Post-Fielding Training Assessment of Dismounted Infantry Simulation

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ABSTRACT

The assessment of training effectiveness for virtual-training systems is best accomplished with two complimentary approaches: experimentation and post-fielding assessment. Obviously, experimentation involves the controlled assessment of system capabilities that should have an impact on training. By contrast, a post-fielding assessment determines the practical advantages and limitations of the system in the context of mission training and can be used to discover ways to increase system utilization and effectiveness. This paper reports the results of a post-fielding assessment of the U.S. Army's recently fielded dismounted infantry simulator: Dismounted Soldier Training System (DSTS). The goal of the assessment was to collect input on DSTS training effectiveness and training issues from Leaders and Soldiers who have used DSTS at home station. A total of 58 surveys and 122 interviews from Leaders (82), Soldiers (90), and DSTS Operators (8) were collected over six months from five U.S. Army installations. On the surveys, respondents indicated that DSTS is capable of providing a training environment for collective task training and assessment. The after action review (AAR) system, as a training tool, received the most positive responses. Respondents were equally vocal in identifying training distracters. Technical issues and simulator sickness were identified as causes of suspended training, while over half of the Soldiers reported less than a complete feeling of immersion. The interview responses echoed these themes and provided insights on effective planning, preparation, and execution of DSTS training. Overall, the results showed that dismounted infantry simulation showed promise as an effective training device. However, improvements to the technology were still needed to provide a reliable training environment. The results also highlighted the positive impact of effective AAR capabilities on training. Future development of dismounted infantry simulation training should formalize the unique AAR capabilities of the technology to provide formative feedback to Soldiers.

ABOUT THE AUTHORS

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INTRODUCTION

The *sin qua non* of training effectiveness is the transfer of skills from the training environment to the real-world. This criterion is especially salient for simulation training because of the many physical-fidelity compromises required in the development of simulation (Bell & Waag, 1998; Blaiwes, Puig, & Regan, 1973; Lintern, 1991). The degree of skills transfer in simulation is, for the most part, a product of the *affordances* available in the simulation environment (Bink, Ingurgio, & James, 2013; Lintern). In one sense, "affordances" refer to a minimum set of properties the simulation must provide in order to allow a given skill to be developed. These *training invariants* (Bink, et al.) can be estimated by or predicted from training performance data in a controlled environment and is usually conducted before a simulator is fielded to provide formative information for system development. In another sense, "affordances" refer to the practical tasks or behaviors that can be accomplished (E. J. Gibson & Walker, 1984; Stoffregen, 2003) in a given simulation regardless of the intended functionality of the device. These *practical* considerations can best be analyzed from trainees' reactions to actual fielded training.

Because skill transfer depends on both the sufficiency of training invariants and the degree of practical utilization, the assessment of training effectiveness for virtual-training systems is best accomplished with two complimentary approaches: pre-fielding experimentation and post-fielding assessment. Obviously, experimentation involves the controlled assessment of system capabilities that should have an impact on training. By contrast, a post-fielding assessment determines the practical advantages and limitations of the system in the context of mission training and can be used to discover ways to increase system utilization and effectiveness. This paper reports the results of a post-fielding assessment of the U.S. Army's recently fielded dismounted infantry simulator: Dismounted Soldier Training System (DSTS). The results of the post-fielding assessment compliment the results from previous research on DSTS training invariants (Bink et al., 2013) to provide a more comprehensive understanding of the training effectiveness of DSTS.

