

# Massively Multi-Player (MMP) Environments for Asymmetric Warfare

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It has been proposed that the Army needs a high-level training capability for asymmetric missions. Current training programs are focused on conventional warfare and are mainly limited to units that are co-located. Where training capability exists, the scenarios have limited interactivity and fail to address a variety of cross-cultural communication issues that troops encounter in the real world.

U.S. Army's Research, Development, and Engineering Command, Simulation, and Training Technology Center in Orlando, Florida, has been conducting an Army Technology Objective (ATO) using massively multi-player (MMP) gaming technology to address these issues. The objective of the ATO is to develop a large-scale, persistent, distributed simulation environment to train soldiers. The research is focused on evaluating the use of MMPs for Army training for operations in asymmetric warfare environments. Weapons of mass destruction, terrorists' actions, crowd and hostage situations, peacekeeping, psychological operations, and civil affairs will be possible interactions faced by the users. OneSAF Objective System computer generated entities will augment the large numbers of real people who will populate the scenarios. The various Armed Forces will be able to engage in such simulation environments anytime, anywhere, using standard personal computers (PCs) connected via the Internet.

The paper details research in the formative evaluation of Internet-based training using soldier participants and gaming technologies. Initial test results with the 101<sup>st</sup> Airborne Division of Fort Campbell, Kentucky, and the Illinois Army National Guard are presented to indicate the potential such technology has to meet new asymmetric training needs and optimize use of soldiers' time while preparing for live training events and actual deployment. The paper also addresses the tools needed to build the training environments and required After Action Review capabilities.

**Keywords:** Asymmetric warfare, virtual environment, massively multi-player, simulation, dismounted infantry, mission rehearsal

## 1. The Asymmetric Threat

The warfare that our Armed Forces are facing in Iraq and Afghanistan today is drastically different from the conventional warfare trained for during the "Cold War" era. Under conventional warfare, the opposing forces represent politically recognized states, and execute their action based on the presumption that the front lines of each side are well defined and that

military doctrine of each side is fairly well known and only evolves slowly over the course of many years. In the case of conventional warfare we can see and identify who our enemies are, we are familiar with their locations, and we know the uniforms they wear. We know and understand their strategic interest, their weapons' capabilities, and their tactics. If a country attacks our forces in a conventional fashion, then our Armed Forces are likely to respond in a prescribed way. The doctrine of conventional warfare is informed by centuries of experience: the previous wars and

tactics of our potential adversaries have been analyzed time and again.

By contrast, asymmetric warfare, which encompasses terrorism inflicted on civilians, is a different sort of threat involving groups sharing various alliances and relationships, each pursuing a range of different goals [1]. For the first time since the Vietnam War, American forces are facing a substantial enemy whose actions are not governed by the same principles that Westerners live by. There is no doctrine to anticipate or study, and little or no historical data to analyze. For example, before 9/11, how many Americans believed that planes would become suicide bombs? Terrorist leaders are by nature unpredictable, and their followers adapt their tactics to keep up the element of surprise. Our forces are left with many unknowns and have to adapt their tactics on-the-fly. They are left only to imagine what tactics the enemies will use, what unconventional weapons they will employ, and even what clothes they will wear. No longer is there a line drawn in the sand with uniforms marking the enemy. We do not know where the next incident will take place or when it will happen. It is this unpredictability and lack of understanding that is a critical challenge to our military training today.

To help prepare our forces for ongoing operations in the Contemporary Operating Environment (COE), primarily in Iraq and Afghanistan, the Army trains its soldiers in the basic warrior skills and other skills they may require in battle. The Army captures lessons learned from recent action and eventually updates training for the soldiers preparing to deploy. However, the current skills training lacks emphasis on certain factors that could strengthen our soldiers' advantage over the enemy, including specific training for the unpredictable behavior of the enemy, and regional and cultural training that would help units to know both the enemy and the civilian population who can help them locate the enemy. Furthermore, the process of transferring lessons learned from active units into current training for units preparing to deploy is slower than the rate at which the enemy is adapting its tactics. The lack of a training system that can put our forces ahead of the learning curve is costly in terms of lives and materiel.

### *1.1 Training for Asymmetric Warfare*

Today, the Army trains soldiers on conventional warfare through schoolhouse courses and through live training events at its Combat Training Centers (CTCs) and Military Operations in Urban Terrain (MOUT) site, but these courses take years to alter in response to the Current Operating Environment (COE) [2]. Recently the Army has begun to utilize Arabic-speaking role-

players to enhance the training at its CTCs. The schoolhouse teaches doctrine at the various levels of soldier roles. Current doctrine is based on recent wars and tactics, and only recently has it begun to address asymmetric threats. Units that are about to deploy may receive training for the general kinds of threats they will be exposed to during unit exercises at training centers [3].

