Initial Real-World Testing of Dismounted Soldier Embedded Training Technologies

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ABSTRACT

Embedded training is a key requirement for many future and current force systems, making it a very important capability for Army transformation. Despite its importance, few demonstrations or tests have been conducted on which to base embedded training systems implementation.

For the past five years, the US Army Research Development and Engineering Command (RDECOM) Simulation and Training Technology Center (STTC) has researched embedded training solutions applicable to individual Soldiers and small teams. To assess the utility of these solutions under field operating conditions STTC sought and found a meaningful culminating event in the Army's premier live discovery experiment, the Air Assault Expeditionary Force (AAEF) experiment.

Three dismounted embedded training prototypes were selected for use in AAEF. The first was an immersive, virtual, untethered, Soldier-worn system, interoperable with other Army simulation systems. The second system was a tablet computer-based system that provided leader mission planning and walkthrough. Both these systems displayed a high fidelity virtual terrain database of the McKenna training area at Ft. Benning where most of the AAEF experiment was conducted. The third application was a first-person shooter game engine modified to operate on the Soldier-worn prototype and supporting workstations.

During the experiment the Soldiers used these systems for mission planning, mission rehearsal and after action review of the rehearsal before carrying out live AAEF missions. Generally, the Soldiers' reactions were positive toward the systems and the systems were seen to have potential for future development. The resultant feedback from this experiment can direct Army research and implementation of embedded training

This paper will discuss AAEF, the embedded training systems used there and the manner in which these systems were used. It will provide anecdotal and questionnaire-based Soldier feedback of their impressions of the training technologies. Finally, it will summarize lessons learned and suggest future research topics.

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BACKGROUND

Embedded training is a training capability built into operational equipment. This is easily imagined for large systems such as a tank or helicopter, but this same technology is also being explored for application to the individual Soldier. The concept for the Soldier envisions that future Soldier ensembles and equipment will one day include all the technology necessary for the Soldier to participate in virtual training and rehearsals as well as other live and constructive training sessions using only his/her normal combat gear.

Embedded training is a key requirement for many of the Army's future and current force systems, including ground Soldier systems. Thus it is a very important technology for Army transformation. Despite its importance, very few demonstrations or tests have been conducted on which to base embedded training systems implementation.

A number of dismounted Soldier embedded training research prototypes were developed by the US Army Research Development and Engineering Command (RDECOM) Simulation and Training Technology Center (STTC). At the culminating event for the most recent research program, three of these dismounted prototype systems were used in the Army Air Assault Expeditionary Force (AAEF) Spiral C experiment at Ft. Benning, GA, in November 2006.

This paper will discuss the systems used at AAEF for embedded training. It will also provide survey and anecdotal information on Soldier feedback, lessons learned and suggested future research topics (IST 2007).

CURRENT RESEARCH

For the past five years, RDECOM STTC has researched embedded training solutions applicable to individual Soldiers and small teams (Marshall, et. al. 2005, Marshall, et. al. 2006, STTC 2007). In order to verify the utility of these solutions under field operating conditions and provide important feedback to guide future embedded training research, these systems were proposed for the AAEF Spiral C experiment. Participation in AAEF required that the technology developers prepare a detailed proposal for the emerging technologies believed to be appropriate for AAEF. The proposal included several dismounted as well as mounted embedded training prototype systems.

In preparing for AAEF, several related efforts were investigated. One of these was the Dismounted Infantry Virtual Environment Training Effectiveness Trial (DIVE TET) conducted at the Copehill Down Urban Training Facility in Warminster UK (QuinetiQ 2003). The aim of this research was to investigate the utility of virtual environments as urban operations training tools. This trial used the Half-Life® game engine for the synthetic environment and workstations for both the friendly and opposing players. The results showed some improvement in the live performance of the trained units after the virtual sessions and no evidence of negative training. Other research using various types of immersive dismounted wearable, workstation and cave based simulators was also reviewed (Knerr, et. al. 2004). The results of these experiments also identified potential for Soldier use of these systems to conduct virtual exercises. This feedback was encouraging to our proposed embedded training experimental participation.

The proposed use of embedded training at AAEF was unique. While other experimental systems would be used during actual AAEF missions, the embedded training systems would be used before mission execution, either to train operators on how to use some of the new systems, or for mission planning and rehearsal. After some investigation it proved unrealistic to attempt to implement embedded training as a training function for new technologies such as robotic systems since these systems were in development and would be moving baselines for training development.

