2011-06

Embedded training and the training requirements for the Abrams main battle tank

Biolchini, Gerald.; Kinney, Karolyn

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

JOINT APPLIED PROJECT

Embedded Training and the Training Requirements for the Abrams Main Battle Tank

---

By: **Gerald Biolchini,**
Kevin Crawley, and
Karolyn Kinney

June 2011

Advisors: **Brad Naegle**
Craig Langhauser

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** June 2011	**3. REPORT TYPE AND DATES COVERED** Joint Applied Project	
4. TITLE AND SUBTITLE Embedded Training and the Training Requirements for the Abrams Main Battle Tank		**5. FUNDING NUMBERS**	
6. AUTHOR(S) Gerald Biolchini, Kevin Crawley, and Karolyn Kinney			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000		**8. PERFORMING ORGANIZATION REPORT NUMBER**	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A		**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol Number ___N/A___.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited		**12b. DISTRIBUTION CODE** A	

13. ABSTRACT (maximum 200 words)

The Abrams tank has had an Operational Requirements Document (ORD) requirement for embedded training (ET) since 1994 and has successfully demonstrated the capability as early as 2001. The most challenging aspect of implementing ET has been to get the Abrams combat development community (User) and materiel development community (Product Manager) to equally consider the need for ET among competing combat capability. The need and priority for embedded training has not been effectively conveyed. Due to the interpretations of embedded training requirements, the direction to PM Abrams to implement embedded training has been weak at best, while the perceived User need for ET continues to grow. Since the technology has been demonstrated, the combat developer has begun to understand the capability and more effectively define the desired state (how he would use it and its benefits). Furthermore, the Army's style of fighting has changed; therefore, the Army's method of training must also change. Embedded training should be recognized by the materiel developer as an essential training tool necessary to keep Soldiers' skills sharp in the changing training environment.

14. SUBJECT TERMS Embedded Training, Abrams Main Battle Tank, Army Requirements			**15. NUMBER OF PAGES** 71
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

EMBEDDED TRAINING AND THE TRAINING REQUIREMENTS FOR THE ABRAMS MAIN BATTLE TANK

Gerald Biolchini, GS-13, Department of the Army
Kevin Crawley, GS-13, Department of the Army
Karolyn Kinney, GS-13, Department of the Army

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN PROGRAM MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June 2011

Authors: _____
Gerald Biolchini

_____
Kevin Crawley

_____
Karolyn Kinney

Approved by: _____
Brad Naegle, Lead Advisor

_____
Craig Langhauser, Colonel, United States Army,
Support Advisor

_____
William R. Gates, Dean
Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

EMBEDDED TRAINING AND THE TRAINING REQUIREMENTS FOR THE ABRAMS MAIN BATTLE TANK

ABSTRACT

The Abrams tank has had an Operational Requirements Document (ORD) requirement for embedded training (ET) since 1994 and has successfully demonstrated the capability as early as 2001. The most challenging aspect of implementing ET has been to get the Abrams combat development community (User) and materiel development community (Product Manager) to equally consider the need for ET among competing combat capability. The need and priority for embedded training has not been effectively conveyed. Due to the interpretations of embedded training requirements, the direction to PM Abrams to implement embedded training has been weak at best, while the perceived User need for ET continues to grow. Since the technology has been demonstrated, the combat developer has begun to understand the capability and more effectively define the desired state (how he would use it and its benefits). Furthermore, the Army's style of fighting has changed; therefore, the Army's method of training must also change. Embedded training should be recognized by the materiel developer as an essential training tool necessary to keep Soldiers' skills sharp in the changing training environment.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

AAR	After Action Review
AGTS	Advanced Gunnery Training System
ARFORGEN	Army Force Generation
CASCOM	Combined Arms Support Command
CAV	Calvary
CCTT	Close Combat Tactical Trainer
CDD	Capability Development Document
CETS	Common Embedded Training System
CITV	Commander's Integrated Thermal Viewer
CMETL	Capability Mission Essential List
COFT	Conduct of Fire Trainer
CTC	Combat Training Center
CONUS	Continental United States
DoD	Department of Defense
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities
ET	Embedded Training
FCS	Future Combat System
FIP	Fault Insertion Plug
FM	Field Manual
GCV	Ground Combat Vehicle
GPS	Global Positioning System
HBCT	Heavy Brigade Combat Team
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HTI	Horizontal Technology Integration
IEMT	Interactive Electronic Technical Manual
IOS	Instructor Operator Station
LRU	Line Replaceable Unit
LVC	Live Virtual Constructive
LVC-ITE	Live Virtual Contractive – Integrated Training Environment
MBT	Main Battle Tank

METL	Mission Essential Task List
MILES	Multiple Integrated Laser Engagement System
MOS	Military Occupation Specialty
MTOE	Modified Table of Organization & Equipment
NCO	Non-Commissioned Officer
NET	New Equipment Training
NPS	Naval Postgraduate School
NTC	National Training Center, Ft. Irwin, CA
ORD	Operational Requirements Document
P3I	Pre-Planned Product Improvement
PM	Program/Product Manager
PM HBCT	Program Manager Heavy Brigade Combat Team
POI	Program of Instruction
RDECOM STTP	Research Development and Engineering Command Simulation and Training Technology Center
ROC	Required Operational Capability
R&D	Research and Development
SEP	System Enhancement Package
STRAP	System Training Plan
SWA	Southwest Asia
TADSS	Training Aids, Devices, Simulations and Simulators
TDR	Training Device Requirements
TESS	Tactical Engagement Simulation System
TCM	TRADOC Capabilities Manager
TRADOC	Training and Doctrine Command
TSR	Training Support Requirement
TSV	Thru-Sight Video
TWGSS	Tank Weapon Gunnery Simulation System
VCSA	Vice Chief of Staff of the Army
VHMS	Vehicle Health Management System

ACKNOWLEDGMENTS

- Program Management Office, Heavy Brigade Combat Team
- Product Management Office, Abrams
- Research Development and Engineering Command, Simulation, Training and Technology Center

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

We need to take training to the Soldier, not the Soldier to training.

Brigadier General Paul E. Funk II

Soldiers and trainers demand more realistic training. The Army's precept is to train the way we fight. If training capabilities were embedded into the vehicle platform, Soldiers would train on the same platform that they operate in combat. As BG Funk stated, we need to take the training to the Soldier not the Soldier to training. Embedded training can bring realistic training directly to the Soldier, providing them the opportunity to train at any time.

The Abrams tank has long had the requirement and the potential capability to provide embedded training. The Abrams Operational Requirements Document (ORD) requirement for Embedded Training (ET) was written in 1994 and the technology has been demonstrated as early as 2001. The most challenging aspect of implementing ET has been to get the Abrams combat development community (User) and materiel development community (Product Manager) to prioritize ET among competing requirements. The need and priority for embedded training has not been effectively conveyed over the past two decades. Due to interpretations of embedded training requirements, the understanding of the ET requirement has been weak at best, while the User need for ET continues to grow as training timelines are continually shortened. Since the ET technology has been demonstrated, the combat developer has begun to understand the capability and more effectively define the desired state (how they would use it and its benefits).

The Army's style of fighting has changed; however, the training methods have not adapted to the new processes. It is, therefore, reasonable to expect the Army to want to advance its methods of training so Soldiers can prepare for different types of missions and different force structures in which they may have to operate. A more agile training method is necessary. The objective of this research is to identity the barriers to achieve an embedded training capability. This research will provide a definition of embedded

training, identify policies regarding ET, identify Abrams and Army requirements regarding embedded and deployable training, discuss the technical capabilities and benefits of embedded training, and recommend a path forward.

I. INTRODUCTION

A. BACKGROUND

> American military training and education have proved to be the sure path to competence, to high standards, and to victory. In our time, the surest way to strengthen the bond between certain preparation in peace and ultimate success in war is through the rigorous development and continuous professional growth of the Army's leaders.
>
> General William Richardson (DA Pam 600-65, 1985, p. 16)

The concept of embedded training (ET) is to allow the Soldier to train anywhere, anytime, even when deployed in a wartime environment. Doing so enables the Soldier to keep his skills sharp during their long deployment phase. According to Army policy and Abrams requirements, ET is the preferred method for training, yet it still is not available. The first mention of ET for the tank is documented in a 25 September 1990 Information Paper written by Army Training and Doctrine Command (TRADOC) New Systems Training Directorate. It states that ET will be a research and development requirement for the Block III tank (Appler, 1990). Even though the Block III tank program never became a reality, many of the requirements, including embedded training were translated into the M1A2 requirements document. Embedded training for the A2 tank has been an official requirement since the Abrams Operational Requirements Document (ORD) was signed in 1994. TRADOC is in the process of documenting lessons learned from Operation Iraqi Freedom and the indication is that there was, and still is, an immediate need for an embedded training capability. Documentation of such findings, however, has not yet been produced. Initial findings show that lengthy rotations and shortened training timelines have resulted in a degradation of gunnery skills. Soldiers were forgetting the procedures to effectively engage a target with the Abrams Main Battle Tank. ET can be a useful tool to refresh those perishable skills, but the data to prove such is still being collected. As solution to this problem, mobile gunnery trainers were immediately shipped to Iraq to continue training Soldiers on the battlefield. The mobile gunnery trainers are simulators housed in a trailer that can be moved to any location (see Figure 14). The transport of the

gunnery trainer, however, was subject to hostile fire, and as a result, the mobile gunnery devices went unused because no one was willing to risk lives to transport the training device and no Soldier was going to leave the battlefield in order to access a training device that could be hundreds of miles from their location. Soldiers must continually train in order to retain their skills. As a result, the tank itself remains a viable option as a training platform in order for crews to maintain a high state of proficiency in skills that are highly perishable.