Dismounted Soldier Training System

DSTS operates on a wireless network allowing Soldiers and weapons to be un-tethered from any external mechanism. The Soldiers wear a backpack computer that generates the virtual environment, a helmet mounted display (HMD) to view the virtual environment, and a surrogate weapon (e.g., M4 carbine or M249 machine gun) with a virtual optic rendered in the virtual environment. The Soldiers remain relatively stationary on a 4-foot diameter pad, and virtual movement is controlled by a thumbstick located on the vertical handgrip of the surrogate weapon. Body sensors translate physical movement of arms and head into virtual movement of arms and head. Soldiers' physical movement from standing to kneeling to prone is captured by leg sensors and mirrored in the VE. The system utilizes radio frequency identification (RFID) tags and hand sensors to allow the Soldier to select and manipulate additional items in the virtual environment, e.g., throw a grenade or open doors. There are five components in a DSTS suite (see Figure 1):

- The nine *Virtual Soldier Manned Modules* (VSMM) consist of a helmet-mounted display with one head sensor, a backpack computer with attached communications junction box, a sensor harness with three sensors per arm and one sensor per leg, a headset and microphone, and a surrogate weapon system with sensor and thumbstick controller.
- The *Virtual Soldier Multi-Functional Work Stations* (VSMW) is a networked desktop computer with keyboard and monitor. The VSMW is a desk top Virtual Battle Space terminal that can be used to replicate

combat multipliers in support of the Infantry Squad. Operators of the VSMW can fill the roles of machine gun teams, vehicle crews, or other roles within any combat unit.

- The *Semi-Automated Force* (SAF) workstation is a networked desktop computer with keyboard and monitor that has the capability of controlling single or multiple SAF. Operators of the SAF workstation have a dual-purpose function as a SAF controller or, if necessary, another VSMW workstation operator.
- The *Exercise Control* (EXCON) workstation consists of a keyboard and two flat panel displays. The EXCON operator controls the DSTS hardware to include powering-up, initialization, troubleshooting and monitoring of the system over the network. The operator is also responsible for modifying, loading, and running each training scenario.
- The *After Action Review* (AAR) station consists of two large flat panel displays, a keyboard, and a mouse. The station uses the Virtual Battle Space 2 AAR capability to record and playback the executed scenario.

