

## Training Dismounted Combatants in Virtual Environments

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### Summary

The U.S. Army Research Institute, U.S. Army Simulation, Training and Instrumentation Command, and the U.S. Army Research Laboratory recently completed a four-year effort to improve capabilities for dismounted soldier simulation. With increased emphasis on Military Operations in Urban Terrain (MOUT) new flexible training methods are needed that can represent a range of urban environments. Virtual environments have that capability but technological challenges must be overcome to produce an effective virtual training system for the dismounted combatant. This paper reviews improvements made during the project in the areas of representing the dismounted combatants' environment, producing realistically performing Dismounted Infantry Semi-Automated Forces, and developing of an After Action Review system that captures performance in MOUT. At the end of each year of the project a Culminating Event was held during which improvements made in technologies made during the year were integrated and then evaluated by soldiers. The paper also contains a discussion of soldiers ratings of the usability and training effectiveness of these capabilities. Significant improvements have occurred as a result of this project taking virtual dismounted soldier simulation a step closer to fielding.

### Introduction

Future wars are likely to be fought in complex urban environments that range from skyscraper jungles to huge shantytowns (U.S. Army Training and Doctrine Command (TRADOC), 2002). According to U.S. Army doctrine "Small unit effectiveness and empowered leadership are critical to the success of these operations. Close urban assault has significant dismounted character, requiring a robust infantry capability to engage and sustain the urban fight (US Army TRADOC, 2002)."

Training to prepare for urban operations, also called military operations in urban terrain (MOUT), is currently limited to live exercises in small, not very complex MOUT villages. During the recent conflict in Southwest Asia, soldiers also trained in a Mobile MOUT facility consisting of prefab containers. Live training is essential for urban operations. However, MOUT villages have a number of limitations that constrain their effectiveness. Use of explosives and weapons is restricted by safety concerns and the cost of reconstruction. MOUT sites have proved difficult to instrument effectively limiting the information available for After Action Review. Soldiers quickly learn the layout of the MOUT village detracting from the realism of training in unfamiliar terrain. Virtual environments could complement live environments to provide a MOUT training alternative whose strengths overcome live environments limitations.

Virtual environments have proven to be effective for training the U.S. Army's mounted forces

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(Boldovici & Bessemer, 1994; Mastaglio, 2003). With the development of SIMNET and later the Close Combat Tactical Trainer (CCTT), armor and mechanized infantry units have been able to train on large terrain databases that are either geo-specific or geo-typical. They can employ weapons as they would be on the battlefield without the safety constraints of live ranges, and After Action Review (AAR) systems can record all the relevant activities that form the basis of discussion during AARs. In contrast, dismounted combatants have not played a major role in the Army's virtual training systems. The CCTT Dismounted Infantry Manned Module (DIMM) has been judged to be unacceptable by infantry soldiers. Early on there was not a lot of interest in the light Infantry community in the use of virtual simulations. However, this is changing. Recent conflicts in Afghanistan and Iraq have highlighted the need for alternative training methods for training dismounted combatants in MOUT (Third Infantry Division, 2003). The Commandant of the Infantry Center and School supports the development of a virtual dismounted combatant training capability. The operational requirements document for a Soldier Combined Arms Tactical Trainer or Soldier CATT is being staffed.

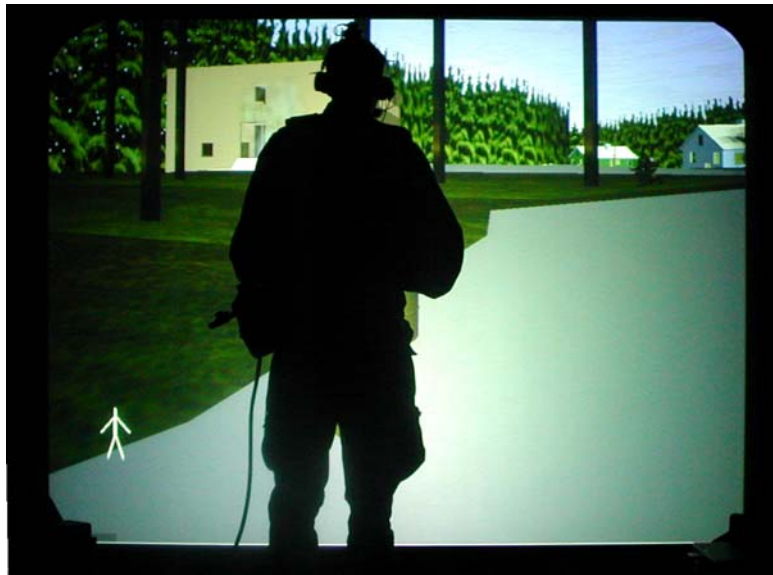
Soldier CATT will require a different approach and development of a new set of technologies to support simulation for dismounted combatants. CCTT trains soldiers in networked vehicle simulators. SIMNET, the predecessor to CCTT, applied innovative networking technology to simulation, but the simulators themselves use the same technologies previously used in aviation simulation (Thorpe, 1987). SIMNET and CCTT simulators place the crew in workstations which mirror those in actual combat vehicles. Visual and auditory displays present an environment that represents the virtual battlefield. Vehicle crews perform on this battlefield using the same controls they would use in the real world. Since dismounted combatants are not in vehicles, a virtual simulation capability must provide them with the means to operate in a virtual environment without the benefit of a traditional simulator. In a Soldier CATT the dismounted combatant must be provided with technologies that allow them to move, shoot and communicate in much the same way that they would in the real world. This presents a set of technical and practical obstacles that must be overcome to develop an effective Soldier CATT. Fortunately, Soldier CATT will have the benefit of Virtual Reality research that the U.S. Army has been conducting over the last ten years (Knerr et. al., 1998).

