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Squad Advanced Marksmanship Trainer

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Abstract: The modernization efforts of the Army seek to build upon the current level of soldier training effectiveness (TE) and must be adaptable to emerging technologies and ever changing requirements. The Synthetic Training Environment (STE) is a combined live, virtual, and constructed training environment that enhances both individual and collective military training by employing new technology. Accordingly, this research aims to create a methodology to assess the TE of the Squad Advanced Marksmanship Trainer (SAM-T), along with other STE tools. Through pairing the capabilities of the SAM-T system with Mission Essential Tasks List (METL) tasks, company Commanders will be given insight into how a synthetic training tool can be most effectively integrated within a unit to increase soldier lethality. The results of this research provide the Army with a training evaluation tool which enables Commanders to better allocate training time to meet unit specific METL tasks.

Keywords: Synthetic Training Environment, Squad Advanced Marksmanship Trainer, Training Effectiveness, Capability Analysis, Common Synthetic Environment, Mission Essential Task List

1. Introduction

The Synthetic Training Environment (STE) is the future direction the Army is heading towards in terms of training and simulation. The aim is to incorporate a realistic, low cost training environment that can be readily accessed anywhere, at any time. Major General (MG) Maria Gervais says it best when she stated, “From wherever they may be located, home station, armories, institutions, or deployed locations we want our Soldiers to enter into a synthetic training environment that immerses them in diverse complex operational environments that replicate where they will fight; with who they will fight with; on the terrain they will fight on!” (MG Gervais, Deputy Commanding General, CAC-T). The Army requires integrated training capabilities that can adapt to emerging technologies, which is the primary aim and focus of the STE. The STE is designed to provide a cognitive, collective, multi-echelon training and mission rehearsal capability for the operational, institutional and self-development training domains within the military. It brings together the virtual, constructive and gaming training environments into a single STE. It will provide training services to ground, dismounted and aerial platforms and command post (CP) points of need (PoN) (USAASC-Army website). This point of need ranges from the individual soldier all the way up to the Army Service Command Component (ASCC) with the end result being to improve soldier proficiency, to increase access to training, and to save money.

1.1 Background

STE became integral in the Army modernization process. STE proceeded through the Army Requirements Oversight Council (AROC), which consists of senior leadership who approve the gaps, concept, and requirements of STE, in order to stake its claim as essential to the modernization goal of the Army. The Army Capabilities Board (ACB) claimed that the Army was behind in the use of synthetic technology. They wanted an improved simulation environment that encompassed live, virtual, constructive and gaming all into one environment, and, as a result, the AROC developed The Army Directive 2017-24, that was established in 2017, creating the STE Cross Functional Team (CFT) to identify better training requirements using faster processes. They developed the requirements with the end state being to improve future training capabilities (STE White Paper).

The STE CFT, led by the Combined Arms Center-Training (CAC-T), utilizes industry collaboration and early user feedback in order to accelerate the development of STE. The benefit of this rapid and collaborative approach is that it will allow for early prototyping, experimentation, and user feedback. The STE also has to be receptive and adaptive to the ever changing realm of technology and the Army. It seeks to deliver prototypes to the units and users based on the Point of Need, and it will initially focus on the development of prototypical capabilities for Company level Combined Arms (CA) Transportable Reconfigurable Virtual Trainers, Global Terrain, and a Training Simulation Software engine (STE White Paper).

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1.2 Related Simulation Research

Simulation is a cost effective method that is readily used in the civilian sector in various fields, such as medical, sports, etc., to improve training of a skill or to replicate tests to find an optimal solution from the data. In regards to surgical training, with laparoscopic cholecystectomy as an example, virtual training simulators have been used to train surgeons in the skills laboratory with the objective being to establish a "clear benefit of Virtual Reality (VR) training that transfers to surgeon skill measured in the operating room (OR)" (Seymour et al., 2002). The results from the experiment found that "Gallbladder dissection was 29% faster for VR-trained residents. Non-VR-trained residents were nine times more likely to transiently fail to make progress and five times more likely to injure the gallbladder or burn non-target tissue" (Seymour et al., 2002).