Research for an embedded training capability on the Abrams tank was re-initiated, in 1997. Development began, and an embedded training capability was successfully demonstrated in October 2001. The demonstrated ET system was hosted in an appended box that plugged into the tank. During the same demonstration, a Bradley Fighting Vehicle exhibited a separate embedded training solution. Fielding of either demonstrated product to the Soldiers, however, was put on hold when the Program Manager Heavy Brigade Combat Team (PM HBCT) instructed Abrams and Bradley Product Managers (PMs) to develop a "Common Embedded Training System" for both platforms. Since then, many efforts have been initiated to bring together the Abrams and Bradley communities, and vehicle manufacturers, to develop a Common Embedded Training Solution (CETS). Gunnery training was chosen to become the initial function in ET because it was shown that it was the most perishable skill set. A fully embedded opportunity gunnery trainer for the tank is being developed and has been funded for fielding in the near future (Figure 1). This system is targeted to be a common system for both Abrams and Bradley vehicles. Planned capabilities beyond gunnery include mission preparation, currently trained in CCTT (Close Combat Tactical Trainer) and static drivers training, however, these capabilities are only in the technology demonstration phase.

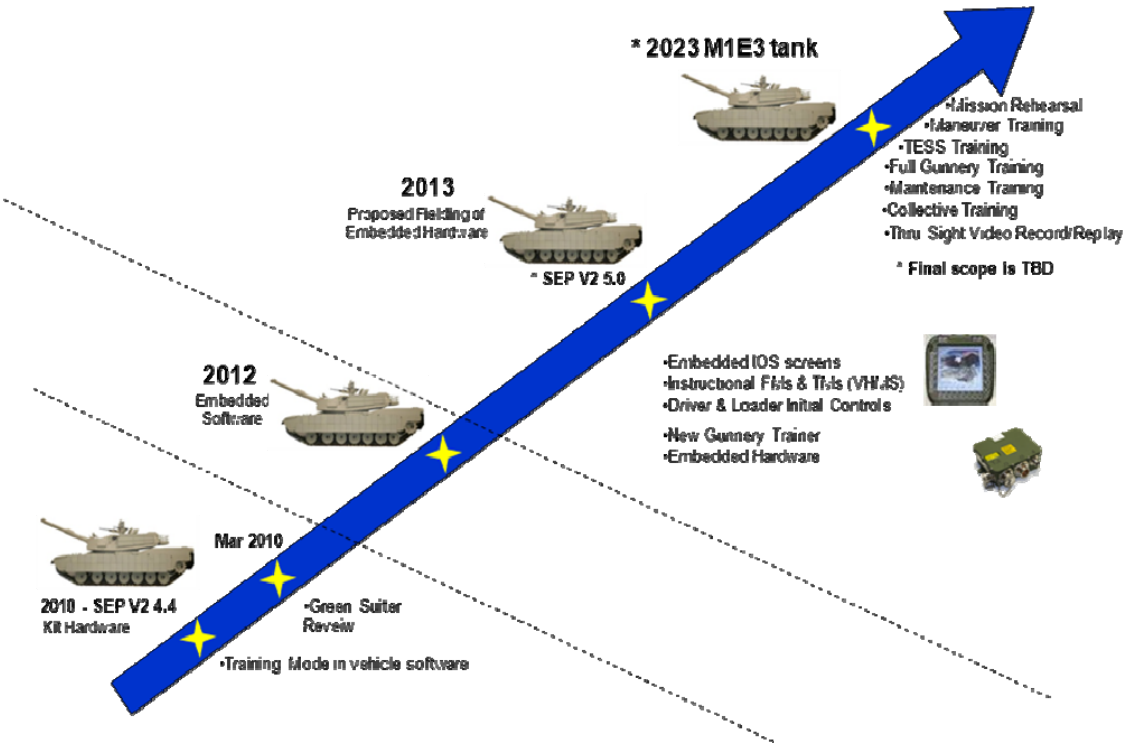

Figure 1. Embedded Training Fielding Schedule

B. PROBLEM IDENTIFICATION

The need for embedded training has not been fully recognized by the material development community. Implementation of embedded training has been a significant challenge for Abrams because of the low prioritization by the program office to implement an ET capability and because of the poor requirements definition of ET by the User training community. In the last decade, the capability was not developed beyond a concept demonstration due to budget cuts, competing higher priority requirements, and the lack of priority for embedded training. The ET requirement was not sufficiently defended by the User. The PM never directed embedded training to progress into development and integration because the PM, as the combat developer, focused on combat capabilities and the lives of Soldiers rather than a noncritical training capability. It is clear that several factors have played a part in the developmental delay of embedded training, including the lack of prioritization of requirements and budgets, lack of understanding what ET is and how the capability would be used, and the ever-changing

training environment. As a result, prioritization of Army ET requirements continues to be challenged by competition for limited resources (funding). In addition, the term "Embedded Training" is poorly defined. Policies are only now being rewritten to provide better guidance regarding the implementation and the use of embedded training. Requirements have been vague and were poorly defined because the technical capabilities to achieve ET were not understood. Furthermore, the Armor Training Strategy does not adequately define the use of ET in training Armor crewman. No one has been able to articulate the training strategy for ET.

This research will provide a definition of embedded training, identify the policies regarding ET, list the current and emerging Abrams and Army requirements, discuss the technical capabilities and benefits of embedded training, and recommend a path forward.

C. THESIS QUESTIONS

- Q1: What is the Army's intent for ET?
- Q2: Why, after more than 20 years, has ET not become a reality on the Abrams tank?
- Q3: Is there still a valid requirement for ET when the Army has done without thus far?
- Q4: What is the current and future vision of ET on the tank?

II. DEFINING EMBEDDED TRAINING

A. EMBEDDED TRAINING

What is "Embedded Training?" DoD (Department of Defense) and Army documents continue to be updated to refine the definition of embedded training. Current definitions include:

> The Department of Defense Instruction Development, Management, and Delivery of Distributed Learning defines Embedded Training as, Capabilities built into, strapped onto, or plugged into operational materiel systems to train, sustain, and enhance individual and crew skill proficiencies necessary to operate and maintain the equipment. (DoDI 1322.26, 2006, p. 8)
>
> The Department of Defense Directive, Military Training, defines embedded training as, Training accomplished through the use of the trainee's operational system within a live virtual constructive (LVC) training environment. (DoDD 1322.18, 2009, p. 2)
>
> Army Regulation 350-1, Army Training and Leader Development says Embedded Training is, A function hosted in hardware and/or software, integrated into the overall equipment configuration. Embedded training supports training, assessment, and control of exercises on the operational equipment, with auxiliary equipment and data sources, as necessary. Embedded training, when activated, starts a training session, or overlays the system's normal operational mode, to enter a training and assessment mode. (AR 350-1, 2007, p. 140)

Although the wording may be somewhat different, the underlying concept is the same. Embedded Training is… training provided by capabilities built into or added onto operational systems, subsystems, or equipment, to enhance and maintain the skill proficiency of personnel (TRADOC PAM 350-37, 2003).

There are a number of methods to deliver ET, whether it be built into, strapped onto or plugged into, and each one has its' benefits and drawbacks. A common characteristic for the delivery methods is that the Soldier is trained using the controls and displays of the actual equipment. "Strapped onto" or "plugged into" the vehicle is seemingly an oxymoron; strapped on and plugged in equipment is embedded? It is

confusing to the materiel and combat developers who are in charge of defining the requirement and developing the capability because the term embedded denotes something that is permanently affixed to the system, yet policies don't define it that way. Essentially, according to the definitions, there are three different methods of implementing embedded training on the platform and they can be defined as in the following.

Fully Embedded training systems contain all training features, except for easily installed training software or courseware and can be easily updated and are fully contained in the prime system itself. Fully embedded ET on a vehicle could allow the Soldier to train while the vehicle is moving, as in a tactical engagement simulation (Witmer & Knerr, 1996).

Appended (Strap-on) The ET capability can be installed on or attached to the prime system when needed and removed when it is not. It will likely require permanent, designed-in components used to connect/install the training set and other built-in components similar to a fully embedded system that requires interface with the on-board system/components. The appended ET system could go to war with the prime system if it were so designed, but it would not necessarily be a requirement. It could have the ability to train on the move as in fully embedded systems, but may require 'ruggedization.' One appended training system could serve multiple prime systems of the same type, but only one can be used at a time (Witmer & Knerr, 1996).

Umbilical ET is similar to appended, but involves physical connections to external components, such as a computer, communications systems, or instructor/operator consoles. It is also likely to require some built-in features to interface with the external components. An umbilical ET system can be used to interconnect many systems in a networked environment to provide force on force training. However, it is not a go-to-war training system and cannot train on the move. One umbilical system can serve multiple prime systems of the same type or it can be designed to support multiple prime systems, which are part of a family of systems, for example, armored vehicles (Witmer & Knerr, 1996).

Policies are now being rewritten to expound on embedded training, therefore, it is necessary to understand what is meant by embedded training. The Army Research and Development Command Simulation and Training Technology Center (RDECOM STTP) director, COL Craig Langhauser, has petitioned TRADOC to change the terminology to "Platform Centric Training," which states the materiel need, not the materiel solution. Doing so would eliminate misinterpretations of the term "embedded." Platform Centric describes the type of training, not how training will be incorporated into the system.

The term, "Platform Centric," however, is even becoming obsolete. Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities, (DOTML-PF) analysis shows the Army moving away from a Platform Centric gunnery training strategy to an "Organization Centric" gunnery training strategy. The new HBCT (Heavy Brigade Combat Team) gunnery manual provides principles and techniques by which to conduct gunnery training. Instead of a platform (Abrams, in this example) specific training strategy, the new gunnery manual "provides a systematic way to train weapon system proficiency for armor, mechanized infantry, reconnaissance, engineers, fire support combat platforms systems within the HBCT as well as sustainment unit vehicles armed with crew-served weapons" (FM 3-20.21, 2009, pp. 1-1). Although there is no written requirement for a common embedded training solution, in light of Organization Centric training, the push for a common system makes sense.

Whichever method of implementing ET is chosen for the tank, the ET system will only be one part of a total training system. To be successful, it will need to include those tasks, functions, or missions that it is best suited for. ET requires more than merely providing the Soldier with an opportunity to practice with the operational system. It must provide a means of assessing Soldier performance and provide feedback in order to reinforce, improve and correct Soldier performance and provide a means of records keeping to allow the evaluation of individual and collective training. It must be a way to identify deficiencies that will require additional training. The bottom line is, whether the training system is fully embedded, appended or umbilical, as long as the vehicle platform is used to train, the training system is considered embedded. The 1990 information paper, Embedded Training (ET) for the Block III tank, recognized this, "ET falls along a

spectrum of technological possibilities. One end of the spectrum envisions all of our training requirements to be totally embedded into the tank (no add-on boxes). The other end of the spectrum suggests that some of the components for training will still have to be appended to the vehicle. Still, at the midrange, there are other possibilities such as adjunctive components connected by an 'umbilical cord'. In any case, the tank will be initially designed to accept these training capabilities as a part of the vehicle characteristics rather than as an afterthought" (Appler, 1990, p. 3).