What the Army does not have is a virtual simulation environment for dismounted infantry (DI) that allows soldiers to train tactics, techniques, and procedures (TTPs), perform mission planning and rehearsal operations, and practice decision-making tasks against current enemy tactics. Virtual training for DI has lagged behind that of vehicles because of the complexity of the tasks and the levels of interaction between avatars (graphical representations of users in virtual space).

The Army trains for asymmetric warfare the only way it knows how: by communicating knowledge gained through experience and providing experience-based training. The sources for experiential knowledge range from reviewing documents from the Center for Army Lessons Learned (CALL), consulting Army-sponsored websites (e.g., [companycommander.com](http://companycommander.com) and [platoonleader.com](http://platoonleader.com)), talking with other units already deployed, and exercises in learning how to deal one-on-one with civilians in the countries of deployment. Training for asymmetric warfare must be realistic; and for maximum training effectiveness, it should be a first-person experience. While some knowledge can be transmitted through text, lecture, and slide presentations, the best learning is embodied in challenges that are personally experienced, and the most optimal method for experience-based learning is often simulation [4]. Soldiers must learn how to prevent or adapt to creative, unpredictable asymmetric threats. Training must challenge leaders to think and to take appropriate measures to provide security and force protection. Units must strive to understand, defend against, and operate in a new, unconventional warfare environment.

Currently, the Army has a Center for Lessons Learned, located at Fort Leavenworth, Kansas, whose mission is to disseminate these lessons. Many of the asymmetric attacks that occur are captured and documented through a written report that is placed on the Army's websites. These reports take quite a bit of time to generate and get into the system for use throughout the Army. Army units can read these reports to garner information about the types of things that deployed units are facing. Even longer is the process for getting these lessons learned into the training simulations used by the Army. Currently, the Army has no timely way to put new TTPs into the current Army training exercises to train its units for these asymmetric threats.

## 1.2 Simulation-Based Training

First-person, experience-based training is being conducted at the National Training Center (NTC) at Fort Irwin, California, and the Joint Readiness Training Center (JRTC) at Fort Polk, Louisiana, where skilled opposition forces (OPFORs) and newly added Arabic-speaking role-players challenge leaders to protect their own forces while continuing to prosecute their mission. These exercises simulate the changing environment that deployed troops will face, with the goal of improving their successful response and increasing survivability. The major problems with this approach are the huge costs, the time involved in conducting this training, and the extremely limited frequency with which this training can be conducted. Soldiers and equipment have to be on site and face a well-trained cadre that continually change their tactics in order to represent the ever-changing threats that will be faced in the COE. Even these training exercise efforts suffer from the same lag time faced by CALL and the web log-based information provided by [companycommander.com](http://companycommander.com) and [platoonleader.com](http://platoonleader.com).

To address these issues, the U.S. Army's Research, Development, and Engineering Command, Simulation, and Training Technology Center (RDECOM-STTC) is researching the ability to leverage and adapt a commercial massively multi-player (MMP) game to build a simulation that will bridge these gaps between distribution of lessons learned and simulation-based training based on the lessons that have been learned. The research effort is known as the Asymmetric Warfare – Virtual Training Technology (AW-VTT). The focus of the effort is to provide an easy-to-use, internet-based simulation framework that leaders can use to introduce and review new TTPs for responding to the asymmetric threat. The simulation becomes a training multiplier when a soldier in Iraq or Afghanistan participates in a virtual training exercise being conducted by a unit preparing to deploy to that location and provides real-time subject matter expertise on current enemy tactics. This can provide a powerful tool that augments and supports Situational Training Exercises (STX), without replacing the required "boots on the ground" training.

## 2. MMP Environments

There are quite a few massively multi-player (MMP) games currently on the commercial market (examples include *Everquest*, *Battlefield 1942*, and *Ultima Online*). MMP games have some common characteristics that distinguish them from traditional games. The most obvious is that they can accommodate large numbers of users at a single time. A typical MMP can

have hundreds of thousands of simultaneous users, although usually only 2,000–3,000 players may be in a particular part of the environment at a time. To address this limitation, industry separates the mass amounts of players into parallel worlds. Another feature of these game environments is that they run on a standard PC and they tolerate internet connections with limited bandwidth. There are typically no unique hardware requirements to run the software.

The Army chose the Forterra Systems, Inc., MMP platform, the same technology used to run the commercial "There" MMP, to determine if this technology can be used by the Army to provide a training capability that does not currently exist. The Army has been trying for years, with limited success, to develop a distributed simulation and training capability equivalent to that of the MMP game sector. The commercial game sector has successfully developed the architecture required to address the technology issues, but the challenge is how to best adapt the technology to meet the Army's needs.