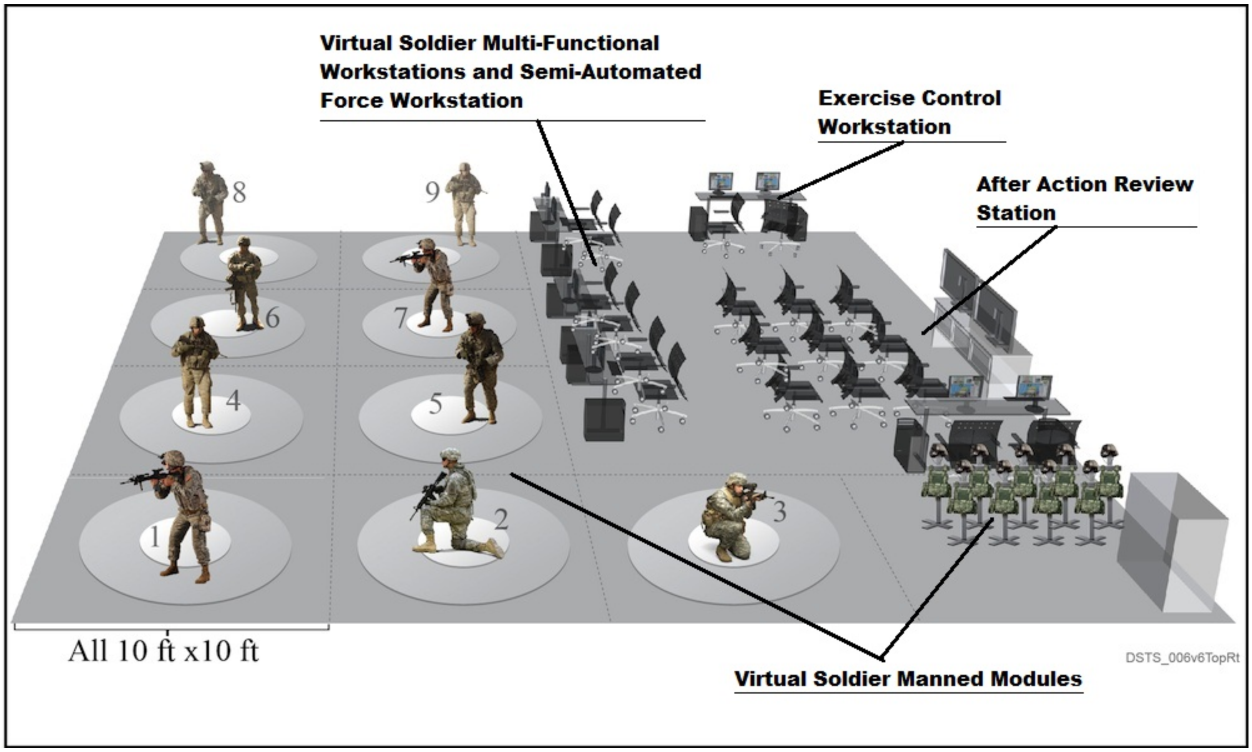

Figure 1. Example Dismounted Soldier Training System Configuration

Assessment of DSTS Training Effectiveness

Affordances are generally defined as functional properties of the environment that prescribe potential action (J. J. Gibson, 1979; Greeno, 1994). Affordances in training can be used to describe a minimum set of sensorimotor properties a training environment (e.g., a simulator) must provide in order for a given skill to be developed (Gross, Stanney, & Cohn, 2005). These so-called training invariants are inherent properties of the training environment that makes critical sensorimotor interaction possible (Bink et al., 2013). Training invariants do not represent tactical skills themselves, but describe sensorimotor interactions that are critical components of skills that make transfer possible (Lintern, 1991). For example, "react to contact" is a tactical skill that should be trainable in dismounted infantry simulation. The ability to train react to contact depends on how well dismounts can identify the origin of fire in the virtual environment.

A set of training invariants for Infantry squad collective skills was identified and was applied to the assessment of DSTS. In order for DSTS (or other dismounted infantry simulations) to support the types of tactical skills necessary for dismounted-infantry operations, the system must allow individual Soldiers to maintain physical orientation in the environment, maneuver in the environment, interact with objects in the environment, communicate with others in the environment, and coordinate action with others (Bink et al., 2013; Knerr, 2007). The assessment of dismounted-infantry training invariants in DSTS used Soldier performance data collected during two capabilities experiments. In both experiments, Soldiers conducted dismounted infantry small-unit tasks (e.g., area reconnaissance) in DSTS and provided feedback on the similarity and difficulty of performing 56 individual and collective actions that support those tasks (e.g., move up and down stairs) and that should be simulated by the immersive system (Pleban, Eakin, & Salter, 2000). The results of the experimentation suggested that DSTS did not fully provide the basic sensory-motor orientation and communication capabilities (i.e., training invariants) that are critical for dismounted simulation trainability. The potential advantages and limitations of DSTS implied by the results suggested that training in large complex environments and interacting with mechanized assets would be difficult with DSTS. By contrast, the results also suggested DSTS could be effectively used to train smaller groups (i.e., fire team or buddy team) in part-task-type training. For example, DSTS would be an effective means to get multiple repetitions of fire team or buddy team move-and-shoot drills or room clearing drills in advance of higher-level collective-training events.

It should be recognized that an analysis of training invariants only provides an understanding of the *potential* training effectiveness of DSTS. While the assessment of training invariants involved actual Soldiers executing actual dismounted infantry tasks, the tasks were performed in the context of experimentation and not for unit training. It may be the case that Leaders and Soldiers find DSTS effective for certain aspects of unit training and recognize a benefit of using DSTS in planning a sequence of training. In order to fully understand the utility of DSTS to train dismounted infantry, data was needed from Soldiers who used DSTS as part of home-station training. There were four goals of the analysis of home-station training:

1. To verify if the insufficiencies in the training invariants negatively impact DSTS training;
2. To identify any potential benefits of DSTS to unit training;
3. To identify the types of training best accomplished in DSTS; and
4. To identify any other technical or procedural issues that would hinder DSTS training.

