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Research Report 1390

Armor Training in Combat Units: Final Report.

Volume 1: Development of Methodologies for Task Selection, Prioritization, and Training Definition

Henry Simpson, Marvin C. McCallum, and Richard G. Fuller
Anacapa Sciences, Inc.

ARI Field Unit at Fort Knox, Kentucky
Training Research Laboratory

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

January 1985

U. S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Technical Director

L. NEALE COSBY
Colonel, IN
Commander

Research accomplished under contract
for the Department of the Army

Anacapa Sciences, Incorporated

Technical review by

Donald M. Kristiansen
Ronald E. Kraemer
Stephen L. Goldberg

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Research Report 1390	2. GOVT ACCESSION NO. AD-A160 330	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ARMOR TRAINING IN COMBAT UNITS; FINAL REPORT. VOLUME 1: DEVELOPMENT OF METHODOLOGIES FOR TASK SELECTION, PRIORITIZATION, AND TRAINING DEFINITION		5. TYPE OF REPORT & PERIOD COVERED Final Report (Year Two) 15 Sept 82 - 15 March 84 6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) Henry Simpson, Marvin C. McCallum, & Richard G. Fuller (Anacapa)		8. CONTRACT OR GRANT NUMBER(s) MDA903-82-C-0380
9. PERFORMING ORGANIZATION NAME AND ADDRESS Anacapa Sciences, Inc. 901 Olive Street, P.O. Drawer Q Santa Barbara, CA 93102		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 6724 2Q263743A794 4121 101
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences (PERI-IK) Fort Knox Field Unit, Fort Knox, KY 40121		12. REPORT DATE January 1985 13. NUMBER OF PAGES 107
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333-5600		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE --

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

Technical quality of this research monitored by Donald M. Kristiansen. Volume 2: Training Products, has been published as ARI Research Note 84-84.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Task analysis	Unit-level training
Task prioritization	Armor training
Task selection	M60A3 training
Training development	Tank crewmen training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Methods were developed to select and prioritize armor crew tasks, and to define the scope, content, and methods to employ in armor crew individual training. These methods were applied to the duties and tasks of M60A3 tank commanders and gunners. Methods, results, and products of this project were the task selection methodology, lists of M60A3 tank commander and gunner tasks selected, task prioritization methodology, prioritized lists of tank commander and gunner tasks, training definition methodology, 46 training modules, and Trainer's and Training Manager's Guides. (Continued)

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20. (Continued)

The task selection methodology is a 13-step top-down, mission-oriented approach that permits the training developer to select tasks systematically for coverage in unit-level individual training. Its effectiveness is limited by the quality of the source documents used and the expertise of the training developer.

Two task prioritization methodologies were developed. Method One is the most objective and reliable, but also the most time- and labor-intensive. It relies primarily on questionnaire data and enables objective, rule-based prioritization. Method Two relies primarily on subject-matter-expert (SME) judgments and is less time- and labor-intensive than the first method, but is also less objective and reliable.

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Henry Simpson, Marvin C. McCallum, and Richard G. Fuller
Anacapa Sciences, Inc.

Contracting Officer's Representative
Donald M. Kristiansen

Submitted by
Donald F. Haggard, Chief
ARI Field Unit at Fort Knox, Kentucky

Approved as technically adequate
and submitted for publication by
Harold F. O'Neil, Jr., Director
Training Research Laboratory

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

January 1985

Army Project Number
2Q263743A794

Education and Training

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FOREWORD

The Chief of Armor and the Close Combat (Heavy) Mission Area Analysis have identified a need for rapid train-up packages in Armor. Heavy personnel and equipment losses sustained by armor units on the modern battlefield will have an adverse impact on combat mission success. While tanks can be recovered and made combat ready relatively quickly, tank crew position vacancies will be more difficult to fill. To quickly replace these vacancies, units must be able to draw from all their available crewmen. Such rapid reassignments require that surviving armor crewmen must be able to assume crew positions for which they are not trained and non-armor unit personnel must be able to perform some critical armor tasks. Thus, units must provide training to armor personnel on difficult crew position tasks (cross-train) and initial training to non-armor personnel in highly combat-critical tasks (train-up).

This report presents methods for selecting and prioritizing tasks so that valuable and scarce training time during force reconstitution or mobilization can be used most efficiently and documents the development of a novel, non-commissioned officer oriented training method for use during the training of individual skills in an armor unit. The task selection methodology derives from the top-down, mission-oriented training approach described in ARTEP 71-2. A 13-step procedure permits the training developer to select tasks systematically for coverage in unit-level individual training. Two task prioritization methods were developed: one objective and reliable but time- and labor-intensive, the second less time-and labor-intensive but also less objective and reliable. The training methodology is based on the Army's performance-oriented training approach. Volume 2 of this report presents prototype training materials and training and training manager's guides.

EDGAR M. JOHNSON
Technical Director

EXECUTIVE SUMMARY

Research Requirement:

To develop and demonstrate methods to select and prioritize armor crew tasks, and to define the scope, content, and methods to employ in training packages that could be used to train armor crew personnel in their crew position, cross-train them for other crew positions, and prepare crewmen for combat after mobilization.

Procedure:

Work performed on this project consisted of four major tasks:

- Develop a methodology to select tasks for coverage in unit-level training
- Develop methodologies to prioritize tasks and determine appropriate training order
- Develop a methodology to define training based on tasks--develop training management plans and training products to use during training delivery
- Apply task selection, prioritization, and training definition methodologies the duties and tasks of M60A3 tank commanders and gunners

Findings:

Methods were developed to select and prioritize armor crew tasks, and to define the scope, content, and methods to employ in armor crew individual training. These methods were applied to the duties and tasks of M60A3 tank commanders and gunners. Methods, results, and products of this project are as follows:

- Task selection methodology
- Lists of M60A3 tank commander and gunner individual tasks selected by applying the task selection methodology.
- Task prioritization methodology
- Prioritized lists of M60A3 tank commander and gunner individual tasks
- Training definition methodology
- Forty-six training modules for use by training supervisors in conducting M60A3 tank commander and gunner training
- Trainer's and Training Manager's Guides for use by unit-level personnel in conducting and managing individual training with the modules

Key objectives in developing both the task selection and prioritization methodologies were to develop methodologies that were (1) objective and reliable, and (2) capable of being employed by Army training developers.

The task selection methodology derives from the top-down, mission-oriented training approach described in ARTEP 71-2. It is based primarily on Army documentation, particularly the Soldier's Manual (SM). It consists of a 13-step procedure that permits the training developer to select tasks systematically for coverage in unit-level individual training. The method's effectiveness is limited by the quality of the source documents used and the expertise of the training developer. Informal validation has shown the methodology to be effective and reasonably objective and reliable for methods of this type, i.e., analytical methods that rely on the judgments of subject matter experts (SME).

Two task prioritization methodologies were developed. Method One is the most objective and reliable, but also the most time- and labor-intensive. To employ it, the training developer must create three questionnaires, administer them, collect and analyze data, develop task dependency networks, and then derive training orders. The first two questionnaires must be administered to approximately 50 subjects and the last to about 15. Total SME time to complete the questionnaires is approximately 130 man-hours. This methodology produces objective and reliable results. Computerization could considerably reduce the amount of analysis required, but additional research and development would be required to create the necessary programs.

Prioritization Method Two employs two questionnaires instead of three--for a total SME time of approximately 100 man-hours--and relies primarily on SME judgments for performing prioritization. This methodology is less time- and labor-intensive than Method One, but is also less objective and reliable.

The training definition methodology is based primarily on the instructional system development (ISD) model, but also incorporates elements of the Army's performance-oriented training approach and of the findings reported in the research literature in training and cognition. It permits the training developer to start with a task analysis and to define systematically the scope and content of a training program for unit-level individual training. The methodology provides the training developer with guidance in determining unit-level training constraints, identifying training resources, selecting appropriate learning activities and resources, and planning the training products for use in training delivery. The training definition methodology was applied within the context of M60A3 armor units and to the duties and tasks of tank commanders and gunners. Training guides and modules were developed to support training on 11 tank commander and 12 gunner individual tasks.

Utilization of Findings:

This report describes the development of the task selection, prioritization, and training definition methodologies, and contains the results of applying those methodologies to a set of armor crewmen tasks. These methods and results will be useful to other researchers, to training developers, and to Army decision makers considering further research or product development in the areas of task selection, prioritization, or training development.

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INTRODUCTION

In recent years, the Army's unit training problems have been well publicized and have been the subject of much discussion. Though the Army has always had training problems, those at the unit level today are unique. They stem from Army policy changes of the mid-1970s to transfer a large part of the training responsibility from formal schools to operational units. This placed new burdens on unit personnel who, in many cases, already felt overwhelmed by the responsibilities of fulfilling their operational mission in an austere economic environment.

The One-Station Unit Training (OSUT) received by a new tank crewman prior to assignment to a unit trains him to perform effectively on only a small percentage of his duty tasks. Army policy is to give limited formal training before assigning personnel to units. Units must therefore develop and implement technical training programs for their personnel as best they can. Most of this training must be done by first-line supervisors--platoon sergeants and tank commanders. These personnel are the key to unit-level training. Unfortunately, many of these supervisors lack both the technical and training skills necessary to be effective trainers. Effective training at unit level also requires careful management to assure that training time is allocated and that this time is used effectively. This management responsibility falls upon platoon leaders, who generally lack the experience necessary to manage training effectively.

Many units are short of experienced NCOs, and there is a rapid rate of turnover of those who are available. These problems may be especially severe with new armor systems such as the M60A3 and M1. Since these systems are new, many NCOs have little experience with them, making their jobs as trainers that much more difficult.

First-line supervisors who want to train their subordinates face several obstacles. One of the first is to decide what to cover during training. The logical place for the supervisor to find out is the Soldier's Manual (SM). By Army doctrine, the SM is the central document around which skill training revolves. It describes the task, conditions, and standards for each task that a soldier at a given skill level, in a particular MOS, is responsible for performing. The SM has not been as effective as it could be for a number of reasons. One of these is that the list of tasks it contains is incomplete. Many tasks which soldiers must perform are left out because they are not critical for the MOS. Even with its omissions, the SM contains an enormous number of tasks, and these are listed without assigned priorities for training. The tank commander, platoon sergeant, or platoon leader--picking up the SM and attempting to decide where to start--gets no help from the SM. In it, all tasks have the same priority. The task omissions and lack of prioritization pose serious problems. Since each unit is, in effect, required to develop its own training plan, it must interpret the SM, select the tasks, and attach priorities to them. Doing this is no easy matter. It is highly improbable that any two units would come up with the same training plan.

In summary, the unit training environment is not promising for effective individual training. The supervisors responsible for conducting training are not equipped to do so, and the training materials available to them are limited. Morever, the unit leaders responsible for planning, managing, and overseeing this training lack the necessary skills. What is basically needed is a "turn-key" training

system that can be taken to armor units and put to use. This system would perform all of the following functions:

- Identify the tasks to cover in training.
- Prioritize them in terms of importance, and identify an appropriate training order.
- Provide ready-to-use training packages that unit trainers can take off the shelf and use to conduct training.
- Provide management plans that unit leaders can use to plan, manage, and oversee training.

This project was designed to develop the methodologies to perform these four tasks, and to apply these methodologies in armor units equipped with the M60A3 tank.

Research Objectives

The overall objective of the research was to develop and demonstrate methods to select and prioritize armor crew tasks, and to develop training modules that could be used at unit level to train armor crew personnel in their crew position, cross-train them for other crew positions, and prepare crewmen for combat after mobilization. The project focused on the individual tasks of tank commanders and gunners in armor battalions equipped with the M60A3 tank.

Project Overview

The technical approach for the project was divided among four major tasks. The relationships among these tasks are shown in Figure 1. Tasks 1, 2, and 3 involve the development of a methodology for task selection, prioritization, and training definition. In task 4, these methodologies were applied to the development of training products for training M60A3 armor crewmen.

This report describes each of the first three project tasks, in separate sections. Project Task Four (Apply Methodology to M60A3 System) is discussed within each of the first three sections as it applies to task selection, prioritization, or training definition, respectively.

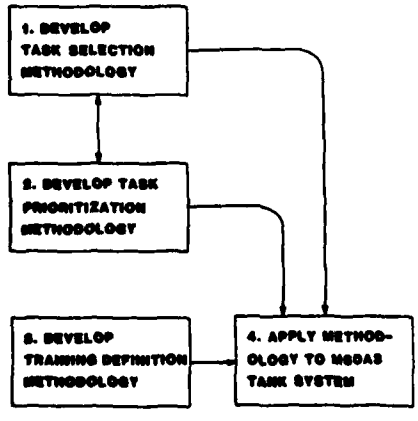

Figure 1. Project tasks.

TASK SELECTION METHODOLOGY

Introduction

The main objective of this task was to develop an objective and reliable method to identify and select the individual tasks to cover in unit-level training. This method could then be applied to specific weapon systems and MOSs in order to develop inventories of tasks to cover in training. During the project, work focused on a specific MOS (19E, armor crewman) and weapon system (M60A3 tank). However, the methodology is general and was intended to apply to other MOSs and weapon systems.

