Mobile, Hand-Held Support Devices for the Dismounted Future Warrior

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ABSTRACT

The U.S. Army Research Development and Engineering Command Simulation and Training Technology Center (RDECOM-STTC) was challenged to develop a low cost, lightweight and low power system for dismounted soldiers to use for mission planning and rehearsals. The Team Mission Assistant-Tactical/Exercise (TeamMATE) device was developed by the Scalable Embedded Training and Mission Rehearsal (SET-MR) Army Technology Objective (ATO) to meet this challenge. The TeamMATE was developed on a Personal Digital Assistant (PDA) and designed to support four modes: Plan, Rehearse, Execute, and Review. A heuristic evaluation was performed on the TeamMATE user interface by the Army Research Laboratory to test its usability and effectiveness. The TeamMATE was also evaluated by dismounted soldiers at the Joint Readiness Training Center at Fort Polk, Louisiana for its usability. The TeamMATE was later demonstrated to the Future Warrior Technology Integration (FWTI) program at Natick Soldier Center in Natick, MA. The capabilities of the TeamMATE were desired, but the form factor had to meet the FWTI system requirements. Using the previous evaluations, the SET-MR ATO team re-engineered the TeamMATE only keeping the core capabilities for the FWTI Team. A new simulation system was then developed to meet the FWTI requirements. The system was entitled Soldier Training Enhancement Package (STEP). The previous evaluations also prompted the RDECOM-STTC team to start a Small Business Innovative Research (SBIR) project to potentially provide advanced capabilities to the FWTI system. The project goal was to develop advanced technologies that the soldiers had identified as critical needs. The team has since identified some off-the-shelf technologies that were readily available to meet the identified critical needs and have since adapted that technology for use. This paper analyzes the results from the studies performed and discusses how those studies have helped in the design and development of the mobile, hand-held devices technologies being used today.

KEYWORDS

Embedded Training, Mission Rehearsal, Mission Planning, Mobile, Hand-Held

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Embedded Training (ET) is defined as training provided by capabilities built into or added onto operational systems, sub-systems or equipment, to enhance and maintain the skill proficiency of personnel (TRADOC, 2003). This is easily imagined for large systems such as a tank or helicopter, but this same technology is also being explored for applications for the individual soldier (Marshall, Garrity, Roberts, & Green, 2007). The vision for ET and the dismounted soldier is that one day the soldier will have all of the technology pieces needed to provide a robust and succinct ET system integrated into his/her battlefield equipment.

Embedded Training is a key requirement for the Army's future dismounted soldier training systems including the Ground Soldier System (GSS). ET is a key performance parameter that the Army desires in its transformation from the current force into the future force of tomorrow. Although Embedded Training is a key factor in the transition of the Army, very few demonstrations or tests have been performed to show the ET capability for dismounted soldier systems.

This paper will discuss the RDECOM-STTC's initial attempts at producing a usable hand-held mobile technology that will provide ET for the dismounted future warrior. The hand-held mobile technology was chosen because it met the low cost, power and weight requirements for the GSS. This paper also discusses the evaluations and feedback sessions that were performed to help cultivate and develop the new and improved ET hand-held mobile application. Using the gathered feedback and suggestions from soldiers, the technology was then re-engineered and integrated into the Future Warrior Integration Technology (FWTI) program and is currently being reviewed to potentially be integrated into the Ground Soldier System of tomorrow.

HISTORY

The US Army Research, Development and Engineering Command (RDECOM) Simulation and Training Technology Center (STTC) has designed and developed many different soldier training system research prototypes. Many of these prototypes use a Head Mounted Display (HMD) to provide a virtual environment that a soldier can train his/her skill set and allow him/her to test cognitive decision making while under simulated battle stress conditions. The soldier is able to move his avatar, his virtual representation of himself, anywhere in the virtual world. Virtual Reality (VR) environments also allow him/her to plan and rehearse missions with other team members. These members could be playing along with the soldier as a teammate, but could also be a leader, fellow soldier or engineer playing as an opposing force. Many of these systems allow soldiers to train on laptops or other desktop computer stations, in man-wearable training systems or a combination of both. Man-wearable systems (e.g., "DAGGERS" & "ETDS") provide an immersive feeling for the user through the use of a HMD and allow a soldier to virtually move through an environment using a joystick or other peripheral device (TRADOC, 2003). Whether in man-wearable systems or on desktop machines, these systems provide an opportunity for the soldier to practice his/her Tactics, Techniques and Procedures (TTPs) and perform other cognitive tasks that are essential for combat. Virtual Reality systems allow users to become familiar with his/her surroundings in a new location that he/she may not be initially familiar with.

