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RE-ASSESSMENT OF DRIVING SIMULATORS FOR THE TRAINING, TESTING AND LICENSING OF COMMERCIAL VEHICLE DRIVERS

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ABSTRACT

The Federal Motor Carrier Safety Administration (FMCSA) is seeking to validate a low- to mid-cost simulator to potentially enhance commercial motor vehicle (CMV) driver training, testing, and licensing. Based on preliminary findings FMCSA believes that simulators hold considerable promise for improving commercial driver performance and highway safety if their value can be sufficiently demonstrated. In the first phase of the truck simulator validation study (SimVal), FMCSA published an initial truck simulator assessment report (1996), which indicated that simulation was sufficiently mature for validation purposes. A research design was then developed to validate the use of simulation technology. In the second and final phase, researchers will conduct the follow-on empirical study using the Phase 1 research design.

This paper describes a second, more detailed, truck simulator re-assessment to learn about technological progress since the publication of the initial report. The re-assessment is based on the simulator functionalities described in the research design report. The completion of this report will assure that FMCSA has the most up-to-date information on commercially available truck simulators in the U.S. when the request for proposals (RFP) is made in FY'02.

This paper draws heavily from previously published FMCSA documents and reports. A version of this paper has been submitted and accepted at the 2001 Large Truck and Bus Safety Symposium in Knoxville, TN November 7-9, 2001.

PROGRAM OVERVIEW

Simulators have been successfully employed within the military and commercial sectors for several decades. Now relatively low-cost, full-mission, high fidelity CMV simulators are available in the marketplace and being employed by various organizations in the trucking industry. As the cost of these devices continue to decrease, while the capabilities seemingly increase, their use will likely increase as well. Truck simulators may be useful tools to supplement training, testing and licensing of CMV operators. However, there has been little, if any, previous effort by either the private or public sector, to empirically examine the transferability of simulation training to real driving, or to assess its usefulness, effectiveness, or efficiency (Emery, Robin, Knipling, Finn, and Fleger 1999).

One of the primary objectives of the SimVal study is to examine how simulation-based training, as compared to conventional training methods, can enhance the training environment and improve the tractor-trailer driver performance. The study will also identify opportunities employing truck driver training simulation technology and examine cost implications.

The SimVal study is the culmination of a number of interrelated research activities conducted by FMCSA over the past several years. The initial truck simulator assessment determined that truck simulator technology was sufficiently mature to conduct a validation study (FHWA, 1996). FMCSA then developed and published a detailed research design and the plan to conduct the empirical SimVal study (Emery, Robin, Knipling, Finn, and Fleger 1999).

The research design reflects the input of industry based on two peer reviews; one on the driving scenarios to be used in the study and a second on the research design itself. The research design consists of three parts, as follows:

Part 1 – Transfer of training (and pilot test)
Part 2 – Advanced simulator capabilities (and pilot test)
Part 3 - Longitudinal study (and pilot test)

Part 1 of the study addresses the forward transfer of training (conventional tractor trailer vs. simulator-based training) for entry-level drivers. This part of the study will involve fifty-four (54) novice tractor-trailer driver students who will be trained on all units of the Professional Truck Driver Institute curriculum, as modified during a peer review. Students will be divided into two groups, with one group receiving conventional truck based training, and the other group receiving simulator-supplemented training. The control group will receive all behind-the-wheel (BTW) training (totaling 44 hours) in an actual vehicle, except for some limited exposure to the simulator for familiarity purposes; the experimental group will receive 66 percent of the BTW training in the simulator (30 hours) and the rest (14 hours) in the vehicle. Driver performance will be assessed and measures will include the number of trails necessary to achieve the skill objective for each of the training lesson, and the amount of time necessary to pass the skill unit. In addition to the requirements for instructional units, student drivers will perform two in-course driving skills tests, the Pre-Street Range Test (PRST) and Final Examination Road Test (FERT). Both of the in-course tests have traditionally been performed in a truck. Student drivers in both the control group and the experimental group will attempt the PRST and FERT first in a truck, and then in a simulator. The ultimate criterion test for the transfer of training will be the student driver's performance on the CDL examination. (FMCSA, February 2000).