The reason that such a methodology is needed is that training developers need an effective method to focus in on the tasks that should be covered in a unit-level training context. In addition, task selection has traditionally been done in a subjective and somewhat arbitrary manner by subject matter experts (SMEs) whose decision criteria were usually obscure and whose selections lack consistency from SME to SME.

The starting point in this work was a close examination of the task-related information that is available to training developers. In recent years, the Army has moved closer to defining, in clear and explicit terms, the individual and collective tasks its personnel are expected to perform. Performance-oriented training has been one of the central reasons for the current emphasis on task documentation and analysis. Most of the individual and collective tasks can be determined by examining Army Training and Evaluation Programs (ARTEPs), crew drills, battle drills, and Soldier's Manuals (SMs). These and other sources provide a base upon which the trainer can develop training programs.

However, there are shortcomings in existing task documentation. This is particularly true for individual tasks. Tasks listed in Soldier's Manuals are "critical" tasks for training. The SM is generally adequate for Skill Qualification Test (SQT) purposes, but is inadequate as a basis for unit training. Second, the "crosswalk" between collective and individual tasks is inadequately defined. The ARTEPs contain such crosswalks, but they have many gaps. This crosswalk is important because there is a logical progression in training personnel first on individual tasks and then transitioning to training on collective tasks that incorporate the underlying individual tasks.

This project task addressed these three problems. A complete inventory of individual duty position tasks was produced, and a task "crosswalk" describing the interrelationships among individual and collective tasks was developed. This section of the report describes the task selection methodology that was developed.

One of our central concerns was to develop a methodology that would work effectively in the hands of others, work in other contexts, and be cost-effective. During the project, the methodology underwent several revisions and refinements. Its basic structure is built on the Army's top-down, mission-oriented training approach.

This methodology and preliminary results were described in Jarosz (1982); Fuller, Jarosz, and Simpson (1983); and McCallum, Fuller, and Simpson (1983). The development and application of the methodology produced a number of results, including complete listings of individual tasks for MOS 19E, collective/individual

task crosswalks for tank commanders and gunners, and a User's Guide that tells how to perform task selection. For the sake of brevity, these results are not included in the present report. The interested reader should refer to the references cited.

Development of the Methodology

There were four steps in developing the methodology: (1) define guidelines and assumptions for methodological development, (2) design methodology, (3) apply methodology and obtain results, and (4) have SMEs review results. Following SME review, the methodology underwent further revision.

The following guidelines were used in initially designing the selection methodology:

- The method had to be congruent with the ARTEPs. The ARTEP is a mission-oriented document that relates missions to subordinate collective tasks and subordinate individual tasks. Our method had to acknowledge this general hierarchical approach--beginning at mission level, relating missions to collective tasks, and relating collective to individual tasks. The key source document was ARTEP 71-2.

- The approach had to be one that could be followed by Army training developers using available documentation. From this it followed that the source information used in identifying and selecting tasks had to be obtained primarily from documents published Army-wide (ARTEPs, Soldier's Manuals, battle drills, crew drills).

- The approach had to be rational rather than empirical and, to the extent possible, had to avoid the use of elaborate surveys or other labor-intensive data collection procedures.

Starting with these guidelines, we developed a preliminary methodology and applied it to the missions and collective and individual tasks identified from Army documents. We produced a draft document describing the methodology and the results obtained by applying it and submitted the draft to ARI. Following ARI review, we revised the methodology, obtained new results, and resubmitted a summary of the methods and results. Through further work and discussion, the methodology underwent considerable revision, refinement, and simplification.

Task Selection Procedure

The following is a brief description of the procedure for performing task selection. The procedure begins by focusing on missions. Once missions have been identified, attention is directed toward the collective tasks performed during each mission. A collective task is any activity performed by a team in support of a mission--such as preparing for operations or taking action on contact with the enemy. Next, individual tasks are identified by reviewing primary source documents. Individual task lists are later refined into lists of tasks that apply to the duty position and the item of equipment. The task descriptions obtained from primary source documents are then reviewed and revised, so that comparable levels of activities are described for each task. Tasks are then grouped into categories

and reviewed by SMEs. In the final two steps, each task is associated specifically with a crew position and the individual tasks which comprise a collective task are identified.

This procedure uses a top-down approach--from missions to collective tasks to individual tasks.

For purposes of clarity, it is necessary to make the distinction between four types of tasks.

- **Collective task:** An activity performed by a crew, acting as a team, in support of a mission. Collective tasks are identified in ARTEPs. Examples of collective tasks for tank crews are: Prepare for operations, move, provide overwatch, and take action on contact.

- **Individual task:** An activity performed by one or more crewmen in support of a crew collective task. Examples of individual tasks performed by tank commanders for the collective task "take action on contact" include: Direct machinegun engagements, engage area targets with caliber .50 machinegun, and engage moving targets with main gun in normal mode from tank commander's station.

- **Common task:** An individual task that can be performed by soldiers in any MOS. Common tasks for tank crewmen include: Read a map, move through enemy territory, and safeguard classified information.

- **Shared task:** An individual task that can be performed by any crewman and that is not specific to a duty position. Examples of shared tasks for tank operations include: Stow ammunition, maintain M3A1 submachine-gun, and remove/install track pads.

Task selection begins with certain givens in terms of missions, equipment, MOS, and crew positions. Once these have been chosen, selection can proceed systematically and in accordance with the logic flow illustrated in Figure 2. Task selection during this project focused on a wide range of combat missions, the M60A3 tank, MOS 19E, and the crew positions of gunner and tank commander.

The task selection procedure is illustrated in Figure 2. This procedure consists of 13 steps, five of which involve decisions that permit tasks to be deleted. In overview, the procedure works in a top-down fashion, beginning with missions, next focusing on collective tasks, and then on individual tasks. Once the data base has been compiled, subsequent steps classify tasks, filter the list to meet certain criteria, and refine the list further. The procedure is described in greater detail in the paragraphs that follow.

Step 1. The analyst identifies unit missions that apply to the MOSs, tasks, and weapon systems of concern in the particular training context. Unit missions are identified from the appropriate Army Training and Evaluation Program (ARTEP) for the type of unit. A list of relevant missions for the unit is compiled. To illustrate, ARTEP 71-2 is the ARTEP for armor units. A review of this ARTEP reveals five armored vehicle and tank crew missions relating to armor crewman tasks. These missions are Prepare for operations, Survive, Move, Attack, and Defend.

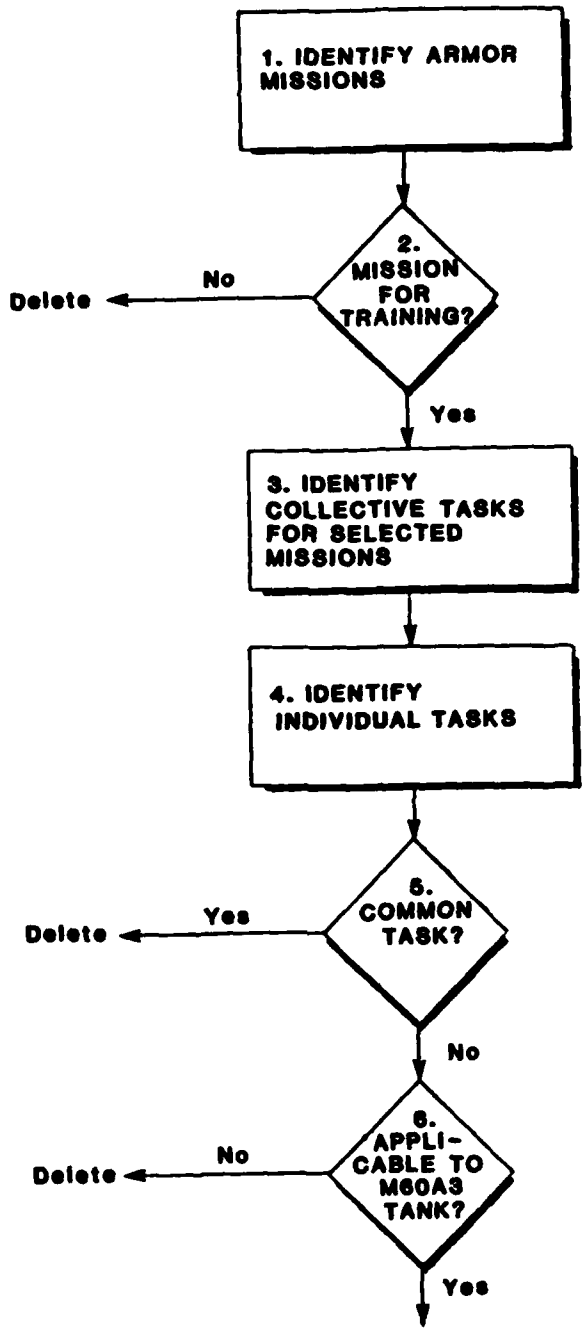

Figure 2. Task selection procedure.

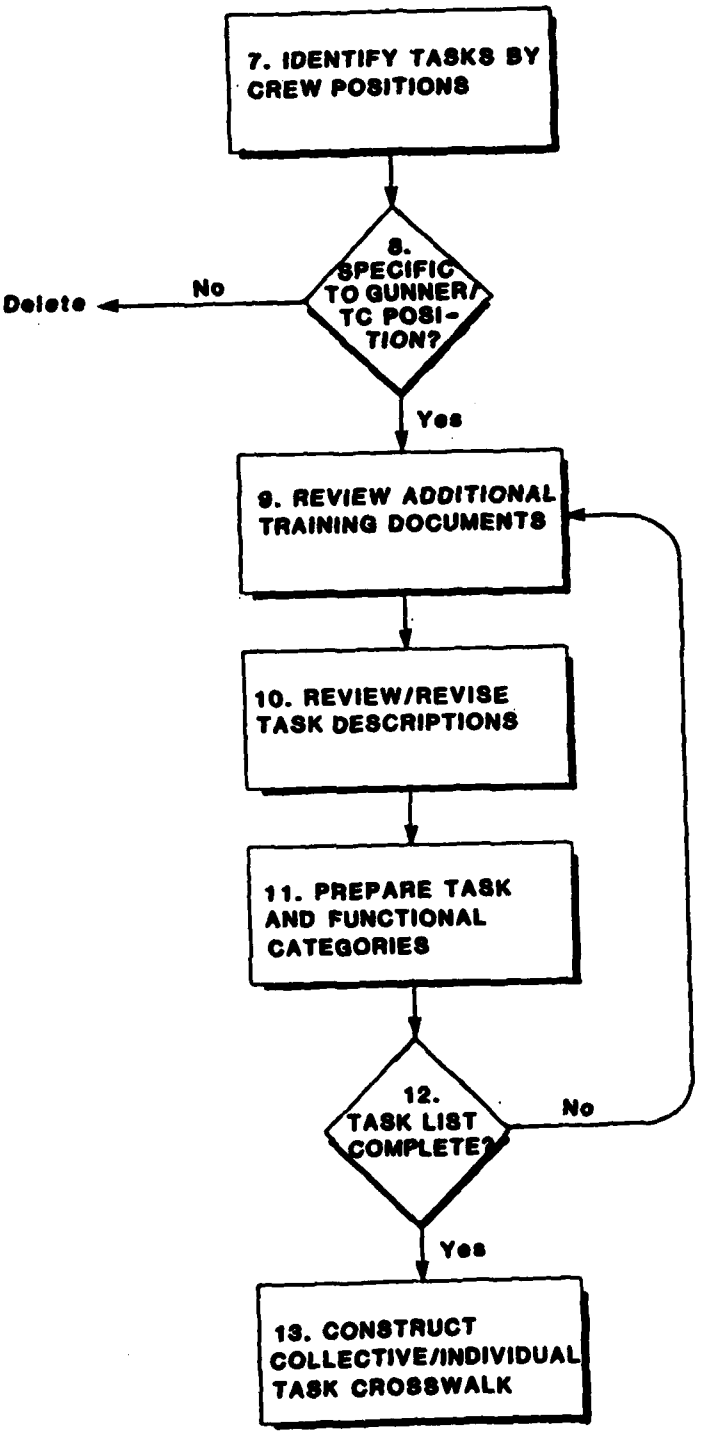

Figure 2 (cont'd). Task selection procedure.

Step 2. The analyst selects the missions that are relevant to the training context. Missions which do not concern the MOSs, tasks, and weapons systems of interest are excluded. Here is an analysis of the five missions given in the example for Step 1:

- The missions "survive" and "move" did not meet the objective to train on gunnery-related crew position tasks, and were excluded from further consideration.

- The remaining missions, "prepare for operations," "attack," and "defend," were found to apply to the objective of training gunnery-related tasks, and were selected for training.

Step 3. The collective tasks that must be performed to accomplish the selected missions are identified. These are obtained primarily from the ARTEPs, which contain collective task diagrams for each mission. The ARTEP is analyzed and relevant missions are identified.