While these systems do provide many training benefits to the dismounted soldier, the cost, weight and power consumption restraints keep them from training soldiers in the field. The future warrior systems of tomorrow desire a new approach that is low cost, lightweight and uses very little power to provide situational awareness, heightened sensor feedback and critical battlefield information to the soldier.

FIRST APPROACH

The RDECOM-STTC researchers teamed up with industry partners to design and develop a small hand-held system to approach the limitations (cost, weight and power) of other systems (Stallman, Marshall, Roberts, & Green, 2006). The team decided to use a Personal Digital Assistant (PDA) that the soldier could carry with him into the field that would not add too much weight or power to his already overloaded

backpack. The PDA had been chosen because it met the hardware requirements of the desired system (low cost, weight and power). But the team still needed to determine if this was a potential technology that could provide beneficial training with the processor speed, limited memory and screen size of a PDA. The team wrote some test software to research the usability of a PDA system and discovered that the PDA could in fact be used as an ET technology. From there, the team designed and developed a system entitled "Team Mission Assistant-Tactical/Exercise" (TeamMATE) (as seen in Figure 1). The system composed of a PDA with TeamMATE software running on the system (using Windows Mobile 3 as the operating system) and had the following potential benefits (Stallman et al., 2006):

- Earlier transition to acquisition programs and fielding
- No training-specific equipment or training-specific influence on system design, and therefore potentially lower cost, size, weight, and power consumption (i.e. these could truly be 'embedded' systems within the GSS context).
- Provides training and rehearsal capabilities to dismounted soldiers that might not otherwise receive fully-immersive technologies due to cost or other considerations ("MIL-HDBK-29612 Part 1A")
- Complements fully immersive technologies in certain situations, e.g. if high-fidelity, current 3D terrain data is not available for a mission location

Figure 1. The TeamMATE software on the Dell Axim.

With these benefits in mind, the research team started to look at what was necessary for mission planning, mission rehearsal and collective training. The TeamMATE system was designed with four main functions for soldier use: Plan, Rehearse, Execute and Review.

Plan mode consisted of allowing soldiers (presumably the squad leader or other higher echelon members of the platoon) to use phase lines to design separate mission execution stages. The stages were used to show that soldiers understood the mission itself and the higher level tasks that need to be accomplished (Figure 2). Only when the previous phase of instructions had been carried out, would the next team leader (or squad member depending on the scenario set-up) then start to carry out his mission. With this in mind, the leader would set up the mission phases and ensure that his team leaders clearly understood what their part in the mission was and when they were to execute. The plan mode also allowed a leader to go over a mission plan step by step using chalkboard features such as drawing

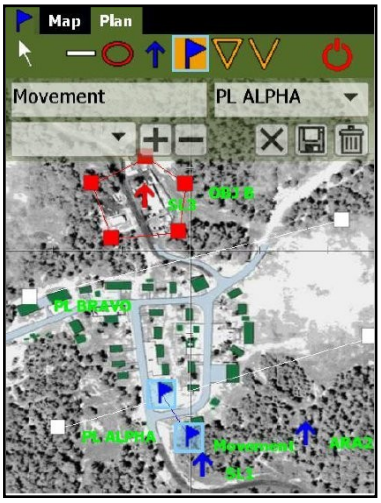

Figure 2. TeamMATE planning mode screen.

lines, circling objects, instantiating way points for soldiers to follow, and phase lines. The sketch mode also allowed a leader to add text to the screen and circle areas or buildings of interest. The sketch feature provided a chalkboard virtual sand-table. The concept was that instead of soldiers using nearby objects to place in the sand and draw lines around them, they could now use the TeamMATE system to perform this mission planning feature. This would prohibit nearby people from looking at what the soldiers were planning and relaying that information back to opposing forces. By using a PDA, the soldiers could secure the mission plan to only those who were supposed to see it.

