attitudes Affective	Level 1 Average Score	Level 2 Average Score	Level 3 Average Score	Level 4 Average Score	Comments/Criterion
Backing up	X	X		79	79	85	88	**Recognizes** the difference of backing up with and without a trailer. Can judge distance and speed relationship between vehicle and objects. Reverses the vehicle direction without contact with other vehicles, markers, barriers, etc.
Checks traffic conditions – uses mirrors								Mirror FOV limited on level 1 and 2 simulators (single channel).
Maneuvers the vehicle in the desired direction and repositioning the vehicle as needed without incident								Mirror FOV limited on level 1 and 2 simulators (single channel). Vehicle steering dynamics in turning on level 1 simulator not replicated with joystick steering. With added engineered steering using reduction gears, steering on level 1 can be replicated therefore becoming as robust as level 2 simulators.
Left & right turns		X		78	80	90	90	**Demonstrates** the ability to stay in lane, does not hit curb, uses mirrors and signals.
Checks traffic conditions – uses mirrors								Mirror FOV limited on level 1 and 2 simulators (single channel). Vehicle steering dynamics in turning on level 1 simulator not replicated with joystick steering. With added engineered steering using reduction gears, steering on level 1 can be replicated therefore becoming as robust as level 2 simulators.
Uses turn signals								Available on level 2-4 simulators. Currently designing steering column that has turn signals, on/off switch for the level 1 sim.
Positions vehicle for turn								FOV limits levels 1 and 2 single channel simulators
Executes and recovers from turn								FOV limits levels 1 and 2 single channel simulators

Summary

In summary, our research clearly demonstrated that diagnostic assessment with tailored remediation was a superior method for assisting adult learners to overcome the achievement of mastery of the skills and knowledge necessary to pass a CDL A test. We believe that the difference is a combination of focusing the learner on the area that they are having difficulty with and the opportunity to practice the skills, whether cognitive or physical, in a non threatening and performance based environment. Furthermore, although it does appear that not all levels of driving simulators are created equal, each can contribute greatly towards improving human performance for certain skills depending on the elements of that skill and the functions available in the simulator to require those elements. By identifying which level of simulator is the best fit according to a task element, we can now more precisely prescribe levels of simulation for diagnostic, testing, pre-hire, remediation, safety issues and advanced driving skills.

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Figure 1 – Level 1 PC Driving Simulator with Joystick Steering Configuration

Figure 2 - Realistic Steering System Configuration

Figure 3 – Level 1.5 FAAC Rabbit

Figure 4 – Level 2 VS2 Truck Driving Simulator

Figure 5 – Level 3 Patrol Driving Simulator

Figure 5 – Level 4 Mark II Full Motion Truck Simulator