Step 4. Interest focuses on individual tasks. The primary source of information on individual tasks is Army documentation, particularly the Soldier's Manual, which lists the critical individual tasks for the MOS. Common tasks are covered in FM 21-2 (Soldier's Manual of Common Tasks for Skill Level 1) and FM 21-3 (Soldier's Manual of Common Tasks for Skill Levels 2, 3 and 4). Soldier's Manuals for the MOS of interest are reviewed to identify all individual tasks required to perform the collective tasks identified during Step 3. These individual tasks are then analyzed and those that do not fit within the training context are deleted.

Step 5. Common tasks--individual tasks that can be performed by soldiers in any MOS--are deleted. These will not generally be of concern during task selection that focuses on the performance of MOS-specific individual tasks. Common tasks can be identified by their Soldier's Manual descriptions and by the training reference citations given with the task statement.

Step 6. The list of individual tasks is reduced further by deleting tasks that do not apply to the equipment of interest during training. Only those tasks which relate to the use of that equipment are retained.

Step 7. The individual task descriptions, conditions, and standards are analyzed to determine the crew positions that apply to each task. The task list is then annotated based on the results of this analysis.

Step 8. Any individual tasks that do not apply to the crew positions of interest are deleted from the task list.

Step 9. The identification of individual tasks is extended beyond the basic source documents used during Step 4. This step is appropriate if training may cover individual tasks that are not defined as critical according to the Soldier's Manual. Additional documents, such as Field Manuals (FM), Training Circulars (TC), and Technical Manuals (TM) are analyzed and individual tasks are identified and added to the task list.

Step 10. The individual task descriptions are refined. Since individual tasks are not always described consistently from document to document, it is necessary

to scrutinize each task on the list to assure that it is written at the appropriate level. A problem commonly encountered is that some task descriptions pertain to duties or task elements, rather than to the series of actions referred to as a task. Therefore, descriptions of duties and task elements must be revised so that a manageable series of actions is targeted for training. In revising the task list, the following three definitions are used as the basis for decisions concerning the appropriateness of the way the task is described in its statement:

- **Duty**--One of the major subdivisions of work performed by an individual. A duty is not specific to a certain time frame, and must be accomplished by performing various series of actions.

- **Task**--An integrated series of actions and decisions initiated in response to well-defined conditions and performed over a specific time frame. A task is the lowest level of behavior in a job that describes the performance of a meaningful function in a job.

- **Task Element**--A simple action or sequence of simple actions that should always be performed the same way as a component of a larger procedure.

Step 11. A list is prepared of all the individual tasks that have been identified during all earlier steps. With a large number of tasks, it is often useful to list tasks on 3 x 5 cards initially so that they can be sorted later into categories. Source documents used to identify each task should be listed with the task for later reference. After the task list has been prepared, the tasks should be sorted into categories by grouping like tasks together. The categories used will generally derive from the mission and selected task statements used earlier. For example, in developing the list of individual tasks for training on the M60A3 tank, tasks were assigned to such categories as material supply, troubleshooting and maintenance, target engagement, and communications. At the conclusion of this step, the analyst will have compiled as complete a list of individual tasks as possible based on available Army documentation.

Step 12. The task list is checked for completeness by submitting it to SMEs. Additions are made, as necessary. This review provides a useful check on task omissions and needed revisions. Following this review, the list of individual tasks is modified accordingly.

Step 13. A crosswalk is constructed that relates collective and individual tasks. The crosswalk is constructed in the form of a matrix such as that shown in Figure 3. Generally, collective tasks will be listed down the left side of the matrix, and individual tasks across the top. The ARTEP, which provides a similar crosswalk, contains task conditions and standards that can be used to match individual tasks to collective tasks. The relation between an individual and collective task is indicated by putting a mark in the cell at the intersection of the row and column of the collective and individual task.

CROSSWALK OF INDIVIDUAL AND COLLECTIVE TASKS

For MOS 19E, Gunner, On M60A3 Tank

COLLECTIVE TASKS (MISSIONS) / INDIVIDUAL TASKS	5. Perform gunner's before-operation PMCS	7. Perform gunner's prepare-to-fire checks and services	17. Install/remove tank searchlight	19. Prepare gunner's station for operation	29. Perform gunner's during firing checks and services	34. Troubleshoot fire control system	35. Troubleshoot main gun	36. Troubleshoot turret	42. Maintain main gun breechblock assembly	57. Boresight M240 coax machinegun	58. Zero M240 coax machinegun	59. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pre-Station)	60. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)	63. Power down and secure gunner's station	76. Perform gunner's after-firing checks and services after-firing checks and services	77. Prepare range card	88. Engage targets with M240 coax machinegun from gunner's station	91. Engage targets with main gun from gunner's station	92. Engage targets from range card data	
Combat load the vehicle (Prepare for operations)			●																	
Perform vehicle operator maintenance (Prepare for operations)	●	●		●		●	●	●	●											
Prepare personnel and individual equipment (Prepare for operations)																				
Conduct prepare-to-fire checks/check weapons (Prepare for operations)				●						●	●	●	●							
Refuel the vehicle (Prepare for operations)																				
Load ammunition on the vehicle (Prepare for operations)																				
Provide overwatch (Attack)																	●	●		
Take action on contact (Attack)																	●	●		
Attack/support by fire (Attack)																	●	●		
Assault (Attack)																	□	□		
Employ supporting fire (Attack/Defend)																				
Move (Attack/Defend)				□													□	□		
Employ direct fire (Attack/Defend)																		□		
React to a main gun misfire (Attack/Defend)					□	□	□													
Consolidate (Attack)					●															
Reorganize (Attack/Defend)														□	□					
Redistribute ammunition (Attack/Defend)																				
Deliver long- and medium-range defensive fires (Defend)																		●	●	
Repel OPFOR assault (Defend)																		●	●	
Select and occupy fighting positions (Defend)																	●			
Prepare fighting positions (Defend)																		●		
Provide searchlight illumination (Defend)																	●	●	●	
Conduct range card engagements (Defend)																				

● Collective task applicable to one mission □ Collective task applicable to two missions

Figure 3. Crosswalk of individual and collective tasks.

Assessment

The main objective of this task was to develop an objective and reliable method to identify and select the individual tasks to cover in unit-level individual training. Another objective was to develop a methodology that would work effectively in the hands of others, work in other contexts, and be cost-effective. Our approach derives from the Army's top-down, mission-oriented approach described in ARTEP 71-2. The resulting methodology was demonstrated to be objective and reliable. However, it has the shortcomings of any top-down, mission-oriented task selection approach that is based primarily on written Army documentation.

How objective and reliable can such a methodology be?

The principal limitation of the task selection methodology is the quality of available task information. By doctrine and by standard practice, the SM is the primary source document used in developing inventories of individual tasks to cover in training. Its existence demonstrates the Army training community's awareness of the importance of developing standardized lists of tasks, conditions, and standards for use throughout the Army. Regrettably, the SM still has shortcomings--it is incomplete, and the tasks it includes are only those that are critical for training. Thus the training developer has the choice of working with the tasks in the SM alone, or of using this as the starting point and adding additional tasks. To do the latter requires some form of data collection. One form of data collection is to observe soldiers in their working environment. This is not usually practical for the training developer, and we did not incorporate it into the methodology. Other ways to collect data include surveys, review of other Army documents, or consulting SMEs. The survey is time- and labor-intensive, and was not included in the methodology. Thus, the method relies primarily on review of additional Army documents and SME judgments--both of which might reduce the objectivity and reliability of the results.

How well does the methodology work?

This question can perhaps best be answered by addressing the completeness and accuracy of the tasks that were included in the final task lists developed. The task lists were formally reviewed by five SMEs from the New Equipment Training Team (NETT) at Fort Knox. Each NETT member independently completed a questionnaire in which he reviewed clusters of tank commander and gunner tasks for completeness and accuracy. The tank commander task list included 53 tasks and the gunner task list included 49 tasks. On the average, each reviewer added 1.2 tasks to the tank commander list and 2.4 to the gunner's list. We regard these results (over 95% agreement in all cases) as indicating that the task lists were reasonably complete and accurate. In general, the task selection methodology is workable and as objective and reliable as is possible within the information, time, and personnel constraints that exist.

TASK PRIORITIZATION METHODOLOGY

Introduction

The objectives of this task were to develop a prioritization methodology that was (1) objective and reliable, and (2) capable of being employed by Army training developers. The methodology would then be applied to the lists of armor crew tasks selected during project task 1 to define a training order. This section provides an overview of the rationale underlying prioritization, technical approach, a description of the two prioritization methodologies that were developed, and presents the results of applying the methodologies to the lists of M60A3 armor crew tasks selected during project task 1. The information presented in this section was previously reported in McCallum (1983); McCallum, Simpson, and Goldberg (1983); and McCallum et al (1983).

The task selection procedure described in the previous section generates a list of tasks which are candidates for coverage during training. Before developing training materials for these tasks, the tasks must be prioritized. Prioritization is a process whereby a metric of task importance is attached to each task and further analysis is performed to determine a logical training order. In general, the higher a task's priority, the earlier it should be covered during training. In addition, when training time is limited, tasks with lower priorities can be dropped from training. This assures that the maximum training benefit will be obtained within the time available.

While the basic concept of task prioritization is simple, its implementation is anything but straightforward. First, there is the matter of deciding what criteria should be used to calculate a task's priority. Training developers have used a number of different criteria in the past, and there are no universally recognized standards for assigning priority.

A second and equally difficult problem is that of translating task priorities into the domain of task training order. These are not the same domains, although they are obviously related. A basic problem is that priorities are normally assigned without regard to a task's prerequisites. Therefore, in practical terms, using a prioritized task list to define training order will result in some cases in which a task would be trained prior to a lower-priority prerequisite. These distortions must be avoided, and therefore the task-ordering process must take prerequisites into account.

The notion of task prioritization is not new--it has been confronted by nearly every training developer at one time or another. When a set of tasks must be trained, the training developer must decide which task to train first, which next, and so on. The order used will depend upon the perspective of the developer and the available time. If unlimited time is available, then he should use a training order that permits the effective development of skills, and maximizes transfer of training among tasks. However, there is usually a time limitation, which means that this ideal cannot be met. When training time is limited, task criticality[1] must be considered along with training effectiveness to determine task training order.

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[1] "Task criticality" is used as an umbrella term that reflects task importance in terms of successfully completing the combat mission. For purposes of this project, "criticality" is a composite of three factors (frequency across collective tasks, assistance availability, consequences of inadequate performance). Each of these components of criticality is therefore a "criticality factor."

There are many ways to consider task criticality and training effectiveness in determining training order, but the logic usually reduces to three steps. The first step is to determine the relative criticality of each task. Step two is to determine orders that maximize the effective development of skills. Most likely, the orders produced by steps one and two will differ. Step three is to resolve disagreements with a tradeoff analysis between task criticality order and skill development training order to derive the final order.

Typically, the training developer has relied upon intuition in conducting these steps and deriving a final training order. Since universal agreement is lacking concerning the importance of different task criticality and training effectiveness factors, the prioritization process has, historically, been highly subjective, different from individual to individual, and unlikely to produce similar results across groups or within a group across time.

One of our principal goals in this task was to develop a prioritization methodology that was replicable or, at the very least, that would produce basically similar results in the hands of different users. Imposing this goal had implications for the types of data collection and analysis methods used in the methodology. Ultimately, we developed not one prioritization methodology, but two.

Method One is the most objective and reliable, but also the most time- and labor-intensive. To employ it, the training developer must create three questionnaires, administer them, collect data, analyze it, develop task dependency networks, and then derive training orders. The first two questionnaires must be administered to approximately 50 subjects and the last to about 15. Total SME time to complete these questionnaires is approximately 130 man-hours. This methodology produces objective and reliable results. Computerization could considerably reduce the amount of analysis required, but additional research and development would be required to create the necessary programs.

Prioritization Method Two employs two questionnaires instead of three--for a total SME time of approximately 100 man-hours--and relies primarily on SME judgments for performing prioritization. This methodology is less time- and labor-intensive than Method One, but is also less objective and reliable.

Development of Prioritization Method One

Prioritization Method One consists of four procedures which were developed in four phases. During each phase we developed procedures, applied them to M60A3 tank commander and gunner tasks, and then reviewed the procedures and results. Method One places heavy emphasis on the use of computer processing in all four procedures. Note that the first and second procedures are primarily clerical but that the third and fourth involve complex decision-making. Since decision-making is more difficult than clerical applications, it was apparent from the outset that the last two procedures were more demanding than the first two. Each phase is summarized below.

Phase 1: Analyze Task Criticality Factors. We developed and refined procedures for measuring three factors of task criticality for combat-related individual tasks--task frequency across collective tasks, availability of task assistance, and consequences of inadequate performance of task.

Phase 2: Rank Tasks Based on Criticality Factors. We developed several alternative procedures for combining the three criticality factors to rank-order tasks based on overall criticality. We applied the procedures to obtain results, and selected one procedure for implementation.

Phase 3: Develop Task Training Order Networks. We developed a procedure for constructing networks of efficient task training orders and applied these networks to the task criticality results for determining training order.

Phase 4: Determine Task Training Order. We developed and applied a procedure for using task criticality and training order network data to determine training order.

The remainder of this section describes each of the phases in greater detail.

Phase 1: Analyze Task Criticality Factors

For purposes of this project, task criticality was defined as the relative importance of a task in terms of successful accomplishment of the combat mission.