The AW-VTT environment is referred to as a "virtual world," and it is in fact a model of the Earth. The environment is a virtual representation of the earth from a terrain perspective, as shown in Figure 1. The architecture of AW-VTT is scalable, enabling the Army to develop terrain for as many parts of this world as are needed, and to create multiple copies of the terrain as needed to accommodate large numbers of trainees wanting to train on the same piece of terrain at the same time. Currently, five areas on this globe have been modeled: a square kilometer of urban terrain representative of Baghdad, a valley in Afghanistan, a MOUT-style camp set in the Philippines, a suburban California city (for emergency response training), and the New York City harbor. Because of the technology's scalable cluster architecture, there is no limit to the terrain that can be added.



Figure 1. Aerial view of MMP World Environment

The AW-VTT world is persistent—meaning that when you return to it, it does not automatically reset itself or restart from the point in time where you left off before. When an individual logs back into the environment, the state of the world reflects the changes other users have made while that individual was not there. In essence, time goes on with or without any particular individual's presence. Optionally, you can reset the state of a scenario, or let it run indefinitely. These options provide considerable training flexibility.

The environment is available 24 hours a day, seven days a week. With an “on-demand” 24/7 available persistent environment, exercises are not limited to short intervals but rather can last for days, months—even indefinitely. Significantly, this also means that the soldiers can log into the environment from any time zone, any location, and train together.

Once the virtual terrain has been modeled for a particular area, such as South Korea, users could run an exercise there while a second exercise is being conducted in a model of Mosul, Iraq. These exercises could be run in conjunction, sharing resources, modeling communication between the two, playing all echelons in the chain of command to include higher headquarters. If it were necessary, units could simulate flying from one location to the other.

### 3. Technology Capabilities

In order to develop an MMP simulation capable of training soldiers against asymmetric warfare threats, there are numerous features that the technology must integrate seamlessly together to create an environment that is scalable, viewable from the air and from the ground, and immersive enough in its representation of people and terrain to be effective for experience-based training. These capabilities include realistic virtual representation of participants (representing soldiers, coalition forces, terrorists, OPFOR, and non-combatants), real-time communication between participants, vehicles, aircraft, and weapons, health management, computer-generated entities to populate the environment, environmental effects, and an after action review (AAR) system. The technology must also be implemented in a scalable way so as to allow unlimited participants and simulated entities, as well as a diversity of terrain to enable training to deploy in any part of the real world.

#### 3.1 Avatars

A key feature of the AW-VTT is the ability to represent avatars in the simulation as unique individuals. In the real world, people identify each other through



Figure 2. Choosing complexions for avatars

distinctions in voice, appearance, demeanor, height, weight, and many more attributes. The AW-VTT allows users to create avatars with many distinctive features. Figure 2 shows the same avatar with medium and dark complexions, respectively.

Users in the AW-VTT are able to modify their avatars in many ways to look like the type of character that they are representing in the environment. Users can modify facial features (eyes, ears, chin, hair), body features (weight, muscularity), flesh tone (light, fair, dark), as well as the overall shape and even the outfit the avatar is wearing. All these changes can be made in real time during the simulation, if desired.

There are other methods used in commercial games to identify individuals. The most commonly used method that also has been tried in AW-VTT is a simple floating name above the avatar. Other possible approaches could include name tapes and rank on the uniforms of soldiers. Regardless of the approach, identification of others is a crucial capability. Figure 3 shows a group of avatar role-players assembling in an Afghan scene, preparing for a medical relief scenario that requires a variety of appearances.

Another way that individuals can be represented is through user profiles. In the AW-VTT, soldiers enter into the world as themselves. AW-VTT includes their visual representation as mentioned above, but



Figure 3. Avatar costume library samples

potential additions could include their actual physical capabilities (i.e., physical training scores) and privileges such as a high mobility multipurpose wheeled vehicle (HMMWV) license. In the real world Soldier X can run a 6-minute mile but Soldier Y can only run an 8-minute mile, and these same attributes could be reflected in the movement capabilities of their virtual avatars. By being able to utilize a soldier's actual physical capability the simulation could model such limitations as how quickly a user could run through a particular type of environment, how quickly the soldier became fatigued, or even how much weight could be carried. By incorporating user profiles, the simulation could limit which users can operate vehicles such as tanks, aircraft, or weapon systems.

### 3.2 Communications

The AW-VTT enables real-time communications between users, including both verbal communications and non-verbal gestures. It currently enables face-to-face communications between avatars using voice over internet protocol (IP), and in the future it could also simulate radio communications using the same technology, directing the voice streams to users in different locations in the virtual world. For cases where the users are not equipped with headsets and microphones for voice input, AW-VTT also allows participants to communicate via typed text, both face-to-face, in which case the text appears in chat balloons over their heads, and over a built-in instant-messaging system. A limitation with the current voice technology is that it does not portray subtle position information. While the technology does model attenuation over distances and provides audio in stereo, hearing a mixture of voices and distinguishing their sources can be difficult in the virtual world.