The Army's dismounted soldier simulation research has culminated in a four-year effort that ended in October 2002. The US Army Research Institute (ARI), US Army Simulation, Training and Instrumentation Command (STRICOM), and the US Army Research Laboratory (ARL)<sup>1</sup> worked together to advance the capabilities of dismounted soldier simulation technologies. The goal was to provide a virtual means by which infantry leaders and soldiers could receive meaningful MOUT or other combined arms training. Each of these US Army agencies had been working independently on problems associated with dismounted soldier simulation. That work formed the baseline from which the cooperative project started. This paper describes progress made in three technology areas key to dismounted soldier simulation and how the growth in these technologies impacted on soldier's impressions and performance. We compared soldiers' impressions at yearly user assessments from the first year of the research to its final culminating event at the end of year four. The three-technology areas are: representing the dismounted combatants' environment; producing realistically performing Dismounted Infantry Semi-Automated Forces; and developing of an After Action Review system that captures performance in MOUT.

## **The Dismounted Combatant Virtual Environment**

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<sup>1</sup> The elements of STRICOM and ARL conducting this research are now part of the US Army Research Development and Engineering Command (Provisional) (RDECOM)



The Squad Synthetic Environment (SSE) served as the baseline virtual environment throughout the course of the dismounted soldier simulation project. The SSE was produced as an outgrowth of earlier research conducted by STRICOM under the Dismounted Warrior Network program (Lockheed Martin, 1998). The SSE as it existed in 1998 was purchased by the U.S. Army Training and Doctrine Command (TRADOC) for use at the Dismounted Battlespace Battle Lab's Simulation Center. In the original purchase enough simulators were purchased to support a nine-man infantry squad. The SSE consisted of individual simulators known as Soldier Visualization Systems (SVS), produced by Reality by Design. The SVS is a personal computer-based, DIS compatible, dismounted infantry simulator that places soldiers in the middle of a square enclosure (approximately eight feet on each side). One side is a rear projections display on which the view of the virtual world is presented in 1024x768 resolution. The other three sides are sound-attenuation fabric. A surrogate weapon with an integrated thumb transducer is used for movement through the virtual environment. Posture changes (standing, kneeling, or prone) and weapon aiming are captured via an Intersense Corporation position tracking system. At the beginning of the four-year research effort the SVS was capable of displaying terrain data bases in daylight, without shadows

***Figure 1. Soldier Visualization Station***

or any other indication of time of day. Figure 1 shows a soldier in an SVS. The only MOUT terrain data base available was a model of the McKenna MOUT Village at Ft. Benning, GA. This data base was limited in that dismounted infantry semi-automated forces (DI SAF) could only enter one of the buildings. That building was the only one that was modeled so that SAF could navigate inside it. Scenarios that could be played out in the virtual environment of 1999 were limited to daylight attacks that emphasized movement techniques. Soldiers did not possess their full range of weapons (grenades, smoke). Buildings had to be entered through doors. It was a limited environment that left room for improvements.

Over the course of the research effort the dismounted combatant virtual environment improved dramatically. These improvements fit into three categories: lighting conditions, weapons and weapons effects, and dismounted soldier-oriented databases.

Updates to the SVS's ability to display lighting conditions included: streetlights, internal building lights, transformers, flashlights, night vision devices, visible and non-visible laser aiming lights, and shadows that change with time of day or night (Knerr et. al., 2002, 2003). Modifications were made to existing 3D Open Flight terrain data bases to include scene illumination from street lights and to place lights in buildings. The ability for lights to be "shot out" or turned off by blowing up a transformer was incorporated to improve movement at night by dismounted soldiers equipped with night vision devices. Immersed soldiers had the ability to use visible and non-visible aiming lights. Visible aiming lights could be seen by soldiers in SVS simulators and by DISAF. Non-visible aiming lights are only visible to those using SVS systems that have image intensification or night vision goggles. Building shadows were introduced to provide soldiers a place to hide. The shape of the shadows changes over to time as they would as the sun moves overhead.