Rehearse mode was a virtual mission rehearsal tool that allowed members of a team the ability to rehearse the mission together by puckstering around an icon that represented each soldier of the team. Each team

member would have control of only his/her icon and would use the icons to move around a map generated by the system. Rehearse mode could also be connected and correlated to other simulation systems via the Distributive Interactive Simulation (DIS) or High Level Architecture (HLA) protocols. The TeamMATE system could link into other training systems including man-wearable or desktop and Live, Virtual, and Constructive (LVC) systems in real-time. Rehearse mode allows soldiers to rehearse their mission before they enter combat environments. They could be rehearsing on their way to the mission, before the mission or while back at the barracks when they had some spare time.

Execute mode allowed soldiers to stow the TeamMATE device while they actually performed a mission in the Live domain. The soldiers then used the PDA to record their locations (using a GPS) while performing the mission. Once the mission was completed, the soldiers could then meet back together at a meeting point and connect their systems through an ad-hoc network. They could then sync their systems and run through the mission as they did in the real world. Their squad leader could correct any wrong actions and monitor the soldiers understanding of the mission before they entered real combat.

Review mode allowed the squad to perform an After Action Review (AAR) of the mission. A squad leader (or other senior soldier) could review the mission in real-time along with the soldiers and comment on the previous mission performance. The system provided a record button to allow the soldiers the ability to record missions as they rehearsed the missions. TeamMATE could record either a live or virtual mission and keep a recording of all of the actions for later viewing. Once reunited, the leader could choose to initiate the AAR using his PDA. TeamMATE would synchronize the PDAs that were within the range of the leader allowing the soldiers to watch the AAR on their separate PDAs. The TeamMATE system provided easy-to-use VCR-like controls to conduct the AAR. A leader could fast forward a mission to a critical event, rewind the mission to discuss a certain event, stop the recording, pause and play the recording. The review mode also displayed an event timeline at the top of the screen that provided event ticks that were colored to time-stamp specific events that took place during the mission exercise.

A yellow tick mark was placed on the time-line when a player spawned into the mission. A black tick mark displayed when a soldier shot his/her weapon and a red mark was displayed when a soldier was killed in the mission rehearsal (Figure 3). A blue mark was displayed if and when an entity was removed. Lastly, a green mark was used if a player re-spawned into the displayed mission.

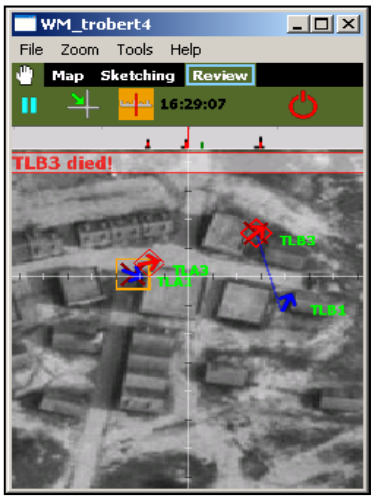

Figure 3. Review Mode with Event Time-Line

HUMAN FACTORS

A heuristic/expert evaluation for usability was performed on the TeamMATE user interface. Specifically, the following tasks were conducted:
(a) Collecting background information: The background information examined includes
• *Context of use and intended user*: TeamMATE is a mission rehearsal and planning tool for the team leader and his/her team members.
• *Environmental factors*: Stress (psychological and temporal) can be potentially involved.
• *Screen size*: The screen size on the PDA is a critical factor for the interface design since it limits the number of buttons that can be displayed to the user. In the case of the Dell Axim 51v, the maximum resolution is 480x640 and is a limiting factor on the user interface design.
• *Network*: TeamMATE works with a larger networked system including multiple TeamMATE hand-held devices.

(b) Heuristic Evaluation for Usability: The list of heuristics by Jakob Nielsen (2007) was used for the HFE assessment. Each feature of TeamMATE was tested, thus ensuring that it did not violate any usability heuristics, while we kept in mind the context of use and network-ability of the system as appropriate.

Based on the evaluation, several changes impacting the general layout, functionality, and navigation of the TeamMATE system software were recommended. A detailed description of the recommended changes to the

user interface is available in a U.S. Army Research Laboratory Technical Report (Clark, Reed, Chen, & Marshall, 2008; ARL-TR-4479).