METHOD

As the Army program of record for dismounted squad collective training, the original DSTS fielding plan deployed a total of 36 training systems to 27 installations between July 2012 and June 2013 with multiple suites (i.e., 2 or 3) located at six installations. Five of the six installations with multiple DSTS suites were used for data collection. A two-pronged quantitative and qualitative approach was used to determine the perceived training capabilities of DSTS and how DSTS was actually used in training. First, surveys were administered to Squad Leaders and Team Leaders at the five Army installations. Second, focus-group interview sessions were conducted with Soldiers, Leaders, and DSTS Operators at those installations.

A total of 58 surveys and 122 interviews from Leaders (82), Soldiers (90), and DSTS Operators (8) were collected. For each installation, the data collection occurred approximately six months after receiving DSTS. This delay assured that DSTS would be utilized from a variety of units and allowed for the possibility that some units would have used DSTS multiple times. In the end, most participants only trained in DSTS one time, but two participants trained in DSTS four times. All participants were from Infantry, Cavalry, or Military Police units.

The survey consisted of two sets of items. The first set of items presented 14 training capabilities to which respondents used a 4-point Likert scale (strongly disagree to strongly agree) to indicate how well DSTS fulfilled those capabilities. The second set used checklists and open-ended responses to capture perspectives on technical issues (e.g., simulator sickness) and the utility of DSTS. The focus-group interview protocol contained between nine and 14 questions focused on planning, preparation, and execution of training and on future uses of DSTS. Three versions of the protocol were developed with each version adapted for each type of participant (i.e., Soldiers, Leaders, and DSTS operators). At each installation, surveys were distributed before interviews were conducted. The surveys were administered by DSTS operators immediately following training in DSTS. The 17 interview sessions were conducted by the second and third authors within a month following a DSTS training session. All participants provided data for only one data-collection session (i.e., only completed a survey or only participated in an interview).

RESULTS

Training Capabilities

A combination of survey responses and interview responses were used to determine the sufficiency of DSTS training capabilities. The percent of survey responses for the “agree” categories and the “disagree” categories were analyzed on each of the 14 Likert-type items. As can be seen in Table 1, the vast majority of respondents agreed that DSTS was effective for all but one training capability. On the one hand, the AAR capability was rated as extremely useful for training. On the other hand, audio and visual cues were rated as insufficient for training.

Table 1. Rank-Ordered Percent of Responses to DSTS Technical Capabilities

	Response Category	
	Agree	Disagree
The AAR System made it easy to determine why things happened the way they did during a mission.	93%	7%
Training in DSTS provided sufficiently realistic conditions in which to train in operational environments.	90%	10%
DSTS would allow your unit to conduct actions on contact in training.	88%	12%
Training in DSTS improved your ability to make more rapid tactical decisions.	86%	14%
Training in DSTS allowed your unit to build proficiency at performing leader, collective, and individual tasks that directly support your unit’s mission.	81%	19%
Training in DSTS improved your individual task performance (Move, Shoot, and Communicate).	79%	21%
Training in DSTS made your unit more prepared to conduct similar live missions (mission rehearsal).	79%	21%
Training in DSTS made you more confident in your ability to make tactical decisions.	78%	22%
DSTS would allow your unit to conduct integration of Fires in training.	77%	23%
Training in DSTS improved your unit’s battle drills.	74%	26%
The audio/visual cues were distinct enough to identify to discriminate between non-combatants and combatants.	74%	26%
DSTS would allow your unit to conduct tasks that are difficult to do in live training.	74%	26%
DSTS would allow you to conduct coordination with adjacent units in training.	73%	27%
The audio/visual cues were distinct enough to identify direction of fire.	31%	69%

In interviews, Leaders and Soldiers both indicated that DSTS has the capability and flexibility for conducting a myriad of collective tasks. In particular, responses indicated that DSTS would be particularly useful for conducting fundamental shoot, move, and communicate training (react to contact – return fire, seek cover, report) for new Soldiers, Joint Readiness Training Center pre-training, patrolling, integration of combat multipliers (e.g., artillery, and fixed and rotary wing close air support), and improvised explosive device lane training. As with the survey results, the interview results also provided very positive feedback on the AAR capabilities. Soldiers indicated that they were able to “ID [identify] our mistakes” and that during subsequent iterations of the scenarios “our communications improved.”

