FOUNDATIONS OF THE

AFTER ACTION REVIEW PROCESS

U.S. Army Research Institute
for the Behavioral and Social Sciences

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FOREWORD

The U.S. Army has adopted the After Action Review (AAR) as the primary method for delivering feedback after unit training exercises. The AAR is also being adopted by proponents within other Services and by proponents for non-military group training feedback applications. The U.S. Army Research Institute (ARI) has supported the development and implementation of AAR procedures for over 20 years.

This report documents the history of the AAR. It also describes the research and development (R&D) efforts conducted to support AAR implementation across the many training situations that have emerged over the years as a result of new training technologies and force modernization.

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Director

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EXECUTIVE SUMMARY

Research Requirement:

The after action review (AAR) is the Army's method for providing performance feedback from a collective training exercise. The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has performed much of the research and development (R&D) for the AAR. The purpose of this report is to review the evolution of the AAR process, identify some of the major behavioral science principles that underlie the AAR, and propose directions for future R&D.

Procedure:

The foundations of AAR were determined by conducting two literature reviews. The first was a historical review to examine the evolution of AAR concepts. This review described, in chronological order, the major historical developments that have shaped methods and concepts related to the AAR process. The second was a conceptual review of research on the AAR process. This review was focused on deriving the behavioral science principles that underlie the AAR process and was organized by general areas of theory and research in behavioral sciences. Finally, the findings from the two reviews were synthesized for implications for future research.

Findings:

The history of the AAR is relatively short, covering only the last 25 years. Before that period, two influences set the stage for the development of the AAR:

1. S. L. A. Marshall's "interviews after combat." This was an oral history technique, first used in World War II.

2. "Performance critique." This was a feedback technique used to provide feedback from tactical exercises before the 1970s.

The first AAR methods were implemented in the mid 1970s in training programs developed by ARI for their optically based Tactical Engagement System (TES) training programs. Soon thereafter, AAR methods were modified for the next-generation TES system, the Multiple Integrated Laser Engagement Simulation

(MILES), and to support training at the Army's National Training Center (NTC). The next important influence on the AAR process was the development of computer networked simulation systems in the mid 1980s—in particular, the Simulation Networking (SIMNET) system. ARI guided the development of two generations of low-cost systems to provide SIMNET the capability to capture and analyze electronic data for the AAR.

Since the initial AAR methods were developed for TES and NTC, ARI has developed specialized AAR methods for application to specific settings, including staff training in constructive simulations, multiechelon training in virtual simulations, and experimental programs for training digitized units. There have also been recent efforts to standardize simulation-based training programs, which include the AAR process (so-called "structured training" programs). ARI also has made input to an ongoing program to standardize and automate the AAR process: the Standard Army After-Action Review System (STAARS). Over this short history, the AAR has become a highly regarded process that has been adopted by other Services and countries.

The review of research on the AAR process indicates that AAR principles were derived from the information feedback, performance measurement, cognition and memory, group processes, communication theory, and instructional science areas of behavioral science. For each of these areas, we identified specific examples of AAR methods, practices, or products.

Five implications for future research were developed and briefly described:

1. Integrate AAR with other sources of feedback.

2. Track adherence to AAR principles.

3. Determine the utility of AAR process and products.

4. Determine the nature of problem-solving in AAR.

5. Use new technologies for content analyses.

Utilization of Findings:

The information provided in this report is intended for individuals and organizations performing R&D on AAR processes. This report provides background for research on the AAR process as well as suggestions for future research.

FOUNDATIONS OF THE AFTER ACTION REVIEW PROCESS

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

FOUNDATIONS OF THE AFTER ACTION REVIEW PROCESS

Introduction

Like combat, collective training exercises are complex events where the causal connections between individual performance, weapons effects, and mission outcomes are obscured by the uncertainty, confusion, and stress of battle (i.e., "the fog of war"). Thus, the answer to the question, "How did the unit do?," may not be immediately obvious to the exercise participants or to those who control and observe collective training exercises. However, to derive training value from these exercises requires detailed feedback to the unit on their individual and collective performance and their relation to combat outcomes.

The Army developed a process, known as the after action review (AAR), to provide such feedback. The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performed much of the research and development (R&D) for the AAR. The purpose of this report is to review the evolution of this process, identify some of the major behavioral science principles that underlie the AAR, and propose directions for future R&D.

As defined in Training Circular (TC) 25-20, A Leader's Guide to After-Action Reviews, (U.S. Army Combined Arms Center [CAC], 1993), an AAR " . . . is a professional discussion of an event, focused on performance standards, that enables soldiers to discover for themselves what happened, why it happened, and how to sustain strengths and improve on weaknesses" (p. 1). In other words, the units perform a collective self-examination in which the more general question, "How did the unit do?," is broken down into three more specific questions:

1. "What happened during the collective training exercise?" In other words, AAR participants attempt to specify the facts (i.e., the important actions and outcomes) of the simulated battle.

2. "Why did it happen?" Given the facts of the exercise, the participants attempt to explain the causes of particularly important actions and outcomes.

3. "How can units improve their performance?" Given that the previous two questions are answered, the

participants determine appropriate actions to solve problems identified in their performance. Example actions include changes to unit standard operating procedures (SOPs) or increased training on basic drills.

These questions are addressed during AAR sessions, which are conducted immediately after the end of a short exercise or during logical breaks in longer exercises. The sessions can be formal or informal. The critical difference is that the formal AARs require more planning, coordination, and preparation than the informal AARs.

AAR sessions are typically organized by echelon. Platoons are scheduled first for about 30-45 minutes, followed by companies for about 1 hour, and then by battalion and above for about 2 hours (CAC, 1993). Discussion participants are unit members who took part in the simulated exercise. The AAR discussion leader is typically not a member of the unit being trained; rather, he is a trainer who controlled and observed the exercise. Throughout the discussion, the leader acts as facilitator of—as opposed to a participant in—the discussion. Unit members have to make their own decisions and reach their own conclusions.

The leader spends considerable time preparing for the AAR—before the exercise (e.g., preparing data collection instruments) and after the exercise (e.g., collecting and aggregating performance data from various sources). Typically, the AAR leader begins the session by reviewing the objectives of the exercise and the unit's mission. Then, by asking open-ended and leading questions, the AAR leader gets the participants to relate the significant events that happened during the exercise. For each event, the AAR leader tries to solicit many perspectives to determine what really happened. After the group agrees on the facts of what happened, the AAR leader guides the discussion to a closer examination of key outcomes to determine why they happened and what could be done to improve performance.

The following fictional vignette of an AAR for an armor company illustrates some possible outcomes from an AAR session. An armor platoon fails to provide covering fire for a second platoon, causing the second platoon to be destroyed by the enemy when it is forced to cross an open area. At the beginning of the AAR, company personnel establish that an implied task in the unit's plan was that the first platoon maintain a position to observe and fire on the enemy should the second platoon become engaged. Further discussion of events reveals that the first platoon arrived late at its battle position. Based on this issue, the unit may decide to identify different methods that can be used to ensure that covering fire is coordinated with movement and to employ one or more of these methods in the future.

To facilitate the AAR process, units can employ AAR aids. For example, Figure 1 shows a situation where a unit is observing a replay of a portion of an exercise as it discusses mission execution. It is important to remember that the focus of the AAR is on unit discussions of exercise events, and AAR aids are one of many tools used to guide and encourage participation. Figure 2 shows a case where the attention of unit members is focused on the comments being made by one of their own.

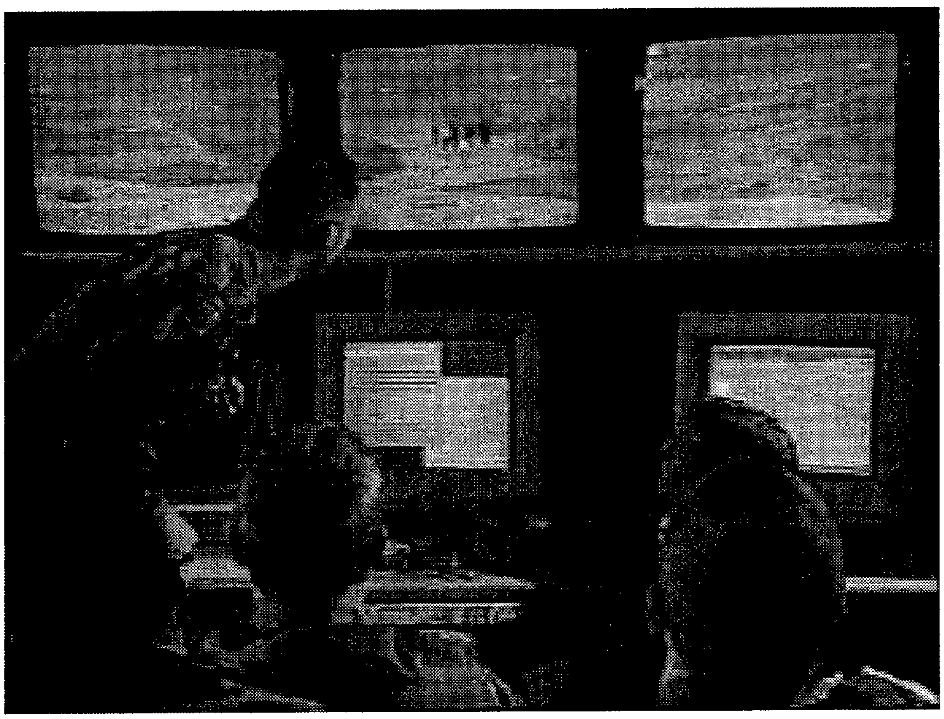

Figure 1. A unit observes a replay of an exercise segment at an AAR station from an "out-the-window" view as members discuss what happened, why it happened, and how to improve or sustain performance.

In addition to a detailed analysis of combat outcomes and unit performance, the AAR session often includes the identification of areas that deserve special attention for training. The AAR leader may identify the critical tasks

Figure 2. Participation of unit members in discussions is key to the AAR process.

performed during the exercise and, for each, ask the participants whether they think their unit is proficient (and should sustain training practices) or deficient (and should improve training). The commander, in his role as the unit's primary trainer, uses all the feedback from the AAR to assess his unit's performance.

The next two sections this report detail the foundations of the AAR. These foundations were determined by conducting two reviews of the literature. The first was a historical review to determine the evolution of AAR concepts. The second was a conceptual review of recent research on the AAR process. This second review focused on deriving the behavioral science principles that underlie the AAR process and was organized by general areas of theory and research in behavioral sciences. The final section synthesizes implications from the reviews into implications for future research opportunities.

Historical Foundations

The concept of the AAR has evolved over the last 25 years—a period that has seen dramatic improvements in collective training technology. At the beginning of this period, Army units conducted relatively free-play, force-on-force exercises that were evaluated in field settings by human umpires who were ill-equipped and poorly positioned to observe performance. Performance feedback, therefore, was based on the umpires' subjective estimates of mission outcomes (e.g., "hits" and "kills" of soldiers and systems) and judgments of overall mission success.

At present, Army units train in live, virtual, or constructive simulation environments[1] that allow automated measurement of a wide array of performance indicators, including tactical movement, engagement outcomes, and communications. Moreover, unit performance is often assessed in the context of a highly structured exercise based on a standardized training support package that specifies training objectives, training events, and performance measures. This marked progress in collective training and evaluation methods parallels the development of methods and technologies related to the AAR process. This section discusses some of the major historical developments that have shaped methods and concepts related to the AAR process.

Antecedents of the After Action Review (AAR)

An important historical antecedent of the AAR is the combat interview developed by military historian Samuel Lyman Atwood (S. L. A.) Marshall (1900-1977) (Gubler, 1997; Bosley, Onoszko, Knerr, & Sulzen, 1979; Word, 1987). S. L. A. Marshall was a member of a team of Army historians tasked to document the events of World War II as they unfolded (Everett, 1992). Initially assigned to the Pacific theater, Marshall was frustrated in his attempts to reconstruct a battle's sequence of events from normal historical data sources, such as official records and documents. Drawing on his experience as a

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[1] These three types of simulation vary primarily with respect to realism. Constructive simulations rely on simulated operators, equipment, and situations; virtual simulations rely on real operators in simulated equipment and simulated situations; and live simulation rely on real operators and real equipment in simulated situations (Sikora & Coose, 1995).

journalist and as a professional historian, Marshall developed an oral history method, which he called the "interview after combat," where he assembled battle participants immediately after the fighting had ended and conducted group interviews. Marshall and his associates would ask questions designed to lead the participants through the battles. These interviews provided a unique source of detailed information about what occurred during the battle. Their efforts expanded, and, by the end of the war, over 2,000 such interviews had been conducted in the European theater alone (Everett, 1992). S. L. A. Marshall and his colleagues extended their work to the Pacific theater and, later, to the Korean and Vietnam wars. The combat interview remains a primary method of military historical research. It became a model for the AAR by providing a method for eliciting objective and reliable information on combat performance.

Another influence on development of the AAR, albeit a negative one, was the performance critique. This was the dominant method for providing performance feedback before the development of the AAR. Before the time when methods were available to assess battle damage objectively, the outcomes of simulated battles were determined subjectively by human umpires. For instance, umpires determined the outcome of an assault on a defended position by subjectively combining factors such as numerical superiority, swiftness, and noise level of the attacking unit (Gubler, 1997). Well after the battle had ended, the senior umpire would determine an estimated outcome along with his interpretation of tactical performance, which would be provided in the performance critique. This feedback often lacked credibility because it was based largely on subjective opinion rather than on objectively measured performance and battle outcomes. The lecture-formatted critique was often negative in tone, thereby fomenting resentment among participants and resistance to the umpire's criticism.

By the early 1970s, a rapidly emerging consensus held that the traditional performance critique was not an effective performance feedback method and was actually counterproductive to the goal of enhancing unit performance. Those who implemented and participated in collective training realized that some form of feedback was needed. This feedback requirement fueled the development of the tactical engagement simulation (TES), which was designed to provide more accurate and objective feedback. Notably, in the early development trials of TES, participants would spontaneously meet to discover and discuss TES feedback to determine what happened during simulated battles (Shriver, cited in Sulzen, 1986).

To realize the benefits of new simulation techniques, the Army determined that a new approach for providing performance feedback was needed. ARI researchers led the effort to develop and implement this new method, which became the AAR. The AAR was designed to incorporate the objectivity and non-punitive atmosphere that was characteristic of S. L. A. Marshall's interviews after combat (Bosley, Osnoszko, Knerr, & Sulzen, 1979). At the same time, the AAR design avoided some of the more egregious deficiencies of the performance critique.

Table 1 compares some of the features of this new approach with corresponding features of the traditional performance critique. As can be seen, the new AAR approach for providing feedback differed from the old performance critique in both form and content. The final entry in Table 1 identifies a critical difference: whereas the performance critique is based on subjective judgment, the AAR is based on objective performance indicators. The technologies that enabled more objective methods for obtaining performance data are discussed in the next section.

Development of Simulation-Based Training Systems

As implied in the definition of the AAR, an initial and fundamental requirement is to determine what happened during a simulated battle. Thus, a significant impetus to the evolution of systematic AAR procedures was the development of objective methods for credible casualty and battle damage assessments (BDAs). The following sections describe modern simulation methods that were developed in the last 25-30 years to provide this capability and that contributed to the development of systematic AAR processes.