A brief study of TeamMATE was also conducted as a student project at the West Point Military Academy as part of an Engineering Psychology class. The cadets studied the TeamMATE product and evaluated its usefulness (Grant, Zwick, & Fine, 2007). They reached a conclusion that using the TeamMATE product alone for retention of the mission information was slightly worse than the traditional sand table exercise. The analysis suggested that the user interface could be partially at fault and that improvements in the interface and iconology could result in TeamMATE being superior to traditional methods. This study also confirms suggestions in the Clark et al. (2008) report with respect to issues such as improving consistency for icon usage and the undo/redo capabilities.

USER FEEDBACK

The TeamMATE was developed and tested rigorously in the laboratory by West Point cadets, a human factors team and multiple engineers, but the real test was how would the TeamMATE system be received as a training device by actual soldiers? The team needed actual feedback from soldiers who would potentially be using the system in the future for training. The team set up a meeting at Fort Polk, Louisiana to demonstrate and discuss the TeamMATE with a group of 27 observer/controllers from the Joint Readiness Training Center (JRTC). All of the soldiers had been recognized as Army Training certified and all had trained soldiers on a regular basis and were familiar with current training standards and practices.

An overview of TeamMATE, its intended purposes and its features were briefed to 27 O/Cs at the JRTC. The intended purpose for TeamMATE was not to replace traditional training of soldiers or to be an exclusive trainer, but was designed to be a training enhancement support device to be used for in-field training. The soldiers were briefed on TeamMATE's features and capabilities, and then a demonstration was given by the design and development team engineers to show how the system was used. After that, the soldiers used the device for a period of time (approximately 20-30 mins). The O/C's were then provided a handout evaluation form and asked to write down their honest assessment of the device and their opinions.

The soldiers were asked to rate the "Ease of Use" for the TeamMATE on a scale of 1 to 10, where 1 was 'not easy' and 10 was 'easy to use'. The following statistics (Figure 4 and Table 1) were derived from the soldiers' responses:

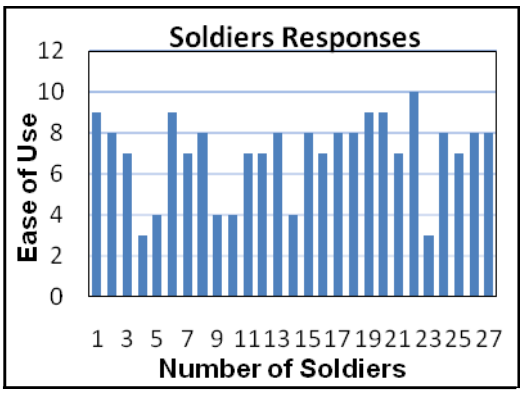

Figure 4. – Soldier Responses to 'Ease of Use' of the TeamMATE device

Mean	7
Standard Error	0.3812
Median	8
Mode	8
Standard Deviation	1.9807
Sample Variance	3.9232
Kurtosis	-0.4308
Skewness	-0.8474
Range	7
Minimum	3
Maximum	10
Count	27

Table 1. Statistics Derived from Study

The average of the soldiers' responses was 7 out of 10 or 70%. This is not a bad response as the soldiers did not have a specified course to learn and use the device. They were simply shown the device and were allowed to use it on their own for approximately 20 mins. With a formal class and a smaller group size, we are confident that the 'Ease of Use' statistic would increase.

The next question the soldiers were asked was "What are the Best Characteristics and/or Functionalities of the Device? In other words, what do you like about the TeamMATE device." This question was open for the soldiers to write short answers on what they perceived as the best characteristic or functionality of the device. The answers varied in response. In this paper, we will only outline what some of the most frequent responses were and what the most important answers were. For this second question the following answers were recorded:

- "*The planning only*", "*Planning purposes*" and "*Actually planning your movements and see what can/could/would happen before actual missions*" These comments were some of the comments made about the mission planning capability. This was not a surprise as Observer/ Controllers conduct mission planning events on a regular basis in order to instruct their trainees.