The technology also enables non-verbal communication through automated and user-controlled gestures and emotional representations. Automated gestures are triggered when an avatar is speaking, which causes its lips, arms, and hands to move. There is an automated gaze system that causes avatars to look at other avatars who are speaking to them. These automated moves work to create a convincing representation of body language while speaking. Users can also meaningfully communicate specific gestures using the menus provided or by typing in the names of the gestures they wish to enact. Figure 4 shows avatars enacting military and Arab gestures.

Future capabilities will look at incorporating an autonomous emotion state dependant upon the users' actions and dialog. The system can currently monitor what is typed and look for words such as "yes" and



Figure 4. Gesturing *salute* and *salaam*

"no," and when these words are identified the avatar displays the appropriate gesture. Future enhancements could include visual representation of the avatar's emotional state based on the context of the dialog.

### 3.3 Health Management

The AW-VTT provides for wounding and killing avatars, and modifying their behavior depending on emotional state. The current wounding capability in the AW-VTT is divided into four different hit zones: head, torso, arms, and legs. The extent of the wounding is based on the type of round used, the zone that is hit, and the number of hits received. Currently the wounding outcome is not based on actual statistical wounding data, but instead on a configurable data table. This table can be modified to resemble actual real-world data. Just as avatars can represent being injured, they can reflect being in an emotional state: avatars can be angry or terrified, in which case their animations and facial expressions differ from avatars who are in the normal state.

New functionalities are currently proposed to add an extensive health simulation model to the AW-VTT. The incorporation of a health management system could represent the user's health and mental status in greater detail. It could manage the wounding or killing of an avatar—the physical fatigue of the avatar based on physical (PT) scores and the amount of action in the environment—and overlay these with an array of emotional states. Each of these capabilities would affect how the user can operate in the simulation.

### 3.4 Computer Generated Forces

What distinguishes the AW-VTT from other commercial game MMP environments is that it will be used for military training and that it will be networked with other existing military simulations. Part of the reason to

use MMP technology is that it can be populated with soldiers receiving training as well as role-players to fill out the scenario. Since numerous role-players may not always be available to populate the environment, some sort of computer generated forces (CGF) need to be linked with the MMP. It is not the intent of this research effort to actually build these CGF behaviors in the MMP environment, but rather to build these behaviors in the Army's premier constructive application, the OneSAF Objective System (OOS), and to link the OOS to the MMP. The OOS will be utilized to populate the MMP environment with non-critical personnel such as hotel clerks, cab drivers, and people in the marketplace. One of the key challenges will be to actually link an MMP with the OOS application without introducing latencies into the systems.

### 3.5 Environmental Effects

Controlling the logistics of the AW-VTT is by no means a simple task. It is its great flexibility that introduces logistical issues, especially in building the specific environment.

The entire world is modeled, so troops from all over the world can access specific locations any time they require training or mission planning. With the flexibility of the AW-VTT, soldiers can access the same location in the world at the same time. In the future, the AW-VTT will provide the tools for the Army to manage training and scheduling in the MMP environment. How the tools are used, who has access to them, and how they are accessed are some of the issues that we are addressing.

Another issue that comes from modeling the entire world is the control of the time of day. Is it done globally, where it represents real-world time? Do we allow the troops to set the time of day in the location they are utilizing? How does that affect others either nearby or on the other side of the world?

Other environmental factors are being considered, such as the environmental effects of heat on a virtual soldier's performance and the potential fatigue this could introduce. The AW-VTT will also model the effects of the soldier's actions on the environment to include dynamic terrain (bullet holes, building and terrain deformation, etc). Dynamic terrain will be an issue because the AW-VTT world is persistent: what happens in the world stays in the world. To enable repeatable training, we will need to be able to reset certain parts of the world back to some "initial" state.

### 3.6 After Action Review

The key to producing an informative after action review (AAR) is not in collecting the data but in

knowing how to display the right information at the right time to the trainees. This issue is the same whether the training is being conducted in a live environment or in a virtual world. In the case of MMPs the collection of data is not a problem: every keystroke, step taken, word spoken, or weapon fired is recorded. The issue with collecting this much information is the amount of disk space required to store the data. This storage space limitation is only amplified when you consider the flexibility in the length of the exercise (days, months) and the extremely large number of participants that could use the system overall, either in multiple parallel small, short-duration exercises or single large-scale long-duration exercises.