Tactical Engagement Simulation (TES)

In 1971, General W. C. Westmoreland, then Chief of Staff of the Army, directed a board of officers to consider new collective training approaches that were motivating and effective (Gorman, 1992). The board initially investigated a system of laser-based emitters and detectors for simulating infantry and armor close weapons effects. This system was later named the Multiple Integrated Laser Engagement System (MILES). Because the MILES technology would require at least 12 years to develop and field, the board also tasked ARI to develop rapidly an alternative, optically based TES system to help bridge the gap (Gorman, 1992).

Table 1

Contrast of Performance Critiques and AARs

Characteristics of Feedback Sessions	Performance Feedback Method	
	Traditional Performance Critique	AAR
Soldier participation	Soldiers are passive members of an audience.	Soldiers are active participants in a discussion.
Main topic of discussion	Errors committed.	Sequence of events.
Direction of communication	One-way (from leader to participants).	Two-way.
Atmosphere	Defensive.	Open to suggestion.
Instructional style	Traditional lecture.	Guided discovery learning.
Source of information: why it happened?	Exercise leader and controllers.	Participants and members of the opposing force (OPFOR) and exercise leaders and controllers.
Source of Information: what happened?	Subjective judgment.	Objective performance indicators.

ARI's work on an optically based TES system began in 1972, and the first product was fielded in 1973. This initial effort produced a method for training small, dismounted infantry units called Squad Combat Operations Exercises (Simulation) or SCOPES. The basic hardware for SCOPES was a 6X telescope mounted on every participant's rifle and helmets with numbers that uniquely identified each soldier in the exercise. To engage the opposition, a participant would identify an opponent's number, fire a blank round, and report the number to a controller. The controller would report to a counterpart controller of the opposition forces, who would then assess the participant whose number was identified as a casualty. The SCOPES approach was extended to combined arms, armor and antiarmor units in a product called REALTRAIN (Realistic Training).

SCOPES and REALTRAIN were significant because they were the first TES technologies to provide trainers and participants an objective representation of "ground truth" from tactical engagement outcomes. As such, SCOPES and REALTRAIN provided an appropriate context for the first reported implementations of the AAR process (Bosley, Onoszko, Knerr, & Sulzen, 1979; Bosley, Onoszko, & Sevilla, 1979). The training programs that incorporated these TES technologies and the AAR methods were evaluated in a series of ARI research projects (e.g., Banks, Hardy, Scott, Kress, & Word, 1977; Root, Epstein, et al., 1976; Root, Hayes, Word, Shriver, & Griffin, 1979; Scott, Banks, Hardy, & Sulzen, 1979). These studies confirmed that the SCOPES and REALTRAIN training programs were effective and motivationally engaging methods for training tactical skills; however, the AAR components of the programs were not evaluated separately. The demonstrable successes of these training packages led to their rapid adoption by the U.S. Army's Training and Doctrine Command (TRADOC). ARI helped to write the TCs published by the Infantry School for SCOPES in 1973 and by the Armor School for REALTRAIN in 1975.

MILES was introduced in 1980, but it was not put into general use until mid-decade (Gorman, 1992). Once fielded, however, its impact was immediate and significant. Zeidner and Drucker (1988) characterized MILES as " . . . one of the most revolutionary changes in combat training ever introduced" (p. 186). Compared with SCOPES and REALTRAIN, the laser-based MILES system significantly increased the accuracy of determining hits and misses. Moreover, MILES greatly reduced the number of controllers required to support a TES exercise and provided more immediate feedback to participants. Although MILES equipment was fielded to units on an Army-wide basis, its initial implementation was at the National Training Center (NTC), where force-on-force maneuvers were first conducted in 1982.

As the NTC rapidly became the Army's premier combat training setting, ARI adapted the AAR process first developed for SCOPES and REALTRAIN to the innovations at NTC, which offered several new resources and technologies for collecting and documenting objective performance data. Most notably, MILES extended ARI's earlier TES methods for providing objective performance data. In addition to MILES, other components of the NTC had a significant impact on the AAR process, including its sophisticated instrumentation system for exercise control and data collection, a highly trained OPFOR, and expert observer/controllers (O/Cs). The NTC's reliance on the AAR as their primary feedback method increased the prominence of the AAR as an effective training method. Accordingly, ARI has continued to adapt the NTC methods to other training contexts, including home station field exercises (Scott, 1983; 1984) and the Army Training Battle Simulation System (ARTBASS)(Kaplan & Fallesen, 1986).

Computer Networked Simulation

The development of the Simulation Networking (SIMNET) system also provided a great stimulus to the development and refinement of AAR processes. Developed and fielded in the 1980s, SIMNET was the first networked system of virtual simulators to be used for collective training of heavy combat units (Alluisi, 1991). Compared with TES and other live simulations, SIMNET has greatly increased the amount of information that can be captured and used in the AAR. As summarized by Meliza (1996), " . . . we went from a situation where vehicle status data were limited to periodic updates regarding the location and damage status of vehicles to the point of having near continuous updates on the locations of vehicles, the speed at which vehicles were moving, the orientation of vehicles, engine speeds, the orientation of gun tubes, the elevation of gun tubes, fuel levels, and ammunition levels . . ." (p. 13).

By providing the ability to reinitialize scenarios rapidly, networked simulations also afford units repeated opportunities to correct problems immediately and apply solutions identified in previous AARs. At the same time, networked simulations shorten the acceptable delay in providing the feedback from tactical exercises (Meliza & Brown, 1996). In live simulations (e.g., those employed at NTC), units typically perform logistic and maintenance functions, such as vehicle maintenance and resupply, immediately after an exercise. In SIMNET, these activities are either not performed or are foreshortened. Therefore, units have come to expect their AAR soon after an exercise ends.

Early Simulation Network (SIMNET) Feedback Aids and Limitations. Despite the inherent potential of SIMNET to provide detailed performance data, the initial training version of SIMNET provided no features to support automated performance measurement.[2] In fact, the initial concept for SIMNET called for

[2] This section refers to the initial training version of SIMNET, called SIMNET-T, as first implemented at Fort Knox, Kentucky. Later SIMNET-T sites, particularly those designed to support gunnery competition, included more extensive automated performance measurement systems, as did developmental sites,

using battle outcomes as the primary performance indicator. The developers of SIMNET proscribed against the use of instructors, controllers, or umpires. The AARs were to be performed solely by the chain of command as they would in actual combat: "Just as in combat, there are no overlords in this type of exercise other than the chain of command" (Thorpe, 1987). Nevertheless, two ad hoc capabilities to document and observe performance were added soon after the system was developed:

1. The Plan-View display, which provided a top-down ("bird's eye") view of the battlefield.

2. The Stealth-View display, which provided a virtual ("out-the-window") view of the battlefield from a vehicle that was not visible to participants (hence, "stealth").

When coupled with a data logger that recorded network data stream elements (or Protocol Data Units [PDUs]) associated with a simulated exercise, both the Plan-View and Stealth-View displays provided the capability to replay all or parts of the battle at variable speed and perspective. Although these features potentially provided a wealth of information for AARs, the displays were initially used primarily to prepare and control ongoing exercises. In addition, Goldberg and Meliza (1993) noted several specific deficiencies in the design of the initial SIMNET-T training facilities with regard to the AAR process:

- The SIMNET training facility allowed many exercises to be conducted concurrently but supported only one AAR at a time. Further, the system could not be used for an AAR if it was employed to support exercise control functions for an ongoing exercise.

- The system did not provide data summary tables and graphics. Despite the fact that SIMNET could provide the most extensive collection of objective data ever available to examine unit performance, it did not include tools for analyzing these data in a training environment.

- Replaying an exercise's history was a slow and cumbersome way to review unit performance. For example, one could watch an engagement lasting 15 minutes to find out that

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called SIMNET-D, at Fort Knox, Kentucky, and Fort Rucker, Alabama.

only two of the four tanks in a platoon fired their weapons, whereas one could look at a table showing rounds fired by individual tanks and immediately know who fired and who did not.

Automated Aids Appended to the Simulation Network (SIMNET). To improve the automated performance measurement capabilities of SIMNET, ARI guided the development of two generations of automated aids for the training system: the Unit Performance Assessment System (UPAS) and the Automated Training Analysis and Feedback System (ATAFS).

In 1990, ARI initiated the development of the first generation of automated performance measurement systems for SIMNET: the UPAS, which was an inexpensive, DOS-based computer system that collected and analyzed information from the SIMNET data stream. The purpose of UPAS was to provide AAR leaders the capability to create and experiment with new aids and displays, which could be produced without special knowledge of computer programming. According to White, McMeel, and Gross (1990), the prototype UPAS provided for two types of AAR aids:

- A top-down Plan-View display that provided a bird's-eye view of the battlefield.
- Graphs and tables that summarized the results of the battle.

The UPAS also provided graph and table editors that non-programmers could use to modify existing graph and table displays and/or to create new ones. Unfortunately, this useful feature of UPAS was not incorporated into successor systems.

The variety of AAR aids that could be produced with the UPAS increased with the continued development of this system, and tools were added to help users manage the presentation of AARs (Meliza and Tan, 1996). Many of the changes made in the UPAS were in response to the results of user feedback (Shlecter, Bessemer, Wade, and Nesselroade, 1994). UPAS aids were designed to capture measures of unit performance that were difficult to collect using SIMNET exercise replays. An example aid is the "Exercise Timeline," which displays a variety of battle events on a timeline. Such displays might reveal when a unit crosses a key battlefield location, such as phase lines. These data might be used to show that a unit made many long halts during its movement. This information could then be used to explain why the unit failed to arrive at its attack position in time.

UPAS offered advantages over those provided by AAR aids built into SIMNET. Although UPAS was improved continually throughout its development, Meliza and Brown (1996) pointed out some serious shortcomings that could not be overcome through software modification.

The fundamental shortcoming of UPAS was that it was implemented on an early-generation, DOS-based machine that could only execute one task at a time. Three specific problems were identified:

1. During exercises, UPAS was fully occupied collecting exercise data; therefore, the task of selecting and creating AAR aids could not begin until the end of the exercise (ENDEX). As a result, the preparation of UPAS feedback regularly exceeded the 10-20 minute time limit that was generally accepted as the minimal acceptable delay—despite software improvements designed to speed up the system.

2. UPAS could not simultaneously collect voice data linked to events while collecting network data. As a result, it could not record and play back radio communications data synchronized with visual data. The lack of voice data was deemed a serious shortcoming in determining what happened during an exercise.

3. UPAS did not provide trainers help in deciding what AAR aids would be useful for a particular exercise and how they might be used. This feature was crucial in determining whether the system would be used as designed.

With the limitations of UPAS in mind, the Army's Simulation, Training, and Instrumentation Command (STRICOM) and the Defense Advanced Research Projects Agency (DARPA) funded and ARI monitored the development of the next generation of automated AAR aids: ATAFS. The ATAFS project's goal was to demonstrate the capability to provide AAR leaders a menu of automatically and manually generated aids for use in the AAR within 10 minutes after the end of a simulation exercise (Brown, Wilkinson, et al., 1996). The ATAFS was able to meet this goal by employing platforms with multi-tasking capabilities and by using a knowledge database to automatically generate AAR aids during exercises. As a result, the ATAFS was able to provide a bin of candidate AAR aids available for use at ENDEX.

Development of Specialized After Action Review (AAR) Methods

The unique needs of particular training environments have demanded the development of specialized AAR methods. As summarized in Table 2, ARI has developed specialized methods and guidance for delivering AARs in a variety of specific training and simulation environments. In Table 2, the descriptions of the training environments are suggestive of the situational variables (echelon, type of simulation, and so forth) that necessitated the development of specialized guidance.

Bosley, Onoszko, Knerr, and Sulzen (1979) developed the first ARI document to guide Army leaders in conducting AARs. It was based upon observations of AARs in association with the use of REALTRAIN. Scott and Fobes (1982) provided a guidebook for conducting AARs at the Army's NTC. This guidebook was based, in part, on observations of AARs in association with the use of REALTRAIN's replacement, the MILES system. It was modified twice to fit new audiences. As part of ARI's efforts to support the fielding of MILES within units across the Army, Scott (1983) modified the guidebook for use by trainers at home station. Kaplan and Fallesen (1986) tailored the guidebook to fit AARs for the ARTBASS constructive training simulation.

In a 1986 ARI report, L. E. Word provided a new source of information for conducting AARs, based on his tour of duty as a senior O/C at the Army's NTC. Among other things, Word stressed the importance of having the OPFOR members participate in the AAR. These OPFOR participants bring two sources of information designed to improve the perspective of the members of the unit being trained:

1. An additional viewpoint on exercise events, as viewed from the perspective of the enemy.

2. Casualty exchange data (casualties inflicted and sustained) that would not normally be known to units because of the "fog of war."

Certain strategies presented in Word's (1987) report for improving the quality of AARs are applicable across training environments, but others have to be modified to fit different environments. This observation mirrors the trend demonstrated by ARI in 1982 and beyond to tailor AAR guidance for specific situations. Since 1982, the guidance developed by ARI for conducting AARs tends to address specific training situations, such as those described in Table 2. The column that provides

Table 2
AAR Guidance for Specific Training Environments

Program Name	Simulation Environment	ARI Publication(s)
Realistic Training (REALTRAIN)	Live, optically based simulation for platoon- and company-level training	Bosley, Onoszko, Knerr, & Sulzen (1979)
National Training Center (NTC)	Live, laser-based simulation and instrumented range for battalion- and brigade-level training	Scott & Fobes (1982); Meliza, Sulzen, Atwood, & Zimmerman (1987)
Army Training and Evaluation Plan (ARTEP)	Live, laser-based simulation for squad-, platoon-, and company-level training	Scott (1984)
Army Training Battle Simulation System (ARTBASS)	Constructive computer-based simulation for battalion staffs	Kaplan & Fallesen (1986)
Precision Range and Integrated Maneuver Exercise (PRIME)	Live, laser-based simulation and instrumented range for crew- and platoon-level tank training	Witmer (1990)
Multi-Service Distributed Training Testbed (MDT2)	Live, virtual, and constructive simulation for training multi-service personnel in close air support	Bell et al. (1997); Mirabella, Sticha, & Morrison (1997)
Virtual Training Program (VTP)	Structured programs of virtual and constructive simulation exercises from crew through brigades	Koger et al. (1996)
Force XXI Training Program (Combined Arms Operations at Brigade Level Realistically Achieved Through Simulation [COBRAS])	Structured programs of virtual and constructive simulation for brigade and battalion staffs	R. C. Campbell et al. (1999)
Staff Group Trainer (SGT)	Constructive simulation training programs for battalion and brigade staff groups	Koger et al. (1998)
Simulation-Based Multiechelon Training Program for Armor Units-Digital (SIMUTA-D)	Virtual and constructive simulation for battalion staffs of digitized forces	Winsch, Garth, Ainslie, & Castleberry (1996)

descriptions of training environments suggests that AAR methods may differ as a function of the simulation (live, virtual, or constructive) and echelon and whether the training is structured or not structured. As the options for training environments increase, the need for tailored guidance will also expand.

Various combinations of training environments and training audiences appear to present certain unique challenges to the AAR process; however, at the same time, many combinations also offer certain unique benefits. For example, consider Word's strategy of having OPFOR take part in an AAR to provide units with information about how the enemy perceived their actions. In most virtual exercises, a computer-generated force represents the enemy, so no human OPFOR take part in the AAR. Similarly, feedback resources for live training may be limited when a series of AARs are conducted, beginning, for example, at the platoon, company, and then battalion level after a battalion exercise. In the latter situation, bringing in that specific part of the OPFOR with which a particular platoon or company interacted would be difficult, so platoons and companies have to look elsewhere for the information they need.