- "*AAR*", "*The device would be very useful in Troop leading procedures and AARs. The ability to develop graphics at platoon level for orders and rehearsals is beneficial*", "*Rehearsal capability. AAR, great for training centers*", "*The fact that you can train and watch it later*." and "*The ability to battle track after the mission. You will also be able to know exactly what happened and where it happened*." These comments were made in reference to the AAR capabilities of the device. This was also not surprising as AARs are very important to O/C's as they train other soldiers.

- "*The map layouts, with interactive moving pieces*", "*Map overview*", "*Being able to plan with up-to-date imagery and map overviews for all soldiers to see.*", "*Ability to create the actions on portion of the Oporder so you can show moving pieces.*" and "*Being able to plan with up-to-date imagery and map overviews for all soldiers to see.*" The mapping features consist of being able to lay down text, overlays and waypoints over the top of a map. This is typically in the form of J-PEG images displayed on the device.

- "*Ease of use. Most lower-enlisted soldiers are proficient at technology being used*." This was also an expected answer as most of the younger soldiers are used to playing video games. Therefore, they could adapt to using the device faster than some of the older soldiers.

The next question asked of the O/C's was "What are the Worst Characteristics and/or Functionalities of the Device. In other words, what do you not like about the TeamMATE device"? The following responses were recorded:

- "*The video game theory*". The "*video game theory" and "soldiers may not take it serious, might take it as a video game. Durability*." The O/C's were concerned that the device was too similar to a video game and therefore would not be taken as a serious training tool. Although no experimental data has been found to support this theory, it is one that the TeamMATE developers have heard before and have to keep this in mind as we develop newer technologies for the future.

- "*Limited to 2D*", "*Lack of 3D. A private wants to know whether he's on a hill, in a trench or behind a building and lack of LOS*" and "*Map data/grids not accessible. No elevation - needs integration with Google Earth/Falconview/FBCB2!!*" These were key statements that the TeamMATE developers had not heard before. This proved to be a very important feature that the soldiers wanted and the current device did not have.

- "*Possible battery life span on the training. As well maximum range of weapon system as well line of sight from icon to icon*.", "*Too many pieces to carry around. Battery life not long enough*" and "*Battery life, longer battery for the system because soldiers are lazy*." These comments reflected a problem that the team was aware of and had been currently taken into consideration. However, there was currently no fix for the TeamMATE device. Although the device did have an extended battery, we did not show that feature during this demonstration. The demonstration and briefing for the JRTC was meant to be a technology demonstration and not a field demonstration. The research team also knew that we would eventually have to choose another hardware device; we were putting off this comment until a final hand-held enhancement device was chosen by the Army for its dismounted soldiers to carry into battle.

- "*Do not know enough about this product. I think the idea is great, however, I have to many concerns about the product and its role in a real world environment when it comes to soldiers at a lower level*", "*May be really time consuming with other training and deployments*." and "*More technical training will take more resources and time to learn/manage/employ time management and access to training may become a serious issue.*" These comments provided a real issue that the research team would eventually have to reason with and resolve if a product like the TeamMATE was to ever be fielded.

The last question that was asked to the soldiers was "If they could, what would they change, or what could be improved on the device"? The following answers were captured:

- "*The security issues*." This was an issue that was discussed in length as this is already a serious

problem with other devices of this nature. Thumb Drives or USB sticks were already a huge security concern of the Army as sensitive information was constantly stored on these devices and many of the devices have been either stolen or lost and ended up in enemy hands. If a TeamMATE device was found by an enemy combatant, he would then know all of the locations and status of the Army soldiers. The soldiers spoke of devising a way to "zeroize" the device. In other words, if the device could be wiped of data before it is lost, then the enemy would never get the information from the device. This issue would be one that would have to be considered before a product like TeamMATE would be fielded.

- "*3D immersive simulation, integrate GPS, longer battery, WIFI/satellite connection, ability to download real-time graphics information for mission changes, etc*.", "*Add 3D and LOS capability*", "*Elevation would be nice, with fire control measure*", "*Graphics on the PDA. Increase speed on the PDA.*" These comments were also a common theme amongst the soldiers. All of the soldiers seemed to want elevation data, Line Of Sight (LOS) information and 3D simulation displays that are necessary for certain operations. Currently, the TeamMATE device could not provide this data.