The mounted technologies were also discarded as applications for embedded training, primarily because of the emphasis on the dismounted Soldier during the experiment. The objective for embedded training eventually focused on using in the virtual environment for mission rehearsal to prepare Soldiers for missions before they conducted the actual mission. The expectation was that the experiment would provide valuable feedback on the use of embedded training since the Soldiers would go from virtual training directly to a live mission permitting evaluation of effectiveness and positive performance transfer as well as identifying shortcomings for future research. Three of the dismounted systems were selected by AAEF management for participation in AAEF.

Research Systems Used at AAEF

Recent research programs developed two man-wearable virtual dismounted training prototypes. These systems - Distributed Advanced Graphic Generator and Embedded Rehearsal System (DAGGERS) and Virtual Warrior - are both fully immersive, untethered, soldier-worn systems. Both track the Soldier's weapon and body movements with sensors and wearable computers while providing the Soldier with a view of the virtual environment from helmet mounted displays (HMDs). The Virtual Warrior system used actual Land Warrior interfaces, batteries and other equipment as part of its design. Virtual Warrior also has a tablet version for mission planning and after action review (AAR). Figures 1 and 2 depict the laptop version of Virtual Warrior and the DAGGERS man-wearable prototypes.

Figure 1: Virtual Warrior

Both Virtual Warrior and DAGGERS have been used to research emerging technologies that will potentially improve interoperable embedded training and mission rehearsal between mounted and dismounted forces. Research also addressed the potential for embedded training in AAR. The assumption of this latter research was that distributed AAR techniques could be used to improve conventional AARs. In conventional AARs,

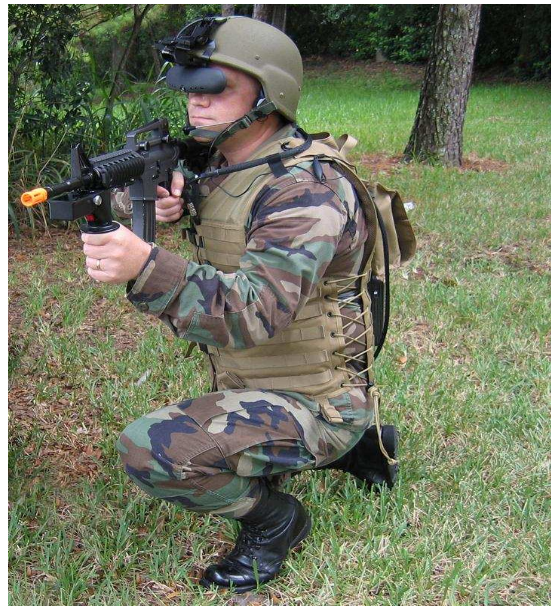

Figure 2: DAGGERS

Soldiers are gathered together at a central location and large screens and production aids are used for AAR. By embedding this functionality on the operational systems, the AAR would be conducted in the field where Soldiers would use their operational equipment (that included embedded training) to view the AAR. The AAR controller could replay a mission from any point of view and share this view with the entire unit via the displays used by the embedded training systems.

After numerous discussions with AAEF management a decision was made to use DAGGERS as the primary embedded training system for an infantry squad and the Virtual Warrior tablet version for platoon mission planning and key leader mission rehearsal. Nine DAGGERS units and five Virtual Warrior tablets were developed to accommodate this plan.

A third research system was used to improve the virtual representation of the environment. Game - Distributed Interactive Simulation (GDIS), developed by a Small Business Innovative Research Phase II program, applied commercial game engine technology to dismounted soldier training. This product was based on the popular Half Life 2® game engine and was selected for AAEF to provide the virtual synthetic environment for embedded training. GDIS offers a high level of realism at low cost in a first-person shooter game environment with detailed urban environments and dynamic effects. This technology permits multiple Soldiers to participate in training over standard internet connections using DIS simulation protocol. For AAEF, the GDIS application was integrated into the DAGGERS man-wearable systems and Virtual Warrior tablets. It was also used on laptops for human-in-the-loop control of individual opposing force (OPFOR) members and for mission observation by exercise observers such as platoon leaders. Figure 3 shows the first-person shooter view from GDIS.