B. POLICIES

It is very important for the project manager to understand that there are policies directing embedded training to be incorporated into their vehicle systems. These policies date back as early as a 1987 policy memo signed by General Thurman who was, at the time, the Vice Chief of Staff. It states:

> Purpose: To provide guidance and establish policy for embedded training. An embedded training capability will be thoroughly evaluated and considered as the preferred alternative among other approaches to the incorporation of training sub-systems in the development and follow on Product Improvement Programs of all Army materiel systems. (Department of the Army Policy Letter, 1987, p. 1)

Department of Defense (DoD) and Army policies acknowledge the need for embedded training, and "Acquisition Policy" states that the PM is indeed responsible for embedded training (AR 70-1, 2003, p. 9). The Abrams ORD, STRAP (System Training Plan) and NET (New Equipment Training) Plan all contain the requirements for embedded training. Yet these documents neither expressly describe, nor define, the strategy for using an embedded training.

In the last few years, PM Abrams invested, and continues to invest tens of millions of dollars to upgrade stand-alone tank training devices, yet the embedded training program has lagged in development and still risks cancellation. This creates a strategic problem for the Armor community as there is clear desire and need for such a capability. In an interview of twelve Master Gunners, all but two (of a total of twelve) expressed that they saw the need and use of embedded training, though each varied to

how they would use it and remained skeptical in their responses towards a yet to be proven capability. Still, the response from the field was clear that it is a desired trait for the tank system.

> The PM has full support from a policy/doctrine point of view:
>
> > ET and development of net-centric training capabilities shall be considered as the first alternative for cost-effective delivery of instruction. (DoDD 1322.18, 2009, p. 3)
> >
> > Embedded training and distributed learning shall be considered as the first option to meet training requirements of defense technology projects and acquisition programs. (DoDI 1322.26, 2006, p. 2)
> >
> > Embedded training capabilities will be evaluated and considered as a preferred means to incorporate training subsystems into the development and follow–on product improvement programs for Army materiel systems. (AR 350-1, 2007, p. 91)

The need for embedded training is more critical today because of the war. The Army Force Generation (ARFORGEN) cycle was developed as a result of the sustained conflicts. AR 350-1, Army Training and Leader Development, states that the ARFORGEN process "generates operationally ready brigades through a structured progression of training and mission preparation" (AR 350-1, 2007, p. 1). Furthermore, "Army training goals/objectives are to support ARFORGEN by… fielding new/improved/displaced materiel systems and providing a complete training subsystem that is, to farthest extent practical, transparent to system operators, maintainers, and leaders by being embedded into the system" (AR 350-1, 2007, p. 3). Reports from the aforementioned Master Gunners indicate that there is little to no training on Crew Gunnery skills due to the missions now being performed by Abrams tanks. Current training methods are adequate in maintaining familiarity. By "providing rigorous/realistic–training venues (at home station, Combat Training Centers (CTCs), and deployed) that enable unit leaders to doctrinally employ their units, to receive expert feedback on performance, and to validate readiness on core competencies or rehearse for specific missions" (AR 350-1, 2007, p. 3).

It is clear that embedded training is essential to keep up with the current fight and to allow units, Soldiers, and leaders to maintain skills and sustain those skills during operational deployments. There are very recent updates to policies regarding training and those updates are generated by lessons learned from the current conflicts and all policies are starting to better define embedded training. There remains, however, a lack of understanding of the desired capability and how it will actually be implemented in the field. This also indicates that neither the User nor PM understands exactly how to implement the capability, both from a technological standpoint and from an operational standpoint. This has allowed all sides to put off the requirement and has had the effect of delaying ET development as well as confusing the true intent of the ET requirement. The 1990 information paper states "We envision ET supporting unit sustainment training" (Appler, 1990, p. 2) and it states that they want stand-alone devices to support the institution. This statement predates the new ET policies that state that stand-alone devices are still required for the institution. Even though this research could not find a documented reason why ET development for the M1A2 tank was cancelled, the reasons can be inferred. First, when the M1A2 tank was fielded, a completely new suite of training devices was developed for a very small institutional quantity requirement. At the same time, ET developmental costs were being incurred. Research may have shown that it was not technologically feasible to incorporate full training capabilities into the tank. Maybe users were not willing to back down on the requirement, or maybe the PM did not see the value in investing in redundant training capabilities. The PM may have made the decision, based on the immaturity of ET technology, to field more off-platform devices and plan to incorporate ET when the technology matured. The training proponent would of course support such a decision given the following.

> We believe our effort to build ET into our next combat systems is the smart way to go until it is proven otherwise. Technology is available to make it a reality. However, as trainers, we are realistic enough to understand that if ET is not cost and training effective, then we have conventional means to integrate as a failback. Nevertheless, we are committed to make embedded training happen. (Appler, 1990, p. 3)

The 1996 Guide for Early Embedded Training Decisions: Second Edition states, “Army leadership has established policy that ET will be thoroughly evaluated and considered as the preferred alternative to other approaches to training” (Witmer & Knerr, 1996, p. V). Why then, have 20 years passed and Army systems still have not implemented embedded training? The guide goes on to state, “implementation of this policy has been hampered by the lack of specific procedures for determining what training should be embedded and what training should be provided by other means” (Witmer & Knerr, 1996, p. V). In the almost two decades since this guide has been written, little has been done by the proponent to define how the Soldier would use an embedded training system.

THIS PAGE INTENTIONALLY LEFT BLANK

III. TANK EMBEDDED TRAINING REQUIREMENTS

A. SYSTEM REQUIREMENTS

When it comes to embedded training, the first thing a program manager asks is, where is the requirement? In addition to the program manager understanding the policies that instruct them to first consider embedded training before any other means of training, it is crucial for the PM to interpret User's embedded training requirement, or training need. The job of the PM is to use policy as guidance and translate the User's requirement into technology(s) capable of meeting that requirement. The requirement for embedded training on the Abrams tank originated in the Abrams Operational Requirements Document (ORD), which states:

> Embedded training devices are desired, and embedded training is the preferred method of training. Hardware and software may be incorporated into the system to assist the training of the crew. (Abrams M1A2 ORD, 1994, p. 20)

We know it is not possible, nor ideal to fully embed all training or eliminate stand alone devices, especially in the training facilities where throughput and time is critical to qualify the Soldier on his Military Occupation Specialty (MOS) requirements. Draft Army policy now states, "As a general rule, ET is not cost effective in an institutional training environment. This is because of the quantities of actual systems that may be needed to support training throughput requirements" (AR 350-38 [Draft], 2008, p. 8). The original intent for the M1A2 tank was to embed all training capabilities and eliminate off platform training devices for unit training. "The Block III ROC (Required Operational Capability) includes embedded training capabilities equivalent to the current/planned suite of devices for Abrams, i.e. precision laser gunnery, COFT (Conduct of Fire Trainer) exercises, thru-sight video" (Appler, 1990, p. 1). In layman's terms, this says that the user wants all training to be embedded in the tank to eliminate off platform devices. The same 1990 memo states the reason for needing stand-alone trainers in addition to embedded training.

> The number of tanks needed to support the total training need is generally never available. Secondly, the number of students we teach in each course per year makes stand-alone trainers more cost effective, i.e. we would not need a large number of vehicles. Third, the stand-alone trainers provide a backup training capability to send to field units should, for any reason, ET fail to be realized. We have planned stand-alone trainers for tank gunnery, tank driving and tactical training. (Appler, 1990, p. 3)

The ROC requirements were incorporated into the ORD requirement, which is still a valid requirements document. Yet, the language is not well defined as the user wanted the same capabilities of the off-platform devices. Additionally, Army Regulation supports the idea that there are alternatives. The last signed version of Army Regulation (AR) 350-38 states, "Using system-embedded TADSS (Training Aids, Devices, Simulations and Simulators) is the preferred approach where practical and cost effective" (AR 350-38, 1993, p. 1). This provides the PM and User enough room to not consider a fully ET approach in favor of supposedly cheaper solutions. No evidence has been found that validates whether or not embedded training is cost effective. The fact that new requirements and policies delete that statement indicates that the User no longer gives the PM the "cost escape clause."

Yet, until the new requirements documents are signed, ET remains an optional capability, and as such, will fall below other priorities such as more armor, better reliability, or any one of other direct combat capabilities. It is difficult for a program manager to stand behind an indefinite requirements definition when having to justify an expensive vehicle upgrade to the leadership in charge of funding the upgrade. In the face of competing requirements, it is the User's role to prioritize requirements. PM's are limited by cost, schedule and performance. If the User views embedded training as a high priority, then they should communicate it as such to the PM.

The M1A2 System Enhancement Package (SEP) Tank System Training Plan (STRAP) states, "Embedded training (ET) (as a pre-planned product improvement (P3I) initiative) is the preferred method to conduct M1A2 SEP Tank training. ET will provide the opportunity to train on the actual system through built-in or systems appended to the M1A2 SEP TANK" (STRAP M1A2, 2000, p. 7). "ET capabilities will provide unit personnel with the necessary training to maintain a level of proficiency as required"

(STRAP M1A2, 2000, p. 10). “An embedded or vehicle appended precision gunnery and tactical force-on-force maneuver training system is required” (STRAP M1A2, 2000, p. 16).

As stated before, the term “embedded” dictates a materiel solution even as stated in policy documents. Even though the software will be ready for implementation, the Abrams tank currently does not have computer hardware capable of hosting the graphically intense ET software. On-board computing and video processors will have to be incorporated into the existing tank architecture in order to accommodate more graphics and computer capabilities. According to the *Guide to Early Embedded Training Decisions*, the capability to provide embedded training must be built into the prime system from the beginning (Witmer & Knerr, 1996, p. 3). A system with a digital architecture can be upgraded to include an embedded training capability. In addition to the hardware, “the requirements for embedded training must therefore be determined early enough to be included in the prime system design” (Witmer & Knerr, 1996, pp. 3–4). The users know they want an embedded training capability, but they just do not know exactly what they want it to do.