ARI continues to analyze the feedback and AAR requirements of new developments in training and force modernization to determine whether new methods or aids are required (Brown, Nordyke, et al., 1998). ARI has focused recent efforts on developments that have immediate impact on feedback requirements: the new information sources provided by digitized command, control, communications, computers, and intelligence (C^4I) systems. Before the advent of digital communications, an O/C monitored voice communications and exercises while playing the roles of higher headquarters, supporting units, and adjacent units. With digital C^4I systems, however, much of the communication of tactical information is displayed visually on computers located in combat vehicles.

Monitoring all sources of verbal and visual information is difficult—if not impossible. The increased emphasis on monitoring communications makes it more difficult for an O/C to perform other duties, such as role playing, exercise control, and so forth. Moreover, without the input from all digital communications, the ability of the O/C to prepare AARs on the C^4I aspects of the mission has been reduced. To aid the O/C in developing AARs for digitized units, ARI is currently monitoring the STRICOM-funded development of the C^4I Training Analysis and Feedback System (CTAFS) for implementation in the Close Combat

Tactical Trainer (CCTT), the system that will eventually replace SIMNET (Brown, Metzler, Riede, & Wonsewitz, 1996; Nordyke, Gerlock, Montague, Huysoon, & Bucher, 1998). CTAFS is designed to provide AAR aids and manage the AAR presentation for digital units in a manner analogous to ATAFS, which assists the development of AARs for conventional units.

Standardization of Collective Training

The so-called "combat model" that dominated thinking in the early days of SIMNET development implied that training would be conceived and conducted by units without benefit of observers, controllers, or instructors. This model presented fundamental problems for training. For one, the concept of the unit's nearly absolute autonomy in training matters ran counter to the widely held principle that Army training should be standardized across the force. Perhaps more fundamentally, this laissez faire concept of simulation training had the potential to undermine SIMNET and other simulations' potential for improving performance on tactical tasks. Partly as a reaction to these specific problems, the Army started to standardize the methods used to conduct simulation-based tactical training.

Structured Training

In the early 1990s, ARI developed a standardized approach to simulation-based tactical training called "structured training." In general, structured training has been defined as a coherent program of instruction and practical exercises for learning and mastering specific learning objectives (ARI, 1996). In the context of simulation-based tactical training, Campbell, Deter, and Quinkert (1997, p. 6) identified the following key features of structured training:

- A focus on the performance of selected critical tasks.
- Standardized exercise control to ensure practice of the tasks.
- Standardized feedback to correct and reinforce performance on the selected tasks.
- Exercise support by means of comprehensive training material.

In structured training, the AAR is more than a mechanism for delivering feedback. It provides the foundation for the development of structured training scenarios. The design of structured training begins with the specification of training objectives (tasks and standards) to be covered in the AAR. The simulation exercises are then carefully designed to ensure that they provide the opportunity for units to perform those tasks and for the O/Cs to observe task performance (ARI, 1996). Long exercises are carefully divided into short segments to allow for frequent AARs (Bessemer & Myers, 1998). The fact that structured training exercises are more controlled allows the AARs to be more "focused" (i.e., limited to the specific training objectives that define the exercise). With this structure, the AAR leader can better anticipate whether and when key exercise events will occur and more quickly prepare appropriate AAR materials (Meliza, 1996). The standardization of scenarios and supporting materials also makes possible the development of AAR materials that can be stored on-line and reused as appropriate (Meliza & Paz, 1996).

In 1993, ARI initiated the development of materials and methods for the first such structured training program. The original training materials were named Simulation-Based Multiechelon Training for Armor Units (SIMUTA). SIMUTA comprised an integrated set of platoon and company exercises (called "tables") for implementation on SIMNET and battalion staff exercises for implementation on Janus, which is a constructive simulation for battle staff training. SIMUTA materials, developed specifically for Army National Guard (ARNG) battalions, provided a "turn-key" package of items required to execute training, including orders, overlays, and videotape demonstrations of successful performance (Hoffman, Graves, Koger, Flynn, & Sever, 1995).

SIMUTA methods and materials were implemented in a program managed by the U.S. Army Armor School. This program was called the Reserve Component Virtual Training Program (RCVTP). A key component of this program was a dedicated team of O/Cs whose role was to guide performance during the exercise and provide feedback during the AAR. According to SIMUTA guidance, AARs should occur frequently (about one every 2 hours or at the end of every table) and should be conducted about 10–15 minutes after exercise completion (ARI, 1996). AARs should include replays from the stealth (i.e., virtual) display of SIMNET and recordings of selected radio messages. Shlechter, Bessemer, Nesselroade, and Anthony (1995) investigated the effectiveness of the RCVTP and concluded that it was an effective program for training ARNG units.

The concepts of structured training and focused AARs have been adopted in subsequent training programs developed by ARI and implemented at the RCVTP, which was subsequently renamed the Virtual Training Program (VTP) to incorporate active and reserve component units (Burnside, Leppert, & Myers, 1996). In addition to SIMUTA, the additional major programs include the following:

- The Simulation-Based Mounted Brigade Training (SIMBART) program developed in 1994 for training heavy combat brigades in the ARNG (Koger et al., 1996).

- The series of efforts entitled Combined Arms Operations at Brigade Level Realistically Achieved Through Simulation (COBRAS) developed in 1995 for training active component brigades (R. C. Campbell et al., 1999).

- The Staff Group Trainer (SGT) training support packages for battalion and brigade staffs (Koger et al., 1998).

In addition, ARI has explored the impact of the digitization of C^4I systems on structured training and on the AAR process (Winsch, Garth, Ainslie, & Castleberry, 1996).

Structured training concepts have also been applied to the CCTT, which is the successor to SIMNET (Deatz et al., 1998). In particular, ARI is developing the Commander's Integrated Training Tool (CITT) to provide CCTT users a tool for selecting, modifying, and developing structured training exercises for platoons and company teams. The CITT will provide the capability to access, modify, and print all required support materials. Two versions of CITT are currently being designed: a standalone version and a distributed version that will be implemented on the Internet (Gossman, Dannemiller, & Bessemer, 1998).

Standard Army After Action Review System (STAARS)

As discussed previously, several AAR methods have been derived to fit particular training situations. Despite the variety of authoring sources and training environments, Cameron, Gentner, Schopper, and Mahaney (1997) observed that " . . . there is a solid core of agreement about what an AAR is, about its purpose and structure, and about how it should be conducted . . ." (p. 5). Even with this tacit agreement, however, there were concerns that the format and content of AAR data were not commensurable across these and other applications.

The Army National Simulation Center (NSC) initiated STAARS in 1995 to develop a structured and standard AAR process. STAARS was intended to produce AAR methods, data, and displays that are standardized across simulation environments (live, virtual, and constructive) and across application domains (training exercises and military operations [TEMO]; research, development, and acquisition [RDA]; and advanced concepts and requirements [ACR]). In 1996, STAARS came under the aegis of the Warfighter XXI (WF XXI) program. As such, it became one of the five major components of the WF XXI program, providing the needed performance feedback loop.[3]

Given ARI's long history of adapting the AAR process to specific training situations, its support of standardization efforts may seem odd, unless one considers the benefits to be gained by appropriate forms of AAR standardization (Meliza, 1999). When correctly applied, the concept of standardizing AAR aids can reduce the amount of work trainers must perform in planning, preparing and conducting effective AARs. Standardization of AAR aids can also (a) reduce substantially the costs of developing and maintaining automated AAR systems across training environments and audiences and (b) make it easier to link training conducted within a wide variety of settings with capstone training events, like rotations to a combat training center CTC.

ARI has been actively involved in the development of STAARS, including providing input to the STAARS Operational Requirements Document (ORD) and STAARS Action Plan (Meliza, 1996). Many of ARI's recommendations concern the capabilities that an AAR system must have to support the timely preparation and efficient delivery of AAR aids in a manner that keeps trainer workloads at a reasonable level and provides users with

[3] The other four components of WF XXI are (1) the Standard Army Training System (SATS), a computer-based software system that integrates and automates the Army's training management doctrine; (2) Training Support Packages (TSPs), an integrated and stand-alone set of products, materials, and instructions needed to plan, prepare and, execute simulation-based training; (3) Training Aids, Devices, Simulations, and Simulators (TADSS), technology-based tools for training soldiers and units to prescribed standards in a resource-effective manner; and (4) the General Dennis J. Reimer Army Training and Doctrine Digital Library, a globally accessible, digital repository of training knowledge sets and interactive applications to support training of individuals and units.

the flexibility to refine products in response to lessons learned regarding their utility. These recommendations were largely based on lessons learned from the UPAS and ATAFS projects.

Current Status and Future Extensions

Over the last decade and a half, the AAR process has become institutionalized in Army training and provides the focus for virtually all collective training (Lockheed Martin Federal Systems, and Illusions, Inc., 1996). The high regard for the AAR process is attested by the following recent sample of testimonials:

> After Action Reviews (AARs) have proven to be the single most important event in collective training. This trend will continue as we progress into the 21st Century (U.S. Army Training and Doctrine Command, 1997, p. 1).

> The Army's institutionalization of the AAR as an essential part of training is one of the most important training interventions ever. . . . At all levels, the AAR provides us an honest appraisal of our performance and directs our efforts to correct shortcomings (Sullivan, 1995, pp. 70, 163).

> Excellent analytical AARs during well organised and supported force-on-force scenarios against a highly capable OPFOR is the secret of the U.S. Army recovery since Vietnam (Hoare, 1996, p. 17).

Another testimony to the usefulness and generality of the AAR concept is that institutions outside of the U.S. Army have adopted it. Experts from the Training and Exercise Division of the Joint Warfighting Center (JWFC) conduct AARs for U.S. Joint Service Elements)MacDonald, 1998). AAR capabilities are also incorporated into two Joint Service training simulations: the Joint Countermine Operational Simulation (JCOS) and the Joint Simulation System (JSIMS). Foreign militaries, including the militaries of the former Soviet Union, have also used the AAR (Pitts, 1997). Finally, the AAR has been cited as a military innovation that commercial organizations should adopt to provide feedback and effect positive change (Davenport & Prusak, 1997; Sullivan & Harper, 1996.

Conceptual Foundations

One of the defining characteristics of the AAR process is that it is expressly based on behavioral science principles. Because the AAR is a multi-faceted process, these principles have been drawn from a variety of behavioral science disciplines. The purpose of this section is to identify and document the behavioral science theories and principles that provide the foundations of the AAR process. We also review recent AAR research that is relevant to those principles.

Identifying behavioral science principles was not always a straightforward process. In some cases, these principles were explicitly stated in the AAR research literature. In other cases, these principles were inferred from the guidance provided. Also, certain prescriptions were not unique to particular theories. For instance, the AARs emphasis on active learning can be derived from various points of view. The reader should keep in mind that the purpose of the analysis was not to provide a definitive and exhaustive listing of all behavioral science principles that have guided the development of the AAR process. Rather, the analysis was intended to provide an appreciation for the range and variety of the theoretical concepts that have been incorporated into the AAR.

Table 3 presents the results of this analysis. This table lists the theories and techniques that have led to methods or products that have been incorporated into the AAR process. For expository purposes, these specific theories and techniques are grouped into six general areas of theory and research:

1. Information feedback.

2. Performance measurement.

3. Memory and cognition.

4. Group processes and dynamics.

5. Communication theory and techniques.

6. Instructional science.

Each area is divided into several specific theories or methods that have given rise to AAR methods, practices, or products. These areas were then used as topics for the more detailed analysis of current research issues.

Table 3

AAR Methods, Practices, and Products Developed from Behavioral Science Principles

Research Areas	Theories and Techniques	AAR Methods, Practices, or Products
Information Feedback	Intrinsic feedback	Development of live simulation systems(SCOPES, REALTRAIN, MILES) to provide realistic BDA
		Use of AAR to determine fidelity requirements
		Live feedback requirements for emerging weapon systems
	Extrinsic feedback	Design that minimizes delay of feedback
		Improvements to take-home package (THP)
		Intervention guidelines for providing coaching and mentoring
Performance Measurement	Process vs. product measurement	Incorporation of process with product measures to aid diagnosis of performance problems
	Automated performance measurement technology	Unit Performance Assessment System (UPAS)
		Automated Training Analysis and Feedback System (ATAFS)
		Standardization of AAR through input to STAARS
	Self-assessment techniques	Experimental methods for providing feedback for multiforce exercises
Memory and Cognition	Transfer of training	Focus on tactics, not gaming
	Memory aiding	Initial review of "what happened" to refresh participants' memories
		Use of summaries to reinforce AAR points
		THPs to refresh memory after AAR
	Problem-solving/ decision-making	Determination of causes of performance problems (why)
		Determination of training solutions (how to improve)
	Mental models	Benefits of multiple points of view
		Participation of OPFOR

(table continues)

Research Areas	Theories and Techniques	AAR Methods, Practices, or Products
Group Processes and Dynamics	Social facilitation and social loafing	Exploiting the positive effects of group context
		Minimizing irrelevant distractions during AAR
		Monitoring participation to prevent "social loafing"
	Group identity and cohesiveness	Establishing positive, non-threatening atmosphere
		Minimizing "finger-pointing"
		AAR leader acting as moderator, not discussant
		Having unit identify problems and provide solutions
Communication Theory and Techniques	Descriptive communication	Use of specific statements instead of abstractions
		References to task goals and objectives
	Questioning techniques	Emphasis on open-ended questioning
	Form and content of feedback	Prescriptive model of feedback that stresses • Performance, not personal characteristics • Importance of rationale • References to goals and objectives • Strategies for improving performance
Instructional Science	Guided discovery learning	Active identification and solution of problems by unit members
		Unit control of AAR content, with AAR leader guiding the process
	Experiential learning	Active learning in a realistic group context
		Importance of iterative cycles of exercises and AARs
	Cooperative learning	Encouragement of group participation in discussions
	Systems concepts	Analysis of AAR processes and subprocesses

Information Feedback

Perhaps the most basic principle on which the AAR is based is that learning and performance are enhanced when appropriate feedback is provided. Feedback refers to information that people receive during or after performance of an action to control and learn the action. As discussed below, the feedback can come from different sources. A fundamental distinction in types of sources for information feedback is that between intrinsic and extrinsic feedback. Intrinsic feedback refers to information that is inherent to task performance, whereas extrinsic feedback denotes information that augments or supplements inherent feedback (Winstein & Schmidt, 1989).

Intrinsic Feedback

In the context of tactical training, Brown, Nordyke, et al. (1998) defined intrinsic feedback as the "downrange" information provided to collective training participants from both real and simulated sources. The simulated outcomes from tactical engagements are important sources of intrinsic feedback, providing information necessary for learning during the battle. This source of feedback is necessary to cue and guide performance during exercises, providing an opportunity for meaningful practice of task performance. For example, if a unit is receiving no feedback during exercises about the location and effects of its artillery missions, the unit cannot meaningfully perform tasks associated with adjusting and terminating the use of artillery. After the battle, exercise participants use their memory of this feedback to answer the first and fundamental issue of the AAR: to establish "what happened" during the battle.

One of the most frequently asked questions in an AAR is why a unit chose a particular course of action (e.g., Why did you decide to open fire as soon as you saw the enemy?") The question sets the stage for ensuring that the unit does what it should do to collect and interpret information about the tactical situation and then select an appropriate course of action. If there are problems with the quality of intrinsic feedback provided to units, artificial aspects of the training situation may guide unit decisions or the training environment may not allow the unit to employ an appropriate course of action. The following sections provide a discussion of ARI's involvement in issues related to intrinsic feedback, first with regard to the fidelity of virtual simulations and then with regard to requirements of live simulations.