The baseline SVS at the start of the research provided limited capabilities to influence events on the dismounted battlefield. Soldiers had individual weapons but they did not have available the other assets necessary to be successful in MOUT. During the last year of the research project attention was placed on adding the tools needed to succeed on the MOUT battlefield. Soldier reaction to initial user evaluations prompted the development and introduction of grenades (both fragmentation and concussion), flares (both airborne and thrown), tracer ammunition, and tactical smoke to cover movements. Satchel charges were also introduced in conjunction with dynamic terrain, allowing holes to be blown in the sides of buildings to facilitate entry. A Dynamic Terrain Server (DTServer) developed by ARL provides a means to blow holes in buildings sized appropriately for the munition and building material and to create rubble in addition to the hole. The DTServer transmits two types of results to receiving networked simulators. The first is a 'ding' packet, which results from small arms fire on a hard surface. Simulators receiving a 'ding' packet display a model of a simulated small crater at the point of impact. The second result is a 'breach'. 'Breaches' could be caused by satchel charges or anti-tank rounds. Receiving simulators of a 'breach' packet would replace polygons in the explosion area with new ones that could be transited by soldiers. Development of the DTServer provided the means to compute and distribute dynamic terrain changes to the simulation network (Thomas, 2003).

Two terrain data bases were developed in addition to the McKenna MOUT Village. One represented the Shuggart-Gordon MOUT Village at Ft. Polk, LA. The other was a notional terrain data base added onto the original McKenna MOUT site. The additions included two new high rise structures (one twenty stories and the other ten stories), numerous single-story buildings, a bridge, and a set of tunnels running below the original McKenna part of the data base. Multiple Elevation Structures were built into all of the buildings in each of the data bases. This allowed DISAF entities to enter and operate in each of the buildings and on all of the floors.

## **Improvements to DISAF**

DISAF was developed to provide a realistic representation of dismounted infantry and civilians on the virtual battlefield. The primary focus of DISAF has been the development of tactical behaviors for individual through squad level operations. Our original aim was to focus on training small unit leaders and DISAF would be used to fill in squads or fire teams to support training of leaders. DISAF would also provide a capable enemy, and fill out the battlefield with armed and unarmed civilians.

DISAF is based on the OneSAF Test Bed (OTB) architecture. Most of the DISAF behaviors are based on validated Combat Instruction Sets. DISAF runs on a PC under Linux or Windows NT. A DISAF

operator uses an execution matrix to preplan the movements and behaviors of DISAF. In the first year of the research we found that it was difficult for the DISAF operator to change where a DISAF entity was going or what he was doing during the course of the exercise. This delay in DISAF reacting to new instructions was unacceptable to soldiers. A major effort was put into producing a more effective DISAF operator interface and developing a capability for small unit leaders to direct DISAF through voice commands. The voice control of DISAF was to provide a means for live and virtual participants in a simulation to interact through spoken statements. The live user can maintain command and control over synthetic entities (DISAF) while the synthetic entities can vocally acknowledge command and provide information to the live participant.

Development of DISAF began under STRICOM's Dismounted Warrior Network project. Over the course of this four year effort behaviors and capabilities were added on a yearly basis. DISAF are organized as individuals and units both enemy, friendly, and civilian. They possess behaviors that allow them to operate in the open and in buildings. During the final year of the project behaviors were added for armed civilians, crowds of civilians, wounding of entities to include visual signs of bleeding. Knerr et. al. (2003) contains a complete list of entities, behaviors and capabilities for DISAF. DISAF has been included as a component of OneSAF Test Bed.

#### Dismounted Infantry After Action Review System (DIVAARS)

**DIVAARS was developed to meet two needs. The first was to provide soldiers with a common understanding of what happened during an exercise and why it happened, so that they can identify ways to improve their performance. The second was to facilitate data analysis, in order to support both training feedback and research and development. Determining what happened during an exercise is particularly difficult in an urban environment, because buildings and other structures break up the visual field and limit the portion of the battlefield that can be observed by any one person.**

The AAR system connects to the network used by the soldier simulators and DISAF, and permits observation and recording of the exercise data. AAR Leaders are central to the design and operation of DIVAARS. They observe what happens during the conduct of an exercise and prepare a presentation that will lead the unit to an understanding of what happened, why it happened, and how to do better. Their presentation should be both interactive and efficient.

