Using Driving Simulators to Train Snowplow Operators: The Arizona Experience

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ABSTRACT

Snowplow driver training is an attractive focus for simulator-based training, since these drivers must operate equipment valued up to $200,000 in stressful shifts in blinding snowstorms. In Arizona, the infrequency of snowstorms and the heavy turnover of drivers make simulator-based training particularly attractive.

In the 2005–2006 snow season, the Arizona Department of Transportation (ADOT) used a fixed-base L-3 Communications TranSim VSIII simulator in the Globe, Arizona, maintenance district to offer two training programs: one on enhancing drivers’ sensitivity to potential hazards, and the other on fuel management and shifting techniques. In response to a request from ADOT’s Transportation Research Center, a research team from Arizona State University assessed the effectiveness of the simulator-based training in addressing these objectives.

The assessment included surveys of driver participants, focus groups of driver participants and district field supervisors, and a review of reports generated by the simulator, as well as an assessment of relevant crash and claims records. Researchers noted the enthusiasm for the driver awareness program, particularly among recent hires. The fuel management program interested experienced as well as less experienced drivers who could see immediate application, and it also appeared promising in terms of improving fleet fuel economy. The experience with simulator training in Arizona left researchers and ADOT personnel optimistic about the potential for driving simulators as an integral part of a comprehensive driver training program.

Key words: Arizona—driving simulators—snowplow driver training
INTRODUCTION

Driving simulators have been widely used for human factors research and automobile driver training and retraining for more than 30 years. Research simulators are often used for human factors and cognitive psychology experiments to study driving behavior (for examples, see Kemeny and Panerai 2003; Reed and Green 1999; Sidaway and Fairweather 1996), while training simulators are frequently used by public and private agencies to teach and evaluate driving skills (for examples, see Emery et al. 1999; Kihl et al. 2006; Strayer and Drews 2003; Strayer, Drews, and Burns 2004; Vance et al. 2002). Driving simulators offer several advantages over real-world driving. Safety is a primary advantage, as simulators can be used to expose drivers to driving conditions too dangerous to consider for real-world driving (Liu, Miyazaki, and Watson 1999; Reed and Green 1999). As a training tool, simulators allow trainees to practice driving and to develop confidence before taking a road test (Liu et al. 1999). Most simulators also have the ability to record and play back training sessions, allowing evaluations to be objectively assessed.

Driving simulators may be categorized as either fixed-base or motion-based. Fixed-base models range from simple, desktop computer models (for example, see Pierowicz et al. 2002), to those utilizing a head-mounted display with head tracking technology (Liu et al. 1999). Some units include partial (Ross-Flanigan 2002) or full vehicle cockpits (for examples, see Pierowicz et al. 2002; Roenker, Cissell, and Ball 2003). Motion-based simulators are generally more sophisticated and feature motion cues that mimic the roll, pitch, and yaw of actual vehicle dynamics. The National Advanced Driving Simulator, located at the University of Iowa, is one of the most sophisticated motion-based driving simulators (Kuhl et al. 1995) and has been used for both research and training purposes.

As simulator technology has improved and prices have dropped, more private corporations and public agencies, including departments of transportation (DOTs), are starting to use driving simulators as training tools. Snowplow training can be attractive for DOTs that are weighing the benefits of incorporating a driving simulator into their existing training programs. Snowplow drivers must operate equipment valued at up to $200,000 in long, stressful shifts in blinding snowstorms and demanding traffic conditions. Recognizing these concerns, DOTs in Pennsylvania (Vance et al. 2002), Utah (Strayer et al. 2004), Minnesota have used simulators to train snowplow operators. The Iowa DOT also introduced a simulator training program for snowplow operators in 2005. All are optimistic about the potential of simulator training in enhancing their driver training programs.

SIMULATOR-BASED TRAINING IN ARIZONA

The Arizona Department of Transportation (ADOT) began using driving simulators to supplement its snowplow operator training program in the 2004–2005 snow season. The primary objective was to increase safety both for drivers and the motorists with whom they share the road. It was thought that the simulator could be used to improve driver confidence and thereby driver retention, both of which would potentially improve overall safety.