Simulation in the United States Army began with the Air Defense Simulation, created by the Army Operations Research Center at Johns Hopkins University in 1948. This was followed by the Carmonette, a series of models that began in 1953, which "significantly improved the mathematical precision and reproducibility of the results" (Smith, 11). These simulations were low fidelity due to the technology of that time period. In recent years, however, the Department of Defense has increased budget allocations for modeling and simulation, allowing a surge in simulation research and development. This paved the way for high fidelity simulators, such as the Close Combat Tactical Trainer (CCTT) and Reconfigurable Virtual Collective Trainer (RVCT). These simulators have provided brigades opportunities to perform live fire simulations at low cost with rapid repetitions, allowing soldiers to virtually train and develop familiarity before live fire exercises.

Currently, there is a lack of effective simulators for dismounted soldiers as the only widely available dismount simulators are Virtual Battlespace (VBS) 3, which is a first-person shooter multiplayer game, and Engagement Skills Trainer (EST) II, a virtual range. VBS 3 is low fidelity but highly customizable while EST II is medium-fidelity with low customizability. EST II was designed as a low cost, high repetition prerequisite to Basic Rifle Marksmanship, the rifle qualification of the Army. However, it is rarely utilized to its fullest potential by Army units. Without a medium to high fidelity simulator with high customizability of training scenarios, Commanders will advocate exclusively for live training.

Simulation is often a cheaper alternative to training, whether in the civilian world or in the military. However, the simulator must train the user either as effectively or more effectively than the baseline training to be an effective replacement or addition to live training. One study on assessing the training effectiveness (TE) of emerging technologies was conducted by the U.S. Army Research Institute (ARI) for the Behavioral and Social Sciences in Virginia. The study aimed to create a methodology of assessing TE to determine training technologies that are effective for training within "the field of complex operational systems" that continues to expand today (Livingston et al., 2005). The study found "three levels of analyses by which SMEs [Subject Matter Experts] could evaluate training technologies at different stages of development." (Livingston et al., 2005).

Another study by the Defense Science and Technology Organization (DSTO) of the Australian Department of Defense, aimed to assess the training effectiveness of "additional simulator training on a basic live-fire qualification task with the M4 weapon" (Stephens and Temby, 2014). In this study, the simulation users did not benefit from the simulation due to "lack of trainee experience with the M4 weapon and iron sights, limitations with the simulator target imagery, and few opportunities for individual coaching" (Stephens and Temby, 2014). Although this study found the simulation was not effective, it was performed nearly five years ago and simulation technology has exponentially improved since then. Also, the trainees were not experienced on the M4. Therefore, if performed again with trainees familiar with the M4 and using the more advanced simulation technology, the results may vary.

2. Capstone Framework

2.1 Model Motivation

The Army requires immediate modernization through the STE to increase soldier lethality and maintain readiness to gain military superiority and overmatch potential adversaries. To increase soldier lethality, the Army has introduced the STE, which converges current live, virtual, and constructed environments into one interchangeable training environment. As an aspect of STE, the Squad Advanced Marksmanship Trainer (SAM-T) acts as an addition to the current EST II system. A capability analysis of the SAM-T will demonstrate the potential benefits to soldier lethality. In addition, an analysis of the current TE measures used to assess the SAM-T will enable the Army to better implement future STE technology.