In 2007, a briefing to the assistant TCM (TRADOC Capabilities Manager) HBCT became very heated when the embedded training solution was presented as an appended box as an interim solution to a fully embedded system. Even though the appended solution was not to be the final fielded solution, the User representative demanded no more “boxes” on the tank. They wanted the PM to consider a better technology solution than stated in the outdated Training Support Requirements (TSR) to M1A2 ORD, (U), “An embedded training capability is incorporated on the tank in the form of appended devices” (Abrams M1A2 ORD , 1994, p. B-3). The TCM may have been overstepping his authority to dictate a materiel solution, however, he had a valid point to encourage the PM to consider better technologies rather than an appended or umbilical solution proven to be logistically cumbersome to the Soldier. The Tank Weapons Gunnery Simulation System (TWGSS) is one such example of a strap on device that is being disposed from Army inventory. These devices took much too long to connect and disconnect into and from the tank, which wasted valuable training time, risked damage to the device as well

as damage to the tank. As a result, the devices sat unused. The materiel solution, however, is ultimately decided by the PM. If the PM chooses not to redesign or alter current tank hardware, yet decides to field ET, then the ET system must be appended in order to provide the needed computing and graphics processing power for the ET system.

In 1987, when the first embedded training policy was written, the Army was graduating the first class of the "Nintendo" generation. Since then, video gaming has evolved exponentially and so have the generations of gaming users. The pursuit of technology for the military has always been compared to the commercial industry. Gaming systems, smart phones, and online games cause the Soldiers to ask why they can't have that technology in their vehicle. Soldiers who have grown up with an array of gaming technology come to the Army and want to see the same technology in their military simulators. The question neither lies in the availability of technology, nor in policy. There is an entire military simulation industry that is intent on designing realistic training for the Soldier. The problem is that the system PM is not in tune with what the simulation industry has to offer. They are much more focused on combat capabilities, rather than training capabilities and no one, thus far, has successfully championed the embedded training effort. Arming the PM with current policies, solid requirements, a mature technology and a clear User need gives him the ability to defend a budget for putting the new capability on the tank.

Even though the Army, since 1987, has preferred embedded training, there hasn't been sufficient strength in the requirement to justify the need for the expensive capability. The training developers recognized this cost during the development of the M1A2 tank, "It will cost money in the short run since ET will be expensive to demonstrate, as is any new R&D (research and development) item" (Appler, 1990, p. 3). The reason why it is difficult to justify installing an embedded trainer on the tank is, in order to fully embed, a significant hardware change to the platform must be made and that costs money. The current tank computing hardware cannot support embedded training software and there is limited physical space in the tank to fit any additional equipment. If an existing "box" in the tank were to be redesigned, then the decision to make it also capable of hosting

embedded training is easy. The necessary processors could be inserted into the box to run the ET software and it wouldn't take up any additional space inside the tank.

A "Green Suitor" review was conducted in March 2010, which allowed actual Soldiers to use a prototype ET system on the tank that consisted of a box cabled to the tank. Their feedback was solicited and the bottom line was, they wanted to know how fast they could get the system and how many systems they would be receiving, which clearly shows a desire to have such a system. Due to the war, the Soldier has experienced degradation in the retention of gunnery skills. Soldier after Soldier, at every instance the ET system has been demonstrated, begs to take the prototype system back to their unit so they can immediately start training with it.

At a minimum PMs can field an initial ET capability so the Users can assess the system capabilities and help the developers mature it and better define the requirement so that future developments can fully meet their needs. The users may be able to better articulate their need for an ET capability once they use it and understand its capabilities as well as limitations. Incremental development of embedded training is the best approach because it would demonstrate the capabilities of the systems from which to build the next iterations of training. This approach will never be successful if the first increment is neither fielded, nor adequately defined. Hindsight shows that the embedded training system, which was demonstrated in 2001, could have been fielded as an interim solution or as a prototype concept to selected units. It would have provided Soldiers nearly a decade of training capability and would have allowed the Soldiers to assess the capabilities to provide useful insight on how to further mature the system to meet their needs. This would allow more time to develop a stronger requirement as well as give the PM time to understand, build, and manage the power, space, and design criteria needed to completely embed more computer hardware.

The new Abrams STRAP and the most recent update to the draft Abrams Modernization Capabilities Development Document (CDD (unclassified)) defines the embedded training requirement in more detail and provides for an incremental approach to embedded training:

> Embedded training is required to support sustainment training and is required due to the increased likelihood of frequent deployments by HBCTs. Embedded training will be achieved using an incremental approach:
>
> (a) Block one/ (T): The Abrams tank requires an embedded limited AGTS, validated by the proponent to allow for training with gunner's thermal sight and the tank commander's GPS (Global Positioning System) extension – thermal mode only, and the CITV (Commanders Integrated Thermal Viewer) – in power mode only. The system should have a record capability that will allow for playback and support AAR (After Action Review) by other unit personnel.
>
> (b) Block two/ (O): The Abrams tank requires an embedded training system integrating the driver's thermal viewer in support of gunnery and maneuver training. Maneuver training will be based on validated Army software, such as CCTT. The embedded training system will include digital communications training.
>
> (c) Block three/ (O): The Abrams tank requires an embedded training system that can fully support gunnery (day and night in power, emergency, and manual mode), maneuver, digital communications training, a tactical engagement system, and mission rehearsal capability at the crew, platoon or higher level. (CDD Abrams Tank Inc I, Draft, p. 37)

This requirement allows for a limited initial ET capability, which is in line with a spiral development process. The User doesn't want to limit himself by defining the capability upfront when he knows that as technology evolves, the capability of the system can increase. The User wants to ask for everything upfront. When technology limits him from getting everything, then he must define the minimum capabilities that he wants to see. The original M1A2 ORD requirement basically states, give me everything if you can and if it's not too expensive. It's no wonder why the requirement was never met. The draft CDD at least defines incremental capabilities, but further definition is required in order to evaluate what is technologically feasible. In this instance, Users must be told the system's technical limitations so they can decide which capabilities are must haves and which ones can be matured later. In the case of Embedded Training they do not want an all or nothing solution. They want something and it will take close collaboration with the materiel development community to define what that something is going to be. The requirement for embedded training will continue to be added to current and future

requirements documents. Even if ET is never implemented, the need for it will never go away. Giving the Soldier an embedded trainer would certainly make a difference to their preparedness for battle and to their ability to fight. The Vice Chief of Staff of the Army during a training program portfolio review stated that the war has changed the way we train. The Army has prided themselves on "train the way we fight." Since the "fight" has changed, the way we train must also change.

B. ARMY TRAINING REQUIREMENTS

> Based on the lessons we have learned in the past eight years at war, our Army has made some remarkable adaptations in the way we train. Nevertheless, the reality of persistent conflict, hybrid threats, and cyclical deployments means that we also have to become increasingly innovative in our training if we are to develop the versatile units and agile leaders required for the future.
>
> GEN Martin E. Dempsey
> Training Development for an Expeditionary Army
> June 2009

The need for embedded training has never been more necessary due to the war and the degradation of skills while deployed. Soldiers are now required to perform different missions, rather than performing their original missions, such as tank gunnery. Soldiers must remain adaptable, but they must also retain their original skill set. "The Army must adopt a new mindset that recognizes the requirement to successfully conduct operations across the spectrum of conflict, anytime, anywhere" (FM 7-0, 2008, p. 1-1). The Army created the Army Force Generation (ARFORGEN) model, which is a cyclic structured process where units move through a series of three force pool phases, the Reset force pool where equipment is refreshed and units execute pre-deployment training requirements, a Ready pool where units are ready to deploy and training is focused on higher collective training, and an Available pool where units validate collective mission essential task list proficiency via mission rehearsal exercises. The Available phase is limited to one year and units can be deployed with a 30-day notice. This process creates a steady state for the Army where units can be deployed without the need for months of

preparation. For all Army units this creates a cycle of readiness and a cycle of training. These cycles could conflict if a unit had to downgrade its readiness status if they were unable to meet training cycle requirements.

Figure 2. ARFORGEN Cycle

The ultimate goal of ARFORGEN is to have a sustained and predictable chain of events to generate trained, flexible, and ready forces, which are trained and equipped for specific mission requirements. These forces can then be assigned to tasks to defend the nation; provide assistance to civil authorities; deter conflict in certain regions; and surge in a major combat operation (Addendum H: 2007 Army Posture Statment, 2007).

Unit training is focused on core Capability Mission Essential Task List (CMETL) tasks, such as offensive and defensive operations, “those which the organization is designed to perform” (FM 7-0, 2008, pp. 2–6), i.e., tankers operating tanks.

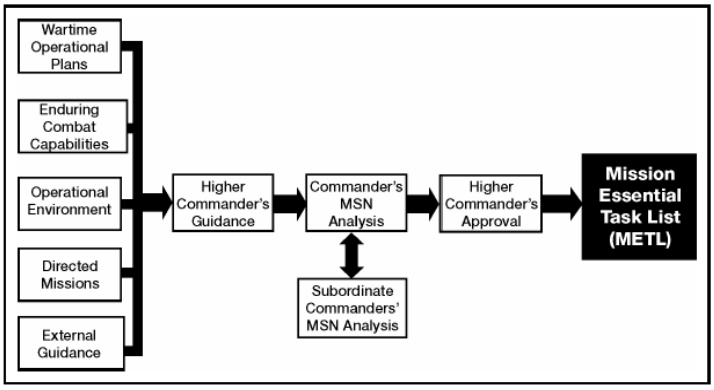

Figure 3. METL

According to the Field Manual, "Training for Full Spectrum Operations,"

> Operational environments, threats, and the Army's operational concept have changed since 2001. Army forces are now expected to conduct full spectrum operations across the spectrum of conflict. Therefore, the mindset of the Army - leadership and Soldiers, military and civilian, Regular Army and Reserve Component – needs to change. All need to adapt to new concepts and think about how the Army can train more wisely, efficiently, and effectively. In a changing training environment, the constant of demanding training that focuses on the basics and achieves tough standards under challenging conditions remains immutable. (FM 7-0, 2008, pp. 1–9)

As the Vice Chief of Staff of the Army stated that we need to change the way we train, the tools for training also must change.