A description of key DIVAARS capabilities follows. The emphasis is on unique DIVAARS capabilities. Figure 3 shows a sample DIVAARS display with many of these features.

*Playback.* Playback controls include actions such as pause, stop, record, play, step forward, fast-

Figure 2. AAR system main display.

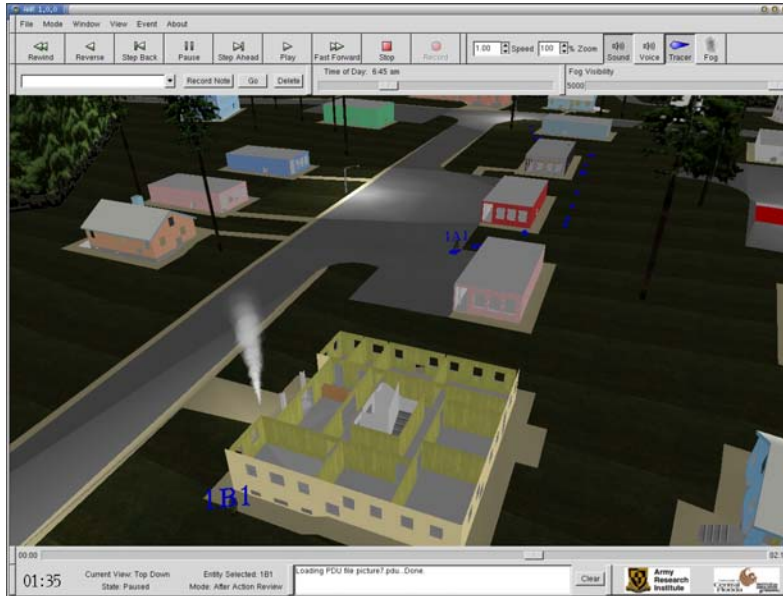
forward, rewind, fast reverse, and step reverse. Variable playback speeds are available. The AAR

Leader also has the capability to mark events during the exercise, and jump directly to them during the AAR.

*Viewing Modes.* Multiple viewing modes are available during both the exercise and the AAR.

- **Preset Views** – An unlimited number of preset views can be selected at any time prior to or during the exercise for immediate use.

- Top-Down – A view of the database looking straight down from above. It can be moved left, right, up, down, and zoomed in or out. It can also be locked onto an entity, in which case it will stay centered  
Figure 2. DIVAARS Screen and Controls



directly above that entity as it moves through the database.

- 2D View - This is the traditional plan view display. It is the same as Top-Down except that depth perspective is not shown.
- Entity View – Displays what a selected entity (including enemy or civilian) sees, including the effects of head turning and posture changes.
- Fly Mode – The AAR Leader can “fly” through the database using the mouse for control.

*Movement Tracks.* Movement tracks show, in a single view, the path an entity travels during an exercise. Markers are displayed at fixed time intervals.

*Entity Identifier.* Friendly force avatars in the DIVAARS, as in the virtual simulators, are identical. A unique identifier, as given in the entity marking field of the DIS Entity State Protocol Data Unit (PDU), is shown above the avatar of each unit member.

*Digital Recording and Playback of Audio Program.* DIVAARS records and plays back audio content for all scenarios.

*Viewing Action inside a Building.* The AAR Leader can select a building and then select a floor of that building to be displayed. Using this feature, the operator can view and display the avatars going through a building without the problem of upper floors or outer walls blocking the view.

*Dynamic Terrain Changes.* DIVAARS receives the PDU messages from the DTServer and updates the display with any changes.

*Bullet Lines.* Bullet flight lines are shown for all weapon firings. The line traces a shot's origin and destination. It is the same color as the originating entity. These bullet lines gradually fade away.

*Event Data Collection and Display.* DIVAARS has the capability to track many events including shots fired, kills by entities, movement, and posture changes. These data can be shown in a tabular format or graphical display. Ten different tables and graphs are available:

- Shots fired, by entity and unit
- Kills, by entity and unit
- Killer-Victim table that shows who killed whom, the angle of the killing shot (front, flank, or back), and the posture of the victim (standing, kneeling, or prone)
- Shots as a function of time, by entity, unit, and weapon
- Kills as a function of time, by entity, unit, and weapon
- Kills by distance from killer to victim, by entity, unit, and weapon
- Rate of movement of each entity, and averaged at team/squad levels
- Percentage of time friendly units were stationary
- Percentage of time friendly units were in different postures
- Display of user-defined events