2.2 Scope

The goals and objectives of STE are intended to change much of how the Army conducts training today and increase soldier proficiency in tasks, make training more efficient, and save resources (time and money). This research seeks to analyze

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the effects of the SAM-T system in the Army, specifically at the Company level and below. In terms of live, virtual, and constructive, the project focuses on the virtual simulation that is SAM-T, as we want to better understand if the virtual training

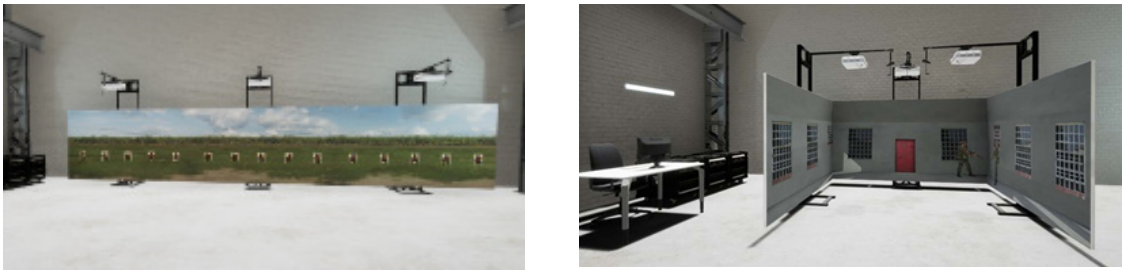

Figure 1. SAM-T Flat Screen (Left) and U-Shape (Right) Configurations

provided by SAM-T properly trains soldiers to prepare for a live field training exercise. The project establishes a baseline for how to best integrate SAM-T into Army units by creating a capability analysis and pairing the capabilities of SAM-T with unit specific METL tasks. Our project focuses on a low to medium level fidelity system, which refers to the degree in which the SAM-T system exactly replicates a live training field training exercise.

2.3 Stakeholder Analysis

Discussion with stakeholders focused on Infantry Company Commanders with moderate amount of exposure to STE. The accuracy of STE training is limited based on the unattainable demands that come with real world training. Factors such as dirt, smoke, terrain, and weather are some of the issues not achievable from STE. STE training in the EST II Range is effective for training soldiers prior to qualifying on live ranges for Commanders to refresh and improve the basic individual soldier skills with units. Stakeholders identified STE capabilities as limited to rifle marksmanship and vehicle training simulations as holding value for training. One stakeholder, Infantry (IN) Captain (CPT) Steven Morse, identified how vehicle training simulators such as the Bradley Fighting Vehicle and Helicopter simulators are applicable to TE because the near identical measurements (high fidelity) of the simulation system match that of the actual vehicle used in live field exercises. Contrary to that, dismounted operations, which involve external stimuli that cannot be replicated accurately in STE, require physical, live training. The fidelity in simulation is crucial for the effectiveness in field application. Stakeholders also identified that the software must be up to date and adaptable to new scenarios to keep the users thinking and reacting.

A stakeholder in the National Guard identified that STE training is very beneficial to resource-depleted units. A National Guard unit typically has only 80-100 rounds of ammunition per year per soldier to qualify on the M4 rifle which makes reaching proficiency goals difficult. By using the EST II extensively prior to field qualification, the trained to proficient percentages of soldiers drastically increases. Analyzing this feedback from units, which have little resources and must use STE tools, identifies a crucial area of need and usefulness of similar STE tools. This point was also made by a Commander in the active duty Army who claimed EST usage is a good way to refresh basic rifle marksmanship (BRM) skills prior to qualification in the field range. Using the EST range to train and retrain soldiers prior to entering the field saves valuable resources for active units, but the downside is EST is limited to low levels of fidelity, making the tool less effective.

2.4 Problem Statement

In an effort to integrate STE tools into modern Army training methods, synthetic training tools must be tailored to identified gaps in Army training requirements based on unit METLs. The objective of this research is to perform a capability analysis on the SAM-T as well as to construct a methodology that can be used to assess TE. The intent of this work is to provide Company Commanders a basis to help implement appropriate synthetic training tools and assess their effectiveness as they strive to increase soldier lethality of their unit.