This project focused on three task criticality factors: (1) **frequency** across collective tasks, (2) the availability of **task assistance** during combat operations, and (3) the **consequences of inadequate performance** of the task during combat operations. Procedures for obtaining criticality subscores for each of these factors were developed using selected tank commander and gunner tasks.

Frequency Across Collective Tasks. The combat-related duties of a specific crew position, such as tank commander or gunner, can be defined in terms of combat-related collective tasks, such as "prepare personnel and individual equipment" or "employ direct fire." Our task selection procedures used critical, combat-related collective tasks to identify critical tasks for crew positions.

We obtained a frequency score for each M60A3 tank commander and gunner task by using the crosswalk of individual and collective tasks prepared during project Task 1. Figure 4 depicts the use of this crosswalk to obtain individual task frequency scores. Circles and squares entered in this crosswalk represent collective tasks applicable to either one (circles) or two (squares) missions. For example, the collective task "employ direct fire" applies to two missions, "attack" and "defend." This coding scheme was taken into account in determining the frequency of individual tasks across collective tasks by counting squares twice. For example, the individual task "prepare gunner's station for operation" is listed in the fourth column of the crosswalk. The task frequency score of 4 was obtained by subtotaling the number of circles in that column (2) and adding this subtotal to the number of squares (1) times two.

The procedure for obtaining task frequency scores was evaluated by examining the distribution of frequency scores across individual tasks. The procedure produced a distribution of scores that divided tasks into separate frequency categories. Tables 1 and 2 provide task rankings based on frequency scores for tank commander and gunner tasks, respectively.

CROSSWALK OF INDIVIDUAL AND COLLECTIVE TASKS

For MOS 19E, Gunner, On M60A3 Tank

COLLECTIVE TASKS (MISSIONS) / INDIVIDUAL TASKS	5. Perform gunner's before-operation PMCS	7. Perform gunner's prepare-to-fire checks and services	17. Install/remove tank searchlight	19. Prepare gunner's station for operation	28. Perform gunner's during firing checks and services	34. Troubleshoot fire control system	35. Troubleshoot main gun	36. Troubleshoot turret	42. Maintain main gun breechblock assembly	57. Boresight M240 coax machinegun	58. Zero M240 coax machinegun	59. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)	60. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)	63. Power down and secure gunner's station	76. Perform gunner's after-firing checks and services after-firing checks and services	77. Prepare range card	88. Engage targets with M240 coax machinegun from gunner's station	91. Engage targets with main gun from gunner's station	92. Engage targets from range card data	
Combat load the vehicle (Prepare for operations)			●																	
Perform vehicle operator maintenance (Prepare for operations)	●	●		●		●	●	●	●											
Prepare personnel and individual equipment (Prepare for operations)																				
Conduct prepare-to-fire checks/check weapons (Prepare for operations)				●						●	●	●	●							
Refuel the vehicle (Prepare for operations)																				
Load ammunition on the vehicle (Prepare for operations)																				
Provide overwatch (Attack)																	●	●		
Take action on contact (Attack)																	●	●		
Attack/support by fire (Attack)																	●	●		
Assault (Attack)																	●	●		
Employ supporting fire (Attack/Defend)																	□	□		
Move (Attack/Defend)				□																
Employ direct fire (Attack/Defend)																	□	□		
React to a main gun misfire (Attack/Defend)					□	□	□											□		
Consolidate (Attack)					●															
Reorganize (Attack/Defend)														□	□					
Redistribute ammunition (Attack/Defend)																				
Deliver long- and medium-range defensive fires (Defend)																		●	●	
Repel OPFOR assault (Defend)																	●	●		
Select and occupy fighting positions (Defend)																				
Prepare fighting positions (Defend)																●				
Provide searchlight illumination (Defend)																		●		
Conduct range card engagements (Defend)																●	●	●	●	
TASK FREQUENCY	1	1	1	4	3	3	3	1	1	1	1	1	1	2	2	2	10	14	2	

● Collective task applicable to one mission □ Collective task applicable to two missions

Figure 4. Use of collective/individual task crosswalk to obtain individual task frequency scores.

Availability of Task Assistance. Availability of task assistance is important to the coordinated conduct of combat missions by small groups of soldiers such as tank crews, as it reflects the autonomy required in performing the task.

TABLE 1

COMMANDER TASKS RANKED BY FREQUENCY

Frequency Score	Task Description
13	Engage stationary targets from tank commander's station with main gun in normal mode
13	Engage stationary targets from tank commander's station with main gun in degraded mode
13	Engage moving targets from tank commander's station with main gun in normal mode
13	Engage moving targets from tank commander's station with main gun in degraded mode
13	Adjust fire from tank commander's station using reengagement technique with main gun
13	Adjust fire from tank commander's station using standard adjustment with main gun
13	Adjust fire from tank commander's station using target form adjustment with main gun
13	Perform misfire procedures with main gun
12	Issue a fire command
12	Issue subsequent fire command
12	Direct main gun engagement in normal mode
12	Direct main gun engagement in degraded mode
9	Select tank firing positions
9	Direct machinegun engagements
9	Engage area targets with M85
9	Engage moving targets with M85
9	Engage aerial targets with M85
9	Perform misfire procedures with M85
7	Control movement
4	Prepare commander's station for operation
3	Supervise personnel handling ammunition
3	Load/unload M85 caliber .50 machinegun
3	Troubleshoot fire control system
3	Fire M239 smoke grenade launchers
2	Power down and secure commander's weapon station
2	Clear M85 caliber .50 machinegun
2	Prepare range card
2	Establish tank firing positions
2	Supervise before-operation PMCS
1	Perform tank commander's prepare-to-fire checks and services
1	Install/remove M85 caliber .50 machinegun
1	Troubleshoot turret
1	Maintain M85 caliber .50 machinegun
1	Inspect DA Form 2408-4 weapons data card
1	Boresight M85 caliber .50 machinegun
1	Zero M85 caliber .50 machinegun
1	Boresight tank searchlight (non-TTS tank)
1	Operate tank searchlight (non-TTS tank)
1	Engage targets with range card data
1	Establish, enter, or leave radio net

We developed a questionnaire for acquiring task assistance data from SMEs. This questionnaire included the following five-point rating scale for assistance availability:

1. **Not applicable** -- the task is so easy that even an untrained soldier can do the task without help.

2. There is **always** time for help on the task. Combat success is never threatened when help is needed on the task.

3. **Most of the time** combat conditions allow for help, but once in a while the task must be performed as quickly as possible.
4. **Some of the time** combat conditions allow for help on the task, but usually there isn't any time.

5. There is **never** time to get help in doing the task. The task must be performed as second nature.

Separate questionnaires were prepared for M60A3 tank commander and gunner tasks. An example of this questionnaire is provided in Appendix A. The questionnaires were administered to separate groups of 56 armor officers and 42 armor NCOs. An SME's data was excluded from analysis if the individual had less than one year in armor and had not qualified on Table VIII exercises. This resulted in a total sample of 47 officers and 41 NCOs, most of whom completed both the tank commander and gunner versions of the questionnaire.

TABLE 2

GUNNER TASKS RANKED BY FREQUENCY

Freq Score	Task Description
14	Engage stationary targets from gunner's station with main gun in normal mode
14	Engage stationary targets from gunner's station with main gun in degraded mode
14	Engage moving targets from gunner's station with main gun in normal mode
14	Engage moving targets from gunner's station with main gun in degraded mode
14	Adjust fire from gunner's station using reengagement technique with main gun
14	Adjust fire from gunner's station using standard adjustment with main gun
14	Adjust fire from gunner's station using target form adjustment with main gun
14	Perform misfire procedures with main gun
10	Engage stationary targets from gunner's station with M240 in normal mode
10	Engage stationary targets from gunner's station with M240 in degraded mode
10	Engage moving targets from gunner's station with M240 in normal mode
10	Engage moving tagets from gunner's station with M240 in degraded mode
4	Prepare gunner's station for operation
3	Perform gunner's during firing checks and service
3	Troubleshoot fire control system
3	Troubleshoot main gun
2	Power down and secure gunner's station
2	Perform gunner's after-firing checks and services
2	Prepare range card
2	Operate M13A3 elevation quadrant (range card)
2	Operate M28E2 azimuth indicator (range card)
2	Engage targets from range card data
2	Perform gunner's before-operation PMCS
1	Perform gunner's prepare-to-fire checks and services
1	Install/remove tank searchlight (non-TTS tank)
1	Troubleshoot turret
1	Maintain main gun breechblock assembly
1	Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
1	Prepare to boresight
1	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)

NCO and officer task assistance ratings were first analyzed separately. A task assistance score was obtained for each task by calculating the arithmetic mean of estimates from each SME group and rounding the mean to the nearest .5 value. Spearman Rank Correlation Coefficients were then calculated to compare the resulting task rankings, based on scores obtained from NCO and officer ratings. Correlations were .94 and .89 for tank commander and gunner tasks, respectively. The highly significant correlation coefficients indicated that task assistance scores obtained from NCO and officer ratings were very similar. Further analyses treated NCOs and officers as a single group.

Tables 3 and 4 present the results of analyzing task assistance ratings for tank commander and gunner tasks, respectively. The left-hand column of each table lists a chi-square value calculated to test the hypothesis that tasks were assigned to the five points of the rating scale with equal frequency by SMEs. The chi-square value is small when each point on the rating scale is used equally often, and large when a task is more frequently assigned to a minority of points on the scale. The critical chi-square value for this test is 9.49 ($df = 4$, $\alpha = .05$), which is surpassed by every task in Tables 3 and 4. This result indicates that there was some degree of agreement among SMEs in rating each task.

The second column in Tables 3 and 4 lists the mean task assistance rating for each task. Tasks are ranked by their mean task assistance rating. These ratings have a range of approximately 1.6 points.

The standard deviation of ratings is shown in the third column of each table. This value can be used to estimate the number of respondents that should be used in future administrations of this or similar questionnaires. Estimation of Subject requirements may be estimated based on three values:

1. An estimate of rating standard deviation (**s**). The present estimate is based on the 90th percentile standard deviation from Tables 3 and 4. This estimate is **s = 1.15.**

2. A selected confidence interval (**CI**) based on the original rating scale. The selected value is **CI = .25.**

3. A selected confidence level (**CL**) which is equal to $1 - \alpha$. The selected value is **CL = .90.**

Given these values for **s**, **CI**, and **CL**, a criterion value can be established for the accuracy of rating mean estimate as a function of the number of respondents. For this example, there is a 90% probability that 90% of the questionnaire items will have a sample mean within $\pm .25$ of the actual population mean provided that the necessary number of respondents complete the questionnaire.

Estimating the number of respondents requires two steps. First, the necessary standard error of the mean (**SE**) must be computed for the selected CI

and the range of normal scores (z) corresponding to the selected CL, using the formula shown below.

$$S\bar{x} = \frac{CI}{z \text{ range (corresponding to CL)}}$$

$$S\bar{x} = \frac{\pm .25}{\pm 1.65} = .152$$

TABLE 3

COMMANDER TASKS RANKED BY ASSISTANCE AVAILABILITY

Chi Square	Mean (N=88)	S.D.	Assistance Score	Task Description
73.77	4.26	0.92	4.5	Engage moving targets from tank commander's station with main gun in normal mode
71.43	4.24	0.91	4.0	Engage moving targets from tank commander's station with main gun in degraded mode
75.52	4.24	0.98	4.0	Adjust fire from tank commander's station using target form adjustment with main gun
70.52	4.23	0.92	4.0	Adjust fire from tank commander's station using reengagement technique with main gun
70.07	4.22	0.94	4.0	Engage moving targets with M85
107.23	4.20	1.20	4.0	Issue a fire command
61.79	4.17	0.92	4.0	Direct main gun engagement in degraded mode
63.14	4.16	0.99	4.0	Engage stationary targets from tank commander's station with main gun in normal mode
*	*	*	4.0	Engage stationary targets from tank commander's station with main gun in degraded mode
66.09	4.15	0.94	4.0	Engage area targets with M85
62.57	4.15	1.03	4.0	Engage aerial targets with M85
*	*	*	4.0	Perform misfire procedures with M85
58.93	4.13	1.01	4.0	Direct main gun engagement in normal mode
76.09	4.10	1.17	4.0	Issue subsequent fire command
52.68	4.07	1.06	4.0	Adjust fire from tank commander's station using standard adjustment with main gun
51.45	4.03	0.91	4.0	Direct machinegun engagements
66.43	3.99	0.95	4.0	Control movement
32.68	3.83	1.16	4.0	Load/unload M85 caliber .50 machinegun
31.32	3.76	1.14	4.0	Fire M239 smoke grenade launchers
33.19	3.72	0.99	3.5	Engage targets with range card data
69.95	3.66	0.81	3.5	Select tank firing positions
23.14	3.65	1.14	3.5	Perform misfire procedures with main gun
16.89	3.60	1.25	3.5	Clear M85 caliber .50 machinegun
52.45	3.59	0.87	3.5	Establish tank firing positions
31.89	3.42	1.00	3.5	Establish, enter, or leave radio net
45.75	3.40	0.89	3.5	Prepare commander's station for operation
52.23	3.31	0.88	3.5	Troubleshoot fire control system
72.57	3.24	0.79	3.0	Troubleshoot turret
46.43	3.24	0.91	3.0	Prepare range card
70.30	3.17	0.78	3.0	Perform tank commander's prepare-to-fire checks and services
47.45	3.14	0.90	3.0	Boresight M85 caliber .50 machinegun
37.00	3.11	0.96	3.0	Zero M85 caliber .50 machinegun
33.25	3.10	1.01	3.0	Maintain M85 caliber .50 machinegun
34.21	3.09	1.02	3.0	Power down and secure commander's weapon station
30.86	3.08	1.04	3.0	Install/remove M85 caliber .50 machinegun
14.78	2.80	1.28	3.0	Operate tank searchlight (non-TTS tank)
21.22	2.77	1.10	3.0	Boresight tank searchlight (non-TTS tank)
22.34	2.73	1.09	2.5	Supervise personnel handling ammunition
44.35	2.72	1.08	2.5	Inspect DA Form 2408-4 weapons data card
65.52	2.70	0.89	2.5	Supervise before-operation PMCS

*These tasks were not included in the task assistance questionnaire. Task assistance scores were estimated by comparison with similar tasks.