Simulator Fidelity. With regard to intrinsic feedback, one issue that continues to interest researchers concerns simulator fidelity (i.e., the correspondence of stimuli and responses between simulators and the actual equipment that they emulate). Many simulator designers have implicitly endorsed what may be termed a "full fidelity" model, wherein the simulator is designed to emulate as much of the physical system as possible. In contrast, SIMNET developers introduced the concept of "selective fidelity," which stipulates that the simulation should replicate only those aspects of the physical system that contribute directly to training. Those aspects of the physical system that do not contribute directly are represented in low fidelity or are not represented at all (Thorpe, 1987).

ARI developed a method for rationally determining the fidelity of SIMNET after it had been fielded (Burnside, 1990). Burnside had subject matter experts rate—according to explicit criteria—the degree to which tasks could be performed within the SIMNET environment, using a 3-point scale: fully trained, partially trained, and not trained. Assuming that tasks must be at least partially performable to be trainable in SIMNET, his results indicated that 35 percent of tasks from the Army Training and Evaluation Program (ARTEP) Mission Training Plan (MTP) could be trained with SIMNET. The platoon echelon had the highest percentage of trainable tasks (41 percent) and of tasks not supported by the simulation (46 percent). On the basis of these findings, Burnside (1990) concluded that this method was an efficient analytic approach to determining the fidelity of any training aid, device, simulation, or simulator. Subsequently, these methods were used to identify appropriate training objectives for, and feedback from, the structured training exercises in SIMUTA (Hoffman et al., 1995).

Behavior of Computer-Generated Forces (CGF). Another major fidelity issue with which ARI has been involved is the realism of the behavior of friendly and enemy computer generated forces (CGF). For example, Meliza and Vaden (1995) compared two versions of software that controlled the behavior of the CGF in

SIMNET: Modular Semi-automated Force (ModSAF) Version 1.2 and Semi-automated Force (SAFOR) Version 4.1.3. One of the comparisons involved using the UPAS to examine movement speeds of tanks generated by each version of CGF as the tanks moved along the same route to decide if one was more sensitive to slope and other terrain variables that should influence speed. The SAFOR-controlled tank drove at the same speed for 98 percent of the test period, while the ModSAF-controlled tank drove at a wide variety of speeds.

Exercise Control for Live Simulations. Trainers for live force-on-force face a heavy workload. In addition to coaching and mentoring units and conducting AARs, they must often help simulate the effects of weapons and play the role of higher, adjacent, and supporting units so that the units they are training will receive appropriate intrinsic feedback. The duties associated with providing this feedback can detract from the time available to prepare for AARs.

The Army is fielding a large variety of new and innovative operational systems over the next 10 years under the "force modernization" and "Force XXI" rubrics, including new weapon systems (smart and non-lethal varieties); reconnaissance, surveillance, and target acquisition (RSTA) systems; and digital communication and decision aid systems. Training developers have suspected that the feedback requirements for these new systems will be significantly greater than those for extant systems and could overwhelm the trainers.

In response to a studies request from the TRADOC Army Training Modernization Directorate, ARI initiated a program in February 1997 to study instrumentation issues relevant to the support of AARs in the live simulation training environment (i.e., at the CTCs and at home station field exercises). The result was a document entitled "The Training Analysis and Feedback Aids (TAAF-Aids) Study" (Brown, Nordyke, et al., 1998). The primary goal of this effort was to describe the impacts of new weapons, RSTA, and digital C^4I systems on exercise and feedback functions performed by O/Cs and analysts who support training. This work also set the stage for the longer term objective of applying automation to support the training feedback process. In that regard, the secondary objective was to present high-level strategies for helping trainers address the increasing workload expected to be required by the new systems.

The TAAF-Aids Study examined the feedback requirements of 142 new systems in live, force-on-force training. Based on the capabilities of current TES and instrumentation systems, this study estimated whether specific elements of feedback would be provided by either the TES-instrumentation system, by O/Cs and the analysts who support them, or through soldier interaction with the operational system. Of particular interest were those cases where current TES-instrumentation systems fail to provide appropriate intrinsic feedback, requiring the O/C-analyst team to affect or control the exercise to provide the needed feedback.[4] On the basis of their findings, Brown, Nordyke, et al. (1998) concluded that, in the absence of effective interventions, the O/Cs, and analysts will be overwhelmed by the need to monitor and control the simulation in order to provide feedback.

Figure 3 shows how the intrinsic feedback needed to cue and guide the employment of one of the new systems during unit exercises can come from interaction with equipment, TES or instrumentation systems, and trainers. In certain cases, there may even be gaps in feedback. For cases where it appears that trainers will be responsible for providing feedback, the exercise control and functions required to provide feedback were identified in the TAAF Aids Study, as shown in Figure 4. An important Army goal is to apply automation (TES systems and instrumentation) to free trainers from supporting simulations so that they can spend more time coaching, mentoring, and preparing for AARs. In deciding where to apply automation, the Army must consider that some of the exercise control functions directly support coaching, mentoring, and AARs, while others distract trainers from these activities.

[4] Brown et al. (1998) studied the effects of modernization on extrinsic as well as intrinsic feedback. They determined that the control tasks they identified as required for intrinsic feedback also supported extrinsic feedback.

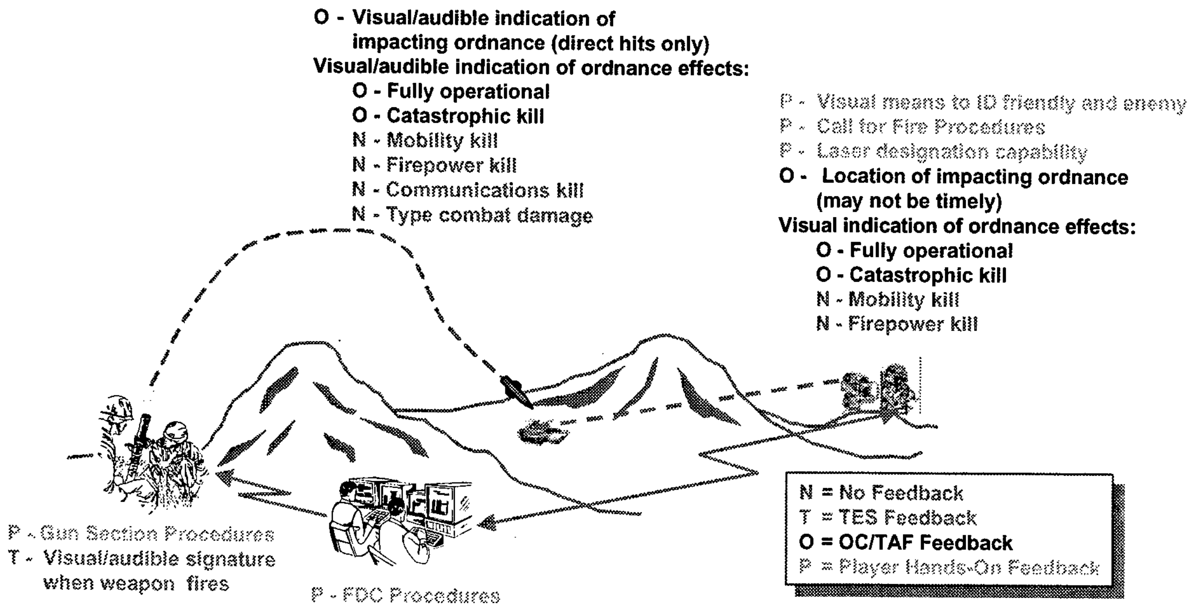

Figure 3. Sources of intrinsic feedback needed by the gun crew, fire direction center, laser designator operator, and target vehicle crew relative to employment of a 120-MM precision-guided mortar munition.

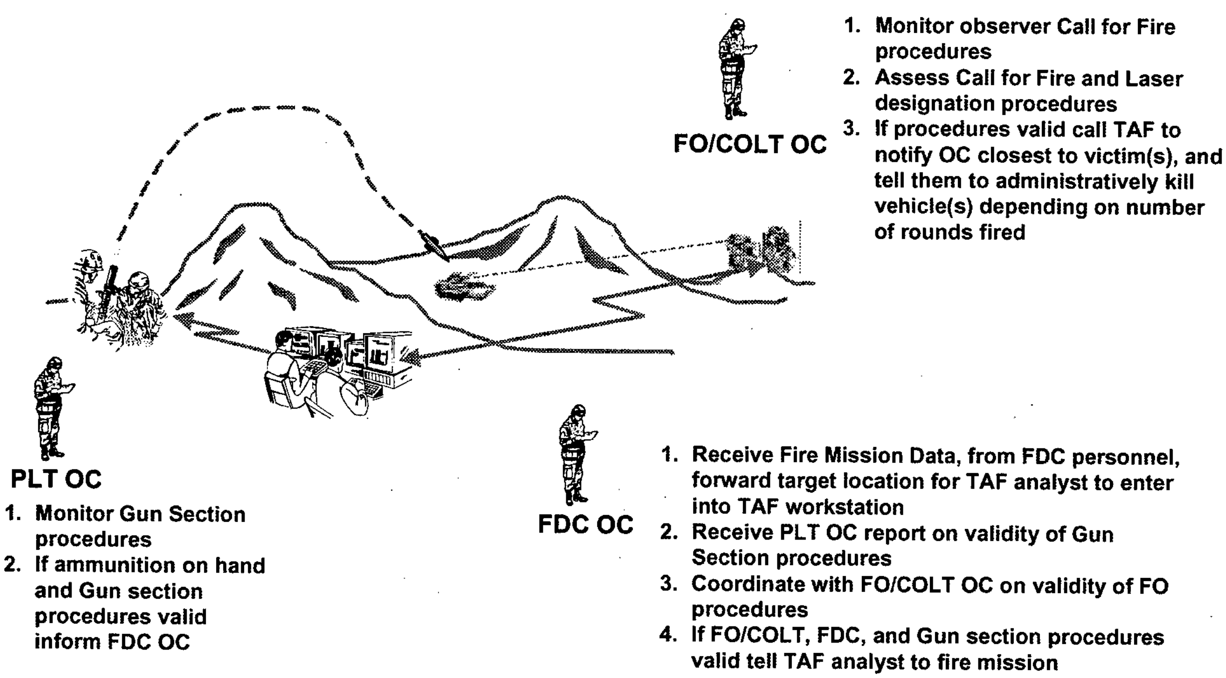

Figure 4. Examples of trainer exercise control and feedback functions involved in providing intrinsic feedback.

Extrinsic Feedback

In collective training, extrinsic feedback refers to information provided in the AAR, coaching and mentoring during the exercise, and information in the take-home package (THP) given to units after a series of exercises. Each of these sources of extrinsic feedback is discussed below.

Information Provided in the After Action Review (AAR). The information provided in the AAR is a form of extrinsic feedback that is sometimes referred to as "knowledge of results" or KR. KR has been repeatedly demonstrated to be one of the most powerful variables in the acquisition and retention of simple and complex tasks. In general, any manipulation that increases the quantity or quality of KR has a positive effect on learning and performance. According to this principle, then, AARs should be scheduled as often as possible, usually immediately after each exercise or simulated mission. Because much of the discussion during the AAR depends on the participants' memories for events and outcomes that occurred during the exercise, the AAR is usually scheduled as soon as possible after ENDEX to mitigate the effects of forgetting. To derive maximum benefit from the AAR, subsequent exercises must be scheduled soon after the end of the AAR so participants can implement lessons learned from their feedback. Accordingly, the tactical training tables and exercises developed for the VTP are designed to minimize two intervals: the interval between the original exercise and the AAR session and the one between the AAR session and the next exercise (Hoffman et al., 1995).

Coaching and Mentoring. For the most part, O/Cs interfere little in simulation exercises and allow participants to experience the consequences of their own decisions and responses. On occasion, however, O/Cs may need to intervene for reasons such as training an inexperienced crew, advancing the action, or preventing counterproductive actions. Research suggests that providing feedback during these interventions can be effective under certain circumstances; however, it must be used judiciously to prevent performers from developing a dependence on extrinsic feedback and to encourage the processing of more appropriate intrinsic feedback sources. The VTP, recognizing the need for occasional coaching while also knowing its potential problems, drafted and tested "intervention guidelines" for instructing O/Cs on when and how to intervene during a SIMUTA exercise (Hoffman et al., 1995).

Take-Home Packages (THPs). Important sources of feedback during the AAR are the discussions on how to sustain performance strengths and improve on weaknesses observed during the simulated exercise. The purpose of the THP is to document these lessons learned so that they can be implemented at home station.

ARI investigated the extent to which THP feedback is actually used by interviewing the leaders of units that had recently trained at NTC (Fobes & Meliza, 1989). Fobes and Meliza found leaders to be generally receptive to NTC feedback. In particular, unit leaders felt that information from the NTC should be used " . . . to improve unit SOPs, refine their Tables of Organization and Equipment, and address gaps in unit training plans" (p. 13). However, these same leaders criticized the print-based parts of the THP for being too lengthy and for being filled with unnecessary, irrelevant, and sometimes inconsistent details. Most important, they thought that the paper-based parts of the THP failed to provide concrete solutions for their training problems. On the other hand, the interviewees found that the videotaped AARs, which were part of the THP, provided focused and specific information that could be used to implement positive innovations. Fobes and Meliza used information from these interviews to provide specific suggestions on the structure and content of THPs.

Fober, Dyer, and Salter (1994) found similar results in their analysis of THPs from units that rotated through the Joint Readiness Training Center (JRTC). The JRTC is similar in concept and purpose to the NTC but focuses on light (as opposed to heavy) combat units. They performed a content analysis of THPs from 45 companies and 15 infantry battalions that rotated through the JRTC in Fiscal Year (FY) 1990. The purpose of their analysis was to determine the value of THPs as a source of performance measures. Overall, they found that THPs provided detailed information on unit strengths and weaknesses that is valuable both as feedback to the unit and as performance data for the researcher. However, they also noted some of the weaknesses of THPs as performance measures. In particular, they examined the training recommendations in THPs as a method to compare unit performance. Their analysis indicated that the training recommendations in the THPs tended be boiler plated information (i.e., that similar training advice is provided for all THPs). For example, many THPs included the recommendation conduct more "force-on-force, multi-echelon training." Although such information is based on actual perceived weaknesses, the generic nature of the feedback makes it difficult to implement in an actual training plan.

Performance Measurement

The AAR process is based on the objective measurement of performance, by either a trained observer or an automated system. In this section, we discuss four performance measurement issues that have a direct impact on the AAR process:

1. Product and process performance measurement.

2. Data stream issues.

3. Automated performance measurement systems.

4. Self-assessment techniques.

The first issue is primarily theoretical, concerning the types of performance measures that can and should be obtained for feedback purposes. The next two issues are essentially technological, relating to the nature of the data stream in Distributed Interactive Simulation (DIS)-based simulation systems and to the automation of performance measurement functions. Finally, the last issue addresses a different approach to performance measurement—an approach that is based on self-assessment.

Product and Process Performance Measures

A fundamental distinction in performance measurement is that between product and process measures. Product measures refer to the outcomes or end results of performance, such as number of friendly and threat vehicles lost during an engagement. Process measures refer to the procedure or technique used to achieve (or attempt to achieve) an outcome, such as percent of tasks correctly performed to standard. A similar distinction is drawn in the test and evaluation (T&E) community between measures of effectiveness (battle outcomes) and measures of performance (process for achieving those outcomes).