Figure 3: View from GDIS

This combination of prototypes – DAGGERS, Virtual Warrior and GDIS - supported virtual training from planning through AAR. To round out the synthetic environment One Semi-Automated Forces (OneSAF) version 2.5 was used to simulate additional OPFOR and civilians. The final experimental configuration is shown in Figure 4.

AERIAL ASSAULT EXPEDITIONARY FORCE EXPERIMENT SPIRAL C

The Air Assault Expeditionary Force experiment is the Army's principal live discovery experiment. AAEF is a unique annual event that links individual Soldiers with emerging communications, battle command, intelligence, surveillance and reconnaissance technologies. AAEF seeks to identify capabilities and technologies that could be sent forward to the current force, determine if the capability or technology needs further testing or should be discarded from the inventory. The AAEF experiment campaign was initiated in 2003 to integrate Command, Control, Communications Computers, Intelligence, Surveillance

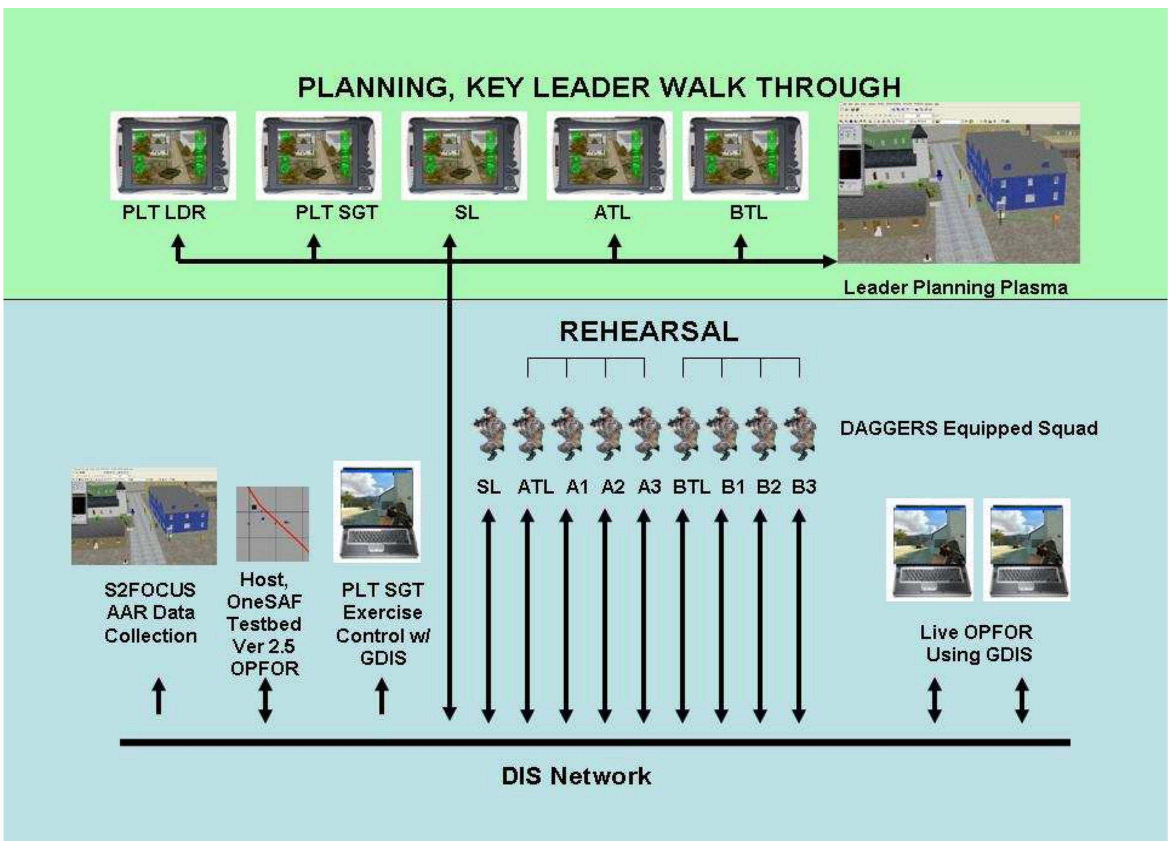

Figure 4: Final Embedded Training Experimental Configuration

and Reconnaissance (C4ISR) into the current force using concepts outlined in Air-Mech Strike and Asymmetric Warfare for the 21st Century (Grange et.al. 2002). The first experiment, Spiral A, focused on networked battle command at platoon and squad levels and was completed in late 2004. Spiral B added the elements of mounted vertical maneuver in the form of UH-60 and CH-47 aircraft and the Small Unit Support Vehicle in 2005.