A relatively short simulator-based training program was offered to drivers in five districts by an outside vendor in a traveling trailer during the 2004–2005 snow season. Then, at the start of the snow season in 2005–2006, ADOT purchased an L-3 Communications TranSim VSIII simulator and housed it at the Globe maintenance district, where four-hour training programs were offered to all drivers in the district by local trainers. In the 2006–2007 snow season, two more L-3 simulators were acquired and based at the Flagstaff and Holbrook maintenance districts. In summer 2007, ADOT purchased an additional L-3 simulator to be based in the Safford maintenance district. Figure 1 shows the Arizona engineering districts.
The TranSim VSIII Driving Simulator is a computer-controlled fixed-base simulator. The main computer system that operates the dashboard controls is located in the TranSim chassis. Image generators provide high-resolution graphics that are displayed on three plasma displays mounted on the chassis, giving the driver a 180-degree view of the simulated driving scenarios (Figure 2).

Although fixed-base simulators have the obvious advantage of relatively lower cost, their lack of motion cues may alter “the perceived motion variables that serve as inputs to [one’s driving] strategy” (Reymond et al. 2001). This becomes especially important during the low-friction conditions associated with snowplow operation. In this case, even small motion cues (e.g., 1 to 2 in., or 25 to 51 mm) make a significant difference in how realistic the simulation experience feels to users. A number of driver trainees have commented about what they call a lack of realism in the simulator training program.

The training programs used in Arizona include both lecture and simulator scenario components. They were developed initially by L-3 and were modified to reflect ADOT policies more directly. The curriculum is punctuated by real-word examples that are introduced by experienced Globe district snowplow drivers who served as trainers.
The primary snowplow driver simulator training course focuses on making drivers alert to unexpected hazards that can intrude into their plowing experience and adds safety challenges such as errant motorists, pedestrian crossings, falling rocks, animal crossings, and icy roadways. The course emphasizes a strategy developed by L-3, SIPDE (Search, Identify, Predict, Decide, and Execute), that is intended to increase driver awareness. Examples and modifications were added by the Globe district. This training program exposes driver trainees to three increasingly challenging 15-minute scenarios that illustrate key points emphasized in the accompanying classroom program. It was first offered in Globe in fall 2005.

A second driving techniques-based simulator training course, offered in March and April 2006, focused on teaching drivers how to reduce fuel consumption and minimize equipment repairs. Here, the classroom training is interspersed with simulator-based opportunities to demonstrate the application of the various driving techniques introduced in the course. In the 2006–2007 snow season, the Globe district trainers combine these two courses and offered it in one long session, thereby minimizing the time drivers are away from their regular duties. That course is still being refined.

ADOT’s Arizona Transportation Research Center engaged an interdisciplinary research team from Arizona State University (ASU) to evaluate the effectiveness of the emerging simulator-based snowplow driver training. The evaluation included both a review of available data and an assessment of perspectives of driver participants and their field supervisors. The objective of the assessment was to determine whether the simulator could assist drivers in modifying their driving behavior. The focus in this paper is primarily on the 2005–2006 training program in the Globe maintenance district.

STUDY PARAMETERS

The training program, offered by experienced Globe snowplow drivers, was intended to alert drivers to the unexpected. Since snowplow drivers frequently have limited time to make decisions and act, it is most important that they remain alert, scanning the setting for potential hazards, identifying them, and trying to predict how a moving hazard will act. Drivers were taught to search their surroundings, identify potential hazards, and predict the path of moving hazards, such as wildlife crossing highways, speeding motorists, or pedestrians. They were then to decide what to do and, finally, execute that decision.
All 61 snowplow drivers within the Globe maintenance district participated in this driver awareness and safety program in October and November 2005. They were divided into groups of four. Each group was given extensive classroom training that was interspersed with simulator seat time. The simulator portion of the training involved driving three different simulator scenarios, each designed to allow the trainees to apply specific aspects of what they had learned in the classroom. The scenarios included a freeway, a two-lane rural mountain road, and a small city. The trainers had the capability to make each of these scenarios increasingly complex by adding whiteout conditions, iced-over windshields, and/or night conditions. Between the simulator drives, the participants discussed driving issues and reviewed the scenarios. A computer-generated report noted traffic violations associated with each driver’s simulated drive.