The spectrum of operations ranges from offensive and defensive operations to stability and civil support operations. The Core METL focuses on tasks the unit was designed to do, while Directed METL is developed by the commander after he has received a directed mission. Units only train one METL at a time. The METL flows "downhill." For training, commanders must recognize Continental United States (CONUS) training limitations faced by their subordinates and they must tailor wartime missions within these constraints. If a commander determines his unit cannot execute all the tasks on the unit's METL to standard, he must request an adjustment of the unit's mission. The commander determines which tasks he can train and execute. He then

negotiates with his wartime commander to ensure the mission and METL are consistent, though in many cases units perform wartime missions even though METL is not trained appropriately (FM 7-15, 2009).

The METL is not prioritized. It may be changed or adjusted if wartime missions change, which under ARFORGEN, becomes important if a unit is re-tasked or is destined to support another mission from the one it previously supported. For example, First Battalion, Seventh Cavalry Regiment (1-7 CAV) in the 1st Cavalry Division may find that a mission it supported as a CAV Squadron in Iraq is now assigned Peacekeeping operations in Africa; completely different missions.

Because of changing missions, Soldiers are losing their core skills. According to the 2012–2020 U.S. Army Training Concept:

> Atrophying full-spectrum operations METL skill sets can be mitigated through the ITE (Integrated Training Environment). High fidelity rehearsals in the ITE, supplemented by institutional support, sharpen the edge of atrophied, but soon-to-be-used, skill sets. Capitalizing on the Army's concept of modular unit training, dispersed units conduct mission rehearsals virtually; this brings participants, platform simulators, and the anticipated scenario together in the ITE, 24/7. Standardized, fully interoperable training capabilities must be embedded into our operational systems to not only give units the ability to train anytime, anywhere but also ensure each unit has real-time, globally distributed, near-real-world mission-rehearsal capability. (TRADOC PAM 525-8-3, 2011, p. 61)

The Army is challenged with being flexible to support an array of operations while maintaining core skills. In a 2010 Infantry Conference speech, General Thurman stated in reference to Full Spectrum Operations, "We must regain our balance in training" (Thruman, 2010). This indicates that there is an imbalance in training today. He further states, "Army units conducting, simultaneously if need be… Offensive, Defensive, and Stability Operation across the spectrum of conflict. Our greatest collective training challenge today" (Thruman, 2010). FM 7-0 reinforces this challenge, "forces involved in protracted stability or support operations require intensive training to regain proficiency in offensive and defensive tasks before engaging in large-scale combat operations" (FM 7-0, 2008, pp. 1–6). Units do not have as much time as they would like to train offensive and defensive operations. Furthermore, a briefing by BG Funk states, "Full Spectrum Ops

includes the Stability Operation and Support Operations of the current fights, but adds the atrophying skills of Offence and Defense against a more traditionally-armed opponent and adds the concept of fighting holistically against a combination of regular, irregular, terrorist, and criminal threats" (Funk II, 2010, p. 13). Clearly the statement of "atrophying skills" is proof that something must be done to sustain those skill sets. The Army must be flexible and agile to tailor training to support different missions. Yet, the Commander does not have the necessary training tools to accomplish this. According to the U.S. Army Training Concept, deployed units are to train their METL tasks to maintain proficiency during long deployments; however, the ability to do so is hampered because of the unavailability of training support products.

"Training support does not provide commanders, Soldiers, or trainers the comprehensive capability to access, retrieve, and present networked, integrated training, nor does it provide access to embedded training from the systems platforms, which would allow Soldiers to reach training information while deployed" (TRADOC PAM 525-8-3, 2011, p. 60).

BG Funk goes on to state, "As the Operational Environment changes, Training must drive technology and technology has to keep up" (Funk II, 2010, p. 13), see Figure 4. Embedded training represents advancement in training technology that gives the Commander one more tool to sustain his unit's readiness. The new Army Training Concept envisions the use of embedded training technologies, "Units remain agile during deployment utilizing embedded TADSS, reaching back to the institution for information, and utilizing other enablers to conduct mission rehearsals, train on atrophying full-spectrum operations METL proficiency, or develop new skills required by changes in the OE (Operational Environment) (TRADOC PAM 525-8-3, 2011, p. 23).

Figure 4. Era of Conflict

Currently, Commanders must still train and prepare with current processes and systems that are neither agile nor flexible. FM 7-0 states, “Training continues in deployed units to sustain skills and adapt to changes in the operational environment” (FM 7-0, 2008, pp. 1–5). When you ask a Soldier how he trained while deployed he replies, with real bullets. Certainly, this method is effective, if the unit is able to expend ammo solely on training, and has an opportunity to engage makeshift targets. The FM goes on to state “As operational environments become more complex and resources (such as time, money, land, and airspace) become more scarce, the value of live, virtual, constructive, and gaming training enablers increases, as depicted in Figure 4 above. These enablers enhance training effectiveness by replicating the conditions of an actual operational environment. Leaders are responsible for integrating and effectively using training, aids, devices, simulators, and simulations (TADSS) to enhance realism” (FM 7-0, 2008, pp. 2–6). Under the train as we fight philosophy, however, leaders are not allowed the opportunity to use simulators as they are deployed because the simulators just aren’t available where they need them. Simulators were shipped to combat regions, but they sat unused. Embedded training can provide a method in which commanders can quickly prepare crew, collective and individual training tasks. BG Funk’s vision is to have deployable simulations and embedded training and mission rehearsal capabilities (Funk II, 2010, p. 14). The Army’s Combined Arms Center supports embedded training as part of a Live, Virtual, and Constructive Integrated Training Environment (LVC-ITE), “The

LVC-ITE is the operationally-focused collective training environment, where soldiers, leaders, and units will conduct multi-echeloned training in order to achieve METL proficiency at a high "walk" or even "run" level while meeting ARFORGEN requirements. Eventually, embedded simulations and simulators with deployed forces will expand training capabilities even further" (Mc Manigal, 2010).

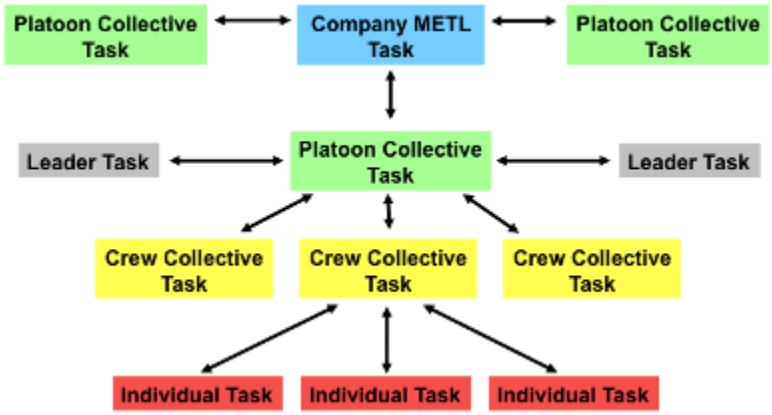

Figure 5. METL Task Tree

In an interview of twelve Master Gunners (a senior NCO [Non-Commissioned Officer] within an Armor unit who is trained in advanced gunnery methodology, turret weapons systems maintenance, and gunnery training management), nearly all the NCOs reported the benefit of having an ET system but were hesitant in their responses towards its use, citing that they would have to understand how it would be utilized in the field, further highlighting the need to define an ET training strategy. Compare this to other answers within the questionnaire that they did not use their tanks much in operations in Iraq. The Soldiers did, however, deploy with tanks. If ET were implemented, the Soldiers could access their tanks in the motor pool and run through training exercises. Soldiers assigned to tank units can be deployed in support of any operation, but must maintain proficiency in their tank gunnery skills, regardless of the current operation.

Currently, commanders are faced with the daunting task of training every possible mission task in order to determine where weaknesses exist. One of the eight tenants of the "Train as You Will Fight" principle is "Train while deployed" and another is "Determine

and use the right mix of live, virtual, constructive, and gaming training enablers to provide conditions for training events that replicate the anticipated operational environment" (FM 7-0, 2008, p. 2–5). Tank commanders and training leaders do not currently have the choice of using simulators when and wherever they are deployed.

Off platform gunnery and collective trainers reflect a static training state and assume a constant state in the mission. ARFORGEN presents a much more dynamic approach to assigning missions to a unit. Yet, the accomplishment of those missions and the training for the unknown was always left to the creative, diligent and experienced leader. ET can be the creative tool that the commander needs.

Embedded training can also allow for greater flexibility as to where training can take place. The ARFORGEN process, "enables the Army to provide a steady–state supply of trained, ready, and cohesive forces for continuous full–spectrum operations; while providing Soldiers, families, and employers more predictable unit rotation schedules" (AR 350-1, 2007, p. 1). As stated before, the training cycle is not in sync with the ARFORGEN cycle. Training devices may not be available when the Soldier reaches their training cycle. Resources to use real weaponry for training are becoming scarce, thus causing an increase in the need for simulated training, which causes an increase in the demand for time on simulators. Soldiers have to qualify; yet they may not have had the necessary time to schedule a necessary training device. ET provides them the opportunity to train anytime, regardless of where they are in their ARFORGEN cycle. METL development does not take into account the availability of stand-alone training devices. Many times units have to schedule on overbooked trainers in a 24-hour cycle in order to accomplish required training. Since ET would potentially be available on every tank, training would be made available anytime, wherever needed. Embedded training could then give commanders greater flexibility and agility in evaluating and planning for mission support within the ARFORGEN cycle. The Army Training Concept is clear in stating the specific outcome necessary for training, "Embedded training capabilities are required capabilities… Embedded training is required to provide the capability for

commanders and leaders to train in a training environment distinct and separate from the OE to enable training in the three interconnected dimensions of full-spectrum operations and support high fidelity mission rehearsals" (TRADOC PAM 525-8-3, 2011, p. 61).

