ARMY RESEARCH LABORATORY

Crusader Battle Lab Warfighting Experiment (BLWE) 1: Assessing Tactics, Techniques, and Procedures (TTPs) for Crusader Units Within a Synthetic Environment

Larry Peterson
William A. Ross
Linda G. Pierce

ARL-TR-1597 JANUARY 1998

Army Research Laboratory

Aberdeen Proving Ground, MD 21005-5425

ARL-TR-1597 January 1998

Crusader Battle Lab Warfighting Experiment (BLWE) 1: Assessing Tactics, Techniques, and Procedures (TTPs) for Crusader Units Within a Synthetic Environment

Larry Peterson
Human Research & Engineering Directorate, ARL

William A. Ross
Hughes Training, Inc.

Linda G. Pierce
Human Research & Engineering Directorate, ARL

Abstract

The U.S. Army Research Laboratory and the Depth and Simultaneous Attack Battle Lab have performed the first Battle Lab Warfighting Experiment that evaluated operational concepts for the Crusader system. The experiment was conducted during June and July of 1996 in the Janus Battle Simulation Center at Ft. Sill, Oklahoma. The research addressed critical operation issues focused on the employment of the Crusader system on the 21st century digitized battlefield. Command and control, and ammunition logistics and resupply systems used by a direct support field artillery battalion when employing the simulated Crusader system were evaluated to identify innovative tactics, techniques, and procedures that could be introduced in conjunction with the fielding of the Crusader system.

This research was conducted using a synthetic battlefield environment that placed field artillerymen into distributed interactive simulation technologies where they used actual tactical data processing equipment to perform fire support functions. There were four major outcomes of this research:

1. A preliminary set of tactics, techniques, and procedures that addressed command and control functions, situation awareness, fire order consistency, and sustainment was identified. This information will be evaluated further by the system developer and field artillery community and will be considered for additional testing during later experiments or closed loop studies.

2. Major findings were

- The Crusader system as currently specified, will deliver effective fires to defeat the projected threat and provide timely support to maneuver forces.
- The pooled resupply concept was successfully demonstrated and shown to be a robust technique in the face of losses of individual resupply vehicles.
- The Crusader will need to have significant on-board processing capabilities to operate most efficiently within the digital battlefield.
- Future command, control, coordination, and intelligence equipment will require some modifications to incorporate the information processing requirements of the Crusader system.
- The digital battlefield will impose an extremely high operational tempo and information processing requirements on all elements of the command and control structure in order to deploy and track self-propelled howitzers and resupply vehicles, keep pace with maneuver forces, track the overall battle, process fire missions, track logistics requirements, reposition logistics resupply points, and coordinate resupply elements.

3. The research extended the state of the art in simulations and demonstrated the benefits of synthetic environments. A flexible distributed interactive simulation test environment where a combined training and learning approach was implemented.

4. The methodology for this research was evaluated to identify how it could be improved and applied during the system development process. In addition to the unique test environment, a methodology and set of metrics to evaluate soldier and system performance in that environment were demonstrated.

CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

This report summarizes research conducted by the U.S. Army Research Laboratory (ARL) and elements of the Depth and Simultaneous Attack Battle Lab (D&SABL) in support of the Training and Doctrine Command (TRADOC) System Manager-Cannon (TSM-Cannon) and the development of the Crusader artillery system. TSM-Cannon is responsible for resolving doctrinal concerns associated with how to most efficiently use this next generation artillery system, which is designed to take full advantage of the information-rich "digital battlefields" of the future. TSM-Cannon has developed a draft operational concept document (OCD) which functions as the foundation for this research.

This research constitutes the first of the D&SABL Battle Lab warfighting experiments (BLWEs) that will use the draft OCD as a baseline from which to conduct a series of studies to validate, modify, or expand the document so that by the time Crusader is fielded, it will be accompanied by an OCD based largely on experience and performance data derived from working with soldiers in a synthetic theater of war (STOW) environment. The BLWEs will take place at a rate of about one major effort per year for a period of at least 3 years (1996 through 1998).

1. The objectives for the first Crusader BLWE were to

- Use soldiers from a field artillery (FA) unit as test participants to evaluate tactics, techniques, and procedures (TTPs), as well as command and control (C2) and resupply issues for the Crusader system.

- Implement a STOW environment capable of emulating the projected Crusader battlefield operations tempo (OPTEMPO).

- Implement and validate a data collection and analysis methodology for evaluating Crusader unit performance in the STOW environment.

- Assess the potential of the STOW environment for training existing artillery units as an alternative or supplement to field exercises.

2. Key findings of BLWE 1 include

- The STOW environment provided a realistic level of stress on the soldier participants.

- The operational procedures and data collection methods provided significant insight into TTPs, C2 issues, and resupply operations.

• It was not possible to assess training adequacy because of resource constraints; this will be done in future work.

• Crusader will impose a much higher OPTEMPO in the processing of fire missions, and the current TTPs and technologies will not be adequate to permit the most efficient use of Crusader's capabilities.

• Early indications, based solely on this one BLWE, would seem to indicate that the roles of the platoon operations centers (POCs) will shift further toward logistics management and individual platform management and that the battalion (Bn) will have to focus more on overall battle management, leaving the details to the lower echelons (i.e., the POCs and Crusaders).

• Real-time terrain management and situational awareness will be critical to success on the digital battlefields of the future. It will not be possible to maintain status of all the critical components using current TTPs because of the OPTEMPO imposed by the next generation systems.

• Much more work needs to be done in exploring ammunition planning and the effects of battle dynamics on the unit basic load (UBL); some sort of "logistician's associate" artificial intelligence (AI) program would seem necessary.

• Development of the components of the digital battlefield (e.g., Crusader, advanced field artillery tactical data system (AFATDS), command and control vehicle (C2V), Appliqué) cannot occur in isolation. Requirements for one become requirements for all because of the interdependence of a common communications requirement and the need for a common, real-time picture of the battlefield at all levels.

• For tactical fire control processes, the Army must achieve an optimal balance between the necessity for human control and the benefits of automated processing. Each time we have human intervention, we add significant time and potential for error, but each time we remove a soldier from the decision process we make the previous human decision more critical and the human errors less likely to be caught before the mission is shot.

3. Future plans include

• Conducting Crusader BLWE 2 using direct support (DS) artillery troops equipped with next generation AFATDS fire mission processing capabilities.

• Adding operator workstations in one of the batteries (six howitzers and six resupply vehicles [RSVs]).

• Assessing the training capabilities of the STOW environment.

CRUSADER BATTLE LAB WARFIGHTING EXPERIMENT (BLWE) 1: ASSESSING TACTICS, TECHNIQUES, AND PROCEDURES (TTPs) FOR CRUSADER UNITS WITHIN A SYNTHETIC ENVIRONMENT

INTRODUCTION

The U.S. Army Research Laboratory (ARL) and elements of the Depth and Simultaneous Attack Battle Lab (D&SABL) conducted this research in support of the Training and Doctrine Command (TRADOC) System Manager for Cannon (TSM-Cannon) and the development of the Crusader artillery system. The Crusader system is being developed by United Defense Limited Partnership (UDLP) and is intended to be the first of the "next generation" of artillery systems, capable of functioning on the digital battlefields of the future. The self-propelled howitzer (SPH) components of this system will shoot farther and faster than their predecessors and will incorporate the latest in on-board and networked information processing, targeting, and command and control (C2) capabilities. The resupply vehicle (RSV) components will move faster and (largely because of increased on-board automation of ammunition and fuel handling) will rearm and resupply more quickly than current systems. TSM-Cannon is responsible for resolving doctrinal concerns associated with how to most efficiently move, group, and shoot (at a rate of as many as 12 rounds per minute) an artillery system with such advanced capabilities, and it has developed a draft operational concept document (OCD) which functions as the foundation for this research.

The Battle Lab warfighting experiments (BLWEs) use the draft OCD as a baseline from which to conduct a series of studies to validate, modify, or expand the document so that by the time the system is fielded, it will be accompanied by an OCD based largely on experience and performance data derived from working with soldiers in a synthetic theater of war (STOW) environment. As shown by Figure 1, the BLWEs will take place at a rate of about one major effort per year for a period of at least 3 years (1996 through 1998). This report summarizes the first in this series.

This first BLWE was conducted during June and July of 1996 and focused on evaluating draft operational concepts for C2, ammunition logistics and resupply issues, and on beginning to build a valid understanding of how the Crusader system can most efficiently be used on the digital battlefields of the future.

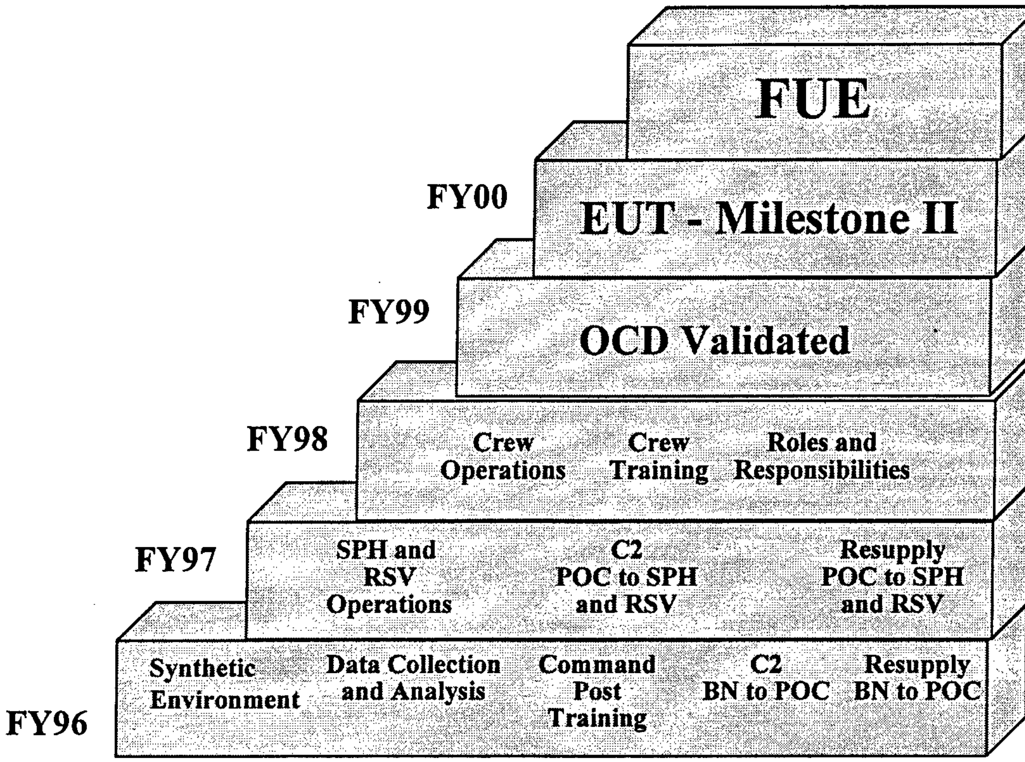


Figure 1. Focus of BLWEs by year.

BLWE 1 OBJECTIVES

Each of the three major participants (TSM-Cannon, the D&SABL, and ARL) has results or objectives that it is trying to obtain from the BLWE process. TSM-Cannon is focused on supporting the Crusader system and producing an effective OCD for it. The Battle Lab is interested in developing an effective STOW environment, which can be used to evaluate a number of future military systems and their interactions on the digital battlefields of the future. ARL is interested in how to best collect and analyze soldier performance data in such an information-rich environment with a view toward supporting future Battle Lab evaluations. ARL also has an interest in looking at the STOW environment as a cost-effective training environment for soldiers and leaders of the future. As the BLWE process evolves, each of these considerations will be addressed and evaluated.

Objective 1: Assess an Initial Set of Critical Operational Issues in the Draft OCD

BLWE 1 focused on two critical issues, C2 at the battalion (Bn)-to-platoon operations center (POC) level and the ammunition resupply process from the ammunition transfer point

(ATP) forward. It was believed that both of these areas were likely to be stressed by the high operations tempo (OPTEMPO) of the Crusader systems on the battlefield and that current tactics, techniques, and procedures (TTPs) would likely need improvement or re-thinking in order to best employ Crusader's capabilities.

TSM-Cannon selected this set of issues after analyzing all the critical operational issues, which were identified as candidates for investigation during the series of BLWEs. The examination of C2 issues was further segregated into

- Overall C2 issues
- Situational awareness
- Fire mission (FM) processing
- Planning and executing tactical moves

Resupply and sustainment issues included

- Keeping pace with the OPTEMPO
- Facilitating the fire support (FS) mission
- Coordination and integration

Throughout the baseline and record runs, these were the primary issues being investigated.

Objective 2: Implement a STOW Research Environment

The path item for BLWE 1, which was critical to the success of all, was the development and implementation of a STOW environment in which soldiers, field equipment, prototype equipment and models of things not yet developed (in this case, Crusader) could interact in a realistic battlefield scenario. This environment had to be large enough in scope to give the participating players the feeling that they were in a real battle situation, while small enough to exercise control over the development of the battle, application of the experimental variables, and collection of valid performance data. The environment we used for BLWE 1 was an amalgam of hardware and software, both proven and developmental, as well as field equipment brought by the unit participants.

For the technically inclined, this document will be followed by a separate report on the STOW environment and its effectiveness for training. That report will go into excruciating detail about the software and hardware components used, as well as the interconnections and lessons learned, but for this report, we will focus on the functionality of the components of the STOW from the viewpoint of the soldier participants. The overall approach is illustrated in Figure 2.

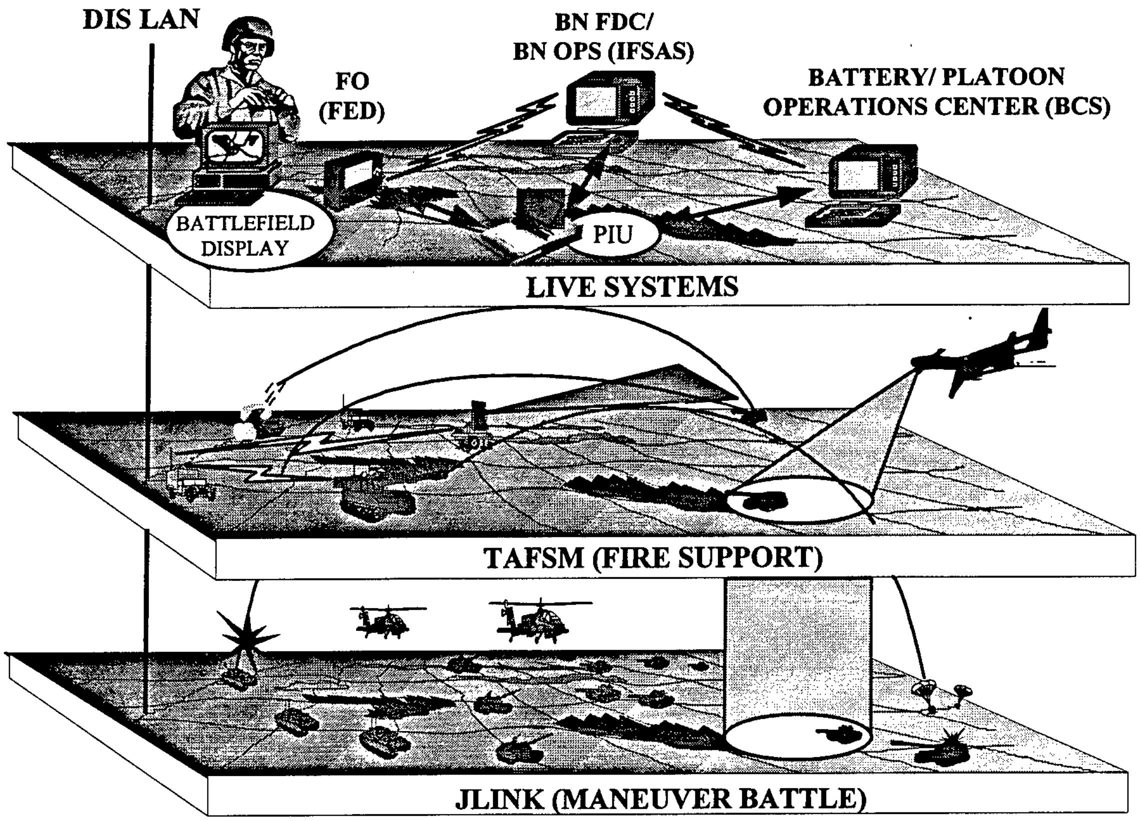


Figure 2. Components of the STOW environment.

Distributed Interactive Simulation (DIS) and Data

The test environment functions collectively as a DIS and employs a seamless confederation of models, simulations, and actual field equipment to simulate the digital battlefield of the future on which Crusader will fight. Data flow digitally among the layers through the use of common protocol packets which encode and decode the information from each of the elements. The use of a DIS environment allows the separate elements of the test environment to function in real time, and for the soldiers participating in the test exercises, there is the feeling that they are functioning in support of maneuver elements in a real developing battle. The separate layers of the test environment are described next.

The Maneuver Battle in J-Link

The overall stimuli for fire missions (FMs) come from a battlefield maneuver simulation called J-Link, which is a DIS-compatible version of a simulation called "Janus." Janus is used at Fort Sill for training officers in basic and advanced field artillery (FA) classes. Janus is, to quote one definition, "...a computer-based, high resolution, two-sided, interactive ground combat simulation with digitized terrain, line of sight for all platforms or weapons systems, and battle calculus computed on probability of kill. Janus models maneuver, FS, air defense, artillery, aviation, engineer support, weather, smoke, and nuclear, biological, chemical (NBC) environments."

Janus is a seminar trainer for commanders' use in training subordinates and principal staff officers in close battle planning and synchronization. Artillery students, playing the "blue" task forces (TFs) fighting a "red" opponent, develop FS plans and then execute those plans in Janus. Full battle scenarios are developed, which are "balanced" so that a good FS plan and good execution of the plan will generally result in a "win" and a poor plan or execution will result in a "loss."

For BLWE 1, the Janus red forces were played in a defensive (southwest Asia [SWA]) scenario by a trained interactor. There were three blue TFs, also led by trained interactors, whose mission was to attack the red positions along a pre-defined corridor of battle. The mission of the soldier participants was to portray a Bn of Crusaders (howitzers and RSVs) in direct support of the blue forces (BLUFOR). Several things need to be kept in mind about the maneuver force battle and its role in BLWE 1:

- The sole purpose of the red and BLUFOR in BLWE 1 was to provide realistic calls for supporting fire from the Crusader Bn.

- The red versus blue battle developed differently for each day's battle, since the opposing "commanders" were allowed to array their forces and try different strategies; thus, nobody could be sure exactly when the blue offensive would reach a specific point of the battle or how the battle intensity would vary over time.

- Consequently, although the Crusader Bn had a general idea of how the battle was planned to develop and what their FS requirements were for each phase (see Figure 3), nobody was sure exactly how the battle would develop that day.

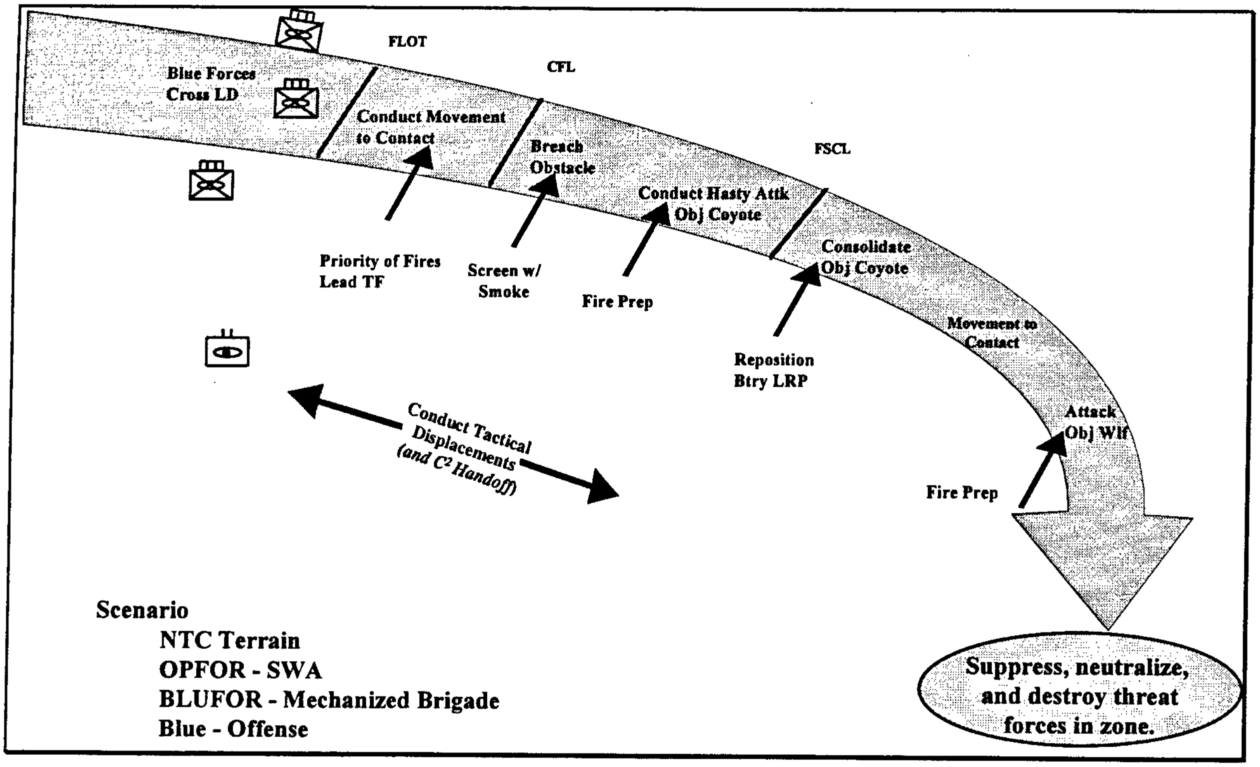


Figure 3. Crusader support requirements by phase of battle.

Live Systems: The Soldiers and Their Field Equipment

There were two forward observers (FOs) using forward entry devices (FEDs) in each of the three blue maneuver nodes. Operators used FEDs to request and plan fires for their supported TF. Additionally, one FO with a FED was assigned to the opposing forces (OPFOR) node to process near real time intelligence to the Bn operations cell. All FED digital traffic was logged into the data logger.

Soldiers from the unit used the Interim Fire Support Automated System (IFSAS) to perform tactical fire control processing at the Bn fire direction center (FDC) node and to communicate FM requests to the POCs. Soldiers at the POCs were equipped with battery computer system (BCS) units to communicate with the POCs and send FMs to the guns (via digital messages to the target acquisition fire support model [TAFSM]).

The players and player-controllers also used five radio networks that were "hard wired" within the simulation center to ensure non-disruptive communications. Radio nets are summarized in Table 1.

Table 1

List of Voice and Digital Radio Nets

Network	Voice	Digital
Command	X	
Administration and logistics	X	
Fire Direction (1)		X
Fire Direction (2)		X
Fire Direction (3)		X

The Crusader Model in TAFSM

TAFSM is a stochastic, two-sided high-resolution simulation, which has been applied extensively for combat developments. TAFSM explicitly moves vehicles about the battlefield, while sensors "search" the battlefield and perform target acquisition. As targets are acquired, messages are created and sent over explicit communications networks to information processing nodes or FDCs in the network where weapon or target allocation is performed.

In BLWE 1, TAFSM used the FM requirements generated by the tactical fire control process (Bn down through POC to "gun" in TAFSM) and performed technical fire control, i.e., calculating the ballistic solution, applying it to a Crusader SPH FM, firing it, and reporting the result to the fire direction officer (FDO) in the POC.

Orders to fire are created for weapons chosen for the missions and transmitted over the communications network to the firing units through the proper chain of command. Weapons are fired at the appropriate chronological time, a volley or a missile at a time. After the appropriate time of flight, the munitions are delivered on the battlefield and assessed against target configurations at that time. TAFSM has been modified to become DIS-compliant and interoperable with live (soldier operated) fielded tactical C2 devices.

Because of TAFSM's fidelity, structure, and ease of modification, coupled with its proven track record in the DIS environment, TAFSM was used in the BLWEs to provide the two-sided combined arms battle context. TAFSM was linked interactively with the Janus battle simulation.

For purposes of the BLWE, the Crusader howitzers and RSVs "lived" in TAFSM. Messages sent (usually by the POC) to Crusader were acted upon in TAFSM, and unlike the usual closed mathematical model, TAFSM responded back in real time to the network (with digital messages) just as the individual Crusader elements would. A request for FM, for example, when sent from the POC to the Crusader howitzer for action, would elicit the same acknowledgment and subsequent messages (e.g., "shot," "splash," "rounds complete") as a live operator would send. This fidelity and immediacy gave the whole STOW environment the ability to produce an OPTEMPO during the battle which provided a very realistic level of stress to the soldiers and the functions (C2 and resupply) during the battles.

Modular Semi-Automated Forces (ModSAF) Representing Situational Awareness

A ModSAF display device was used at the Bn operations center to provide an overview of the emerging battle. This device superimposed icons of the OPFOR onto a pictorial representation (displayed on an 18-inch monitor) of the digital terrain, much as one would draw marks on a map to indicate locations of various objects. The Crusader Bn staff was thus able to track progress of the unit both individually and collectively. This enabled them to identify "stragglers" or groups of RSVs or SPHs that were not keeping pace with the battle, something which was very difficult to do with just the digital message traffic. Because of the OPTEMPO, there was simply no time at the Bn level to track the individual platoons accurately without some sort of overview and summary screen, which ModSAF provided.

Although this capability is not presently available to the Bn staff, it was felt that programs such as Appliqué would be able to provide a similar capability by the time Crusader is fielded, and so we provided it to the Crusader Bn staff.

Synergy: The Synthetic Environment as a Whole

The description of the components of the synthetic environment, while admittedly brief, should give an adequate foundation for understanding the environment in which the Crusader research took place. The important thing to remember is that from the perspective of the soldiers (manning the Bn FDC, the battalion operations center (BOC) and the POCs) their mission was to support the blue TFs in the offensive battle against red defenders. Their contact with the battle came primarily from calls for FS from the blue TFs and the overall situational awareness display of ModSAF at the Bn FDC. As the battle progressed and the OPTEMPO increased, the soldier participants became increasingly "caught up" in the battle. Over time, the synthetic battlefield environment proved itself quite capable of generating a high level of user involvement, even though the howitzers and RSVs were played in TAFSM and could be communicated with only by formatted digital messages. The real-time response capabilities of the TAFSM model, coupled with the realism of the developing battle provided by the blue and red force interactors, provided a degree of realism and immediacy essential to the collection of meaningful data.

Objective 3: Develop a Data Collection and Analysis Methodology

The third objective of the research was to develop and refine a methodology for assessing unit performance as well as collecting findings that might eventually lead to new recommended TTPs for the Crusader system. Since much of the communication occurred across the digital network, a "data logger" was inserted to track the message flow and record times and message paths. Some of the digital data were available for use in the daily after action reviews (AARs) and formed the basis for discussing the day's battle results. In addition to the objective data collected in the data logger, subjective comments and insights from the participants (and, in some cases, the observers) were collected through two primary techniques: AARs and focus (guided discussion) groups.

AARs

Daily assessments of the BLWE, in the form of AARs, were conducted to review progress in meeting BLWE objectives, to capture lessons learned, and to reconstruct the Crusader unit's performance in the offensive scenario. The AAR consisted of a presentation of an event time line for BLUFOR and OPFOR, a summary of Crusader performance during the event, and identification of areas for improvement or sustainment. Some data were retrieved from the data logger for use in each AAR. Critical discussion topics, problems noted, and recommendations from the AAR participants were recorded.

Focus Groups

During the BLWE and shortly after the end of exercise (ENDEX), the data collection team conducted small group discussions. Subjects were used to form multi-disciplinary groups to discuss topics such as C2, FS operations, resupply, and maneuver. Discussions were "focused" around a specific topic, but as can be seen from the information in Appendix A, the discussions sometimes ranged considerably from the main topic.

Objective 4: Assess Training Potential of STOW Environment

Along with the other three goals of the first Crusader BLWE, it was recognized that the overall synthetic battlefield that had been developed had great potential for use purely as a training environment. The reprogrammable and reconfigurable nature of the component models and hardware could be used to improve the functioning of existing units, with (for example) the TAFSM model playing the characteristics of the Paladin howitzer system. A fourth goal was thus to evaluate how to optimize the training experience for soldiers using the STOW environment.

PARTICIPANTS

Participants playing the roles of the Crusader Bn for BLWE 1 were drawn from a Bn-level staff from the 1st Battalion, 17th Field Artillery (1-17 FA), a III Corps Artillery general support (GS) unit. We had a total of 40 participants, although not all were present at all times because of ongoing unit support requirements. In addition to the soldier participants, we had interactors (who "commanded" the red and blue forces) as well as technical staff who functioned as data collectors, facilitators, and computer operators. Roles and functions of the participants are summarized in Table 2.

Table 2

Roles and Functions of Participants

Crusader BLWE 1- Participants' Roles and Functions

Players (III Corps Artillery) 40 personnel	Interactors (AFAS Janus simulation center) 5 personnel	Technical Staff (DCD, D&SABL, ARL) 13 personnel
- Direct support artillery	- 3 x Maneuver TF	- DIS configuration (J-Link, TAFSM)
- Bn TOC	- Role play FSO	- Communications (voice, digital)
- Bn FDC	- OPFOR	- Simulation operation
- Bn LRP	- Intelligence and sensors	- Simulation enhancement
- 6 x POCs	- Offensive scenario	- Data collection
	- Databases	- AARs

AFAS = advanced field artillery system
DCD = Directorate of Combat Developments
TOC = tactical operations center
LRP = logistics resupply point
FSO = fire support officer

PROCEDURES

Following a series of engineering tests to verify that all parts of the electronic environment worked and that all of the participants understood the procedures, baseline and experimental "runs" were conducted. Each run consisted of a simulated red versus blue battle, lasting as long as 4 hours, during which the Crusader FS elements supported the blue maneuver forces. The Bn was responsible for maintaining effective artillery support through timely and efficient FM processing as well as real-time situation awareness of the locations of the various howitzers, RSVs, ammunition transfer points (ATPs), and changing battlefield geometry (e.g., the forward line of troops [FLOT]). Bn personnel had to relocate the vehicles and ATPs as the battle developed and were also responsible for resupplying the RSVs and rearming the SPHs when required. The majority of this was done digitally, using Bn equipment and operators, to ensure that the STOW environment was played as realistically as possible. The details of FM processing are described next, and the important thing to remember is that since the TAFSM model was interactive in real time, messages to and from the Crusader elements appeared to the Bn as quickly as if they had been generated by a "live" system.

The Road to War

The road to war (see Appendix B) describes the events that led to a specific warfighting scenario. It is prepared as a briefing and reference document for the participants to establish the initial conditions leading to the battle in which the Crusader systems will be engaged. The road to war document defines the terrain, committed and available forces, and any special factors or restrictions that commanders must consider. The "road to war" for BLWE 1 used a conventional setting in which a U.S. corps conducts offensive operations as part of a long-term campaign to restore international borders. This is the framework from which the specific battle scenario is developed.

The Battle Scenario

We developed and rehearsed a division-level scenario that was used throughout the baseline and record runs. As shown, the scenario required the blue maneuver force to conduct offensive operations against a stylized-SWA threat. The actual digital terrain used was a portion of the desert at the National Training Center (NTC) in California, a battleground with which many artillery personnel are very familiar. We established initial combat ratios of blue attackers to red defenders at 1:1.

In this scenario, the Crusader Bn played a direct support (DS) role for an attacking brigade and its three blue maneuver TFs. The battle plan required a movement to contact that included a reconnaissance, hasty attack, obstacle breaching, forward passage of lines, and deliberate attack by the maneuver forces. The FM load varied by phase. The offensive scenario is depicted in Table 3. This table also shows the roles and responsibilities of the blue and red TF commanders and the Crusader fire support element (FSE) for each of the stages of the battle.

Table 3

Execution Matrix for Crusader BLWE 1 Offensive Operations

Time (hours): 0, 1, 2, 3, 4, 5 →

Unit Activity

Battlefield event →	Reconnaissance	Move LD to object coyote	Seize object coyote	Pass TF 2-3, 3-3	Seize object wolf	Consolidate & reorganize
BLUFOR maneuver (TF 1-3)	• scouts forward • cross line of departure/line of contact (LD/LC) & attack in zone to seize obj coyote	• identify high value targets (HVT) • engage targets • clear & mark lanes	• conduct deliberate attack • DF engagements • neutralize strong points	• coord "hand-over" • hasty consolidation • upload Classes 3 & 5 • revert to brigade reserve	• assume reserve role • position to support commitment	• prepare defensive position • rearm, resupply, refit
BLUFOR maneuver (TF 3-3)	• deploy scouts • follow and assume TF 1-3, 3 km behind	• F/O TFs cross • LD/LC @ 3 km • close on lead TF & enter lanes	• close on lead TF & enter lanes	• movement in zone • identify HVT • engage targets	• breach obstacles • conduct deliberate attack north • DF engagements • neutralize strong points	• prepare defensive position • rearm, resupply, refit
OPFOR	• defend in depth • recon forward	• engage HVTs • provide intel • indirect fires • counterfires	• direct fire • disengage/delay • counterfires	• cover withdrawing force w/fires • establish obstacle belt • counterfires	• establish security zones • position recon forward of defensive position • counterfires	• defend from prepared position • mass fires • cover obstacles • conduct withdrawal under pressure

• Terrain-NTC terrain database • OFFOR-Samaran, SWA • BLUFOR - mechanized brigade
• Operations-Offense, movement to contact • weather-clear, daylight

Role of the Maneuver Element

There was one maneuver cell for each of three blue TFs and one maneuver cell for OPFOR player-controllers. An interactor, who fought the maneuver battle as the TF commander and role-played the fire support officer (FSO), and two FOs manned each blue maneuver cell. Similarly, the OPFOR fought OPFOR in the defense and role-played the FS coordinator for his formations. See Appendix C, Unit Orders, for detailed unit orders, target list, and target list worksheets.

Role of the Crusader - BLUFOR FS

The Crusader DS Bn tactical operations center (TOC) was manned by an operations element with access to the voice command net and the digital networks. The Bn TOC processed battlefield information, reports, and directives (gleaned from voice and digital traffic) to perform tactical fire control and was also responsible for analyzing maneuver support requirements and preparation, dissemination, and implementation of its FA support plan (FASP).

The command element, represented by the S3, resided in the TOC. The TOC monitored the maneuver battle and ensured performance of roles and responsibilities associated with the Bn's DS mission. Personnel in the TOC maintained and updated displays and maps needed to perform tactical fire control. The TOC was responsible for maintaining overall battlefield situation awareness by developing, maintaining, and disseminating information used to create a common picture of the battlefield.

Role of the POCs

Each POC was staffed to perform technical and tactical fire control. Staffing included a platoon leader, fire direction noncommissioned officer (NCO), computer operator, and map technician. Each POC was equipped with a BCS to perform the technical calculations and to disseminate fire orders to SPHs and RSVs. The POC maintained situation awareness by receiving information (voice and digital), updating displays, posting the situation map (SITMAP), and seeking clarification or guidance from the Bn TOC. POCs had to know the location and status of each SPH and RSV, be prepared to assume control of other fire units, and implement the FASP.

