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**RESEARCH
NOTES:**

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SNOWPLOW SIMULATOR TRAINING EVALUATION

BACKGROUND

Snowplow drivers must operate \$200,000 units of heavy equipment during long, stressful shifts through blinding snowstorms under demanding traffic conditions. Yet traditional training, with limited funding and staff, can result in new drivers being sent out alone after only two or three storm shifts with a trainer. For this level of responsibility, training needs to be enhanced, to improve driver safety and morale.

In response to this need, the Technical Training Group (ITD-Tech) of the Arizona Department of Transportation (ADOT) contracted in late 2004 with L-3 Communications - MPRI Ship Analytics to give third-party simulator training to snowplow operators in rural Arizona. L-3's mobile simulator classroom traveled to five ADOT districts: Globe, Flagstaff, Holbrook, Kingman, and Safford. L-3 instructors delivered a 2-1/2-hour basic safety awareness course, with both classroom and simulator training segments. The Year One trainee group (the 2004-05 snow season) included 149 snowplow drivers.

Based on initial field reactions to the L-3 training and after a review of similar options, ADOT procured its own L-3 simulator for Year Two, which was assigned to the Globe Maintenance District.

In Year Two (the 2005-06 snow season), more extensive in-depth training was provided on this new L-3 TranSim VSIII simulator. All 61 Globe snowplow operators were trained, in two four-hour courses: situational and space awareness training in the fall, and then, fuel management and shifting skills in the spring. All of the Year Two trainers were experienced ADOT snowplow operators from the Globe District.

In late 2004, an interdisciplinary team from Arizona State University (ASU) was engaged to evaluate the effectiveness of driving-simulator-based training for snowplow drivers as a new dimension in ADOT's winter maintenance training program. The study was conducted for ADOT's Arizona Transportation Research Center (ATRC) and the Technical Training Group. The key focus areas were driver response to the simulator training, and the effectiveness of that training in terms of both public safety and potential ADOT cost savings.

RESEARCH

The university team evaluated the effectiveness of simulator training through quantitative and qualitative assessments of driver response to the training. In Year One, the trainee snowplow drivers were surveyed on the training they had received in the simulator, followed by a series of focus groups at the end of the snowplow season. Interviews with maintenance supervisors and a ride-along task analysis also provided useful qualitative information.

A parallel assessment in Year Two provided a comparative evaluation. The ASU team also held four post-winter focus groups in the Globe District, and a fifth focus group involved the supervisors from all seven maintenance yards in the district.

Training snowplow drivers via simulators is a relatively new concept, although driving simulators have been widely used for human factor research and automobile driver training for more than 30 years. Simulators offer a safe environment to practice infrequent, dangerous driving scenarios (e.g., a tire blowout). A driver who has over-learned the proper skills in a simulator may be better equipped to

manage an actual blowout in real life. By incorporating “active error training,” a process in which trainees learn by making errors, driving simulators can be effective tools for what is called “analogical transfer.” Through repetitive practice of specific skills, drivers develop expertise at skills similar to those being taught. Simulators are also well suited to training for “adaptive transfer,” using one’s existing knowledge base to change a learned procedure, or develop a new solution to a problem.

ASU Mid-Season Survey Results

In the Year One survey in early 2005, over 44 percent of the trainees said the L-3 course had fully related to challenges they faced, and another 40 percent felt that it related to some of their concerns. In Year Two, 49 percent of the trainees felt that it related to their specific challenges, but 41 percent said it had not sufficiently addressed issues of visibility, traffic, roadway hazards, and actual plow operations.

As to further training, the majority in Year One wanted scenarios relating more closely to local conditions, and this was still an issue in Year Two. Most of the drivers in Year Two were satisfied with the fidelity of the simulator. Still, 65 percent of the more experienced drivers and 35 percent of the less experienced drivers called for more local scenarios in Year Two.

In Year Two, drivers were also asked which of the concepts they learned in the simulator had been used on the job. Not surprisingly, 26 percent of these respondents made observations related to awareness, which was the primary focus of the course. Another 9 percent made comments relating to hazards on the road, and a number of other points were also noted.

Driver Focus Groups and Field Staff Interviews

At the end of the Year One snow season, in spring 2005, ASU held focus groups in Globe, Kingman, Flagstaff, Holbrook, and Safford to get longer-term perspectives from snowplow drivers on the L-3 training program. What emerged was a wealth of information on the December 2004 simulator course, as well as a fuller understanding of the multi-task aspects of driving and of the challenging conditions facing snowplow drivers.