A primary rationale for developing TES methods in 1970 was to provide objective indicators and measures of battle outcomes. Some felt that these types of product measures were more relevant than process measures and provided all the information that soldiers needed. For example, Shriver et al. (1975) maintained that " . . . the measurement objective was to record data that indicated whether the defined job had been successfully performed . . . rather than whether the correct processes or techniques had been employed . . ." (p. 5). This same emphasis on product measurement was also notable in the early days of SIMNET development (e.g., Thorpe, 1987).

Early on, however, ARI researchers realized that process measures were necessary in AARs to identify causes of outcomes (i.e., to answer the question "Why did it happen?"). For instance, significant differences between REALTRAIN and conventionally trained units were observed for several process-oriented performance measures (Meliza, Scott, & Epstein, 1979; Scott, Meliza, Hardy, & Banks, 1979). To explain how light infantry squads approached and crossed danger areas during movement to contact missions, ARI placed a data collector on the far side of a danger area to collect this information. In the pre-training tests for both training conditions and in the post-training test for conventionally trained units, the data collectors observed most members of the squad before the first soldier crossed the danger area and usually heard the unit approaching the danger area before observing any soldiers. For the squads trained using TES and AARs, very few soldiers were observed before the first soldier crossed the danger area, and the data collector usually heard nothing before seeing the first soldier. The well-trained squads made contact with the enemy in a manner that caused minimum risk to the squad as a whole, helping to explain why these units demonstrated a higher rate of mission success, inflicted more casualties on the enemy, and sustained fewer casualties.

Training programs that were developed later have provided for the collection of product and process performance measures. For instance, the AARs in the VTP used outcome data from UPAS and process measures of unit performance collected by O/Cs (Hoffman et al., 1995). The present consensus is that both types of information are useful in AARs: product measures appear most helpful in answering the first AAR question (What happened?), whereas process measures aid participants in answering the second AAR question (Why did it happen?). Feedback can be particularly effective when those two types of data are integrated to provide a more complete understanding of battle events. An example of integrated AAR display is the Exercise Timeline incorporated in the UPAS (Meliza, Bessemer, & Tan, 1994). This display provides information on product measures (e.g., enemy vehicles destroyed) along with crew processes (e.g., radio reports) depicted on a common timeline.

Data Stream Issues

The potential for automating performance measurement functions was greatly enhanced with the introduction of computer-based simulations, which provide rich data streams for analysis and feedback. However, the technology for measuring performance on such systems is complex and is constantly evolving. ARI has continued to monitor this technological issue through the Workshops on Standards for the Interoperability of Defense Simulations, where standards are written and monitored for the DIS protocols that replaced SIMNET protocols. These standards are being developed for all U.S. Services, allied military units, and industry with the intent of supporting exercises in the live, virtual, constructive, and mixed environments.

An example data stream issue that impacts AAR is the Change of Status (COS) data packet. ARI requested a DIS data packet that would serve the same function that the COS data packet had served in SIMNET. A simulated entity sends this packet over the network when the entity is tactically damaged or destroyed, administratively destroyed, or administratively reincarnated. This packet identifies the nature of the status change and the cause of the status change. Under the original DIS protocols, there was no direct replacement for the COS packet. As a result, the AAR system (or the human operator) was tasked with deciding the cause of status changes when preparing many data summary graphs and tables, thus slowing down the preparation of AAR aids (Meliza, 1995).

Automated Performance Measurement Systems

Automating performance measurement systems have had a positive effect on the AAR process in at least two ways. First, they potentially have increased the amount and accuracy of information available for the AAR. Second, they have relieved O/Cs from many manual performance measurement functions and have allowed them to focus on other important functions, such as observing global aspects of performance and providing coaching and mentoring as appropriate. As discussed in the Historical Foundations section, ARI directed the development of two systems for automating performance measurement functions in SIMNET and other DIS systems: UPAS and ATAFS. The following sections summarize the R&D efforts that supported the production of UPAS and ATAFS. They also include research on STAARS, an evolving system that is based on the lessons learned from these two systems.

<u>Unit Performance Assessment System (UPAS)</u>. Meliza, Bessemer, Burnside, and Shlechter (1992) examined the ARTEP MTP, which describes the requirements for tactical training. From these requirements, these researchers recommended that the UPAS Plan View Display be improved by including the major terrain features and tactical control measures. Some additional recommendations included the ability to search rapidly through the exercise file (as opposed to a slower visual search) and the ability to magnify the battlefield depictions to sections as small as 200 × 200 m. In addition, they suggested that UPAS include the following display formats:

- Battle Flow. This is an animated figure that traces the movements of vehicles and units throughout the mission or mission segment. Symbols are used to mark positions at specified time periods (e.g., every minute). Unlike the Plan View Display, the symbols do not indicate vehicle and weapons system orientation. This display was primarily designed to provide feedback on movement formations and techniques.

- Battle Snap Shot. This provides still shots of vehicle positions in relation to terrain and control measures. This display includes icons that indicate vehicle and weapon system orientation.

- Exercise Timeline. This displays events on three timelines corresponding to movement, direct and indirect firing, and communication. The purpose is to provide feedback on the coordination of these three functions. Figure 5 presents a typical Exercise Timeline Display that can be used at an AAR.

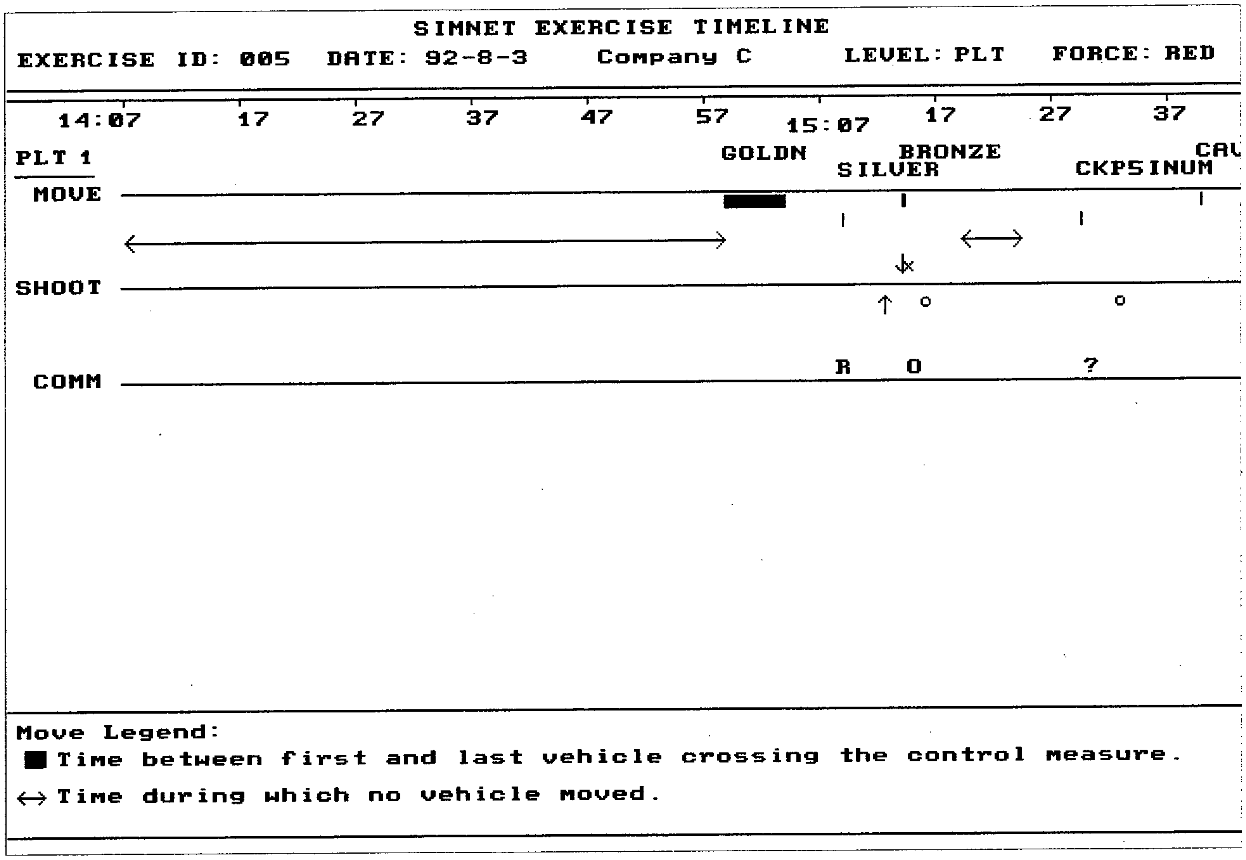

Figure 5. Example of an exercise timeline display from UPAS.

Shlechter, Bessemer, Wade, and Nesselroade (1994) had potential users of UPAS rate how likely they were to use each of the four display formats described by Meliza, Bessemer, Burnside, and Shlechter (1992): the Plan View, Battle Flow, Battle Snap Shot, and Exercise Timeline. They also had users rate two additional display formats, Battle Scorecard and Graphs, which provide summary data in tabular and graphical forms, respectively. (Figure 6 presents an example of a UPAS Graph.) Users indicated a preference for the Battle Snap Shot Display and suggested that line-of-sight vectors be added to indicate clear visual paths and blind spots in crewmembers' fields of vision. Users also suggested the development of a Fire Fight Display, which would show the results of selected segments of the battle by indicating the hits, kills, and misses for each tank by displaying color-coded vectors among all vehicles (live or dead) at the end of a designated time segment.

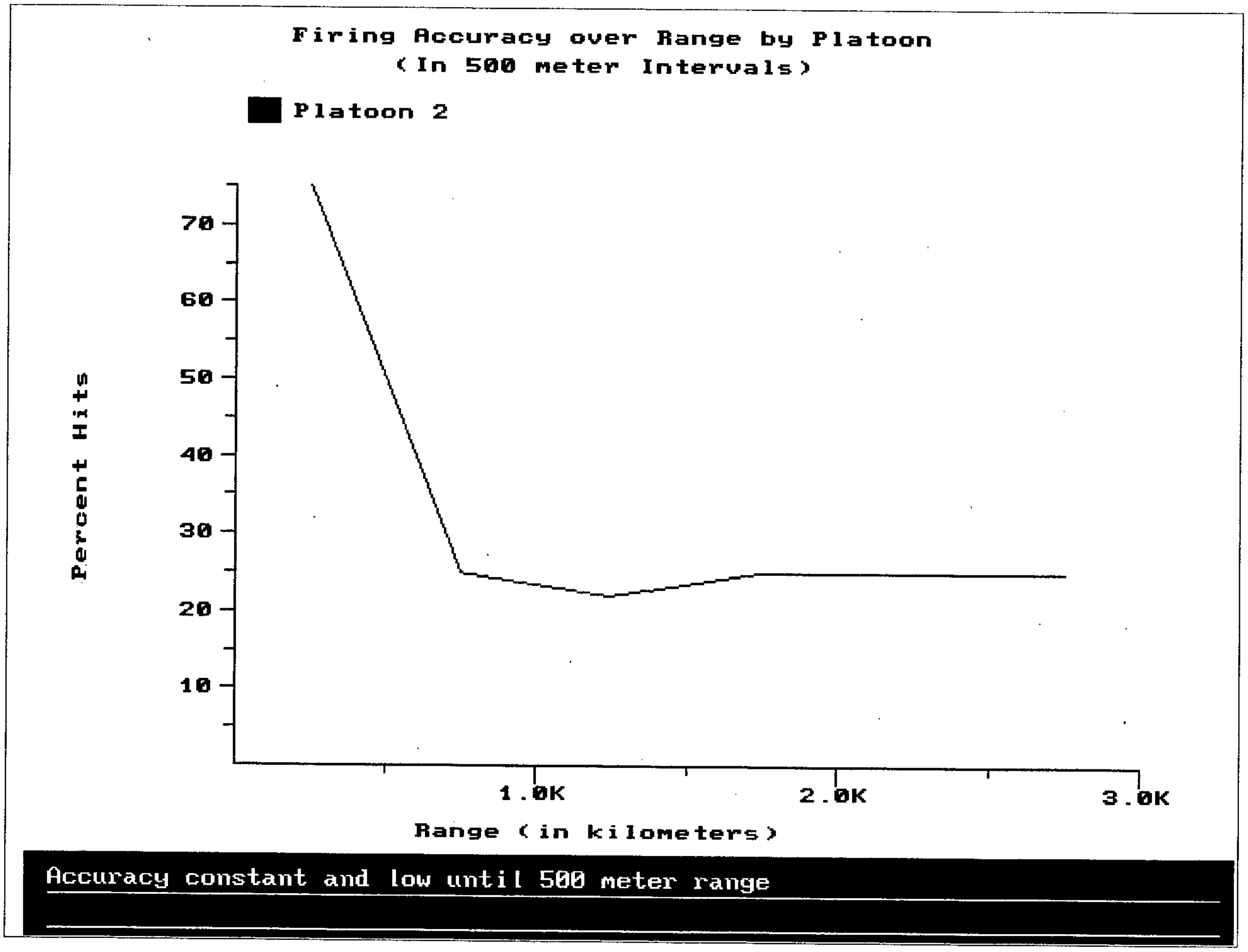

Figure 6. Example of a battle graphics display from UPAS.

Meliza, Bessemer, and Tan (1994) also documented a variety of improvements to the UPAS. In addition to display improvements described in an earlier report (Meliza, Bessemer, Burnside, & Shlechter, 1992), Meliza, Bessemer, and Tan discussed the following enhancements to UPAS:

- Improving methods to select, filter, and process PDUs from the network. The purpose was to prevent UPAS from becoming overloaded with data.
- Increasing the rate at which network data are loaded into a relational database. The goal was to have data analyzed 10 minutes after ENDEX.
- Adding a time indexing file for PDUs for use with all map displays. This facility permits users to move quickly from one point in the exercise to another.

- Introducing an AAR Presentation Manager. This tool is intended to integrate the various UPAS displays into a smooth AAR presentation.

Automated Training Analysis and Feedback System (ATAFS). incorporated four display formats that were shown to be useful in UPAS: the Plan View, Battle Snap Shot, Fire Fight, and Battle Flow. (Figure 7 shows an example of the Fire Fight Display.) ATAFS also provided graphs and tables similar to those used in UPAS. However, ATAFS differed from UPAS in some critical ways. First, ATAFS was implemented on a faster hardware platform and was better able to meet the minimum acceptable delay in preparing feedback for a SIMNET AAR. Second, the multi-tasking system and audio capabilities of ATAFS allowed it to record and play back radio communications synchronized with battle events. Third, and most important, ATAFS incorporated a limited internal knowledge base, which was designed to help the O/C choose and create AAR displays.