Part 2 provides for an evaluation of the advanced capabilities of the simulator to replicate the more complex driving skills, such as the operation of double and triple combination vehicles, evasive maneuvers, jackknives, and driving on black ice. Simulation appears to lend itself particularly well to driving situations that are dangerous, unusual, or infrequently encountered. The objective of the advanced capabilities assessment is to "showcase" and assess the technology to determine the efficacy of simulation for training, testing and licensing CMV drivers on these particular maneuvers and vehicle configurations. This part of the test will involve eight experienced drivers and eight students. Experienced drivers will have at least 15 years of professional driving experience and a tenure of at least 2 years with the same carrier with no reportable accidents or citations for 3 consecutive years. Novice truck drivers will be a subset of those students who participated in the conventionally trained group of the forward transfer of training (Part 1) who obtained the CDL. After drivers receive a brief orientation to the simulator, researchers will administer a general skills pre-test to establish a baseline differences between the two groups. Scores from the pre-test will be collected in the form of instructor's observations for the number of pass/fails performance on each trial. Following the pre-test, all drivers will be tested individually on four defined advanced capabilities scenarios: Special Rigs (doubles and triples), Speed Management, Extreme Driving Conditions, and Emergency Maneuvers. Upon completion of the scenarios, all drivers will participate in post-test procedures similar to the pre-test. Additionally, the experienced drivers will complete a post-experiment questionnaire to determine the degree of agreement among experienced drivers

on the simulator's ability to present driving situations in a realistic and useful manner. (FMCSA, February 2000)

Part 3 is a continuation of Part 1, and will determine if simulation based training ultimately results in reliable differences in driver's performance. The student driver's post training driving record will be examined at 3 and 12 months following the completion of the CDL examination (and full time employment as a tractor-trailer driver). Measures of on-the-job driver performance during this part of the study will include the number of crashes, the number of citations, supervisory ratings, and other measures, as deemed appropriate.

The SimVal program is being developed to provide answers to a number of questions regarding simulator-based training and subsequent performance. These questions are included in the research design report. A sub-set of these questions is provided below:

- Does simulation-supplemented training result in same, or better performance by the drivers on the CDL examination?
- Does simulation promote more efficient and/or more effective training for the completion of the instructional objective during training?
- Does training method predict job performance?
- Are there differences in job performance (e.g., accident rates, number of violations) between drivers trained using simulation and those trained using conventional methods?
- Can simulation adequately assess driver ability for advanced capability skills?

This paper describes the truck simulator re-assessment study in support of the empirical SimVal phase 2 efforts. The re-assessment is based on the simulator functionalities and driving scenarios described in the research design report. The completion of the re-assessment report will assure that FMCSA has the most up-to-date information on commercially available truck simulators in the U.S. A request for proposals (RFP) for the actual SimVal study will be made in FY'02. As such, the re-assessment report will be useful to vendor's responding to the RFP.

SIMULATOR SELECTION PROCESS

Veridian Engineering was tasked with performing a re-assessment of commercially available truck simulators to evaluate advances in this technology and to assess new systems. Veridian Engineering personnel reviewed literature on commercially available truck simulators. Sources included web searches, promotional literature, and professional contacts. This process produced a list of 25 simulators that fit the general system criteria. The list of candidate simulators was derived by eliminating those systems in which:

- The company was no longer in business
- The simulator was not commercially available
- No operational system was available for evaluation
- No truck configuration available

The final list of truck simulators that appeared to meet the needs of the SimVal study included six systems. A partial listing of these systems is provided in Table 1. Note that the table lists only four systems, since the process of formally releasing information from two manufactures is not complete.

TABLE 1 Partial List of Truck Simulators Evaluated

Manufacturer	System
Doron Precision Systems	L-301 VMT
I*Sim Corporation	TruckSim
Digitran Simulation Systems	SafeDrive 1000
FAAC Incorporated	Driver Training System

THE SIMULATOR ASSESSMENT EXPERT TEAM

In order to evaluate the truck simulators, FMCSA and Veridian Engineering assembled a team of experts. These individuals brought specific skills in areas necessary to evaluate the simulators. Included in the team were experts in commercial driver training, simulator use and development of experimental programs on simulators, an award winning truck driver, and human factors experts. The team members were required to travel to each simulator facility as recommended by the manufacturers. The Team members, their affiliation, and area of expertise are listed in Table 2.