## User Evaluations

### *Methods*

**At the end of each year of the research and development effort, Culminating Events (CEs) were held to insure the compatibility of individual technologies under development, assess their usability in a realistic setting, and obtain soldier feedback on their use and effectiveness. While the specific details of the CEs varied from year to year, those for the first, third, and fourth years were very similar. Each involved the conduct of a series of tactical urban scenarios by full or partial squads of Infantry soldiers in networked immersive simulators, the SSE. DISAF served as enemy and civilians, and filled some friendly positions within the squads.**

**Soldiers reported to the Dismounted BattleSpace BattleLab Virtual Simulation Lab, Fort Benning, Georgia, for either a one- or two-day period. Upon their arrival, they were briefed on the purpose of and procedures for the exercises, assigned duty positions, and given instruction and practice on the use of the simulators. A series of tactical exercises sessions followed. Each session consisted of delivery of the mission order, squad leader development of the mission plan and brief to his squad, conduct of the mission, and an AAR. After the AAR questionnaires were administered and interviews conducted.**

We were interested in the how well the technology permitted the soldiers to perform their required tasks, their perceptions of the individual technologies, and how much they learned during their training. We made extensive use of questionnaires and interviews. While there were variations in some of the questionnaire items from year to year, there was a common set of questions used in all CEs. The *Simulator Capability Questionnaire* asked soldiers to rate their ability to perform various tasks in the simulators. The *SAF Performance Questionnaire* asked leaders to compare the performance of SAF with that of real soldiers. The AAR questionnaire asked about the effectiveness of the AAR. The *Training Effectiveness Questionnaire* asked leaders only how much they thought their performance improved during the exercises.

The simulator network configuration for the Year 4 CE is shown in Figure 3. The following items were connected to the network:

- Six SVS individual soldier simulators used by the squad leader, two fire team leaders, and three Fire Team A members. All SVSs were equipped with headsets which permitted verbal communication.
- One Voice Recognition PC
- Two DIVAARS Systems
- One Dynamic Terrain Server
- One BattleMaster/DISAF Operator Station. The DISAF Operator and the Exercise Controller used this station.
- One Desktop SVS used by a role player

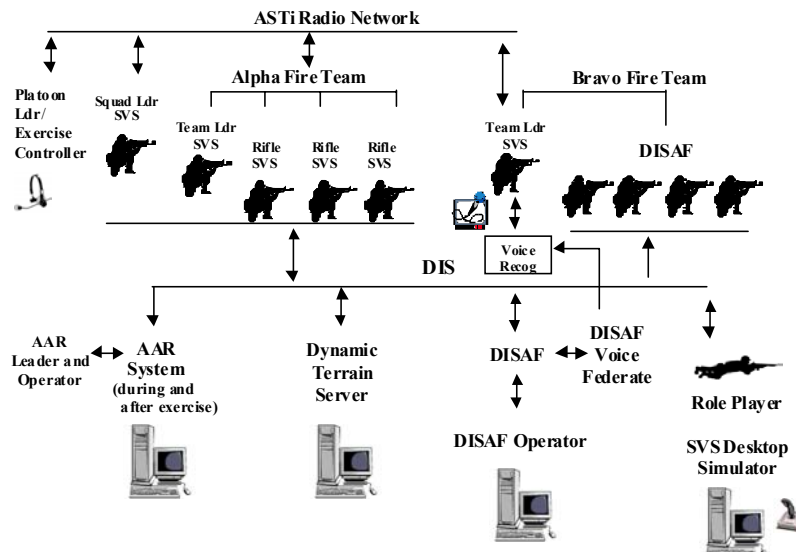


Figure 3 Year 4 CE Configuration

All soldiers completed the Simulator Capability Questionnaire. Scores were calculated for each task by assigning a response of *Very Poor* a value of 0, *Poor* a value of 1, *Good* a

value of 2, and *Very Good* a

value of 3. Table 1 provides a comparison of the simulator capability ratings across Years 1, 3, and 4. The items are listed in order of descending Year 4 mean value. The most noticeable result is a fairly consistent pattern of higher ratings in Year 4 than in Year 3 and, to a lesser extent, Year 1. The overall mean of the common items was 1.90 in Year 1, 1.74 in Year 3 and 2.12 in Year 4.

Thirty-six of 52 tasks were rated *Good* or higher (mean equal to or greater than 2.0) in Year 4, as compared with 16 in Year 1 and 14 in Year 3. The more highly rated tasks consisted of identification of types of people (such as civilians and non-combatants) and tactically significant areas, imprecise movement, and communication. The lower rated tasks consisted of precise or rapid movement, including aiming, distance estimation, and locating the source of enemy fire using either visual or auditory cues. Twenty-two Year 4 item means were significantly higher than the same items in Year 3, and 20 were higher than corresponding Year 1 means ( $p < .05$ ). Items for which the means changed significantly are shown in Table 1.