- "*Durability*", "*Ruggedize it. Keep it at SL and above. It might work; little kinks need to be worked out*." and "*Solar panel to charge in the field compatible with loading different maps. Zeroing option (OPSEC), secure net, no biometric system. Can't be passed to next in chain of command*." These were all ideas on how to ruggedize the system or make it worthy of the field. Again, the PDA device was only a starting point and the research team knew that we would eventually be moving to a new hardware device, but the soldiers' ideas were definitely worth noted.

- "*The presentation was not extremely informative. There should have been a full demonstration on the projector. Just getting hands on with no knowledge of the equipment was not very effective*" and "*This needs a class to teach soldiers exactly how to use it. Allow a "pencil" function for leaders/soldiers to personally draw routes, objectives rather than relying on straight lines and waypoints*." These comments were made to let the research team know that if this system were to go into the field, soldiers would need more time to get to know how to use it before taking it out. This was a reasonable concern, but a training class could be provided.

- "*Voice recognition/command" and "Voice command*." These were good ideas that the research team had not thought of until the soldiers mentioned it. Adding voice recognition or voice commands could be added, so a note was taken to think this over for the next iteration of TeamMATE.

- "*I would not likely use it. Virtual training tools are always limited in their usefulness. There is no way to make a soldier "virtually" physically, mentally and emotionally exhausted. These conditions always have a very big impact on mission performance.*" This is a true statement, but as stated previously, the point of the TeamMATE was not to replace traditional training but to enhance the cognitive processes that were essential to mission success.

- "*I think it can be made to where you can't shoot through buildings to make it more realistic*." and "*Keep it in the classroom. Make it more realistic so you cannot shoot through buildings*." These comments were also typical and the research team knew that we would need to incorporate "Physics" modeling into the system to make it more realistic and less like a game to strengthen its training potential.

A NEW APPROACH

The RDECOM-STTC team collected the suggestions and comments about the TeamMATE. The feedback and questionnaire comments that were presented at the JRTC were recorded and studied. The team also studied the feedback that was previously collected from the National Training Center (NTC). (Stallman et al., 2006). Both sets of feedback and user evaluations were used to determine what the benefits of using a system such as TeamMATE would be. The team also studied what capabilities and functionalities were needed to improve TeamMATE to be used in the field. The main idea and goal of this effort was to provide useful techniques and capabilities to soldiers while in the field where traditional training systems could not be used. The research team of RDECOM-STTC and Institute for Simulation and Training (IST) worked together to re-design the TeamMATE to better serve the soldier. The team also wanted to apply the feedback results that we had gathered from all of the various feedback sessions into a new and improved

hand-held enhancement support device. The team decided to create a new and improved device that used the core features of TeamMATE as a starting point. At the same time, the team also wanted to incorporate some newer innovations and technologies into a hand-held device to meet the soldiers' feedback requirements. The team broke the problem into two separate programs. The first team worked on developing a newly designed hand-held device that incorporated the soldiers' suggestions. The newly designed hand-held device allowed the team to take advantage of current technologies and integrate them into a new hardware platform. The new hardware platform would allow the team to also meet the soldiers stated requirements. The second team developed and published a Small Innovative Business Research (SBIR) topic to bring in companies that provided challenging features that were not ready today, but could be ready in a few years. The plan was that the two teams would integrate their work later down the road providing a well designed and stable platform that still included new technology. The first team consisted of RDECOM-STTC researchers, S&T Managers and Institute for Simulation and Training computer scientists and computer engineers. The team designed a new enhancement and support mobile hand-held device that could be used for training entitled Soldier Training Enhancement Package (STEP). While in the initial phases of designing the STEP system, the team approached members of the Future Force Warrior (FFW) team and asked if the STEP system could potentially be designed to use in response to the Future Force Warriors Program's needs. The FFW team was already planning on using a hand-held device for training soldiers in the field so the STEP system seemed like a natural fit to the FFW program and provided the RDECOM-STTC and IST team a transition path for their work.