Processing an FM

FM processing by the Bn fire direction personnel was initially performed in accordance with current doctrine, Field Manual (FM) 6-20-40 (U.S. Army Field Artillery School, 1990). The event cycle is depicted in Figure 4.

During the battle, FMs for the Crusader Bn were generated either directly from TAFSM or from soldiers, with FEDs, acting as FOs in support of the blue maneuver forces. The event cycle was initiated when the FED operator depressed the "send" key to transmit the FM, or when an "FM; call for fire" (FM;CFF) message was generated within TAFSM. Events were logged when the receiving node (Bn FDC) transmitted an acknowledgment. A unique target number identified each event cycle. A data logger was used to store the logged data for post-processing and analysis.

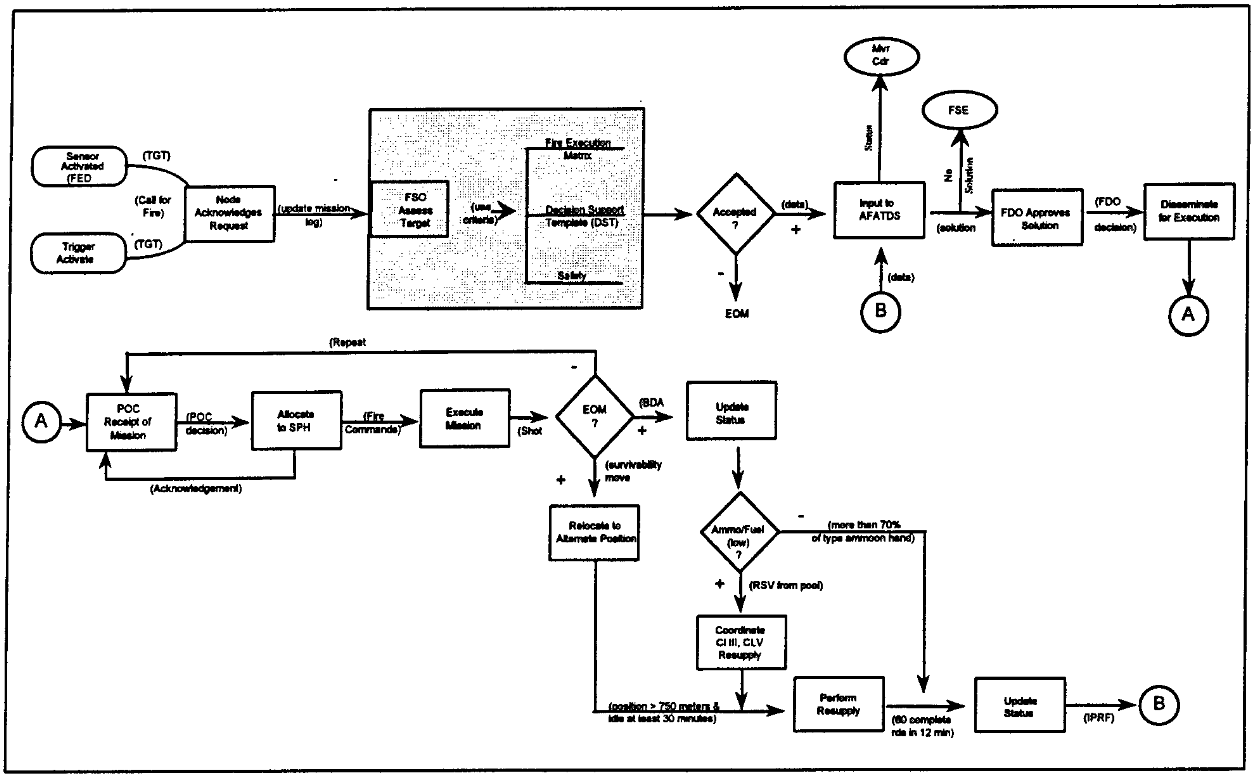


Figure 4. Crusader FM event cycle.

Once the Bn FDC accepted the mission request, it performed tactical fire control by selecting the method of engagement, unit to fire, and generating a fire order. Once approved by the Bn FDO, the IFSAS operator transmitted the "FM; fire commands" (FM; FC) message to the selected firing platoon. At the POC that used BCS, tactical fire control functions were performed to select the specific firing piece that would calculate the firing data. These data were then sent by the POC to the firing piece as fire commands. For BLWE 1, all the actions of the Crusader system components (both howitzer and RSV) were modeled in TAFSM, which received and responded to the digital message traffic.

The TAFSM model of the Crusader SPH processed and fired the missions, then generated a rounds complete message. Once an SPH received an end of mission (EOM) message from its POC, it updated its status (generating howitzer; ammunition update [HOW;AMOUP]; and howitzer; move [HOW;MOVE] messages) and executed a survivability move. Survivability moves required displacement of at least 750 meters from the position at EOM and relocation to a position area that was inactive (not fired from) for at least 30 minutes. Survivability moves were required at the end of each FM. Sometimes, missions were directed to SPHs that were in a move status. When this occurred, the SPH would stop, fire, receive an EOM, and generate the necessary status reports.

Concurrently with FM processing requirements, the POC was required to assess the need for ammunition resupply and, if necessary, direct a rearming of the howitzer from an RSV within the new position area before any firing occurred. Both vehicles submitted platform status update (HOW:UPDATE) and HOW;AMMOUP messages to record ammunition transfers and locations. Once the rearm operation was complete, RSVs were directed to return to a designated hiding area, or the Bn directed them to the logistics resupply point (LRP) for resupply.

RESULTS

Caveat: Limitations When n = 1

We tried to minimize artificialities in the environment, which would significantly affect the validity of the results of the experiments. Nonetheless, when fighting a large battle inside a small building with limited resources, some parameters differed from the ideal. Additionally, this was the first in a series of BLWEs and had (we hope) a higher "confusion factor" than we will see in later work.

Moreover, this research did not and will not focus on performance of the Crusader (which can only be estimated, modeled, and inferred at this stage of development) but on the refinement or development of TTPs by which the Army can best use the capabilities of this system. We were looking at the roles of the soldiers and the C2 environment in which they operate and at the resupply and rearming process, and so some of the limitations had minimal effect on our success. Critical assumptions and limitations are discussed next.

The Assumptions Included

• The synthetic environment could create an OPTEMPO which would approximate at least a significant part of the stress of a real battle.

- This proved to be a valid assumption. As previously discussed, even the interactors became absorbed in the progress of the battle, and the overall OPTEMPO that the Crusader elements generated led to a consistently high level of effort on the part of the soldiers at the Bn and POC levels to keep them resupplied and moving with the battle.

• Consistency in the maneuver battle from run to run could be achieved with trained interactors, ensuring that the overall scenario event sequence is reproduced regardless of the maneuver tactics employed in each separate battle.

- This was a trade-off between predictability and repeatability. If we had scripted the battle, we could have had a more consistent set of event time lines within each battle and a set of data, which would have made it easier to compare between battles. Scripting, however, would have led to very predictable responses from the red and blue forces and to the feeling of fighting the same battle over and over. Indeed, it was the "what are they going to do next" feeling that contributed strongly to the sense of realism and involvement among the players. We were able to follow the planned event cycles, but each day's battle remained a unique and interesting event.

Artificialities and Constraints Included

• The combat ratio was less than doctrinally recommended to conduct offensive operations.

- Doctrinally, the attacking forces would want at least a 3:1 advantage over an entrenched, defending enemy force. We used a ratio of almost 1:1 in order to stress the Crusader C2 process as much as possible by increasing the number of targets that could be attacked during the various phases of the battle.

• No tactical air or army aviation assets were used because of limitations in the processing ability of the network.

• We used no reinforcing or general support reinforcing (GSR) artillery for BLUFOR.

- This imposed a greater load on the C2 system earlier in the scenario and resulted in the unit performing some tasks that would normally be passed to the reinforcing (R) artillery headquarters.

• The number of FEDs (and operators) available for use was 1/8 (12.5%) of those that would normally be used.

• We needed to add message sets specific to C2 of Crusader FS and resupply operations.

- We have developed and tested procedures for use with IFSAS and BCS and have prepared a standard set of system; plain text message (SYS;PTM) messages that will facilitate interface between the models and tactical systems. This may have resulted in some increased processing time at the POC level.

- The unit available for BLWE 1 was a GS unit.

- GS units are not organized, trained, or equipped to perform the DS mission. What effect this had on the outcome of the initial BLWE is not known at this time. Later, if we run a DS unit, we may be able to make some post hoc observations.

- We did not use a maneuver control cell to provide brigade-level inputs.

- This meant that the FSO function was simulated and that FMs were assumed to be safe and necessary at the time they are requested. This may have had some shortening effect on the mission cycle timing and may have somewhat increased the FM throughput.

- Resupply time used for the RSV only considers transfer of Class V, ammunition.

- Since the RSV will serve as the prime mover for all classes of supply needed within the firing unit, we are using an artificially shortened delay time at the LRP.

- We limited the battle to a 4-hour slice.

- Therefore, we did not see a complete planning and decision cycle, were unable to see long term effects of outages and losses, and the long term effects on process performance were not evident. The aim of BLWE 1 was to stress the C2 and resupply networks by achieving maximum mission throughput within the 4-hour block.

- We used unclassified databases, which may have affected the number of rounds selected for certain missions.

- Again, we were trying to stress C2 and resupply, so we sometimes artificially "pumped up" the rounds required for an FS mission to increase the OPTEMPO and load on the soldiers.

Results: Baseline Runs

The purpose of the baseline runs was to "benchmark" the system's performance relative to guidelines established during an earlier developmental event known as the cost and operational effectiveness analysis (COEA). The COEA uses a model of the Crusader that incorporates required operational characteristics of the final production item (such as desired speed, rate of fire, range of gun) and plays them in a mathematical model to help the system designers look at possible trade-offs and alternatives during actual hardware development. Since the COEA was the best extant set of data on the Crusader so far, we extracted some of the values (see Appendix D, Operational Mode Summary/Mission Profile [OMS/MP]) to gauge whether we were reaching the desired level of OPTEMPO during the battle scenarios. The goals for the baseline runs were thus:

1. Achieve desired level of FS performance and OPTEMPO, and

2. Establish and maintain a realistic synthetic environment.

During the two baseline runs, we held constant some conditions which would later be varied during the experimental runs. Baseline conditions included grouping the SPHs and RSVs in a "balanced" platoon organization, in which each of the two platoons in a battery had command and control responsibility for three SPHs and three RSVs. These vehicles operated in a "pooled" manner with any of the three RSVs in a platoon able to resupply any of the SPHs in the same platoon. During baseline runs, no RSVs were allowed to be "killed" by counterfire, but they were still susceptible to failure as a function of reliability, availability, and maintainability (RAM) factors programmed into the vehicle models. General conditions for the baseline run are summarized in Table 4.

Table 4

Conditions for Baseline Runs

Conditions	State
C2 organization	Balanced platoon organization, 3 SPHs and 3 RSVs per platoon
Tactical fire control capability- Bn FDC	Single IFSAS at Bn FDC
Tactical fire control capability- POC	Single BCS at each POC
RSV control	Centralized at POC level; pooled-RSV concept
RSV attrition	No catastrophic losses (kills), possibility of RAM outage
OPFOR counterfire	Inactive

Results of the baseline runs are shown in Tables 5 and 6.

Table 5

Comparison of Achieved Baseline Run 1 Results to the Crusader OMS/MP

Total run time, hrs:min (Ti)	Measures	Individual tube missions per day per tube (M)	Rounds per individual tube mission (R)	Total rounds fired during run	Predicted rounds fired per day (MxRx18)	Total rounds transferred during run RSV to SPH	Percent of RSV rounds on board 2,340 transferred
3:30	OMS/MP guidance	45	10.0		8,100		
	Achieved	47.1	7.6	1,250	6,443	98	4.2%
	Percent difference from OMS/MP	+4.7	-24.0		-20.4		

Table 6

Comparison of Achieved Baseline Run 2 Results to the Crusader OMS/MP

Total run time, hrs:min (Ti)	Measures	Individual tube missions per day per tube (M)	Rounds per individual tube mission (R)	Total rounds fired during run	Predicted rounds fired per day (MxRx18)	Total rounds transferred during run RSV to SPH	Percent of RSV 2,340 rounds transferred
4:30	OMS/MP	45	10.0		8,100		
	Achieved	42.2	7.4	1,406	5,621	1,083	46.3%
	Percent difference from OMS/MP	-6.2	-26.0		-30.6		

As these tables show, we were able to approximate the OPTEMPO of a Crusader Bn during the baseline runs. They also show several other things about the baseline runs, which merit explanation.

The variation in total run time is attributable to the speed with which the battle progressed, which is of course a function of how the red and blue commanders chose to fight the battle on that particular day.

The tube missions per day and rounds per individual Crusader tube mission are calculated by taking the total actual values for that day's battle, dividing by the number of hours of actual "battle," and "normalizing" them for an 18-hour battlefield day, which is how the values are stated in the OMS/MP. As an overall measure, these values have some validity, but they fail to describe a lot about the actual variations in intensity within a specific battle. In addition, the OMS/MP notes (section 6.a) that the average howitzer expenditure of 448 rounds per tube per day was achieved with a standard deviation of 199 rounds, which leaves a pretty large margin to work around. In summary, we felt that we were achieving a reasonably high OPTEMPO relative to the previously modeled studies.

The increase in total rounds transferred between the first and second baseline runs is a function of learning from the first battle when the unit successfully supported the blue maneuver elements but had focused much more on processing FMs than resupply. The result was that at the end of the battle, their SPHs would have been out of action for a significant amount of time while everybody rearmed and resupplied. This was highlighted during the AAR at the end of the first day, and the second baseline run shows a much improved emphasis on resupply as well as on FM processing.

At the end of the second baseline run, we concluded that the overall OPTEMPO was adequate to exercise the C2 and resupply functions, and we were ready for the record runs and excursions.

Results: Record Runs and Excursions

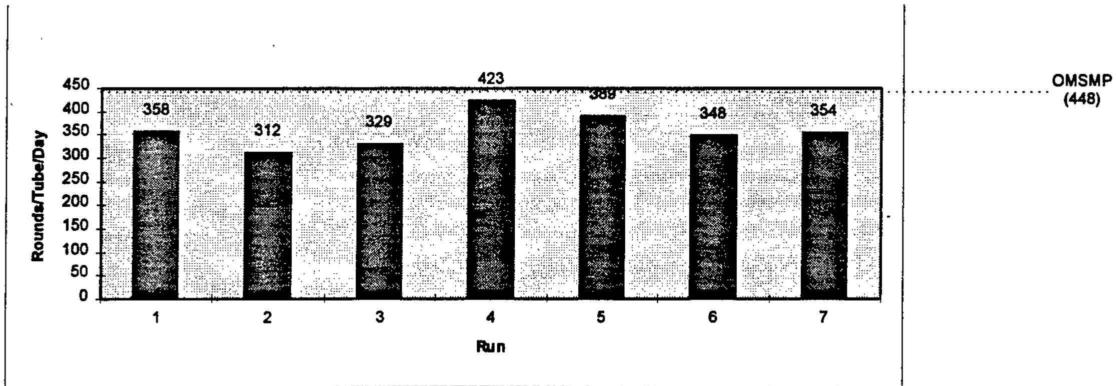
OPTEMPO: the Primary Goal

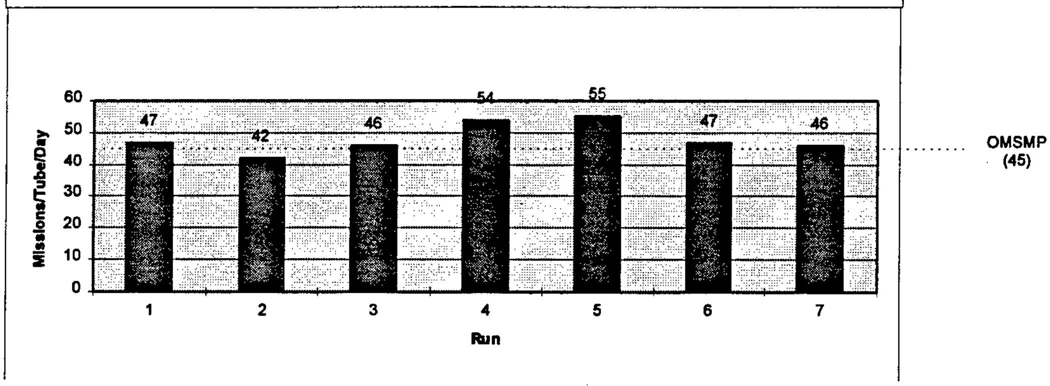
As we have discussed, the main purpose of BLWE 1 was to generate information about TTPs for TSM-Cannon, as well as data that would be used in assembling the draft OCD to accompany initial fielding of Crusader. To ensure that the TTPs were generated during conditions as realistic as possible, we tried to keep the overall OPTEMPO at an overall high level. As shown in Table 7, we were very close to OMS/MP guidance on missions per tube per day and reasonably close on rounds per tube per day.

Runs number 1 and 2 on these charts represent the baseline runs, and Runs 3 through 7 represent the "record" runs. The primary difference between the baseline and record runs is that in the record runs we changed some of the conditions we had previously held constant.

Table 7

OPTEMPO Relative to OMS/MP Guidance





Excursions

Table 8 illustrates the approach we took to manipulate the resources or conditions of the battle once we had established the baseline conditions (Runs 1 and 2). Note that in none of the battles, baseline or excursion, were we able to cause a complete breakdown of either the C2 or resupply functions. Even with only one IFSAS at the BOC, the soldiers were able to keep pace with the battle OPTEMPO, although the stress level was significant. Two factors bear on the performance data: length of battle and the effect of continued training.

The longest battle we fought was 4-1/2 hours. This was not really enough to get the soldiers to the point where significant increases in C2 errors would occur as a result of fatigue and stress. A second consequence was that the resupply functions never "broke," even when we deliberately introduced attrition by removing one or more RSVs from play. Future BLWEs will include more extended battles so that we can better assess the effects of fatigue and resource attrition.

Table 8

Conditions by Run

Synthetic environment	Resupply operations	Command and control
Run 1 Establish environment Operate models Baseline conditions Collect data	Run 3 Pooled RSV Low RSV attrition Dual IFSAS Balanced platoons	Run 5 Pooled RSV High RSV attrition Dual IFSAS Balanced platoons OPFOR counterfires
Run 2 Establish environment Operate models Baseline conditions Collect data	Run 4 Dedicated RSV Low RSV attrition Dual IFSAS Balanced platoons	Run 6 Pooled RSV High RSV attrition Dual IFSAS Imbalanced platoons OPFOR counterfires
		Run 7 Pooled RSV No RSV attrition Dual IFSAS Dual BCS POC OPFOR counterfires

A second factor bearing on performance was training. Most of the unit participants had some level of training on the field equipment (IFSAS and BCS) that they brought with them, but it was clear that they had not had extensive experience working together as a unit in the kind of realistic battlefield environment that we were able to provide. The result was that the unit continued to improve individual and collective skills throughout both the baseline and record runs and simultaneously refine their TTPs so that the FM processing and resupply tasks became more efficient. These improvements in performance confounded attempts to draw firm conclusions from the excursions other than those reflected in the TTPs and guided discussion groups. Training to asymptotic performance before doing the excursions, however, was simply not possible because of time constraints. Even when the unit returned in October for more testing and training, there was some relearning for previous unit members as well as training for new personnel in the unit.

Both of these factors are correctable in future BLWEs, and training to asymptotic performance will likely be easier with longer battles and the use of DS units. For BLWE 1, however, the results of the excursions are better reflected in the TTPs than in the differences in performance parameters.

As a final note, Appendix E, AAR Field Notes and Daily Summary Notes, should be reviewed along with the following narrative of the record runs if a more detailed picture of the events is desired. Two methodologies are employed: field notes and AAR summary charts. Until the start of the baseline and record runs, a detailed set of field notes was kept by the subject matter experts (SMEs) (see pages 137 through 185) about the early AAR discussions, recommendations for modifications of the TTPs, and observations of the unit performance at the various C2 elements. After we started the record runs, we conducted more formal AARs focused on how the unit performed relative to the experimental changes we had made for that day's battle. For each of the seven more formal AARs, we assembled a set of five briefing charts with the following information:

- Chart 1 - The Crusader BLWE 1 mission statement and unit objectives for that battle,
- Chart 2 - Number of rounds fired by type per time period,
- Chart 3 - Distribution of FMs: Number of rounds by firing unit,
- Chart 4 - Distribution of FMs: Number of missions and rounds per type round, and
- Chart 5 - Distribution of missions by gun-target range.

The field notes are snapshots of what the SMEs observed or heard in conversation with the troops. They are included for completeness, but remember that the data are in no particular order of importance or are in any way intended to present a formal picture to the reader. No significant filtering has been done; they are presented as they were written.

With all of this in mind, let us now proceed to the record runs.

Record 1

Run 3, or record run 1, was the first in a series of five record runs that were conducted to measure performance when conditions had been varied from the baseline.

Objectives

1. Observe the effects of RSV losses on ammunition resupply operations.

Conditions

The performance variables and their initial state are listed in Table 9.

Table 9

Experimental Conditions for Record Run 1

Conditions	State
C2 organization	Balanced platoon configuration
Tactical fire control capability- Bn FDC	Dual IFSAS at Bn FDC
Tactical fire control capability- POC	Single BCS at each POC
RSV control	Centralized at POC level; pooled-RSV concept
RSV attrition	RSV losses, maximum one per battery
OPFOR counterfire program	No OPFOR counterfire program

Findings

The performance summarized in Table 10 was achieved during record run 1 with variation from the baseline conditions.

Table 10

Achieved Results for Record Run 1 Compared to the Crusader OMS/MP

Total run time, hrs:min (Ti)	Measures	Individual tube missions per day per tube (M)	Rounds per individual tube mission (R)	Total rounds fired during run	Predicted rounds fired per day (MxRx18)	Total rounds transferred during run RSV to SPH	Percent of RSV 2,340 rounds transferred
	OMS/MP	45	10.0		8,100		
2:33	Achieved	46.3	7.1	841	5,917		
	Percent difference from OMS/MP	+2.9	-29.0		-27.0		

• The results of record run 1 indicated that the unit was able to sustain an OPTEMPO for C2, FS processes, and combat service support (CSS) operations comparable to the baseline runs. Tactical fire control measures such as specifying the number of volleys instead of establishing a level of effect tended to suppress the number of rounds fired. Data about RSV ammunition transfers were not available for this run.

• Total time for record run 1 was significantly less than the average (3:46) of the seven runs. This was attributable to problems with the synthetic environment. The rounds per individual tube mission remained significantly lower than the OMS/MP. No attempt was made to alter or influence the manner in which the Bn FDC implemented tactical fire control. Ammunition was available and distributed among the firing and resupply vehicles in accordance with the unit basic load (UBL) for this mission.

• Total rounds fired per day was less than the OMS/MP rate. This result was consistent with other measures of FM throughput and was attributable to tactical fire control decisions.

Record 2

Run 4, or record run 2, was the second in a series of five record runs that were conducted to measure performance when conditions had been varied from the baseline.

Objectives

1. Observe the effects of RSV losses on ammunition resupply operations.
2. Add a second IFSAS at Bn FDC to enhance tactical fire control performance.
3. Demonstrate dedicated RSV operations during tactical movements.

Conditions

The performance variables and their initial state are listed in Table 11.

Findings

The performance summarized in Table 12 was achieved during record run 2 with variation from the baseline conditions.

• The results of record run 2 indicated that the unit was able to sustain an OPTEMPO for C2, FS processes, and CSS operations comparable to the baseline runs.

Table 11

Experimental Conditions for Record Run 2

Conditions	State
C2 organization	Balanced platoon configuration
Tactical fire control capability- Bn FDC	Dual IFSAS at Bn FDC
Tactical fire control capability- POC	Single BCS at each POC
RSV control	Centralized at POC level; pooled RSV concept
RSV attrition	RSV losses, maximum one per battery
OPFOR counterfire program	No OPFOR counterfire program

Table 12

Achieved Results for Run 2 Compared to the Crusader OMS/MP

Total run time, hrs:min (Ti)	Measures	Individual tube missions per day per tube (M)	Rounds per individual tube mission (R)	Total rounds fired during run	Predicted rounds fired per day (MxRx18)	Total rounds transferred during run RSV to SPH	Percent of RSV 2,340 rounds transferred
	OMS/MP	45	10.0		7,920		
2:48	Achieved	54.3	7.8	1,182	7,624	959	41.0%
	Percent difference from OMS/MP	+20.7	-22.0	-5.9			

• Total time for run 2 was significantly less than the average of the seven runs. This decrease was attributed to the battle tactics employed by the interactors and not related to the Crusader system performance. Sufficient ammunition and the full complement of SPHs remained at ENDEX.

• The rounds per individual tube mission remained lower than the OMS/MP.

• Similarly, total rounds fired per day was less than the OMS/MP rate, which was consistent with other measures and attributable to tactical fire control decisions.

• Total rounds transferred from RSV stocks as a percent of available RSV inventory was 41%. This result is consistent with the OPTEMPO. The unit was unable to satisfy all its ammunition requirements without returning to LRPs and uploading from palletized loading systems (PLSs). There were 58 rounds, about 11%, transferred at one LRP.

Record 3

Run 5, or record run 3, was the third in a series of five runs that were conducted to measure performance when conditions had been varied from the baseline.

Objectives

1. Observe the effects of RSV losses on ammunition resupply operations.

2. Maintain a second IFSAS at Bn FDC and include a "ground truth" display (i.e., ModSAF).

3. Demonstrate dedicated RSV operations for resupply and during tactical movements.

4. Operate with a balance platoon organization.

5. Conduct OPFOR counterfire operations to identify survivability issues.

Conditions

The performance variables and their initial state are listed in Table 13.

Table 13

Experimental Conditions for Record Run 3

Conditions	State
C2 organization	Balanced platoon configuration
Tactical fire control capability- Bn FDC	Dual IFSAS at Bn FDC
Tactical fire control capability- POC	Single BCS at each POC
RSV control	Centralized at POC level; pooled RSV concept
RSV attrition	RSV losses, maximum three per battery
OPFOR counterfire program	No OPFOR counterfire program against a minimum number of Crusaders based on simulated radar acquisitions

Findings

The performance summarized in Table 14 was achieved during record run 3 with variation from the baseline conditions.

• The results of record run 3 indicated that the unit was able to sustain an OPTEMPO for C2, FS processes, and CSS operations comparable to the baseline runs. It exceeded the FM throughput standard by nearly 25% from the OMS/MP and fired more rounds than anticipated during the run. This increase indicates a response to feedback from AARs and increases in proficiency within the FS system (as determined by SMEs).

Table 14

Achieved Results for Run 3 Compared to the Crusader OMS/MP

Total run time, hrs:min (Ti)	Measures	Individual tube missions per day per tube (M)	Rounds per individual tube mission (R)	Total rounds fired during run	Predicted rounds fired per day (MxRx18)	Total rounds transferred during run RSV to SPH	Percent of RSV 2,340 rounds transferred
4:30	OMS/MP	45	10.0		8,100		
	Achieved	55.6	7.0	1,751	7,006	2,086	89.1%
	Percent difference from OMS/MP	+23.5	-30.0		-13.5		

• Total time for run 3 was significantly greater than the average of the seven runs. This increase was attributed to the tactics employed by the interactors and tactics used by the DS Bn related to positioning and shifting or priorities. There were ammunition outages that resulted in some missions not being fired.

• The rounds per individual tube mission remained significantly lower than the OMS/MP. No attempt was made to alter or influence the manner in which the Bn FDC implemented tactical fire control.

• Similarly, total rounds fired per day were fewer than the OMS/MP rate, which was consistent with other measures and attributable to tactical fire control decisions.

• Total rounds transferred from RSV stocks as a percent of available RSV inventory was 89%. This was the greatest use of LRPs, and it occurred despite the largest number of RSV losses of any run. The unit was unable to satisfy all its ammunition requirements without returning to LRPs and uploading from PLSs. About 36% (571 rounds) was transferred from the three LRPs to RSVs.

OPFOR initiated its counterfire program with little effect on BLUFOR artillery systems. The level of counterfire activity was not intense. Initially, the counterfires were used to demonstrate proof of principle that fires could be controlled and their effects measurable. The survivability tactics (i.e., displacement after each EOM) provided sufficient protection from the effects of counterfire.

Record 4

Run 6, or record run 4, was the fourth in the series of five runs that were conducted to measure performance when conditions had been varied from the baseline.

Objectives

1. Observe the effects of RSV losses on ammunition resupply operations.

2. Maintain a second IFSAS at Bn FDC to enhance tactical fire control performance.

3. Demonstrate C2 processes from new POC arrangements.

4. Implement OPFOR counterfires to identify survivability issues.

Conditions

The performance variables and their initial state are listed in Table 15.

Findings

The performance summarized in Table 16 was achieved during record run 4 with variation from the baseline conditions.

Table 15

Experimental Conditions for Record Run 4

Conditions	State
C2 organization	Balanced platoon configuration
Tactical fire control capability- Bn FDC	Dual IFSAS at Bn FDC
Tactical fire control capability- POC	Single BCS at each POC
RSV control	Centralized at POC level; pooled RSV concept
RSV attrition	RSV losses, maximum three per battery
OPFOR counterfire program	No OPFOR counterfire program against a minimum number of Crusaders based on simulated radar acquisitions

Table 16

Achieved Results for Run 4 Compared to the Crusader OMS/MP

Total run time, hrs:min (Ti)	Measures	Individual tube missions per day per tube (M)	Rounds per individual tube mission (R)	Total rounds fired during run	Predicted rounds fired per day (MxRx18)	Total rounds transferred during run RSV to SPH	Percent of RSV 2,340 rounds transferred
4:20	OMS/MP	45	10.0		8,100		
	Achieved	47.1	7.4	1,509	6,273	1,921	82.1%
	Percent difference from OMS/MP	+4.7	-26.0		-22.6		

• The results of record run 4 indicated that the unit was able to sustain an OPTEMPO for C2, FS processes, and CSS operations. The unit's tactical fire control processes achieved FM throughput about 5% greater than the expected standard from the OMS/MP. Because of tactical fire control solutions, fewer rounds were fired than anticipated.

• Total time for record run 4 (4.20 hours) was significantly greater than the average (3.46 hours) of the seven runs. This increase was attributed to the tactics employed by the interactors and tactics used by the DS Bn related to positioning and shifting or priorities. The unit experienced ammunition outages that resulted in some missions not being fired. These shortfalls were reported as mission denials for "ammunition availability".

- The rounds per individual tube mission remained significantly lower than the OMS/MP. No attempt was made to alter or influence the manner in which the Bn FDC implemented tactical fire control. The commander's attack guidance was specified in volleys and not effects.

- Similarly, total rounds fired per day were fewer than the OMS/MP rate, which was consistent with other measures and attributable to tactical fire control decisions.

- Total rounds transferred from RSV stocks as a percent of available RSV inventory was about 82%. This level of LRP use was high and similar to the earlier record run 3. The unit was unable to satisfy all its ammunition requirements without returning to LRPs and uploading from PLSs. About 42% (665 rounds) was transferred between the three LRPs and the unit's RSVs.

OPFOR initiated its counterfire program with little effect on BLUFOR artillery systems. The level of counterfire activity was not intense. Initially, the counterfires were used to demonstrate proof of principle that fires could be controlled and their effects measurable. The survivability tactics (i.e., displacement after each EOM) provided sufficient protection from the effects of counterfire.

Record 5

Run 7, or record run 5, was the fifth in the series of five runs that were conducted to measure performance when conditions had been varied from the baseline.

Objectives

1. Observe the effects of various POC arrangements.
2. Introduce a second BCS at the POC level and observe tactical fire control performance.
3. Demonstrate the RSV operational cycle.
4. Conduct OPFOR counterfires to identify survivability issues.

Conditions

The performance variables and their initial state are listed in Table 17.

Table 17

Experimental Conditions for Record Run 5

Conditions	State
C2 organization	Imbalanced platoon configuration in one battery Balanced platoon configuration in one battery All systems controlled by a single POC within one battery
Tactical fire control capability- Bn FDC	Dual IFSAS at Bn FDC
Tactical fire control capability- POC	Single BCS at each POC in two batteries Dual BCS in one battery that control six SPHs and six RSVs
RSV control	Centralized at POC level; pooled RSV concept
RSV attrition	No RSV losses
OPFOR counterfire program	No OPFOR counterfire program against a minimum number of Crusaders based on simulated radar acquisitions

Findings

The performance summarized in Table 18 was achieved during record run 5 with variation from the baseline conditions.

Table 18

Achieved Results for Run 5 Compared to the Crusader OMS/MP

Total run time, hrs:min (Ti)	Measures	Individual tube missions per day per tube (M)	Rounds per individual tube mission (R)	Total rounds fired during run	Predicted rounds fired per day (MxRx18)	Total rounds transferred during run RSV to SPH	Percent of RSV 2,340 rounds transferred
2.10	OMS/MP	45	10.0		8,100		
	Achieved	46.0	7.7	767	6,376	725	46.3%
	Percent difference from OMS/MP	+2.2	-23.0		-21.3		

• The results of record run 5 indicated that the unit was able to sustain an OPTEMPO for C2, FS processes, and CSS operations. The fact that the run preceded a holiday and was the final day of the experiment may also account for some of the differences from earlier runs. The unit's tactical fire control processes achieved slightly higher levels of FM throughput than the expected standard by the OMS/MP. Because of tactical fire control solutions, fewer rounds were fired than anticipated.

• Total time for record run 5 (2.1 hours) was significantly less than the average (3.46 hours) of the seven runs. This decrease was attributed to the ENDEX activities and some unforeseen communications problems. The unit avoided ammunition shortfalls by initiating resupply actions early.

• The rounds per individual tube mission remained significantly lower than the OMS/MP. No attempt was made to alter or influence the manner in which the Bn FDC implemented tactical fire control. The commander's attack guidance was specified in volleys and not effects.

• Similarly, total rounds fired per day were fewer than the OMS/MP rate, which was consistent with other measures and attributable to tactical fire control decisions.

• Total rounds transferred from RSV stocks as a percent of available RSV inventory was about 46%. This level of LRP use was lower than the two previous record runs 3 and 4 because of the length of the run. The unit was able to satisfy its ammunition requirements because it forecasted requirements and began resupply at the LRPs sooner than earlier runs.

• OPFOR initiated its counterfire program with little effect on BLUFOR artillery systems.

Results: Focus Groups and AAR Discussions

Delivery of Effective Fires

C2

Tactical Movement Control

Description

During offensive operations, the maneuver force moved rapidly through its zone of attack to seize its objective. Initially, the DS FA Bn employed a "leapfrog" approach to movement of displaced howitzers while other systems remained in position ready to fire. The unit observed the speed at which the SPH progressed and the amount of time required to accept an FM from the march. Using this insight, the unit employed a tactical formation for its movement along axes of advance for each platoon-size element. The axis of advance enables section chiefs and platoon leaders to exercise tactical judgment in route and firing position selection. This approach to tactical movement control meant that all operational systems could move in a battle formation.

Source

Interviews with Bn staff.

Analysis

DS units used battle formations to conduct tactical movements. On-board processors transmitted ammunition and fire unit update (AFU:UPDATE) messages to report status for each SPH once it reached the position area or when it had accepted an FM. The consequence of this tactic was it became more difficult for Bn TOC or FDC to maintain current SPH locations, and RSVs were often left behind. The tactical movement TTP should include provisions for RSV displacement and criteria for relocation of the LRP during offensive operations.