For AW-VTT, the AAR design will include the capability for the trainer to configure the data being collected. This ability to customize the collection of data allows for a tailored AAR based on the task being performed and the skills being trained. Other considerations include when and where to conduct the AAR. The flexibility of the MMP environment puts no constraint on the length of time to run an exercise. As mentioned earlier, the MMP environment is available 24 hours a day, seven days a week. In theory, exercises could run for days, weeks, or even months, although these are not considered to be typical use cases. With these long duration training exercises, it becomes critical to identify when to deliver the AAR. For example, is feedback given when the users make a mistake, periodically, or at the end of the exercise? It is also important to identify where and how the AAR is to be conducted.

The Army has procedures and regulations on how AARs are to be conducted. These procedures are based on the premise that all participants are co-located. Since the MMP environment provides a distributed training network, it is very likely that all the trainees, role-players, and observer/controllers will not be located at the same facility. Rather, it is envisioned that soldiers will participate from around the world in these training events. One of the strengths of the environment is that it can function as a virtual conference room; once the AAR capability is completed, all users will be able to attend the AAR from their remote locations.

### 3.7 Scalable Architecture

AW-VTT is based upon the OLIVE (On-Line Interactive Virtual Environment) architecture that underlies the consumer service "There" (<http://www.there.com>). The There consumer service has operated continuously since 2003 with tens of thousands of users. OLIVE is designed for scalability both in the size and density of

the virtual world that is represented, and the number of simultaneous players in the world.

By their nature, large-scale virtual worlds require multiple computers to operate. One client computer is needed for each user, and servers are often required to host simulated objects. Some virtual environments use the client machines to do all or part of the simulation work thus minimizing or eliminating the need for servers. While this peer-to-peer configuration appears advantageous from a hardware requirement standpoint, this approach has some serious performance and scalability limitations. Instead, OLIVE centralizes the simulation into a cluster of co-located servers that represent the entire virtual environment and all of the entities within it. OLIVE then requires its client software to *co-simulate* that part of the world that the client can “see” or has interest in.

Within the server cluster, OLIVE splits the world into geographic sectors whose size and shape vary depending on the virtual environment. The granularity of a sector may be as small as 50 meters or extend out for thousands of kilometers and, in fact, cover the entire world. OLIVE sectors are not static and may be adjusted at runtime to maintain a consistent load balance amongst the servers. This is important for simulations where large numbers of objects can converge on a single location whose associated server might otherwise become overloaded. This type of architecture both enables the kind of scalability required for training and the dynamic load balancing needed to maintain performance in highly kinetic situations such as combat operations, where individuals, ground vehicles, and air vehicles are all in motion in unpredictable ways, often in urban environments.

#### 4. Training Effectiveness Evaluation of MMP Technology

For a training technology to be evaluated the training curricula must be identified and sample applications built. Until recently there were no working examples of multi-person simulation environments constructed for training purposes, making summative evaluation impossible. Some virtual environment systems have been developed and examined, for example the collaborative effort by Knerr et al. to evaluate new technologies for dismounted soldier simulation [5]. That work, as with this effort, did not actually have a “curricula” established as a target, but used U.S. Army field manuals and ARTEPS as the basis for skilled activities on which soldiers continually work to improve. That work also took the standard approach of asking for estimations from the users

about their skill improvement and learning resulting from participation in exercises. To date, this project has included two formative evaluations of the AW-VTT prototype, described in the next section, in which soldiers, including trainers, rated the potential training effectiveness of the technology, and provided detailed feedback and prioritization on features and improvements needed to fulfill that potential.

There has been at least one formal evaluation conducted on a multi-player game technology, namely, Full Spectrum Command [6]. While this technology is not large scale as is the case with AW-VTT, and it lacks the flexibility of scenarios inherent in the use of human role-players, it is the closest relative to the AW-VTT technology that has a documented evaluation. Unfortunately, that evaluation did not produce a usable comparison of training effectiveness against the control group as had been intended. However, it did include a formative evaluation with valuable insights into the training potential of the technology as well as evaluation procedures themselves.

In their 2005 technical report, the Advanced Distributed Learning Initiative acknowledges the dearth of published research on Massively Multi-player Online Games (MMOGs, which are based on MMP technology) for military training and education, and lays out a framework for future research in this area [7].

This paper presents evaluation efforts on AW-VTT to date, with the anticipation that the project will also provide further examples to help populate the framework.

#### 5. Soldiers’ Evaluation of AW-VTT

In 2004, the AW-VTT prototype was evaluated by two groups of soldiers from the U.S. Army, one from the National Guard and the other from a Combat Division. In preparation for these soldier evaluations, a suitable scenario was needed to illustrate the technology’s potential. Candidate scenarios that would be supported by the prototype technology included military checkpoint operations, convoy operations, cordon-and-search, building assault, intelligence operations, and force protection. RDECOM selected checkpoint operation in urban environments (drawn from ARTEP 7-5-MTP) as the test example from which soldiers would be asked to evaluate the technology’s suitability for a variety of applications for introductory training, skills training, situational awareness exercises, and mission rehearsal.