AAEF Spiral C took place in October-November 2006 at Fort Benning, Ga. Spiral C tested C4ISR and other technologies to see if they would increase the survivability of a small modular combat unit. Spiral C experimented with a small mounted unit in a live force-on-force field experiment within an Urban Assault Brigade Combat Team/Joint Task Force context. The scenario was in the year 2014 with a mix of special purpose and insurgent forces, and restrictive rules of engagement. During the experiment a series of day and night operations took place that incorporated mixed offensive and defensive operations on a cluttered, urban battlefield. AAEF experimental force (EXFOR) was provided by a platoon from Company A, 1/29th INF. The remainder of the battalion was controlled constructively by the White Cell (US Army TEC 2007).

The Spiral C experiment had two phases in which Soldiers executed simulated combat operations during both day and limited visibility conditions. The first or base case phase was the controlled experiment in which a series of ten combat missions were conducted in the Fort Benning training areas. For this phase the EXFOR was equipped with technologies available to Soldiers who are currently conducting operations in Afghanistan and Iraq. Upon entering the second or advanced case phase, Soldiers underwent six-weeks of training on new technologies and then executed the same ten scenarios, this time incorporating future capabilities such as unmanned aerial and ground vehicles, 3D command and control, see-through the wall sensors, light enhancing eyewear and new communications technologies. Over 35 developing systems and capabilities were employed for Spiral C.

EMBEDDED TRAINING AT AAEF

After six months of integration and closely managed preparation, the STTC team began its AAEF participation on Oct 11, 2006 at Ft. Benning with training for the EXFOR. Unlike other technologies in AAEF, the embedded training technologies would not be used during either the base or advanced case missions. Instead, these technologies would be used by the EXFOR before each advanced case mission for mission planning, mission rehearsal and after action review of the mission rehearsal. Platoon and squad leaders were trained on both Virtual Warrior and DAGGERS. Two different squads were trained on DAGGERS.

The Plan for Embedded Training

The embedded training plan called for the platoon leader to start the process by entering the squad's mission plan in Virtual Warrior using objectives, routes, points of interest and other graphic control measures (Figure 5). The leadership would

Figure 5: Virtual Warrior Planning

then make use of five Virtual Warrior tablets to conduct a key leader walk-through using the virtual environment to familiarize the team leaders with their individual roles during mission execution. After the mission plan was finalized and leadership walk-though completed, the mission plan would be downloaded to the DAGGERS systems. The EXFOR squad with the primary role in the mission would don the nine DAGGERS systems and conduct a virtual mission rehearsal. When wearing the DAGGERS systems the Soldiers could see each other, the OPFOR, the virtual environment and the mission plan control measures, all in 3D. Following the rehearsal, the leadership would use Virtual Warrior and DAGGERS to conduct a distributed AAR. If time permitted, a second rehearsal could be conducted on the same or a revised plan.

Execution of Embedded Training

Given the myriad tasks required by the platoon in the few hours available from receipt of an operations order to mission execution, the EXFOR rarely had time to perform all the planned embedded training tasks. Typically the squad leader entered the mission data and conducted the key leader walk through with his team leaders. The full squad then used DAGGERS to rehearse the missions. The AAR was conducted in conjunction with the DAGGERS rehearsals with on the spot corrections. In one mission the platoon sergeant ran the squad through a second rehearsal and made on the spot corrections in both. This was by far the most effective rehearsal.

The team participated in Pilot Test 2 on Oct 24. This was one of three dress rehearsal scenarios conducted prior to the start of the advanced case missions. The ten advanced case scenarios were conducted from Oct 26 to Nov 8. Seven of the ten scenarios included assault or defend missions in the McKenna Military Operations in Urban Terrain (MOUT) training area. The McKenna MOUT area is a full scale reconstruction of a small town, complete with buildings, houses, a church and other typical urban landscape features where Soldiers train for warfighting in urban areas. As the McKenna MOUT area was the only Ft. Benning training area for which a high resolution database was available, the seven scenarios involving McKenna were the only ones supported by embedded training. For one advanced case mission the embedded training suite of equipment was relocated to Strupp Field and the planning and rehearsal conducted in a field location. The other six missions were conducted in a double wide trailer provided by AAEF. Figure 6 below shows a squad using DAGGERS to conduct a mission rehearsal in the trailer.