Conclusions

Based on data collected during the experiment and subsequent analysis, the following conclusions describe how processes used to transfer C2 facilitated FS.

1. Crusader system will displace more rapidly than current FS systems.

2. Battle tracking and situation reporting are necessary when Crusader systems are displacing.

3. SPHs and RSVs paired displacements were preferred to pooled moves by subjects.

FM Radio Limitations

Description

Subjects described how current frequency modulated (FM) radio systems will limit Crusader effectiveness. They believed this to be true even with the introduction of single channel, ground, airborne radio system (SINCGARS). In open terrain, the best that could be expected is a 15- to 20-kilometer range for reliable communications. In hilly terrain, such as Korea, terrain masking would severely limit all forms of FM radios to 5 to 12 km. This limitation could not be tested or observed during the experiment because an SWA terrain database was used and perfect communications were assumed. However, some administrative communications disruption did occur and resulted in non-acknowledgments between tactical processors.

Source

Interviews with POC personnel.

Analysis

The communications architecture used during future experiments must be robust so that we can measure the effects that disruption will have on the C2 process. Terrain masking and effects of distance should be represented in future simulations to develop "workarounds" and new TTPs for communications outages.

Sharing Battlefield Information

Description

At the beginning of the experiment, each C2 node was surveyed to determine what information was displayed to support that node's performance. These displays were typically man-made, manually maintained, and frequently contained information that was outdated or inaccurate. The arrangements were non-standard and reflected the unit standing operating procedure (SOP) requirements or the experience of senior NCOs. Each POC and the Bn maintained a SITMAP that contained battlefield geometry, planning aids to support movement, friendly unit locations, and battlefield spot reporting. No SITMAP had an "as of time." Platoon leaders or map NCOs/specialists maintained SITMAPs. The displays in each C2 node are listed in Table 19. An asterisk (*) indicates that the display was present but not completed at time of observation, "o" indicates display not observed at that POC, and "x" indicates display with information was present.

Table 19 shows that the POCs accumulated a large knowledge base of information displayed along the walls of their C2 shelter. What the table does not show is how often the information was used or updated.

Table 19

Operation Center Displays

Description	Bn	A1	A2	B1	B2	C1	C2
Unit mission	x	*	*	o	x	x	x
Next higher headquarters (HQ) mission	x	x	x	o	o	x	x
Two levels higher HQ mission	x	o	o	o	o	o	o
Commander's intent	x	*	o	o	*	x	x
Higher commander's intent	x	x	o	o	o	x	x
Critical FS tasks	x	x	o	*	x	x	x
Enemy situation	o	x	*	o	x	x	x
Friendly situation	o	x	*	o	o	x	x
Unit locations	o	x	x	*	x	x	o
Chemical downwind message	o	*	*	o	o	*	*
Battlefield geometry	o	*	*	o	o	x	x
FS coordination measures	o	x	o	o	o	x	x
Air defense status	x	x	o	o	x	x	x
Casualty collection point	o	*	o	o	o	x	*
Intelligence summary (INTSUM)	o	*	o	o	o	x	x
Priority information requirements (PIR)	o	x	o	o	o	x	x
Commander critical information requirements (CCIR)	x	x	o	o	o	x	x
Mission-oriented protective posture (MOPP) status	o	x	o	*	*	x	x
UBL	x	x	x	x	o	x	x
Combat vehicle status	x	o	o	o	o	o	o
Target list	x	x	o	o	x	x	o
Subscriber table	x	o	x	x	x	x	o

At the POC, UBL, target lists, subscriber tables, and SITMAPs were accessed most frequently. The UBL was used to initialize systems and rarely used afterwards. Ammunition expenditures were maintained, but they were seldom cross-walked into UBL. Target lists were most frequently used since they are planning aids. Fire direction NCOs and computer operators relied on the accuracy of target lists for processing fire requests. The target lists were a staple of the POC. Subscriber tables were used to initialize the system and to re-establish communications throughout the event. Target lists were debugged, and accurate SITMAPs were central to tactical control. Their principal functions were to provide a movement template and to track FS coordination measures, primarily the coordinated fire line

(CFL), the fire support coordination line (FSCL), and the FLOT. Platoon leaders used the fire control information to verify safety and to position SPHs in conjunction with directed tactical moves.

The Bn TOC used the SITMAP and a combat system status board. Both had little planning application; instead, they were used for tracking.

Source

Observation of C2 nodes.

Analysis

Developers should carefully evaluate the knowledge base being used by DS artillery nodes in order to determine the type of information most useful for performing tactical control functions. Even when information is not routinely accessed, it was learned from the subjects that the displays are a key preparation step for operations. This is because they require a review of planning documents and this preparation step frequently produces questions that confirm a common understanding of the situation.

Tactical Control: Need for Automation

Description

Battle tracking posed significant problems at all C2 nodes within the unit. The quantity of information from external sources was minimal and came primarily through FED operators to the Bn TOC. Information about the status of individual POCs was processed via voice and digital traffic. The S3 indicated the desire for an automated system for tracking that featured a large color display, graphical user interfaces, light pen interfaces, split screen display capabilities to manage operational and technical data concurrently, windows-like operating system, and simpler formats.

Source

Interview with the S3

Analysis

Battle tracking is an important management technique that permits a unit to fulfill its mission requirements in a proactive manner by recognizing risks and accounting for uncertainty. The wide dispersion of Crusader assets, the added dynamic of constant movement, and the speed at which the situation can change combine to place a premium on accurate battle tracking. Planners and decision makers will require an easy-to-use system that can be tailored to their management style.

Tactical Control: Dual Processing

Description

Bn FDC was unable to efficiently manage its mission load in a single IFSAS configuration. Contributing to this situation were the volume of FMs being processed, training and staffing of the FDC, and frequent requests to update mission status by the POCs or FED operators. Each SPH is capable of conducting as many as three concurrent missions. The maximum mission load observed at Bn during the experiment was 33.

This combination of factors made it extremely difficult for Bn FDC to maintain situation awareness and process large volumes of FMs concurrently. Frequent voice requests for mission status added to the load and disrupted FM processing. Bn FDC accounted for this level of mission "backup" as a staffing issue (i.e., with more personnel, the situation would be controllable). With the addition of a second IFSAS at Bn FDC and the reorganization of functions within the FDC, the Bn FDO was able to reduce backlog and improve situation awareness. With the dual IFSAS configuration, one operator handled the "no problem" FMs while the other workstation handled the "problem" missions (e.g., out of range, needed to be assigned to another gun) and responded to the voice requests for status updates of previously requested missions.

POCs had a similar problem; however, the consequences never reached the magnitude observed at Bn FDC. Each SPH can process three missions concurrently (54 active missions within the Bn). Current POCs, equipped with a BCS, can process three missions concurrently; its three-gun platoon can process as many as nine missions at the guns, and the Bn can process as many as 12 missions with its IFSAS. Under the current organizational structure, neither the Bn FDC nor POC is staffed to manage the level of errors or anomalous situations that occur during peak periods.

Source

Interviews with S3 and POC personnel

Analysis

Dual processing, with one node handling the automated missions and the other node handling the exceptions, significantly improved mission throughput.

It has been reported that the new advanced field artillery tactical data system (AFATDS) elements also use two AFATDS at each level, probably for the same reason. We should have a good concept of this during future tests with AFATDS-equipped units.

A second area of concern is the amount of voice traffic, which tends to monopolize critical people and results in longer queue times for FMs. Voice traffic will have to be reduced in the future to ensure rapid FM processing.

Finally, we noticed an overall trend in FM processing of consistent improvement in throughput, quicker technical fire control, and enhanced team performance. This pattern continued and seemed independent of Crusader. This is attributable to an ongoing training function for the unit, which had obviously not reached asymptotic performance before the experimental testing began. The increased participation of key personnel, reorganization (such as adding a second IFSAS), daily AARs, and familiarity with the requirements interacted to improve Bn FDC performance. Bn TOC performance improved concurrently but not as much as Bn FDC. The major innovation at the Bn TOC was the ModSAF and its capability to view the battlefield. This reduced reliance on digital message streams and made assimilation of the overall tactical situation easier.

Conclusions

As the unit became better trained and implemented some of the general TTPs, performance improved. Since improved battlefield performance with the Crusader system was our goal, this confirmed that we were on the right track. It is difficult in some cases to separate the improvement in performance attributable to training versus implementation of TTPs, but in the future we can look in more detail at individual TTP recommendations and compare the performance to our baseline group.

Situation Awareness

Battle Tracking

Description

Battle tracking involved maintaining information needed to perform tactical fire control function within a node. The essential elements of situation awareness (battle tracking) include information that describes the progress of the battle, that is, FLOT, target status assessment, spot reports, fire unit locations, fire unit status, ammunition status, ammunition expenditures, RSV status, RSV holdings, and LRP location. While other information is also useful, our focus was on these pieces. Most POCs devised manual systems to keep track of this and similar information. The unit's approach often involved another record keeper, scraps of paper, and the SITMAPs. Fire unit status was normally available directly from the BCS display, or it could be found in the message traffic. The ability of any node to maintain complete situation awareness was limited, while re-examination or queries of Bn often resulted in more delays and FM queuing in the IFSAS. More effective means of maintaining, querying, and displaying information are needed to ensure that battle tracking takes place. Otherwise, incomplete information may result in fratricide, unresponsive FS, or ineffective fires.

The ModSAF display was introduced at the Bn TOC as a means for the command group (S3) to monitor the situation. Battlefield geometry, friendly and enemy dispositions, and FM activity were displayed from data generated by the simulations. In a short amount of time, the S3 relied on ModSAF. The Bn TOC's SITMAP became irrelevant because it was not easy to access information, and information was incomplete or outdated.

Source

Interviews with subjects; AARs

Analysis

Situational awareness will be a key element in winning on the battlefields of the future, and current methods will not provide the immediacy or level of detail required.

Conclusions

1. Current battle-tracking technology and techniques are too slow for effective implementation of Crusader on the battlefield.

2. Future systems such as appliqué should provide increased situational awareness; however, these systems should be integrated into the BLWE test process as soon as they are available to ensure overall compatibility.

Terrain Management

Description

Crusader operations had an impact on the management and availability of terrain. In the offense, the unit employed a variety of techniques to control movement and manage terrain during survivability moves. Current unit practice is to establish

1- by 2-km position areas that coincide with grid squares. Subjects viewed terrain management as a constraint during survivability move conditions, that is, SPHs were required to move after every FM, displace at least 750 meters, complete the displacement within 90 seconds, and ensure that the new position had not been used within past 30 minutes. The geometry of these movement rules within the small position areas eventually resulted in very large moves outside the designated position area and on a real battlefield, would likely produce territorial conflicts with other organizations. In a rapidly developing offensive scenario, the dynamics of the battle may mask the effects of limited terrain availability, but during a protracted defensive engagement, this could become a critical factor.

Another terrain management problem arises from both the speed and independence of the Crusader SPHs. One SPH was given an FM during a forward move. The SPH stopped, fired the mission, and resumed advancing toward the battle. The unit SPH cleared the area with plenty of time to spare to avoid the counterfire threat. However, subsequent SPHs and RSVs that were also advancing toward the battle passed through the same area from which the unit fired and were in danger of receiving the counterfire meant for the previous SPH. The problem for implementation of the digital battlefield is how to meet this kind of need for instant and continual awareness of danger areas in a rapidly developing battle.

Source

AAR and SME observation

Analysis

Planning aids should be available at POCs and SPHs to ensure that terrain management does not impact survivability moves. The decision rules for survivability moves should reflect mission, enemy, troop operations, terrain, and time (METT-T) available and may be adjusted to reflect the threat capabilities to target and attack Crusader once it has fired.

Situation Awareness

Description

The C2 nodes were unable to maintain a common picture of the battlefield on their SITMAP displays. SITMAPs had no "as of" time posted. There were discrepancies in the status of fire support coordination measures between maps. In addition, battlefield intelligence given on SITMAPs did not include time, which made these reports less useful for planning purposes. Because of software limitations, the unit employed SYS:PTM; or voice messages to pass information concerning spot reports. Intel reports (ATI:CDR; formats) were processed between nodes as part of the experiments; however, few of these reports were assessed or used to plan for FS. Because the information contained in ATI:CDR; message formats was difficult to assimilate quickly and the overall OPTEMPO did not allow for lengthy analysis, dissemination of intelligence to POCs had little effect on their perception of the battlefield.

Source

AAR

Analysis

The battlefield information needed by the POC to perform essential FS functions can be summarized in spot reports that meet the size, activity, location, unit, time, and equipment (SALUTE) standard (i.e., include information about size, activity, location, unit, time, equipment). During the transition to the digitized battlefield, simple, easy-to-assimilate reports are needed to prevent information overload.

FM Processing

Technical Fire Control

Description

The unit suggested that a number of current BCS or IFSAS message formats be revised for Crusader applications. Additionally, a number of SYS:PTM; messages were produced to supplement the current message set, and these slowed mission processing as well. The information in Table 20 was provided to FS command, control, and communications (FSC3) directorate staff during the experiment.

Source

AAR, observations of platoon operation centers

Analysis

The introduction of Crusader will require the incorporation of additional messages to provide for C2 of the RSV and for selected SPH functions (i.e., multiple rounds, simultaneous impact [MRSI] missions).

Table 20

List of BCS Message Format Functions and Required Changes

Message format	Status	Function of message
HOW:MSN;	OK	Receive fire mission data from POC to SPH.
HOW:UPDATE;	Fix	Transmit SPH location and status to POC. Need to add a "rearming" option under STATUS:
HOW:AMOUP;	OK	Transmits ammunition status from SPH to POC
HOW:MOVE;	Fix	Transmit from POC to SPH to direct or control displacement. Need a field that identifies a "position area" designator.
HOW:REQUEST;	OK	Transmit from POC to SPH to request an update to databases
HOW:STATUS;	Fix	Transmit from SPH to POC to update status including reason for outage. Need the ability to report status of fuel, water, CL 1. Currently implemented with SYS:PTM;
RSV:UPDATE;	Fix	Transmit from RSV to POC and SPH to provide location and status. Status should include options for "rearming, resupply, maintaining, relocating." Currently implemented with HOW:UPDATE;
RSV:AMOUP;	Fix	Transmit from RSV to POC and SPH to provide status of ammunition, propellants, and fuzes, and to report current process information. Similar information of fuel, water, CL1 should be provided. Currently implemented with HOW:AMOUP;
RSV:MOVE;	Fix	Transmit from POC or SPH to RSV to direct or control displacement. If in the dedicated mode, identify the paired SPH. Currently implemented with HOW:MOVE;
RSV:MSN;	Fix	Transmit from POC or SPH to direct resupply operation for a specific SPH, or to rearm the RSV at the LRP. Currently implemented with SYS:PTM;
RSV:LRP;	Fix	Transmit from POC to RSV to report or revise location of LRP. Currently implemented with SYS:PTM;
RSV:STATUS;	Fix	Transmit from RSV to POC to update status including reason for outage. Need the ability to report status of field, water, CL 1. Currently implemented with SYS:PTM;
RSV:REQUEST;	Fix	Transmit from POC to RSV to request an update to databases. Currently implemented with HOW:REQUEST;
RSV:UBL;	Fix	Transmit from POC to RSV to implement changes in UBL and adjust ammunition holdings on specific RSVs. Not currently implemented.
FM:CFF;	Fix	Initiates a call for fire. Method of engagement (ME) should include MRSI option or some form of interval option that permits FO to specify time interval between rounds.
FM:COMMDS	Fix	Transmit fire commands from POC to SPH. Insufficient for multiple round type mission.
BCS:	Fix	Process fire missions. Maximum of three active fire missions plus one Copperhead and an FPF. This needs to be expanded to match the increased Crusader mission throughput.
BCS:HOWSUM;	Fix	Used at POC to summarize status of assigned fire units. Insufficient fields for maximum number of vehicles.

Adapting to Rapid OPTEMPO

Planning Tactical Moves

Description

The unit felt that the number and frequency of Crusader survivability and tactical movements would cause the unit to modify its planning process. Crusader systems were in nearly constant motion once the movement to contact phase began, and this resulted in wider and wider dispersion because of survivability movement rules. Platoon leaders commented that position areas were too small to accommodate frequent survivability moves.

Source

Interview with subjects

Analysis

Decision aids are needed to manage movement control and terrain. The unit S3 suggested an arrangement similar to the multiple launch rocket system (MLRS), which included a central POC location, survey control points, ammunition holding areas, and a planned route within the position area that has predesignated firing points. This approach seems to meet the advanced planning need.

Conclusions

The possible relationship of emerging MLRS tactics to Crusader needs to be explored further. It may be that in function and operation on the battlefield, the Crusader will be more like an MLRS than a Paladin.

Processing "EOM"

Description

Current doctrine requires the fire support team (FIST) to initiate EOM and process this directive through the intermediate C2 nodes. Once EOM is received at the firing pieces, subsequent tasks (i.e., survivability moves) may be conducted. During the experiment, EOM processing delays occurred at the FED and at the Bn FDC. EOM processing resulted in delays of several minutes which increased SPH risks to counterfire and also caused additional message traffic that created congestion on radio nets. POCs began issuing EOMs to SPHs and permitting survivability moves in order to shorten the time delays.

Source

AAR

Analysis

Field Manual 6-20 (U.S. Army Field Artillery School, 1983) defines the FS process, which ensures that the maneuver concept of operations is fully supported by the scheme of fires. Accurate, timely fires are essential elements of FS effectiveness. Responsiveness to maneuver requirements is fundamental to FS performance. POCs monitored radio nets and either waited for 2 minutes before issuing EOM or issued it upon hearing the FO's call to Bn if this occurred in fewer than 2 minutes. These methods were not timed; however, in every instance, the new procedure enhanced Crusader survivability because it shortened the FM cycle time.

EOM initiation at the POC level violates current doctrine. The POC can still meet the responsiveness standard even if the SPH has begun its survivability move sequence. The survivability time line includes EOM, march order, displacement, orientation, resupply, and reporting. The mission can be resumed at any point during a displacement, once the fire command (FM:COMMDS) is received at the SPH. Since Crusader is designed to satisfy responsiveness standards, EOM processing can be initiated by the POC after "Rounds Complete" has been sent from the SPH.

Axis of Advance

Description

Tactical movement of Crusader units was conducted using battery level control along an axis of advance. Platoon leaders issued commands for SPHs, which permitted off-the-road movements within 5 km of the axis. End points were defined for SPHs. Howitzer section chiefs within TAFSM selected firing points within 750 meters of the respective end points.

Source

Observations of Bn TOC and platoon operations centers

Analysis

The use of "axis of advance" as a movement control technique permitted the Bn to displace in a battle formation that positioned SPHs forward. Bn defined the axis and units had as much as 5 km latitude when proceeding along the axis to the new position area. It was unnecessary for the Bn to "leapfrog" its assets in order to maintain continuous FS. This TTP leveraged the capability of the SPH to move cross country at high rates of speed and to initiate timely, accurate fires from the march within 20 seconds of receipt of a fire order.

There were practical implications to tactical control during movements: the Bn was unable to track its firing units until SPHs stopped, oriented, and reported (HOW:UPDATE;). Also, movement planning and control initially tended to focus on SPHs. RSV movement control took two forms. Initially, RSVs were left in hiding areas. This increased time-distance factors for subsequent resupply operations between RSVs and SPHs. In the early runs, the RSVs were left in place and time-distance factors took SPHs "out" until resupply was completed. The maximum separation between RSVs and SPHs noted and attributed to a unit action was 20 km. The SPH was reported out of action once the RSV began its movement to the rearm point and reflected a model parameter that may be unrealistic. Once the Bn experienced the extended SPH outages because of rearming, the S3 implemented a paired tactical movement technique. That is, whenever a tactical movement was directed, RSVs and SPHs were paired. This approach ensured that time-distance factors were reduced and RSVs were forward. After the tactical move, RSVs reverted to the centralized pooled concept. RSVs occupied hiding areas about 2 km to the rear of the SPHs.

Finally, LRP displacement became an issue because when RSV resupply was conducted, LRP locations were far to the rear. This added distance increased the RSV operational cycle time.

Unit Basic Load (UBL)

Description

The UBL was developed by the S3 and served as the principal product of his mission analysis (see Appendix F for some insight into the evolution of the unit UBL). The S3 adjusted the UBL as he gained more experience with Crusader. His intent was to disseminate a UBL that would be flexible enough to support all aspects of the movement to contact. He was not constrained by controlled supply rates (CSR) or available supply rate (ASR). He also chose to establish this UBL in each SPH, so that all SPHs and RSVs had the same distribution of rounds at start of exercise (STARTEX). This facilitated flexibility by permitting any available firing unit to respond to a call for fire. As the experiment progressed, the UBL design appeared inadequate because of the high rate of ammunition consumption on a single piece, the skewed distribution of FMs, and the unit's reliance on specific types of ammunition. One POC sought ways around the UBL limitations by expending certain types of munitions and circumventing the resupply model, that is, replacing the same type of projectile fired in order to maintain the UBL proportions.

Source

AAR

Analysis

The UBL reflected the S3's best estimate based on his mission analysis, METT-T, and his experience. The UBL was modified and the databases revised for each run; no optimum solution was introduced. The UBL addresses the DS unit's goal of providing effective fires to the maneuver force. To achieve this aim, UBLs must be designed for flexibility throughout the operation.

Mission processing rules also complicated this issue. The S3 directed that one SPH was to be used for missions requiring 10 or fewer rounds. Two SPHs were to used for 11 to 20 round missions, and so forth. The S3 was planning for survivability as well as maximization of fire unit availability by employing Crusader's rapid rate of fire and MRSI capability. Because most missions required fewer than 10 rounds (eight rounds, average) many single gun missions were planned. Often, there were insufficient rounds of the required type available on a single gun. For example, an individual SPH had six rounds of M116A1, smoke B (SM-B). A mission requiring more than six rounds of SM-B would have to be split between two SPHs and would initiate a resupply for both SPHs. Both systems and the RSV were out of action during ammunition resupply.

Range errors also prompted the POC use of greater amounts of extended range munitions, particularly dual purpose, improved, conventional munition--extended range (DPICM--ER) (see Figure 5). This reliance on DPICM-ER resulted in an inappropriate strategy class V resupply. The POC used one RSV until its stock of the normal range munitions was depleted. Only at that time could the extended range munitions be substituted. As a result, DPICM-ER was employed an average of 65% of its range capability, with nearly 48% of these rounds fired at ranges shorter than 22.5 km. This area of tactical control should be evaluated.

Finally, the UBL was fragmented, that is, there were small numbers of many round types, and the effect of this distribution was not clear at Bn. Planning and decision aids need to incorporate UBL design factors as well as automated ammunition tracking by system at Bn level. Otherwise, POCs will be in the tactical control business by default. POCs will be pressed into adjusting the UBL without understanding the larger implications on the operation. This area needs significant further study.

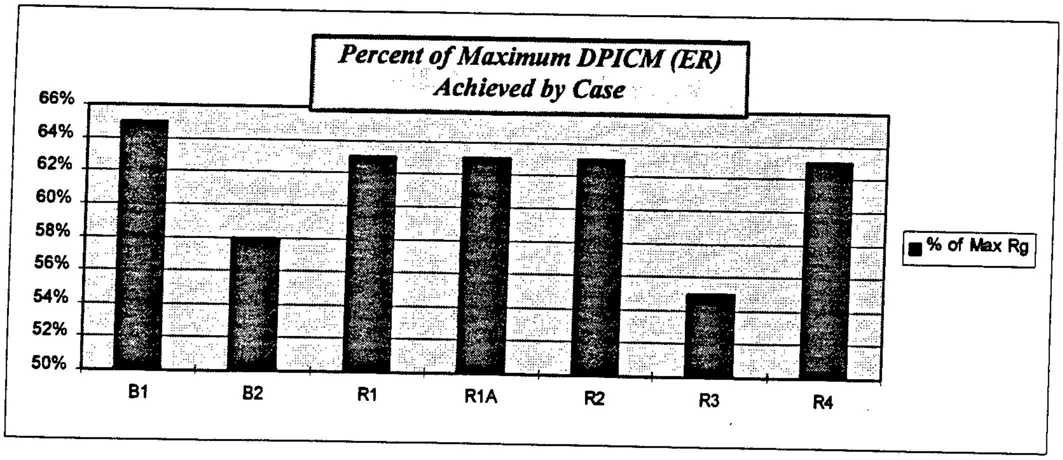


Figure 5. Dual purpose, improved, conventional munition--extended range (DPICM--ER) expenditure by percent of maximum range.

Resupply and Sustainment

Keeping Pace

RSV Hiding Areas

Description

Initially, firing batteries employed a pooled RSV concept. RSV positioning took into account LRP location because battery commanders wanted to ensure the RSV operational cycle would not be affected by time-distance factors. The desired LRP location, according to firing battery commanders, was "midway between the SPHs and the LRP."

Regardless of the RSV concept used (pooled or dedicated), POCs tended to locate their RSVs near the SPHs. The separation distances between RSVs varied as the POCs gained more experience with the systems and learned to manage terrain.

Hiding areas are concealed positions defined by the POC where RSVs can be staged for rearm operations. RSV hiding areas are similar to MLRS hiding areas because each is centrally located within position areas to facilitate rapid rearm operations and must occupy terrain within an active position area. In addition to considerations of METT-T, hiding areas provide RSVs and PLSs cover and concealment, access to lines of communications, and protection from the effects of counterfire on SPH firing points. The platoon leader, who wanted to ensure that RSVs would be capable of rearming systems in the shortest possible time, selected positions for pooled RSVs. Additionally, POCs ensured that RSV positioning considered the counterfire threat.

Source

Interviews and observations at platoon operations center

Analysis

The use of RSV hiding areas close to the SPHs facilitates rapid rearming in conjunction with survivability moves. RSVs must be positioned outside the 750-meter counterfire "footprint." There were several instances when RSV hiding area positions fell within the counterfire footprint. Since hiding area location was determined at the POC level, this conflict was attributable to inadequate situation awareness at the POC level.

Time-distance factors between the RSVs and LRPs or SPHs seemed to be a non-issue once the players instituted controls to ensure that RSV displacement maintained contact with SPHs. The speed and mobility of the RSV make travel time (to rendezvous with an SPH) an insignificant consideration. The larger delays occur during ammunition uploading and transfer operations.

RSVs and the UBL

Description

UBL defines the distribution of ammunition by type and quantity to the firing and resupply systems based on the S3's analysis of mission requirements as well as logistics constraints. The UBL is carried on SPHs and RSVs (see Appendix F for details about initial and developed UBLs). The Bn also had 18 PLSs that carried 522 complete rounds per vehicle. Ammunition was delivered from the ammunition supply point (ASP) to the ATP on PLSs as combat configured loads (CCLs) that have been prescribed by the corps ammunition officer.

Initially, the unit distributed its ammunition uniformly to each SPH and RSV. This distribution pattern resulted in frequent ammunition transfers between RSVs and SPHs, and the demand for specific munitions became greater for extended range shells than for other types.

In the pooled RSV concept, each ammunition transfer had to be directed to RSVs by the POC for specific SPHs. Ammunition was replaced on a one-to-one basis. Substitutions occurred when rounds became unavailable on the RSV. Each POC maintained a copy of the UBL, which it decreased as rounds were fired. Using this manual approach for ammunition accountability, platoon leaders rearmed SPHs to restore the UBL on that system.

Source

Interviews, AARs, and observations at POC

Analysis

The unit determined that ammunition resupply does not equal restoring the initial UBL on an SPH or RSV. In order to fulfill FS requirements, the unit must retain the flexibility to adjust ammunition levels. The intent of the S3 was to establish a UBL that would facilitate FS across the Bn. He distributed ammunition evenly so that no SPH would be kept in reserve because the SPH had been uploaded with only one or two types of munitions.

POCs proposed that ammunition be distributed based on mission requirements. The POC solution was to harness the superior Crusader rates of fire and range capabilities and distribute ammunition to SPHs based on expected missions (e.g., long shooters, smoke shooters, and short shooters). Players at the POC level reasoned that this approach would result in fewer rearm requirements and more efficient ammunition uploading by RSVs. There are no quantifiable data that demonstrate the potential payoff to the POC approach, but it is an excellent area for future study.

The ammunition management function at all levels, including accountability, SPH rearming operations, and RSV resupply operations, is a complex cognitive and manual operation, and some kind of decision or process support system is needed.

Facilitating the FS Mission

RSV Tactical Movements

Description

Tactical movement of SPHs and RSVs involved the displacement systems into a pre-defined set of position areas directed by a C2 node. In many instances during the initial battle runs, POCs did not coordinate the displacement of RSVs, and time-distance factors for subsequent resupply grew excessive, as much as 15 km separation. To eliminate the problem of excessive distance between SPHs and RSVs, the unit implemented a paired arrangement that linked a specific SPH and RSV for tactical movements. This technique also provided a capability for the RSV to resupply an SPH while moving. Once in the new position area, separate howitzer; move (HOW:MOVE) messages were issued by the POC to RSVs for occupation of a hiding area. The MOVE message defined a radius around a universal transverse Mercator (UTM) coordinate as the new hiding area location.

Source

Interviews and AARs

Analysis

The unit adapted tactical movement techniques for RSVs that complemented the SPH capabilities. The Bn directed tactical movements along axes of advance and the POC-implemented directives. In some instances, the new technique was implemented without including the RSVs. This resulted in long rearming delays. (TAFSM initially placed the SPH in an "out of action" status from the time the RSV began its movement.) To preclude the development of large gaps between RSVs and SPHs, POCs used paired arrangements for tactical movement. This approach to tactical moves ensured that RSVs were not left behind, resulted in quicker resupply following an "emergency" mission, and improved situation awareness at the POC level because UPDATE messages were transmitted at intermediate checkpoints and final position areas.

Hiding Area Organization

Description

Although the RSV operations were performed within the synthetic environment, participants were asked to describe how to establish an RSV hiding area. Several variables in addition to METT-T were considered:

1. Time-distance to the SPHs. POCs wanted to ensure that SPHs could be resupplied quickly. This requirement meant that RSV hiding areas were located fewer than 2 km from SPHs, which sometimes placed systems within the counterfire footprint. In the pooled RSV concept, minimizing time-distance also meant selecting one RSV that had the right mix of munitions for servicing firing pieces. Most rearm operations involved one RSV servicing more than one SPH.

2. RSV survivability. POCs selected position areas that would afford the RSVs protection from indirect fires. Positioning outside counterfire footprints and dispersion within the hiding area were used. Within the position area, platoon leaders suggested inter-vehicle distances ranging from 100 to 750 meters. Wide dispersion of RSV defines an area as large as a platoon firing position.

3. Accessibility. RSVs must occupy positions, and alternate routes and positions must be defined within the area. POCs considered trafficability and looked for hiding areas that were adjacent to the road network to facilitate movement to LRPs or access by PLS vehicles to hiding areas.

4. C2. In the pooled RSV concept, RSVs are centrally controlled by the POC. This C2 arrangement requires that voice and digital communications be established between the POC and its RSVs. Therefore, because of fire missing communications range limitations, distance and terrain masking, RSV hiding positions had to account for C2 communications.

Source

Interviews and observations within platoon operation centers

Analysis

- RSV hiding areas will occupy a large piece of terrain, which can influence friendly maneuver.

- Exposed RSVs can attract enemy direct fires once they have been detected.

- Hiding areas deny the threat information about logistics support in the brigade area.

- Hiding areas afford RSVs with some protection from detection and attack if platoon leaders and ammunition section chiefs consider METT-T and survivability.

- Each RSV hiding area should be near to SPHs since effective rearming should be timely to ensure continuous FS.

- Hiding areas should support the RSV operational cycle by optimizing time-distance factors and permitting sufficient time for crew rest.

Battle Tracking of RSVs

Description

During tactical movements, the RSV (as modeled in TAFSM) demonstrated high cross-country mobility, achieving speeds of 48 km/hr. This rate of speed enabled RSVs to quickly reach and pass the maneuver force (which was not reporting the FLOT frequently). The Bn TOC was unable to track the location and status of all 36 warfighting systems, six POCs, three LRPs, and the maneuver battle. This lack of tactical control increased the risk to Crusader RSVs and had to be corrected by alerting units and re-directing them rearward. As the unit gained experience, this unplanned penetration of the FLOT occurred less frequently.

Source

Observations of POCs

Analysis

The inability of this unit to perform routine battle tracking for its elements was unexpected. When the Bn TOC became aware of the situation, the S3 instituted tactical movement control that included several intermediate firing points and position reporting along the route of advance. This procedure in effect stimulated status reporting and minimized the risks to detection and targeting by threat or friendly forces but interfered with FM processing at the Bn level.

Several factors contributed to the situation, including the synthetic environment, lack of information from the maneuver force, and an inability to assimilate information at C2 nodes because of the battle OPTEMPO. Adjustments of the database reduced RSV speed, changes in the simulation support system were introduced that gave player staffs access to a maneuver display, and the unit improved its reporting procedures. The presence of a brigade FSO would also have helped to alleviate this problem because he is responsible for correlating the FS and maneuver pictures and informing C2 nodes.

Dedicated RSV Operations

Description

Dedicated RSV operations were a variation from the baseline condition, pooled RSVs. It was unclear at STARTEX which RSV concept would produce more effective sustainment for FS. Dedicated RSV operations are decentralized to the

SPH level. In the dedicated RSV support arrangement, an SPH and RSV were paired for all operations, and the SPH section chief directed the RSV. POCs simply received messages of interest needed to maintain a picture of the battlefield. As the scenario unfolded, decentralized rearm and resupply operations reverted to the pooled concept because POCs could not track RSV status without significant manual intervention. RSV ammunition status was seldom current or accurate.

The dedicated RSV concept appeared to be useful only during tactical movement when the pooled RSV arrangement, which is fully centralized control under a POC, was implemented. In this instance, tactical control was exercised by linking RSV movement to specific SPH displacements in the offense. The POC received updates about status and location at intermediate firing points along the axis of advance, and the POC resumed control once the SPHs had reached the new position area.

Source

Interviews and Observations of POCs

Analysis

Dedicated RSV operations were unable to sustain effective FS of offensive operations primarily because of type-projectile availability and information gaps. This shortfall was attributable to the UBL design that had uniformly distributed ammunition to RSVs and SPHs in order to achieve maximum flexibility. However, in practice, the SPH rate of fire demanded more rounds of a specific type than were available on a single RSV. The results were mission denials for munitions.

Dedicated RSV operations yielded to pooled RSV after the first set of FM was processed and the cause for mission denials became evident to platoons. POCs were unable to reorganize rapidly when the dedicated RSV concept was established. The SPH-RSV relationship was too rigid and did not lend itself to cross-leveling of munitions once the battle began.

Conclusions

- Players preferred pooled RSV operations because they offered greater flexibility during execution of tactical control.

- Dedicated RSV operations preclude the establishment of an RSV operational cycle, which leads to disruption in FS.

• Dedicated RSV operations may be appropriate for operations other than movement to contact, deliberate attack, or hasty attack, which were executed during the experiment.

Coordinate and Integrate

The LRP

Description

Within the Bn, 18 PLS vehicles were operating. Three PLSs were "chopped" to each battery and were the nucleus of its LRP operation. The mission of battery PLSs was to transfer munitions to RSVs, the third component of the RSV operational cycle.