**Table 1**

**Simulator Capability Questionnaire Responses**

Task	VE STO Year 1 Mean <sup>a</sup>	VE STO Year 3		VE STO Year 4	
		Mean	N	Mean	N
Execute planned route.	1.89*	2.06*	18	2.67	18
Identify assigned sectors of observation.	2.06*	1.94*	17	2.53	17
Move in single file.	2.00*	1.94*	18	2.50	18
Look around corners.	1.47*	1.29*	17	2.50	18
Communicate enemy location to team member.	2.06*	1.89*	18	2.50	18
Understand verbal commands.	1.94*	2.29	18	2.47	18
Fire weapon in short bursts.	2.00*	1.89*	18	2.44	18
Move quickly to the point of attack.	1.94*	1.89*	18	2.44	18
Communicate spot reports to squad leader.	1.94*	2.00*	18	2.44	18
Scan from side to side.	1.72*	1.94*	18	2.44	18
Identify sector of responsibility.	2.11*	2.17	17	2.39	18
Identify civilians.	2.72*	2.22	18	2.33	18
Coordinate with other squad members.	1.88*	2.00	18	2.33	18
Execute the assault as planned.	1.89*	1.83*	18	2.33	18
Locate support team positions.	2.00*	1.72*	18	2.33	18
Identify covered and concealed routes.	1.94*	1.94*	18	2.28	18
Identify safe and danger areas.	2.22	2.11*	18	2.28	18
Maneuver below windows.	2.06	1.61*	18	2.22	18
Locate buddy team firing positions.	1.94	1.78*	18	2.22	18

Engage targets within a room.	2.06	1.61*	18	2.22	18
Identify enemy soldiers.	2.44	1.53*	17	2.22	18
Identify areas that mask supporting fires.	1.72*	2.00	18	2.17	18
Take hasty defensive positions.	1.89	1.71*	17	2.11	18
Determine other team members' positions.	1.78*	2.00	18	2.06	17
Scan the room quickly for hostile combatants.	1.76	1.29*	17	2.06	17
Maintain position relative to other team members.	1.78*	2.06	18	2.06	18
Maneuver around corners.	1.67*	1.06*	18	2.00	18
Maneuver around obstacles.	1.67*	1.39*	18	1.94	18
Estimate distances from self to a distant object.	1.72	1.22*	18	1.89	18

**Notes:** Year 1 N=18. A blank in a cell indicates that that question was not included in that year.

**\* significantly different from the Year 4 mean at  $p < .05$ . AAR System**

All soldiers rated the AAR system on eight items. Table 2 shows the percentage of the soldiers who agreed or strongly agreed with those positively-worded statements about the effectiveness of DIVAARS in both Year 3 and Year 4. The ratings likely reflect the combined performance of the AAR Leader and DIVAARS. DIVAARS was a tool the AAR Leader used to analyze problems with the unit execution, determine the causes of problems, and then facilitate participant dialogue. The ratings are overall very high, with at least 94% of the soldiers agreeing or strongly agreeing with every item.

Table 2  
AAR System Ratings

The AAR system	Rating	Year 3 (N=18)	Year 4 (N=17)
...was effective in displaying movement outside of buildings	<b>Strongly Agree</b> Agree Total	28% 61% 89%	82% 18% 100%
...was effective in displaying movement inside of buildings	<b>Strongly Agree</b> Agree Total	33% 50% 83%	82% 18% 100%
...was effective in replaying communications	<b>Strongly Agree</b> Agree Total	28% 28% 56%	82% 12% 94%
...made clear what happened during a mission	<b>Strongly Agree</b> Agree Total	44% 56% 100%	82% 12% 94%
...made clear why things happened the way they did during a mission	<b>Strongly Agree</b> Agree Total	44% 39% 83%	76% 24% 100%
...made clear how to do better in accomplishing the mission	<b>Strongly Agree</b> Agree Total	28% 56% 84%	71% 24% 95%
...made clear the order in which key events occurred during the mission	<b>Strongly Agree</b> Agree Total	33% 67% 100%	82% 12% 94%
...was more effective than conducting an AAR without any visual or auditory playback (just talking)	<b>Strongly Agree</b> Agree Total	50% 33% 83%	94% 6% 100%

### **DISAF Performance**

The Squad Leaders and Fire Team Leaders rated DISAF performance. Results are shown in Table 3. A rating of 0 indicated that the DISAF were about the same as real soldiers, while a +1 indicated they were slightly better, and -1, slightly worse. Ratings in Year 4 improved relative to Year 1 and Year 3. DISAF can locate/identify the enemy better than real soldiers, but have trouble moving to and firing at the correct locations, and reporting their observations or activities to their Fire Team Leader. Generally, those activities rated lower in Year 4 than in Year 1 were activities, primarily control of movement, that were performed by

the DISAF operator in Year 1 and by an immersed leader via voice control in Year 4. Thus while the introduction of voice control may have reduced the workload of the DISAF operator, it was not necessarily an improvement from the leader’s perspective.