TABLE 2 Expert Team Members

Name	Affiliation	Area of Expertise / Role
John Pierowicz	Veridian Engineering	Program Manger
Dr. Valerie Gawron	Veridian Engineering	Operator Training, Human Factors
Dr Ginger Watson	University of Iowa	Simulator Design, Use, Human Factors
Bill Nestor	Markinetics, Inc.	Award-winning truck driver
Wade Murphree	AIT Incorporated	Driver training, licensing

DEVELOPING THE SIMULATOR ASSESSMENT TOOL

Veridian Engineering developed a truck simulator assessment tool in concert with FMCSA personnel and the Expert Team. The assessment tool was based on the aforementioned SimVal Research Design Report.

The assessment tool provides a standardized format to assess simulator capabilities and driving scenarios addressed in the research design. Table 3 describes a sub-set of over 183 distinct factors contained in the Assessment tool. Each simulator factor was assessed in terms of “Adequate”, “Not Adequate”, or “Not Available”. In addition, the assessment tool provided an area for the Expert Team’s comments.

SIMULATOR ASSESSMENT

Arrangements to assess each simulator were scheduled with the individual manufacturers. The visits were not always to the manufactures facility; in a number of cases, the Expert Team was requested to evaluate a system at a customer facility. The manufacturers were provided the opportunity to have a representative present during the evaluations.

The Expert Team visited and tested a total six simulators. During these visits the team assessed the capabilities of the simulator with respect to the simulator evaluation tool. The site visits generally were conducted in a single day. The team spent on average seven to eight hours reviewing the capabilities of the system, with a minimum of six hours within the simulator itself. In some instances, the team was able to split into groups to investigate different parts of the simulator, such as the dynamic capabilities of the system and the features available for training drivers. This allowed all areas of the simulator evaluation to be covered in detail.

The simulator assessments were developed though a consensus process including all members of the Expert team. In situations where specific questions remained, the manufacturer or simulator operator was requested to demonstrate specific simulator capabilities.

SELECTED ASSESSMENT TOOL AREAS

Tables 4-6 list selected characteristics of the simulators evaluated. Please note that results for the four simulators are listed. The process of releasing data from the other two manufacturers is underway at this time. Therefore, the results from those evaluations are not presented. It is also pointed out that due to the interim nature of this paper, the research findings are limited strictly to the "availability" of the specific features discussed.

TABLE 3 Selected Evaluation Assessment Tool Areas

Evaluation Criteria	Evaluation Factor
Vehicle Cab Environment	Cockpit controls replicated
	Horn present, functional
	Radio present, functional
	Flashers, present, functional
	Driver restraints present
Visual Scene	Scenery Elements replicated?
	Roadway properly replicated?
	Objects such as signs (speed limit, stop signs) replicated?
Mirrors, Transmission	Mirror configuration
	Trailer, roadway visible in mirrors?
	Transmissions replicated
	Train proper shifting practices
Maneuvering in Restricted Quarters	Serpentine maneuvers
	Figure 8, restricted Figure 8
	Sharp, restricted turns
	Movable traffic cones
Proficiency Development	Close quarter maneuvers
	Alley dock
	Parallel park
	Overhead clearance
Vehicle Gap Management	Crossing, passing traffic
	Changing lanes
	Vehicle headway
Speed management	Hills
	Curves
	Turning
	Passing
Emergency maneuvers	Blind Intersection
	Slippery Surfaces
	Blow out
	Payload overloading
	Steering deterioration
Training Tools	Bird's eye view
	Record / Play/ Demonstrate
	Data Storage
	Data Printout