In June 2006, in four focus groups in the Globe District, Year Two drivers again conveyed their enthusiasm for the potential of the simulator-training program. The topics discussed included the “driver awareness” training offered in the fall, and the “fuel management and shifting” training offered in the spring. In terms of driver awareness training, there

was a striking difference between attitudes of the newer and more experienced drivers. Newer drivers were enthusiastic about the chance for a jump-start on the season, and said the simulator training had helped them though some “white knuckle” plowing challenges. The experienced drivers said they learned little that was new, and without operational controls on the simulator, they could not practice the more challenging multi-tasking aspects of plow operation.

The spring 2006 fuel management/shifting training was well received by all Globe drivers operating manual transmission vehicles, who immediately put their training into practice to see how much fuel they could save. Those driving trucks with automatic transmissions found it not particularly useful. The simulator can report on each trainee’s driving performance in such areas as riding the clutch, riding the brake, and grinding the gears. Training in these areas might reduce the amount of maintenance and keep the full fleet operational in a snowstorm.

In Year One, the ASU team also visited with district maintenance managers about initial perceptions of the simulator training. Most were optimistic about the potential benefits; their comments on the need for greater realism echoed those of the drivers. A Year Two focus group with Globe District supervisors reinforced their enthusiasm for a system that can provide new drivers with a jump on the snow season, and also give more experienced drivers a refresher before the start of the winter.

Quantitative Assessment

A parallel quantitative study was launched to determine benefits and costs of snowplow simulator training. The study involved assessments of historical data on plowing accidents, liability and insurance claims, and repair records of ADOT snowplows over five winter seasons (1999-2000 through 2003-04). This established a baseline for measuring the effectiveness of two years of simulator training to reduce repair costs to snowplows, to reduce snowplow-related accidents, and to improve roadway driving conditions so as to reduce accident rates on Arizona highways.

ADOT equipment repair records for the 2004-05 winter season showed that six of the 149 drivers with initial simulator training were involved in accidents, resulting in \$9,968 in repair costs. By contrast, nine of the 145 snowplow drivers who were not simulator trained had accidents that caused \$15,973 in repairs to ADOT equipment. These findings are not statistically significant, but they may indicate a trend. For Year Two, plowing repair figures for Globe were

compared to the other four Year One districts, as well as for Prescott, which had no simulator training. The results were inconclusive; Globe's Year Two figures were similar to other districts, and in some cases, higher. Given the small number of accidents in any snow season, a single event is likely to skew reports of repair costs, however. And, accident avoidance is very difficult to quantify. Nevertheless, when repair costs and liability costs are related to driver *exposure* (measured in terms of miles plowed, or hours spent in plowing, or in snowfall inches) the performance in Globe improved on all three measures after the intensive simulator training in Year Two.

Public Safety

Another indicator of snowplow training effectiveness relates to overall public safety. The stated goal of ADOT snow-management planning is "to provide safe and reliable surfaces for public vehicular use in transporting persons and products." The proportion of injury-related and fatal accidents associated with snow and ice are relatively small in Arizona, generally less than one percent of such accidents in the state in any given year. Still, the cost impact to Arizona of the 335 personal injuries and 10 fatalities on snow, slush, and ice-covered roadways in 2005 is estimated as \$18,012,940. Training ADOT snowplow operators to maneuver more efficiently and safely is expected to result in fewer snowplow accidents, and to also reduce accidents among private vehicles.

Commercial Shipping Delays

Minimizing delay costs for commercial freight shipments in winter is another potential long-term benefit of simulator training. Arizona commercial vehicle operators estimate that a one-day delay costs \$700 per truck, and a one-hour delay costs \$65. On average, 5,177 trucks cross Interstate 40 daily in the snow season. Using Arizona figures, just a one-hour delay can cost freight operators more than \$335,505. If all those trucks had to make the full 355-mile trip on snowy and icy roads across the state at 40 mph, rather than the typical 60 mph, the resulting three-hour delay would cost them more than \$1 million.

Efficient, effective snow removal is essential to keeping Arizona's highways open. The simulator is essentially an investment in sharpening the skills and effectiveness of ADOT snowplow operators, helping to assure that the priority routes stay open.

Transfer of Training

In order to evaluate the effectiveness of the ADOT simulator-training program, the ASU research team focused on transfer of training: the ability to apply what is learned in one context to another. In the

current study, this refers to the ability of snowplow operators to apply what they have learned in their simulator training to on-the-road driving practice.

To better understand the key driving skills required, the ASU team rode in plow trucks and held focus groups with operators. From this, they sorted the key driving activities into five categories: Inspecting, Communicating, Driving, Plowing and Spreading. Michon's (1985) driving model served as the framework for this activity model. Three levels of activity describe the 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. Tactical tasks focus on the choice of maneuvers and immediate goals in getting to a destination. Control tasks focus on the moment-to-moment operation of the vehicle.

Driving Skills and Transfer of Training

The surveys, focus groups, and performance reports recorded by the simulator all suggest that the L-3 SIPDE (Search, Identify, Predict, Decide and Execute) Driver Awareness course was relatively successful at training tactical skills, but less so for control skills. The Fuel Management and shifting program, on the other hand, seems better designed for teaching control skills.