When a battery LRP had used most of its ammunition, its PLS returned to the DS Bn ATP and was replaced by a fully loaded PLS. Battalion sent its empty PLS to the division-operated ASP for uploading. The battalion staff did not relocate its ATP during the offensive scenario. Batteries relocated their LRPs forward in order to reduce the time-distance factors associated with uploading.

The relocation of the Bn ammunition point was considered unnecessary because of the duration of the operation. The LRP was represented as a single point where a battery operated its resupply from three PLS heavy expanded mobility tactical truck (HEMTTs). Initially, these vehicles were situated equidistant between firing units and the Bn ATP. As the battle progressed and the FLOT shifted west, batteries relocated LRPs to keep pace and reduce turn-around times with the POCs.

Source

Interviews and observation of operation centers

Analysis

The experiment provided data about ammunition resupply issues within the Bn and assumed that the logistics above Bn was operational. Of the five record runs, no data are available for Run 1. Case Runs 2 and 3 are most typical of resupply operations in the offense. The levels of LRP and ATP activity are summarized in Table 21.

Table 21

Summary of Available Data for Ammunition Transfers Involving PLSs

		Percent of Total Rounds Transferred from the LRP or ATP by Run			
Resupply point	Total rounds available	R1A	R2	R3	R4
LRP A	522	11	21	58	30
LRP B	522	0	47	30	0
LRP C	522	0	42	40	0
ATP	1,566	0	22	11	0

RSV rearming operations remained fairly constant during the record runs, with most variation accounted for by technical problems in the TAFSM. Each LRP had 522 rounds of ammunition initially available. During latter runs (Runs 2 through 4), units expended their initial RSV loads and drew heavily from battery LRP stocks. LRPs had sufficient ammunition during the scenario and did not send any PLS to the Bn ATP for additional rounds. The maximum ammunition transfer at the LRP was 58%. The Bn ATP was not required to consolidate ammunition requests and draw ammunition from the ASP since few rounds were ever transferred at the ATP during the record runs.

Conclusions

- Ammunition consumption did not stress the resupply infrastructure within the Bn because of the duration of the battle and the initial rounds available.

- Decentralization of Bn PLS assets to battery level streamlined the ammunition resupply process.

SPH Rearming Frequency

Description

In pooled RSV operations, POCs directed rearm operations after completion of a survivability move that follows each FM. A single RSV was dispatched to service more than one SPH. RSVs were issued a MOVE message that required a specific RSV to conduct a short tactical move and rendezvous with the SPH. Once the RSV was at the new firing point, ammunition transfers replaced rounds expended from the previous firing point. Once the transfer was complete, both the RSV and SPH updated their ammunition status, and the SPH reported "ready to fire."

Source

Interviews

Analysis

Pooled RSV operations required the POCs to maintain current information about the status of FMs and ammunition accountability for specific vehicles, and the ability to integrate administration and logistics requirements with ongoing FM processing. The Crusader preliminary operational concept states that the rearming "trigger point" is when the SPH has expended 30% (18 rounds) of its ammunition.

In practice, POCs did not adhere to this guidance and rearmed more frequently. This approach was necessary because specific types of shells were being expended and had to be replaced. In effect, the UBL had small quantities of each type of munition uniformly distributed to the SPHs. Some portions of the UBL, such as illumination rounds, were never used and thus reduced the number of effective rounds on SPHs and RSVs. Tactical fire control decisions specified high volumes of low density rounds (e.g., DPICM-ER). Platoon leaders sensed that the requirement for extended range munitions would continue, so platoons constantly conducted RSV resupply operations to ensure that sufficient ammunition was available when needed at each SPH.

The UBL design and the distribution of munitions across the firing units affect rearm frequency. The less fragmented the UBL becomes, the lower the rearm threshold can be. When the UBL is fragmented and distributed unevenly across firing units, rearm frequency can be tailored and varied across the unit. This increases, however, the ammunition management tasks associated with a "non-standard" UBL. This process needs to be better modeled and experimented with to help us gain some more insight into how to do this for Crusader.

Timing of LRP Displacement

Description

The unit sensed that LRP locations were critical to timely rearming of SPH and RSVs. The unit relocated the battery LRPs after directed tactical movements were complete. This approach for pushing support activities forward during the offense is similar to a "follow and support" TTP. Accurate, timely reporting became key to the POCs whenever an LRP, that is, the three battery PLSs, had re-located. This information was reported via voice communications because other than a SYS:PTM; there was no digital format for reporting the change in LRP location.

Source

Interviews and AAR

Analysis

Even with the increased mobility of RSVs and SPHs, locating LRPs where battery and Bn logistics sites are easily accessible contributed to FS effectiveness. The use of voice or "hand-carried" messages to update LRP locations was impractical because POCs had insufficient resources to process the information to SITMAPs. The most frequently used approach for recording this information was on a "scrap" of paper that was maintained by the platoon leader.

Because there was little interaction between LRPs and the Bn ATP during this experiment, the LRPs tended to move farther away from the ATP in order to reduce RSV turn-around time. LRPs typically made two displacements during a scenario run while the ATP remained fixed. In at least one instance, the LRP occupied a firing position that had been active within the previous 30 minutes. Logistics facilities should be included in the information flow to preclude losses attributable to counterfires meant to attack rapidly moving SPHs. The LRP was targeted but not fired because of controller intervention. This technique reduced coordination at the Bn level, which in this experiment seems appropriate. PLSs do not possess the mobility of RSVs and are more bound to the road networks.

A rule of thumb for LRP positioning is to establish the LRP one third of the distance between RSV hiding areas and the ATP. This facilitates sustainment of the RSV operational cycle and supports future use of the ATP as an ammunition resupply point.

Planning and Conducting RSV Movements

Description

Tactical movement involves decisions issued by the Bn TOC to displace firing units to forward position areas along an axis of advance. Movement directives were issued over voice nets to POCs. The movement order defined units to move, time of the movement, and new position area. Routes were part of the FASP, and in this experiment, the Bn adopted a technique that employed axes of advance for each firing battery. The axes corresponded to specific TF zones of action. POCs acknowledged the directives and implemented them.

Implementation of movement orders involved completion of missions in process and transmission of MOVE messages to SPHs and RSVs. The MOVE message defined a firing point coordinate and a radius around the point within the new position area. Separate MOVE commands were issued to RSVs. When RSVs moved, two options were used: (a) pooled, or (b) dedicated. In a pooled move, a MOVE message was broadcast to the RSVs in TAFSM. The RSVs, after an appropriate time interval for preparation, began their displacement. This approach assumed that each RSV was in the hiding area. In a dedicated move, individual MOVE messages were issued to SPHs, and RSVs were paired with the SPH. Once the pair reached the new firing point, each system transmitted an UPDATE message to the POC. At that time, the POC issued a MOVE message to the RSV and sent him to his new hiding area.

Source

Observations of POC

Analysis

Both methods for controlling RSV movement reduced the incidence of long delays attributable to resupply operations. Initially, these delays were exaggerated because of TAFSM decision rules. That is, whenever an RSV was directed to perform a resupply, the affected SPH would report an "out" status attributable to resupply from the time that RSV movement commenced. When large gaps developed between RSVs and SPHs, these time delays for resupply became excessive. In subsequent runs, the TAFSM was changed and placed the SPH in an "out" status only when the RSV was at the firing point conducting a transfer of rounds.

The unit preferred dedicated to pooled movements because dedicated RSV movements were automated within TAFSM. Once TAFSM processed the SYS:PTM; resupply or MOVE message, the model managed operations. Status reports were submitted from intermediate points along the route, at the completion of movements or ammunition transfer.

Existing message formats and procedures for initiating RSV movements were not adequate. Instead, a "family" of message formats is required for RSVs. The current approach for RSV tactical control within BCS is a "work-around" that incorrectly portrays the RSV as a firing system. These recommended formats are summarized in Table 22.

Table 22

List of RSV Message Format Functions and Required Changes

Message format	Routing	Function of message
RSV:UPDATE;	Transmit from RSV to POC and SPH	Provide RSV location and status. Status should include options for "rearming, resupply, maintaining, relocating."
RSV:AMOUP;	Transmit from RSV to POC and SPH	Provide status of ammunition, propellants, and fuzes. Report information for fuel, water, CL1.
RSV:MOVE;	Transmit from POC or SPH to RSV	Direct or control RSV displacement. If in the dedicated mode, identify the paired SPH and define duration.
RSV:MSN;	Transmit from POC or SPH	Direct resupply operation for a specific SPH, or to upload the RSV at the LRP. Specify quantity and types of ammunition to be transferred.
RSV:LRP;	Transmit from POC to RSV	Report or revise location of LRP.
RSV:STATUS;	Transmit from RSV to POC	Update RSV status including reason for outage. Need the ability to report status of fuel, water, CL 1.
RSV:REQUEST;	Transmit from POC to RSV	Query a specific RSV and request an update of databases.
RSV:UBL;	Transmit from POC to RSV	Implement changes in UBL and adjust ammunition holdings on specific RSVs.

Conclusions

Based on data collected during the experiment and subsequent analysis, the following conclusions describe how the unit's command structure managed RSVs in a manner that contributed to effective sustainment.

Results Versus Objectives

To summarize, the objectives for the first BLWE were

- A BLWE using soldiers as test participants to look at TTPs, C2, and resupply issues for Crusader,
- A STOW environment capable of emulating Crusader battlefield OPTEMPO,

- A data collection and analysis methodology for the STOW environment, and
- An evaluation of the potential of the STOW environment for training.

As in all endeavors, some of the initial objectives for BLWE 1 were achieved more completely than others. The first three, critical to TSM-Cannon, were achieved within the scope of the first BLWE. The last required a second effort on the part of the troop operations and the experimenters. Significant progress has been made since BLWE 1, particularly in the areas of detailed data analysis and the use of the STOW environment for training. Subsequent research will be documented in publications to follow this initial report. The following is a discussion of where we were at the end of the first BLWE, ending in July 1996.

Objective 1: Assess an Initial Set of Critical Issues for Crusader

The objectives for the first BLWE were to validate the environment and methodology for conducting a set of research efforts to help TSM-Cannon evaluate TTPs for the Crusader system, and to collect the first set of experimental data. We focused on the issues of C2 and resupply and were able to generate much information to TSM-Cannon, which is being fed into the latest revision of the draft OCD and being used by TSM-Cannon representatives to contribute to design discussions at the contractor's facility. Limitations in the overall fidelity to the BLWE 1 Crusader battlefield environment were recognized but were assessed as acceptable.

Results

Even given these limiting factors, the results met our (and TSM-Cannon) objectives in terms of generating soldier input and TTPs related to the final fielding of Crusader. Future BLWEs will address and correct these.

However, three significant factors should be kept in mind when evaluating any of the results of the first BLWE: we did not use a DS artillery unit, the unit we used was not equipped with AFATDS, and we played a "perfect" Crusader. These factors and their relative significance are discussed next.

Factor No. 1: The Unit Was Not a DS Unit

The artillery unit we used was a general support unit; there are no DS artillery units at Fort Sill. Some of the command personnel in the unit had experience with MLRS and believed that there was much similarity in C2 with Crusader, but most of the personnel tested had to learn the specific requirements of a DS unit in order to "play" the Bn responses correctly. There was some training time for this, but it is not clear how significant this difference was in terms of what we wanted the unit to do. The variables of OPTEMPO and how Crusader handled resupply were probably far more significant to the unit performance than whether the unit was originally a DS or GS unit. Crusader is going to be a new and unique entity on the battlefield, and previous skills or specialties may be of lesser importance than how to handle the demands of a Crusader-equipped unit.

Overall, the unit personnel displayed a high level of motivation and competence, and it is of lesser significance that they were not a DS unit at the start of the experiments. We plan in the next BLWE to use a DS unit, partially so that we can look at what, if any, differences exist between them and our initial test participants.

Factor No. 2: The Unit Equipment Was Not the Same as Will be in the Field With Crusader

Unit equipment was a far more significant source of concern in terms of being able to infer eventual Crusader unit procedures and effects, such as mission throughput rate and queuing levels at Bn, POC, and guns. The unit tested had the latest in current equipment (BCS and IFSAS) and did a remarkably good job in keeping pace with the OPTEMPO resulting from Crusader's rapid rates of fire and speed on the battlefield. By the time Crusader is fielded, the current data-processing equipment will have been replaced by AFATDS, a tactical system geared toward operation on the digital battlefields of the future. AFATDS incorporates a high level of sophistication in its FM processing and information handling procedures and has a significantly different set of operator interface displays and procedures. It is highly likely that mission processing procedures and results at the various levels (Bn and POC) will vary significantly from those in BLWE 1. It would be illogical to treat any of the FM processing times achieved by unit soldiers in BLWE 1 as accurate representations of what could be expected when Crusader is fielded.

The unit did achieve the desired level of OPTEMPO to exercise the C2 and resupply processes, and this was our goal since, if you remember, the focus of the BLWEs is on developing and refining TTPs and defining the operational concept. Any performance data are relative only to the unique BLWE 1 mix of experimental equipment, soldiers and their equipment, and modeling of Crusader and the digital battlefield.

TSM-Cannon has proposed that the next BLWE be conducted at Fort Hood using elements of the 1st cavalry division artillery (DIVARTY) who are a DS unit and are also among the first to be equipped with AFATDS equipment. Discussions have begun to try to make this happen.

Factor No. 3: We Played the Perfect Crusader

As noted previously, the Crusader elements (the SPHs and the RSVs) were modeled in TAFSM, as were the ammunition resupply points. The models used accurately reflect the expected design parameters of Crusader in terms of firing rate, platform speed, rearm and resupply times, and the likelihood of system outage because of a RAM failure. We purposely did not garble any of the communications to or from the Crusaders nor did we introduce any random behavior at the platform level. Except for a RAM failure, the Crusaders executed the missions, moved and re-supplied tirelessly and flawlessly. Obviously, this perfect behavior is unlikely once we put real soldiers in the loop. In BLWE 2, we will be adding 12 workstations to represent the six SPHs and six RSVs in one of the batteries. Each workstation will have a soldier interacting digitally (and probably by voice if required) with the platoon and other Crusader elements to perform fire and resupply missions during the same kind of simulated battle we used in BLWE 1. We may choose to negatively affect communications or to periodically "lose" some of the messages to or from the workstations to see how the soldiers handle the problems in real time.

Objective 2: Implement a STOW Research Environment

The STOW environment is the key to the Crusader research program and proved to be capable of generating the OPTEMPO we needed to obtain a realistic assessment of operator performance during BLWE 1. Some features still need to be added, most notably the ability to pause in the middle of a battle (e.g., in case of a communications failure) and resume play without having to restart the battle from time zero. Overall, though, the total environment functioned extremely well and provided the kind of real-time responses that we needed to keep the interest of the test participants.

One critical aspect of the battle environment is, of course, the red and blue TF commanders. Although they are ostensibly coworkers, when they sit at their respective screens, they become competitors at a fairly high level of ferocity. Winning the battle (or at least inflicting heavy casualties on the opponent) confers a degree of "gotcha" to the competitor who succeeds. At times, this "gamesmanship" significantly affected the progress of the battle.

In one instance in the previous day's play, the red forces had deployed far forward on the battlefield and were occupying the first objective (objective coyote) in force. At the same time, the blue commander decided to attack aggressively, gambling that red would not have enough forces deployed to withstand a quick initial attack. BLUFOR took quite a mauling.

The next day, red took the opposite tack and kept most of his forces back at the final objective (objective wolf) and deployed only minimal armed reconnaissance forces forward at objective coyote. Blue, having been overly aggressive on the previous day, crept forward very slowly and conducted the advance of the maneuver forces with great caution. As a result, artillery did not receive much of the support it requested during most of the battle. We (the experimenters) had to intervene to remind the force commanders that their role was to generate FMs for the Crusader research and that a little more aggression was needed to get the OPTEMPO to the point where we stressed the C2 and resupply systems. This demonstrates that all the players, including the experimenter and controllers, were absorbed in the digital battle.

Result

The environment worked very well and let us gather performance data for unit FM processing. In this area, the results met our objectives.

Objective 3: Develop a Data Collection and Analysis Methodology

The data collection and analysis effort worked very well. We focused on TSM cannon's goals of looking at the operational concept and associated TTPs for this emerging Crusader system, and the AARs and guided discussion groups proved very successful at eliciting soldier comments and proposed changes to accommodate the severely increased OPTEMPO and automated resupply concept inherent in Crusader operations.

We encountered two problems, one with data collection and one with analysis methodology. Both were related to the amount of time and people available for the overall effort.

The initial set of questionnaires was not well focused and needed considerable revision to be effective. We were not able to do this in time for BLWE 1 but were able to develop a more useful set for the October exercise. However, after having administered them and evaluating the results, it is clear that they offer little additional insight into our goals. The AARs and guided discussion groups are really the best techniques for generating comments and suggestions for TTPs from the soldiers about how they would handle Crusader on the battlefield. These, coupled with the information flow from expert observers, were very successful in meeting our information needs. It may be that questionnaires are of little value to the BLWE process other than for the collection of descriptive data (e.g., age, rank, level of experience with a particular piece of equipment).

On the data analysis side, the good news was that we had an on-line data logger, which captured all the digital traffic on the net, time-tagged it, noted the sender and recipient, the mission number, and tracked how long the messages took to process at the nodes along the way (e.g., FED to Bn IFSAS, IFSAS to POC, POC to gun, and finally, time of first shot). The bad news was that a single battle produced so much information, and there were so many ways to look at it, that it took a long time to get any usable data from the data logger in a format that would allow us to gain any significant insight into what was really happening. We are still working to develop a set of "screens" that will let us look at selected aspects of the battles as they develop, but we are a long way from complete success in this area. The data logger, however, will be a critical tool in future BLWEs since once we develop the "screens" we want to see and a way to link them with the developing battles, we will have a more objective way of assessing overall unit performance. We have developed an initial set of screens that were used to generate the AAR data as well as some summary screens giving an overview of BLWE 1. These are discussed in the results section of this report.

Result

The AARs and guided discussion groups, along with expert observations and summary data from the automated data collection process, were successful in providing the desired quantity and quality of information to satisfy TSM cannon requirements for the initial BLWE. Increased sophistication in the area of automated data analysis may provide some crucial insights into where "choke points" exist in the FM processing chain or when existing TTPs may need revision. Overall, we were successful in this area but have just begun to tap the potential of the automated data collection and analysis capabilities, which can be applied to the mass of data in the data logger.

Objective 4: Assess Training Potential of STOW Environment

A fourth objective was to assess how well the STOW environment could be used to train soldiers, not only in the systems of the future such as Crusader, but also perhaps with the systems of the present (such as Paladin). The ease of reconfiguration for the TAFSM model could allow for input of mobility characteristics, FM rates, and ranges for any particular system. The data collection and analysis techniques developed for the Crusader BLWEs could probably transfer very well, with a little modification, to assessing unit performance relative to specific training objectives.

Unfortunately, we were not able to focus very well on this objective in BLWE 1; we simply had no more time or people required to prepare and assess a logical evaluation plan and implement it in conjunction with a defined and measurable set of training objectives for the unit. However, the unit leaders were so pleased with how well the STOW environment and the repeated "battlefield experience" had improved the functioning of their unit as a whole, that they volunteered to come back later in October 1996 for additional sessions (BLWE 1, the focus of this paper, was conducted in June and July 1996). They anticipated considerable change in Bn personnel and were enthusiastic about using the STOW environment to train their new people about their equipment and procedures.

Obviously, this coincided with our training assessment goals and also gave us an additional opportunity to collect data for TSM-Cannon about the Crusader, so we were able to run a second set of studies with a focus broadened to include an evaluation of the training potential of the STOW environment.

Result

BLWE 1 did not allow us to do a good evaluation of the training potential of the STOW environment, although anecdotal evidence and direct observations indicated that training was occurring. During the subsequent October evaluation, we were able to show significant improvements in unit performance relative to a specific set of training goals developed with the unit. Data from this set of studies will be published as a separate document.

MAJOR FINDINGS AND CONCLUSIONS

BLWE 1 met the requirements of TSM-Cannon for collection of an initial set of data and soldier input to TTPs for the fielding of the Crusader artillery system. We did not answer all the questions that exist about Crusader and, as anticipated, raised some new questions to prominence for investigation in the next round of research. We were able to provide significant insight into how an artillery unit will have to address Crusader's information and logistics requirements, and we built a firm foundation for future research in this area. We can now express a degree of confidence in our ability to investigate these issues and report findings in a timely manner (although we need a little improvement in the "timely" part).

There are many ways to look at the results of BLWE 1, but several key findings emerge no matter what the perspective:

• Crusader will impose a much higher OPTEMPO in the processing of FMs, and the current TTPs and technologies will not be adequate to permit the most efficient use of Crusader's capabilities.

• Early indications, based solely on this one BLWE, would seem to indicate that the roles of the POCs will shift further toward logistics management and individual platform management and that the Bn will have to focus more on overall battle management, leaving the details to the lower echelons (i.e., the POCs and Crusaders).

• Real-time terrain management and situational awareness will be critical to success on the digital battlefields of the future. It will not be possible to maintain status of all the critical components using current TTPs because of the OPTEMPO imposed by the next generation systems.

• Much more work needs to be done in exploring ammunition planning and the effects of battle dynamics on the UBL; some sort of "logistician's associate" artificial intelligence (AI) program would seem to be necessary.

• Development of the components of the digital battlefield (e.g., Crusader, AFATDS, C2V, Appliqué) cannot occur in isolation; requirements for one become requirements for all because of the interdependence on a common communications requirement and the need for a common, real-time picture of the battlefield at all levels.

• For FM processing, we have to achieve an optimal balance between the necessity for human control and the benefits of automated processing. Each time we have human intervention, we add significant time and potential for error, but each time we remove a soldier from the decision process, we make the previous human decision more critical and the human errors less likely to be caught before the mission is shot.

In terms of overall conclusions about Crusader, the word (or, in this case, acronym) that comes to mind is OPTEMPO, Operational Tempo. The rate at which Crusader consumes ammunition and processes FMs leads inescapably to the conclusion that the existing tactical fire direction process needs to be streamlined if we are to take full advantage of Crusader's capabilities. How and where to implement that streamlining will likely be the focus of the future BLWEs and associated research efforts.

REFERENCES

(U) U.S. Army Field Artillery School (1996). Cost and operational effectiveness analysis for the crusader solid propellant system. Fort Sill, OK: Author. (CLASSIFIED).

U.S. Army Field Artillery School (1995). Preliminary operational concept document for the crusader. Fort Sill, OK: Author.

U.S. Army Field Artillery School (1983). Fire support in combined arms operations (Field Manual 6-20). Fort Sill, OK: Author.

U.S. Army Field Artillery School (1990). Tactics, techniques, and procedures for fire support for the heavy brigade (Field Manual 6-20-40). Fort Sill, OK: Author.

Preceding Page Blank

APPENDIX A

GUIDED DISCUSSION GROUP FIELD NOTES

GUIDED DISCUSSION GROUP FIELD NOTES

Overview

Unit personnel were the best source of ideas and recommendations for new tactics, techniques and procedures (TTPs) for employing the Crusader system in experiments using soldiers-in-the-loop simulations. Guided discussion groups that complemented other quantitative data sources were used to obtain participant opinions about Crusader operations. The participant comments have been included in the findings of this report. The attached set of field notes were prepared following each discussion group session by a member of the data collection team. The field notes address the theme or focus for the session, the specific items along with summaries of the responses, and statements of agreement developed through the process.

Participants

Players and player controllers were identified by the Battalion S3. Selection was based on focus area expertise and availability. The number of participants varied from three to five. Each group was facilitated by a member of the data collection team.

Focus Areas

A focus topic is a statement of a performance issue that was identified during the conduct of the battle lab warfighting experiment (BLWE). The specific focus topics are identified in Table A-1.

Table A-1

List of Crusader BLWE Focus Topics for Guided Discussion Groups

Serial	Focus topics
1	RSV survivability
2	Planning RSV moves
3	RSV C2
4	Crusader software improvements
5	Crusader SPH tactical movements
6	Defining roles and responsibilities
7	Training applications for simulations

Procedure

At the completion of the baseline runs and twice following the experimental runs, guided group discussions were conducted with members of the unit. The purpose of these guided discussions was to record the participants' views concerning specific focus areas. The participants who served as players and player/controllers comprised a unique population of potential Crusader users that had developed opinions during the BLWE concerning its employment and operations. A focus group method was used to elicit feedback about specific performance issues. Nine focus groups were planned; however, only six focus groups were conducted because of scheduling changes.

Guided discussion groups met after the AAR in a conference room. A facilitator outlined rules for conducting the focused discussion, maintained field notes of comments, and facilitated the discussion. The duration of each discussion was about 30 minutes.

Protocol for the Guided Discussion Group

A standard format was used for each group. Facilitators were introduced to this approach during "hands-on" observer training. All input to the group was accepted on a non-attribution basis. Therefore, only position titles are identified as the source.

1. Review the rules - openness and candor; speak up, no devaluing; stay focused to complete task within assigned time.
2. Define the issue - obtain a common understanding of the issue
3. Validate - propose reasons for pursuing the topic
4. Define the problem - state the components of the issue observed during the BLWE
5. Identify courses of action - surmise what could be done to address the problem
6. Consensus - obtain closure on the nature of problem and solutions

The facilitator prepared a summary of comments and these were coordinated with participants on a subsequent day. Items shown in italics from the field notes are questions presented to the group for discussion. The data collection team reviewed the summary for completeness and content. If clarification was required, the facilitator sought it with participants informally.

Results

Copies of the guided discussion group field notes are attached to this appendix. The major conclusions have been integrated with findings and results sections of this report.

Summary of Crusader BLWE I
Discussion Group 1 Comments

Topic: Crusader Resupply Vehicle (RSV) Survivability

June 27, 1996

Four members of the subject unit met as participants in a 30-minute facilitated discussion about the topic of Crusader RSV survivability. The discussion took place following baseline run 2.

Participants included one platoon leader, one ammunition platoon officer, one platoon fire direction officer (FDO), and one platoon ammunition noncommissioned officer (NCO).

The focus topic was broadly stated as RSV survivability.

Why This Focus Topic?

Crusader offers a significant advantage to maneuver forces because individual pieces can rapidly deliver fires throughout the depth of the battlefield without compromising speed or mobility. The RSV is the primary source of ammunition for Crusader, and without sufficient ammunition, a significant portion of its capability could be forfeited.

Instances were observed during the battle when platoon personnel repositioned their RSV assets without considering firing position activity. The platoon operations center (POC) was not able at this time to formulate a consistent approach for moving RSV assets forward into hiding areas.

Responses of the participants to questions from the facilitator.

- *What do you perceive are the primary threats to RSVs?*

Typically, we see the greatest threats as air, special operations forces, and the ground threat.

The threat to RSVs includes visual detection while operating on the battlefield, especially when moving between hiding areas and rearm points. RSVs are also vulnerable to counterfire when they operate in the vicinity of self-propelled howitzer (SPH) firing points. Mobility kills are likely if RSVs must operate in areas that have been mined.

- *What can be done to minimize the threat to RSVs?*

We have relied on passive measures to reduce the threat. For example, POCs have established RSV hiding areas. These areas are situated to minimize transit time to SPH rearm points. RSVs move to POC-designated rearm points; SPHs will not move to the hiding area.

Within the hiding area, we disperse RSVs to avoid losses to air or indirect fire systems. RSVs should be at least 300 meters apart in the hiding area. When we are in the pooled RSV concept, we will be able to provide for self protection by integrating the fires of three crews. In the dedicated RSV concept, self protection would require us to take more risk because the crews are so small.

We will rely on natural camouflage and concealment when we are supporting offensive operations. Camouflage netting seems impractical.

- *What about active measures; what tactics do you think will work?*

The Mark 19 automatic grenade launcher is the primary self-defense system planned for the RSV.

In addition to hiding areas, we need speed--something greater than 50 km/hour. The faster we are able to move, the more difficult it will be to target us. There are also systems such as the "Avenger" or Stingers that can become part of the RSV organization. We are really concerned about countering the air threat (helicopters and aircraft).

We would also like some sort of laser detector such as that found on the current M1 Abrams tank. Precision guided munitions may be available to target us, and it would be helpful to detect lasers so we could take some form of evasive action (smoke or movement).

- *How close to the "gun" line are hiding areas established?*

During offensive operations, we are constantly moving RSV hiding areas forward to keep travel time to the guns short. Hiding areas are about 1,000 meters from the guns. In this scenario, where we are fighting on open terrain, hiding may be impossible, so we have to keep moving and cover one another with fires.

- *At what level will RSV losses interfere with your operations?*

A single RSV loss will impact a unit's performance. That is why the paired concept may be a problem. It seems like all our eggs are in one basket; there is greater risk of a loss.

- *What are the RSV survivability issues?*

Crews are small and must implement active and protective measures to ensure survivability of each system. In a pooled concept, there is a greater, more immediate effect on the platoon's operations when an RSV loss occurs. We need to create and practice tactics that enhance survivability.

Participants' Statements of Agreement.

Current tactics for the employment and protection of ammunition RSVs may not be applicable to the RSV because its operational profile parallels the Crusader SPH.

Responsibility for implementing active and passive measures to protect the RSV rests with its three-member crew.

Pooled RSV employment concepts afford the unit with more dependable resupply because an RSV cycle can be implemented.

RSV assets should be managed by the battery and not the battalion. (Note. The battalion staff was not represented.)

RSV should have armored protection comparable to the SPH since it is required to operate in similar battlefield conditions.

Summary of Crusader BLWE I
Discussion Group 2 Comments

Topic: Planning RSV Moves

June 27, 1996

Four members of the subject unit met as participants in a 30-minute facilitated discussion about the topic of planning Crusader RSV moves. The discussion took place following baseline 2.

Participants included one platoon leader, one platoon ammunition officer, one platoon FDO, and one platoon ammunition noncommissioned officer.

The focus topic was broadly stated as RSV moves.

Why This Focus Topic?

Throughout Crusader BLWE I, there were instances when platoon personnel positioned their RSV assets far to the rear of advancing SPHs. The unit at this time was unable to formulate a consistent approach for moving RSV assets forward. The SPH and RSV share an interdependence that significantly affects fire support effectiveness when tactical movement is not carefully managed.

Responses of the participants to questions from the facilitator.

- *What RSV movements must be planned and coordinated?*

RSVs will make internal and external movements. Internal movements are those directed by the POC to resupply firing systems. This will involve movement from the hiding position and between guns. External movements are those necessary to rearm and resupply the RSV itself. This will involve movement from the hiding position to the logistics resupply point (LRP) and back to a hiding position.

- *What are the planning factors you must consider when planning movements?*

Time and distance factors are most important. If the LRP is too far away, it will take too long to perform an upload onto the RSV. We cannot afford for the RSV to be out of the battle too long. Right now, 30 seconds is too long to load a round. There is an RSV operational cycle that must be defined and managed.

- *What is the RSV operational cycle?*

In the pooled RSV concept with three systems, one RSV is rearming guns, one RSV is in the hiding area, and one RSV is reloading at the LRP. "Two-up and one-back" provides us the greatest mission capability.

Using this approach, we would transfer effective or high demand rounds (HE-M and HE-R) to a forward RSV and send an empty RSV to the LRP. Upload time at the LRP is excessive and should be reduced.

- *What criteria are you using to direct an RSV to conduct an external move?*

For ammunition resupply, we send an RSV to the LRP when the situation permits or when ammunition is low or out. The directed movement will be made when selected ammunition reaches a predetermined level, all ammunition has been downloaded, or during a lull to "top-off." The RSV does not have to be completely empty because some rounds from the UBL may be unusable.

(Note. At this time during the discussion, the RSV role and capability to transport and transfer other classes of supply and water were introduced. This information tended to broaden the topic area and introduced other discussion points.)

- *Who is responsible for LRP operations?*

A maximum of three RSVs can be staged at the LRP concurrently. The first sergeant (1SG) or the platoon ammunition officer will manage the LRP. It is important to have a digital system that links RSVs to the LRP so that commodities, fuel, and water can be staged and ready at the LRP. If we have to organize after the RSV arrives at the LRP, we cause delays and backlogs. This requirement becomes vital when we consider all classes of supply. The 1SG and maintenance teams will not be able to drive all over the battlefield searching for platoon firing positions. They are moving all the time and it will be difficult to reach everyone in a timely manner.

- *Where should the LRP be located to ensure no disruptions because of ammunition availability?*

We place LRPs about half way between the platoon and the battalion ammunition transfer point. In the BLWE, we frequently moved the LRP forward on our palletized loading systems (PLS), but the battalion was not moving forward at all. That meant we increased the turnaround time to battalion, and in a longer battle, that would create longer time delays or added distance. LRP is best situated 2000 meters to the rear of the guns.

- *How do you monitor LRP activities?*

We must have digital links so that POCs and ammunition officers have a common perception of RSV status. Status includes not only what is on board but what will be needed on the next resupply visit to the LRP. Right now, we do not have visibility on individual classes of supply.

It would be beneficial to us if we could query each system (SPH and RSV) to determine its status: how much fuel, ammunition, water, food, repair parts. There is too much paper and manual operations. We need automated tools that give us this type of information without interfering with the crews.

With all the automation, there are discrepancies in ammunition inventories by type, lot for projectiles, propellant, and fuzes.

• *At what level will RSV losses interfere with your operations?*

A single RSV loss will impact a unit's performance. If we rely on the RSV as the primary transport vehicle between the LRP and the firing units because of its speed, mobility, and carrying capacity, we will have to rethink the roles the 1SG, supply, and maintenance.

• *Organizationally, who performs which functions?*

The POC's functions include

1. Fire mission processing
2. Battle tracking
3. Logistics monitoring and operations
4. Position reconnaissance, selection, and occupation

Battalion operations functions include

1. FA support planning
2. Tactical fire support synchronization
3. Situation and battle tracking
4. Logistics coordination

Battery operations functions include

1. Organization and operation of the LRP
2. Resource management

• *Who should manage RSV assets?*

Short-term RSV management should be controlled at the battery or platoon level. Ammunition officers do not appreciate the tactical situation, and they need it with a Crusader system on line. A battery can or must be able to cross-level assets. Battalion has the information but should not reallocate battery RSV assets based on short-term shortfalls.

We may need additional RSV assets. With four RSVs per three guns, we can maintain the RSV cycle and keep adequate ammunition at the guns. Depending on the scenario and mission, enemy, troops, terrain, and time (METT-T) factors, an additional RSV, combined with reduced upload, time at the LRP could significantly improve effectiveness at the platoon level.

Participants' Statements of Agreement.

Current techniques used to manage tactical movements of RSVs are not appropriate for the Crusader RSV because of continuous and flexible separation among LRPs, SPHs, and RSVs. Some representation of the battlefield is missing so that each C2 node within the battalion shares a common perception.

Temporal and spatial relationships between the RSVs and firing units they support must be constantly re-evaluated in the pooled concept. No one technique seemed to fit all situations.

Ammunition officers need situational awareness comparable to the operations officers. These officers need equal access to the digital battlefield.

Tactical planning and control can occur at any level when Crusader is fielded. Nevertheless, RSV tactical movement should remain the purview of the battery and its platoons.

Summary of Crusader BLWE I
Discussion Group 3 Comments

Topic: Crusader RSV C2 Structure

July 1, 1996

Four members of the subject unit met as participants in a 30-minute facilitated discussion about the topic of Crusader RSV C2 structures. The discussion took place following experimental run 2.

Participants included the battalion FDO, one platoon leader, and two one platoon FDOs.

The focus topic was broadly stated as RSV C2 structures.

Why This Focus Topic?

