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John F. Brock

Milestone Group, LLC Alrington, VA

Cynthia Jacobs

Milestone Group, LLC Alrington, VA

Richard Buchter

Milestone Group, LLC Alrington, VA

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DESIGN OF A GUIDEBOOK FOR THE ACQUISITION AND USE OF DRIVING SIMULATORS FOR TRAINING TRANSIT BUS OPERATORS

John F. Brock
Cynthia Jacobs
Richard Buchter
Milestone Group
Arlington, Virginia
E-mail: jbrock@milestonegroup.net

Summary: The Transit Cooperative Research Program of the Transportation Research Board recently sponsored an 18-month research program to develop a set of Guidelines that transit agency trainers and managers could use to (1) determine if driving simulators could help meet training objectives and (2) if so, what kind of simulators to acquire. The end product of this research is a set of task-based criteria that lead to specific simulator characteristics. That is, one should purchase a training simulator based upon what tasks need to be trained. This paper reports on the limited available data on the effectiveness of driving simulators for training, the task clusters various technologies can train, and the decision aids developed for transit agencies that actually have applicability to any potential user of training simulation. The project included a literature review, visits to driving simulator users nationwide, a review of European simulator programs, and the collection of training data and accident data from both users and non-users of driving simulators. Instructors, students, course graduates, and managers were interviewed. The results of the research are presented and a simulator evaluation methodology is proposed.

INTRODUCTION

Purpose of the Research

The purpose of the research is to provide transit agency managers with a handbook that can help them decide whether their agency should add driving simulation to his or her training program and, if so, what kind of simulation should be acquired. In addition, the handbook (Jacobs and Brock 2001) provides supporting material that can add to the effectiveness of any simulator selected by a particular transit agency. It also provides a brief history and overview of simulation, particularly driving simulation.

The authors believe that when simulation is used correctly student performance improves, cost savings are realized, and safety in the domain being simulated is improved. The handbook does not recommend a specific training device or simulator. Rather, it provides the handbook user with the background, vocabulary, and data so that he or she can reach an informed decision. The handbook leads the user through a series of questions that will lead to a narrowing of simulator options. Tables and figures are used to compare the three kinds of simulators available to training transit bus operators. However, the handbook user is advised to read the text of the document as well. The handbook is not a kind of *Driving Simulation for Dummies*. Rather, it is

designed to help transit agency managers integrate the use of simulation in their agency's training programs in a cost effective and beneficial way. Although developed specifically for the transit community, it is applicable to any potential user of driving simulation to train vehicle operators.

Literature Review

There is a long and rich body of scientific and technical literature on simulators and their use for training that goes back to at least to the early 1950's. The literature can be broadly characterized as falling into four main areas. These areas are: 1) descriptions of simulators, or simulator components, their characteristics, and how they are being used, 2) advice on what characteristics are required in a simulator, 3) results of research on the effects of simulator characteristics on performance, and 4) results of research on the effects of simulator characteristics on training.

The vast amount of this literature is in the context of flight simulators because that has been the predominant use of simulators for the past sixty years. Within this body of literature, the smallest segment has been research on how certain simulator characteristics affect the rate of learning and proficiency. However, over an accumulated history of the study of these devices, there is evidence that training simulators, particularly flight simulators, are effective training tools. Specifically, it is believed that time spent in the simulator trades off for some amount of training time using actual equipment (Brock, McCauley, Jacobs, and Van Cott, 2000).

MAJOR FINDINGS

Driving Simulators

There are currently three primary kinds of bus driving simulators/trainers in use in United States transit agencies: Open-Loop Video, Low-End Simulator, and Mid-Range Simulator. Each has been shown to improve both driver training and safety although some data are based on a very limited number of users. All three devices have strong proponents and detractors. And, although each device trains some sub-set of the skills transit bus operators must have, none trains them all. Table 1 summarizes the characteristics of these three systems.

It was obvious during the research team's visits to various transit agencies that driving simulators appeal to both current and future users. Therefore it is the authors' belief that driving simulators in transit agency bus operator training are inevitable; one goal of this research project is to ensure that transit agencies get maximum effectiveness and efficiency from the acquisition and use of those simulators.

The research team did not find staff or trainees who felt that the limitations of the various simulator configurations kept the simulators from meeting the instructional objectives of the training; rather all felt that the simulators contributed to the learning process. Trainers who used the simulators reported cost savings from using the devices.

Finally, we also observed that a critical feature in the success of these training programs is the competence and enthusiasm of the instructional staff. The simulators provide an opportunity for instructors and students to work closely together in the learning experience. Although not part of

the engineering design of a simulator, it is a feature of the simulation experience that cannot be ignored.

Site Visits Data

The research team visited most transit agencies with simulators and found that all the simulators are used to train new drivers and many are also used to re-train more experienced drivers. In at least one case, a simulator is used to train drivers other than bus operators. There are some variations among the various agencies on how much time each student spends inside the simulator configurations. This is partly the result of the judgment of individual training managers and partly the result of the scheduling problems attached with having training devices that can only train one student at a time. All agencies with simulators report that new drivers can be taught the fundamentals of bus operation in the simulators. Those fundamentals will change depending upon the simulator being used.