The ASU research team observed several of the four-hour class sessions, including both the training lectures and the driver simulation sessions. At the end of the snow season in April 2006, the research team distributed a written survey soliciting drivers’ opinions about the simulator training program after they had the opportunity to apply what they had learned in the real world.

In the spring of 2006, additional simulator training was conducted in the Globe district. The same drivers who were trained in the fall were given instruction on techniques that could improve fuel economy. In this course, initially developed by L-3 communications, the focus was specifically on shifting gears (using the gear shift, clutch, and accelerator), rather than on the overall driving experience (as was the case with all previous simulator training sessions). Trainees received a combination of stand-up lecture training, computer-based training (CBT), and simulator “seat time.” The stand-up training covered the basic principles of shifting for fuel economy, while the CBT reinforced these points with one-on-one modules in which the trainees received instruction (via headphones) and responded to questions posted on a desktop computer screen. In the simulator, drivers were given approximately 15–20 minutes of practice time, during which they were coached by trainers. In a timed pre-test, each driver drove the simulator along the same simulated road scenario. At the end of the program, they all drove a timed post-test over the same simulated roadway. Fuel efficiency reports for both tests were compared by the research team.

In early June, the ASU team held four focus groups with a total of 24 drivers (with a range of experience levels) who had completed both the snowplow driver awareness program and the fuel management simulator program. One additional focus group involved the 14 supervisors representing all the maintenance organizational subsections in the Globe district.

In addition to these qualitative sessions, the research team also reviewed computer-generated reports related to individual driver performances in both simulator-based training programs. The reports generated by the snowplow program noted violations incurred by each driver while driving the scenarios in the simulator. Violations included such actions as sliding while trying to accelerate and encroaching on another lane, as well as actual collisions. The reports generated for the fuel management program listed fuel consumption records for each driver and driving-related issues, such as riding the brake or clutch and shifting improperly. The research team reviewed these reports to note trends and to suggest areas for additional simulator training. In addition, the team reviewed accident and claims records for the 2005–2006 snow season in comparison with similar records for the five years prior to simulator-based training.

**Michon’s Driving Model**

To better understand the driving skills important to snowplow operators, the ASU research team rode in plow trucks and interviewed operators. From this information, the various operator activities were sorted into five major categories: Inspecting, Communicating, Driving, Plowing, and Spreading (some of these activities would be different for different types of heavy equipment). Michon’s (1985) driving model was used as a framework onto which this activity model could be overlaid (see Table 1). The description of
Michon’s driving model provided by Wickens, Gordon, and Liu (1998) is especially useful and is worth quoting fully:

Three levels of activity describe the complex set of tasks that comprise driving—strategic, tactical, and control... Strategic tasks focus on the purpose of the trip and the driver’s overall goals; many of these tasks occur before we even get into the car. Strategic tasks include the general process of deciding where to go, when to go, and how to get there... Tactical tasks focus on the choice of maneuvers and immediate goals in getting to a destination. They include speed selection, the decision to pass another vehicle, and the choice of lanes... Control tasks focus on the moment-to-moment operation of the vehicle. These tasks include maintaining a desired speed, keeping the desired distance from the car ahead, and keeping the car in the lane. (p. 438)

The awareness curriculum addresses primarily tactical driving skills related to driving and communicating. The tactical skills are associated with driving activities that include avoiding other drivers and objects and monitoring vehicle speed, all issues that are emphasized strongly in the SIPDE curriculum. While the awareness program was broadly based, the fuel management training program was narrowly focused, emphasizing proper gear shifting (and related clutch usage). As shown in Table 1, gear shifting is comprised of control-level driving skills corresponding to the driving activity of snowplow operation. The TranSim III simulator is capable of supporting either type of training program, but within limits. In particular, the training of control-level skills requires very specific real-world controls (and, other than shifting, few snowplow-related controls are incorporated into the current TranSim III simulator).

**The ADOT Snowplow Operator Training Program**

Snowplow operators must focus not only on driving safely in severe winter conditions; they must also operate a plow, monitor instruments and radios, and look through icy windshields for road obstructions, traffic, and the road’s edge. The challenges faced by all snowplow operators are more obvious in parts of Arizona, where major snow events are infrequent and drivers have limited opportunity to gain or maintain proficiency between these events. In the last five years, snowfall in the Globe district, for example, varied between 38 in. (965 mm) and 80 in. (2,032 mm) per snow season. In 2005–2006, almost all of the snowfall (53.3 in./1,354 mm) occurred during one week in March. Turnover rates of 25% (and higher) among drivers in the district mean that some drivers experience only limited on-the-job training before they drive a plow in a heavy snowstorm.