TABLE 4 Simulator System - Selected Characteristics

Criteria	Factor	Doron L-301 VMT	I*Sim TruckSim	Digitran SafeDrive 1000	FAAC Driver Training System
Cab Environment	Simulator replication of truck cab	Generic cab simulated	Freightliner day cab	Generic "half-cab"	Generic "half-cab"
Mirror Replication	Simulator replication of mirrors	Concave / Convex utilized both sides	Concave utilized both sides, no convex	Mirrors reproduced in visual scene	Mirrors reproduced in visual scene
Motion Base	Motion base system utilized	None	Hexapod	None	Hexapod
Tractor Trailer Configurations	Tractor Trailer configurations tested	Single trailer only	Single, double, tanker available	Single, double, tanker available	Single trailer only

TABLE 5 Training Related Selected Characteristics

Criteria	Factor	Doron L-301 VMT	I*Sim TruckSim	Digitran SafeDrive 1000	FAAC Driver Training System
Basic Control Exercises	Simulator duplicates basic control exercises on range with cones	Available	Available	Not Available	Available
Transmission Shifting	Simulator permits training in proper shifting techniques	Available	Available	Available	Available
Gap Management	Simulator permits training in vehicle to vehicle gap management	Not Available	Available	Available	Available
Speed Management	Simulator permits training in vehicle speed management	Not Available	Available	Available	Available
Emergency Maneuvers	Simulator permits training in emergency maneuvers	Not Available	Available	Available	Available

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TABLE 6 Selected Simulator Characteristics – Visual Elements

Criteria	Factor	Doron L-301 VMT	I*Sim TruckSim	Digitran SafeDrive 1000	FAAC Driver Training System
Visual Scene Elements	Roadways	Available	Available	Available	Available
	Traffic	Not Available	Available	Available	Available
	Buildings	Available	Available	Available	Available
	Pedestrians	Not Available	Available	Available	Available
	Special zones (construction, etc.)	Not Available	Available	Not Available	Available
Roadway Elements	Highway	Not Available	Available	Available	Available
	Arterials	Not Available	Available	Available	Available
	Collector lanes	Not Available	Available	Not Available	Available
	On and Off Ramps	Not Available	Available	Available	Available
	Intersections	Available	Available	Available	Available
	Loops	Not Available	Available	Available	Available
	Traffic Signals	Stop Sign only	Available	Available	Available
Lighting Conditions	Is day / night driving conditions available?	Day, night available	Day, night available	Not Available	Day, night available
Adverse Weather Conditions	Are adverse weather conditions available (rain, snow, fog)?	Not Available	Available	Not Available	Available

PROGRAM STATUS

Currently, all simulator evaluations by the Expert Team are complete. A final report, containing the results of the simulator evaluations is in development by Veridian Engineering in coordination with FMCSA Office of Research & Technology. This final report will be published and widely disseminated in FY'02. The RFP for the SimVal study will be made following the release of the Truck Simulator Re-assessment report.

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ADDITIONAL SIMULATOR RESEARCH: FMCSA USE OF THE NATIONAL ADVANCED DRIVING SIMULATOR (NADS)

The NADS is a $60 million state-of the-art, best-in-the-world driving simulator located at the University of Iowa, under the stewardship of the National Highway Traffic Safety Administration (NHTSA) It will be used to conduct fundamental research in highway safety, integrated vehicle highway systems and advanced vehicle design. Now that the NADS is operational, FMCSA has commenced a program to strategically integrate the NADS into the FMCSA Research and Technology program. For example, the NADS could be used to help improve low-cost truck simulators.

FMCSA engaged Veridian Engineering to develop a FMCSA NADS Utilization Report. The report will assess NADS capabilities from a FMCSA truck perspective and result in a number of potential NADS projects that can be selected from during the next few years. Brainstorming sessions have been conducted at FMCSA to help generate candidate projects and to develop a process for successfully integrating the NADS into FMCSA R&T Program. A test drive of the NADS configured with the truck buck is also planned so as to better understand the capabilities of this device. FMCSA regards NADS as a useful research tool for addressing many driver-related human factor issues including driver fatigue, medical conditions, driver selection and training (not as a driver trainer per se, but as a tool to improve training simulators and methods), human performance evaluation/enhancement and technology assessment for improving CMV driver safety. However, like any research tool, its applicability and cost/benefit effectiveness for any research problem will have to be assessed to assure the optimum utilization.

REFERENCES

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