Second, the required number of respondents (N) is obtained by using the value of $S\bar{x}$ calculated above and the estimated value of s. The definitional formula for $S\bar{x}$ (see below) is used to solve for N.

$$S\bar{x} = \frac{s}{\sqrt{N-1}}$$

$$N = \left(\frac{1.15}{.152}\right)^2 + 1 = 58.24$$

TABLE 4

GUNNER TASKS RANKED BY ASSISTANCE AVAILABILITY

Chi Square	Mean (N=79)	S.D.	Assistance Score	Task Description
53.72	4.13	0.99	4.0	Adjust fire from gunner's station using standard adjustment with main gun
56.57	4.09	1.14	4.0	Engage moving targets from gunner's station with main gun in normal mode
43.97	4.04	1.07	4.0	Adjust fire from gunner's station using target form adjustment with main gun
41.57	4.00	1.12	4.0	Engage stationary targets from gunner's station with main gun in normal mode
*	*	*	4.0	Engage moving targets from gunner's station with main gun in degraded mode
*	*	*	4.0	Engage stationary targets from gunner's station with main gun in degraded mode
44.56	3.96	1.17	4.0	Adjust fire from gunner's station using reengagement technique with main gun
38.53	3.96	1.16	4.0	Engage stationary targets from gunner's station with M240 in normal mode
35.37	3.94	1.11	4.0	Engage stationary targets from gunner's station with M240 in degraded mode
31.06	3.87	1.09	4.0	Engage moving tagets from gunner's station with M240 in degraded mode
29.67	3.82	1.20	4.0	Engage moving targets from gunner's station with M240 in normal mode
20.43	3.61	1.24	3.5	Perform misfire procedures with main gun
28.15	3.57	1.02	3.5	Engage targets from range card data
41.82	3.52	0.90	3.5	Perform gunner's during firing checks and service
33.22	3.38	0.96	3.5	Troubleshoot main gun
56.13	3.37	0.80	3.5	Troubleshoot fire control system
34.44	3.29	0.99	3.5	Operate M28E2 azimuth indicator (range card)
26.76	3.19	1.03	3.0	Operate M13A3 elevation quadrant (range card)
43.92	3.18	0.86	3.0	Prepare gunner's station for operation
44.18	3.10	0.89	3.0	Troubleshoot turret
45.24	3.03	0.86	3.0	Prepare range card
35.58	2.95	0.98	3.0	Maintain main gun breechblock assembly
46.00	2.94	0.87	3.0	Perform gunner's prepare-to-fire checks and services
41.36	2.94	0.92	3.0	Power down and secure gunner's station
58.13	2.94	0.83	3.0	Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
42.68	2.93	0.90	3.0	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)
48.03	2.91	0.89	3.0	Prepare to boresight
55.62	2.89	0.80	3.0	Perform gunner's before-operation PMCS
59.05	2.79	0.81	3.0	Perform gunner's after-firing checks and services
39.18	2.31	1.02	2.5	Install/remove tank searchlight (non-TTS tank)

*These tasks were not included in the task assistance questionnaire. Task assistance scores were estimated by comparison with similar tasks.

This result indicates that the sampling criterion corresponding to CI = $\pm$ .25 and CL = 90% should be met for approximately 90% of the tasks in the questionnaire if approximately 58 SMEs complete the questionnaire.

The two right-hand columns in Tables 3 and 4 list the assistance score and corresponding task descriptions. Review of these columns suggests that the task assistance scores provide a valid index of the availability of assistance during combat. Although the majority of scores range between 4.0 and 3.0, this provides an adequate degree of discrimination between tasks. The task assistance procedure was judged as meeting the objective of providing a useful and meaningful criticality subscore.

Consequences of Inadequate Performance of Task. Consequences of inadequate performance of the individual task during combat were assessed by administering questionnaires to SMEs and analyzing results. Questionnaire directions instructed SMEs to classify "the effect on combat mission success if a task is performed incorrectly" into one of the five categories listed below:

1. Combat mission success will not be affected.

2. Sometimes incorrect task performance will result in combat mission failure.

3. Incorrect task performance will result in combat mission failure about half the time.

4. Most times incorrect task performance will result in combat mission failure.

5. Incorrect task performance will always result in combat mission failure.

Separate questionnaires were prepared for M60A3 tank commander and gunner tasks. An example of this questionnaire is provided in Appendix B. The questionnaires were administered to 37 armor officers. Each officer completed both questionnaires. Four officers from the sample did not meet the minimum SME criterion of one year in armor and one qualification on Table VIII exercises, resulting in a sample of 33 respondents.

Tables 5 and 6 present the results of our task consequence rating analyses for tank commander tasks and gunner tasks, respectively. The left-hand column of each table lists a chi-square value calculated to test the hypothesis that SMEs assigned a task to each of the five points in the rating scale with equal frequency. The critical chi-square value for this test is 9.49 (df = 4, α = .05). Fifteen tank commander tasks and four gunner tasks have chi-square values below this critical value. This finding indicates that there was no statistically significant degree of agreement among SMEs in rating these 19 tasks. The relatively greater reliability of the task assistance scores, as compared to the consequence of error scores, was taken into account in determining the final procedure for ranking tasks based on criticality.

TABLE 5

COMMANDER TASKS RANKED BY CONSEQUENCE OF ERROR

Chi Square	Mean (N = 33)	S.D.	Consequence Score	Task Description
21.29	4.07	0.81	4.0	Direct main gun engagement in degraded mode
18.36	4.00	1.09	4.0	Control movement
17.45	4.00	1.03	4.0	Establish tank firing positions
14.97	3.97	1.08	4.0	Direct main gun engagement in normal mode
12.55	3.90	1.05	4.0	Engage stationary targets from tank commander's station with main gun in degraded mode
8.00	3.85	1.12	4.0	Engage moving targets from tank commander's station with main gun in degraded mode
12.30	3.82	1.18	4.0	Engage stationary targets from tank commander's station with main gun in normal mode
10.19	3.72	1.05	3.5	Troubleshoot fire control system
13.21	3.67	1.16	3.5	Adjust fire from tank commander's station using target form adjustment with main gun
9.88	3.64	1.11	3.5	Adjust fire from tank commander's station using standard adjustment with main gun
10.19	3.63	1.16	3.5	Adjust fire from tank commander's station using reengagement technique with main gun
7.45	3.61	1.39	3.5	Issue subsequent fire command
12.00	3.61	1.12	3.5	Perform tank commander's prepare-to-fire checks and services
8.36	3.58	1.20	3.5	Load/unload M85 caliber .50 machinegun
13.21	3.58	1.00	3.5	Select tank firing positions
8.31	3.56	1.11	3.5	Engage moving targets from tank commander's station with main gun in normal mode
5.94	3.52	1.44	3.5	Issue a fire command
14.12	3.48	0.97	3.5	Engage moving targets with M85
10.50	3.47	1.34	3.5	Perform misfire procedures with main gun
8.67	3.45	1.09	3.5	Perform misfire procedures with M85
11.70	3.42	1.00	3.5	Maintain M85 caliber .50 machinegun
12.00	3.36	1.03	3.5	Direct machinegun engagements
8.97	3.36	1.08	3.5	Engage area targets with M85
7.45	3.33	1.14	3.5	Prepare commander's station for operation
12.69	3.28	1.05	3.5	Troubleshoot turret
5.33	3.24	1.30	3.0	Engage targets with range card data
8.06	3.21	1.19	3.0	Prepare range card
17.67	3.10	1.09	3.0	Fire M239 smoke grenade launchers
11.70	3.06	1.03	3.0	Zero M85 caliber .50 machinegun
11.70	3.06	1.03	3.0	Supervise before-operation PMCS
2.30	3.06	1.30	3.0	Establish, enter, or leave radio net
4.12	3.03	1.33	3.0	Clear M85 caliber .50 machinegun
10.48	2.94	1.20	3.0	Boresight M85 caliber .50 machinegun
1.70	2.76	1.37	3.0	Install/remove M85 caliber .50 machinegun
1.70	2.76	1.32	3.0	Engage aerial targets with M85
5.58	2.54	1.25	2.5	Power down and secure commander's weapon station
20.48	2.30	0.95	2.5	Supervise personnel handling ammunition
16.24	2.21	1.22	2.0	Boresight tank searchlight (non-TTS tank)
32.39	2.03	0.80	2.0	Operate tank searchlight (non-TTS tank)
31.09	1.88	0.82	2.0	Inspect DA Form 2408-4 weapons data card

The second columns in Tables 5 and 6 list the mean task consequence rating for each task. Tasks are ranked by mean ratings, which vary from a high of 4.07 to a low of 1.88 for tank commander tasks, and from a high of 4.45 to a low of 1.77 for gunner tasks. These extreme values have high chi-square values, which supports the conclusion that the functional range of mean task ratings on this questionnaire is between 2.0 and 2.5 points on the original rating scale.

The third columns in Tables 5 and 6 list the standard deviations of SME ratings for each task. The standard deviations can be used to estimate the number of respondents required for administration of this or similar questionnaires. Using the same sampling criteria and method described in the preceding subsection, the standard deviation (s) is estimated by determining the 90th percentile value of S.D. in the two tables. For this questionnaire, $s = 1.30$, $CI = \pm .25$, $CL = .90$, and the required $S\bar{x} = .152$. The number of required subjects (N) is computed as shown below.

$$N = \left(\frac{1.30}{.152}\right)^2 + 1 = 74.15$$

The result indicates that use of this or a similar questionnaire would require approximately 75 respondents to assure 90% likelihood that 90% of the mean task ratings would be within $\pm$ .25 points of their actual value. This is more respondents than estimated for the task assistance questionnaire.

TABLE 6

GUNNER TASKS RANKED BY CONSEQUENCE OF ERROR

Chi Square	Mean (N = 33)	S.D.	Consequence Score	Task Description
47.55	4.45	0.96	4.5	Engage stationary targets from gunner's station with main gun in normal mode
36.44	4.34	0.97	4.5	Adjust fire from gunner's station using target form adjustment with main gun
31.12	4.25	0.76	4.5	Engage moving targets from gunner's station with main gun in degraded mode
29.48	4.23	0.92	4.0	Engage moving targets from gunner's station with main gun in normal mode
24.65	4.23	0.92	4.0	Adjust fire from gunner's station using reengagement technique with main gun
22.06	4.16	0.92	4.0	Perform misfire procedures with main gun
20.96	4.07	1.04	4.0	Engage stationary targets from gunner's station with main gun in degraded mode
18.94	3.97	1.18	4.0	Prepare gunner's station for operation
15.81	3.97	1.06	4.0	Adjust fire from gunner's station using standard adjustment with main gun
14.97	3.94	1.09	4.0	Boresight and system calibrate an M60A3 tank using muzz'e boresight device (Pye-Watson)
15.50	3.94	1.16	4.0	Prepare to boresight
15.61	3.90	1.14	4.0	Troubleshoot fire control system
11.10	3.81	1.08	4.0	Troubleshoot main gun
10.19	3.66	1.18	3.5	Perform gunner's prepare-to-fire checks and services
9.67	3.63	1.19	3.5	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)
7.06	3.56	1.16	3.5	Maintain main gun breechblock assembly
17.55	3.55	0.89	3.5	Troubleshoot turret
8.94	3.53	1.29	3.5	Engage targets from range card data
15.19	3.50	1.16	3.5	Perform gunner's before-operation PMCS
16.00	3.50	1.25	3.5	Engage moving targets from gunner's station with M240 in normal mode
17.37	3.45	1.06	3.5	Engage stationary targets from gunner's station with M240 in normal mode
8.31	3.41	1.13	3.5	Perform gunner's during firing checks and services
10.17	3.38	1.04	3.5	Operate M28E2 azimuth indicator (range card)
17.23	3.29	1.16	3.5	Engage moving targets from gunner's station with M240 in degraded mode
13.79	3.28	1.10	3.5	Engage stationary targets from gunner's station with M240 in degraded mode
13.94	3.22	1.01	3.0	Perform gunner's after-firing checks and services
12.69	3.22	1.13	3.0	Prepare range card
12.69	3.03	1.15	3.0	Operate M13A3 elevation quadrant (range card)
3.56	2.70	1.30	2.5	Power down and secure gunner's station
32.39	1.77	0.67	2.0	Install/remove tank searchlight (non-TTS tank)

The two right-hand columns in these tables list the consequence scores and corresponding task descriptions. Review of these columns suggests that the task consequence score provides a useful criticality subscore. However, there appear to be some inconsistencies in the order of tasks. For example, tasks that are central to the tank commander crew duty, such as "issue a fire command" and "select tank firing positions," appear lower in the list than would be expected.