The main issue with the FFW system was that the hand-held device and all of its current software programs were running a different operating system than the TeamMATE. The FFW system was using the Linux operating system already contained in their PDA-type device that was already being used for the FFW program. After researching their chosen hardware platform, the FFW hand-held mobile device met all of the soldiers' requirements and the team decided to use this hardware base for the STEP system. The RDECOM-STTC and IST team worked with Natick Soldier Research Development and Engineering Center (NSRDEC) to determine a way to provide the Future Force Warriors a mission planning and mission rehearsal capability that could run on their already existing hand-held device (Figure 5). Through the use of a plug-in architecture, the RDECOM-STTC was able to develop simulation layers that could be integrated into the FFW system via a plug-in architecture and an Application Program Interface (API). The newly designed and developed STEP system proved to be the perfect fit for the Future Force Warrior Program.

Figure 5. - Soldier Training Enhancement Package (STEP) integrated into the FFW systems

FUTURE WARRIOR TECHNOLOGY

The Future Force Warrior system uses two different systems: one for the leader of the exercise and one for soldiers. The leader system includes a Panasonic Toughbook™ laptop computer that runs the software system "Falconview". This software package is the same package that one of the soldiers at the JRTC suggested to be used for a hand-held mobile system. The base soldier system runs on a Nomad PDA and uses a program developed by the Communications and Electronics Research Development and Engineering (CERDEC) Army center called Command and Control Mobile Intelligent Net-centric Computer System (C2MINCS). The STEP software forms a simulation layer on top of both programs. This simulation layer allows leaders to plan a mission and then send it to soldiers for use in mission rehearsals. The soldier, or basic system, allows a soldier to rehearse missions by puckstering an icon that represents him or herself in the virtual battle space. The icon appears on top of a virtual database that the mission is planned around. In setting up the system in this manner, soldiers do not have to learn any new software systems to be able to train; they simply use the same system that they would use in actual combat. The STEP system uses many of the same features that TeamMATE used but added more features to help the soldier navigate and move in the virtual battle space. A virtual chalkboard application is still available, and waypoints can be placed on the map to guide soldiers while rehearsing

their mission. Mission planning is still available for the leader of the team/squad, but is now accomplished using the Falconview software system. The base system allows the soldiers to virtually rehearse missions using C2MINCS in three separate settings: while on the way to their actual missions, while not in combat in the field or while they have some quiet time at their bunks. Using the FFW system, the hand-held Nomad PDA provides a longer battery life than the Microsoft PDA that the TeamMATE used. Also, with a higher processor speed, the Nomad allows real-time processing power for soldiers' use. Using the actual PDA that the Army is considering for use by its dismounted soldiers also alleviates the "video game theory" in that the PDA is the actual device that the soldiers will be using for both training and in actual combat forcing soldiers to use their equipment wisely. The AAR capabilities were also kept and integrated into both Falconview and C2MINCS for the leaders to use for AARs. The soldiers can still synch in to the AAR as they could with TeamMATE and learn from their mistakes. The low power (extended battery life), low cost and low weight set forth by the Army for the hand-held device can all be accomplished by using the Nomad system.

Targeting and shooting areas are also available in the STEP system. The range of many different weapons is modeled to represent the firing range of that weapon. If a user tries to use the weapon outside of its allowable range, the weapon will not fire. The STEP system also uses limited physics to represent buildings and other structures that cannot be fired through. Waypoints and ingress/egress movement paths must also be accurately modeled as soldiers are not able to walk through buildings or other structures and must use correct paths to navigate the training terrain.

Another large program for the Army and dismounted soldier systems is that of Land Warrior. Land Warrior was a system designed to enhance the warfighters' capabilities and give him/her an upper hand in battle. The systems were tested by the 4th Stryker Brigade Combat Team (SBCT) in Iraq and obtained very high remarks from the squad members. The Future Warrior Technology Integration (FWTI) program is going to merge systems with the Land Warrior systems to form the future of dismounted soldier systems; the Ground Soldier System (GSS). Currently, STEP is slated to be integrated into the GSS as the Embedded Training device for the future warrior. The Army is currently researching what the best hand-held device will be for the Ground Soldier System, but the STEP software is highly modular and portable since it is based on simulation layers that can be used with any pug-in architecture and API.