In addition, the geography of the Globe maintenance district offers numerous challenges to snowplow operators. The northern portion is a high plateau and the southern portion includes two small mining communities wedged up against the mountains and a rural area around the lake created by Roosevelt Dam. In between is a scenic highway characterized by a narrow roadway and many switchbacks with limited shoulders. Guardrails offer drivers the only protection from driving off a cliff in whiteout conditions. Over the 90 miles (145 km) from Globe in the south to the high plateau in the north, the road ascends about 3,000 ft. (915 m). See Figure 3.
Table 1. Snowplow operator activities and Michon’s driver behavior model

<table>
<thead>
<tr>
<th>Activities of snowplow operators</th>
<th>Levels of driving skills</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strategic (Planning)</td>
</tr>
<tr>
<td>Inspecting (pre- and post-trip and while plowing)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Communicating</td>
<td>• Broad ADOT policies (e.g., public safety)</td>
</tr>
<tr>
<td></td>
<td>• District policies</td>
</tr>
<tr>
<td></td>
<td>• Receive orders from Snow Desk</td>
</tr>
<tr>
<td>Driving</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Plowing</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreading</td>
<td>N/A</td>
</tr>
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</table>

Figure 3. Snowplow heads up mountainous highway in Globe district
FINDINGS

Driver Awareness Training

Surveys, designed to measure how well the training was received by snowplow operators, were distributed by the maintenance supervisors in each organizational subsection and returned to the ASU researchers. More than 80% of the drivers returned surveys. Among the respondents, 45% had less than two years experience driving snowplows for ADOT, while 10% had over 16 years of experience. Nevertheless, 75% of all respondents had more than five years experience in driving various other types of heavy equipment.

Most drivers were satisfied with their simulator training. The majority felt that the four-hour classroom/simulator training was adequate. (That was reassuring, since the overwhelming proportion of driver respondents the year before felt that the two-and-a-half-hour program offered by L-3 the year before did not offer enough simulator time.) Among the respondents, 98% felt that they were at least relatively successful in the simulator training. Only 20% of the respondents found the training somewhat demanding; none felt it was very demanding.

Drivers were asked to identify specific challenges that they faced in snowplowing and whether the driver awareness training addressed these challenges. Drivers emphasized problems with limited visibility (53% of respondents) and dealing with traffic (59%) as the two most serious challenges they faced. Twenty-two percent of all respondents felt that the simulator fully addressed these concerns. Among the respondents, 43% felt that they experienced major challenges relating to roadway issues (such as guard rails, narrow mountain roads, and limited roadway shoulders), and only 22% felt these issues were adequately addressed by the simulator scenarios that did not include the roadways as challenging as those in the Globe district. When asked what aspects of the training they were able to use on the job, the largest proportion of driver respondents (29%) noted (via write-in responses) that they were able to use concepts that related to driver alertness to hazards or potential hazards. Indeed, that was the primary focus of the driver awareness simulator training course.

For newer drivers, the simulator training met a real need for practice driving in the snow; 65% of them wanted more time in the simulator. The problem for more experienced drivers, according to survey results, was that the simulator did not include controls for the sander and de-/anti-icing chemicals or levers to lift and angle the plow. These were features that were not available on the L-3 simulator, but represented continuing challenges.

Computer reports were generated in response to each of the three simulator runs performed by individual drivers. They reported a full array of driving violations, including collisions, following distance, sudden deceleration, stalling the engine, riding the brake, and riding the clutch. Among the driver participants, 26.5% were involved in a collision in at least one of the scenarios during the driver awareness program, highlighting the importance of sharpening drivers’ awareness of existing and potential hazards.