In comparing the overall results obtained from the task assistance and task consequence questionnaires, we find that the task assistance results: (1) provide more frequent agreement among SMEs, (2) require fewer subjects to meet the same sampling criterion, and (3) result in an order of tasks which has fewer apparent inconsistencies.

Phase 2: Rank Tasks Based on Criticality Factors

The objective of this phase was to develop a procedure for ranking individual tasks based on the three criticality subscores (frequency, assistance, consequence). The resultant task ranking would list the tasks most important for combat at the top of the list and those least important at the bottom.

Many different procedures could be used to rank tasks based on criticality subscores. We limited the type of procedures we developed based on two considerations. First, SME judgment data used in deriving task assistance and consequence subscores are ordinal in terms of their measurement scale. Therefore, we did not consider ranking procedures that required these values to be multiplied. Second, task frequency was judged to be the least important ranking factor, and our procedures reflect this fact.

Three alternative ranking procedures were developed and applied to the task scores, and the resulting task rankings were then evaluated. Each procedure ranked all tasks first using one criticality subscore (or the sum of two scores), and then broke any ties between tasks using subsequent scores. Alternative ranking procedures applied task assistance and consequence subscores in different orders. The earlier a subscore was used, the stronger its influence on the ranking.

Table 7 shows the order in which criticality subscores were used to rank tasks using the three alternative procedures. Note that Alternative C differs from Alternatives A and B in that its first ranking is based on the sum of assistance and consequence subscores. This is the only alternative that adds subscores.

The results obtained with the three alternative ranking procedures are shown in Table 8 (tank commander tasks) and Table 9 (gunner tasks). Note that many tasks have identical scores on all three factors, resulting in ties.

Tables 8 and 9 show that the three ranking procedures produced similar results. Spearman Rank Correlation Coefficients were computed between task rankings resulting from each pair of procedures. Correlations were high (above .95 for commander tasks and above .90 for gunner tas s) and significant (.05 level).

TABLE 7

ALTERNATIVE RANKING PROCEDURES

Alternative A	Alternative B	Alternative C
1. Assistance	1. Consequence	1. Assistance + Consequence
2. Consequence	2. Assistance	2. Frequency
3. Frequency	3. Frequency	

We used three ranking procedures in order to consider several alternatives before selecting a single procedure for implementation. ARI and Anacapa personnel reviewed the task rankings and concluded that (1) the assistance subscore was the most important in determining task criticality for combat, (2) ranking based on the consequence subscore was second best, and (3) a frequency-based ranking was least useful. This led to the choice of ranking alternative A (see Table 7) in subsequent prioritization work.

Phase 3: Develop Task Training Order Networks

The objective of this phase was to identify factors (other than combat criticality) that should influence task training order, and use these factors in prioritizing tasks. In line with our basic research strategy, we developed a procedure that emphasized objectivity and reliability. This procedure was applied to the selected M60A3 tank commander and gunner tasks. The procedure and results were then reviewed by project staff and ARI personnel.

To identify the factors that should influence training order, we held discussions with ARI and reviewed related procedures, such as those described in TRADOC Pamphlets 350-30 (Interservice Procedures for Instructional Systems Development, 1975) and 351-4 (Job and Task Analysis, 1978). These procedures require training developers to construct a series of networks showing the training dependencies among different skills. Figure 5 shows an example of such a network from TRADOC Pamphlet 350-30. This type of network depicts skills that should be trained early at the bottom and skills that should be trained later at the top. Links between boxes show dependent training orders between skills. Ellipses indicate portions of the network that are not completely depicted.

We adopted the TRADOC approach toward network generation shown in Figure 5, but made two changes. First, our objective was to prioritize tasks rather than skills and knowledge. We therefore changed the meaning of the links in the model from "dependent training orders between skills" to "efficient training orders between tasks." Second, we adopted the notion of "training efficiency" because it aided the design of a comprehensible questionnaire rating scale. Questionnaires were being designed for enlisted Army personnel, who would have had difficulty in rating tasks on the basis of constructs such as "task similarity" or "training transfer."

We modified the method of network construction to make it more objective and replicable. The TRADOC procedures are performed by a training developer who develops networks based upon personal experience. This procedure is not readily replicable. Our procedure consisted of the development, administration, and analysis of a questionnaire to obtain SME opinions concerning efficient training orders.

TABLE 8

RESULTS OF THREE ALTERNATIVE RANKING PROCEDURES (TANK COMMANDER TASKS)

Rank Order Resulting from Each Alternative			Criticality Subscores			
I	II	III	Assistance	Consequence	Frequency	Task Description
1	8	1	4.5	3.5	13	Engage moving targets from tank commander's station with main gun in normal mode
3	2	3	4.0	4.0	13	Engage moving targets from tank commander's station with main gun in degraded mode
3	2	3	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in normal mode
3	2	3	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in degraded mode
5.5	4.5	5.5	4.0	4.0	12	Direct main gun engagement in degraded mode
5.5	4.5	5.5	4.0	4.0	12	Direct main gun engagement in normal mode
7	6	7	4.0	4.0	7	Control movement
9	10	9	4.0	3.5	13	Adjust fire from tank commander's station using target form adjustment with main gun
9	10	9	4.0	3.5	13	Adjust fire from tank commander's station using reengagement technique with main gun
9	10	9	4.0	3.5	13	Adjust fire from tank commander's station using standard adjustment with main gun
11.5	12.5	11.5	4.0	3.5	12	Issue subsequent fire command
11.5	12.5	11.5	4.0	3.5	12	Issue a fire command
14.5	15.5	14.5	4.0	3.5	9	Engage moving targets with M85
14.5	15.5	14.5	4.0	3.5	9	Engage area targets with M85
14.5	15.5	14.5	4.0	3.5	9	Perform misfire procedures with M85
14.5	15.5	14.5	4.0	3.5	9	Direct machinegun engagements
17	18	17	4.0	3.5	3	Load/unload M85 caliber .50 machinegun
18	26	20.5	4.0	3.0	9	Engage aerial targets with M85
19	27	23.5	4.0	3.0	3	Fire M239 smoke grenade launchers
20	7	18	3.5	4.0	2	Establish tank firing positions
21	19	19	3.5	3.5	13	Perform misfire procedures with main gun
22	20	20.5	3.5	3.5	9	Select tank firing positions
23	21	22	3.5	3.5	4	Prepare commander's station for operation
24	22	23.5	3.5	3.5	3	Troubleshoot fire control system
25	28	25	3.5	3.0	2	Clear M85 caliber .50 machinegun
26.5	29.5	28	3.5	3.0	1	Engage targets with range card data
26.5	29.5	28	3.5	3.0	1	Establish, enter, or leave radio net
29	24	28	3.0	3.5	1	Troubleshoot turret
29	24	28	3.0	3.5	1	Perform tank commander's prepare-to-fire checks and services
29	24	28	3.0	3.5	1	Maintain M85 caliber .50 machinegun
31	31	31	3.0	3.0	2	Prepare range card
33	33	33	3.0	3.0	1	Boresight M85 caliber .50 machinegun
33	33	33	3.0	3.0	1	Zero M85 caliber .50 machinegun
33	33	33	3.0	3.0	1	Install/remove M85 caliber .50 machinegun
35	36	35	3.0	2.5	2	Power down and secure commander's weapon station
36.5	38.5	38.5	3.0	2.0	1	Operate tank searchlight (non-TTS tank)
36.5	38.5	38.5	3.0	2.0	1	Boresight tank searchlight (non-TTS tank)
38	35	36	2.5	3.0	1	Supervise before-operation PMCS
39	37	37	2.5	2.5	3	Supervise personnel handling ammunition
40	40	40	2.5	2.0	1	Inspect DA Form 2408-4 weapons data card

The training order questionnaire was designed to obtain classifications of pairs of tasks (labeled Task A and Task B) into one of four categories. The four categories refer to how task training order would affect training efficiency. Each pair of tasks in the questionnaire was to be classified into one of the following four categories:

1. **Does Not Matter.** The efficiency of training would not be increased by training Task A and Task B in any specific order.

2. **Task A First.** The efficiency of training would be increased by training Task A before Task B.

3. **About Same Time.** The efficiency of training would be increased if Task A and Task B were trained at about the same time, but learning one task does not make it easier to learn the other task.

4. **Task B First.** The efficiency of training would be increased by training Task B before Task A.

TABLE 9

RESULTS OF THREE ALTERNATIVE RANKING PROCEDURES
(GUNNER TASKS)

Rank Order Resulting from Each Alternative			Criticality Subscores			Task Description
I	II	III	Assistance	Consequence	Frequency	
2	2	2	4.0	4.5	14	Adjust fire from gunner's station using target form adjustment with main gun
2	2	2	4.0	4.5	14	Engage moving targets from gunner's station with main gun in degraded mode
2	2	2	4.0	4.5	14	Engage stationary targets from gunner's station with main gun in normal mode
5.5	5.5	5.5	4.0	4.0	14	Adjust fire from gunner's station using standard adjustment with main gun
6.5	5.5	5.5	4.0	4.0	14	Engage moving targets from gunner's station with main gun in normal mode
5.5	5.5	5.5	4.0	4.0	14	Engage stationary targets from gunner's station with main gun in degraded mode
5.5	5.5	5.5	4.0	4.0	14	Adjust fire from gunner's station using reengagement technique with main gun
9.5	15.5	10.5	4.0	3.5	10	Engage stationary targets from gunner's station with M240 in normal mode
9.5	15.5	10.5	4.0	3.5	10	Engage stationary targets from gunner's station with M240 in degraded mode
9.5	15.5	10.5	4.0	3.5	10	Engage moving targets from gunner's station with M240 in degraded mode
9.5	15.5	10.5	4.0	3.5	10	Engage moving targets from gunner's station with M240 in normal mode
12	8	8	3.5	4.0	14	Perform misfire procedures with main gun
13.5	9.5	13.5	3.5	4.0	3	Troubleshoot main gun
13.5	9.5	13.5	3.5	4.0	3	Troubleshoot fire control system
15	18	16	3.5	3.5	3	Perform gunner's during firing checks and services
16.5	19.5	17.5	3.5	3.5	2	Engage targets from range card data
16.5	19.5	17.5	3.5	3.5	2	Operate M28E2 azimuth indicator (range card)
18	11	15	3.0	4.0	4	Prepare gunner's station for operation
19.5	12.5	19.5	3.0	4.0	1	Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
19.5	12.5	19.5	3.0	4.0	1	Prepare to boresight
23	23	23	3.0	3.5	1	Perform gunner's prepare-to-fire checks and services
23	23	23	3.0	3.5	1	Perform gunner's before-operation PMCS
23	23	23	3.0	3.5	1	Troubleshoot turret
23	23	23	3.0	3.5	1	Maintain main gun breechblock assembly
23	23	23	3.0	3.5	1	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)
27	27	27	3.0	3.0	2	Operate M13A3 elevation quadrant (range card)
27	27	27	3.0	3.0	2	Prepare range card
27	27	27	3.0	3.0	2	Perform gunner's after-firing checks and services
29	29	29	3.0	2.5	2	Power down and secure gunner's station
30	30	30	2.5	2.0	1	Install/remove tank searchlight (non-TTS tank)

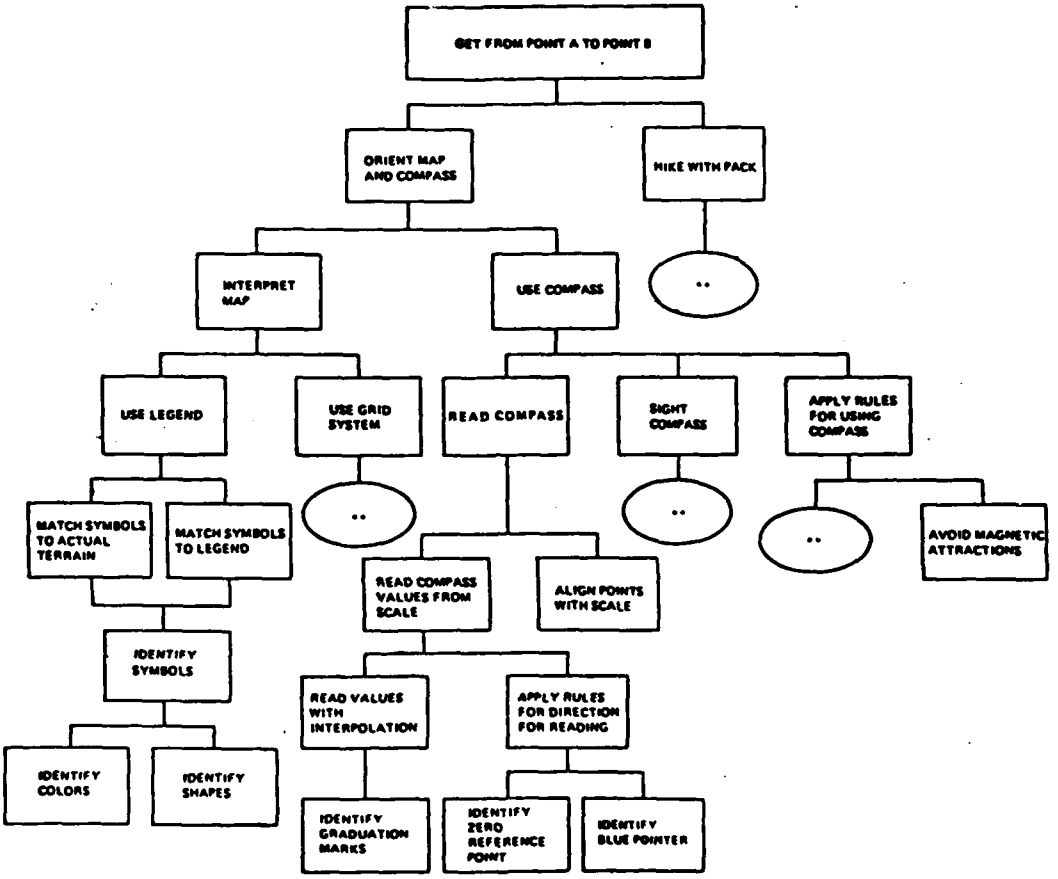

Figure 5. Training dependency network (from TRADOC PAM 350-30).