3. Methodology

The methodologies used throughout this project are driven by the requirements of the Army. Synthetic tools exist in many of the commercial industries today, and it is imperative that they are considered for implementation into Army units to maintain technological superiority and address identified areas for improvement. However, simply because a tool is available

does not justify a necessity of use. In order to attain this justification of use, the tool must produce a measurable improvement to the organization to account for its cost. Through a capability analysis of a synthetic tool such as the SAM-T, the Army can realize the full range of possibilities that the tool provides to a unit. This is specifically important for company Commanders who are seeking to improve their unit's proficiency of mission essential tasks.

Providing a capability analysis informs the commanding officer of the viable options available when deciding upon a course of action, while a supplemental assessment of how it impacts TE produces the measurable benefit required to justify the synthetic tool's implementation. Ultimately, the goal is to increase soldier lethality. The value that a synthetic tool brings to an organization is based upon the extent to which it can achieve this goal and is measured through an assessment of the TE tailored specifically to the synthetic tool. The methodology used to assess SAM-T is rooted within TE analyses conducted on similar tools and must address the capabilities of the synthetic tool that impact effectiveness.

3.1 Course of Action

The courses of action used to address the SAM-T system are applicable to future analysis of synthetic training tools being considered by the Army. Composed of two distinct processes, the courses of action cover both how to assess the current capabilities of SAM-T and how to evaluate the effectiveness of training involving the system. The capabilities of SAM-T are broken down in the context of their relevance to METL tasks of a dismounted infantry unit. This analysis is followed by a methodology for measuring the TE of SAM-T in future studies.

3.1.1 Capability Analysis

Analyzing the capabilities of SAM-T requires both an in-depth understanding of the trainer itself and a firm grasp on the requirements of the Army. For this reason, the course of action for the capability analysis began with a collection of inputs from relevant stakeholders. These stakeholders included those developing the SAM-T as well as those who would potentially be deciding to utilize SAM-T in their unit's training. From this stakeholder analysis, relevant tasks and value measures were identified for analysis and then prioritized based on the feedback from subject matter experts (SMEs) in the maneuver community.

With the initial stakeholder analysis complete, all components and capabilities of the SAM-T were compiled into a list so relevant aspects of the tool could be readily identified using dismounted infantry METL tasks as a frame of reference. A matrix was then formed, pairing SAM-T capabilities with METL tasks based on previously determined value measures. This matrix, in combination with swing weights established by stakeholders, produced scores for each SAM-T capability regarding how well it addressed the METL. These scores were used to prioritize the capabilities of the SAM-T system for future development so that a focus could be placed on components producing the greatest benefit to the user. This capability analysis can be used to advocate for funding of the development of specific components as well as provide Company Commanders a clear format to assist them in effectively integrating SAM-T into their unit training.

Table 1. SAM-T METL and Capabilities Analyzed

METL Task	METL Task Title/Description
SAM-T	
Individual Tasks	
071-COM-0030	Engage Targets with an M16-Series Rifle/M4-Series Carbine
071-COM-0033	Correct Malfunctions of an M16-Series Rifle/M4-Series Carbine
071-705-0009	Engage targets using M150 Rifle Combat Optic (RCO) on an M16/M4 Rifle/Carbine
071-705-0014	Engage Targets Using M68 Close Combat Optic (CCO) on an M16/M4 Rifle/Carbine
191-376-5158	Engage Targets with an M9/M17/M18/GLOCK 19 Pistol during Limited Visibility
071-004-0010	Engage Targets with an M17/M18 Pistol
071-COM-0005	Correct Malfunctions of an M9/M17/M18/GLOCK-19 Pistol
191-381-1254	Engage Targets With a 12-Gauge Shotgun.
071-COM-4029	Correct Malfunctions of an M249 Machine Gun
071-COM-4024	Engage Targets with an M249 Machine Gun
NA	Engage Targets Using the M145 Machine Gun Optic (MGO) on a M249 Machine Gun
Collective (Fire Team) Tasks	
07-SQD-D9509	Enter and Clear a Room
07-PLT-D9501	React to Direct Fire Contact while Dismounted
071-COM-440	Employ Hand Grenades
071-COM-0608	Use Visual Signaling Techniques