TABLE 1. Levels of Transit Bus Operator Simulators

<p><u>Level 1 – Open-Loop Video</u></p> <p>The most popular method of driver training delivery in use in transit agencies. It uses Open-Loop Video to display traffic and other instructional information. It consists of several student stations, each with a steering wheel, gas and brake pedals, and a rudimentary dashboard. This device is characterized as an “open loop” system because it is non-interactive. Although each station is equipped with a steering wheel, gas pedal, and brake pedal, the student’s engagement of any of these controls will not produce any appreciable effect on the video display.</p> <p>The system, as designed, trains and tests very specific bus operator activities (e.g., reaction time and visual recognition). Stopping distances, road conditions, the relationship of speed to both, and the role of reaction time can be shown and then practiced. Because the instructor station for the system measures performance in each learning station, the instructors can monitor and identify students who are not correctly responding as the scenarios play out.</p>
<p><u>Level 2 - Low-End Simulator</u></p> <p>The second method of driver training delivery is a model-board system. In this low-end simulation, a miniature camera is installed in a small model of a bus that physically moves about on a small terrain board in an adjoining room. This system replicates the visual, auditory, and vibratory effects of driving a bus in an urban, crowded environment in order to train student operators to maneuver a transit bus in relatively tight and unforgiving situations. The system demonstrates basic maneuvering of transit buses in typical urban areas. Such skills as approaching a bus stop, parking, tight turns, and backing can be taught to a single student without risk of damage to either an actual bus or to platforms, other vehicles, or pedestrians.</p>
<p><u>Level 3 - Mid-Range Simulator</u></p> <p>The third driver training delivery method is a mid-range simulator that uses realistic audio and video; including rear projection, to deliver a fuller replication of the driving experience. A larger field-of-view (FOV), on the order of 180 degrees forward, a vertical FOV of at least 45 degrees, and 60 degrees to the rear, distinguishes this simulator from the low-end simulator described above. Additionally, a more sophisticated vehicle model is provided, along with more complex environmental effects (weather, day-night, and road friction), and motion cues to replicate the look and feel of the outside world as seen by a driver looking out of the windows of a bus cabin.</p> <p>One of the very strong features of this device is the fact that the mirrors in the simulated cab are actual mirrors; they can be physically manipulated to reflect the imagery that is projected behind the simulator cab. The visual imagery for this system was developed for the specific driving environment of the transit buses for which the operators are being trained. Therefore, the device provides high fidelity simulation of actual driving situations that trainees are likely to encounter upon completion of the training program.</p>

Survey Data

As part of the research study, instructors and training managers of all agencies currently using bus operator simulators were asked if they were satisfied with the training simulator. 92 percent of respondents from all locations reported a high level of satisfaction with their training simulator. Only one respondent expressed concern regarding the sickness associated with the use of the training simulator.

Trainers rated bus simulator training high in the areas of effectiveness in training first-time drivers and utility in the overall training curriculum. When asked if the simulator is more effective than traditional training for teaching certain types of knowledge, skills, or attitudes, 58 percent of respondents reported that the simulator is more effective than traditional training methods.

When asked what role simulator training plays in the overall bus operator curriculum, respondents in all locations reported that bus simulators reinforce the concepts taught in the classroom. Most trainers feel that simulator training validates defensive driving techniques taught in the classroom. All respondents believe that the simulator training provides an excellent opportunity to experience a hazardous situation without actually being in a hazardous situation.

Performance Data

Almost all of the training personnel at the visited agencies reported that the use of simulation has decreased drop out rates from the training program. The user of the most advanced simulator reported a 35% reduction in attrition rate compared to students in a conventional course. In one heavy user of both the Level 1 and Level 2 systems, the training manager reported a 95% pass rate.

Several agencies reported reduced training time by replacing bus training with simulator-based training. One agency reduced training time from 19 days to 17 days. Another agency, using just the Level 1 system, was able to reduce its training program by five full days. Another agency, with the same simulator system, reported no cost savings in the training process at all.

The only agency currently using a Level 3 bus operator driving simulator reports significant safety benefits from using the simulator to train beginning drivers. One quarter of all the new drivers were trained using the simulator; 75% of the new drivers were trained without the simulator. The accident rate for the simulator-trained drivers over the 90 days after completing the training was 18% (i.e., slightly less than one in five had an accident). The accident rate for the drivers conventionally trained was almost 32%.

Perhaps more significantly, the tasks specifically trained by the simulator resulted in 17 accidents for the simulator students and 154 for the non-simulator group. These were tasks related to overtaking and being overtaken by vehicles on the left and right sides of the bus. Another transit agency collected data to compare the number of accidents 20 months before and after undergoing the Level 1 and Level 2 combined simulator-training programs. That program was reported to effect a 10% reduction in collisions.

THE GUIDELINES

Any transit agency responsible for training its bus operators should seriously consider using driving simulation as one tool for such training. The Guidelines developed for this research program provide specific criteria for selecting one or more simulators. The data supporting the value of driving simulators, when training is designed and managed with the simulator in mind, are unambiguously positive. The Guidelines provide an aid for deciding what kind of simulator to acquire and also offer options for smaller transit agencies to gain access to simulator technologies. Table 2 is one of several tables and figures from the Guidelines that compare the transit simulator options.

Although this study concentrated on driving simulators for transit bus operators, the study techniques and basic guidelines will apply to any driving simulator evaluation. By linking specific tasks and skills to simulator characteristics, training managers can acquire the simulation technology they need.

Table 2. Operational Capabilities Matrix

	Open Loop	Low-End Simulation	Mid-Range Simulation
Throughput/Session	8	1	1
Simulated Vehicle Environment	✓	✓	✓
Interactivity		✓	✓
High Task Fidelity			✓
Model Terrain Board		✓	
Realistic Audio/Visual Systems			✓
Instructor Console	✓		✓
Realistic Gauges and Instruments	✓	✓	✓
Performance Measurement Tools	✓	✓	✓
Full Visual Replication of Driving Scene			✓
Fully Functional Traffic Signals			✓
Virtual driving world encompassing 50 square miles			✓
Intelligent Traffic			✓
Real Mirrors			✓
Skill-based Training	✓	✓	✓
Rule-based Training		✓	✓
Knowledge-based Training			✓

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