Separate questionnaires were prepared for tank commander and gunner task lists. Appendix C contains an example of this questionnaire. Task pairs judged by project staff as possibly requiring common skills and knowledge for performance were included in the questionnaires. The questionnaires were administered to 20 members of the Ft. Knox M60A3 New Equipment Training Team. Each respondent completed both the tank commander and gunner versions of the questionnaire during a single morning session.

The completed questionnaires were analyzed in three steps. During Step 1, a computer program performed a series of binomial exact tests and assigned each task pair to one of the four training order categories. Task pair assignment to Categories 2 and 4 (i.e., a specific task order was judged as increasing training efficiency) were the only results used in further analyses. Two statistically significant ($\alpha = .10$) results were required for task pair assignment to Categories 2 or 4: (1) the proportion of SMEs assigning a task pair to Categories 2, 3, and 4 was to exceed .50; and (2) of the subset of SMEs who assigned a task pair to Categories 2, 3, and 4, the proportion assigning that task pair to either Category 2 or Category 4 was to exceed .50.

During Step 2, a computer program performed a series of algebraic tests on the results of Step 1 to derive linear training sequences consisting of two or more tasks. This analysis condensed the task pair results into task sequences. Table 10 provides a hypothetical example of the computer program results.

Step 1 results consist of pairs of tasks identified by number and the training order category to which they were assigned after questionnaire analysis. For this hypothetical example, the three numbers in the top left-hand row of Table 10 indicate that "Task 8" was labeled as "Task A" in the questionnaire, "Task 4" was labeled as "Task B," and Step 1 of the analyses resulted in the assignment of this task pair to Category 2 (i.e., Task 8 should be trained before Task 4). Step 2 results consist of task sequences that share a common efficient training order, where tasks within each sequence should be trained from left to right. For this hypothetical example, the second sequence listed indicates a training sequence of "Task 8," followed by "Task 2," followed by "Task 4." This result would be obtained from Step 2 analysis only if the following three pair-wise sequences were obtained from Step 1 analyses: "Task 8" before "Task 2," "Task 8" before "Task 4," and "Task 2 before "Task 4."

Step 3 involved construction of training sequence networks from the results of Step 2. These networks were to show the most efficient order for training on related tasks. Networks were constructed by a project staff member who combined overlapping linear sequences of tasks resulting from Step 2 analyses. Figure 6 illustrates a hypothetical network derived from the training order results listed in Table 10. Training sequences are depicted vertically--training order is from bottom to top of the model.

Figure 7 shows one of the training order networks derived from the results of the tank commander training order questionnaire. This network shows the interrelated sequences of task training judged to be most efficient for M85 machinegun engagement, as obtained from Steps 1-3 analyses. Appendix D contains the complete set of training order networks.

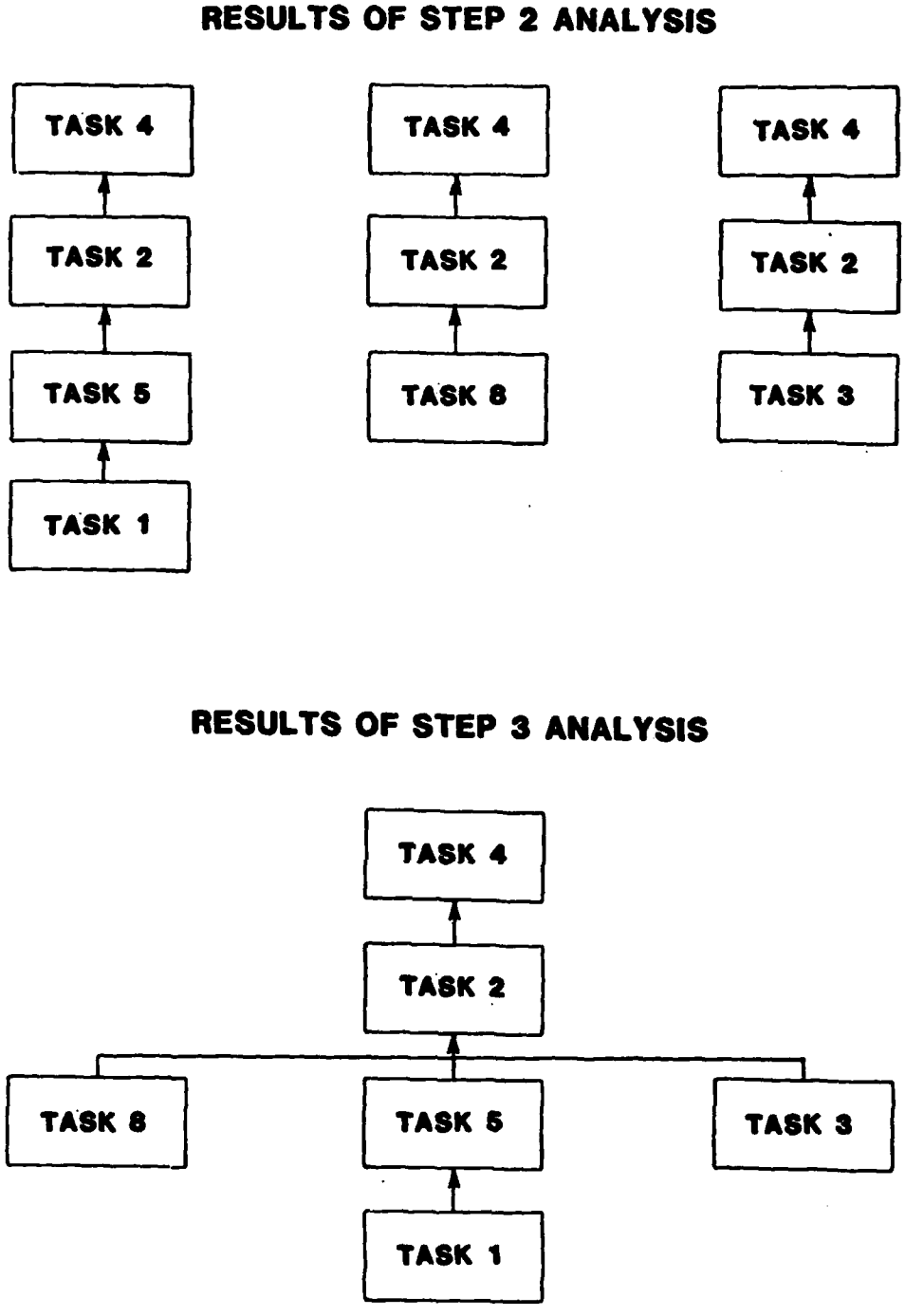

Figure 6. Construction of hypothetical task training order network from linear sequences of tasks.

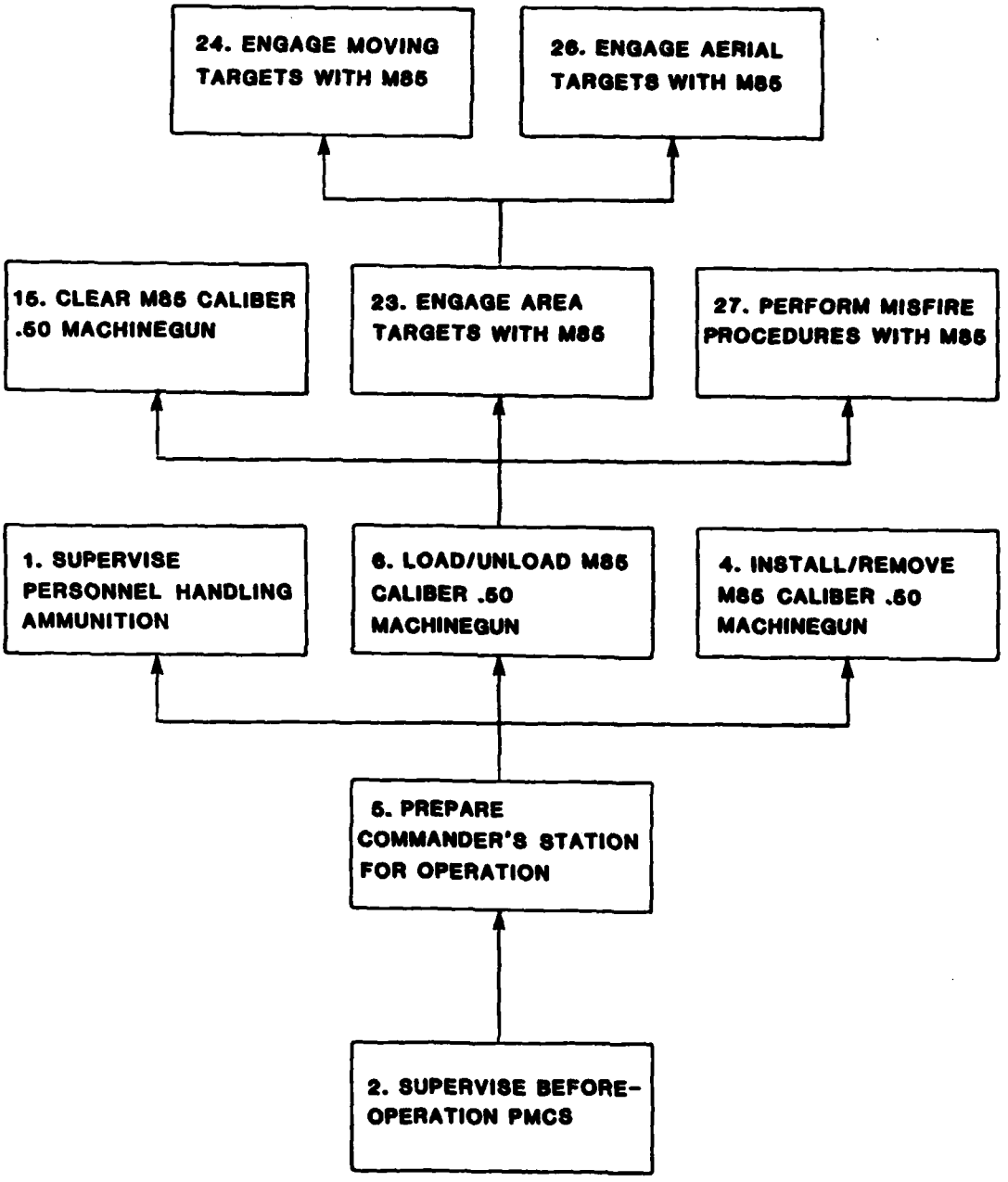

Figure 7. Training order network for tank commander M85 machinegun engagement tasks.

TABLE 10

TRAINING ORDER QUESTIONNAIRE ANALYSIS RESULTS
(HYPOTHETICAL)

Results of Step 1 Analysis						Results of Step 2 Analysis
Task A Number	Task B Number	Task Pair Category	Task A Number	Task B Number	Task Pair Category	Task Training Sequence
8	4	2	2	5	4	
3	1	3	4	3	4	1--5--2--4
5	8	3	6	4	3	8--2--4
2	4	2	8	1	3	3--2--4
5	1	4	3	8	3	
3	5	3	3	2	2	
2	1	4	4	1	4	
9	3	3	7	5	1	
4	5	4	8	2	2	

Phase 4: Determine Task Training Order

The training order networks were intended to serve as graphic aids in determining actual training order. Training developers determine task training order by modifying the task criticality ranking so that the final training order reflects both task criticality and training efficiency.

Training order is derived by performing the following two steps, iteratively, until all tasks have been covered.