THIS PAGE INTENTIONALLY LEFT BLANK

IV. EMBEDDED TRAINING CAPABILITIES ANALYSIS

> We have defined ET for armor to represent those training features now possessed by [Conduct of Fire Trainer] COFT (to include networked simulation above crew level), Thru-Sight Video… plus driver and operator maintenance training. (Appler, 1990, p. 2)

Delaying the integration of embedded training on to current platforms appears to reduce the opportunity for training, impact the commanders' ability to assess readiness, and reduce training flexibility for supporting new missions within the units' METL. It is technologically feasible to integrate ET on the current M1A2 SEP v2 tank as the current M1A2 tank has already demonstrated an ET capability.

Policies state that embedded training must be considered up front during system development and in the case of the M1A2 tank, although it was never implemented, it was considered during development. Any vehicle that has a digital architecture is capable of hosting some form of embedded training system. The base technology to implement and mature embedded training with initial training capabilities exists within the architecture of digital platforms. Further embedded training development, however, would need to be planned during a modification or upgrade program, to current platforms. This is certainly true when it comes to training systems such as laser engagements systems, which would require extensive hardware modifications to implement sensors onto the M1 tank. This would require the modification to be applied either in a Depot, or at the manufacturing facility.

Embedded training was considered upfront in the development of the M1A2 tank, "ET will be included in the fire control demonstrator contract… October 1990" (Appler, 1990, p. 1). Because ET was considered in the initial design and the M1A2 Abrams tank is a digital platform, it would be relatively easy, from a technological standpoint, to implement embedded training because it makes use of the existing tank architecture. For example, gunnery training can be implemented via software with gunnery scenarios displayed on the existing vehicle screens (Figure 6). The biggest challenge comes with hosting the graphically intense software on an existing computer system on the tank. It

requires a considerable amount of computing and graphics processing power to effectively operate the simulated gunnery databases such as a virtual urban database, which might have a significant amount of buildings, cars, people, etc. The more intricate the scene, the more processors required to render that scene. Increasing the number of processors causes more power draw and more heat dissipation. The existing tank system is not currently equipped with high-end graphics cards and computer processors needed for the proposed gunnery ET. Since 1990, when the M1A2 tank architecture was being developed, there has been much advancement in the world of simulation software. In order to provide the Soldier with more realistic training, the databases have become more realistic and, therefore, require much more computing power to run.

Since the tank has a digital architecture it can accept graphics cards and computer processors with much less integration than an analog system. The issue is with the space, weight and power required to house and run those cards and processors. The current M1A2 SEP v2 tank is maxed out on power, overweight, and out of space. These issues will be addressed in a modernization program, however, because the modernization process, units will not see these updates for a full decade or more. If ET is not implemented onto the current tank, it will be pushed off again. That is why it is critical now to push fielding any ET capability, first to meet the User's requirement, and second to mature the technology and provide more capability during the next evolution tank.

Ever evolving technology advancements will make ET possible. The current Abrams plan is to incorporate ET into the redesign of an LRU (Line Replaceable Unit) computer that is already being developed for the tank. Scenarios and menu screens can be displayed on the commander and gunner sights. For example, the purpose of gunnery training is to train acquisition, identification, and engagement of targets using both primary and alternate fire control systems for the tank's commander and gunner. Embedded gunnery training can help alleviate the need to coordinate crew availability with the availability of off-platform training devices. The embedded tank gunnery system on M1A2 components, as depicted in Figure 6, is planned to incorporate a training capability that will include a vehicle training mode to allow for safe setup, transition into training mode, and training mode icons (the images displayed are virtual

images for training purposes and are considered unclassified). The gunnery training skill capabilities will include target acquisition, hunter/killer (target handoff), main gun and coaxial machinegun, laser range finder and offensive/defensive exercises.

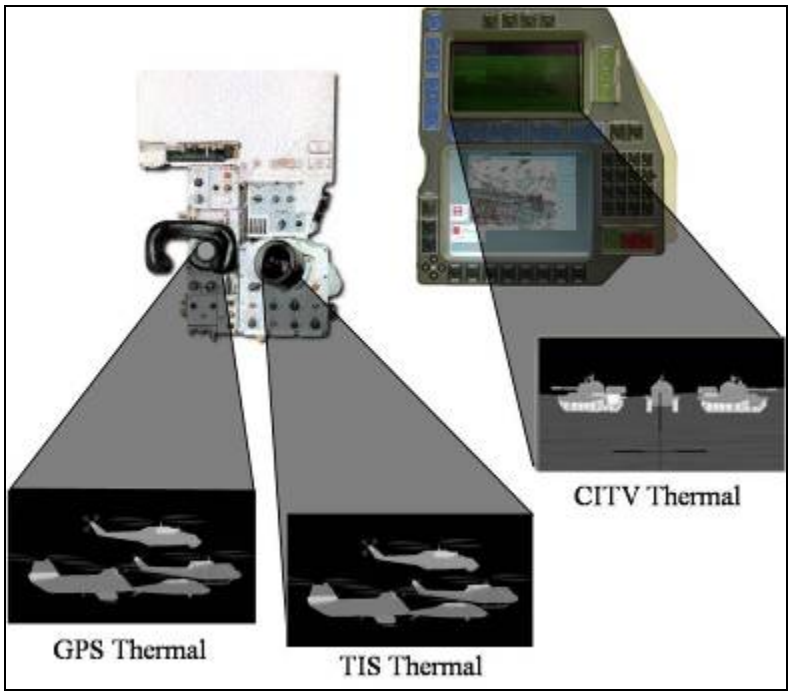

Figure 6. Embedded Tank Gunnery System

No one will know the full advantages and disadvantages of the ET system until it is fielded. Some potential concerns include the concern that using tactical components for training will increase the wear and tear on those components. Until an ET system is fielded, this concern will remain an unknown. The 1990 Embedded Training Information Paper for the Block III Tank (which became the M1A2 tank) stated some disadvantages of an ET system (Appler, 1990, p. 3):

- Unproven training technology concept for combat systems
- Significantly different from conventional training practices
- Some resistance encountered within the materiel/ combat development communities
    - Will probably increase the per-unit cost of each tank (although total cost of training subsystem should be lower)

- Concern that if the training subsystem malfunctions, then the tank is deadlined (TDR [Training Device Requirements] states no degradation allowed)

The Full Spectrum of Operations states that the way we train must change. Therefore, the "disadvantage" of ET being "significantly different from conventional training" can be now considered a positive if it proves to change in a positive way. There continues to be resistance within the combat development community. One observation is that there are not many people in the combat development community who are also knowledgeable of training requirements; therefore, it is difficult to provide rationale to the PM for implementing ET. As with any new technology, problems and issues will arise. The only way to truly mature the ET technology is to field the capability so that Soldiers can use it. Improvements to the system could then be made during future tank enhancements.

Once the current ET solution is proven as a future enhancement to gunnery and maneuver training, displays could be embedded into the optical vision blocks to allow simulated imagery to be injected. This capability could provide a daylight training mode, which could allow full gunnery and maneuver training capabilities (see Figure 7).

Figure 7. Optical Vision Blocks

Collective engagement of targets is a requirement in the draft CDD for the modernization tank. Vehicles equipped with embedded gunnery training could potentially be networked together, permitting the crews to train in a collective manner. Embedded training is a requirement for future vehicles; therefore, the tank fleet must have embedded

training in order to be able to train in a collective training environment. This concept was envisioned in the 1990 information paper, “The [ET] training capability can sustain the training need of an individual/crew and, when networked, support training at platoon and above. Mission rehearsal is one such example of networked training” (Appler, 2009, p. 2).

Embedded Mission Rehearsal was demonstrated on the Abrams tank in 2008, which demonstrated maneuver training networked between the vehicle and several training systems. Figure 8 shows a graphic depiction of that demonstration (all images depicted are training scenarios and are unclassified).

Figure 8. Embedded Mission Rehearsal Demonstration

A maneuver trainer trains units from the platoon level up to a battalion task force in collective exercises. These systems provide Soldiers the opportunity to develop and conduct structured exercises as a combined arms team against a virtual enemy in a virtual environment. The maneuver training system typically includes: Soldier operated simulators including tanks, Bradley Infantry Fighting Vehicles, High Mobility

Multipurpose Wheeled Vehicles (HMMWVs), Armored Personnel Carriers, Fire Support Vehicles, as well as dismounted infantry modules. Maneuver trainers focus on the coordination skills of the Soldier to effectively maneuver with other vehicles.

Embedding a maneuver training capability can make platoon training easier as multiple crews can train with their vehicles, which can alleviate the burden of scheduling class time on overbooked trainers. The off platform Close Combat Tactical Trainer, (CCTT) provides training from the individual crew level to a full battalion/squadron tank force, allowing them to practice all aspects of battle coordination and maneuver against computer-generated opposing forces (STRAP M1A2, 2000, p. 16). Additionally, real time mission rehearsal could be implemented if current missions and maps could be uploaded into a training scenario. Figure 9 shows the vision of mission rehearsal as it was being developed under the former Future Combat Systems (FCS) program. As shown, the tank would incorporate the same embedded training capabilities in order to cooperatively train with the future vehicles. A future networked environment can be used for training capability and the current tank force would be required to "play" in that environment.

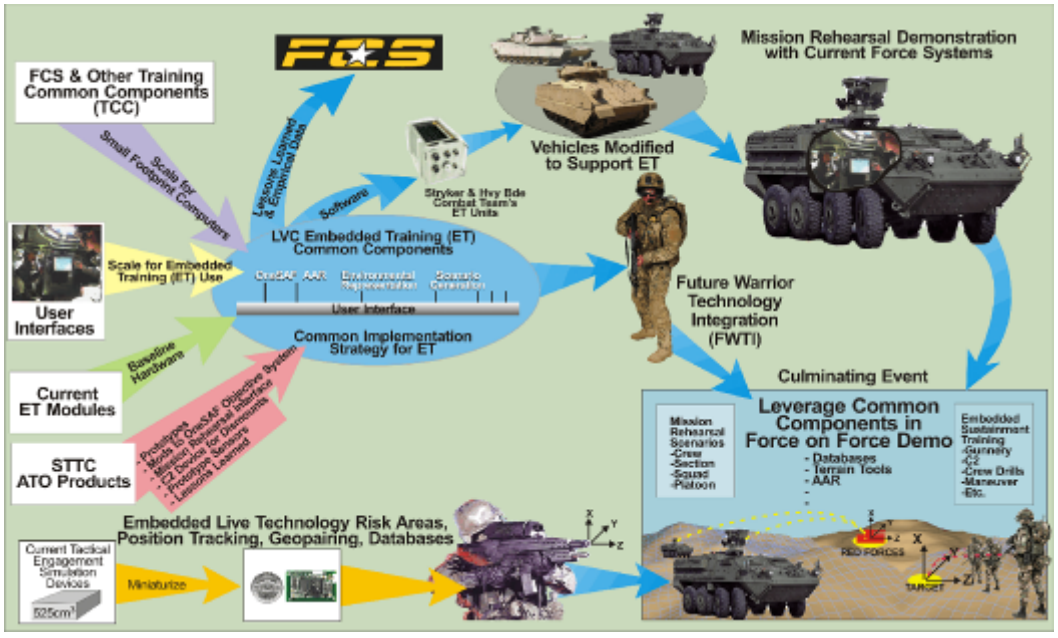

Figure 9. Future Combat System Mission Rehearsal

Embedded mission rehearsal, or even driver's training, is not intended to replace off platform devices, as stated in the Abrams STRAP, but rather augment current training and provide for more training opportunities.