Figure 6: DAGGERS in Use at AAEF

SURVEYS

Two survey instruments were used at AAEF. Participants completed a simulation sickness questionnaire (SSQ) provided by Army Research Institute (ARI) after EXFOR training and after one of the advanced case mission rehearsals. These were the only opportunities when the EXFOR had sufficient time to complete this survey. The SSQ contains 16 simulation sickness symptoms. Participants rated their experience with each symptom as none, slight, moderate, or severe. The survey differentiated between "warm" sweating, a normal response to room temperature and/or exertion, versus "cold" sweating, an indicative of motion illness. The average total severity score of 35 fell within the range of 19 to 55 reported by Kennedy and Stanney and others for several other systems using HMDs (Kennedy and Stanney 1997, Kennedy et. al. 1992, Lampton et. al. 2000). No participants withdrew because of simulator sickness. "Warm sweating" was the symptom with the highest average rating, slightly above "moderate". The next highest rated symptoms, general discomfort, eyestrain, difficulty focusing, and fatigue, averaged slightly above "mild".

An ARI simulator capability questionnaire (SCQ) was modified for DAGGERS and administered after EXFOR training. In the SCQ Soldiers rated their ability (very good (4), good (3), poor (2), very poor (1) and not used) to perform each of 55 tasks relevant to squad level infantry operations using DAGGERS. For this study the average score was 2.8 where a rating of 3 corresponds to "good" and where higher scores are more favorable than lower. Nine of the SCQ items had mean ratings above 3 (good). These tasks are shown in Table 1. Tasks from several different categories are in this top group. The findings are similar to previous results reported by ARI (Knerr, et. al. 2003, Knerr, et. al. 2004) with the exception that "fire weapons in short bursts" was previously one of the lowest rated items but is one of the highest rated items here. This may indicate an improvement in firing control.

Table 1. Highest (Best) Rated Items From the Simulator Capabilities Questionnaire

Engage targets within a room.	3.29
Locate assigned areas of observation	3.25
Fire weapon in short bursts.	3.25
Move close to walls.	3.25
Locate support team positions.	3.17
Identify non-combatants within a room.	3.17
Identify sector of responsibility.	3.14
Move according to directions.	3.13
Communicate SPOT reports to squad leader.	3.13

The five tasks rated the most difficult are shown in Table 2. These ratings are all below 2.5, the mid point between "poor" and "good". Note that four of these involve movement and maneuver. This is consistent with Soldier comments that it was difficult to use

DAGGERS in tight spaces such as stairwells inside buildings.

Table 2. Lowest (Worst) Rated Items From the Simulator Capabilities Questionnaire

Maneuver below windows.	2.43
Maneuver past other personnel in a room.	2.43
"Slice the pie" around corners.	2.43
Move quickly through doorways.	2.13
Use M203 grenade launcher	2.13

LESSONS LEARNED

The following observations and lessons learned are derived from Soldier's comments during the training, from embedded training team members and others who observed the training.