Measured Capabilities Addressed
Personal Equipment Variation (Armor, MOPP, Weapons, etc.)
Respiration and Heart Rate Tracker
Weapons/Soldiers can maneuver 50 ft. radius
Weapon Skill Development
Use of Force Training
Battle Drill Training
Movement Drills/ Requirements
Calisthenic Tasks (Aerobic/ Anaerobic)
Differing Threat Levels
Various Target Distances
Lighting Changes
Integration of Obstacles (Physical Variation of SAM-T footprint)

3.1.2 Training Effectiveness

The TE of SAM-T can be initially assessed with the Training Technology Evaluation Tool (TTET) (Livingston et al., 2005). This tool allows military trainers and SMEs to evaluate current training technologies with the additional capacity to

evaluate emerging technologies due to the flexibility of the different components factoring into the overall assessment. The TTET centers on task and subtask evaluations of pre-training and post-training skill deficits that have been identified by military SMEs such as a commanding officer of a unit. The basis for this tool is the Device Effectiveness Forecasting Technique (DEFT) which required analysis of four main areas: Training Problem (TP), Acquisition Efficiency (AE), Transfer Problem (TRP), and Transfer Efficiency (TT) (Livingston et al., 2005). TP is the deficiency in skills the trainer seeks to improve; AE is the quality of training through the capabilities of the training tool. These two areas compose a total Acquisition score. TRP is the remaining skill deficiency of the user upon completion of the training, factoring in residual deficits due to physical and functional discrepancies with the actual task being assessed; TT is how well the skills learned through the simulation will be retained upon transferring to live training (Livingston et al., 2005). These two areas compose a total Transfer score, which, when combined with the Acquisition score, produces the total effectiveness of the training technology. This evaluation tool applied to the SAM-T system will allow for a unit's TE to be assessed one critical METL task at a time.

To gauge the progression of individual soldier marksmanship levels in SAM-T, two test groups of soldiers can be created: one that trains solely on the SAM-T system, and one that only trains through live-fire exercises. After running numerous iterations on SAM-T to feel competent in their marksmanship skills, soldiers will then conduct a live-fire exercise to measure how well competence in the SAM-T training translates to successful live-fire training. If the group that solely conducts live-fire training outperforms the simulation group, then changes will need to be made to address the difficulty level of the SAM-T training to compensate for the fidelity of the system. The measures SAM-T must evaluate and record feedback on are: 1) consistency of trigger squeeze, 2) precision (low standard deviation) of shot-grouping, 3) consistency of breathing technique, 4) degree to which the shooter maintains the same sight picture, 5) stability of butt stock and front of weapon, and 6) positive control of weapon to allow timely scanning of the soldier's sectors of fire. All the skills listed are necessary for training a competent marksman and improving his qualifying marksmanship score. Timely and accurate feedback proves essential to the development of the soldier, so that he may focus his attention on areas in need of improvement.

Assessing the TE of the marksmanship components of SAM-T is the primary task, followed by soldiers being evaluated as a collective squad aiming to maximize lethality and synchronize movement and fires. To do this, the soldiers must set a standard for spacing, perform a training simulation, and receive feedback about when and how often the spacing standard was breached, and even discuss potential reasons for why it was breached. Next, soldiers must be assessed on the degree to which they maintain their sectors of fire throughout the mission. Then, data is collected on how quickly the squad reacts to contact and effectively neutralizes the target(s). A baseline of target times and scores must be assigned to create a standard for what constitutes meeting, exceeding, or failing to meet the standard. The squad then conducts a similar live-fire training exercise and gets feedback in all the necessary areas to gauge whether the squad met all of the criteria and mission requirements to label it a success. If the results show that running through multiple iterations in SAM-T properly prepare soldiers to display the same competence in real life training exercises, then the intent is met.