Setting up and operating checkpoints are common missions in asymmetric operations for dismounted infantry. These missions draw upon the basic warrior skills, require knowledge of the Army’s Field Manual

25-4 and, in addition, require implementation of a unit's specific TTPs that incorporate previous lessons learned. Soldiers manning checkpoints are required to follow rules of engagement, often making split-second decisions on which rules apply based on their situational awareness. They are required to observe and interact with the local population, and although they often are communicating through translators and civil affairs officers, any language skills and cultural knowledge they possess will enhance their ability to accurately read a situation and take appropriate action.

To support the training for checkpoint operations, Forterra Systems modeled a geo-typical representation of one square kilometer of urban terrain, notionally in Baghdad, Iraq. To illustrate the ability of the technology to allow trainers to configure the environment to suit specific scenarios, the developers created a "checkpoint set" of moveable concertina wire, barriers, signs, traffic cones, and white lines for the pavement. To populate each exercise, they developed avatar templates with skin and body types and clothing for Iraqi civilian men and women, Iraqi police, and U.S. Army soldiers. From these templates, an unlimited supply of avatars could be created to support the exercises. Culturally appropriate gestures were developed for the Iraqi and American avatars, and Forterra Systems provided military and civilian weapons for use by the blue and red forces, in addition to ground vehicles and helicopters. Figure 5 provides a screenshot of checkpoint operations in progress.

### 5.1 Evaluation Groups

As introduced above, formative evaluations using the checkpoint operations were conducted with two groups of soldiers: the first from the Illinois Army



Figure 5. Checkpoint operations

National Guard, 2-123 Field Artillery based in Moline (ILARNG), and the second from the U.S. Army 101<sup>st</sup> Airborne Division based in Fort Campbell, Kentucky (101<sup>st</sup> Airborne). Basic demographic characteristics of the two groups are shown in Table 1. Significantly, the ILARNG group had not been deployed to Operation Iraqi Freedom (OIF) at the time of the evaluation, whereas 14 of the 15 soldiers in the 101<sup>st</sup> Airborne group had returned from OIF within the previous year. It should also be noted that all participants were male.

Table 1. Soldier participant demographics

	ILARNG	101 <sup>st</sup> Airborne
Group size	27	15
Force type	Army National Guard	Regular Army
MOS categories	Field artillery (18), Supply/services (4), Chemical (2), Infantry (1), MP (1), Medical (1)	Infantry (13), MP (2)
Service Grades	E3 – E7, O1-O3	E6 – E8
Age range, average	21 – 52 (average 31)	25-40 (average 32)
Prior OIF experience	No	Yes

One of the major issues in conducting any kind of evaluation is the representation of the target population evidenced by the test group; see Campbell and Stanley, and Boldovici et al. [8, 9]. In formative evaluations, the intent is focused on gaining sufficient information to guide the development process; and, therefore, issues of statistical power do not enter in as they do in summative evaluations. Still, the group(s) providing the information should have some validity in representing the target population. Our Army groups are obviously not randomly recruited from the Army population, but are opportunistically recruited from the Army. In order to establish some validity for our participant sample, our demographics are matched with available Army information; see Table 2 in [10], Under Secretary of Defense for Personnel and Readiness.

Table 2. Relevant Army demographics, 1998

Average age	27.5 yrs.
Average time in service	7.33 yrs.
E3 – E7	81.6% of enlisted
O1 – O3	58% of officers

## 5.2 Formative Evaluations

The formative evaluations for each group were structured as a one-day, seven-hour session, with approximately one-third of each group attending on each day. The sessions started with an overview of the system, initial questionnaires, and one hour of training on how to use the technology, including hands-on practice. The next several hours were used in a cycle of presentations covering system features and tools available (both existing and under development), followed by questionnaires and discussions about the existing and planned capabilities.

Following a complete review of the system, soldiers were given a mission to accomplish in a geo-typical virtual Baghdad requiring checkpoint operations. A leader was selected or appointed, received the operational order (OPORD), then directed the soldiers according to the OPORD. The exercise was conducted with soldier participants acting as blue forces and with live role-players (some remotely logged in from California) playing red forces and civilian bystander roles. RDECOM personnel on site filled the observer/controller (O/C), OPFOR, and civilian roles. After the exercise, soldiers conducted an AAR (without replay, as that was not implemented for these sessions).

Structured discussions were held throughout the day to obtain qualitative feedback, and online questionnaires were used to collect demographic information and quantitative feedback on the individual tools and features of the system.