During Crusader BLWE I, centralized and decentralized RSV control were employed. Neither method was fully adapted by the unit as it discovered challenges in maintaining control of its RSV assets during fast paced, offensive operations.

Responses of the participants to questions from the facilitator.

- *Why in your opinion is RSV C2 an issue?*

RSVs are players in both the fire direction and logistics functions. The fire direction system involves processing of fire missions at battalion and distributing missions to firing platoons. The firing battery node is removed from the loop.

Logistics is different because battalion communicates and supports firing platoons through the battery. This arrangement makes it easy to consolidate logistics requirements and distribute supplies within the battery.

- *What role does the battery commander play in resupply operations?*

The battery commander establishes and operates something equivalent to battery trains. The battery commander is the only individual who has direct knowledge of battalion and platoon needs. The system is a "push" system where supplies flow downward.

- *Who coordinates operations in the battery trains area?*

The battery executive officer (XO) performs this role best. He is no longer managing the "line of metal." Working with the 1SG, he coordinates all resupply activities.

- *Which C2 arrangement did you find most appropriate in the offense?*

In general, the pooled or centralized control was most appropriate. In the offense, we made frequent tactical moves to maintain the momentum of the attack. By pairing RSVs with SPHs for movement, we improved our ability to control assets. We also believed that fire support would be more effective should missions occur while systems were moving.

In general, dedicated or decentralized control could not be employed successfully once RSV losses occurred. It is just not possible to maintain an RSV cycle after an RSV is lost.

- *What level of RSV losses were sustained?*

Our RSV losses were limited. No more than two RSVs were lost from one platoon. The loss of RSV capability results in severe stress on both C2 and logistics because ammunition stocks are rapidly consumed.

- *What C2 tools are needed to manage RSV assets?*

The XO and 1SG need a capability to track the status of each RSV including location, ammunition inventory, and readiness status. The battery should operate its own "admin-log" net, both voice and digital. Using single channel, ground, airborne radio system (SINCGARS) permits the XO and 1SG to establish and operate on a local network to maintain visibility on battery assets and requirements.

- *How would you monitor RSV activities?*

We must use digital links so that POCs and ammunition officers have a common perception of RSV status. Status includes not only what is on board but what will be needed on the next resupply visit to the LRP. Right now, we do not have sufficient visibility on individual classes of supply.

It would be important for us if we could remotely verify RSV status. Automated tools that provide us C2 information without interfering with the crews.

- *Who should control RSV assets?*

RSVs should be controlled by the POC.

<u>Participants' Statements of Agreement.</u>

C2 involves managing information, decisions, and battlefield implementation. In a Crusader-equipped unit, the C2 challenge is to maintain situational awareness for each entity individually and collectively.

The battery commander's role seems diminished. It appears that C2 responsibilities must be reassigned to avoid unnecessary duplication between nodes.

Summary of Crusader CEP I
Discussion Group 4 Comments

Topic: Crusader Software Improvements

July 1, 1996

Five members of the subject unit met as participants in a 30-minute facilitated discussion about the topic of crusader software improvements. The discussion took place following experimental run 2.

Participants included battalion FDO, one platoon leader, two platoon fire direction noncommissioned officers, and the battalion FDC noncommissioned officer.

The focus topic was broadly stated as improvements in automated system software that is currently used within FA battalions, that is, Interim Fire Support Automated System (IFSAS) and battery computer system (BCS).

Why This Focus Topic?

The Crusader CEP highlighted the advantages of information technologies in solving the numerous shortfalls and inefficiencies that exist in the current generation of technical and tactical fire control systems. The performance of current data processing systems interfered with mission planning, situation awareness, and fire mission processing. The unit improvised and developed work-arounds to accomplish its DS mission.

To successfully compete for information dominance, the artillery must be fully integrated into the digitized battlefield. Current tactical fire control processors will not be able to sustain Crusader mission throughput without changes.

Responses of the participants to questions from the facilitator.

- *As you assess the Crusader system performance, what problems did you note in automated systems such as the IFSAS and BCS?*

At the battalion level, making changes in fire missions is tedious and time consuming. Some missions require the operator to page through several screens in order to make a simple modification of a specific fire command. In contrast, the BCS, which is located at the POC, can be modified on the screen directly. With the Crusader's mission-handling capability, battalion must find ways to streamline mission processing.

Ammunition accounting must be maintained by individual SPHs and expenditures processed through the POCs to battalion. This process requires operator intervention and is not automatic. Ammunition updates should be disseminated across the network with no operator action.

Ammunition reporting at the battalion level is "ammunition on hand." With current systems, this information can be derived manually. What is needed is a heads-up display that is simple to access, easy to read, and is continuously updated. This is vital for maintaining situation awareness without introducing manual operations.

The battalion S3 should be able to establish threshold levels that trigger status messages for display at battalion operations. The intent is to facilitate management and actions by the ammunition officer or S3.

Since the battalion will establish and operate a digital network to process tactical and technical fire control, any C2 node on the network should be able to access information for internal use. Therefore, the automated ammunition tracking and reporting system can be used at any level of the battalion to maintain situational awareness.

- *Were there many instances when system incompatibility interfered with mission processing?*

There is incompatibility among FED, IFSAS, and BCS which required the operators to re-enter data instead of simply processing them. Whenever messages must be reformatted or changed, the unit expended valuable time to "fix" the problem and restore the mission cycle.

- *Describe the information flow within the battalion.*

In order for the battalion to be proactive, it must develop and maintain a common picture of the situation at all C2 nodes. A top-down information flow operated during the CEP, and it was inadequate. Ideally, information must move in both directions to accommodate rapid changes. ATI:CDR; and SYS:PTM; message formats were used to pass battlefield information. These formats cannot easily be prepared, nor are they easily assimilated in operations centers. Often, the unit relied on voice communications to paint a more complete picture. Units need the ability to create and knowledge bases that contain current, relevant information.

The syntax of most digital message traffic is too rigid. It would be far more effective to receive graphics that can be displayed in each tactical operations center (TOC). These displays could be tables, matrices, overlays, or sketches. Information connected to these graphics could include target plots, battlefield geometry, and artillery range fans. Access to a terrain database would facilitate the use of this type of data and make them more valuable for tactical fire control applications.

- *What types of tools or decision aids are needed for Crusader?*

Immediate needs include route planning and survivability tools. Some form of expert system that processes the known information and variables that affect system survivability could be applied immediately to fill the gaps in proficiency when Crusader platoons operate autonomously.

IFSAS and ensuing systems should include some form of mission tracking system. Mission tracking would be keyed to target numbers so that operators could determine status, rounds complete, and end of mission (EOM). Along with mission tracking is the ability to process as many as nine fire missions concurrently. Trigger events could be included that alert the operator when the mission cycle has been disrupted.

- *Can all technical and tactical fire control procedures be performed while moving?*

One critical aspect of C2 "hand-off" is the inability of current system to be fully operational while moving. System performance can be sustained and some risks associated with hand-off can be avoided by making these system accessible while POCs are moving.

Participants' Statements of Agreement.

The current generation of software applications used to perform technical and tactical fire control is inadequate and not suited for Crusader operations because they slow fire mission processing.

Information technologies used in Crusader (the SPH, RSV, and C2 nodes) must give operators an easy-to-access knowledge base.

Information sharing is vital to success on the digital battlefield. System design must accommodate information flows that build and maintain a common picture of the battlefield.

Embed reports and summaries that assist personnel located at C2 nodes with accurate ammunition status reporting and forecasting, route and movement planning, and management (by-exception triggers).

Summary of Crusader BLWE I
Discussion Group 5 Comments

Topic: Crusader Tactical Movements

July 1, 1996

Five members of the subject unit met as participants in a 30-minute facilitated discussion about the topic of Crusader tactical movements. The discussion took place following experimental run 2.

Participants included battalion FDO, one platoon leader, two platoon fire direction noncommissioned officers, and the battalion FDC noncommissioned officer.

The focus topic was broadly stated as tactical movements and does not include survivability moves.

<u>Why This Focus Topic?</u>

The Crusader BLWE showed that with its speed and mobility, Crusader could keep pace with maneuver forces. This increased capability, coupled with the system's ability to rapidly process missions while moving, signaled a shift in movement techniques from "echelonment" to battle formations.

Responses of the participants to questions from the facilitator.

• *As you assess the Crusader system performance, what are the imperatives for tactical movement?*

The subject unit employed several techniques to conduct tactical moves. All tactical moves were directed by battalion. The battalion frequently conducted tactical moves with all firing systems. RSVs should trail SPHs and occupy a hiding position within 2000 meters of the firing positions.

Planning for tactical movement requires battlefield information that must be shared from battalion to SPH level. Information concerning minefields, breaches, trafficability, and coordination points must be accessible by individual SPHs and POCs.

Movement must be carefully controlled to prevent outpacing of the maneuver force. This will require information from FSOs who operate with maneuver formations. Control can be facilitated through the use of limits of advance, axes of advance, and position areas to define operational areas.

Tactical movement of RSVs and SPHs must be coordinated to ensure that fire support is continuous. This also includes POC displacement to maintain communications. Tactical movements may require C2 hand-over if fire control systems do not operate while moving.

• *What planning or control measures would be required for tactical moves?*

Tactical movement can be managed by battalion using control measures such as phase lines and intermediate check points that produce status reports used to update the situation. POCs use techniques such as route planning tools that include updates of the tactical situation to coordinate movement within the battalion and between the battalion and adjacent units.

- *How can we reduce threats during tactical movements?*

Tactical moves can be made cross country at high speeds. SPHs and RSVs can be paired during movements to increase self protection. Crusader should be equipped with identification-friend-or-foe (IFF) devices to prevent fratricide during movements.

- *What sort of passive measures can be used to protect Crusader systems?*

Camouflage nets are useful when they reduce the infrared signature and reflect radar; however, they can only be used when Crusader is inactive for an extended period. Typically, Crusader will be moving.

<u>Participants' Statements of Agreement.</u>

Crusader speed and mobility as modeled in this experiment permit it to keep pace with maneuver forces without any compromise of fire support responsiveness.

Crusader tactical moves can be conducted using battle formations along axes of advance. This technique would permit the battalion to coordinate movement with the maneuver force instead of "leapfrogging" elements forward. Crusader can provide continuous fire support.

With the exception of the SPH, Crusader C2 nodes do not currently possess the speed and mobility to keep pace with Crusader. C2 hand-over may be necessary to maintain centralized control.

RSV movement must be included in the tactical movement planning and implementation.

Summary of Crusader BLWE I
Discussion Group 6 Comments

Topic: Defining Roles and Responsibilities

July 3, 1996

Five members of the subject unit met as participants in a 30-minute facilitated discussion about the topic of defining roles and responsibilities for Crusader units. The discussion took place following run 3.

Participants included the battalion S3, battalion FDO, a platoon leader, a platoon FDO, and a battery FDC noncommissioned officer.

The focus topic was broadly stated as new roles and responsibilities.

Why This Focus Topic?

Deployment of the Crusader system may fundamentally alter the organization and functions of FA units. Not only will crew sizes be reduced significantly, but tactical and technical control will be deployed to the howitzer level because of on-board information technologies and automated decision aids.

Responses of the participants to questions from the facilitator.

- *How should Crusader be perceived as an innovation?*

If one views the Crusader as an enhanced fire delivery system, he or she is making a mistake. Crusader is an integrated system that is capable of more than servicing targets faster and at a greater depths than its predecessors.

Crusader is a C2 node. It will have access to all the battlefield information needed to perform effectively. Key is the ability to field a "team" capable of harnessing the capability.

- *What do you mean team?*

This BLWE has shown that using Crusader requires a multidisciplinary effort. Functions of the officers will have to change whatever POC configuration we use.

Each battery would be organized with a battery commander, an ammunition officer, an operations officer, and two platoon leaders. More study of this is needed, but we found ammunition management will become more critical, terrain management a greater consideration, and continuous operations an imperative. The combined effect of these needs requires solutions that leverage Crusader operational characteristics, especially information processing, speed, and delivery capability.

Like the multiple launch rocket system (MLRS), Crusader will operate in a decentralized mode. This requires effective C2 at all levels because the situation is constantly evolving and the number of systems that must be controlled has grown.

• *What C2 arrangements are most suited to this system, based on your experience during the BLWE?*

Like MLRS, the Crusader will operate in a centralized mode to leverage its enhanced mobility and information processing capabilities. This requires a more efficient firing battery design to ensure that critical mission functions are performed and that unnecessary redundancy is eliminated.

• *Where should we place functional interfaces between Crusader and elements responsible for tactical fire control?*

On-board processing capabilities are necessary to achieve the full Crusader operational capability. This capability should include communications and tactical data processors that permit the howitzer and RSV section access to the unit's knowledge base.

A critical assumption for an effective Crusader system is that information processors and communications systems will be sufficiently robust to enable Crusader to operate at its full potential. When the unit adopted a two-POC arrangement, the effects were sufficient redundancy to sustain operations and greater spans of control at battalion. Redundant POCs also provide the means to minimize the effects of guns' out-of-action outages during tactical movement of POCs or SPHs, individual system failures, and C2 re-configurations.

(The following detailed items were generated by the unit. These items are based on the unit's limited experience with the Crusader systems as modeled in TAFSM for BLWE 1 and are not the result of actual field experience.)

Critical Functions of the POC. The platoon is a C2 node that performs four functions:

1. Battle tracking
2. Logistics
3. Fire mission processing
4. Terrain management

Roles and responsibilities include

Platoon Leaders. Platoon leaders perform tactical fire direction related to positioning, controlling, and organizing assigned SPHs. Platoon leaders should not be the FDO. Technical fire direction should take place at the SPH with mission processing at battalion. Platoon leaders should circulate among SPHs to ensure the highest state of operational readiness. They establish and operate voice and digital fire direction nets within the platoon. They are responsible for reconnaissance, selection, and occupation of position (RSOP) within battalion-designated position areas, and will implement guidance for tactical movement in battle formation or as individual pieces within the platoon.

Platoon leaders should have access to a visual display of the battlefield. That display would show each entity, battlefield geometry, and fire support coordination measures. Status of any entity could be obtained by querying the system database or by requesting an update from a specific vehicle.

Platoon NCOs. Platoon NCOs manage the information holdings of the POC including SPH status, ammunition accountability, and battlefield information. When tactical data processing is consolidated within a POC in a dual BCS configuration, it facilitates the performance of critical tasks including ammunition management and tactical fire control. Information can be organized by function and processed separately within the POC. Requirements for individual SPHs are more visible within respective C2 nodes.

SPH Section Chiefs. Section chiefs perform technical and tactical fire control for their piece based on mission requirements processed from POCs. They are responsible for orienting the SPH, monitoring on-board status, and conducting survivability movements to areas designated by the platoon leader. They also monitor voice and digital internal fire direction and command nets.

Critical Functions of the Battery Operations Center. The battery interfaces with battalion to facilitate logistics and support for its firing platoons. Its primary functions will include

1. Organization and operation of the logistics resupply area
2. Consolidation of resupply requests
3. Distribution and dissemination of commodities
4. Situation awareness

Roles and Responsibilities include

Battery Commander. The battery commander monitors the tactical situation and positions logistics facilities to support firing elements of the battery. He monitors voice and digital command nets to ensure timely response to change. He supervises the ammunition and operations officers in order to track the situation.

1SG. The 1SG should manage the LRP for the battery commander.

Ammunition Officer. The ammunition officer should serve as the ammunition platoon leader and is responsible for the employment of assigned RSV assets and any PLS attached from the battalion. His role is to manage the RSV operational cycle to ensure that sufficient ammunition of the appropriate type is available. He will coordinate with the battery operations officer and schedule resupply with individual SPHs. He will select and establish hiding positions for his vehicles whether in a pooled (centralized) or dedicated (decentralized) operating mode. He will monitor voice and digital nets (internal command, and the admin-log).

Operations Officer. The operations officer should manage the tactical C2 systems in order to maintain situational awareness at the battery level. He will disseminate tactical direction to POCs and manage the flow of logistics information within the battery. He will monitor voice and digital nets (internal and external command and the admin-log.)

- *What other activities will be imperative within the Crusader unit?*

Coordination of SPH and RSV operations will be essential because the combination of survivability moves and ammunition consumption tends to remove systems because of ammunition availability.

Situation awareness must be shared across the battery. That will require a common database, a common perception of the battlefield, and an ability to act quickly in response to change. The key interface will take place between the ammunition officer and the operations officer. The role of the battery commander is to interface with higher headquarters, establish priorities, and resolve conflicts. The battery commander becomes an expediter.

Platoons will have the greatest flexibility when they control six SPHs and operate from a battle formation to maintain pace with the rapid maneuver advance. The POC maintains centralized control of firing assets, while resupply assets are centrally controlled in a pooled concept.

POCs will require 10 personnel to provide a continuous operational capability (five per shift).

Crusader force structure should provide a solution that results in transferability of skills between the RSV and SPH. This arrangement supports the need to sustain operations.

- *What factors contribute to Crusader effectiveness?*

1. Information technology: overall situational awareness should be accessible in Crusader and other C2 nodes. The ability to filter and organize the information so that it is timely and can be used will require training. Information management is needed at all levels.

2. Speed: movement speed and sustained rate of firing will permit Crusader to keep pace with the maneuver force and deliver fires that achieve desired effects. The ability to rapidly change from a movement to a firing posture dictates new methods for displacing. It may no longer be necessary for the battalion to displace by leapfrogging. Now, artillery can use "battle formations" that parallel the supported maneuver force. The battery commander must communicate the method of movement as clearly as we define method of engagement in order to provide effective fire support at all times and avoid placing some fire systems out during movement.

3. Survivability: "shoot and scoot" techniques proved effective for minimizing the effects of threat counterfire. The dynamics of the battlefield mean that situation tracking must be near real time.

4. Interdependence: ability to operate in tactical and technical domains concurrently. The boundaries between tactical and technical control have blurred and are not well defined. There is a synthesis of these functions at battalion and at the SPH. They should be merged at the battery and platoon levels as well.

- *What parallels do you see between Crusader and MLRS roles and responsibilities?*

Crusader, MLRS, and other advanced fire support systems will benefit if they share certain commonalities. Their tactical employment seems similar because both employ survivability tactics that depend on detailed situation awareness, common perceptions of the situation, and positive control of terrain.

These commonalities may result in similar tactics that permit cross-utilization of personnel and reduce specialization in many functions.

The lethality of both systems is increased because of their ability to mass firepower on a target with the smallest number of firing units.

Participants' Statements of Agreement.

Crusader operations involve an integrated, systems approach: SPH-RSV-POC comprise the system.

Information technologies require new proficiencies at all levels of the Crusader system. We must be able to "surf" the network to obtain commander's critical information requirements or have them displayed on demand.

Crusader will impact the structure of FA units. Expect more cross training because many tasks are cross functional.

Crusader will place new demands on C2 systems and the personnel will assume new roles as a result. This area requires additional formal study. BLWE environment was too *ad hoc* to find answers.

Decision aids, such as the MODSAF, are the type of digital system needed to control Crusader. User-friendly, that is, mouse driven, interfaces are necessary; keyboards are too cumbersome.

Crusader should achieve high levels of system availability. C2 hand-off must be possible at all levels to avoid placing systems out of action.

Ammunition management will become a critical performance area with the Crusader capability for rapid firing and movement (OPTEMPO).

Summary of Crusader BLWE I
Discussion Group 7 Comments

Topic: Training Application for Simulations

July 3, 1996

Five members of the subject unit met as participants in a 30-minute facilitated discussion about the topic of Crusader tactical movements. The discussion took place following experimental run 3.

Participants included the battalion S3, battalion FDO, a platoon leader, a platoon FDO, and a battalion FDC noncommissioned officer.

The focus topic was broadly stated as application of simulations to training.

<u>Why This Focus Topic?</u>

The Crusader CEP was a first of its kind application of distributed, interactive simulations. The experiment used a synthetic environment in which subjects could practice warfighting, war planning, and decision-making skills. Experimental objectives were complemented by unit training objectives, and this produced a synergistic effect. The results indicate greater potential for using simulation-supported activities to support a range of applications.

Responses of the participants to questions from the facilitator.

- *What benefits did you realize as a battle staff during the CEP?*

The most important payoffs involve preparation for Paladin transition, operating in the DS role, which we rarely practice as a unit, and the sustained intensity of the event.

The environment that was created for the CEP allowed us to deploy operationally and practice collective tasks. We were able to establish and operate a C2 architecture with enough control to see problems, develop solutions, and measure our performance. There was a tremendous amount of teamwork that was facilitated by the proximity among C2 nodes within the simulation center.

The training would have been better if missing elements such as the FSO and maneuver players had been active. We had to create workarounds to compensate for the functions that were not represented.

- *Was the only training benefit at the collective level?*

In the synthetic environment used for the CEP, we were able to focus on specific performance areas because the Crusader objectives were specific. Individuals benefited because they were able to learn new skills, there were many opportunities to practice specific tasks, and we got to see how the "pieces" fit together.

We also were able to accomplish a good deal of cross training.

• *What do you mean by cross training?*

Because the unit is experiencing a great deal of turnover at this time, it was often necessary to bring newly assigned personnel into the POCs and battalion operations center. In addition to being unfamiliar with our SOP, many of these personnel had not used the processors.

Additionally, we were able to take 13-Bs (cannoneers) and use them as BCS operators. This is not possible during normal training cycles since staffing levels are low, rounds are limited, and training objectives tend to preclude that approach.

• *Were you fully satisfied with the training results?*

There were several artificialities within the system that could result in "negative" training. For example, radio telephone operator (RTO) procedures were not disciplined. There were insufficient nets, and that meant voice communications became sloppy.

The absence of a reinforcing battalion had an impact. Tactical moves, counterfires, and battle hand-off were not handled realistically. We did not execute some critical C2 tasks that could be relevant to Crusader operations such as intelligence preparation of the battlefield, interaction with a fire coordination element, planning fires for a reinforcing unit, rear area operations, and coordination with the maneuver commander.

The representation of intelligence flow and reporting was non-standard. Situational awareness could not be maintained because we did not have brigade and FSE functions to process intelligence into targets. Similarly, target assessments were sketchy.

• *How were you able to measure performance during the CEP?*

There were obvious things such as the amount of time needed to initialize and establish good communications; the number of missions we were able to process at any one time; troubleshooting and problem solving within and between POCs; quality of RTO procedures; proficiency on the new equipment; flexibility and adaptability; and overall situational awareness.

There were also subtle changes in individual ability to take the initiative. There was a healthy competition that saw vast improvement in POC performance and a overall increase in mission throughput compared to the baseline.

• *What changes do you believe are needed to make the simulation center more accessible and useful to tactical units as a training center?*

The staff must come prepared. We assembled a new, almost *ad hoc* group and expected them to perform like a DS unit. Individually, we had experience, but we had never done this as a team. We need better training and preparation to perform successfully. A significant part of the preparation is to focus training on specific outcomes.

Performance improved with each iteration. After a while, the tasks became repetitive, and some participants were not easily motivated. We need to isolate ourselves from external requirements. There were too many disruptions caused by administrative requirements.

Communications systems need to be labeled clearly. The wiring in the building is great as long as it works. We had difficulty discerning what was a computer problem and what was a communications problem.

ModSAF was great. It needs to represent objects to the SPH level.

The simulation center is a great place to introduce tactical units to emerging technology. Keep tactical units involved in experiments and tests so they can contribute to developments early and often.

J-Link and TAFSM need more development. We need to be able to pause or return to a point other than start of exercise (STARTEX). We spent far too much effort recovering and having to restart the battle. We ought to be able to extend the digital network to our tactical vehicles.

Future scenarios ought to include additional functions: maneuver cell, intelligence cell, radar.

Participants' Statements of Agreement.

Overall, the unit experience was positive and rewarding. Simulations have potential for training individual and collective tasks and preparing this unit for transition to Paladin.

Simulation-supported events such as the CEP provide an opportunity to train collective and individual tasks.

Training objectives helped the unit focus on specific performance areas.

J-Link and TAFSM were able to produce a context where training could take place and performance feedback was supportable.

The unit must prepare itself before it uses simulations. Training before the event will result in better data, improved performance, and less confusion.

Negative training can occur unless the unit implements a training plan and evaluates its performance using accepted standards.

The simulation center is suitable for training. Improvements in maneuver, intelligence, communications, and target acquisition functions should be part of the exercise design for the Crusader BLWEs and training events using these training simulations.

APPENDIX B

ROAD TO WAR AND SCENARIO

ROAD TO WAR AND SCENARIO

Crusader Road To War
Offensive Scenario

On 1 March 1996, after several years of increasing tension, the Peoples' Republic of Samara broke off diplomatic relations with Mojavia and moved its armed forces to the international border. Mojavia put its forces on nation-wide alert and moved into defensive positions. To prevent any appearance of provocation, Mojavia established a 10-km demilitarized zone. Samara, however, continued to provoke Mojavia by funding and arming Parumphian Separatist guerrillas operating inside Mojavia. On 10 March 1996, the Mojavian government formally requested U.S. assistance. The U.S. responded by deploying elements of the 10th (U.S.) Corps to Mojavia. The 10th (U.S.) Corps completed its deployment on 5 May 1996 and moved the 22nd (U.S.) ID (M) into defensive positions to the north of the 1st Mojavian Army. The 23rd and 52nd (U.S.) AD occupied assembly areas approximately 25 km behind the 1st Mojavian Army.

On 2 June 1996, the Samaran 21st Corps launched a massive attack across the international border with two divisions abreast, the 43rd Inf Div in the northern sector and 42nd Mech Div in the southern sector, and one trailing division, the 44th Inf Div. The division reserve, 41st AR Div, remained at the international border. The 43rd Inf Div was rendered combat ineffective during the initial engagements of the battle and are now under the C2 of the 44th Inf Div. The 42nd Mech Div and combined 43rd/44th Inf Div are currently estimated at 80%. Both the attack in the north by the 43rd Inf Div and in the south by the 42nd Mech Div have stalled because of heavy resistance from the 22nd (U.S.) ID (M) and the 1st Mojavian Army. Forward Samaran divisions are waiting reinforcement from the 41st AR Div to continue its attack east. Elements of the 44th Inf Div have established a lodgment along the NK30 north-south grid line and are attempting to force openings into Granite (NK3920) and Alpine (NK2629) Pass for use by the 41st AR Div to attack the flanks of the 1st Mojavian Division. The 44th Inf Div is currently in contact with the 22nd (U.S.) ID (M) in the northern sector. Elements of the 42nd Mech Div have established defensive positions in the vicinity of Crash Hill (NK2521) and a forward security zone vi Hill 876 (NK4012). The 42nd Mech Div is currently not in contact with the 1st Mojavian Division in the southern sector.

The 1st Mojavian Army remains in defensive positions and is continuing to resupply its forward forces in preparation for the attack of the 41st AR Div. The mission of the 10th (U.S.)

Corps is to assist the 1st Mojavian Army in the defeat of the Samaran Army and to re-establish the international border. The 22nd (U.S.) ID (M) is currently holding mountainous areas and passes on the northern flank of the 1st Mojavian Division. The 23rd (U.S.) AD is currently preparing to conduct a forward passage of lines through the 1st Mojavian Division to defeat remaining elements of the 42nd Mech Div for ensuing U.S. forces, 52nd (U.S.) AD, to blunt the attack of the 41st AR Div and restore the international border.

APPENDIX C

UNIT ORDERS

UNIT ORDERS

Copy____of____
3d Bde, 23d Armd Div
Fort Irwin, CA
15 April 1996

OPERATIONS ORDER CRUSADER-O

REFERENCES: MAPS, Series V9755, CALIFORNIA, Sheets: 2654II, 2654III, 2655III, 2754IV, 2755II, 2755III, 2854II, Edition 2-DMA Scale: 1:50,000.

Time Zone Used Throughout the Order: UNIFORM

Task Organization:

TF 1-3 Mech
1-90 Mech (-)
A/1-3 Armor
B/1-3 Armor
A/503d EN
1/A/1-44 ADA

TF 2-3 Armor
1-3 Armor (-)
B/2-3 Armor
A/1-90 Mech
D/1-90 Mech

TF 3-3 Armor
2-3 Armor (-)
B/1-90 Mech

Brigade Control
1-40 FA (155, SP) (DS)
503 EN (Sapper) (-) (DS)
A/1-44 ADA (-) (DS)
IEWSE/23 MI BN
1/IPW/Tm B/23 MI BN
1/1/B/23 MI BN (GSR)
1/23 MP Co (DS)
1/23 CHEM (DECON)
1/5/23 CHEM (SMK)
1/A/23 SIG (DS)
3 FSB (DS)

1. SITUATION (Refer to Appendix 1 [Theater Sketch] to Annex A [Sketches].)

a. Enemy Forces.

(1) Appendix 2 (Enemy Sketch) to Annex A (Sketches).

(2) After attacking across the international border with 2 lead divisions abreast, and 1 trail division, the Samaran 21st Corps attack stalled. The 43d Inf Div was rendered combat ineffective during the initial engagements of the battle and are now under the C2 of the 44th Inf Div.

Remnants of the 43rd Inf Div's 1st echelon, the 117th Inf Bde, are located along the NK30 north-south gridline. Elements of the 42d Mech Div's 2d echelon, the 111th and 112th Mech Bdes, are located vic NK4012 and NK3800. The 21st Corps' reserve, 41st AR Div, is located at the international border. The combined strength of the 43rd and 44th Inf Div are estimated at 80% strength. The 111th and 112th Mech Bdes are estimated at 80% strength. The 41st AR Div is at 100% strength. They have been in defensive positions for approximately 48 hours and are oriented east-southeast. The 21st Corps has nuclear and chemical capabilities, but has not shown a willingness to use them. The 21st Corps can no longer achieve local air superiority but can be expected to launch rotary wing attacks into the flanks of attacking friendly formations. The 21st Corps has the capability to reinforce the 111th or 112th Mech Bde with a 2 company sized air assault force.

b. Friendly Forces.

(1) Appendix 3 (Friendly Sketch) to Annex A (Sketches).

(2) 23d (U.S.) Armd Div attacks in sector to destroy elements of the 42d Mech Div vic NK4012 and NK2521. Division intent is to clear and secure OBJ COYOTE and WOLF to provide unimpeded passage of the 52d (U.S.) AD. On order be prepared to either continue the attack west or to reinforce the 22d (U.S) ID (M) to the north.

(3) 22d (U.S.) Mech Div (north) defends in sector to retain mountainous areas and passes on the northern flank of the 1st Mojavian Army.

(4) 2d Bde, 23d (U.S.) Armd Div (south), division supporting attack. Conduct forward passage of lines through the 2d Mojavian Bde, attack to destroy remnants of the 112th Mech Bde and secure OBJ FOX.

(5) 1st Bde, 23d (U.S.) Armd Div (east), initially the division reserve. Follow and support 3d Bde. On order, be prepared to continue the attack west to the international border.

(6) 1st Bde, 1st (MO) Inf Div (west), defends in sector to allow the forward passage of lines of the 3d Bde, 23d (U.S.) Armd Div.

2. MISSION

3d Brigade, as the division main attack, attacks in zone to destroy remnants of the 111th Mech Bde and secure OBJ COYOTE and WOLF. On order, be prepared to either continue the attack west or reinforce the 22d (U.S.) ID (M) to the north.

OPORD CRUSADER-O--3d Bde, 23d Armd Div

3. EXECUTION

a . Concept of the Operation. Intent of the 3d Bde commander is to destroy remnants of the 111th Mech Bde in OBJs COYOTE and WOLF to support the Corps attack to re-establish the international border. At the end of this operation, the Bde should be in position to either continue the attack west or to reinforce the 22d (U.S.) ID (M).

(1) Maneuver. This is a four phase operation.

(a) PHASE I. Begins when the lead element task force (TF) scouts cross line of departure/line of contact (LD/LC) toward OBJ COYOTE to locate and identify enemy defensive positions. Phase I ends when the lead TF element begins breaching operations vic OBJ COYOTE.

(b) PHASE II. Begins when TF 1-3 Mech enters the breech vic OBJ COYOTE. TF 1-3 Mech attacks to destroy remnants of the 111th Mech Bde on OBJ COYOTE. Once OBJ COYOTE is secure, two passage points will be established by TF 1-3 Mech. One passage point in the northern half of OBJ COYOTE and one in the southern half of OBJ COYOTE. TF 2-3 Armor will conduct a forward passage of lines through TF 1-3 Mech using the southern passage point. TF 3-3 Armor will conduct a forward passage of lines through TF 1-3 Mech using the northern passage point. After the forward passage of lines TF 1-3 Mech becomes the brigade reserve. Phase II ends when the lead TF element completes its passage of lines with TF 1-3 Mech.

(c) PHASE III. Begins when the lead TF element completes its passage of lines with TF 1-3 Mech. TF 2-3 Armor and TF 3-3 Armor attack abreast to destroy remaining elements of the 111th Mech Bde on OBJ WOLF. TF 2-3 Armor will secure OBJ WOLF SOUTH. TF 3-3 Armor will secure OBJ WOLF NORTH. Phase III ends when OBJs WOLF NORTH and SOUTH are secure.

(d) PHASE IV. Begins when OBJs WOLF NORTH and SOUTH are secure. TF 2-3 Armor will establish a passage point vic OBJ WOLF SOUTH and pass elements of the 52d (U.S.) AD through. TF 3-3 Armor will establish a passage point vic OBJ WOLF NORTH and pass elements of the 52d (U.S.) AD through. Phase IV will end when the 52d (U.S.) AD passage of lines is complete.

(2) Fires. Priority of fires to TF 1-3 Mech during Phase I and II. Priority of fires shifts to TF 2-3 Armor during Phase III and TF 3-3 Armor during IV. Brigade will plan a 20-minute prep on OBJ COYOTE to be fired by TF 1-3 Mech. Brigade will plan a 20-minute prep on OBJ WOLF to be fired by TF 2-3 Armor.

(3) Counterair Priority. Counterair priority of effort is to protect maneuver forces from enemy CAS and to retain freedom of movement. Priority for protection, in order, to TF 1-3 Mech, TF 2-3 Armor, TF 3-3 Armor, and Bde command post (CP). Weapon control status is TIGHT. AD warning is RED.

(4) Intelligence. Priority of intelligence efforts will be to locating the defensive belt and command elements of the remnants of the 42d Mech Div. Priority of intelligence targets are: division main CP, division forward CP, brigade CPs, and regimental artillery groups (RAGS).

(5) Electronic Warfare. Priority of jamming to threat reconnaissance elements, division C2, second-echelon Mech Bdes C2, fire control, and air defense artillery (ADA) nets.

(6) Engineer. Mobility priority of support is to TF 1-3 Mech during Phases I and II, shifts to TF 2-3 Armor during Phase III. Brigade has 4 short duration field artillery (FA) family of scatterable mines (FASCAM) mine fields. FASCAM Priority is to TF 3-3 Armor then to TF 2-3 Armor. Approval authority is the brigade commander.

b. Tasks to Maneuver Units.

(1) TF 1-3 Mech.

(a) Attack to defeat second-echelon enemy forces in zone vic OBJ COYOTE and establish 2 passage points.

(b) On order, pass TF 2-3 Armor through the southern passage point and TF 3-3 Armor through the northern passage point.

(c) On order, brigade reserve.

(d) On order, continue attack either to the west toward the international border or north to reinforce the 22d (U.S.) ID (M).

(2) TF 2-3 Armor.

(a) Follow TF 1-3 Mech in the south.