Since the maneuver training demonstration incorporated the driver into the scenario, the system could also be used as a static driver training device. Embedded maneuver trainers could be used to train the driver with the driver's night vision devices. There have been cases where the drivers have not been on their vehicles for upwards of 15 months and have forgotten basic driving skills due to deployments away from institutional training bases. Tank driver trainers only exist in the institutional training base. An embedded driver trainer could be used to refresh and sustain those critical tasks needed to keep the Soldier fluent in his operational skill set. Incorporating driver training would fulfill the original vision of the training developers; "We envision ET supporting unit sustainment training… driver and operator maintenance training" (Appler, 1990, p. 2).

Is embedded maintenance training possible on the Abrams tank? The short answer is yes. The Bradley Fighting Vehicle already has the ability to simulate maintenance faults. Many tactical vehicles have embedded maintenance manuals and have implemented animated maintenance procedures into the Interactive Electronic Technical Manuals (IETMs). The IETMs, once embedded, inherently become an embedded maintenance tool and should be incorporated into the maintenance training curriculum. Certainly, the Armor Maintenance School would have to change the way they teach tank maintainers with the implementation of an embedded maintenance trainer, especially with the implementation of IETMs and the Army's new diagnostic system, Vehicle Health Management System (VHMS), but that is true of any new technology.

There are two schools of thought when it comes to maintenance training on the tank. TRADOC studies have shown that it is more cost effective to have maintenance trainer simulators than using the actual vehicle because of the cost of tank components. A $500,000 plus engine, for example, is very expensive to replace if a student accidently

damaged it beyond repair. The second school of thought is some schoolhouses would prefer using an actual vehicle because of their lack of space in the schoolhouse facility for a maintenance simulator.

Aside from the tank maintainers, the tank Master Gunner School has developed a requirement to train fault isolation in the turret. Special cables, termed Fault Insertion Plugs, (FIPS), Figure 10, have been developed for their curriculum.

Figure 10. Fault Insertion Plug

These plugs are vehicle cables that have been modified so that, when they are plugged into the vehicle, they simulate a Line Replaceable Unit (LRU) fault without damage to the vehicle or the LRU. The FIPS are connected between the vehicle cable and the LRU, thus reducing the obvious signature of a disconnected cable and allows the student to correctly identify faults. This type of training can certainly be replicated via software through the embedded training system.

Providing the tank operators and maintainers a fully embedded maintenance capability would definitely change the Program of Instruction (POI) for maintenance. It could enhance the potential for anyone to access a maintenance training program to train on repair of the tank, not just the tank maintainers. It would also need to follow the Army's two-level maintenance plan. Lower ranked enlisted Soldiers must progress in skill in order to be promoted. A senior NCO mechanic, for instance, will have trained and be skilled on repairing a wide variety of vehicles in the Army inventory. At the moment

there are few mechanisms to allow such training. This creates a problem for maintenance planners because maintenance teams are made of a mix of MOS' and skill sets. An ET solution would allow NCOs the ability to train their soldiers on a vehicle that they have never seen. This makes it possible for a Bradley mechanic to quickly diagnose an Abrams tank, with little formal training. The action of remove and replace becomes a different teaching point, but maintenance is largely about diagnostics and troubleshooting. Bridging that gap with an ET solution would go a long way to quickening training cycles. These things are merely concepts, but will be fully investigated as part of the embedded training development program.

Embedded training block three, as defined by the CDD, involves making significant hardware modifications to the tank. The tank currently uses off-platform devices for live and collective training including Thru-Sight Video (TSV) and Multiple Integrated Laser Engagement System (MILES). It is possible to embed those capabilities in the current platforms, however replacing all of the vehicle sights and embedding sensors can be a major effort and may be a very expensive modification to the platform. A business case analysis needs to be performed to assess the feasibility to incorporate these embedded training capabilities onto the current M1A2 platform.

The current Thru-Sight Video capability is a vehicle-appended system that provides video and audio recording of gunnery tactical engagement exercises in real-time. The TSV system is designed to support training at all proficiency levels as well as during simulated or live-fire exercises. Embedding TSV capabilities into the tank will eliminate the risk of damaging mission-critical connections since it eliminates having to plug in cables. Also, incorporating the TSV capabilities directly into the vehicle would eliminate the time currently spent installing and uninstalling the TSV system. Currently, it takes two crewmembers to lift and install the TSV equipment. Reducing this burden would be a great benefit to the User.

Using hardware permanently installed in the vehicle to record audio and video would allow more information to be recorded during a training exercise. The hardware would allow more vehicle states to be recorded by allowing playback of ammunition selection and other important gunner actions. Incorporating TSV capabilities into the

vehicle also provides more possibilities for when and where After Action Reviews (AARs) could be performed. By using vehicle screens, the gunner and commander would have the ability to review their performance after the exercise takes place. Embedding TSV would definitely reduce the footprint of Abrams training devices. The TSV would become a tank component rather than a stand-alone training device.

Another major training device that has very practical benefits to fully embed is the Tactical Engagement Simulation Systems (TESS). TESS support force-on-force training on real terrain and use actual vehicles without firing live ammunition rounds. The devices use lasers and laser detectors in place of live ammunition. The current system is the Multiple Integrated Laser Engagement System (MILES). See Figure 11 for a depiction of MILES components which are instrumented onto the tank.

Figure 11. Multiple Integrated Laser Engagement System Components

Fully embedding a TESS capability would eliminate the current strap-on training devices, which are required for force on force training. Currently, a laser is appended to the vehicle's gun and sensors are attached to the vehicle to detect incoming laser shots from opposing forces systems. When vehicle crews install MILES, they must connect the training device at multiple connection points within the vehicle. Disconnection and reconnection of cables and connectors carries the potential to damage or cause wear-and-tear to vehicle cables and/or training device cables. Embedding TESS would eliminate

the repeated connections into the vehicle. Less movement of equipment in and out of the vehicle will help to prevent damage either to the training equipment or to the vehicle itself and would make installation faster and easier.

The real cost benefit to the Army would come when all platforms have an embedded TESS capability. If TESS were to be embedded on the tank it would benefit the individual tank training, but the rest of the brigade would still need to be instrumented before practicing exercises. When the TESS capability is fully embedded in the tank, it is still critical to involve the appropriate live training proponents in the requirements development so that the system can meet the collective training requirements, which in laymen's terms, means the tank needs to be able to play laser tag with all of the other vehicles participating in a coordinated training exercise.

There is the potential to make the current vehicle tactical laser range finder dual use for training. These lasers could be used in a training exercise to simulate weapons fire by lasing a training target. The tank also has the ability to detect when it is being lased. The ET system could be used to capture the data from that detection to determine when it has been "hit" by a laser during training. Software would have to be developed to capture the data needed to determine what type of round was fired at the tank during training. The requirements currently exist and once the embedded training system is in place, the technology can be further matured to meet future requirements.

THIS PAGE INTENTIONALLY LEFT BLANK

V. CONCLUSIONS/RECOMMENDATIONS

We cannot allow our Soldiers' skills to degrade. We must give them every opportunity to train so their skills are sharp and ready for battle. There is no doubt that the Abrams community believes that ET will be an effective capability. The only question is where it fits in the priority compared to survivability, maneuverability, and lethality. Over two decades have passed since the training developers stated; "We believe our effort to build ET into our next combat systems is the smart way to go until it is proven otherwise. Technology is available to make it a reality. However, as trainers, we are realistic enough to understand that if ET is not cost and training effective, then we have conventional means to integrate as a fallback. Nevertheless, we are committed to making embedded training happen" (Appler, 1990, p. 4). Obviously, that vision was never fully realized.

It is not always obvious that training can increase the survivability or lethality of Soldiers by improving their skills in combat as tangibly as armor increases survivability, or more accurate weapons increase lethality. Soldiers are expected to accomplish their mission regardless of their ability to train. Units and commanders are expected to maintain core competency in METL tasks regardless of where and what mission the unit is performing. As an example, a tank battalion must still be proficient in establishing defensive positions even though they are currently conducting civil affair duties. Additionally, as training time is cut in order to get Soldiers into the field faster, the Army must to come to terms with what it needs to do in order to train effectively. Wartime operations expose many problems that come out in lessons learned. Looking towards the future and anticipating future threats is a continued partnership between the User and the development community. A clear and precise definition and a clear priority for Embedded Training is needed. This will allow the PM to pursue a source of funding and to establish essential program requirements for development.

It is then recommended, that embedded training can and should be implemented on the current M1A2 SEP v2 platform. The method and technical aspect of embedded

training implementation should not be the issue. Those can be solved with time and available funds Soldiers have wanted it for decades and policy dictates that it shall be considered as the preferred method of training.

This research has provided the logical linkage between policy and platform requirements. ET must be considered and pursued. Deployments cause Soldiers to be out of sync with the training cycle and away from installations that have training simulators for extended periods of time. ET can be the common thread drawn between legacy, current, and future forces so our Soldier's and wartime operations are not hindered. ET can keep our Soldier's skills sharp before, during, and after deployments. Embedded training can provide the Soldier a training capability anywhere, anytime.

LIST OF REFERENCES

Abrams M1A2 ORD. (1994). *Abrams Modernization Program M1A2 Operational Requirements Document.* Washington, D.C.: Office of the Deputy Chief of Staff for Plans and Operations, Force Development.