4. Results and Analysis

In order to make a method of assessing the effectiveness of the SAM-T for training, assessments of prior training tools were referenced to form a standard of evaluation. In a study on the effectiveness of rifle marksmanship simulation for training, general takeaways are that the simulation scores are inflated when compared with the live-fire scores, and that the fidelity of the system is too low and did not properly prepare soldiers to fire a live weapon. Soldiers stress a need to feel the proper amount of recoil when shooting as well as the weight of the weapon system they carry as those represent important factors in rifle marksmanship. The simulation training is an important function in developing fundamentals of rifle marksmanship for soldiers, but it does not challenge their skillset enough or provide them with the real experience of firing a live weapon. As a result of the simulation marksmanship study, two design recommendations are to "Make the simulator training sufficiently challenging so Soldiers can meet or exceed desired live-fire performance," and to "create an effective and efficient training feedback system … that provides what Soldiers and trainers need at different stages of learning, yet still support the throughput required by marksmanship programs of instruction in initial entry training" (Dyer et al., 2016).

The SAM-T incorporates a user-friendly feedback system that provides useful performance feedback to the trainee. Additionally, the flexibility of the SAM-T allows the operator or Commander to create a simulation that tailors the training to each specific soldier, taking into account his strengths and areas requiring improvement. The goal is to record scores from the simulation exercise that are equal to or lower than scores in the live-fire exercise as that will correlate to the simulation providing an ample challenge for the soldiers. A more demanding simulation exercise can translate to an increased performance in live-fire results. Likewise, an appropriate level of simulation fidelity for the SAM-T can also translate to increased performance as it is tailored to its respective stage in the train-up process.

Despite its numerous capabilities, the SAM-T requires improvement in certain areas to remain viable as a training simulator. The two main areas requiring improvement are lighting changes and integration of obstacles. These capabilities are

necessary to improve fidelity, and thus improve training value. Lack of these aspects of simulation limit training value as SAM-T will not train some of the necessary METL tasks at the soldier/squad level.

5. Conclusions and Recommendations

Based on the analysis of the results and findings produced, several recommendations can be made regarding the SAM-T. Starting with the capability analysis, the results from stakeholders have indicated that the trainer will be best used for weapon skill development and components of battle drill training, including a focus on multi-distance targets. A recommendation to implement this into unit training is to integrate the use of SAM-T into the train-up for a live fire as a qualification table that needs to be validated. In this manner, SAM-T does not replace the live-fire train up but supplements the process with a reduction of costly resource usage. Additionally, SAM-T can be implemented into a unit's training remediation process to focus on specific aspects of tasks that are identified as deficient. The input from stakeholders also revealed the importance of after action reports (AARs) to training, as they substantiate the value of the training being conducted and identify areas where a unit can develop. A recommendation addressing AARs is to continue the development of the bio-ware technology components of SAM-T in an effort to capture more holistic performance measures for the unit.

As for the methodology for assessing the TE of SAM-T, the effectiveness can be assessed through the TTET. This four-part analysis tool determines deficiencies in soldier lethality, the quality of training through the simulator's capabilities, remaining deficiencies in soldier lethality after training, and finally, how well the skills are retained when assessed in live training. It is recommended that a future capstone project group collects data from soldiers utilizing the SAM-T and assess the TE of the system through the TTET. A focus should be placed on data collection relating to the performance of collective tasks specifically. This focus would tailor the TE methodology to synthetic training tools, which are primarily being implemented into military training to target collective training, and provide data in an area of focus that currently lacks analysis. The TE of individuals has been focused on but in order to truly assess the impacts of synthetic training tools, that focus should be expanded to the TE of a collective group. Synthetic tools provide many capabilities to our soldiers but they come at a cost. Accordingly, discovering how they improve soldier lethality is a worthwhile process and SAM-T can be the starting point as new potentially beneficial technologies emerge each day.

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