There seemed to be some correlation between the number of collisions and the type of scenario. For example, only 10% of drivers experienced a crash in a scenario involving mountain roads, the environment most familiar to Globe district drivers, while 33% of the crashes were associated with a scenario featuring a downtown in a small city. Globe drivers do not typically plow in towns, with signalized intersections, parked cars, and pedestrians. The importance of the awareness training was not lost on drivers who drove the challenging town scenario. An animated discussion followed in the classroom session after all drivers finished the town scenario.
Focus Groups on Driver Awareness

A series of focus groups in June provided an opportunity to follow up on observations shared by the drivers in the April mail-back survey and to probe further into issues related to transfer of training. Recently hired drivers commented that they felt that the driver awareness training offered them a “jump start” on the snowplow season. In Arizona, where the snowplow driver turnover rate is greater than 25% in most maintenance districts, this is a substantial benefit. Some inexperienced drivers recounted stories in which they were white-knuckled while driving in whiteout conditions. But when they stopped, took a deep breath, and reviewed in their minds their awareness training, they were able to persevere. Nearly all of the drivers who experienced the simulator training appreciated the driving awareness aspects, suggesting that it “opens your eyes” and “makes you think.” More experienced drivers, however, again pointed out the need for a simulator with controls they could use to practice key operational skills. They agreed that the SIPDE training course served as a refresher course on overall driver awareness (which was precisely the focus of this training course), but they wanted a program that would sharpen the skills they felt were essential to plowing snow.

A focus group of maintenance supervisors was overwhelmingly positive about the snowplow simulator. They, like the inexperienced drivers, saw the potential of the simulator as a tool for teaching driving safety skills. They also pointed out that even the experienced drivers were not fully alert to potential hazards and were involved in crashes on the simulator. The supervisors felt that operational techniques had to be learned on the job.

Fuel Management Training

Overall, the driver response to the fuel management training was more positive than for the driver awareness training, and there was greater consensus among new drivers and veterans. (Indeed, some veteran drivers admitted that the fuel management training was the first training they had received on the subject of proper shifting techniques).

Although the drivers were virtuously unanimous in their opinion that saving fuel while plowing snow was nearly impossible, many (even some veterans) said they had learned something of value in the fuel management training that they could use year-round. Indeed, reports generated by the simulator suggest that most drivers’ performances did improve over the course of the training, as shown in Figure 4. Figure 4 graphs the changes in miles per gallon used by individual drivers in a timed scenario before and after the training course.

Many drivers, who scored low on their pre-test, made substantial improvements on their post-test at the end of the fuel management course. There were, however, drivers who performed better on their pre-test than on their post-test during the fuel management training. This may be a reflection of the lack of adequate practice time during the training program or of the fact that a number of the drivers regularly use automatic trucks and are not accustomed to shifting gears.

The focus groups revealed that drivers are very much aware of the fuel economy they get with their trucks. Many reported that they have applied the shifting techniques learned in class and have demonstrated improved fuel economy, which is apparent evidence of transfer of training.
ASSESSMENT

How Real is Real Enough?

Many trainees, especially those with many years of driving experience, criticized the driver awareness simulator program for its lack of realism. However, from what the surveys and focus groups revealed, even these skeptical trainees seemed to have learned something from both the driver awareness and fuel management courses. One might reasonably expect there to be a strong relationship between simulator realism and knowledge transfer, but this is not necessarily so. According to Vance et al. (2002), the realism (or fidelity) required of a particular simulator depends upon the training to be conducted, and “certain tasks and skills can be learned even in very crude simulators.” In fact, according to these researchers:

> Reasoning or cognitive ability tasks do not require high physical fidelity levels. The skills in these settings are generalizable to many different areas, not only truck driving, and the physical layout need not be exact. High physical fidelity is necessary when the training involves learning perceptual-motor skills, or the interaction of the trainee with the layout of the equipment. An example of where high fidelity is needed is when the goal is to practice tasks that cannot be practiced in the field because they are too dangerous, such as simulated spinouts on ice. (p. 13)

Transfer of Training

In order to evaluate the effectiveness of the ADOT simulator training program, therefore, the research team focused attention not on the fidelity of the simulator, but on the potential for transfer of training, the ability to apply what is learned in one context to another context (Goldstein 1986). As Emery et al. (1999) note, “The validation of simulation... for the training of a particular skill is most appropriately addressed
through an assessment of whether that training actually transfers to the environment in such a way as to encourage skill proficiency and safe operating practices.”