LAYERED TERRAIN FORMAT

The Layered Terrain Format (LTF) was introduced to the STEP developers and the software met a critical need for the soldiers in the field (Figure 6). LTF uses many different terrain layers and libraries and only uses the critical information that is needed therefore reducing processor and memory requirements for smaller devices. Specialized terrain formats attempt to solve terrain requirements by determining trade-offs of library and terrain sizes, accuracy and performance. LTF only uses the exact area needed for the mission and only the exact libraries required for the mission. Using LTF, soldiers can now find their Line-Of-Sight (LOS) to a target, building or landmark and can determine when they have Non-Line-Of-Sight (N-LOS) to a target and potentially need to move in order to engage the enemy. By using LTF, a soldier can also obtain his/her elevation data anywhere he/she is on the map. In essence, LTF provides soldiers with 3D terrain information over a 2D map.

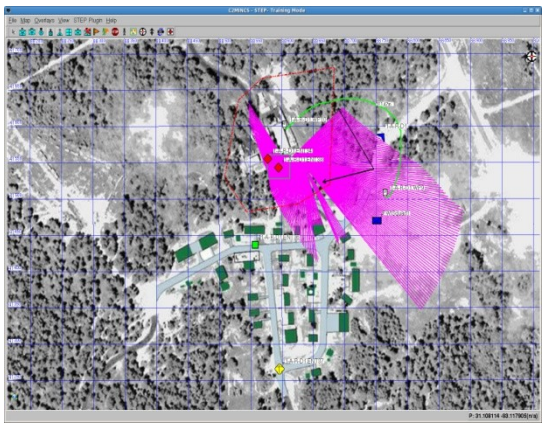

Figure 6. - Top-Down 2D View of Map with LTF (Line-Of-Sight (LOS))

When tasking a soldier to move across certain terrain, LTF calculates the real-time traversing of the terrain including the soldier's weight with gear. The software factors in the change of performance of the soldier due to these factors. The factors are weighted in the algorithm to produce a more accurate and realistic speed and time for the soldier over a distance that he/she traverses. While in certain terrain, a soldier may not want to wait for his display to update with accurate real-time information, STEP allows a soldier to use a fast forward button to increase his speed of travel over a long distance. This is very helpful when soldiers are dropped into a landing zone and want to rehearse the mission, but not wait for the 2 hour ingress that they would have to perform in real time.

ADVANCED FEATURES AND CAPABILITIES

Once the STEP system was initially designed and development, the RDECOM-STTC S&T Managers started a SBIR topic to investigate other desired advanced technologies that may help soldiers down the road. The main purpose of this effort is to provide Live, Virtual and Constructive (LVC) training capabilities to be added to the hand-held devices of the future. Using the feedback that we obtained through the JRTC and NTC sessions, a SBIR topic was written and proposed. The topic awarded two separate Phase I contracts to two companies. Both companies were to design and develop advanced features for STEP. These features were to enhance the system's communications, information and graphics. The advanced graphics were to overlay 3D imagery onto the 2D display. This could help in making sure that soldiers perform certain tasks in the correct manner (such as stacking against a wall, or clearing a building). The 3D information could be full 3D imagery or it could simply provide snapshots of areas of concern for leaders and trainers to look into to make sure that the soldiers were performing the correct maneuvers. The new features were not to interfere with the 2D map interface, as that information is still very important for soldiers to use for navigation and planning. Advanced tracking capabilities were also investigated to potentially allow soldiers to seamlessly navigate from the inside of a structure to the outside while continuously tracking a soldier. With mobile technologies advancing every day in the game industry and communication fields, those technologies could potentially be used to enhance the training effectiveness and realness of Army training systems providing enhanced proficiency, skills and cognitive decision making of the soldiers of the Army.

CONCLUSIONS

In this paper, we discussed the history of using mobile hand-held devices for enhancement and support of Embedded Training for soldiers in the field. We discussed the first attempts into this relatively new research area for the Army and then provided studies, results and feedback from the initial tests of the early devices used to meet this critical training need. We used the on-going feedback, evaluations and studies to help guide current devices that are planned on being used in the future warrior systems of tomorrow and showed how today's Soldiers and researchers are working toward developing tomorrow's support devices. We discussed the newly designed and developed enhancement and support devices and showed that the capabilities that are desired by the soldier are actually being tested and developed by today's researchers. The mobile hand-held device of the future can be used to successfully train soldiers while in the field and allow our future soldiers to train anywhere and at anytime and also allow our future soldiers to truly train as they fight and fight as they train.

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