(b) On order, conduct forward passage of lines through TF 1-3 Mech in the southern sector of OBJ COYOTE. As the brigade main attack, continue attack west to defeat second-echelon remnants of the 111th Mech Bde vic OBJ WOLF SOUTH.

(c) On order, continue attack either to the west toward the international border or north to reinforce the 22d (U.S.) ID (M).

(3) TF 3-3 Armor.

(a) Follow TF 1-3 Mech in the north.

(b) On order, conduct forward passage of lines through TF 1-3 Mech in the northern sector of OBJ COYOTE . As the brigade supporting attack, continue attack west to defeat second-echelon remnants of the 111th Mech Bde vic OBJ WOLF NORTH.

(c) On order, continue attack either to the west toward the international border or to the north to reinforce the 22d (U.S.) ID (M).

c. Tasks to Combat Support Units.

(1) Fire Support.

(a) Air Support. (Omitted)

(b) Chemical support. (Omitted)

(c) FA Support. Priority of fires to TF 1-3 Mech during Phases I and II, on order TF 2-3 Armor during Phase III, on order TF 3-3 Armor during Phase IV. TF 3-3 Armor plans two 400-meter by 400-meter standard FA-delivered FASCAM minefields. TF 2-3 Armor plans one standard FASCAM minefield and brigade holds one minefield. Long duration FASCAM release held at division. Short duration FASCAM release held at brigade. Plan for FASCAM execution only on the north and western side of OBJ WOLF if the enemy is successful securing GRANITE (NK3920) and/or ALPINE (NK2629) PASSES. TF 2-3 Armor and TF 3-3 Armor each plan one final protective fire to the north and west of OBJ WOLF. Counterfire priorities: indirect fires affecting passage of lines operations, first-echelon RAGS, second-echelon RAGS, division CPs, and brigade CPs. Brigade will plan two 20 minute preparations. First prep will be planned on OBJ COYOTE to be fired by TF 1-3 Mech. Second prep will be planned on OBJ WOLF to be fired by TF 2-3 Armor.

(d) Nuclear Support. (Omitted)

(e) Fire Support Coordinating Instructions.

1. PL LAWTON is on-order Corps FSCL.

2. Attack Guidance Matrix.

OPORD CRUSADER-O--3d Bde, 23d Armd Div

CATEGORY		HP Number	WHEN	HOW	RESTRICTIONS
1	(C3)	25,26,28	A	N/Scouts	Coordinate w/TF Cdrs
2	(FS)	1,3,6,18,19,21	I	D	Coordinate w/TAB
3	(MAN)	47,49	A	N	Consult w/FSE
4	(ATGM)	AT5	I	D/Scouts	
5	(ADA)	54,55	A	N	
6	(ENG)	69	A	N	
7	(RSTA)	83,84	A	D/Scouts	
8	(REC)	100	A	N/Scouts	
9	(N/CE)	81,82	I	D	Forward Tgts to Division
10	(POL)	115	A	D	
11	(AMMO)	118,119	A	D	
12	(MAINT)	124	A	N	
13	(LIFT)	128	A	S	
14	(LOC)		A	N	

3. Fire Support Execution Matrix. Refer to Annex C.

(2) Engineer Support. (Omitted)

(3) Military Police. (Omitted)

d. Coordinating Instructions.

(1) High-Payoff Target List.

OPORD CRUSADER-O--3d Bde, 23d Armd Div

Priority	Category	Sheet Number	Description
1	FS	21	Mortars
2	FS	1,3,18	Arty Bn FDC, COP, FA BTRY
3	FS/Man		AT-5
4	FS		2S6
5	RSTA/FS		Regt Recon/Ambushes

(2) PIR. (Omitted)

4. SERVICE SUPPORT (CRUSADER - to be determined)

5. COMMAND AND SIGNAL

a. Command

(1) TAC CP follows TF 1-3 Mech initially, Phase II TF 3-3 Armor, Phase III vic NK2521.

(2) Main CP at ____________. Future location at _________________.

(3) Alternate CP is TF 2-3 Armor CP.

b. Signal

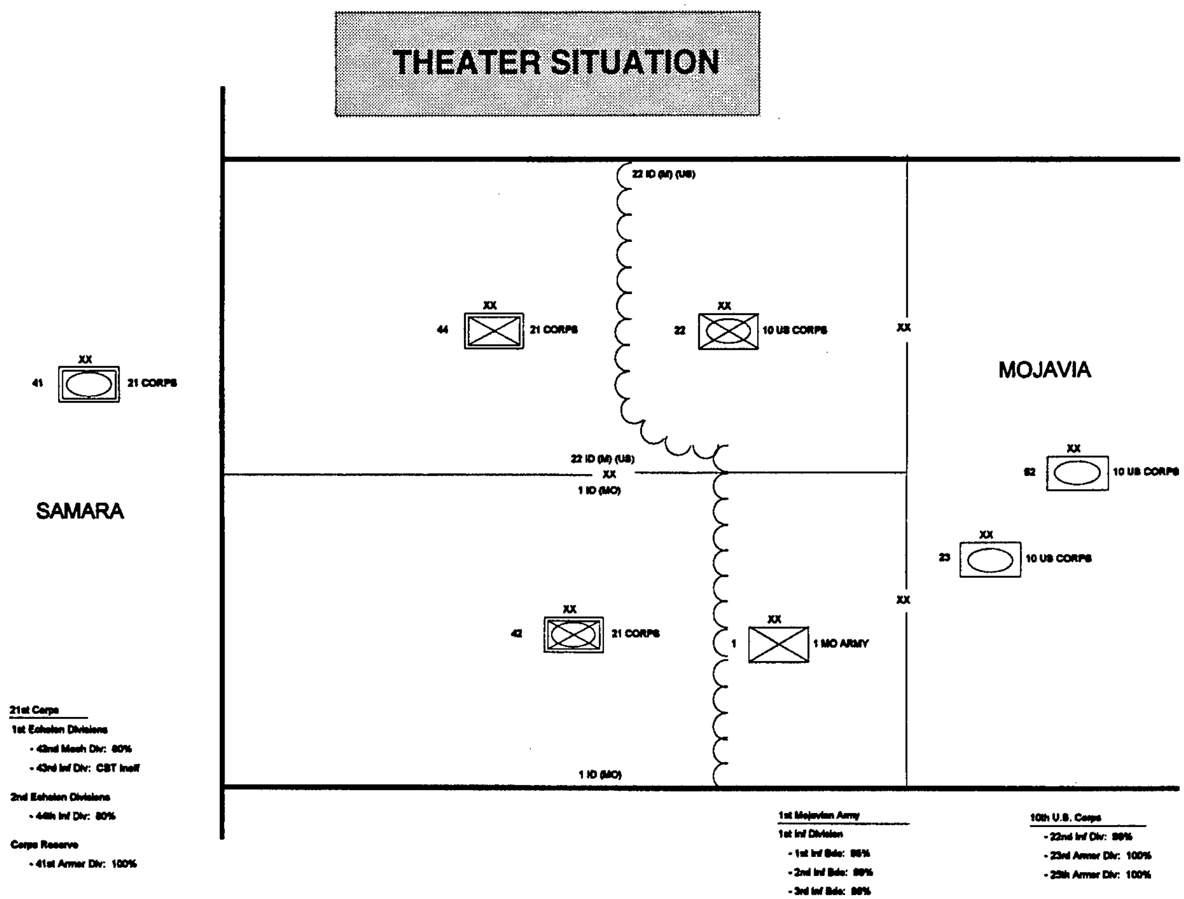
(1) Current SOI in Effect.

PATTON
COL

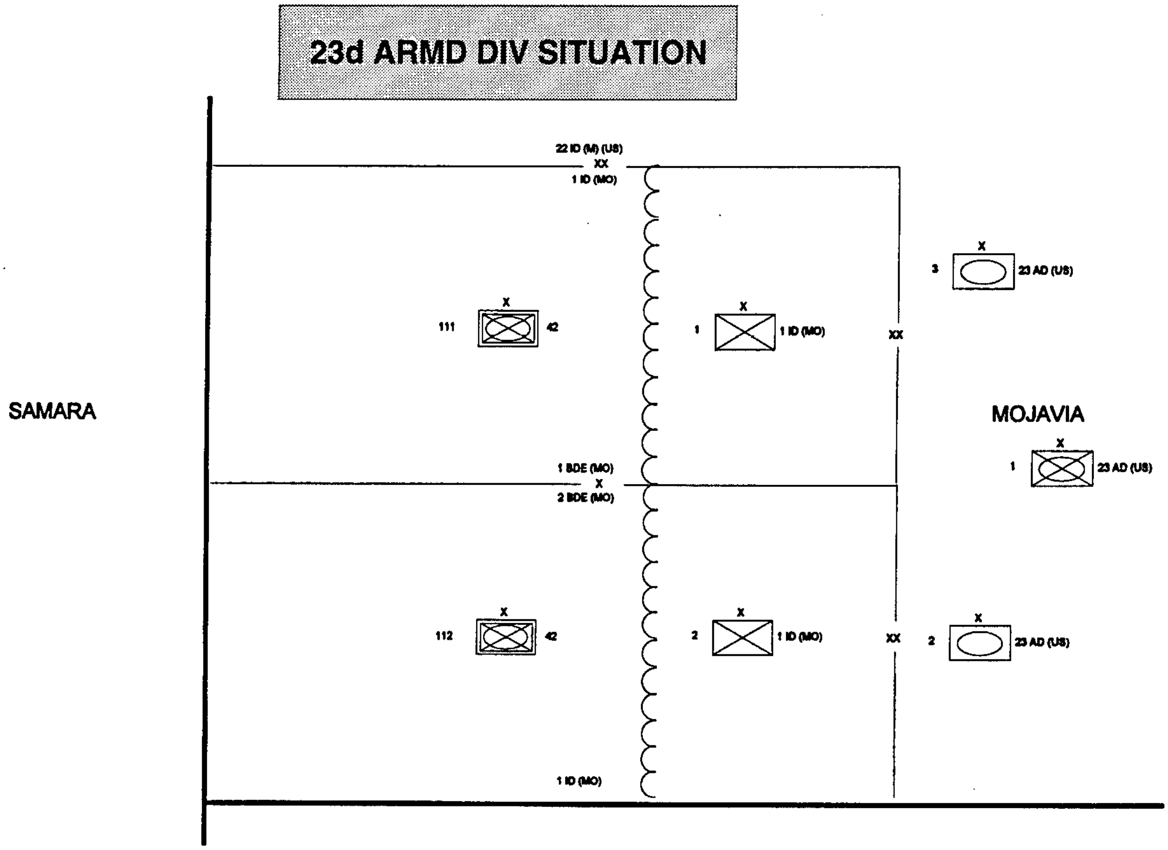
OFFICIAL:
DOHERTY
S3

Annexes:
A--Situation Sketches
B--Operation Overlay (to be provided [TBP])
C--Fire Support Execution Matrix
D--Engineer Matrix (omitted)
E--Brigade Target List
F--FA Support Plan (TBP)

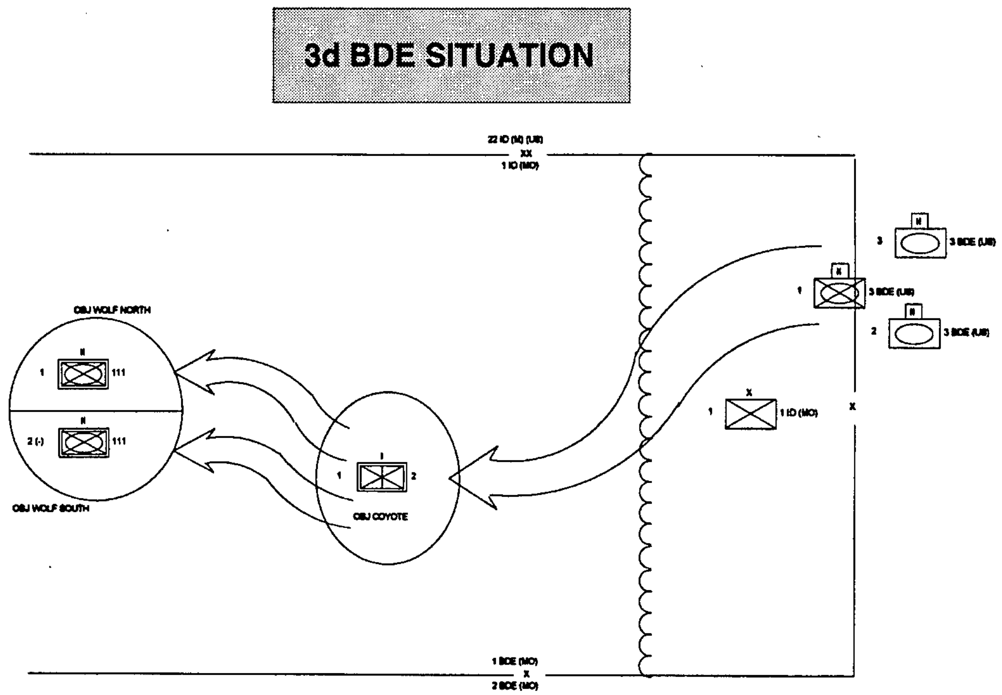
APPENDIX 1 (THEATER SITUATION) TO ANNEX A (SKETCHES) TO OPORD CRUSADER-O--3d Bde, 23d Armd Div



APPENDIX 2 (ENEMY SKETCH) TO ANNEX A (SKETCHES) TO OPORD CRUSADER-O--3d Bde, 23d Armd Div



APPENDIX 3 (FRIENDLY SKETCH) TO ANNEX A (SKETCHES) TO OPORD CRUSADER-O--3d Bde, 23d Armd Div



ANNEX E (TARGET LIST) TO OPORD CRUSADER--3d Bde, 23d Armd Div

Reference: Map, Series V9755, CALIFORNIA, Sheets 2654II, 2654III, 2655III, 2754IV, 2755II, 2755III, 2854II, Edition 2-DMA Scale: 1:50,000.

LINE NUMBER	TARGET NUMBER	DESCRIPTION	LOCATION
1	AQ0001 (a)(h)	SUSPECTED OP	NK411138
2	AQ0002 (a)(h)	SUSPECTED OP	NK396135
3	AQ0003 (a)	SUSPECTED OP	NK401125
4	AQ0004 (b)(h)	DUG-IN INF POSITION	NK366135
5	AQ0005 (b)	DUG-IN INF POSITION	NK364129
6	AQ0006 (b)(h)	ROAD INTERSECTION	NK358133
7	AQ0007 (c)	SUSPECTED OP	NK365185
8	AQ0009 (c)	SUSPECTED OP	NK363164
9	AQ0010 (c)	SUSPECTED OP	NK339170
10	AQ0012 (d)	SUSPECTED OP	NK333161
11	AQ0013 (d)	SUSPECTED OP	NK315160
12	AQ0015 (d)	SUSPECTED OP	NK295146
13	AQ0016 (e)	DUG-IN INF POSITION	NK252211
14	AQ0017 (f)	DUG-IN INF POSITION	NK237233
15	AQ0018 (e)	DUG-IN INF POSITION	NK229217
16	AQ0019 (e)	DUG-IN INF POSITION	NK253217
17	AQ0021 (f)	DUG-IN INF POSITION	NK242242
18	AQ0022 (f)	DUG-IN INF POSITION	NK262248
19	AQ0025	CHOKE POINT	NK105251-104242
20	AQ2000	SUSPECTED OP	NK563173
21	AQ2001	SUSPECTED OP	NK506178
22	AQ2002	SUSPECTED OP	NK506093
23	AQ2004	BRDM POSN	NK491109
24	AQ2007	BMP POSN	NK439117
25	AQ2010	CHOKE POINT	NK418097
26	AQ2011	BRDM POSN	NK452162
27	AQ2013	CHOKE POINT	NK399115
28	AQ2014	CHOKE POINT	NK355110
29	AQ2015	CHOKE POINT	NK392199
30	AQ2016	CHOKE POINT	NK389171
31	AQ2018	SUSPECTED OP	NK374194
32	AQ3000	CHOKE POINT	NK324130

ANNEX E (TARGET LIST) TO OPORD CRUSADER--3d Bde, 23d Armd Div

LINE NUMBER	TARGET NUMBER	DESCRIPTION	LOCATION
33	AQ3001 (g)	DUG-IN INF POSITION	NK256179
34	AQ3002	CHOKE POINT	NK225205
35	AQ3003	CHOKE POINT	NK135233-131225
36	AQ3004	FPF	NK199228-193220
37	AQ3005 (g)	DUG-IN INF POSITION	NK250185
38	AQ4000 (g)	CHOKE POINT	NK263241
39	AQ4001	SUSP ADA POSN	NK200248
40	AQ4002	SUSP ARTY POSN	NK222262
41	AQ4003	FPF	NK248265-252263
42	AQ4004	CHOKE POINT	NK262274-265270
43	AQ4005	CHOKE POINT	NK180290-179283

REMARKS:

(a) Group A1Q
(b) Group A2Q
(c) Group A3Q
(d) Group A4Q
(e) Group A5Q
(f) Group A6Q
(g) Group A7Q
(h) Series Slasher
(i) Series Basher (TBD)

APPENDIX D

OPERATIONAL MODE SUMMARY/MISSION PROFILE (OMS/MP)

OPERATIONAL MODE SUMMARY/MISSION PROFILE (OMS/MP)

Advanced Field Artillery System (AFAS) OMS/MP

1. Purpose. This document establishes the OMS/MP for the AFAS. Data provided include

a. Mission profile (MP).
b. Operational mode summary (OMS).

2. Definitions.

a. Mission Profile. A measure of the level of effort (in rounds, kilometers traveled, number of communications transmissions) expected of a system under various levels of combat intensity. MP consists of estimates for three levels of combat intensity. These intensity levels are defined as follows:

(1) Supported. The level of effort (rate) expended per day over an extended period of combat for a committed division. Combat intensity greater that this is expected to occur 25% of the time. The rate used to represent this intensity is the expected value of the 0 to 75th percentile.

(2) Surge. The level of effort expended when a division faces a main attack. This level is expected to occur less than 20% of the time. The rate used to represent this intensity level is expected to occur for the 75th to 95th percentile.

(3) Peak. The level of effort expended during an intense period of combat and most likely to occur for the direct support (DS) and/or reinforcing artillery within a single maneuver brigade area. This level is expected to occur less than 5% of the time. The rate used to represent this intensity level is the expected value for the 95th to 99.8th percentile.

b. Operational Mode Summary. A single measure of level of effort developed as a weighted arithmetic mean across all three levels of combat intensity.

3. Assumptions.

a. The U.S. Army Training and Doctrine Command (TRADOC) Southwest Asia (SWA) 4.2 scenario is a valid representation of future combat.

b. The artillery ammunition resupply system can deliver the required quantity of artillery ammunition.

c. Survivability moves are made after 3 minutes or completion of a fire mission, whichever is longer. This is based on the current operational concept and our understanding of threat counterfire capabilities and techniques.

4. Parameters.

a. System. AFAS (Crusader)

b. Scenario. SWA 4.2

c. Data Source. Target Acquisition/Fire Support Model (TAFSM)
U.S. Army Field Artillery School
Combat Sample Generator (COSAGE) and
Concepts Evaluation Model (CEM)
U.S. Army Concepts and Analysis Agency (CAA)

d. Prepared by. Analysis Division
Directorate of Combat Developments
U.S. Army Field Artillery School
Ft. Sill, OK 73503-5600
Phone: DSN 639-4715

e. Date. 17 April 1996

5. Methodology.

a. Mobility. Capable of supporting armor, mechanized infantry, and armored cavalry in all types of weather, day or night, and moving on primary (10%) and secondary (48%) roads and cross country (42%). One or two fording operations during a 24-hour period are possible. These mobility requirements were derived from multiple TAFSM rounds used in the sense and destroy armor (SADARM) cost and operational effectiveness analysis (COEA) with AFAS as a one-to-one replacement for Paladin.

b. Firepower. Capable of providing responsive and lethal fires throughout all phases of combat operations; capable of providing close fires in support of front line elements and, when within range, engaging echeloned division elements at the point when employment can have an impact on the supported commander's concept of operations.

c. Tasks. The AFAS will provide continuous fires in support of heavy brigade or division and regimental maneuver elements during all phases of operations with existing and developmental conventional and special munitions, propellants, and fuzes, to include precision guided munitions. It will be capable of interfacing with existing and future command and control (C2) and fire control systems.

d. TAFSM and the TRADOC analysis center's vector in command (VIC) low resolution model, in conjunction with CAA's scenarios developed through the use of the CEM model were used to generate usage factors for individual weapons systems.

e. TAFSM was used to determine total rounds fired, mission frequency, survivability moves, number of rounds per mission, mobility, communications, and charge distribution requirements. The time period used in the analysis was a 2000 time frame for blue forces fighting a 2005 red force. The specific scenario used in the analysis was SWA 4.2 developed by the combined arms center using VIC. CEM-generated rates were used to determine relative combat intensity factors since the VIC and TAFSM scenarios are relatively short duration.

f. The total number of rounds fired by each 155-mm howitzer was extracted from the TAFSM model and scaled to the combat intensity level derived form CAA gaming reports over extended periods of combat. The combat activity gamed in TAFSM was 24 hours of offensive operations. TAFSM is the model of choice for levels of effort (rates) since it is a high resolution model that plays the artillery in significantly more detail than any of the other models. Note that the number of rounds per tube per day depicted in the OMS/MP will differ significantly from those computed for the purpose of logistic planning factors. The OMS/MP values include consideration of weapon survivability and reliability while logistical planning factors do not.

g. Intensity of combat varies with time and type of combat activity. Type of combat refers to offensive, defensive, delay, etc. The relative intensity for each type of activity was developed using ammunition expenditures from CAA's CEM model. The intensity factor for SWA 4.2 (attack, prepared defensive position) was 0.58. This factor was used to determine the average rates for the AFAS.

6. Analysis.

a. Firepower. For the SWA 4.2 TAFSM scenario, a total of 26,136 rounds was fired by the 90 AFASs supporting the division level battle during the 24-hour scenario. This equates to 290 rounds per tube per day. When operational availability (reliability failures and attrition) was considered, the rate of fire for the available tubes increased to 346 rounds per tube per day in this scenario. Based on the scenario's combat intensity factor and adjusted for an 18-hour combat day, the average howitzer expends 448 rounds per tube per day, with a standard deviation of 199 rounds per tube per day.

b. Fire Missions. In the SWA 4.2 scenario, howitzers participated in an average of 34 missions per howitzer per 24-hour day. Normalizing the TAFSM data as discussed before results in a mean mission rate of 45 missions per howitzer per day with a standard deviation of 17 missions per howitzer per day.

c. Mobility. Howitzers are required to make both tactical and survivability moves. In the SWA 4.2 scenario, a very movement intensive operation, howitzers made an average of 30 survivability moves per howitzer per day over an average distance of 1340 meters. Howitzers averaged 11 tactical moves per day, with an average move distance of 6131 meters. The total distance traveled per howitzer was 100 to 110 kilometers over the course of the scenario.

7. AFAS Operational Mode Summary and Mission Profile (OMS/MP)

a. MP.

Level	Firepower[1]	Mobility[2]
Supported (75%)	0 to 56 missions 39 missions (mean) 0 to 582 rounds 364 rounds (mean)	1 to 50 moves
Surge (20%)	56 to 72 missions 62 missions (mean) 582 to 774 rounds 661 rounds (mean)	50 to 63 moves
Peak (5%)	72 to 103 missions 77 missions (mean) 774 to 1141 rounds 856 rounds (mean)	63 to 87 moves

[1]per tube per day. The average mission consisted of 10 rounds per tube. The range for missions and rounds is the minimum and maximum values in the appropriate percentile bands for supported, surge, and peak conditions.

[2]Includes both tactical and survivability moves. The range of numbers of moves is the minimum and maximum values in the appropriate percentile bands for supported, surge, and peak conditions.

b. OMS (War).

(1) Fire power: 45 missions per tube per day
448 rounds per tube per day

(2) Mobility: 30 survivability moves per tube per day

(3) Communications: The communications systems must be in the receive mode at all times when they are operational. The transmit time is 2 hours and the receive time is 4 hours. These times include times for fire missions, ammunition resupply operations, and C2 reporting.

(4) On-Board Electronics: 24 hours

c. Distribution of Rounds Fired by Gun-Target (G-T) Range.

KM	Percent	Cumulative percent
3-6	0.7	0.7
6-9	2.3	3.0
9-12	4.9	7.9
12-15	8.3	16.2
15-18	11.8	28.0
18-21	15.4	43.4
21-24	13.6	57.0
24-27	23.8	80.8
27-30	5.5	86.3
30-40	13.7	100.0

APPENDIX E

AAR FIELD NOTES AND DAILY SUMMARY NOTES

AAR FIELD NOTES AND DAILY SUMMARY NOTES

Introduction

AARs were conducted each day of the experiment following the run. The AAR was a facilitated discussion that reviewed objectives and performance. During the AAR, members of the data collection team observed the discussions and recorded items of interest for the TRADOC System Manager (TSM)-Cannon.

The following summaries are "field notes" produced each day in an effort to minimize the loss of critical information. The field notes were given to the unit operations officer for review during the experiment. These field notes do not represent formal, edited, documentation. They are reproduced here to illustrate the type of source materials used to generate the Findings section of the final report.

AAR FIELD NOTES
AND DAILY SUMMARY NOTES
June 11, 1997

These are summaries of discussions conducted during AARs. Some points were generated as written comments by participants, and some emerged directly from the AAR discussions. The sources are noted in each response.

Purpose: To collect lessons learned, observations, and TTPs from the Crusader CEP.

Background: These observations were collected during a unit AAR facilitated by Major Durrett, S3, 1-17 FA. All participants from the unit were present. The AAR was conducted in the bleacher area of the Janus Battle Simulation Center. Comments came from unit participants and interactors. Others attending included Dr. Pierce (Army Research Laboratory (ARL)), Mr. Peterson (ARL), J. Flanagan (Hughes Training, Inc.(HTI)), and W. Ross (HTI).

Discussion: The following items are provided in summary form based on field notes from the AAR. These may be elaborated after discussions with participants.

- 1.1 In a discussion of C2 issues, one officer commented that Crusader's mobility made operational areas obsolete in the DS of offensive operations. Instead, he recommended that the S3 assign an axis of advance that would permit Crusader to maintain pace with maneuver elements.

- 1.2 In a discussion of C2 issues, one officer commented that Crusader be attached to the supported maneuver brigade. This arrangement would require Crusader to operate on brigade command nets and keeps the FA current with the situation. It was noted that in the current DS role, information was delayed, incomplete, or secondhand.

- 1.3 In a discussion of C2 issues, one noncommissioned officer commented that battle tracking was impossible. The current automated systems detracted from the unit's situational awareness. It was noted that decision aids would incorporate information technologies that will expand system wide visibility and situation tracking, including digital interfaces with the inter-vehicular information system (IVIS).

- 1.4 In a discussion of C2 issues, one noncommissioned officer commented that reported unit locations were more than three kilometers from the planned location. This difference is significant and severely interferes with the operations centers' ability to manage its fire units. This information was passed to the TAFSM modeler for resolution. The firing position area will be defined by a 2 x 1 km rectangle to reduce this discrepancy.

- 1.5 In a discussion of C2 issues, one commissioned officer commented that we may be letting the terrain and scenario bias assessments of Crusader performance and employment considerations. Dr. Pierce commented that a Korean terrain database may be used in upcoming CEPs.

• 1.6 In a discussion of C2 issues, one noncommissioned officer commented that AFU:OPCO; messages were insufficient for maintaining the current forward line of troops (FLOT). Observer coordinates were grouped too closely to be useful at Bn Ops. The TAFSM modeler noted the comment and will determine how to fix this problem since C2 handoff and battlefield information must be passed between C2 nodes.

• 1.7 In a discussion of ammunition resupply issues, one commissioned officer commented that a dedicated-RSV concept would perform better than the pooled concept. He reasoned that maneuver forces were moving too quickly (63 km/hr) during the offense, and pooling was non-responsive. The simulation center officer in charge (OIC) verified that the cross-country movement speed was 20 km/hr. Initially the pooled-RSV concept will be employed until sufficient data are available to justify an adjustment.

• 1.8 In a discussion of resupply issues, one commissioned officer commented that resupply would be more effective if a paired howitzer concept were employed.

• 1.9 In a discussion of Crusader issues, one commissioned officer commented that career patterns for FA officers should be assessed to ensure that they received a balance of MLRS and Crusader developmental assignments.

• 1.10 In a discussion of C2 issues, one commissioned officer commented that Crusader batteries be staffed by a captain battery commander and four lieutenants serving as an ammunition officer, operations officer, and two platoon leaders.

• 1.11 In a discussion of C2 issues, one commissioned officer commented that Crusader is more mobile than the current A3 systems and that the unit must consider moving 100% of the battalion concurrently rather than the using a 1/3-2/3's rule. Crusader can stop and orient itself of a fire mission within 40 seconds of receipt of a fire order.

• 1.12 In a discussion of C2 issues, one commissioned officer commented that Bn S3 had to perform planning tasks better. He recommended that S3 plan 2 or 3 moves into the future, not just the next stop.

• 1.13 In a discussion of C2 issues, one commissioned officer commented that Crusader performance and employment considerations require a comparable capability for the command vehicles. He recommended the introduction of the command and control vehicle (C2V) which has the communications package and mobility needed.

• 1.14 In a discussion of C2 issues, one commissioned officer commented that current FM radios, even SINCGARS, have insufficient range for Crusader C2 functions. He stated that FM communications is 15-20 km on open terrain, and 5-12 km on hilly terrain like Korea.

• 1.15 In a discussion of CEP issues, one noncommissioned officer commented that the unit needed 30 minutes to upload TAFSM ammunition data at STARTEX. This information was provided to the simulation center OIC who allocated 45 minutes for this activity. He indicated that STARTEX would be no earlier than 0745 on CEP dates.

• 1.16 In a discussion of Crusader issues, one commissioned officer commented that DS and organizational maintenance would be integral to Crusader units as it is in MLRS units.

• 1.17 In a discussion of C2 issues, one commissioned officer commented that if the enemy were to capture an intact Crusader, operations would be compromised because of on-board information systems. In response, it was noted that the security implications would be managed like AFATDS which has a memory erasing feature. Thermite grenades were also identified as a means of rendering the system unusable.

• 1.18 In a discussion of C2 issues, one noncommissioned officer commented that two platoons from the same battery had no communications and asked what to do. Battalion fire direction center (Bn FDC) confirmed the report and indicated it just issued EOMs for all missions to this battery. It was suggested that this contingency could arise and another platoon or battalion should be prepared to assume control. One platoon could manage up the six SPHs, and RSVs could be either be grouped or controlled over voice nets until communications were restored.

AAR FIELD NOTES
AND DAILY SUMMARY NOTES
June 12, 1997

These are summaries of discussions conducted during AARs. Some points were generated as written comments by participants, and some emerged directly from the AAR discussions. The sources are noted in each response.

Purpose: To collect lessons learned, observations, and TTPs from the Crusader CEP.

Background: These observations were collected during three runs on June 12, 1996. Comments came from unit participants and interactors. The data collectors included Ms. Virginia Phillips (ARL), J. Flanagan (HTI), and W. Ross (HTI).

Discussion: The following items are provided in summary form based on notes from the AAR. These may be elaborated after discussions with participants.

• 2.1 During observations of a POC, tactical movement of Crusader units was conducted using battery level control along an axis of advance. Platoon leaders issued commands for SPHs which permitted off-the-road movements within 5 kms of the axis. End points were defined for SPHs. This TTP leverages the ability of the SPH to deliver timely, accurate, fires on the move within 20 seconds of receipt of a fire order.

• 2.2 During observations of a POC, platoon movement along an axis of advance was facilitated by coordinating movement of RSVs in pairs with a specific howitzer. This TTP provided for immediate resupply of the howitzer and facilitated control of platoon assets in a highly mobile situation.

• 2.3 During observations of a POC, the DS artillery unit moved at its maximum (survivability) rate of speed (48 km/hr). The unit was unaware that it had bypassed the supported maneuver force due to incomplete battlefield information on the friendly situation. Several factors contributed to the situation including the synthetic environment, lack of information from the maneuver force, and an inability to assimilate information at C2 nodes. Adjustments to the database were made to reduce the speed, changes to the support-system were introduced that gave subject planning staffs access to a maneuver display, and the unit improved reporting procedures.

• 2.4 During observations of a POC, there was no proven method for interrupting a tactical movement before its end point. The subject unit used work-arounds to define intermediate position areas that met commander's set criteria. Voice and digital communications means were used to communicate changes in march orders.

• 2.5 During observations of a unit AAR, the participants discussed communications requirements. They concluded that with a 3-person crew, it was only feasible to manage two radio nets: a voice" command net, and a digital" fire direction net. This approach is consistent with the current Crusader Operational Concept Document.

• 2.6 During observations of a unit AAR, the participants discussed data processing requirements for the POC. They assessed that current IFSAS/BCS which provides technical control was inadequate for performing all platoon operations. A "dual" computer configuration is dictated by the need to maintain situational awareness, manage resupply and tactical movement of SPHs and RSVs, and computation of firing data. A single platform is planned for the objective Crusader system. In the interim, work-arounds are necessary.

• 2.7 During observations of a unit AAR, the participants discussed whether the platoon leader could perform tactical fire direction by altering method of engagement, or shell-fuze combinations. This discussion arose because HE (High Explosives) was substituted for dual purpose improved conventional munitions (DPICM) against a personnel target. His rationale involved availability of rounds and tactical considerations. The unit was unwilling to permit a change without battalion approval.

• 2.8 During observations of a unit AAR, the participants discussed whether the UBL was suitable. This discussion arose because platoon leaders believed they had insufficient quantities of smoke and DPICM to fulfill mission requirements. The UBL reflected the units best estimate based on its mission analysis, METT-T, and experience. The UBL was modified and the databases revised. The TTP involves the unit's need for flexibility in defining ammunition loads. This area needs refinement and planning tools.

• 2.9 In a discussion of Crusader issues during a unit AAR, the participants expressed dissatisfaction with user interface with existing message formats. They preferred a "windows-like" environment, with menus and screens, instead of the current fixed format message sets. Even though they are experienced users of the current hardware and software, they concluded Crusader will require more keystrokes and this detracts from system performance. The TSM-Fire Support Command, Control, and Communications (FSC3) representative asked that participants focus on POC information requirements, since formats will be developed in a windows-like" environment.

• 2.10 In a discussion of Crusader issues during a unit AAR, participants commented they were unable to achieve situational awareness because the forward entry device (FED) operators were the only source of information. Additional maneuver representation and information flow are needed to produce the quality and quantity of information about the supported force and the friendly situation. This issue involves design of the simulation support system.

• 2.11 In a discussion of Crusader issues during a unit AAR, one unit commander stated that it was impractical to relocate the battery LRP until tactical movements were complete. He justified this approach by employing a "follow and support" TTP that organized support between SPH and RSVs.

• 2.12 In a discussion of Crusader issues during a unit AAR, one unit commander stated that a "mobile LRP" concept was most viable during tactical movements. This approach involves the allocation of two heavy expanded mobility tactical trucks (HEMMTs) to each battery with battalion retaining six HEMMTs. This TTP should be weighed against METT-T and the battery's ability to manage additional assets.

• 2.13 During observations of a POC, it was noted that when ordered to displace to forward position areas along an axis of advance, movement commands were issued to SPHs. Later RSVs were ordered to displace with up to a 20 km gap between systems. This TTP was not accepted as tactically sound.