- Audio spatial awareness - The DAGGERS system lacks audio spatial awareness. As a result, Soldiers commented that voices and simulated sounds cannot be located based on their virtual direction. Noise cancelling headphones would be useful to mask noise from other Soldiers that are physically near, but virtually remote.
- Physical separation – The area in the trailer was marked with red tape in six foot squares in an effort to prevent Soldiers from straying into each other while wearing the HMDs. Soldiers commented that more physical separation between the individual Soldiers would be beneficial.
- Gestures - Soldiers commented that when using HMDs, the inability to communicate with gestures hampered control.
- Ability to identify other players - When Soldiers looked at avatars of their counterparts a display appeared above the observed avatar's head that identified the other Soldier by duty position, e.g., TL1, SQ1. In GDIS this display appeared when the weapon was pointed at a target. As this was not a desirable technique to invoke this feature for training, GDIS was modified so that the display appeared when a soldier's head was oriented toward one of their squad members. It was suggested that avatar recognition could be further enhanced by adding Soldiers' faces to the appropriate avatar.
- Size of units in rehearsals - Both Soldiers, their leaders and AAEF evaluators commented that for effective rehearsals DAGGERS systems should be available for the entire platoon, not just a single squad. Since the squad was participating in a platoon mission, the DAGGERS squad needed to directly coordinate their actions with those of supporting squads. These supporting squads were not visible in DAGGERS. It is feasible to equip a full platoon, or even company, but this was not affordable for AAEF.
- Number of OPFOR – Embedded training scenarios were set up in advance. The number of OPFOR in these scenarios approximated the number and type shown for each mission in the AAEF OPFOR plan. This plan was based on the platoon mission. Since the embedded training system only supported one squad of EXFOR, the number of OPFOR that the EXFOR encountered in the first missions was larger than a single squad would normally engage. OPFOR had to be scaled back to a number more appropriate for a squad mission.
- Take away products - Almost all of the Soldiers commented that they would have liked to have had a scorecard to take with them. A simple printout of shots fired, number of kills and accuracy would have been sufficient. Future participation should consider providing a tangible item to the Soldier that he/she can keep. This would add to the training as the Soldier would have an item in hand that could key reflection on the experience.
- Computer generated forces (CGF) behaviors – OPFOR and neutral force entities controlled by Modular Semi-Automated Forces (ModSAF) were not useful in exercise play. The available CGF behaviors for individual combatants and non-combatants alike were too coarse and inflexible to accurately reflect the urban fight. Neutral forces could not be programmed to react as expected during movement to contact or during the fight. According to EXFOR Soldiers, the live OPFOR in the advanced case exercises employed tactics such as small teams of three or four OPFOR that attempted to lure the Soldiers into engagement range of larger forces. These and other OPFOR urban tactics were not possible with the CGF.
- CFG fair fight issues - Typically fair fight issues between live players and CGF players concern mismatched rules of engagement, target acquisition capability, mobility and reactional behaviors (Marshall, et. al. 1996). The most apparent issue at AAEF was that the OPFOR engaged approaching assault squad members well before the squad was within range of the OPFOR. This forced the EXFOR to hold fire until they were closer to the OPFOR.
- Role playing OPFOR – GDIS proved to be an excellent tool to role play OPFOR or neutral forces. The ability to place humans in direct, responsive control of OPFOR gives the OPFOR flexibility far beyond that of SAF-controlled OPFOR. The drawback to this approach is that it is manpower intensive. The one-to-one relationship between

controllers and entities limits the number of entities that can be played in this manner in a given exercise. A new control paradigm is needed to benefit from the flexibility of human-in-the-loop OPFOR.

- HMD field of view - The 40 degree field of view in the DAGGERS HMDs is too narrow for realistic operations in a MOUT environment. The restricted field of view also makes movement difficult in tight places such as stairwells. HMDs with larger fields of view exist but were not within the DAGGERS cost, power and performance metrics.
- DAGGERS weapons sighting calibration – It was difficult to calibrate the weapon aim point as seen in the HMD with the actual firing point in the virtual world. Calibration also tended to drift rapidly during operations. To simplify the process a workaround solution was implemented that used a button push to calibrate sight/firing points.
- Use of Virtual Warrior – Leaders tended not to like the Virtual Warrior system for planning missions. They commented that it took too long to plan with this tool as it had a complex array of control menus. Also, since only those leaders who had Virtual Warrior tablets showed up on the 2D and 3D displays during planning, it was difficult to understand the plan because the locations and roles of supporting squads and platoons were not visible as the plan was developed.
- Support for radios and experimental equipment used at AAEF - Ideally the embedded training systems should support all equipment used by the unit including robotic and sensor systems. Given the complexity of adding these to the GDIS virtual environment and moving baselines of these experimental systems they were not included for AAEF.
- Safety Release - Since the experimental systems were to be used by Soldiers, a safety release was required prior to AAEF participation. This proved to be a non-trivial process. Several key AAEF participants withdrew their systems due to failure to obtain a safety release within the required time schedule. Acquiring safety releases is a long-lead time activity.
- Development and integration issues – Preparation for AAEF revealed numerous technical issues with game engines.
  - Some of the game physics models had to be scaled to support embedded training applications. For example, for entertainment purposes, game avatar walking and running speeds are typically set much higher than is humanly possible. Considerable time was required to scale these movements to that of humans.
  - The visible avatar in GDIS is surrounded by a bounding box that is considerably larger than the visible avatar. This bounding box proved to be too large to pass through some doorways in the terrain database, requiring that the doors be widened.
  - Collisions between the avatar bounding box and terrain objects such as walls also made navigation in tight spaces difficult.
  - The weapon aiming point and eye point are the same in the game engine. For embedded training they had to be separated.
- McKenna terrain database – Evaluator comments indicated that the McKenna virtual terrain was very realistic, but did not represent a large enough area on the ground to represent all the experiment areas.
- Surrogate systems - When using surrogate systems such as the embedded training prototypes the surrogates sometimes do not have the look and feel of operational systems. As an example, the buttons on the weapon used for virtual locomotion are unlike any buttons on the weapon. This should be avoided whenever possible as it is perceived as negative training.