In the current study, this refers to the ability of snowplow operators to apply what they have learned in the simulator training course to on-the-road driving practice. If drivers trained in the simulator perform better on the road than those drivers not trained in the simulator, then it could be concluded that positive transfer has occurred.

To date, the indicators are the self-reports included in the surveys, positive discussions in focus groups, and individual driver comments about having greater confidence when driving in low visibility. An assessment of crash and claims data proved to be inconclusive because of the limited number of incidents; one crash involving a snowplow can cause a spike in the report. Nevertheless, there are some encouraging initial findings.

**Quantitative Assessment**

Table 2 provides an indication of the level of operational losses associated with snowplowing in the Globe district that were incurred by ADOT over time. These operational loss figures include all ADOT equipment repair costs and claims associated with snowplow-related injuries or accidents. Operational losses included auto liability claims (claims involving a plow’s contact with another motor vehicle), general liability claims (claims by an outside party for damage caused by a plow or plowing materials), injury to private property (inadvertent damage to private property caused by a plow), and ADOT equipment repairs (repairs of plow-related equipment other than normal wear and tear). Workers’ compensation claims are generally not included in operating costs and have not been included in the table. (The liability claim data was obtained through ADOT Risk Management from the Arizona Department of Administration, and ADOT Equipment Services provided the truck repair data.)

Logically, the potential for these losses would increase with the level of exposure, so an effort was made to normalize losses by relating them to levels of exposure. Exposure for snowplowing operations, however, can be measured in different ways. Table 2 divides the total annual operational costs associated with snowplowing in the Globe district first by miles plowed, second by hours of operation, and finally by number of snowfall inches. The table shows considerable variability in terms of level of losses associated with the Globe district over six snow seasons and offers a comparison in terms of several measures of exposure. It is worth noting is that the Globe district fared better in the 2005–2006 snow season after all its drivers had taken the awareness simulator training. The loss costs were lower in terms of all measures of exposure after the simulator training program. (The figures in the table do not reflect any annual compounding.)

As indicated above, a single major accident, even one where the ADOT driver is not at fault, can cause the operational losses to spike in a single season, despite all efforts to train drivers. Nevertheless, the decline in total operational losses and in all measures of exposure is encouraging. Future years of data will indicate whether this trend can be sustained.
Table 2. Measures of exposure related to operational loss costs in Globe, AZ

<table>
<thead>
<tr>
<th>Snow season</th>
<th>Total operational loss costs associated with snowplowing ($)</th>
<th>Cost/mile of snowplow operation ($/mile)</th>
<th>Cost/hour of snowplow operation ($/hour)</th>
<th>Cost/inch of snowfall ($/inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999–2000</td>
<td>14,332</td>
<td>0.14</td>
<td>3.35</td>
<td>480.94</td>
</tr>
<tr>
<td>2000–2001</td>
<td>7,640</td>
<td>0.03</td>
<td>0.66</td>
<td>78.68</td>
</tr>
<tr>
<td>2001–2002</td>
<td>6,916</td>
<td>0.04</td>
<td>1.09</td>
<td>181.52</td>
</tr>
<tr>
<td>2002–2003</td>
<td>19,911</td>
<td>0.10</td>
<td>2.59</td>
<td>247.65</td>
</tr>
<tr>
<td>2003–2004</td>
<td>5,450</td>
<td>0.02</td>
<td>0.64</td>
<td>105.62</td>
</tr>
<tr>
<td>2004–2005</td>
<td>42,574</td>
<td>0.25</td>
<td>5.00</td>
<td>588.03</td>
</tr>
<tr>
<td>2005–2006</td>
<td>18,631</td>
<td>0.19</td>
<td>3.05</td>
<td>355.17</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The driver awareness program seemed to do a good job of training tactical skills, while the fuel management program seemed to do a good job of teaching control skills. However, all of the training took place on the same driving simulator. Transfer of training, therefore, seems to have as much to do with the skills being trained as the simulator’s realism (or fidelity). While none of the control skills shown in Table 1 is addressed in the driver awareness program, it is important to note that the program was never intended to teach control skills. The L-3 TranSim VS III model simulator lacks the physical fidelity needed to facilitate training of many control skills (gear shifting being a notable exception).