• 2.14 In a discussion of Crusader issues during a unit AAR, the use of broadcast messages was proposed as a means of minimizing processing time needed to organize unit movements. While this TTP is advocated, a question arose concerning actions of an SPH when it is engaged in a fire mission.

• 2.15 During observations of battalion and POCs, the observer noted the displays that were manually posted by the participants to facilitate their understanding of the battlefield. These relate to POC information requirements. In addition to a situation map (SITMAP) and overlay, POCs maintained the displays shown in Table E-1. An asterisk (*) indicates display present but not completed at time of observation, "o" indicates display not observed, and "x" indicates display with information was present.

Table E-1

Operation Center Displays

Description	Bn	A1	A2	B1	B2	C1	C2
Unit mission	x	*	*	o	x	x	x
Next higher HQ mission	x	x	x	o	o	x	x
Two levels higher HQ mission	x	o	o	o	o	o	o
Commander's intent	x	*	o	o	*	x	x
Higher commander's intent	x	x	o	o	o	x	x
Critical FS tasks	x	x	o	*	x	x	x
Enemy situation	o	x	*	o	x	x	x
Friendly situation	o	x	*	o	o	x	x
Unit locations	o	x	x	*	x	x	o
Chemical downwind message	o	*	*	o	o	*	*
Battlefield geometry	o	*	*	o	o	x	x
FS coordination measures	o	x	o	o	o	x	x
Air defense status	x	x	o	o	x	x	x
Casualty collection point	o	*	o	o	o	x	*
INTSUM	o	*	o	o	o	x	x
PIR	o	x	o	o	o	x	x
CCIR	x	x	o	o	o	x	x
MOPP status	o	x	o	*	*	x	x
UBL	x	x	x	x	o	x	x
Combat vehicle status	x	o	o	o	o	o	o
Target list	x	x	o	o	x	x	o
Subscriber table	x	o	x	x	x	x	o

• 2.16 During observations of battalion and POCs, the observer noted that participants updated their situation maps with map pins and symbols that did not include information concerning time or nature of the report. This seemed to limit the value of the information for planning and support.

• 2.17 During observations of battalion and POCs, the observer noted that participants did not always maintain event journals. It was not easy to verify or follow-up on voice traffic or intelligence reports. There were many instances when operators referred to their printouts to verify or correct information. Crusader crews will have to develop TTPs for tracking information by creating and using knowledge bases. This may include an automated journal.

AAR FIELD NOTES
AND DAILY SUMMARY NOTES
June 13, 1997

These are summaries of discussions conducted during AARs. Some points were generated as written comments by participants, and some emerged directly from the AAR discussions. The sources are noted in each response.

Purpose: To collect lessons learned, observations, and TTPs from the Crusader CEP.

Background: These observations were collected during a unit AAR facilitated by Major Durrett, S3, 1-17 FA. Comments came from unit participants and interactors. Others attending included Dr. Pierce, L. Peterson, J. Flanagan (HTI), and W. Ross (HTI). An TSM-FSC3 representative, MAJ R. DeJong was present and facilitated the AAR.

Discussion: The following items are provided in summary form based on notes from the AAR. These may be elaborated after discussions with participants.

- 3.1 In a discussion of C2 issues, summary data were presented that indicated fire mission processing was skewed and uneven. The preponderance of missions were allocated to the first firing platoon of each battery, and the range of missions per firing platoon was from 0-6. During the AAR, the Bn FDC NCO was unable to account for this distribution. The unit referred to this requirement as mission management and saw it as a Bn FDC function.

- 3.2 In a discussion of C2 issues, one noncommissioned officer reported the TAFSM is unable to process mixed shell combinations. During one fire mission where he was required to fire two volleys of smoke followed by eight volleys of HE, he was required to process the mission twice to each gun. This type of mission processing needs to be streamlined.

- 3.3 In a discussion of resupply issues, functional LRP operations were discussed. LRP will be established at the battalion and for each battery. The LRP is a distribution point where the unit can rearm, refuel, and replenish stock levels for platoons. It will be managed by the battery commander and 1SG. When an RSV arrives at the LRP, it will move through a series of points established for each commodity. It will be uploaded based on a consolidated order placed by its respective POC. This order will be part of a standardized digital request. In order to expedite processing and enhance the survivability of the area, up to two RSVs will be handled concurrently. The individual stations will be dispersed and camouflaged. The RSV will carry 130 rounds, fuel, Class I, water, and Class IX. Class IX will be delivered to a DS maintenance contact team or to the howitzer section.

- 3.4 In a discussion of resupply issues, participants commented that resupply does not equal restoring the UBL. They viewed UBL as the starting point for on-hand Class V and planned to tailor their PLS based on mission requirements. The unit's PLS which can carry 825 rounds each contained a single munition type: rocket-assisted projectile (RAP), smoke, and DPICM. They viewed this as a means of expediting ammunition upload.

• 3.5 In a discussion of resupply issues, participants commented that RSV resupply targets were not achieved due to a TAFSM software problem. SPHs were unable to resupply or received rounds they did not request. The TAFSM modeler is reviewing the issue and initiating a fix.

• 3.6 In a discussion of resupply issues, participants commented that resupply from the RSV required an inter-vehicular communications so neither crew was required to leave their vehicles. They preferred a non-FM source to minimize detection while the ammunition and fuel transfer processes were underway. They saw water, food, and parts transfer taking place with crew members exposed.

• 3.7 In a discussion of C2 issues, participants noted that they would employ a "jump" TOC to assume C2 during tactical displacement of the battalion TOC. This transfer would be accomplished by ensuring messages of interest were processed to the "jump" TOC, databases were current, and communications were on-line.

• 3.8 In a discussion of C2 issues during the AAR, it was noted that the unit was unable to maintain a common picture of the battlefield because their SITMAP displays were inconsistent. No SITMAP has an "as of time", battlefield geometry had significant differences, and intelligence postings were not identified. Due to software limitations, the unit employs SYS;PTM or voice messages to pass information concerning spot reports. There is not a standard means of processing this information in the POCs.

• 3.9 In a discussion of C2 issues during the AAR, the unit examined the range capability of the Crusader and the facilitator noted that 55% of the day's missions were fired from 21-27 gun-target ranges. There were no requests for missions beyond that range. There were no requests for SADARM-type munitions.

• 3.10 In a discussion of C2 issues during the AAR, the unit concluded that SADARM could be employed to break ambushes where opposing forces (OPFOR) was deployed to attack the approaching maneuver force from its flanks.

• 3.11 In a discussion of C2 issues during the AAR, the participants reported using the FM;OBCO message as the primary means to define the FLOT. This method of battle tracking was employed due to simulation-system design.

• 3.12 In a discussion of C2 issues during the AAR, the unit proposed using multiple-round, simultaneous impact (MRSI) missions during preparation fires. They believed that this attack method would achieve greater effects in the target area in less time (20-minute preparation could be delivered in 5 minutes). They also believed a prep could be delivered with fewer fire units. Preparation fires should be viewed as a "special" mission and will require pre-positioned ammunition stocks. No movement would occur during a prep to facilitate maximum fire support. In summary MRSI missions produce mass in the target area, mean higher survivability, require more planning, and permit transition to follow-on missions. (MRSI missions can be executed with the current version of TAFSM software but are featured in the Crusader design.)

• 3.13 In a discussion of C2 issues during the AAR, participants reported a need to report and track enemy bypassed units as one means of enhancing Crusader survivability. A similar requirement was stated for barriers and obstacles. AFATDS may provide a solution for both.

• 3.14 In a discussion of C2 issues during the AAR, participants discussed the terrain requirements for survivability moves. Current unit practice is to establish 1 x 2 km position areas that coincide with grid squares. Participants viewed terrain management as a constraint for achieving survivability move conditions, i.e., move after every fire mission, displace at least 750 meters, complete the displacement within 90 seconds, and find a new position has not been used within the past 30 minutes. The geometry of these movement rules will eventually result in very large moves outside the designated position area and could produce conflicts with other organizations. The issue requires further study.

• 3.15 In a discussion of resupply issues during the AAR, participants could not visualize the loading plan for an RSV. Where are individual crew equipment stored, how are rations, parts, tools, and water carried? If a drawing of the RSV compartments were available, the unit could propose a solution.

AAR FIELD NOTES
AND DAILY SUMMARY NOTES
June 20, 1997

These are summaries of discussions conducted during AARs. Some points were generated as written comments by participants, and some emerged directly from the AAR discussions. The sources are noted in each response.

Purpose: To collect lessons learned, observations, and TTPs from the Crusader CEP.

Background: These observations were collected during an end-to-end pilot test and in-process review conducted by Major Itao. Comments came from unit participants and interactors. Others attending included Ms. Phillips (ARL), J. Flanagan (HTI), and W. Ross (HTI). A TSM-Cannon representative, LTC Freeman, was present and was briefed by Mr. Flanagan.

Discussion: The following items are provided in summary form based on notes from the end-to-end test. These may be elaborated after discussions with participants.

• 4.1 In a discussion of sustainment issues with participants, UBL design was addressed. Throughout the experiment, the UBL design has produced shortfalls in ammunition and increased the need to manage ammunition.

• 4.2 In a discussion of operational issues with participants, one platoon described how it organized internally to provide responsive fire support. The platoon attempted to separate functions and streamline information handling within the POC. This approach met with limited success because most of the information came through a single source, BCS. Information that came over voice radio nets was intended to clarify rather than inform.

• 4.3 In a discussion of fire support issues, it was noted that the BCS/IFSAS continues to produce firing solutions that are result in a "mission denial" for range limitations. The Bn TOC had insufficient information to maintain situation awareness and assigned missions to firing units based on platoon center plots rather than actual fire unit location.

• 4.4 In a discussion of resupply issues, participants commented that resupply does not equal restoring the UBL. They viewed UBL as the starting point for on-hand CL V and planned to tailor their PLS based on mission requirements. The unit's PLS which can carry 825 rounds each contained a single munition type: RAP, smoke, and DPICM. They viewed this as a means of expediting ammunition upload.

• 4.5 In a discussion of resupply issues, participants commented that RSV resupply targets were not achieved due to a TAFSM software problem. SPHs were unable to resupply or receive rounds they did not request. The TAFSM modeler is reviewing the issue and initiating a fix.

• 4.6 In a discussion of resupply issues, participants commented that resupply from the RSV required an inter-vehicular communications so neither crew was required to leave their vehicles. They preferred a non-FM source to minimize detection while the ammunition and fuel transfer processes were underway. They saw water, food, and parts transfer taking place with crew members exposed.

• 4.7 In a discussion of C2 issues, participants noted that they would employ a jump" TOC to assume C2 during tactical displacement of the Bn TOC. This transfer would be accomplished by ensuring messages of interest were processed to the jump TOC, databases were current, and communications were on-line.

• 4.8 In a discussion of C2 issues during the AAR, it was noted that the unit was unable to maintain a common picture of the battlefield in that their SITMAP displays were inconsistent. No SITMAP has an as of time", battlefield geometry had significant differences, and intelligence postings were not identified. Due to software limitations, the unit employs SYS;PTM or voice messages to pass information concerning Spot reports. There is not standard means of processing this information in the POCs.

• 4.9 In a discussion of C2 issues during the AAR, the unit examined the range capability of the Crusader and the facilitator noted that 55% of the days missions were fired from 21-27 gun-target ranges. There were no requests for missions beyond that range. There were no requests for SADARM-type munitions.

• 4.10 In a discussion of C2 issues during the AAR, the unit concluded that SADARM could be employed to break ambushes where OPFOR was deployed to attack the approaching maneuver force from its flanks.

• 4.11 In a discussion of C2 issues during the AAR, the participants reported using the FM;OBCO message as the primary means to define the FLOT. This method of battle tracking was employed due to simulation-system design.

• 4.12 In a discussion of C2 issues during the AAR, the unit proposed using MRSI missions during preparation fires. They believed that this attack method would achieve greater effects in the target area in less time (20-minute prep could be delivered in 5 minutes). They also believed a prep could be delivered with fewer fire units. Preparation fires should be viewed as a special" mission and will require pre-positioned ammunition stocks. No movement would occur during a prep to facilitate maximum fire support. In summary MRSI missions produce mass in the target area, mean higher survivability, require more planning, and permit transition to follow-on missions. (MRSI missions cannot be executed with the current version of TAFSM software but are featured in the Crusader design.)

• 4.13 In a discussion of C2 issues during the AAR, participants reported a need to report and track enemy bypassed unit as one means of enhancing Crusader survivability. A similar requirement was stated for barriers and obstacles. AFATDS may provide a solution for both.

• 4.14 In a discussion of C2 issues during the AAR, participants discussed the terrain requirements for survivability moves. Current unit practice is to establish 1 x 2 km position areas that coincide with grid squares. Participants viewed terrain management as a constraint for achieving survivability move conditions, i.e., move after every fire mission, displace at least 750 meters, complete the displacement within 90 seconds, and new position has not been used within past 30 minutes. The geometry of these movement rules will eventually result in very large moves outside the designated position area and could produce conflicts with other organizations. The issue requires further study.

• 4.15 In a discussion of resupply issues during the AAR, participants could not visualize the loading plan for an RSV. Where are individual crew equipment stored, how are rations, parts, tools, and water carried? If a drawing of the RSV compartments were available, the unit could propose a solution.

AAR FIELD NOTES
AND DAILY SUMMARY NOTES
June 25, 1997

These are summaries of discussions conducted during AARs. Some points were generated as written comments by participants, and some emerged directly from the AAR discussions. The sources are noted in each response.

Purpose: To collect lessons learned, observations, and TTPs from the Crusader CEP baseline and engineering-level tests.

Background: These observations were collected during a end-to-end pilot test and in-process review conducted by Major Durrett, S3, 1-17 FA. Comments came from unit participants and interactors. Others attending included Ms. Phillips (ARL), J. Flanagan (HTI), and W. Ross (HTI). Major DeJong, a TSM-FSC3 representative, was present and facilitated the AARs.

The objective for the day was to conduct the first of two baseline runs. This objective was not achieved because TAFSM went down on one occasion and numerous resupply discrepancies continued to appear. During the 1 hour and 12-minute run, more than 200 rounds were fired in 26 individual tube missions. This loading is approximately 80% of the objective and has already stressed the limits of the existing C2 arrangement (structure, communications, information processors). The Assistant Commandant visit went well.

Discussion: The following items are provided in summary form based on notes from the end-to-end test. These may be elaborated after discussions with participants.

- 5.1 Tactical movement of SPHs and RSVs employed a pre-defined system of position areas. One platoon used a system of movement that placed one piece at a central point, and the remaining pieces in-line 500 meters from the central piece. Other activities that must be accounted for within the position area are: RSVs, a POC, survey control, hide area, ammunition holding areas, and alternate firing points. Establishment and organization of the position area involves many functions in addition to the SPHs.

- 5.2 During the AAR, the participants attempted to describe features for an automated system. These included: a larger display, graphical user interfaces, light pen interfaces, split screen display capabilities to manage operational and technical data concurrently, windows-like operating system, and simpler formats. C2 would be facilitated with more user-friendly systems.

- 5.3 During the AAR, one platoon leader commented that when he needed information he relied on voice communications. It was concluded that with smaller staffs and greater information flows, the use of voice communications would create more confusion because it tended to divert attention from the digital systems. Each C2 node needed more training and discipline so the digital information systems could be mastered.

- 5.4 In a discussion of resupply issues during the AAR, many platoons noted that resupply operations were not producing expected results. SPHs were resupplied with rounds from the

RSV that it had not requested. The participants expected a one-for-one replenishment of expended rounds. Instead, the system uploaded different munitions than those fired by the SPH.

• 5.5 In a discussion of RSV operations, one subject suggested that RSVs be positioned about 1,000 meters behind the guns. In his opinion positioning should provide for minimum turn-around during local resupply and hide areas needed to be situated to avoid possible counterfire.

• 5.6 In a discussion of resupply issues, participants commented that battalion staffs must consider the impact of not relocating the battalion ammunition transfer point or LRP during the offense. In this unit, each battery maintained three PLS-HMETs. These vehicles would be located equidistance between the battery firing units and the battalion ammunition stocks. In the offense, this will result in longer travel turn-around times.

• 5.7 In a discussion of C2 issues, participants noted that the battalion TOC was experiencing information overload. They were unable to maintain situation awareness and process large volumes of fire missions concurrently. They believed that these are characteristic of staffing problems. There is a disparate fire mission processing capability within the existing processors: SPH can each process three missions concurrently (54 active missions within the battalion), current POC equipped with a BCS can process three missions concurrently (its 3-gun platoon can process up to nine missions at the guns, and the battalion can process up to 12 missions with its IFSAS. Under the current organizational structure, the staff is unable to manage errors or anomalous situations that occur.

• 5.8 In a discussion of C2 issues during the AAR, the participants discussed a need to manage fire support control measures (FSCMs) in new ways. For example, can the platoon process EOM directly with the fire support team (FIST)/sensor; automated battlefield geometry; automatic updates with manual override.

• 5.9 In a discussion of C2 issues during the AAR, the unit discussed the implications of employing tactics, techniques, and procedures similar to those found in MLRS firing units. These included cross functional preparation of officers, and long term standardization of operational doctrine. The effect is to avoid over-specialization and more opportunity for branch qualification.

• 5.10 In a discussion of C2 issues during the AAR, it was determined that there were inconsistencies in unit databases. It was stated that it is the responsibility of the platoon to verify its database before distribution across the network.

• 5.11 In a discussion of RSV survivability, one platoon employed a tactic that the RSV maintain a 100 meter separation in hide areas. It believed this was sufficient for ensuring maximum control and survivability from attack.

• 5.12 In a discussion of resupply operations, participants discussed techniques it used to schedule RSV resupply. One subject believed resupply should occur whenever rounds were transferred from the RSV. Another subject believed that all useable rounds should be downloaded from an RSV before it returns to the LRP. This leaves other RSVs with full loads for rearming operations. Success of both approaches may depend on travel time and number of RSV systems available.

• 5.13 In a discussion of C2 issues during the AAR, it was noted that no two POCs had similar manning or organization. A focus group may be needed to sort out roles and responsibilities.

• 5.14 In a discussion of C2 issues during the AAR, participants commented that there were large discrepancies in gun-target ranges when processing fire missions. It was believed that the simulation suite (TAFSM, J-Link, BCS, IFSAS) may use different reference points to determine fire unit location.

CRUSADER CEP 1
After Action Review
20 June 1996

Mission Establish and operate a synthetic environment where CRUSADER tactical employment concepts can be investigated.

Objectives

Verify TAFSM enhancements
Establish communications architecture
Achieve baseline conditions
Conduct two baseline runs
Capture performance issues
Initiate corrective actions

CRUSADER CEP 1
After Action Review
20 June 1996

Number of Rounds Fired by Type per Time Period

	M864	M483A1	M795	M825A1	M898	M110	Total
Hour 1		30	18				48
Hour 2		26	18				44
Hour 3							
Hour 4							
Total		56	36				92

CRUSADER CEP 1
After Action Review
20 June 1996

Distribution of Fire Missions: Number of Rounds by Firing Unit

Firing Organization	1/A/1/17	2/A/1/17	1/B/1/17	2/B/1/17	1/C/1/17	2/C/1/17	1-17 FA Bn
Number of Indiv Tube Missions	3	3	2	4	0	3	15
Total Number of Rounds Fired	9	5	6	40	0	32	92

CRUSADER CEP 1
After Action Review
20 June 1996

Distribution of Fire Missions: Number of Rounds by Type Round

Ammunition Type	M864	M483A1	M795	M825A1	M898	M110	Total
Number of Indiv Tube Missions		13	2				15
Total Number of Rounds Fired		56	3 6				92

CRUSADER CEP 1
After Action Review
20 June 1996

<u>Distribution of Rounds Fired by Gun-Target Range</u>

G-T Range in Kms	M864	M483A1	M795	M825A1	M898	M110	Total
0-5							
6-10							
11-15							
16-20			36				36
21-25		8					8
26-30		6					6
31-35		42					42
36-40							
40-45							
Total		56	36				92

CRUSADER CEP 1
After Action Review
28 June 1996, Run 1

Mission Establish and operate a synthetic environment where CRUSADER tactical employment concepts can be investigated.

Objectives

- Conduct Experimental Run 1
- Vary from CEP baseline conditions
- Implement dual IFSAS station
- Administer surveys and questionnaires
- Conduct focus group discussions
- Capture performance issues
- Initiate corrective actions

CRUSADER CEP 1
After Action Review
28 June 1996, Run 1

Number of Rounds Fired by Type per Time Period

	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Hour 1	18	66	44	77	2	0	0	207
Hour 2	97	116	46	71	0	8	3	341
Hour 3	61	121	18	89	0	4	0	293
Hour 4								
Total	176	303	108	237	2	12	3	841

CRUSADER CEP 1
After Action Review
28 June 1996, Run 1

Distribution of Fire Missions:
Number of Missions and Rounds by Firing Unit

Firing Organization	1/A/1/17	2/A/1/17	1/B/1/17	2/B/1/17	1/C/1/17	2/C/1/17	1-17 FA Bn
Number of Indiv Tube Missions	30	27	20	12	10	19	118
Total Number of Rounds Fired	230	127	152	126	66	140	841

CRUSADER CEP 1
After Action Review
28 June 1996, Run 1

Distribution of Fire Missions: Number of Missions and Rounds by Type Round

Ammunition Type	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Number of Indiv Tube Missions	23	32	21	29	1	11	1	118
Total Number of Rounds Fired	176	303	108	237	2	12	3	841

CRUSADER CEP 1
After Action Review
28 June 1996, Run 1

Distribution of Missions Fired by Gun-Target Range and Round Type

G-T Range in Kms	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
0-5								0
6-10	0	0	1	2	1	0	1	5
11-15	10	7	8	4	0	2	0	31
16-20	1	5	12	17	0	8	0	43
21-25	5	5	0	5	0	1	0	16
26-30	4	11	0	1	0	0	0	16
31-35	1	4	0	0	0	0	0	5
36-40	2	0	0	0	0	0	0	2
40-45								0
Total	23	32	21	29	1	11	1	118

CRUSADER CEP 1
After Action Review
28 June 1996, Run 2

Mission Establish and operate a synthetic environment where CRUSADER tactical employment concepts can be investigated.

Objectives

- Conduct Experimental Run 2
- Vary from CEP baseline conditions
- Implement dual IFSAS station
- Administer surveys and questionnaires
- Conduct focus group discussions
- Capture performance issues
- Initiate corrective actions

CRUSADER CEP 1
After Action Review
28 June 1996, Run 2

Number of Rounds Fired by Type per Time Period

	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Hour 1	34	84	83	45	0	0	9	255
Hour 2	40	323	47	102	0	0	2	514
Hour 3	161	186	23	43	0	0	0	413
Hour 4								
Total	235	593	153	190	0	0	11	1,182

CRUSADER CEP 1
After Action Review
28 June 1996, Run 2

Distribution of Fire Missions: Number of Missions and Rounds by Firing Unit

Firing Organization	1/A/1/17	2/A/1/17	1/B/1/17	2/B/1/17	1/C/1/17	2/C/1/17	1-17 FA Bn
Number of Indiv Tube Missions	41	23	31	24	12	21	152
Total Number of Rounds Fired	278	151	260	211	95	187	1,182

CRUSADER CEP 1
After Action Review
28 June 1996, Run 2

Distribution of Fire Missions: Number of Missions and Rounds by Type Round

Ammunition Type	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Number of Indiv Tube Missions	32	61	30	25	0	0	4	152
Total Number of Rounds Fired	235	593	153	190	0	0	11	1,182

CRUSADER CEP 1
After Action Review
28 June 1996, Run 2

Distribution of Missions Fired by Gun-Target Range and Round Type

G-T Range in Kms	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
0-5								0
6-10	7	1	4	3	0	0	0	15
11-15	5	10	16	5	0	0	1	37
16-20	2	9	9	5	0	0	1	26
21-25	3	9	1	7	0	0	2	22
26-30	7	22	0	5	0	0	0	34
31-35	7	10	0	0	0	0	0	17
36-40	1	0	0	0	0	0	0	1
40-45								0
Total	32	61	30	25	0	0	4	152

CRUSADER CEP 1
After Action Review
1 July 1996, Run 3

Mission Establish and operate a synthetic environment where CRUSADER tactical employment concepts can be investigated.

Objectives

Conduct Experimental Run 3
Vary from CEP baseline conditions
Implement dual IFSAS station at battalion FDC
Employ OPFOR counterfire
Conduct focus group discussions
Capture performance issues
Initiate corrective actions

CRUSADER CEP 1
After Action Review
1 July 1996, Run 3

Number of Rounds Fired by Type per Time Period

	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Hour 1	16	12	78	12	0	0	6	124
Hour 2	24	0	5	12	0	0	12	53
Hour 3	58	248	76	151	0	0	18	551
Hour 4	61	242	31	159	7	0	0	501
Hour 5	192	210	5	91	22	0	0	522
Total	354	712	195	425	29	0	36	1,751

CRUSADER CEP 1
After Action Review
1 July 1996, Run 3

Distribution of Fire Missions: Number of Missions and Rounds by Firing Unit

Firing Organization	1/A/1/17	2/A/1/17	1/B/1/17	2/B/1/17	1/C/1/17	2/C/1/17	1-17 FA Bn
Number of Indiv Tube Missions	48	24	49	46	38	45	250
Total Number of Rounds Fired	295	150	341	319	296	350	1,751

CRUSADER CEP 1
After Action Review
1 July 1996, Run 3

Distribution of Fire Missions: Number of Missions and Rounds by Type Round

Ammunition Type	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Number of Indiv Tube Missions	62	69	44	59	8	0	8	250
Total Number of Rounds Fired	354	712	195	425	29	0	36	1,751

CRUSADER CEP 1
After Action Review
1 July 1996, Run 3

Distribution of Missions Fired by Gun-Target Range and Round Type

G-T Range in Kms	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
0-5								0
6-10	1	0	0	3	0	0	5	9
11-15	9	7	15	16	2	0	3	52
16-20	10	22	26	30	2	0	0	90
21-25	17	14	0	8	4	0	0	43
26-30	9	12	0	5	0	0	0	26
31-35	6	14	0	0	0	0	0	20
36-40	10	0	0	0	0	0	0	10
40-45								0
Total	62	69	44	59	8	0	8	250

CRUSADER CEP 1
After Action Review
2 July 1996, Run 4

Mission Establish and operate a synthetic environment where CRUSADER tactical employment concepts can be investigated.

Objectives

- Conduct Experimental Run 4
- Vary from CEP baseline conditions
- Maintain dual IFSAS station
- Employ OPFOR counterfire system
- Conduct focus group discussions
- Capture performance issues
- Initiate corrective actions

CRUSADER CEP 1
After Action Review
2 July 1996, Run 4

Number of Rounds Fired by Type per Time Period

	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Hour 1	0	0	47	18	0	0	0	65
Hour 2	78	97	5	217	0	2	9	408
Hour 3	48	324	25	161	0	0	6	564
Hour 4	97	247	38	71	10	0	9	472
Hour 5								
Total	223	668	115	467	10	2	24	1,509

CRUSADER CEP 1
After Action Review
2 July 1996, Run 4

Distribution of Fire Missions: Number of Missions and Rounds by Firing Unit

Firing Organization	1/A/1/17	2/A/1/17	1/B/1/17	2/B/1/17	1/C/1/17	2/C/1/17	1-17 FA Bn
Number of Indiv Tube Missions	62	28	26	15	37	36	204
Total Number of Rounds Fired	376	158	223	143	262	347	1,509

CRUSADER CEP 1
After Action Review
2 July 1996, Run 4

Distribution of Fire Missions:
Number of Missions and Rounds by Type Round

Ammunition Type	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Number of Indiv Tube Missions	40	69	25	58	2	1	9	204
Total Number of Rounds Fired	223	668	115	467	10	2	24	1,509

CRUSADER CEP 1
After Action Review
2 July 1996, Run 4

Distribution of Missions Fired by Gun-Target Range and Round Type

G-T Range in Kms	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
0-5								0
6-10	2	1	0	0	0	0	4	7
11-15	5	17	8	28	0	0	1	58
16-20	6	15	16	19	2	0	3	61
21-25	10	25	1	9	0	1	2	48
26-30	12	7	0	2	0	0	0	21
31-35	2	4	0	0	0	0	0	6
36-40	3	0	0	0	0	0	0	3
40-45								0
Total	40	69	25	58	2	1	9	204

CRUSADER CEP 1
After Action Review
3 July 1996, Run 5

Mission Establish and operate a synthetic environment where CRUSADER tactical employment concepts can be investigated.

Objectives

Conduct Experimental Run 5
Implement BOC for command and control
Maintain dual IFSAS station
Employ OPFOR counterfire system
Conduct focus group discussions
Capture performance issues
Initiate corrective actions

CRUSADER CEP 1
After Action Review
3 July 1996, Run 5

<u>Number of Rounds Fired by Type per Time Period</u>

	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Hour 1	78	98	0	190	8	0	15	389
Hour 2	121	148	15	82	0	2	10	408
Hour 3								
Hour 4								
Hour 5								
Total	199	246	15	272	8	2	25	767

CRUSADER CEP 1
After Action Review
3 July 1996, Run 5

Distribution of Fire Missions:
Number of Missions and Rounds by Firing Unit

Firing Organization	1/A/1/17	2/A/1/17	1/B/1/17	2/B/1/17	C/1/17	1-17 FA Bn
Number of Indiv Tube Missions	21	11	17	16	35	100
Total Number of Rounds Fired	108	90	132	130	307	767

CRUSADER CEP 1
After Action Review
3 July 1996, Run 5

Distribution of Fire Missions: Number of Missions and Rounds by Type Round

Ammunition Type	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
Number of Indiv Tube Missions	24	30	3	30	3	2	8	100
Total Number of Rounds Fired	199	246	15	272	8	2	25	767

CRUSADER CEP 1
After Action Review
3 July 1996, Run 5

Distribution of Missions Fired by Gun-Target Range and Round Type

G-T Range in Kms	M549A1	M864	M483A1	M795	M825A1	M898	M110	Total
0-5								0
6-10	0	1	2	0	2	0	2	7
11-15	2	4	1	8	0	0	3	18
16-20	0	4	0	16	1	0	3	24
21-25	10	7	0	1	0	2	0	20
26-30	7	13	0	5	0	0	0	25
31-35	0	0	0	0	0	0	0	0
36-40	0	0	0	0	0	0	0	0
40-45								0
Total	24	30	3	30	3	2	8	100

APPENDIX F

UNIT BASIC LOAD (UBL)

Unit Basic Load for a CRUSADER Battery in the Direct Support Role as of 7 June 96

CRUSADER

Btry: 6 guns x 60 rounds = 360
POC: 3 guns x 60 rounds = 180

Resupply Vehicle (RSV)

6 RSVs x 130 rounds = 780
3 RSVs x 130 rounds = 390

		Range	1 Gun	3 Gun	1 RSV	3 RSVs	POC
M549	HER	40.7	9	27	18	54	81
M864	HEM(ER-DPICM)	360	9	27	30	90	117
M483	HEF (DPICM)	22.5	21	63	41	123	204
M795	HEL (HE)	27.2	9	27	17	51	87
M485A2	ILA (ILIUM)	22.5	3	9	6	18	27
M825A1	SMC (WP)	22.5	3	9	6	18	27
MIIO	SMB (HC)	22.5	3	9	6	18	27
M898	SAD (SADARM)	25.0	3	9	6	18	27
M731	AMS (RAAM)	22.5	0	0	0	0	0
M741	APS (ADAM)	22.5	0	0	0	0	0
		Totals	60	180	130	390	570

Unit Basic Load for a CRUSADER Battery in the Direct Support Role as of 18 June 96

CRUSADER	Resupply Vehicle (RSV)	Palletized Loading System (PLS)
Btry: 6 guns x 60 rounds = 360	6 RSVs x 130 rounds = 780	4 HEMTTS x 174 rounds = 696
POC: 3 guns x 60 rounds = 180	3 RSVs x 130 rounds = 390	2 HEMTTS x 174 rounds = 348
Service Battery:		18 HEMTTS x 174 rounds = 3,312

		Range	1 Gun	3 Gun	1 RSV	3 RSVs	2 PLSs	POC
M549	HER	40.7	12	36	24	72	124	232
M107DC	HEB * (ER-DPICM)	36.0	20	60	51	153	124	337
M483AI	HEF (DPICM)	22.5	5	15	15	45	0	60
M107NC	HEA * (HE)	27.2	14	42	42	66	0	108
M485AI	ILA * (ILIUM)	22.5	0	0	0	0	0	0
M825	SMC * (WP)	22.5	3	9	9	18	100	127
M116AI	SMB * (HC)	22.5	3	9	9	18	0	27
M898	SAD (SADARM)	25.0	3	9	9	18	0	27
M741	AMS (RAAM)	22.5	0	0	0	0	0	0
M731	APS (ADAM)	22.5	0	0	0	0	0	0
		Totals	60	180	130	390	348	918

* Substitutions:
M107NC HEA substituted for M795 HEL
M485AI ILA substituted for M485A2 ILA,
M825 SMC substituted for M825AI SMD,
M116AI SMB substituted for M110 SMB

Unit Basic Load for a CRUSADER Battery in the Direct Support Role as of 20 June 96

CRUSADER	Resupply Vehicle (RSV)	Palletized Loading System (PLS)
Btry: 6 guns x 60 rounds = 360	6 RSVs x 130 rounds = 780	4 HEMTTS x 174 rounds = 696
POC: 3 guns x 60 rounds = 180	3 RSVs x 130 rounds = 390	2 HEMTTS x 174 rounds = 348
Service Battery:		18 HEMTTS x 174 rounds = 3,312

			1st Platoon			2nd Platoon		
		Range	RSV 1	RSV 2	RSV 3	RSV 4	RSV 5	RSV 6
M549	HER	40 7	0	6	6	64	64	4
M107DC	HEB * (ER-DPICM)	36 0	0	67	67	0	0	69
M483AI	HEF (DPICM)							
M107NC	HEA * (HE)	27.2	13	43	43	4	4	43
M485A1	ILA * (ILIUM)	22 5	47	0	0	0	0	0
M825	SMC * (WP)							
M116AI	SMB * (HC)	22.5	51	0	0	0	0	0
M898	SAD (SADARM)	225	0	0	0	0	0	0
M741	AMS (RAAM)							
M731	APS (ADAM)	22.5	0	0	0	0	0	0
		Totals	130	130	130	130	130	130

* Substitutions:
M107DC HEB subshtuted for M864 HEM
M107NC HEA substi~d for M795 HEL
M485AI ILA substitutod for M485A2 ILA,
M825 SMC substituted for M825AI SMD,
M116AI SMB substituted for M110 SMB

APPENDIX G

BACKGROUND READING

BACKGROUND READING

Annotated Background Information and Reference List for the Crusader Concept Experimentation Program (CEP) 1

U.S. Army Combined Arms Command (1984). Staff organization and functions (Field Manual 101-5). Fort Leavenworth, KS: Author.
This doctrinal publication defines the command and staff relationships that comprise battle staffs. The traditional planning and decision process is described.

U.S. Army Communications and Electronics Command (1994). Operator's manual cannon battery computer system software for fire control system AN/GYK-37 (Technical Bulletin 11-7025-293-10-2). Fort Monmouth, NJ: Author. *This technical publication describes the operations and maintenance of the battery computer system. It also defines the legal entries for the tactical fire control message set used to communicate directions and orders within the firing battery equipped with the battery computer system.*

U.S. Army Field Artillery School (1995). Preliminary operational concept document for the crusader. Fort Sill, OK: Author.
The OCD defines a baseline concept for employment of the Crusader system. Experiments are conducted from the baseline to develop and evaluate tactics, techniques, and procedures.