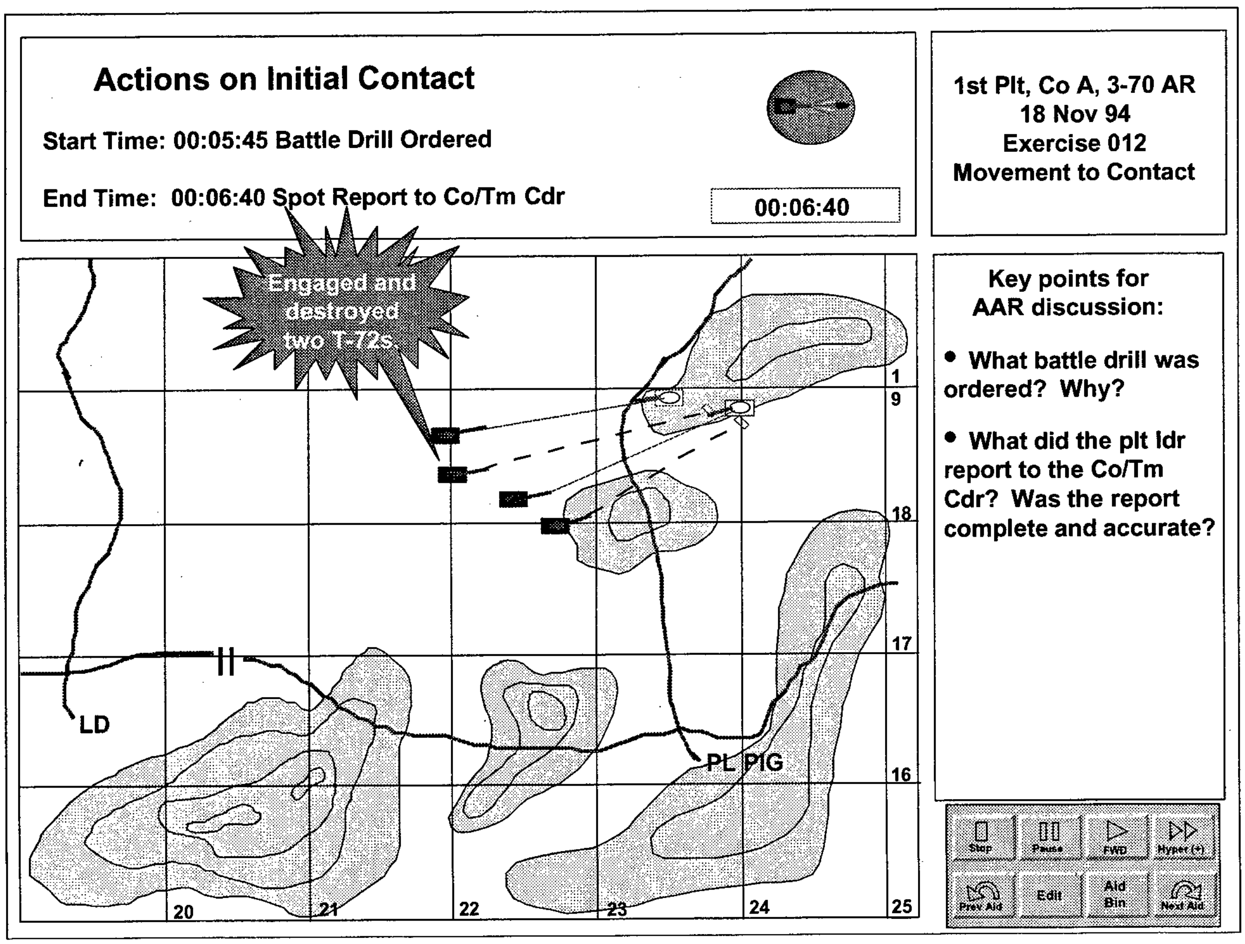

Figure 7. Example of a fire fight display from ATAFS.

The ATAFS knowledge base could be used to generate a sample set of prototype displays that were automatically created based on performance elements of the platoon task entitled "Execute Actions on Contact." In addition, O/Cs could manually generate other aids to help illustrate points in the AAR. All aids were stored in a "bin" from which the user selected and sequenced the aids for presentation. Figure 8 provides a display of items in a typical ATAFS bin. As indicated by the VCR button in the bottom right of this figure, ATAFS also has the capability to load display images onto videotape. This feature frees up the ATAFS workstation for subsequent data collection and creates a tangible product that AAR participants can replay at home station.

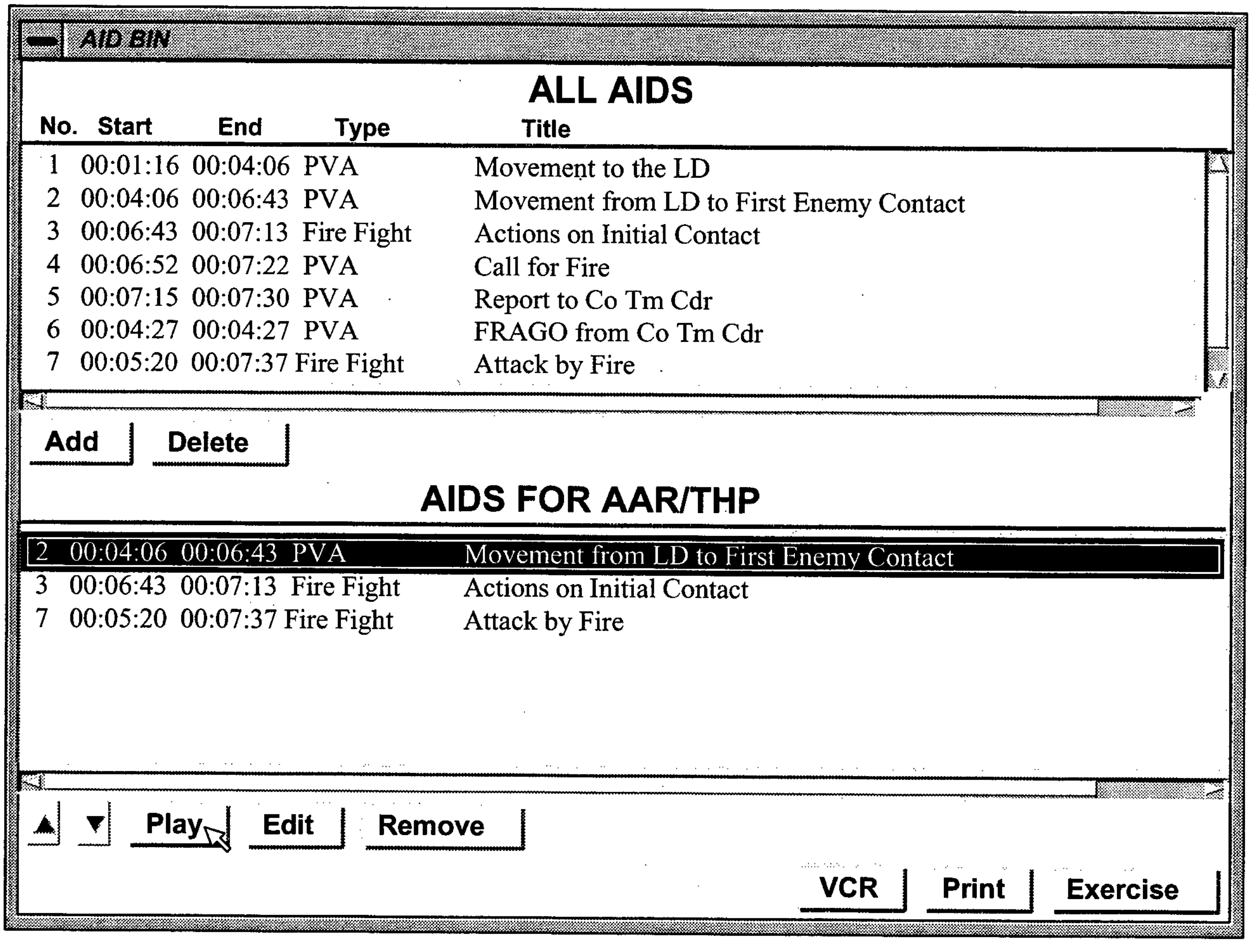

Figure 8. Example of display showing items in the ATAFS AAR aid bin.

Meliza and Brown (1996) discussed improvements to the ATAFS system that potentially increase its effectiveness in providing relevant feedback to units. The current ATAFS is capable of generating a virtually unlimited number of "ground truth" aids, which are best suited to answering the "what happened" and perhaps the "why it happened" questions. The next-generation system should include artificial intelligence components designed to aid the trainer to select and generate a limited number of aids for display during the AAR. In addition to "ground truth" aids, this system should also display aids to address the "how to improve" question. Typically, AAR leaders identify a relevant diagram from a "How To Fight" manual, which must then be displayed separately from the ATAFS displays (e.g., by using an overhead projector). The next-generation system should also include a library of such slides and provide the trainer help in selecting displays and inserting them in the proper points in the AAR.

Self-Assessment Techniques

In examining the training requirements for multiforce exercises, Mirabella, Siebold, and Love (1998) noted that the standard approaches for measuring AAR performance present some distinct disadvantages. First, the typical multiforce exercise focuses on planning and executive management functions rather than on the tactical control and performance outcomes that characterize lower echelons. Thus, automated outcome measures from simulations are not relevant to these kinds of exercises. Second, the overhead costs for O/Cs in a complex multiforce exercise would be prohibitive. Third, many of the processes pertaining to a planning exercise are covert and, therefore, are not subject to third-party observation.

Mirabella, Siebold, and Love's (1998) solution for providing feedback in multiforce exercises is to base the AAR process on self-assessments of performance that are moderated through a Delphi process. Abbreviated or "mini-" AARs are interspersed throughout these extended exercises. Before the mini-AAR, participants use standardized instruments to rate independently the performance of the tactical cell to which they belong. Then, the cell leader brings the individuals together, reviews all ratings, and identifies major differences in ratings. The cell leader then conducts a discussion among cell members to promote consensus. This procedure results in a set of group ratings on which members can agree. Note that the processes of individuals independently rating performance, identifying differences, and building a consensus are essential elements of the Delphi process of problem-solving.

Mirabella, Siebold, and Love (1998) also discuss two enhancements to this basic procedure that can be used to validate self-assessments. One enhancement specifies that those cells receiving outputs from the cell being assessed rate the timeliness and quality of those outputs. The other enhancement is to have O/Cs complete the same rating instruments that cell members complete as a check for consistency and convergent validity. Both enhancements are designed to be used as resources allow.

Preliminary applications of this self-assessment procedure have been encouraging. However, Mirabella et al. conclude that more research is needed to validate the system formally for use in higher echelon AARs.

Memory and Cognition

Researchers agree that the AAR is not simply an event where exercise participants passively receive feedback; rather, it is an instructional process where participants learn about the causes of their actions and develop strategies for improving their performance. Because the AAR is a learning process, developers have recognized the relevance of memory and cognition. The following sections discuss topics related to the learning process in the AAR.

Transfer of Training

In the present context, transfer of training refers to improvements in combat performance resulting from practice on a training exercise. One of the most fundamental principles underlying this concept is that the amount of transfer varies directly with the similarity of conditions between training and actual combat. In accord with that principle, Army doctrine encourages leaders to "train as you fight" to maximize transfer of training from simulations to combat.

Transfer of training principles have some important implications for the AAR. One is that the discussion should emphasize the conditions of combat, not those of the simulation. Accordingly, one "rule of engagement" for conducting the AAR, as stated in the STAARS Handbook, is to " . . . discuss tactics, not gaming" (TRADOC, 1997, p. 13). The AAR leader must also point out when outcomes from a simulation do not correspond to combat outcomes or to outcomes from other simulations. The intent of the tactical focus is to increase the probability that competencies acquired in the AAR will, in fact, transfer to combat situations.

Memory Aiding

The AAR learning process depends heavily on memory. Although technologies such as TES, virtual simulation, and automated performance measurement may help substantiate what happened, participants' memories of an exercise remain an essential source of information for understanding what events occurred and why they happened. Further, participants depend on their memories to remember the suggested changes to unit training identified during the AAR so that they can implement these changes in subsequent performance or at home station.

Several aspects of the AAR are specifically designed to aid the participants' memories for these questions. The AAR session starts with a review of "what happened" to refresh the participants' memories before discussing the events. The discussions provide additional details to broaden the understanding of events. The AAR concludes with a summary to reinforce the AAR points. Finally, the THPs provide cues for remembering the performance events and training solutions discussed during the AAR. As such, the THP is designed to provide a bridge between the AAR and home station training.

The potential effectiveness of these AAR memory aids is beyond question. The question is whether they are, in fact, used as designed. For instance, Fobes and Meliza (1989) found that the print-based portions of the THP were not being used to develop unit training plans because:

- The THPs were too large and complex (sometimes over 1,000 pages in length).

- Some of the detailed information was unnecessary and irrelevant, and important details (e.g., nature of deficiencies and personnel/unit involved) were often omitted.

- There were inconsistencies within THPs and between THPs and AARs.

- Training solutions are typically not provided or are buried in the details.

It would be interesting to find out if present-day THPs suffer from some of the same problems.

Problem-Solving

The authors of A Leader's Guide to After-Action Reviews (CAC, 1993) explicitly recognized that AAR is a "problem-solving process" (p. 4-3). As has been described previously, exercise participants are faced with a three-part problem, which corresponds to the three questions that comprise the focus for the AAR. The problem posed by the first AAR question (What happened?) is relatively simple in that it can be answered by studying the recorded portions of the battle and recalling events from memory. Answers to the remaining two questions (Why did it happen? and How can performance be sustained or improved?) are clearly more challenging since they require participants to make inferences about the causes and outcomes of their actions.

Many theories describe problem-solving and decision-making processes, and prescribe procedures and training techniques for enhancing these interrelated processes. Most of these theories fall on a continuum—with formal, analytic models on one end and naturalistic, perception-based models on the other end. According to the formal model (e.g., Keeney, 1982), decision-making is a linear process. Participants solve a problem by breaking it down into a linear sequence of steps. An example series of steps might be described as follows:

- Determine goals and objectives.
- Develop alternative courses of action.
- Compare and evaluate courses of action on criteria consistent with goals and objectives.
- Choose course that best matches criteria.
- Implement the decision.

The naturalistic model of decision-making (e.g., Zsambok & Klein, 1997) assumes that most real-world decisions are not—and cannot be—made in such a slow and deliberate fashion. Instead, this model maintains that decisions are based on a recognition process that matches the present problem with one or more similar problems that the problem solvers remember having faced in the past. Thus, the former model emphasizes formal analysis, whereas the latter model stresses experience in the problem-solving process.

Mental Models

A mental model is an internal construct of a learner's physical or social world to remember, think about, and explain events and concepts. In the context of the AAR, mental models help explain the events that occurred during the simulated exercise. As participants acquire more diverse details about exercise events, their mental models become more elaborate. More elaborate mental models are easier to remember and manipulate and, thus, are associated with enhanced performance. Moreover, because AARs typically involve teams of individuals (e.g., staffs, crews, platoons), they should share identical (or, at least, very similar) mental models so that they have a common understanding of events and their causes.

A particularly effective method for providing more elaborate details about the simulated battle is to hear and react to input from others. The AAR embodies this idea by encouraging participants to provide their experiences and listen to interpretations from others. This technique is particularly effective in fostering shared mental models of task performance. Another approach is to have members of other teams also discuss the events from their points of view. OPFOR members provide a valuable input because they offer a diametrically opposed point of view on the exercise.

Group Dynamics

In addition to being a learning process, the AAR is a social process in that participants come together to make collective decisions about their performance. As collective process, the facilitating and constraining effects of group dynamics are relevant to AAR processes. Some of the better known effects of group dynamics are discussed below.

Social Effects on Performance

Research indicates that the presence of others has significant effects on performance. As described below, these effects may be either positive or negative.

Social Facilitation. The AAR benefits from the positive effects of social facilitation—which is the enhancement of performance caused by the mere presence of other humans. This phenomenon is widely observed and is usually attributed to increased motivation or arousal (e.g., Zajonc, 1965). However, the presence of others may depress performance when a new and/or difficult task is being performed or when this presence causes distractions. These exceptions do not seem to apply to the AAR for two reasons:

1. Factors such as evaluation apprehension, fatigue, and exercise complexity may increase difficulty of the AAR; however, participating in AARs is normally a routine activity and is not particularly difficult.