## 5.3 Results of Evaluations

The results presented here follow the structure of the presentations and discussions, and are based on seven-point scaled and anchored responses to questionnaire items. The scales have all been adjusted so that 1 indicates a very low rating, while 7 is the highest value available.

Both groups provided good initial ratings of the system's potential for augmenting normal unit training following the introduction and practice session on the system (see Table 3). The 101<sup>st</sup> provided generally more favorable ratings (approximately a one-half point edge) for movement, menus, and general system interactions than the ILARNG following the initial demonstrations and training sessions as shown in Table 2. The general evaluations of these functions were all above the middle anchor of "usable/good enough" for training with the exception of the "teleporting" function used for entering buildings (ILARNG = 3.8; 101<sup>st</sup> = 3.33). It should be noted that the "teleport" function is an artifact of the commercial version of the software for

**Table 3.** Ratings from early demonstrations

	ILARNG	101 <sup>st</sup> Airborne
Training aid in normal ops.	6.11 7 = MOUT site	5.13 5 = Sand table
Movement controls	5.19	5.73
Aiming weapons	4.67	5.0
Visual inspections	4.81	5.2

There.com and is not intended to be used in any final version of a military training system.

Following a more detailed briefing and demonstrations of the system tools and environmental features, ratings were obtained on the importance of terrain, weather, and lighting aspects in the environment. Both groups rated these issues as highly important, with ratings from 5.4 to 6.5 on the seven-point scale (7 being "critical" for training). When questioned about possible *training improvements* based on easy trainer manipulation of these features, both groups assigned ratings averaging in the 5.6 to 6.4 (with 7 anchored as "twice as effective as current training").

The 101<sup>st</sup> were given a more detailed series of questions (based on open-ended discussions with the ILARNG) about AAR tools and typical exercise difficulties. In general, soldiers from the 101<sup>st</sup> saw O/C control aspects (see Table 4) as moderately important for implementation in exercises and AARs. Complementing these ratings were their responses to questions about typical exercise difficulties. The 101<sup>st</sup> rated the difficulty of evaluating overlapping fires by individuals and teams as moderate (Table 4), and the evaluation of building clearing movement and squad formation shifts as easier.

When queried about the *value* of these types of information for AARs, the ratings provided were at the top end of the scales. The value of showing tracked events during replay was rated moderately high (see Table 4). The capability to measure and replay movement, rules of engagement (ROE) violations, and data graphics were all important for AARs. The soldier/trainers of the 101<sup>st</sup> also saw great value in the capability to observe an exercise replay while in the environment and immediately repeat the critical task following the review (6.2 rating, with 7 anchored at "great benefit"). This capability, while discussed, is not an easily implemented feature, however.

The 101<sup>st</sup> were also given the opportunity to rank-order needed objects for development that the ILARNG identified in open discussions and open text entries. These rankings are presented in Table 5. (Soldiers had a hard time assigning non-repetitive rankings to requirements, often listing several items as "first.") The items and capabilities are those that the soldiers felt would be needed by themselves, the OPFOR, or both

**Table 4.** STX difficulties and AAR tools

Issue Addressed	101 <sup>st</sup> Response and Anchors
Stealth point of view	4.79 5=Moderate, 7=Critical
Time and position marks	5.53
Event control	5.60
Soldier/Unit tracking	5.87
Weapons fire data	5.53
Difficulty tracking squad locations	3.27 1=Very easy
Eval. formation shifts	3.4 4=Requires O/C monitor
Eval. overlapping fires	4.67
Eval. bldg. clearing move	3.67
Info value in AAR	7=Very high/Useful
Weapons fire time/place	5.79
OPFOR actions	5.8
Comm. events	5.8
Wall/Floor transparent	6.33
Movement tracking	6.53
ROE violations	5.6
Visualization graphics	5.67

**Table 5.** Object and capabilities rankings (101<sup>st</sup>)

Object/Capability	% of Group	Ranking*
Explosives	86	1 <sup>st</sup> / 2 <sup>nd</sup>
Weapons	71	1 <sup>st</sup> / 2 <sup>nd</sup>
RPGs	79	1 <sup>st</sup> / 3 <sup>rd</sup>
Vehicle damage	71	1 <sup>st</sup> / 3 <sup>rd</sup>
Avatar damage	71	1 <sup>st</sup> / 3 <sup>rd</sup>
Terrain damage	71	1 <sup>st</sup> / 5 <sup>th</sup>
Helicopters	71	1 <sup>st</sup> / 5 <sup>th</sup>

\* Range of ranks provided by percentage of group

during an effective asymmetric warfare exercise. It is obvious that soldiers want to be able to cause damage and see the result when running through their training exercises.