U.S. Army Field Artillery School (1983). Fire support in combined arms operations (Field Manual 6-20). Fort Sill, OK: Author.
This doctrinal publication defines the framework for field artillery support of maneuver warfare.

U.S. Army Field Artillery School (1990). Tactics, techniques, and procedures for fire support for the heavy brigade (Field Manual 6-20-40). Fort Sill, OK: Author. *This doctrinal publication defines the innovative tactics and techniques to be employed by field artillery formations that support of heavy maneuver brigades. It outlines the processes that must be in place to produce effective fire support for all maneuver missions.*

U.S. Army Field Artillery School (1981). Army training and evaluation program (ARTEP) 6-400-30-MTP, mission training plan for the field artillery cannon battery (M109A3/5). Fort Sill, OK: Author. *This training plan defines the tasks, conditions, and standards for field artillery units equipped with M109A3/5 systems.*

U.S. Army Field Artillery School (1994). Army training and evaluation program (ARTEP) 6-Paladin-30-MTP, mission training plan for the field artillery cannon battery (M109A6) Paladin. Fort Sill, OK: Author. *This training plan defines the tasks, conditions, and standards for field artillery units equipped with M109A6 systems.*

U.S. Army 1st Cavalry Division (1995). Advanced field artillery tactical data system (AFATDS) initial operational test and evaluation position guide for the cannon battery/platoon fire direction center. Fort Hood, TX. This job aid provides operator level instructions for initializing and operating the next generation of tactical fire control digital processors.

U.S. Army Training and Doctrine Command (1988). Training the force (Field Manual 6-25). Fort Monroe, VA: Author.
This doctrinal publication describes the manner in which training and exercises will be used to support training. The components of the training and exercise design are defined.

U.S. Army Training and Doctrine Command (1994). Force XXI operations (TRADOC Pamphlet 525-5). Fort Monroe, VA: Author.
This warfighting publication describes operational concepts for forces who will be engaged on future battlefields. It defines the context that Crusader must support.

APPENDIX H

LIST OF ACRONYMS AND ABBREVIATIONS

LIST OF ACRONYMS AND ABBREVIATIONS

1SG	First Sergeant
AAR	after action review
ADA	air defense artillery
AFAS	advanced field artillery system
AFATDS	Advanced Field Artillery Tactical Data System
AI	artificial intelligence
AMOUP	ammunition update (message format)
ARL	U.S. Army Research Laboratory
ARTEP	Army training and evaluation program
ASP	ammunition supply point
ASR	available supply rate
ATP	ammunition transfer point
BCS	battery computer system
Bde	brigade
BLWE	Battle Lab warfighting experiment
BLUFOR	blue (or friendly) forces
Bn	battalion
BOC	battalion operations center
C2	command and control
C2V	command and control vehicle
CAA	U.S. Army Concepts and Analysis Agency
CCIR	Commander's critical information requirements
CCL	combat configured load
CEM	concepts evaluation model
CEP	concept experimentation program
CFL	coordinated fire line
COEA	cost and operational effectiveness analysis
COSAGE	combat sample generator
CP	command post
CSR	controlled supply rate
CSS	combat service support
D&SABL	Depth and Simultaneous Attack Battle Lab
DCD	
DIS	distributed interactive simulation
DIVARTY	division artillery
DPICM--ER	dual purpose, improved, conventional munition--extended range
DS	direct support
ENDEX	end of exercise
EOM	end of mission

FA	field artillery
FASCAM	family of scatterable mines
FASP	field artillery support plan
FDC	fire direction center
FDO	fire direction officer
FED	forward entry device
FIST	fire support team
FLOT	forward line of troops
FM	field manual
FM	fire mission
FM	frequency modulated
FO	forward observer
FPF	final protective fire
FS	fire support
FSC3	fire support, command, control and communications
FSCL	fire support coordination line
FSCM	fire support control measures
FSE	fire support element
FSO	fire support officer
GS	general support
GSR	general support reinforcing (artillery)
G-T	gun-target
HE	high explosive
HEMTT	heavy expanded mobility tactical truck
HQ	headquarters
HTI	Hughes Training, Inc.
IFF	identification friend or foe
IFSAS	interim fire support automated system
INTSUM	intelligence summary
IVIS	inter-vehicular information system
LD/LC	line of departure/line of contact
LRP	logistics resupply point
METT-T	mission, enemy, troops, terrain, and time
MLRS	multiple launch rocket system
ModSAF	modular semi-automated forces
MOPP	mission-oriented protective posture
MRSI	multiple rounds, simultaneous impact
NBC	nuclear, biological, chemical
NCO	noncommissioned officer
NTC	National Training Center
OCD	operational concept document

OIC	Officer in charge
OMS/MP	operation mode summary/mission profile
OP	observation post
OPFOR	opposing forces
OPORD	operations order
OPTEMPO	operational tempo
PIR	priority information requirements
PLS	palletized loading system
POC	platoon operations center
RAGS	regimental artillery groups
RAM	reliability, availability, maintainability
RAP	rocket-assisted projectile
RSOP	reconnaissance, selection and occupation of position
RSV	resupply vehicle
RTO	radio telephone operator
S3	operations officer
SADARM	sense and destroy armor
SALUTE	size, activity, location, unit, time, and equipment
SINCGARS	single channel, ground, airborne radio system
SITMAP	situation map
SM-B	smoke B
SME	subject matter expert
SOP	standing operating procedure(s)
SPH	self-propelled howitzer
STARTEX	start of exercise
STOW	synthetic theater of war
SWA	southwest Asia
TAFSM	target acquisition/fire support model
TBD	
TBP	to be published or provided
TF	task force
TOC	tactical operations center
TRADOC	U.S. Army Training and Doctrine Command
TSM	TRADOC system manager
TTP	tactics, techniques, and procedures
UBL	unit basic load
UDLP	United Defense Limited Partnership
UTM	universal transverse Mercator
VIC	vector in command
XO	Executive Officer

NO. OF COPIES	ORGANIZATION
2	ADMINISTRATOR DEFENSE TECHNICAL INFO CENTER ATTN DTIC DDA 8725 JOHN J KINGMAN RD STE 0944 FT BELVOIR VA 22060-6218
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN AMSRL CS AL TA RECORDS MANAGEMENT 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN AMSRL CI LL TECHNICAL LIBRARY 2800 POWDER MILL RD ADELPHI MD 207830-1197
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN AMSRL CS AL TP TECH PUBLISHING BRANCH 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	CECOM SP & TERRESTRIAL COM DIV ATTN AMSEL RD ST MC M H SOICHER FT MONMOUTH NJ 07703-5203
1	PRIN DPTY FOR TECH GY HDQ US ARMY MATL CMND ATTN AMCDCG T M FISETTE 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001
1	PRIN DPTY FOR ACQTN HDQ US ARMY MATL CMND ATTN AMCDCG A D ADAMS 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001
1	DPTY CG FOR RDE HDQ US ARMY MATL CMND ATTN AMCRD BG BEAUCHAMP 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001

NO. OF COPIES	ORGANIZATION
1	DPTY ASST SCY FOR RSRCH & TECH SARD-TT F MILTON RM 3EA79 THE PENTAGON WASHINGTON DC 20310-0103
1	ODCSOPS D SCHMIDT WASHINGTON DC 20310-1001
1	OSD OUSD(A&T)/ODDDR&E(R) J LUPO THE PENTAGON WASHINGTON DC 20301-7100
1	ARL ELECTROMAG GROUP CAMPUS MAIL CODE F0250 A TUCKER UNIVERSITY OF TEXAS AUSTIN TX 78712
1	DUSD SPACE 1E765 J G MCNEFF 3900 DEFENSE PENTAGON WASHINGTON DC 20301-3900
1	USAASA MOAS-AI W PARRON 9325 GUNSTON RD STE N319 FT BELVOIR VA 22060-5582
1	CECOM PM GPS COL S YOUNG FT MONMOUTH NJ 07703
1	GPS JOINT PROG OFC DIR COL J CLAY 2435 VELA WAY STE 1613 LOS ANGELES AFB CA 90245-5500
1	ELECTRONIC SYSTEMS DIV DIR CECOM RDEC J NIEMELA FT MONMOUTH NJ 07703
3	DARPA L STOTTS J PENNELLA B KASPAR 3701 N FAIRFAX DR ARLINGTON VA 22203-1714
1	SPECIAL ASST TO THE WING CDR 50SW/CCX CAPT P H BERNSTEIN 300 O'MALLEY AVE STE 20 FALCON AFB CO 80912-3020

NO. OF COPIES	ORGANIZATION
1	USAF SMC/CED DMA/JPO M ISON 2435 VELA WAY STE 1613 LOS ANGELES AFB CA 90245-5500
1	DIRECTORATE FOR MANPRINT ATTN DAPE MR DEPUTY CHIEF OF STAFF PERSONNEL 300 ARMY PENTAGON WASHINGTON DC 20310-0300
1	DIRECTOR ARMY AUDIOLOGY & SPEECH CENTER WALTER REED ARMY MED CENTER WASHINGTON DC 20307-5001
1	OUSD(A)/DDDR&E(R&A)/E&LS PENTAGON ROOM 3D129 WASHINGTON DC 20301-3080
1	CODE 1142PS OFFICE OF NAVAL RESEARCH 800 N QUINCY STREET ARLINGTON VA 22217-5000
1	WALTER REED ARMY INST OF RSCH ATTN SGRD UWI C (COL REDMOND) WASHINGTON DC 20307-5100
1	DR ARTHUR RUBIN NATL INST OF STANDARDS & TECH BUILDING 226 ROOM A313 GAITHERSBURG MD 20899
1	COMMANDER US ARMY RESEARCH INSTITUTE ATTN PERI ZT (DR E M JOHNSON) 5001 EISENHOWER AVENUE ALEXANDRIA VA 22333-5600
1	DEFENSE LOGISTICS STUDIES INFORMATION EXCHANGE ATTN DIRECTOR DLSIE ATSZ DL BLDG 12500 2401 QUARTERS ROAD FORT LEE VA 23801-1705
1	DEPUTY COMMANDING GENERAL ATTN EXS (Q) MARINE CORPS RD&A COMMAND QUANTICO VA 22134
1	HEADQUARTERS USATRADOC ATTN ATCD SP FORT MONROE VA 23651

NO. OF COPIES	ORGANIZATION
1	COMMANDER USATRADOC COMMAND SAFETY OFFICE ATTN ATOS (MR PESSAGNO/MR LYNE) FORT MONROE VA 23651-5000
1	COMMANDER US ARMY MATERIEL COMMAND ATTN AMCAM 5001 EISENHOWER AVENUE ALEXANDRIA VA 22333-0001
1	DIRECTOR TDAD DCST ATTN ATTG C BLDG 161 FORT MONROE VA 23651-5000
1	COMMANDER USA OPERATIONAL TEST & EVAL AGENCY ATTN CSTE TSM 4501 FORD AVE ALEXANDRIA VA 22302-1458
1	USA BIOMEDICAL R&D LABORATORY ATTN LIBRARY FORT DETRICK BUILDING 568 FREDERICK MD 21702-5010
1	HQ USAMRDC ATTN SGRD PLC FORT DETRICK MD 21701
1	COMMANDER USA AEROMEDICAL RESEARCH LAB ATTN LIBRARY FORT RUCKER AL 36362-5292
1	US ARMY SAFETY CENTER ATTN CSSC SE FORT RUCKER AL 36362
1	CHIEF ARMY RESEARCH INSTITUTE AVIATION R&D ACTIVITY ATTN PERI IR FORT RUCKER AL 36362-5354
1	AIR FORCE FLIGHT DYNAMICS LAB ATTN AFWAL/FIES/SURVIAC WRIGHT PATTERSON AFB OH 45433
1	AAMRL/HE WRIGHT PATTERSON AFB OH 45433-6573

NO. OF COPIES	ORGANIZATION
1	US ARMY NATICK RD&E CENTER ATTN STRNC YBA NATICK MA 01760-5020
1	US ARMY TROOP SUPPORT CMD NATICK RD&E CENTER ATTN BEHAVIORAL SCI DIV SSD NATICK MA 01760-5020
1	US ARMY TROOP SUPPORT CMD NATICK RD&E CENTER ATTN TECH LIBRARY (STRNC MIL) NATICK MA 01760-5040
1	DR RICHARD JOHNSON HEALTH & PERFORMANCE DIVISION US ARIEM NATICK MA 01760-5007
1	LOCKHEED SANDERS INC BOX MER 24 1583 NASHUA NH 03061-0868
1	MEDICAL LIBRARY BLDG 148 NAVAL SUBMARINE MEDICAL RSCH LAB BOX 900 SUBMARINE BASE NEW LONDON GROTON CT 06340
1	USAF ARMSTRONG LAB/CFTO ATTN DR F WESLEY BAUMGARDNER SUSTAINED OPERATIONS BRANCH BROOKS AFB TX 78235-5000
1	DR JON FALLESEN ARI FIELD UNIT PO BOX 3407 FORT LEAVENWORTH KS 66027-0347
1	COMMANDER USAMC LOGISTICS SUPPORT ACTIVITY ATTN AMXLS AE REDSTONE ARSENAL AL 35898-7466
1	ARI FIELD UNIT FORT KNOX BUILDING 2423 PERI IK FORT KNOX KY 40121-5620
1	COMMANDANT USA ARTILLERY & MISSILE SCHOOL ATTN USAAMS TECH LIBRARY FORT SILL OK 73503

NO. OF COPIES	ORGANIZATION
1	COMMANDER WHITE SANDS MISSILE RANGE ATTN STEWS TE RE WHITE SANDS MISSILE RANGE NM 88002
1	COMMANDER WHITE SANDS MISSILE RANGE ATTN TECHNICAL LIBRARY WHITE SANDS MISSILE RANGE NM 88002
1	USA TRADOC ANALYSIS COMMAND ATTN ATRC WSR (D ANGUIANO) WHITE SANDS MISSILE RANGE NM 88002-5502
1	STRICOM 12350 RESEARCH PARKWAY ORLANDO FL 32826-3276
1	COMMANDER USA TANK-AUTOMOTIVE R&D CENTER ATTN AMSTA RS/D REES WARREN MI 48090
1	COMMANDER USA TANK-AUTOMOTIVE R&D CENTER ATTN AMSTA TSL (TECH LIBRARY) WARREN MI 48397-5000
1	COMMANDER USA COLD REGIONS TEST CENTER ATTN STECR TS A APO AP 96508-7850
1	INSTITUTE FOR DEFENSE ANALYSES ATTN DR JESSE ORLANSKY 1801 N BEAUREGARD STREET ALEXANDRIA VA 22311
1	PURDUE UNIVERSITY SERIALS UNIT CDM KARDEX 1535 STEWART CENTER WEST LAFAYETTE IN 47907-1535
1	GOVT PUBLICATIONS LIBRARY 409 WILSON M UNIVERSITY OF MINNESOTA MINNEAPOLIS MN 55455

NO. OF COPIES	ORGANIZATION
1	DR RICHARD PEW BBN SYSTEMS AND TECH CORP 10 MOULTON STREET CAMBRIDGE MA 02138
1	DR HARVEY A TAUB RSCH SECTION PSYCH SECTION VETERANS ADMIN HOSPITAL IRVING AVENUE & UNIVERSITY PLACE SYRACUSE NY 13210
1	DR ROBERT C SUGARMAN 132 SEABROOK DRIVE BUFFALO NY 14221
1	DR ANTHONY DEBONS IDIS UNIVERSITY OF PITTSBURGH PITTSBURGH PA 15260
1	MR R BEGGS BOEING-HELICOPTER CO P30-18 PO BOX 16858 PHILADELPHIA PA 19142
1	DR ROBERT KENNEDY ESSEX CORPORATION SUITE 227 1040 WOODCOCK ROAD ORLANDO FL 32803
1	DR NANCY ANDERSON DEPARTMENT OF PSYCHOLOGY UNIVERSITY OF MARYLAND COLLEGE PARK MD 20742
1	MR LARRY W AVERY BATTELLE PACIFIC NW LABS PO BOX 999 MAIL STOP K6-66 RICHLAND WA 99352
1	DR BEN B MORGAN DEPARTMENT OF PSYCHOLOGY UNIVERSITY OF CENTRAL FLORIDA PO BOX 25000 ORLANDO FL 32816
1	LAWRENCE C PERLMUTER PHD UNIV OF HEALTH SCIENCES THE CHICAGO MEDICAL SCHOOL DEPT OF PSYCHOLOGY 3333 GREEN BAY ROAD NORTH CHICAGO IL 60064

NO. OF COPIES	ORGANIZATION
1	DR ARTHUR S KAMLET BELL LABORATORIES 6200 EAST BROAD STREET COLUMBUS OH 43213
1	GENERAL MOTORS CORPORATION NORTH AMERICAN OPERATIONS PORTFOLIO ENGINEERING CENTER HUMAN FACTORS ENGINEERING ATTN MR A J ARNOLD STAFF PROJ ENG ENGINEERING BLDG 30200 MOUND RD BOX 9010 WARREN MI 48090-9010
1	GENERAL DYNAMICS LAND SYSTEMS DIV LIBRARY PO BOX 1901 WARREN MI 48090
1	DR LLOYD A AVANT DEPARTMENT OF PSYCHOLOGY IOWA STATE UNIVERSITY AMES IA 50010
1	DR PAUL R MCCRIGHT INDUSTRIAL ENGINEERING DEPT KANSAS STATE UNIVERSITY MANHATTA KS 66502
1	DR MM AYOUB DIRECTOR INST FOR ERGONOMICS RESEARCH TEXAS TECH UNIVERSITY LUBBOCK TX 79409
1	MR KENNETH C CROMBIE TECHNICAL LIBRARIAN E104 DELCO SYSTEMS OPERATIONS 6767 HOLLISTER AVENUE GOLETA CA 93117
1	MR WALT TRUSZKOWSKI CODE 522.3 NASA/GODDARD SPACE FLIGHT CENTER GREENBELT MD 20771
1	DIRECTOR US ARMY AEROFLIGHT DYNAMICS DIR ATTN SAVRT AF D (A W KERR) AMES RESEARCH CENTER (MS 215-1) MOFFETT FIELD CA 94035-1099
1	DR NORMAN BADLER DEPT OF COMPUTER & INFORMATION SCIENCE UNIVERSITY OF PENNSYLVANIA PHILADELPHIA PA 19104-6389

NO. OF COPIES	ORGANIZATION
1	COMMANDER US ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE NATICK MA 01760-5007
1	DR DANIEL J POND BATTELLE PNL/K6-66 PO BOX 999 RICHLAND WA 99350
1	HQDA (DAPE ZXO) ATTN DR FISCHL WASHINGTON DC 20310-0300
1	HUMAN FACTORS ENG PROGRAM DEPT OF BIOMEDICAL ENGINEERING COLLEGE OF ENGINEERING & COMPUTER SCIENCE WRIGHT STATE UNIVERSITY DAYTON OH 45435
1	COMMANDER USA MEDICAL R&D COMMAND ATTN SGRD PLC (LTC K FRIEDL) FORT DETRICK MD 21701-5012
1	PEO STANDARD ARMY MGMT INFORMATION SYSTEM ATTN AS PES STOP C-3 FT BELVOIR VA 22060-5456
1	PEO ARMORED SYS MODERNIZATION US ARMY TANK-AUTOMOTIVE CMD ATTN SFAE ASM S WARREN MI 48397-5000
1	PEO COMBAT SUPPORT ATTN AMCPEO CS US ARMY TANK AUTOMOTIVE CMD WARREN MI 48397-5000
1	PEO MGMT INFORMATION SYSTEMS ATTN AS PEM STOP C-2 BLDG 1465 FT BELVOIR VA 22060-5456
1	PEO ARMAMENTS ATTN AMCPEO AR BLDG 171 PICATINNY ARSENAL NJ 07806-5000
1	PEO INTELLIGENCE & ELECTRONIC WARFARE ATTN AMCPEO IEW VINT HILL FARMS STATION BLDG 197 WARRENTON VA 22186-5115

NO. OF COPIES	ORGANIZATION
1	PEO COMMUNICATIONS ATTN SFAE CM RE FT MONMOUTH NJ 07703-5000
1	PEO AIR DEFENSE ATTN SFAE AD S US ARMY MISSILE COMMAND REDSTONE ARSENAL AL 35898-5750
1	PEO STRATEGIC DEFENSE PO BOX 15280 ATTN DASD ZA US ARMY STRATEGIC DEFENSE CMD ARLINGTON VA 22215-0280
1	PROGRAM MANAGER RAH-66 ATTN SFAE AV BLDG 5300 SPARKMAN CENTER REDSTONE ARSENAL AL 35898
1	DENNIS L SCHMICKLY CREW SYSTEMS ENGINEERING MCDONNELL DOUGLAS HELICOPTER 5000 EAST MCDOWELL ROAD MESA AZ 85205-9797
1	JON TATRO HUMAN FACTORS SYSTEM DESIGN BELL HELICOPTER TEXTRON INC PO BOX 482 MAIL STOP 6 FT WORTH TX 76101
1	CHIEF CREW SYSTEMS INTEGRATION SIKORSKY AIRCRAFT M/S S3258 NORTH MAIN STREET STRATFORD CT 06602
1	GENERAL ELECTRIC COMPANY ARMAMENT SYSTEMS DEPT RM 1309 ATTN HF/MANPRINT R C MCLANE LAKESIDE AVENUE BURLINGTON VT 05401-4985
1	JOHN B SHAFER 250 MAIN STREET OWEGO NY 13827
1	OASD (FM&P) WASHINGTON DC 20301-4000
1	COMMANDER US ARMY MATERIEL COMMAND ATTN AMCDE AQ 5001 EISENHOWER AVENUE ALEXANDRIA VA 22333

NO. OF COPIES	ORGANIZATION
1	COMMANDANT US ARMY ARMOR SCHOOL ATTN ATSB CDS (MR LIPSCOMB) FT KNOX KY 40121-5215
1	COMMANDER US ARMY AVIATION CENTER ATTN ATZQ CDM S (MR MCCRACKEN) FT RUCKER AL 36362-5163
1	COMMANDER US ARMY SIGNAL CTR & FT GORDON ATTN ATZH CDM FT GORDON GA 30905-5090
1	DIRECTOR US ARMY AEROFLIGHT DYNAMICS DIR MAIL STOP 239-9 NASA AMES RESEARCH CENTER MOFFETT FIELD CA 94035-1000
1	PROJECT MANAGER SIGNALS WARFARE ATTN SFAE IEW SG (ALAN LINDLEY) BLDG P-181 VINT HILL FARMS STATION WARRENTON VA 22186-5116
1	COMMANDER MARINE CORPS SYSTEMS COMMAND ATTN CBGT QUANTICO VA 22134-5080
1	DIRECTOR AMC-FIELD ASSIST IN SCIENCE & TECHNOLOGY ATTN AMC-FAST (RICHARD FRANSEEN) FT BELVOIR VA 22060-5606
1	COMMANDER US ARMY FORCES COMMAND ATTN FCDJ SA BLDG 600 AMC FAST SCIENCE ADVISER FT MCPHERSON GA 30330-6000
1	COMMANDER I CORPS AND FORT LEWIS AMC FAST SCIENCE ADVISER ATTN AFZH CSS FORT LEWIS WA 98433-5000
1	HQ III CORPS & FORT HOOD OFFICE OF THE SCIENCE ADVISER ATTN AFZF CS SA FORT HOOD TX 76544-5056

NO. OF COPIES	ORGANIZATION
1	COMMANDER U.S. ARMY NATL TRAINING CENTER AMC FAST SCIENCE ADVISER ATTN AMXLA SA FORT IRWIN CA 92310
1	COMMANDER HQ XVIII ABN CORPS & FORT BRAGG OFFICE OF THE SCI ADV BLDG 1-1621 ATTN AFZA GD FAST FORT BRAGG NC 28307-5000
1	SOUTHCOM WASHINGTON FIELD OFC 1919 SOUTH EADS ST SUITE L09 AMC FAST SCIENCE ADVISER ARLINGTON VA 22202
1	HQ US SPECIAL OPERATIONS CMD AMC FAST SCIENCE ADVISER ATTN SOSD MACDILL AIR FORCE BASE TAMPA FL 33608-0442
1	HQ US ARMY EUROPE AND 7TH ARMY ATTN AEAGX SA OFFICE OF THE SCIENCE ADVISER APO AE 09014
1	COMMANDER HQ 21ST THEATER ARMY AREA CMD AMC FAST SCIENCE ADVISER ATTN AERSA APO AE 09263
1	COMMANDER HEADQUARTERS USEUCOM AMC FAST SCIENCE ADVISER UNIT 30400 BOX 138 APO AE 09128
1	HQ 7TH ARMY TRAINING COMMAND UNIT #28130 AMC FAST SCIENCE ADVISER ATTN AETT SA APO AE 09114
1	COMMANDER HHC SOUTHERN EUROPEAN TASK FORCE ATTN AESE SA BUILDING 98 AMC FAST SCIENCE ADVISER APO AE 09630

NO. OF COPIES	ORGANIZATION
1	COMMANDER US ARMY PACIFIC AMC FAST SCIENCE ADVISER ATTN APSA FT SHAFTER HI 96858-5L00
1	COMMANDER US ARMY JAPAN/IX CORPS UNIT 45005 ATTN APAJ SA AMC FAST SCIENCE ADVISERS APO AP 96343-0054
1	AMC FAST SCIENCE ADVISERS PCS #303 BOX 45 CS-SO APO AP 96204-0045
1	COMMANDER ALASKAN COMMAND ATTN SCIENCE ADVISOR (MR GRILLS) 6-900 9TH ST STE 110 ELMENDORF AFB ALASKA 99506
1	CDR & DIR USAE WATERWAYS EXPERIMENTAL STATION ATTN CEWES IM MI R (A S CLARK) CD DEPT #1153 3909 HALLS FERRY ROAD VICKSBURG MS 39180-6199
1	MR GARY PERLMAN COMPUTER & INFORMATION SCIENCE OHIO STATE UNIV RM 228 BOLZ HALL 2036 NEIL AVENUE COLUMBUS OH 43210-1277
1	DR SEHCHANG HAH DEPT OF BEHAVIORAL SCIENCES & LEADERSHIP BUILDING 601 ROOM 281 US MILITARY ACADEMY WEST POINT NEW YORK 10996-1784
1	US ARMY RESEARCH INSTITUTE ATTN PERI IK (DOROTHY L FINLEY) 2423 MORANDE STREET FORT KNOX KY 40121-5620
1	DENNIS SCHMIDT HQDA DAMO FDQ 400 ARMY PENTAGON WASHINGTON DC 20310-0460

NO. OF COPIES	ORGANIZATION
1	US MILITARY ACADEMY MATHEMATICAL SCIENCES CENTER OF EXCELLENCE DEPT OF MATHEMATICAL SCIENCES ATTN MDN A MAJ DON ENGEN THAYER HALL WEST POINT NY 10996-1786
1	NAIC/DXLA 4180 WATSON WAY WRIGHT PATTERSON AFB OH 45433-5648
1	ARL HRED AVNC FIELD ELEMENT ATTN AMSRL HR MJ (R ARMSTRONG) PO BOX 620716 BLDG 514 FT RUCKER AL 36362-0716
1	ARL HRED MICOM FIELD ELEMENT ATTN AMSRL HR MO (T COOK) BUILDING 5400 ROOM C242 REDSTONE ARSENAL AL 35898-7290
1	ARL HRED USAADASCH FLD ELEMENT ATTN AMSRL HR ME (K REYNOLDS) ATTN ATSA CD 5800 CARTER ROAD FORT BLISS TX 79916-3802
1	ARL HRED ARDEC FIELD ELEMENT ATTN AMSRL HR MG (R SPINE) BUILDING 333 PICATINNY ARSENAL NJ 07806-5000
1	ARL HRED ARMC FIELD ELEMENT ATTN AMSRL HR MH (J JOHNSON) BLDG 1109B 3RD FLOOR FT KNOX KY 40121-5215
1	ARL HRED CECOM FIELD ELEMENT ATTN AMSRL HR ML (J MARTIN) MYER CENTER RM 3C214 FT MONMOUTH NJ 07703-5630
1	ARL HRED FT BELVOIR FIELD ELEMENT ATTN AMSRL HR MK (P SCHOOL) 10115 GRIDLEY ROAD SUITE 114 FORT BELVOIR VA 22060-5846
1	ARL HRED FT HOOD FIELD ELEMENT ATTN AMSRL HR MV (E SMOOTZ) HQ TEXCOM BLDG 91012 RM 111 FT HOOD TX 76544-5065

NO. OF COPIES	ORGANIZATION
2	ARL HRED NATICK FIELD ELEMENT ATTN AMSRL HR MQ (M FLETCHER) ATTN SSCNC A (D SEARS) USASSCOM NRDEC BLDG 3 RM R-140 NATICK MA 01760-5015
1	ARL HRED FT HUACHUCA FLD ELEMENT ATTN AMSRL HR MY (B KNAPP) GREELY HALL (BLDG 61801 RM 2631) FORT HUACHUCA AZ 85613-5000
1	ARL HRED FT LEAVENWORTH FLD ELE ATTN AMSRL HR MP (D UNGVARSKY) TPIO ABCS 415 SHERMAN AVE RM 327 FT LEAVENWORTH KS 66027-1344
1	ARL HRED FLW FIELD ELEMENT ATTN AMSRL HR MZ (A DAVISON)* 320 ENGINEER LOOP STE 166 FT LEONARD WOOD MO 65473-8929
1	ARL HRED OPTEC FIELD ELEMENT ATTN AMSRL HR MR (D HEADLEY) PARK CENTER IV RM 1450 4501 FORD AVENUE ALEXANDRIA VA 22302-1458
1	ARL HRED SC&FG FIELD ELEMENT ATTN AMSRL HR MS (L BUCKALEW) SIGNAL TOWERS RM 207 FORT GORDON GA 30905-5233
1	ARL HRED STRICOM FIELD ELEMENT ATTN AMSRL HR MT (A GALBAVY) 12350 RESEARCH PARKWAY ORLANDO FL 32826-3276
1	ARL HRED TACOM FIELD ELEMENT ATTN AMSRL HR MU (M SINGAPORE) BLDG 200A 2ND FLOOR WARREN MI 48397-5000
1	ARL HRED USAFAS FIELD ELEMENT ATTN AMSRL HR MF (L PIERCE) BLDG 3040 RM 220 FORT SILL OK 73503-5600
1	ARL HRED USAIC FIELD ELEMENT ATTN AMSRL HR MW (E REDDEN) BLDG 4 ROOM 332 FT BENNING GA 31905-5400
1	ARL HRED USASOC FIELD ELEMENT ATTN AMSRL HR MN (F MALKIN) HQ USASOC BLDG E2929 FORT BRAGG NC 28307-5000
1	US ARMY RSCH DEV STDZN GP-UK ATTN DR MICHAEL H STRUB PSC 802 BOX 15 FPO AE 09499-1500

<u>ABERDEEN PROVING GROUND</u>

NO. OF COPIES	ORGANIZATION
2	DIRECTOR US ARMY RESEARCH LABORATORY ATTN AMSRL CI LP (TECH LIB) BLDG 305 APG AA
1	LIBRARY ARL BLDG 459 APG-AA
1	ARL SLAD ATTN AMSRL BS (DR JT KLOPCIC) BLDG 328 APG-AA
1	USMC LIAISON OFFICE ATTN AMST ML RYAN BUILDING APG-AA
1	USATECOM RYAN BUILDING APG-AA
1	COMMANDER CHEMICAL BIOLOGICAL AND DEFENSE COMMAND ATTN AMSCB CI APG-EA
1	CDN ARMY LO TO TECOM ATTN AMSTE CL TECOM HQ RYAN BLDG
1	CHIEF ARL HRED ERDEC FIELD ELEMENT ATTN AMSRL HR MM (R MCMAHON) BLDG 459 APG-AA

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 1998	Final

4. TITLE AND SUBTITLE

Crusader Battle Lab Warfighting Experiment (BLWE) 1: Assessing Tactics, Techniques, and Procedures (TTPs) for Crusader Units Within a Synthetic Environment

5. FUNDING NUMBERS

AMS: 622716.H700011
PR: 1L162716AH70
PE: 6.27.16

6. AUTHOR(S)

Peterson, L. (ARL); Ross, W.A. (Hughes Training, Inc.); Pierce, L.G. (ARL)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Research Laboratory
Human Research & Engineering Directorate
Fort Sill, OK 73503-5600

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Research Laboratory
Human Research & Engineering Directorate
Aberdeen Proving Ground, MD 21005-5425

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

ARL-TR-1597

11. SUPPLEMENTARY NOTES Comments or questions concerning this report should be directed to Mr. L. Peterson, Human Research and Engineering Directorate of the U.S. Army Research Laboratory, Ft. Sill, OK. The phone number is DSN 639-5630 or commercial (405) 442-5630.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The U.S. Army Research Laboratory and the Depth and Simultaneous Attack Battle Lab have performed the first Battle Lab Warfighting Experiment that evaluated operational concepts for the Crusader system. The experiment was conducted during June and July of 1996 in the Janus Battle Simulation Center at Ft. Sill, Oklahoma. The research addressed critical operation issues focused on the employment of the Crusader system on the 21st century digitized battlefield. Command and control, and ammunition logistics and resupply systems used by a direct support field artillery battalion when employing the simulated Crusader system were evaluated to identify innovative tactics, techniques, and procedures that could be introduced in conjunction with the fielding of the Crusader system.

This research was conducted using a synthetic battlefield environment that placed field artillerymen into distributed interactive simulation technologies where they used actual tactical data processing equipment to perform fire support functions. There were four major outcomes of this research:

1. A preliminary set of tactics, techniques, and procedures that addressed command and control functions, situation awareness, fire order consistency, and sustainment was identified. This information will be evaluated further by the system developer and field artillery community and will be considered for additional testing during later experiments or closed loop studies.

2. Major findings were

- The Crusader system as currently specified, will deliver effective fires to defeat the projected threat and provide timely support to maneuver forces.
- The pooled resupply concept was successfully demonstrated and shown to be a robust technique in the face of losses of individual resupply vehicles.
- The Crusader will need to have significant on-board processing capabilities to operate most efficiently within the digital battlefield.
- Future command, control, coordination, and intelligence equipment will require some modifications to incorporate the information processing requirements of the Crusader system.

(continued on reverse)

14. SUBJECT TERMS

artillery, command and control, modeling, synthetic environment, automation, crusader, simulation, training

15. NUMBER OF PAGES 220

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Item 13 continued

• The digital battlefield will impose an extremely high operational tempo and information processing requirements on all elements of the command and control structure in order to deploy and track self-propelled howitzers and resupply vehicles, keep pace with maneuver forces, track the overall battle, process fire missions, track logistics requirements, reposition logistics resupply points, and coordinate resupply elements.

3. The research extended the state of the art in simulations and demonstrated the benefits of synthetic environments. A flexible distributed interactive simulation test environment where a combined training and learning approach was implemented.

4. The methodology for this research was evaluated to identify how it could be improved and applied during the system development process. In addition to the unique test environment, a methodology and set of metrics to evaluate soldier and system performance in that environment were demonstrated.