The fuel management training program is much more narrowly focused, emphasizing proper gear shifting (and related clutch usage). As shown in Table 1, gear shifting is comprised of control-level driving skills corresponding to the driving activity of snowplow operation. Here, there are already indications that positive transfer of training is taking place. Drivers in the focus groups reported that they quickly applied what they had learned on the simulator to their everyday driving and saw positive results (not only in ADOT vehicles, but in their personal vehicles as well). Although not statistically significant, study results also suggest positive transfer of training. A more complete analysis is underway in a follow up study.

Findings Related to the Michon Model

The findings, when seen through the lens of Michon’s driving model, lead to some useful insights. These insights may be valuable to others considering the use of simulators for training operators of snowplows or other heavy equipment.

1. New and experienced snowplow operators seem to want different things from simulator training. While the novices are content with learning tactical-level driving skills, veterans look to the simulator primarily for a “refresher course” focused on control-level skills (the skills they don’t get during their daily off-season work). How well each group of drivers will respond to simulator training, therefore, may depend on the driving skills being taught.

For states like Arizona, with high rates of driver turnover, even simulators with relatively low physical fidelity might be very useful for training tactical-level driving skills that are more closely related to issues of safety, the primary concern of DOTs. This, of course, is precisely the point emphasized in driver awareness courses.

The strong relationship between safety and tactical skills may help explain the apparent contradiction between the supervisors’ and the veteran drivers’ views of the simulator training.
ADOT supervisors seem to focus primarily on tactical-level skills that further safety, rather than the control-level skills desired by experienced drivers.

2. It may be easier to quantify transfer of control-level skills than transfer of tactical-level skills. Because tactical skills are more “big picture” skills, they are also more complex to study and measure. It’s relatively easy to determine if drivers are shifting gears more efficiently (e.g., fuel consumption, reduced clutch maintenance, etc.), but it’s much more challenging to determine if drivers are using SIPDE techniques. It is important to note, however, that “overlearning” control-level skills frees up cognitive resources, and therefore may improve performance of tactical skills; these two skill types are clearly interrelated.

For the purposes of a cost/benefit analysis, focusing on issues related to control-level skills may prove more fruitful than focusing on more elusive issues related to tactical-level skills. However, if it is true that safety issues are more strongly related to tactical skills (see (1) above), then issues related to tactical skills must not be ignored for the sake of a simpler cost/benefit analysis.

3. How a training program is presented to trainees is critical to its success. For example, some drivers resented the thought of being taught fuel management. Drivers were virtually unanimous in their opinion that saving fuel while at the same time plowing snow was nearly impossible. However, they were quite eager to learn about proper shifting techniques (which was the real focus of the course). Similarly, the driver awareness course was generally referred to as “Snowplow Simulator Training,” which built up specific expectations (for control-level skills training) in the minds of trainees. Had the course been called something like “Driving Awareness Training,” perhaps it would have been better received (especially by those who criticized its lack of realism).

The first step in designing or purchasing a training program, then, ought to be asking what driving skills are needed. (This ought to be straightforward, since training is generally aimed at addressing some existing problem.) Are the skills to be taught control-level or tactical-level skills? How the course is marketed to trainees (and others in the organization) should be based on the skills being taught. It seems reasonable to think that training programs that are better received by trainees are more likely to be more effective learning tools.

4. Trainees were unanimous in their praise of the ADOT trainers, who are all veteran snowplow operators. In fact, the trainees reported that they learned as much from the low-tech storytelling aspects of the training sessions as from the high-tech simulator. These in-house trainers are valuable assets to the organization and could be leveraged further in a variety of training programs (especially important in organizations with high turnover rates). They have such a wealth of personal experience that they are able to teach both tactical- and control-level driving skills, which may translate to the simulator environment.

SUMMARY

The experience with simulator training for snowplow operators in Arizona leaves both the research team and ADOT optimistic about the potential for driving simulators to be an integral part of a comprehensive driver training program for state DOTs. Clearly, there are elements of these driver training programs for which the simulator is not well-suited; this is especially true of simulators with low physical fidelity. Nothing can replace real-world, behind-the-wheel training. Broadly speaking, simulators seem to be better at training for tactical-level driving skills than for control-level driving skills. However, when appropriately equipped, simulators can be effective tools for teaching control skills as well.
REFERENCES