Addendum H: 2007 Army Posture Statment. (2007, February 14). *2007 U. S. Army Posture Statement Addendum H: Army Force Generation*. Retrieved May 25, 2010, from 2007 U. S. Army Posture Statement: http://www.army.mil/aps/07/addendum/h.html

Appler, D. E. (2009). *Information Paper - Embedded Training (ET) for the Block III Tank.* Unknown.

AR 350-1. (2007). *Army Training and Leader Development.* Washington, D.C.: U.A. Army Publishing Directorate.

AR 350-38 (Draft). (2008). *Training Aids, Devices, Simulators, and Simulations (TADSS) Policies and Managenent.* Washington, D.C.: U. S. Army Publications Directorate.

AR 350-38. (1993). *Training Device Policies and Management.* Washington, D.C.: U. S. Army Publication Directorate.

AR 70-1. (2003). *Army Acquisition Policy.* Washington, D.C.: U.S. Army Publication Directorate.

CDD Abrams Tank Inc I, Draft. *Capability Development Document (CDD) for the Abrams Tank Increment I, Draft Version 1.2.* U. S. Army Training and Doctrine Command, unpublished.

DA Pam 600-65. (1985). *Leadership Statements and Quotes.* Washington, D.C.: U. S. Army Publication Directorate.

Department of the Army Policy Letter. (1987, March 3). Embedded Training. Washington D.C.

DoDD 1322.18. (2009). *Department of Defense Directive Number 1322.18.* Washington, D.C.

DoDI 1322.26. (2006). *Development, Management and Delivery of Distributed Learning.* Washington, D.C.

FM 3-20.21. (2009). *Heavy Brigade Combat Team (HBCT) Gunnery.* Washington, D.C.: HQ Department of the Army.

FM 7-0. (2008, December 12). Training for Full Spectrum Operations. Washington, D.C.: U. S. Army Publications Directorate.

FM 7-15. (2009). *The Army Universal Task List.* Washington, D.C.: Headquarters Department of the Army.

Funk II, P. E. (2010, August 17). *Army Integrated Training Environment.* Retrieved December 4, 2010, from Army Knowledge Online: https://www.us.army.mil/suite/files/24259225

Mc Manigal, M. A. (2010, August 17). *Army Integrated Training Environment.* Retrieved December 4, 2010, from Army Knowledge Online: https://www.us.army.mil/suite/files/24259225

STRAP M1A2. (2000). *System Training Plan (STRAP) for M1A2 System Enhancement Package (SEP) Tank.* Fort Knox: U. S. Army Armor Center and Fort Knox.

Thruman, J. D. (2010, September 13). *The United States Army: Ft. Benning.* Retrieved 3 January 2011, from 2010 Infantry Warfighting Conference: http://www.benning.army.mil/iwc/2010/downloads.html

TRADOC PAM 350-37. (2003). *Objective Force Embedded Training (OFET) User's Functional Description.* Ft. Monroe: U.S. Army Training and Doctrine Command

TRADOC PAM 525-8-3. (2011). *The U. S. Army Training Concept 2012-2020.* Fort Monroe, Va: Department of the Army.

Witmer, B. G., & Knerr, B. W. (1996). *A Guide for Early Embedded Training Decisions.* Alexandria: U. S. Army Institute for the Behavior and Social Sciences.

APPENDIX ABRAMS TRAINING DEVICE DESCRIPTIONS AND DEFINITIONS

The purpose of a training simulator is to teach the Soldier how to shoot the weapons, move the vehicle, maneuver with other vehicles, and communicate with other Soldiers within a virtual environment. Current Abrams training device capabilities, how to shoot, for example, can potentially be fully or partially integrated into the vehicle platform, as shown in Figure 12, where a training scenario is displayed on the Abrams tank commander's screen.

Figure 12. Abrams Tank Commanders Screen

The following training simulators are stand-alone devices that are used to teach Soldiers how to operate the tank. They are used either in classrooms, or at the Unit's home station.

Maintenance Trainers

Figure 13. Maintenance Trainers

Purpose: To teach the Soldier system operation, fault diagnosis, troubleshooting, adjustments, parts removal/replacement, and parts repair tasks without causing damage to the actual vehicle.

Gunnery trainers

Figure 14. Gunnery Trainers

Purpose: To develop and sustain individual, crew and platoon precision and degraded gunnery skills for the tank in a simulated environment. It teaches the Soldier how to engage target shots before they transition to live fire training or combat gunnery.

Driver Trainer

Figure 15. Drivers Trainer

Purpose: To provide driver training without the safety risk of using an actual tank.

Multiple Integrated Laser Engagement System (MILES)

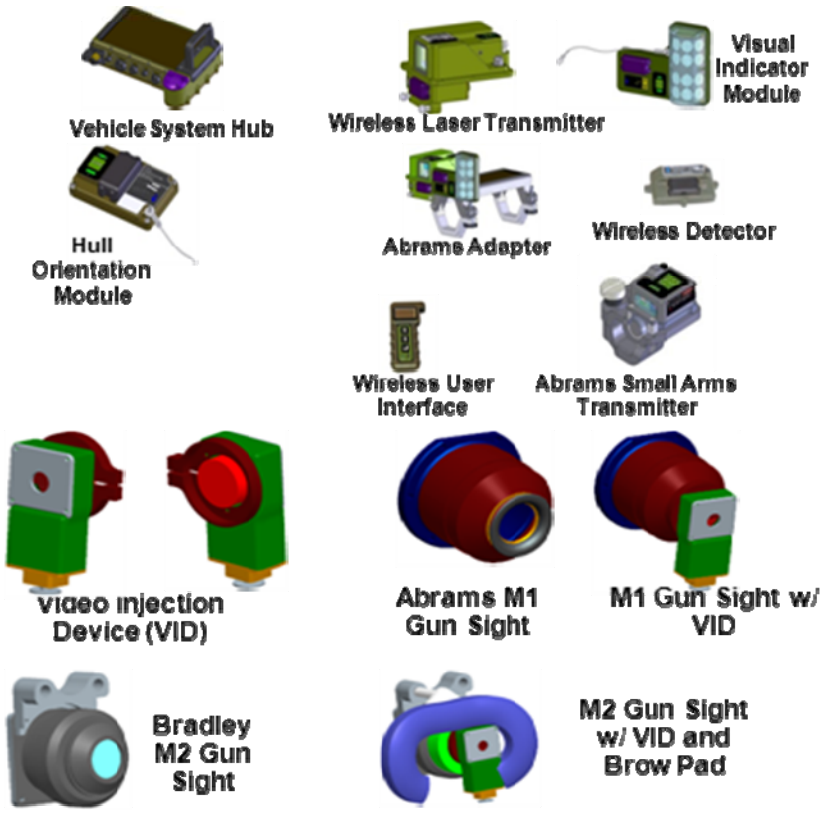

Figure 16. MILES Components

Purpose: To provide laser based live training for force-on-force combat. The sensors and lasers are strapped onto a vehicle to provide the capability to train a combat scenario using actual vehicles, but with simulated ammunition. The concept is like laser tag.

Thru-Site Video (TSV)

Figure 17. Thru-Site Video (TSV)

Purpose: Provides audio / video recording of gunnery engagements for playback in an After Action Review (AAR). Thru-site video is installed in the tank and records what is happening during a training session so that the tank commander can playback the training event to evaluate the Soldier's performance.

Close Combat Tactical Trainer (CCTT)

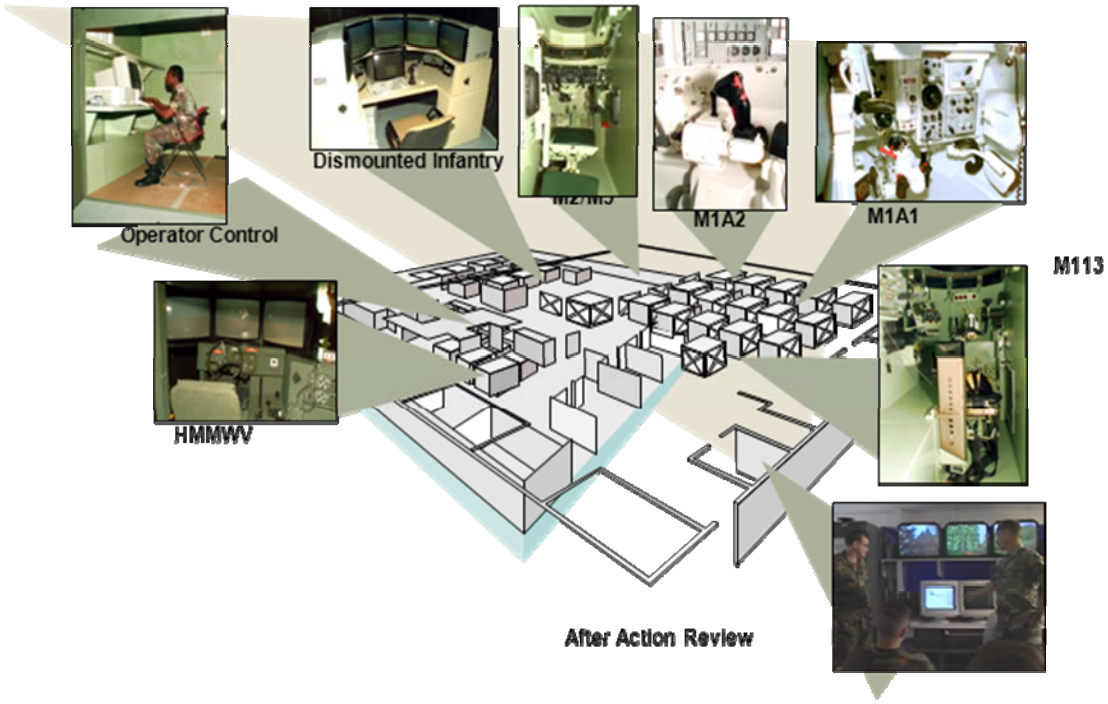

Figure 18. Close Combat Tactical Trainer (CCTT)

Description/Purpose: CCTT is a networked system of simulators that teach Soldiers how to move with other vehicles on a simulated battlefield.

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California