CONCLUSIONS AND WAY FORWARD

DAGGERS, enabled by GDIS, was well received by AAEF Soldiers. Anecdotal comments indicated Soldiers found the DAGGERS technology easy to use and very useful for mission rehearsals. The most critical comments related to difficulty using the system in close quarters such as stairwells and the need to expand the use beyond a single squad to an entire platoon or even company. Presently a commercial version of DAGGERS is used as part of the Virtual Squad Training System (VSTS) demonstration project for the Battle Command Training Center (BCTC) at Schofield Barracks, HI, where it has demonstrated utility as an alternative to dismounted virtual simulations such as workstations and immersive caves. DAGGERS was never intended as a deployable training system. It was used as a surrogate for a possible virtual ET system on a futuristic Ground Soldier System during AAEF. However it is very promising as an institutional virtual simulation for dismounted Soldiers. Future research should focus on alternatives that could be supported under current Soldier system limitations and in areas such as tracking technologies, improved HMDs, wearable computer components, and gesture recognition.

The AAEF evaluator feedback stated that the embedded training suite of equipment provided a good planning tool at the squad level. It allowed the leader to monitor their subordinate's progress and stop and adjust their mission and behaviors. Mission planning with Virtual Warrior was not as well received by Soldiers. Leaders did not see the utility of this system compared to their current mission planning tools. The platoon leader did say that Virtual Warrior was easier to use than the fielded system they were using (Future Battle Command Brigade and Below), but it still fell short of basic rock drills. Future embedded training devices for Soldiers must address usability issues such as rapid train up, rapid set up and ease of use. Soldiers have very little time to rehearse in preparation for missions so the ease of preparation and use will determine whether or not the system is accepted. This is counter to the functionality of many simulation control and AAR systems that have complicated controls and excessive functionality. In a recent experiment with Stryker vehicles and simulated dismounted Soldiers using GDIS (Rohall, 2007), Soldiers again emphasized the need for ease of use. They also raised concerns between differences in the rehearsal needs of deployed units versus units at home station reiterating that deployed units have very little time for rehearsals. Future research should consider differences in rehearsal requirements between these two use cases and pursue functionalities best serving each. This experiment also surfaced the need for additional research in methods to link mounted and dismounted embedded training.

CGF provided unrealistic OPFOR behaviors with numerous weaknesses in the urban scenarios used during the experiment. Current CGF is limited in both entity behaviors and operator control flexibility. Research is needed on CGF alternatives that perform effectively in urban situations and are easy to use. Technologies likely to address this shortcoming include game engine control mechanisms that could provide a 3D environment and intuitive game-based controls. This would allow Soldiers to easily generate and control scenarios that take advantage of current battlefield intelligence information. This was called out in the AAEF final report as a desired capability.

Participation in AAEF was a very valuable experience for the embedded training team. Lessons learned and Soldier feedback developed there will be applied to ongoing embedded training and mission rehearsal research that is seeking to accelerate fielding of embedded training in current force systems. This program is also sharing ideas and research products with the US Marine Corps Expeditionary Force Vehicle embedded training program.

Although embedded training is a requirement for Future Force Warrior and Ground Soldier Systems, the specifics of the Soldier tasks, conditions and standards to be supported by embedded training have not yet been defined. It appears that it will be useful for rehearsals, for tasks that required coordinated teamwork and timing, and for many others including dangerous, repetitive or costly tasks. Participation in experiments such as those at AAEF Spiral C will assist in refining the training requirements for implementation.

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