Technical Issues and Immersion

Responses given in the survey written comments and in the interviews supported the overall view that DSTS provided training value, but technical issues (e.g., reliability) detracted from the overall training value. For example, 57 out of 58 survey respondents indicated that at least one technical issue occurred during training, and 50% of survey respondents reported experiencing at least one simulator-sickness symptom. Likewise, 33% of interview participants (Soldiers) indicated having simulator-sickness symptoms, 11 of which stated the symptoms affected their performance. Seven of the 11 Soldiers indicated that they were removed from DSTS with the most severe symptoms resulting in vomiting.

For the most part, the technical issues led to the loss of immersion, or "presence," in the simulation. Presence has been defined as "the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)" (Knerr et al., 1998, p. 32), or in laymen's terms a sense of "being there." In the interviews, 41% of the Soldiers responded "Yes" they felt fully immersed, while 59% responded "No." Some factors that contributed to presence were the realism of the scenarios and the ability to view the scenario in a natural way through the helmet-mounted display (i.e., turning their heads and seeing the corresponding change in view of the virtual world). By contrast, both survey responses and interview responses indicated that the distraction due to the frequent need to recalibrate the system, the open communications channel (i.e., Soldiers can hear all voice chatter regardless of relative location in the virtual environment), and difficulty in controlling and moving the virtual avatar all contributed to the lack of presence.

Best Uses of DSTS in Training

Most Leaders in the interviews indicated their lack of familiarity with DSTS before training precluded their ability to effectively integrate the simulation into their training plans. However, after recognizing the capabilities of the simulator, the majority (92%) of the Leaders also indicated that they would use DSTS to train their Soldiers in the future. The best training uses of DSTS identified in interviews and surveys involved training collective tasks for new or young Soldiers with examples such as situational training exercises and urban operations for the Fire Team or Squad that exercised communication, formations and order of movement exercises, and battle drills. In addition, DSTS was perceived as useful for mission rehearsal exercises, exercising command and control, developing and validating standard operating procedures (SOP), and rehearsing any high-risk events. Figure 2 presents the frequencies of survey responses that identified useful aspects of DSTS. Clearly, the data in Figure 2 indicates DSTS was useful for developing communication SOPs and practicing battle drills. It is also important to note that only one Leader reported any attempt to train combined arms maneuvers in DSTS. This fact is important because it was noted in the pre-fielding assessment that training with mechanized assets would be difficult in DSTS.

Current utilization of DSTS, as indicated by the majority of the participants, is purely introductory and constrained by time and knowledge of the simulator. For example, interviews revealed that units (Squads or Sections) who scheduled DSTS for one day were limited to an average of 2.5 hours of familiarization training followed by an average of 3.0 hours of situational-exercise training. The exceptions were two platoons of Infantry Soldiers whose leaders conducted pre-coordination and scheduled one week of training. These Soldiers conducted the same amount of familiarization training but then progressed through a series of pre-planned daily exercises designed to prepare the Squads for a scheduled live fire exercise.