2. AAR leaders are trained to keep the discussion focused on the key points of the AAR. While leaders encourage participants to speak freely, they request that participants speak one at a time to minimize distractions.

Another limitation to social facilitation is that the function relating number of participants to motivation and/or performance is often depicted as being non-linear in form. That is, the effect is positive up to small or moderately sized groups but decreases and perhaps turns negative as group size increases beyond some given number. This has been related to an oft-cited generalization, sometimes referred to as the Yerkes-Dodson law, that describes the effects of arousal on performance as an inverted U-shaped function: the effects are increasing up to some optimal point and decreasing beyond that. In addition to this theoretical constraint, there is a practical constraint to social facilitation: it is simply more difficult to control the interpersonal distractions in larger crowds than in smaller crowds. For both reasons, some optimal size probably exists for an AAR. However, the optimum is likely to vary with other variables, such as the format of AAR (formal or informal), the echelon (platoon, company, battalion, or higher), and the type of simulation (live, virtual, or constructive).

Social Loafing. In contrast to social facilitation, the related concept of social loafing has a negative effect on performance. Social loafing is the effect of decreased individual performance observed in larger groups, where individuals let others in the group do their work (Latane, Williams, & Harkins, 1979). The phenomenon of social loafing appears to occur when the group produces a single product and individuals are not held accountable for their own performance. Social loafing is minimized in AAR sessions because leaders encourage everyone to participate actively in the discussion. In this regard, one technique that AAR leaders use is to address questions directly to those participants who do not appear to be contributing to the discussion. In general, the best advice to prevent social loafing may be to enforce the AAR rule that requires everyone to participate actively in the process (e.g., Scott, 1983, 1984; Scott & Fobes, 1982; Bosley, Onoszko, Knerr, & Sulzen, 1979).

Group Identification and Cohesiveness. The AAR participants are not a group of unrelated individuals; rather, they are members of a unit or team. In general, behavioral research has shown that group performance improves to the extent that members identify with and are committed to the group. The document entitled A Leader's Guide to After-Action Reviews(CAC, 1993) acknowledges this effect when it states that one purpose of the AAR is to " . . . promote bonding and esprit . . ." among unit members (p. 1). Siebold and Kelly (1988) developed a short questionnaire designed to assess the cohesiveness of combat platoons. In a subsequent ARI study, Keesling, Ford, O'Mara, McFann, and Holz (1992) examined the relationship of responses to this questionnaire and platoon performance at NTC. They found a relatively small but positive correlation between performance and a component of the instrument related to the leader characteristics—specifically, his perceived competency and how well he trains with his platoon members.

A recent review of research has shown that the apparent mechanism for the positive effects of group cohesiveness is the group's commitment to the task (Mullen & Copper, 1994). Moreover, the relationship is bidirectional: cohesiveness increases task performance by increasing commitment to the task and the act of performing the task together increases commitment, thereby increasing cohesiveness. The first component of this bidirectional relationship implies that increasing cohesiveness could promote better performance in the AAR and in subsequent exercises. The second component implies that cohesiveness is a result rather than a cause of good performance in exercises—the interpretation favored by Keesling et al. (1992).

Regardless of the direction of the relationship, increased group cohesiveness is a valued outcome. In that regard, many theories and findings in social psychology suggest that the following factors increase group cohesiveness:

- Increasing intergroup interactions.
- Inducing agreement on group goals using consensus-building.

- Increasing intergroup competition.
- Reducing intragroup competition and discord.
- Emphasizing group success.
- Maintaining a pleasant, positive atmosphere.

Many factors that increase cohesiveness are operative during the AAR or are actively promoted by the AAR leader. For instance, the fact that the unit has just fought against a common enemy (intergroup competition) should increase unit cohesiveness. Kaplan and Fallesen (1986) stressed the importance for the AAR leader to maintain a positive atmosphere in which participants can disagree without fear of retribution. A Leader's Guide to After-Action Reviews (CAC, 1993) echoes this idea, recommending that leaders should " . . . create a positive atmosphere conducive to maximum participation" (p. 4-2). In addition, the leader is advised not to allow blame ("finger-pointing") to focus on any member or group of members. This reduces the threat of intragroup competition, which could reduce cohesiveness.

Another AAR strategy is also designed to increase group cohesiveness: the advice to AAR leaders that they facilitate but not take part in the discussion concerning group performance problems and solutions. Staying out of this process promotes unit integrity. It also encourages the unit to develop their own training solutions, thereby increasing group commitment toward any solution that they derive. As Scott (1983, 1984) suggested, having the unit members discover and solve their own problems promotes "ownership" of the problem and the solution, and increases the likelihood that the solutions are actually implemented. An additional implication is that the process of agreeing on these common goals should also provide feedback to promote more group cohesion.

Communication Theory and Techniques

AAR success is highly dependent on the quantity and quality of communication among participants and communication between participants and the AAR leader. Thus, implications for the AAR have been drawn from the field of communication theory and techniques.

Descriptive Communications

The term "descriptive communications" refers to a set of techniques that are regarded as being highly effective and are used in several different fields, such as management, psychiatry, and law. For the AAR, Kaplan and Fallesen (1986) described descriptive communications as methods that replace abstractions with specific statements. In so doing, these methods discourage judgmental comments in favor of more specific comments about behavior. Using the concept of descriptive communications, Downs, Johnson, and Fallesen (1987, p. B-3) derived the following four prescriptions for the AAR leader:

1. Be specific—abstractions should be avoided. Statements such as "I didn't get a good feel for . . . " or "We didn't have our timing down" should be replaced with more specific statements.

2. Be thorough—avoid the inclination "to make a long story short."

3. Focus on behaviors.

4. Refer to goals and how successfully or unsuccessfully they were met.

Use of descriptive communications techniques should have two effects on AAR processes. First, these techniques should increase AAR learning by increasing the probability of successful communication (i.e., being understood by others). Second, these methods should minimize overly judgmental comments, thereby decreasing the resentment that could result from negative feedback. This latter affective consequence increases the probability that participants will implement the strategies at home station.

Questioning Techniques

The various sources for AAR guidance consistently agree on the importance of the AAR leader's using "open-ended" questions. One of the initial ARI sources (Bosley, Onoszko, Knerr, & Sulzen, 1979) identifies asking open-ended questions as an essential skill that AAR leaders must learn. The term " . . . refers to questions that are structured to allow for many acceptable answers. . . . Open-ended questions are used to stimulate thinking and to elicit discussion" (Cameron, et al., 1997, pp. 35-36). A Leader's Guide to After-Action Reviews (CAC, 1993) advises the following:

> [The AAR leader] should not ask yes or no questions, but encourage participation and guide discussion by using open-ended and leading questions. An open-ended

question has no specific answer and allows the person answering to reply based on what was significant to him. Open-ended questions are also much less likely to put him on the defensive . . . (p. 4-3).

Because open-ended questions purportedly stimulate discussion and thought about battle incidents, they seem particularly well suited to addressing the causes of particular performance problems (i.e., the "why" question). However, recent research suggests that open-ended questions may also be helpful for the initial question (the "what happened" question). This research, which is based on naturalistic or "real-life" conception of memory, has shown that open-ended questions can improve the recall of facts and incidents (Koriat & Goldsmith, 1996). The facilitation is thought to be caused by the learners' increased control of their own memory processes.

To the extent that open-ended questions are abstract, their use appears to contradict guidance from descriptive communication that specific comments are better than abstract ones. In fact, results from ARI research (Downs, Johnson, and Fallesen, 1987) suggest that, during the AAR, specific questions tended to elicit specific comments, whereas abstract questions elicited abstract comments. Downs, Johnson, and Fallesen (1987) suggest that perhaps the best advice is to mix abstract and specific comments. The issue here appears to be one of timing: open-ended questioning may be good to initiate a discussion, but specific questions and comments may be needed later to focus on particular incidents and causes.

Form and Content of Feedback

Downs, Johnson, and Fallesen (1987) used message content analysis methods to determine the form and content of feedback provided in AARs. They examined videotaped AARs of six battalion-level exercises on the ARTBASS. Transcripts of AAR sessions identified individual utterances, which were defined as uninterrupted verbal strings. Trained analysts then classified each utterance with respect to certain characteristics, including those derived from a prescriptive model of performance feedback. According to their prescriptive model, feedback should provide four types of information:

1. Performance vs. personal characteristics. Feedback should be directed toward correctable behaviors rather than toward personal characteristics.

2. Rationale. Feedback should provide a rationale for participants' performance to explain why they did what they did.

3. Goals. Feedback information that references task goals or objectives should be provided along with specific information about performance.

4. Corrective actions. Feedback should provide strategies for continuing effective behaviors and changing ineffective ones.

Results indicated that most comments came from the battalion commander, the ARTBASS leader, and company commanders. Fewer comments came from battalion staff officers (intelligence, operations, logistics, and fire support staff officers) and from the OPFOR. The content of most messages concerned the adequacy of information provided during the battle (e.g., failure to request or provide the appropriate vital information) and coordination issues (e.g., expending resources too quickly and failure to understand battle objectives). With regard to their prescriptive model, the analysts deemed that adequate feedback was provided in three of the four categories. The exception was the relative infrequency of requests for and submissions of information on the rationales of performance. The most serious problem noted by the authors was the AAR leaders' failure to use questions to guide the AAR process.

Instructional Science

Instructional science refers to the practical science and technology related to the design, development, implementation, and evaluation of training. Because the AAR is a pedagogical process, the principles of instructional science should be used to enhance the effectiveness of the AAR. A variety of instructional science principles have been applied to the AAR process, some of which are discussed below.

Guided Discovery Learning

The concept of "discovery learning" is generally attributed to Jerome Bruner as a component of his learner-based theory of instruction. According to Bruner (1961), learning is a rearrangement and transformation of existing knowledge. This implies that learning is a personal and active process. The best method for achieving true insight is for learners themselves to "discover" the solution to problems based on their own knowledge and experience and with little or no intervention from an instructor. In his model of instruction, the teacher does not lecture; rather, the teacher facilitates the learning process. The AAR process is consistent with this model since the leader facilitates in AAR discussions rather than directly participating in these discussions. Through the process of self-discovery, moreover, unit members achieve a better understanding of events, causes of those events, and solutions for performance problems.

Early in the development of the AAR, discovery learning was recognized as an important part of the process (e.g., Shriver et al., 1975) and continues to be acknowledged in more recent publications (e.g., Cameron et al., 1997; Gubler, 1997; TRADOC, 1997). In particular, Gubler (1997) used the term "guided discovery learning" to imply that AAR leaders, although they avoid direct participation in the AAR discussion, provide direction and structure to the process. For instance, the AAR leader is typically advised to guide the discussion and to keep it focused on the key issues. The dilemma is this: whereas some guidance may be needed to keep the AAR on track, too much guidance could turn the free-play exercise into a lecture. Research should be addressed to determine the amount and kind of guidance that is actually needed in the AAR.

Experiential Learning

Cameron et al. (1997) point out that, in addition to discovery learning, the AAR is based on experiential learning concepts. Experiential learning has roots in the "project method" of instruction that dates to the early part of this century. This approach stipulates that learning is facilitated by real-world experiences and is therefore often associated with the phrase "learn by doing." This is not to deny the role of more abstract forms of learning. In fact, starting in the early 1980s, formal theories of experiential learning have increasingly specified the conditions under which concrete experience should facilitate more abstract forms of learning. For instance, Kolb (1983) has described a sequential and cyclic model of learning that includes the four stages of (1) concrete experience, (2) reflective observation, (3) abstract conceptualization, and (4) active experimentation. Furthermore, active experimentation (stage 4) restarts this cycle by causing the apprehension of a new experience (stage 1). Presumably, the AAR process corresponds to stages 2 and 3, whereas the simulation exercise corresponds to stages 1 and 4.

A key feature of the experiential learning approach is its emphasis on active learning through experimentation. In that sense, it is similar to discovery learning. There are two differences, however. First, experiential learning is more structured. It is carefully designed by teachers, and learners must critically reflect on their experiences (Fardouly, 1999). Second, discovery learning evolved from concept learning research on individuals, whereas experiential learning emphasizes the role of peer group interaction, particularly in providing feedback and helping others to reflect on the results from experience (Cameron et al., 1997).

For the AAR process, the implications of experiential learning are similar to those derived from discovery learning: to achieve maximum benefits, unit members must actively participate in the process. In addition, experiential learning emphasizes the importance of feedback from others who share the learning experience. Also, the cyclical nature of experiential learning implies that the unit realizes the full benefit from observation and conceptualization provided in the AAR only if it follows that up with actively experimenting in the simulation and experiencing the results. In many ways, the iterative cycles of exercises and AARs used in the VTP provide an ideal environment for experiential learning.

Cooperative Learning

Related to the concept of social facilitation is the instructional concept of cooperative learning. This concept stipulates that simply providing the opportunity for students to work together enhances academic achievement. Although cooperative learning is an old concept, modern research on the topic dates back only to the early 1970s. Slavin (1995) recently reviewed this work and characterized it as " . . . one of the greatest success stories in the history of educational research" (p. 1). Not only is cooperative learning a popular topic for educational research and theory, but also surveys by Slavin and others show that it is a popular teaching method across the United States.

Slavin (1995) maintained that the effects of cooperative learning are usually explained using one of four theoretical perspectives:

1. Motivation. Cooperative learning is a situation in which group members are rewarded for group, as opposed to individual, performance. This situation creates an interpersonal reward structure wherein members give or

withhold social reinforcers in response to groupmates' task-related efforts.

2. Social cohesion. Motivation is mediated by the cohesiveness of the group. That is, students help one another learn because they care about one another and want one another to succeed.
3. Developmental. Interaction among students around appropriate tasks increases their mastery of critical concepts.
4. Cognitive. Peer tutoring increases the cognitive restructuring, or elaboration, of to-be-learned material. The facilitation helps both tutor and tutee—but especially the former.

Slavin's review provided evidence suggesting that all four theoretical perspectives may influence achievement. However, the evidence for the motivational interpretation was most convincing, because almost any cooperative learning manipulation could be enhanced by the addition of group goals and individual accountability. The exception is instruction on tasks that are high in cognitive complexity—that is, tasks without a well-defined path to the solution or a single solution. In this case, it appears that participating in discussions and debates or even listening to others do so may be sufficient to enhance learning. This definition of a cognitively complex task fits the task that the participants face in an AAR session.

Like experiential learning, the research on cooperative learning suggests that AAR performance may be enhanced by active interaction among participants. The research on cooperative learning also suggests that this interaction may take the form of group discussions and even arguments among participants. Further, research suggests that the AAR leader does not have to establish a complex system of rewards to reap the benefits of cooperative learning.

Systems Concepts

Lockheed Martin Federal Systems and Illusions, Inc. (1996), in their review of the AAR concept, made the point that the AAR was originally conceived as a discrete <u>event</u> occurring at ENDEX, where a leader mediates and facilitates discussion. This concept was especially true in the early days, given that most AARs were informal in nature. However, with the advent of advanced instrumentation and data processing, much more information can now be integrated into the AAR. With more information that directly supports the unit's training objectives and increased preparation of structured materials, the AAR is now conceived as a process. This process view of the AAR has encouraged the application of systems concepts to the design, development, and delivery of the AAR. This system-analytic interpretation of AAR processes is consistent with the Army's Systems Approach to Training (SAT), which is a more general model for the design, development, and implementation of training.