While the SIPDE-Driver Awareness program has a broad focus, the L-3 Fuel Management and shifting training is more narrowly focused on proper gear shifting and related clutch usage. Drivers reported that they quickly applied what they had learned, and saw positive results. Although not statistically significant, the results do suggest positive transfer of training of tactical skills from Driver Awareness training, and control skills from Fuel Management

Summary Observations

Based on the Year Two experience in Globe, and the need for consistent new-hire training, ADOT made a policy decision to procure two more L-3 simulators in mid-2006, in order to expand this training program into more of its critical snow-country districts. With three units now deployed to the Globe, Flagstaff, and Holbrook Districts, the following points, as regards sound planning and consistent training course development, will be crucial.

1. New and experienced snowplow operators seem to want different things from the L-3 simulator training. How well each group of drivers will respond to the simulator training may depend on the driving skills being taught. For states like Arizona, with high rates of driver turnover, the current simulators are quite useful for training tactical-level driving skills for

inexperienced drivers and enhancing their safety — the primary concern for all levels of DOT agencies.

2. It may be easier to quantify the transfer of control-level skills than the transfer of tactical-level skills. Tactical skills are more “big picture” skills, and therefore are more complex to study and measure. It is relatively easy, however, to determine if drivers are shifting gears more efficiently (e.g., by way of fuel consumption, reduced clutch maintenance, etc.).

3. How a training program is presented to trainees is critical to its success. The first step in designing or purchasing a training program, then, ought to be asking what driving skills are needed and how is the course to be “marketed” to trainees? ADOT’s new Simulator Working Group (SWG) for 2006-07 includes the Globe, Flagstaff, and Holbrook Districts, each with an L-3 unit. This team of plow operator-field trainers will be critical in defining desired outcomes of the simulator training, and in shaping the way in which it is marketed to trainees.

4. Globe trainees unanimously praised the ADOT trainers - all veteran snowplow operators. In fact, the trainees reported that they learned a great deal from the ‘low-tech’ storytelling aspects of their training sessions, as well as from the ‘high-tech’ simulator.

RECOMMENDATIONS

The following specific recommendations are drawn from the research team’s two-year assessment:

- Offer consistent programs in all three of the districts with simulators in 2006-07, and maximize the Globe successes in using experienced local drivers as trainers.
- Challenge the new multi-district Working Group to identify specific training issues, and to refine the simulator programs to address those concerns. Market the courses with titles that clearly inform drivers and underscore course objectives. For example, winter SIPDE classes could be called Driver Safety or Driver Awareness Training, and the spring fuel management course might be called Training in Driving Techniques.
- Enhance the content of the courses so that they relate to challenges faced in the real world, and allow

the drivers time to practice using scenarios to address those challenges.

- Enhance driving technique courses with training of key functions for all participants. In a course on manual shifting techniques, for example, add relevant lessons for drivers of automatic transmission trucks.
- Offer all drivers documented feedback on their performance, and the opportunity to practice in their areas of concern.
- Separate the more experienced drivers from the less experienced or new drivers in SIPDE - Driver Awareness courses.
- Offer the more experienced drivers an advanced class on those tactical issues that are challenging for all drivers, such as dealing with motorists, visibility, and hazards, in as realistic a setting as possible.
- Provide more independent practice time for less experienced drivers so that they can better integrate their simulator and their on-the-job training.
- Enhance the fuel management / shifting course with more focus on reports provided by the simulator. Criteria can be set to reflect desired driving policies of each district, and of ADOT in general.
- Incorporate references to the de-icing training by highlighting the timing and conditions for applying the chemicals, and encouraging drivers to regularly check their (imaginary) temperature gauge.

SUMMARY

Two years of experience with simulator training for snowplow operators in Arizona leaves an optimistic feeling about the potential of simulators as an integral part of comprehensive winter maintenance and driver-skill training programs.

Further research has been initiated for a third year, with a focus on proper gear shifting (a control-level skill) to improve fuel efficiency and to reduce repair costs. As the study proceeds, it will continue to evaluate the simulator’s effectiveness, providing quantitative documentation to reinforce the qualitative results and to define broader benefits of the driving simulator for heavy equipment operations.

The full report: *Snowplow Simulator Training Evaluation*, by Dr. Mary Kihl with Donald Herring, Peter Wolf, Stephanie McVey and Vamshee Kovuru, Arizona State University (Arizona Department of Transportation, report number FHWA-AZ-06-585, November 2006) is available on the Internet. Educational and governmental agencies may order print copies from the Arizona Transportation Research Center, 206 South 17th Avenue, MD 075R, Phoenix, AZ 85007; FAX 602-712-3400. Businesses may order copies from ADOT’s Engineering Records Section.