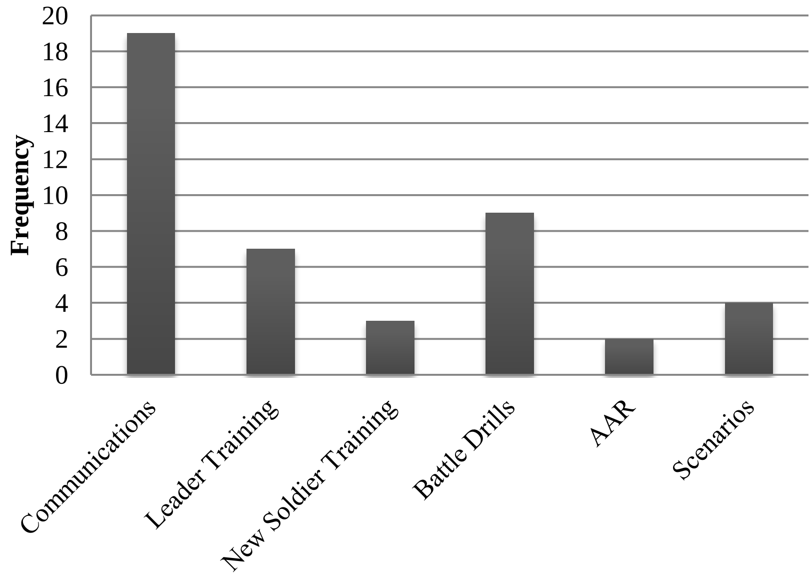

Figure 2. Response Frequencies for the "Useful Aspects" of DSTS

DISCUSSION

Overall, the results of the post-fielding evaluation indicated that DSTS provided training value, but technical issues, simulator sickness, and low perceived levels of immersion detracted from the overall training effectiveness. To a certain extent, these results were not surprising. Simulating dismounted infantry is a very difficult endeavor. Simulating humans in a natural environment is difficult because the human-environment interface is dynamic and the human directly interacts with the physical environment. The technology for dismounted infantry is still relatively immature compared to the technology that supports, say, aviation simulations. What is more, simulation training for dismounted infantry is a relatively new capability. Training developers and trainers are still trying to determine how to best utilize simulation to train dismounted infantry skills. In light of the limitation of dismounted infantry simulation, the results of the DSTS post-fielding offered some encouragement for the continued development of the system.

Interestingly, Leaders' responses on the survey indicated difficulties with training invariants were not insurmountable in actual training. For example, 79% of Leaders' responses agreed that DSTS could train "individual task performance (i.e., Move, Shoot, and Communicate)," which is a set of tasks extensively impacted by training invariants. The contradiction between predicted difficulties from experimentation and the experiences of actual training in the system support the necessity of utilizing experimental data and "practical" data to determine levels of training effectiveness for simulation training. The results of the post-fielding evaluation (i.e., "practical" data) were instrumental in identifying how DSTS was best-used in home-station training and what aspects of DSTS were most useful in training. Subsequent training-effectiveness assessments for simulation training could benefit from a similar two-phase approach.

The post-fielding data also provided practical input to increase DSTS utilization. Obviously, the technical issues identified in the post-fielding evaluation need to be addressed in order for DSTS to be fully utilized. In addition, there was an identified gap in training-support materials available for DSTS. The following recommendations may help provide greater utilization of DSTS.

RECOMMENDATIONS

Manage Soldier and Leader Expectations

Participants who had more experience with DSTS were able to adjust their perceptions of the system and to refine their expectations. They recognized that collective and Leader training could be executed in DSTS because the system provided the necessary level of interaction with varied environments. The key element was that when Leaders recognized the benefits and shortcomings of DSTS, they were able to plan and execute the training events that were supported by the system and avoid the distractions to training. Therefore, when Leaders receive appropriate information about the system, they can organize and conduct effective training using DSTS. This information can come from experience using the DSTS, but would be most beneficial if it were provided to Leaders during training planning so that DSTS could be integrated into their training program. Hence, some training product or material (e.g., short video, pamphlet) that adequately explains the DSTS capabilities and limitations could be useful to those planning training with DSTS.

Provide More Useful Training Support Materials

Providing DSTS training support materials could benefit units in multiple ways. First, introductory information could be provide to unit Leaders enabling them to better integrate DSTS into their training program while at the same time informing the Soldiers on what to expect when they arrive at the DSTS training site. Secondly, squad based scenarios with appropriate materials could enable units with multiple military occupational specialties to better plan and prepare for training and execute battle drills that might not be possible given resource constraints. Lastly, by providing AAR training, units can better benefit from training through the use of the AAR capability, which is one of the most important training benefits in DSTS.

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