**Table 3**

**Mean DISAF Behavior Ratings**

SAF Behavior	Year 1 (N=9)	Year 3	Year 4 (N=9)
Distinguish between friendly and enemy positions.	-0.90	0.22	0.89
Locate known or suspected enemy positions.	-1.10	-0.22	0.67
Clear a room.	-1.44	-0.44	0.56
Fire weapons accurately.	-0.40	-0.43	0.22
Clear a building.	-1.33	-0.38	0.11
React to contact.	-1.00	-0.89	0.00
React to ambush.	-0.88	-1.11	-0.22
Move through open areas.	-1.00	-1.00	-0.67
Take hasty defensive positions.	-0.50	-1.11	-0.67
Maintain position relative to other squad or team members.	-0.50	-1.29	-0.67
Deliver suppressive fire.	-0.80	-0.88	-0.78
Support by fire.	-0.67	-1.38	-0.78
Move through built-up areas.	-0.67	-1.00	-0.89
Move to designated location.	-0.10	-0.13	-1.11
Perform fire and movement.	-0.67	-1.00	-1.25
Communicate information to squad leader.	-0.80	-1.11	-1.38
Change formation.	-0.62	-1.25	-1.56
<b>Mean</b>	<b>-0.79</b>	<b>-0.79</b>	<b>-0.44</b>

*Note.* Year 3 N varies from 7 to 9.

### Training Effectiveness

Generally, Squad and Fire Team Leaders said that their performance improved as a result of the training. The percentage who said that their performance improved at least slightly ranged from 82% for the task “Clear a building” to 100% for “Assess the tactical situation,” “Control your squad or fire team,” and “Plan a tactical operation.” Year 4 ratings were generally better, and in only one case worse, than those given to the same tasks in Year 3 CE. Complete results are shown in Table 4. In general, ratings for coordination, communication, and control tasks were higher than those for specific unit tasks or battle drills, although this difference was not as pronounced in Year 4 as it had been in previous years.

Table 4  
Squad and Fire Team Leader Training Effectiveness Ratings

Task	% Indicating Improvement		
	Year 1	Year 3	Year 4
N	9	15	18
Assess the tactical situation.	67%	93%	100%
Control your squad or fire team.	67%	80%	100%
Plan a tactical operation.	33%	73%	100%
Squad/fire team communication and coordination.	78%	80%	94%
Control squad or fire team movement during assault.	67%	80%	89%
React to Contact Battle Drill.	44%	80%	89%
Locate known or suspected enemy positions.	44%	67%	89%
Coordinate activities with your chain of command.	44%	100%	88%
Control squad or fire team movement while not in contact with the enemy.	67%	80%	83%
Clear a room.	44%	53%	83%
Clear a building.	56%	57%	82% <sup>a</sup>

Note. Squad and Fire Team Leaders who participated for two days completed the questionnaire at the end of each day.

<sup>a</sup>N = 17

### Discussion

Perhaps the most significant accomplishments of the VE STO are not reflected in the ratings or performance data that were collected but in the level of sophistication and complexity of the scenarios that were run. In the Year 1 CE, at the end of the first year of the STO, five different scenarios were used. All were basically the same: initiate movement to an objective building, react to enemy contact in route, resume movement and finally assault the

building. It was always daylight. DISAF could not enter buildings. Few civilians were present, and their behaviors were limited to either standing still or moving on a preplanned route. Buildings could not be breached. Neither force could use smoke or grenades. A hit always equaled a kill. A fire team leader could control DISAF only by giving a verbal command to the DISAF operator, who then implemented that command at his console. Routes for DISAF had to largely be scripted in advance. AARs were limited to linear playback on a stealth viewer. In Year 4, there were six different scenarios. Scenarios could be conducted at any time of day or night. DISAF could go anywhere, and could carry out some highly sophisticated behaviors autonomously, such as room clearing. Civilians moved about freely, as individuals and in crowds, and could be armed. Holes could be blown at any location in any building. Flares, smoke, and grenades were available to all participants. Soldiers could be wounded as well as killed when hit. These factors greatly increased the variety and realism of the training situations that could be presented.

### *Simulator Capabilities*

While it was satisfying to find that soldier ratings of the simulator capabilities were generally higher than in previous years, it was difficult to relate the changes in rating on specific items to a likely cause. For example, why did soldiers give the task “move in single file” a higher rating in Year 4 than in Year 3? While capabilities have been added to the SVSs, the basic characteristics remain the same. The most likely explanation is that the soldiers responded to the individual items on the basis of both the specific item content and their perception of the overall quality of their experience in the simulators. The new capabilities, like smoke and grenades, which were rated highly (and the absence of which was a cause for complaint in prior years), may have increased the overall quality of this experience and, by extension, the ratings of individual tasks that were not directly affected.