Analysis of Processes

One of the distinguishing features of systems concepts of instruction is the analysis of training development and implementation into sequential phases. For instance, the original Interservice Procedures for Instructional Systems Development (IPISD) divided training development into five phases: analyze, design, develop, implement, and control (Branson et al., 1975). In turn, each of these phases was broken down into smaller units of activities called "blocks," which were broken into individual steps.

In similar fashion, Kaplan and Fallesen (1986) described the AAR process for ARTBASS exercises as comprising four phases: determine training objectives, observe the exercise, prepare the AAR, and conduct the AAR. Each phase was analyzed further into multiple sequential steps. Lockheed Martin Federal Systems and Illusions, Inc. (1996) portrayed the AAR process as comprising only three phases: preparation, execution, and review. The latter phase encompassed both the preparation and conduct of the AAR. These two analyses provide similar, but not identical, views of the AAR process.

Evaluation Component

An essential element of any systems approach to instructional development is the assessment or evaluation process, which functions as feedback to the system. For instance, the control phase of IPISD fulfills just this function. In contrast, the process models of the AAR (Kaplan & Fallesen, 1986; Lockheed Martin Federal Systems and Illusions, Inc., 1996) lack this crucial process. We need an evaluation procedure specifically designed for the AAR process. Such a procedure would allow participants and third-party observers to evaluate AAR sessions by established principles and practices. Crissey (publication in preparation) identifies some AAR objective performance measures that could be included: ratio of unit to AAR leader comments, number of solutions developed/planned, whether or not problem solution is reinforced through retraining, and time between training and the AAR and between the AAR and retraining. The instrument should also include subjective but structured items on the perceived effectiveness and efficiency of the AAR process. This proposed instrument would provide feedback to AAR leaders, who would use the information to improve their performance, and it would provide data for research on the AAR process.

Embedded System

Another hallmark of systems models is embeddedness: small systems are often embedded in larger, more encompassing ones. Accordingly, the method for developing structured training (C. H. Campbell et al., 1997) depicts the AAR process as subsystems within a larger system describing development and delivery of structured simulation-based training. In this model, the AAR process is divided into separate development and implementation subprocesses, which are embedded into two of the four components of the overall model as described below:

1. Needs analysis. Determine the critical tasks and the resources needed to train them.
2. Development of training support package. Develop all materials, including scenario and tactical materials, guides for all support personnel, and training materials, which contain observation guides and AAR materials.
3. Training processes. Identify and provide cues from the simulation, scripted messages, and role players.
4. Learning processes. Monitor performance and feedback on critical tasks, and execute the AAR.

This embedded systems model makes the point that AARs do not exist in isolation. AARs have implications for the development and evaluation of simulation exercises, and the proposed systems model of AAR processes must include inputs from and outputs to larger, more inclusive instructional systems.

Research Opportunities

Our analysis of the principles that underlie the AAR suggested several potential areas for research. Some of these areas are described below.

The After Action Review (AAR) and Other Sources of Feedback

As suggested by Brown, Nordyke, et al. (1998), the AAR should be viewed in the context of all sources of feedback. Current simulation-based training should be examined to identify appropriate and inappropriate sources of feedback, including that provided in an after-exercise session facilitated by a leader. Hoffman et al. (1995) took a larger perspective in their analysis of SIMUTA training materials, but their analysis and conclusions focused narrowly on the methods and simulations used in the RCVTP.

We propose that the requirements for feedback be examined for the general case. The proposed method would be to review the literature to answer basic questions about when and where feedback should be presented. For instance, this research could determine whether it would be better to present certain types of feedback during the exercise (as coaching and mentoring) or after the exercise. By viewing the AAR in a larger context, we see how it fits in with other complementary feedback systems.

Compliance with After Action Review (AAR) Principles

The principles that underlie the AAR are relatively well known. They are presented in Army documents (e.g., TC 25-20) and are discussed in detail in the research reports cited in this document. However, it would be useful to document the extent to which the principles outlined in this report and other Army documents are complied with in practice. Gubler (1997) attempted to do this, but his attempt was based on only seventeen videotaped platoon and company AARs from the NTC and JRTC. This sort of work should be expanded to include examples of AARs from higher echelons and from other training sites, such as ARTEPs conducted at home station and collective exercises performed at simulation centers.

A model of effective AARs should be synthesized from the research literature and military guidance. The model would suggest appropriate methods for research. For instance, one part of the model might relate to methods for enhancing memory for feedback. In that case, it would be useful to track, through interview or systematic observation, the extent to which

AAR practices enhance memory. For example, do participants engage in active discussions that elaborate on memory content? When such discussions occur, do all participants remember or understand the events? For AAR summaries, one could similarly ask the following questions: Do AAR leaders provide a summary? Is the content of AAR summaries sufficient to aid memory and understanding? Do participants remember these summaries?

The model of effective AARs may provide a potentially useful by-product of this research because it could be used to derive a checklist of activities that should occur during an AAR. This checklist could serve as an instrument for evaluating AARs. Ironically, AAR leaders, who provide feedback to units, do not have a standardized instrument for receiving feedback on their own performance.

Utility of Take-Home Packages (THPs) and Related After Action Review (AAR) Products

This issue was last addressed when Fobes and Meliza (1989) conducted interviews in March and April of 1987 on the utility of THPs from NTC. As documented in this present study, much has been learned and developed in the 10 years since their research. It would be useful to compare and contrast THPs from NTC with the automated THPs that are used at the VTP. It would also be useful to revisit this issue in a wider context than NTC, including various instances of live, virtual, and constructive simulations.

Problem-Solving and Decision-Making

The consensus among researchers and military writers is that AAR sessions involve problem-solving and decision-making processes. However, writers have not specified the nature of these internal processes as they apply to the AAR. To enhance these key processes, a more detailed concept of these processes has to be developed.

One research approach might be to compare and contrast the processes that are characteristic of successful and unsuccessful AAR sessions. Findings may help determine whether decision-making follows the formal model (e.g., Keeney, 1982) or a recognition-based process (e.g., Zsambok & Klein, 1997). Findings from such exploratory research might lead to subsequent research on appropriate prompting and/or aids for AAR sessions. If the formal model of decision-making were demonstrated to be applicable to the AAR, the literature on applied decision-making could be used to improve the AAR process. If, on the other hand, the research confirmed that successful AAR sessions are characterized by a recognition-based process as opposed to an analytic one, the instructional approach may need to center on drawing from or building up the participants' base of experience. For instance, AAR leaders may want to construct prompts to get participants to use their experience in their discussions. Alternatively, if the experience base of the participants were limited, the leader could supply appropriate cases as appropriate. Clearly, both models have implications for the conduct of AARs.

Group Cohesiveness Measures

The research literature implies that group cohesiveness can have two relations with AAR effectiveness. Cohesiveness can contribute to AAR effectiveness, and it can also be an outcome of the AAR. Empirical research should be performed to determine whether one or both of these implications are true.

ARI has developed a questionnaire for assessing the cohesiveness of combat platoons (Siebold & Kelly, 1988). The methods and items used to develop this instrument could be used to assess the cohesiveness of higher echelons. To differentiate causes from effects, experiments could be devised that vary the time of administration and/or conditions that affect cohesiveness.

Depending on the findings of the research, there should be important implications for cohesiveness and the AAR process. If cohesiveness is shown to be a positive factor in the AAR process, the AAR designers and leaders should actively promote the development of group cohesiveness before and during the AAR session. If cohesiveness is an outcome from an effective AAR, measures of cohesiveness should be incorporated as an important index of AAR effectiveness.

Computer-Aided Analysis of After Action Review (AAR) Content

Downs, Johnson, and Fallesen (1987) provided much insight into the nature of AAR feedback through detailed content analysis of videotaped AARs. However, the number of AAR samples was greatly limited because of the labor-intensive nature of content analysis. Since that time, software has been created to speed the content analysis process. This improved technology could greatly increase the potential number and range of AARs included in a sample and reduce concerns about reliability of measurement.

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Appendix A: Acronym List

AAR	After Action Review
ACR	Advanced Concepts and Requirements
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARNG	Army National Guard
ARTBASS	Army Training Battle Simulation System
ARTEP	Army Training and Evaluation Program
ATAFS	Automated Training Analysis and Feedback System
BDA	Battle Damage Assessment
BDS-D	Battlefield Distributed Simulation-Developmental
C^4I	Command, Control, Communications, Computers, and Intelligence
CAC	Combined Arms Center
CCTT	Close Combat Tactical Trainer
CGF	Computer-generated Forces
CITT	Commander's Integrated Training Tool
COBRAS	Combined Arms Operations at Brigade Level Realistically Achieved Through Simulation
COS	Change of Status
CTAFS	C^4I Training Analysis and Feedback System
CTC	Combat Training Center
DARPA	Defense Advanced Research Projects Agency
DIS	Distributed Interactive Simulation
DOS	Disk Operating System
ENDEX	End of the Exercise
FY	Fiscal Year
IPISD	Interservice Procedures for Instructional Systems Development
JCOS	Joint Countermine Operational Simulation
JRTC	Joint Readiness Training Center
JSIMS	Joint Simulation System
JWFC	Joint Warfighting Center
KR	Knowledge of Results
MDT2	Multi-Service Distributed Training Testbed
METT-T	Mission, Enemy, Terrain, Time, and Troops
MILES	Multiple Integrated Laser Engagement System
ModSAF	Modular Semi-automated Force
MTP	Mission Training Plan
NSC	National Simulation Center
NTC	National Training Center
O/C	Observer/Controller
OPFOR	Opposing Force
ORD	Operational Requirements Document
PDU	Protocol Data Unit

PRIME .... Precision Range and Integrated Maneuver Exercise
R&D .... Research and Development
RCVTP .... Reserve Component Virtual Training Program
RDA .... Research, Development, and Acquisition
REALTRAIN ..... Realistic Training
RSTA .... Reconnaissance, Surveillance, and Target Acquisition
SAFOR .... Semi-Automated Force
SAT .... Systems Approach To Training
SATS .... Standard Army Training System
SCOPES .... Squad Combat Operations Exercises (Simulation)
SGT .... Staff Group Trainer
SIMBART .... Simulation-Based Mounted Brigade Training
SIMNET .... Simulation Networking
SIMUTA .... Simulation-Based Multiechelon Training for Armor Units
SIMUTA-D ...... Simulation Unit Training Assembly-Digital
SOP .... Standard Operating Procedure
STAARS .... Standard Army After Action Review System
STRICOM .... Simulation, Training, and Instrumentation Command
T&E .... Test and Evaluation
TADSS .... Training Aids, Devices, Simulations, and Simulators
TAFF-Aids ..... Training Analysis and Feedback Aids
TC .... Training Circular
TEMO .... Training Exercises and Military Operations
TES .... Tactical Engagement Simulation
THP .... Take-Home Package
TRADOC .... U.S. Army Training and Doctrine Command
TSP .... Training Support Package
UPAS .... Unit Performance Assessment System
VTP .... Virtual Training Program
WF XXI .... Warfighter XXI

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14. ABSTRACT *(Maximum 200 words)*:

The U.S. Army has adopted the After Action Review (AAR) as its primary method of providing feedback after unit collective training exercises. The AAR is an interactive discussion in which unit members decide what happened, why it happened, and how to improve or sustain collective performance in future exercises. Other services and organizations outside the military are also beginning to employ the AAR as a feedback tool. This report describes the twenty-five year history of AAR research and development and the major behavioral research areas contributing to AAR development and refinement. In addition, this report defines goals for future AAR research.

15. SUBJECT TERMS After Action Review (AAR) Collective Training Training Feedback Intrinsic Feedback Extrinsic Feedback National Training Center (NTC) Combat Training Centers Force-on-Force Training Take Home Packages Tactical Engagement Simulation

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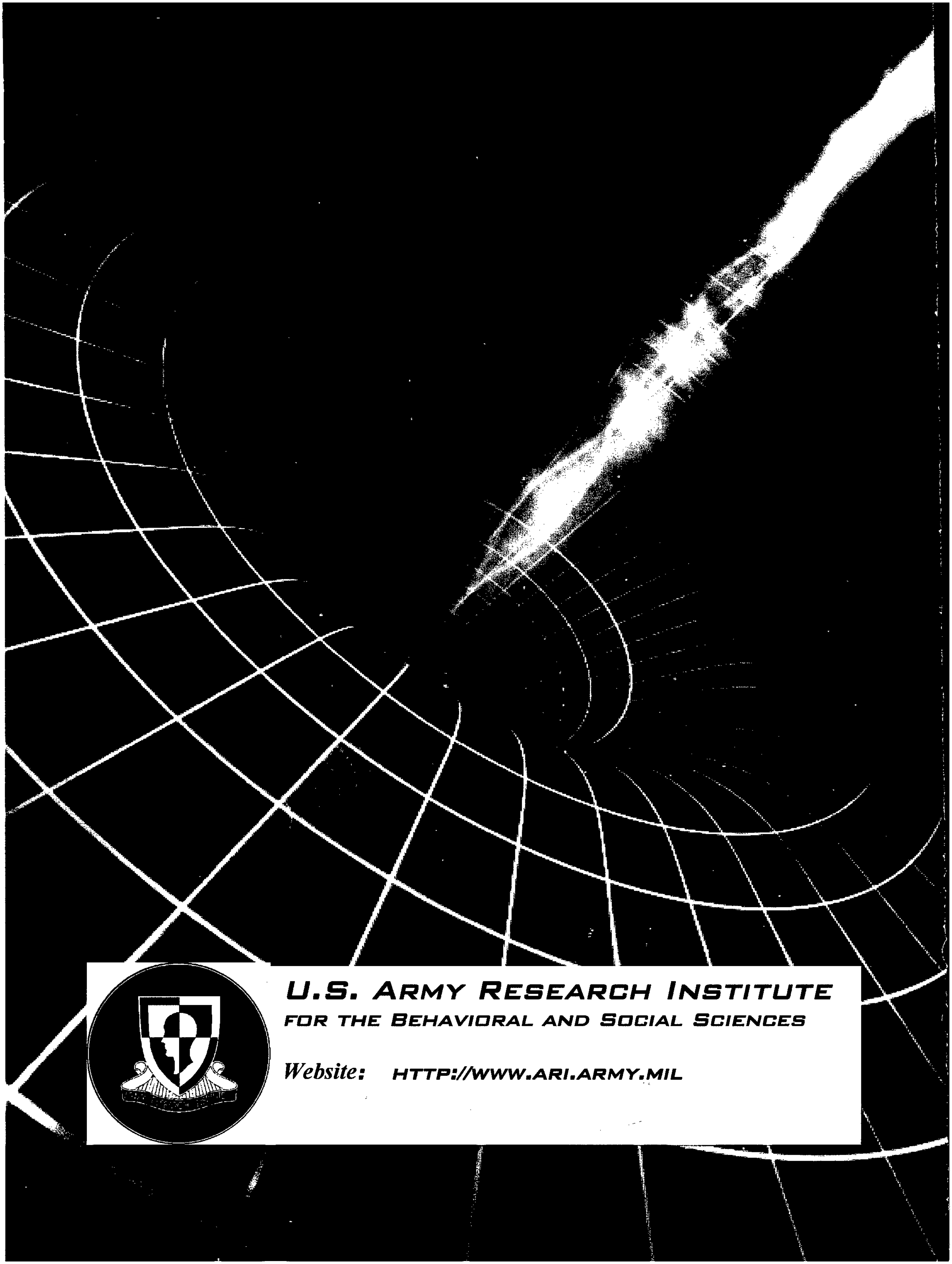

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