The 101<sup>st</sup> also provided rankings that agreed with the ILARNG general discussion on the need for selection of individual equipment and individual control over avatar configuration, rating these needs between 1<sup>st</sup> and 5<sup>th</sup> (but not seeing any need for lots of clothing selections, ranked 5<sup>th</sup> through 8<sup>th</sup>). The only other need that ranked higher was the need for overall scenario modification controls, ranked 1<sup>st</sup>-3<sup>rd</sup> by all soldiers in a separate selection set.

When asked about visual factors in the simulation, the 101<sup>st</sup> rated individual avatar identification and accurate injury visualizations (both average = 6.3) as near “absolutely critical” (the #7 anchor; see also the rankings provided in Table 4). This reflected the extensive comments that the medical representatives in the ILARNG group had for injury indications, arguing that everything in a mission exercise changes when a soldier is wounded during a mission and that this aspect must be included in training.

Finally, the ILARNG were asked whether the system could be effective for any Army training, with a resounding 88% positive. During the later evaluation phase, the 101<sup>st</sup> were asked to evaluate the system’s general adequacy for simulation and most appropriate level for training application (issues not considered by the ILARNG). When asked about the adequacy of the system in supporting introductory training, 64% of the soldiers thought it was appropriate for or could supplement that level of training. In addition, 86% thought the system was appropriate for skills training, and 93% thought the system was appropriate for or could supplement situational training exercises. An additional question, in the context of a discussion about using the system within the “crawl-walk-run” sequence of training exercises, generated an evaluative rating average of 5.4 (with 4 anchored as “moderately good” and 7 as “great”).

### 5.3 Discussion

The rating, ranking, and discussion data presented above are, as is typical of formative evaluation data from subject-matter experts, soft and subjective in nature. The data were also collected in the framework of system developers presenting both existing and projected features, tools, and capabilities. Nevertheless, the information can be, and has been, used to shift development sequences and prioritizations. Overall, the ratings, rankings, and comments provide support for the approach as a simulation supplement for training exercises, especially in the current era of changing threats and roles for soldiers.

Minor indications of successful alterations can be found in the general increase of ratings over the six months between the ILARNG session and the 101<sup>st</sup> interviews, with regard to the movement, menus, and weapons controls. The low ratings for the temporarily necessary “teleporting” function for entering buildings has increased the prioritization of developing the capability to directly enter buildings through representative doors. (Kicking down, blowing open, and other standard building entry techniques

are even more difficult to implement.) The recent addition of easily modifiable explosives—improvised explosive devices (IEDs)—that allow refuse piles, bags, carcasses, and vehicles to blow up on command reflects the continued focus on soldier-identified needs for asymmetric threats in training. Other identified needs have been prioritized and are being addressed as funded capabilities become available.

Perhaps the most encouraging evaluation information comes from the soldiers' recognition of training benefit. The first indication of this comes from their evaluation of the benefit that comes from being able to replay a simulation exercise, and even repeat a critical task immediately following the AAR presentation. Secondary evidence comes from the high agreement with statements on the system's adequacy in supporting and supplementing situational training exercises, and relatively good rating on usefulness in the crawl and walk phases of training.

Two further rounds of evaluations are planned, both with National Guard and active Army combat units, as our opportunities arise. The first evaluation will be a preliminary summative evaluation that attempts to establish performance/learning change with a single squad as a result of experience in using the developed environment. That is planned to lead to a culminating event at the end of the ATO in the summer of 2006 in which the system will be used by multiple squads in preparation for an STX. Their preparation time, performance, and training outcomes will be compared with other groups using existing home station preparation routines. While this type of comparative evaluation may not provide for a definitive statistical comparison with empirical power [9], it will serve as an initial data point toward measuring the benefit to be accrued from the application of this technology.

## 6. Conclusion

This Army project leverages a commercial MMP environment and evaluates its potential for training soldiers for the asymmetric warfare missions that they are facing today in places like Iraq and Afghanistan. By representing participants as individuals and enabling the enemy role-players to model the unpredictable behaviors of terrorist groups in a scalable, diverse environment, AW-VTT offers the Army training capabilities for the Global War on Terror that it does not possess today.

AW-VTT represents a new way to train within the Army. It could become a Virtual Combat Training Center used to supplement training at schools, at home-station, and military training centers. It can prepare troops for more expensive live drills and actual deployment, integrating basic warrior skills

with reinforced situational awareness, decision making, and asymmetric warfare skills acquired through experiential learning about the enemy and surrounding civilian population.

Perhaps the most tantalizing benefit, however, is that by enabling deployed troops to log in and coach soldiers who are preparing to deploy, the AW-VTT environment will enable the Army to rapidly develop, validate, communicate, and train new TTPs at a velocity that provides individual soldiers and teams on the ground with an increasing advantage over insurgencies and terrorist organizations that are embedded in local populations.

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