Other factors may have had less straightforward but nevertheless substantial effects on the ratings. As described above, the training scenarios have become increasingly challenging and complicated over the course of the STO. While this made the training more realistic, it required the soldiers to try to perform more complicated tasks in the simulators, and may also have made it more likely that the soldiers would encounter the limits of the simulators. The video gaming experience of the soldiers may also have been a factor in the ratings. It appeared from the interviews and informal interactions that the game-playing experience of the soldiers has increased over the years. On the one hand, their gaming experience has given them opportunity to acquire necessary “basic skills” that make it easier to learn to function in the SVSs. One group of soldiers reported in their interviews that they had no difficulty learning to use the SVSs because “We’re the Nintendo generation.” On the other hand, the impact of the increasing sophistication of computer and video games may have caused soldiers to have higher standards for simulator performance. The simulator capabilities are being compared with increasingly realistic and sophisticated commercial products. This has, in effect raised the standards by which automated entities and environments are judged.

## *Training Effectiveness*

Leader ratings of training effectiveness constitute perhaps the biggest success story of the STO. Since Year 1, we have seen a consistent increase in leader ratings of training effectiveness. Like the ratings of simulator capability, these ratings were likely influenced by the changes in the backgrounds and experience of the leaders and administrative changes (primarily the separation of the roles of the O/C and the AAR Leader).

There is a broad range of tactical skills that could conceivably be trained in VE. At one end of the continuum are small unit leader decision-making skills. Pleban, Eakin, Salter, and Matthews (2001) found that these skills could be trained effectively in VE. Training these skills does not require a high fidelity, fast, or precise interface with the virtual world. Success is more likely to depend on the scenarios and the quality of the role-players. At the other end of the continuum are the specific squad drills and tasks, like building clearing, which involve less decision making, more communication and coordination among unit members, but above all require rapid and precise positioning, movement and use of weapons. A recent experiment by Pleban and Salvetti (2003) indicates that, while there are a number of interface and technology problems to be overcome, VE nevertheless shows promise for this type of training as well, although it appears not to be effective as real world training at present. The types of squad-level exercises conducted during the last two CE's fall somewhere in the middle, targeted at improving leader decision-making and command and control skills in a variety of mission types.

Given the current state of technology, it does not appear that VE is an effective complete replacement for real world tactical training. However, it could be used effectively for some types of training and some stages of training. VE training could provide the walk phase of the training, concentrating on improving the decision-making, situation awareness, communication, and coordination skills. Real world training would place greater emphasis on the motor skills. VE training also has the advantage of being more flexible, in that terrain databases and environmental conditions can be changed more rapidly than a real world urban training center.

## *AAR System*

DIVAARS performed very well, although in looking at the DIVAARS ratings it must be kept in mind that the AAR is a product of the combination of a skilled AAR Leader and the AAR system.

## *DISAF Performance*

DISAF capabilities have increased enormously since the start of the VE STO. This permits more realistic scenarios. DISAF does some things better than others. For example, they are quite good (better than human soldiers) at detecting and firing upon the enemy, but control of their movement, particularly in a dynamic situation, is awkward.

## Conclusions and Future Directions

Substantial improvements have been made during the last four years in the capability of virtual simulation to provide training for the leaders of small dismounted Infantry units. These developments in technology have greatly increased the level of realism that is possible through virtual simulation, and the breadth of tasks that can be trained. While the samples are small, both leader self-ratings and independently-obtained performance scores during this CE indicate that soldier skills improved with practice in VE. Moreover, leader-self-ratings of skill improvement have increased regularly since the first year of the STO. The Year 3 and Year 4 CEs have focused on sustainment and support operations, and in that context, the leaders reported more improvement in command and control, coordination and communication, planning, and situational awareness skills than in skills conducting specific unit tasks or battle drills. Similarly, Pleban et al. (2001) found VE effective for training platoon leader decision making skills.

Given the current state of technology, it appears that VE could be used effectively for some types of training and some stages of training. VE could be used for the walk phase of the training, concentrating on improving the decision making, situation awareness, communication, and coordination skills, while real world training could place greater emphasis on the motor skills. The level of interest in virtual simulation has increased in the Infantry community as evidenced by the current interest in Soldier CATT. This research effort has made significant progress in developing a capable training system. The next step should be an advanced development effort, taking a total systems approach, to produce a prototype VE training system for the dismounted Infantry leaders and soldiers training for MOUT.

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