A. Identify the task with the highest criticality score.

B. Identify all tasks linked to the most critical task that are lower in the network. List these tasks in the order given by the network, and end with the original (most critical) task.

When Step B has been completed, return to Step A, identify the most critical task that has not yet been included on the training order list, and so on, until all tasks have been covered.

The above procedure requires reference to all training order networks for a particular crew position at one time. This procedure is labor-intensive and subject to error and for this reason we developed a computer program to perform it.

The results of applying the program are shown in Tables 11 (tank commander tasks) and 12 (gunner tasks). These tables include all tasks and correspond to a training program without time constraints.

To handle situations in which training time is more limited, we used a "filtering" technique to lower the training priority of certain tasks. This technique consists of modifying Step B (above) such that no task selected during Step B can be placed before the task selected during Step A unless the task assistance score of the former task is within .5 of the latter. This reduces the effect of "training order efficiency" and increases the effect of task criticality on the final training order. Tables 13 and 14 contain the results of this modifed task prioritization procedure--the task lists may be shortened to deal with shorter training windows by removing the required number of tasks from the bottom of the lists.

TABLE 11

TANK COMMANDER TASK TRAINING ORDER (PRELIMINARY)

Task Order	Criticality Subscores: Assistance	Consequence	Frequency	Task Description
1	4.5	3.5	13	Engage moving targets from tank commander's station with main gun in normal mode
2	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in normal mode
3	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in degraded mode
4	4.0	4.0	13	Engage moving targets from tank commander's station with main gun in degraded mode
5	4.0	3.5	12	Issue a fire command
6	4.0	3.5	12	Issue subsequent fire command
7	4.0	4.0	12	Direct main gun engagement in normal mode
8	4.0	4.0	12	Direct main gun engagement in degraded mode
9	4.0	4.0	7	Control movement
10	4.0	3.5	13	Adjust fire from tank commander's station using reengagement technique with main gun
11	4.0	3.5	13	Adjust fire from tank commander's station using standard adjustment with main gun
12	4.0	3.5	13	Adjust fire from tank commander's station using target form adjustment with main gun
13	4.0	3.5	9	Direct machinegun engagements
14	4.0	3.5	9	Engage area targets with M85
15	4.0	3.5	9	Engage moving targets with M85
16	4.0	3.5	3	Load/unload M85 caliber .50 machinegun
17	4.0	3.5	9	Perform misfire procedures with M85
18	4.0	3.0	9	Engage aerial targets with M85
19	4.0	3.0	3	Fire M239 smoke grenade launchers
20	3.5	3.5	9	Select tank firing positions
21	3.5	4.0	2	Establish tank firing positions
22	3.5	3.5	13	Perform misfire procedures with main gun
23	3.5	3.5	4	Prepare commander's station for operation
24	3.5	3.5	3	Troubleshoot fire control system
25	3.5	3.0	2	Clear M85 caliber .50 machinegun
26	3.5	3.0	1	Engage targets with range card data
27	3.5	3.0	1	Establish, enter, or leave radio net
28	3.0	3.0	1	Install/remove M85 caliber .50 machinegun
29	3.0	3.5	1	Perform tank commander's prepare-to-fire checks and services
30	3.0	3.5	1	Troubleshoot turret
31	3.0	3.5	1	Maintain M85 caliber .50 machinegun
32	3.0	3.0	2	Prepare range card
33	3.0	3.0	1	Boresight M85 caliber .50 machinegun
34	3.0	3.0	1	Zero M85 caliber .50 machinegun
35	3.0	2.5	2	Power down and secure commander's weapon station
36	3.0	2.0	1	Boresight tank searchlight (non-TTS tank)
37	3.0	2.0	1	Operate tank searchlight (non-TTS tank)
38	2.5	3.0	1	Supervise before-operation PMCS
39	2.5	2.5	3	Supervise personnel handling ammunition
40	2.5	2.0	1	Inspect DA form 2408-4 weapons data card

TABLE 12

TASK TRAINING PRIORITY BASED ON TRAINING ORDER NETWORKS (GUNNER TASK TRAINING WITHOUT TIME CONSTRAINTS)

Training Priority	Task Description
1.	Perform gunner's before-operation PMCS
2.	Prepare gunner's station for operation
3.	Perform gunner's prepare-to-fire checks and services
4.	Engage stationary targets from gunner's station with main gun in normal mode
5.	Engage stationary targets from gunner's station with main gun in degraded mode
6.	Adjust fire from gunner's station using reengagement technique with main gun
7.	Adjust fire from gunner's station using standard adjustment with main gun
8.	Adjust fire from gunner's station using target form adjustment with main gun
9.	Engage moving targets from gunner's station with main gun in normal mode
10.	Engage moving targets from gunner's station with main gun in degraded mode
11.	Engage stationary targets from gunner's station with M240 in normal mode
12.	Engage stationary targets from gunner's station with M240 in degraded mode
13.	Engage moving targets from gunner's station with M240 in normal mode
14.	Engage moving targets from gunner's station with M240 in degraded mode
15.	Perform misfire procedures with main gun
16.	Troubleshoot main gun
17.	Troubleshoot fire control system
18.	Perform gunner's during firing checks and services
19.	Operate M28E2 Azimuth indicator (range card)
20.	Operate M13A3 elevation quadrant (range card)
21.	Prepare range card
22.	Engage targets with range card data
23.	Prepare to boresight
24.	Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
25.	Troubleshoot turret
26.	Maintain main gun and breechblock assembly
27.	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)
28.	Perform gunner's after-firing checks and services
29.	Power down and secure gunner's station
30.	Install/remove tank searchlight (non-TTS tank)

Development of Prioritization Method Two

Prioritization Method One was reviewed within both ARI and Anacapa, and it was concluded that it was reliable, could be used to construct networks of efficient training orders, and could handle training-time windows of different lengths. However, the procedure was criticized because of the time and resources required to conduct data collection and analysis. As a result, we decided to relax the criteria of objectivity and reliability somewhat in order to develop a prioritization methodology that made less demand on time and resources. The result was prioritization Method Two. The first two phases of this methodology are identical to those of Method One, and so these phases will not be discussed below. Method Two has three phases, and relies primarily on expert judgment to determine task dependencies and training order, rather than on algorithms such as those used in Method One.

The following discussion describes the final phase of development of Method Two. This methodology was designed to meet three objectives:

- Minimize time and resources required to conduct data collection and analysis.
- Provide a means of distinguishing between necessary and efficient instructional sequences for tasks.
- Provide a means of modifying the task list to match the amount of time available for training.

TABLE 13

TASK TRAINING PRIORITY BASED ON TRAINING ORDER NETWORKS (TANK COMMANDER TASK TRAINING WITH LIMITED TIME AVAILABLE)

Training Priority	Task Description
1.	Issue a fire command
2.	Engage stationary targets from tank commander's station with main gun in normal mode
3.	Engage moving targets from tank commander's station with main gun in normal mode
4.	Engage moving targets from tank commander's station with main gun in degraded mode
5.	Engage stationary targets from tank commander's station with main gun in degraded mode
6.	Direct main gun engagement in normal mode
7.	Direct main gun engagement in degraded mode
8.	Control movement
9.	Adjust fire from tank commander's station using reengagement technique with main gun
10.	Adjust fire from tank commander's station using target form adjustment with main gun
11.	Adjust fire from tank commander's station using standard adjustment with main gun
12.	Issue subsequent fire command
13.	Prepare commander's station for operation
14.	Load/unload M85 caliber .50 machinegun
15.	Engage area targets with M85
16.	Engage moving targets with M85
17.	Perform misfire procedures with M85
18.	Direct machinegun engagements
19.	Engage aerial targets with M85
20.	Fire M239 smoke grenade launchers
21.	Select tank firing positions
22.	Establish tank firing positions
23.	Perform misfire procedures with main gun
24.	Perform tank commander's prepare-to-fire checks and services
25.	Troubleshoot fire control system
26.	Clear M85 caliber .50 machinegun
27.	Prepare range card
28.	Engage targets with range card data
29.	Establish, enter, or leave radio net
30.	Troubleshoot turret
31.	Supervise before-operation PMCS
32.	Boresight M85 caliber .50 machinegun
33.	Zero M85 caliber .50 machinegun
34.	Maintain M85 caliber .50 machinegun
35.	Install/remove M85 caliber .50 machinegun
36.	Power down and secure commander's weapon station
37.	Operate tank searchlight (non-TTS tank)
38.	Boresight tank searchlight (non-TTS tank)
39.	Supervise personnel handling ammunition
40.	Inspect DA form 2408-4 weapons data card

The time and resources required for the application of Method Two were reduced by dropping the training order efficiency questionnaires. In place of these questionnaires, a set of guidelines was developed for identifying and distinguishing between necessary and efficient task training orders. These guidelines are to be used by the training developer who has selected the tasks for training and conducted the task criticality analysis. The construction of task training order networks was also dropped. The revised procedure relies instead on the training developer's internal model of the relationships. These revisions also provided a basis for modifying the task training list to fit the available training time.

TABLE 14

TASK TRAINING PRIORITY BASED ON TRAINING ORDER NETWORKS
(GUNNER TASK TRAINING WITH LIMITED TIME AVAILABLE)

Training Priority	Task Description
1.	Engage stationary targets from gunner's station with main gun in normal mode
2.	Engage stationary targets from gunner's station with main gun in degraded mode
3.	Adjust fire from gunner's station using reengagement technique with main gun
4.	Adjust fire from gunner's station using standard adjustment with main gun
5.	Adjust fire from gunner's station using target form adjustment with main gun
6.	Engage moving targets from gunner's station with main gun in normal mode
7.	Engage moving targets from gunner's station with main gun in degraded mode
8.	Engage stationary targets from gunner's station with M240 in normal mode
9.	Engage stationary targets from gunner's station with M240 in degraded mode
10.	Engage moving targets from gunner's station with M240 in normal mode
11.	Engage moving targets from gunner's station with M240 in degraded mode
12.	Perform gunner's before-operation PMCS
13.	Prepare gunner's station for operation
14.	Perform gunner's prepare-to-fire checks and services
15.	Perform misfire procedures with main gun
16.	Troubleshoot main gun
17.	Troubleshoot fire control system
18.	Perform gunner's during firing checks and services
19.	Operate M28E2 Azimuth indicator (range card)
20.	Operate M13A3 elevation quadrant (range card)
21.	Prepare range card
22.	Engage targets with range card data
23.	Prepare to boresight
24.	Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
25.	Troubleshoot turret
26.	Maintain main gun and breechblock assembly
27.	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)
28.	Perform gunner's after-firing checks and services
29.	Power down and secure gunner's station
30.	Install/remove tank searchlight (non-TTS tank)

The following is a detailed description of the three steps of Method Two that replace Phases 3 and 4 of Method One.

Step 1: Modify Task Order Based on Logical Criteria. During this step, training developers determine an effective training order among tasks with identical task assistance scores. Tasks with identical task assistance scores are first separated into sets, using task cards with criticality scores and task descriptions for each. In this way, the task assistance score defines sets of tasks with comparable criticality scores. The order among tasks within each set is then modified according to three guidelines:

- **Prerequisite tasks first.** If you must know how to perform Task "A" before you can learn to perform Task "B," then Task "A" is a **prerequisite** for Task "B" and should be trained on first. Task A is not a prerequisite if it would only be "nice to know" but not "necessary to know" before Task B. For example, knowing how to "operate the azimuth indicator" is necessary for learning how to "prepare range card.

- **Simple tasks first.** If performance of one task is simpler but related to another task, put the simple task ahead of the complex task. For example, stationary target engagement is simpler than moving target engagement with the same weapon.

- **Common modes first.** The most common system modes for a task should be ahead of less common modes. For example, "normal mode" tasks should be ahead of "degraded mode" tasks involving operation of the same equipment.

Training developers are instructed to maintain the order of tasks based on criticality scores, within the limits of these guidelines. In this way, task consequence scores and frequency scores have an effect on the final training order. Tables 15 and 16 show the orders of tank commander and gunner tasks resulting from performing this step. Task criticality subscores are provided in this table to aid the reader in identifying modifications in task order.

Step 2: Modify Task List Based on Prerequisites. Training developers are instructed to review the entire task list during this step and modify the order among tasks with different task assistance scores, following the prerequisite tasks first guideline from Step 1. The instructions caution developers to limit task list modifications to task prerequisites. The following procedure is recommended in conducting this step:

1. Start with the top task on the list.

2. Look down the list, task by task, for prerequisites.

3. If you find a prerequisite, move its task card up above the original task. (Task descriptions are written on task cards and used during the sorting process.)

4. Take the next task on the list, search down the list for prerequisites, and rearrange, as necessary.

5. Continue in this manner until you go through the entire list.

When this step is completed, the developer will have obtained the final training order for all selected tasks. Tables 17 and 18 show the results of performing this step on the task lists contained in Tables 15 and 16. Tasks that were moved during this step have an asterisk next to their priority number.

Step 3: Reduce Task List to Fit Available Time. The following instructions were developed to help the training developer modify the length of a task list to fit available training time.

At the conclusion of Step 2, you obtained a training order for all the tasks that you were prioritizing. You may not have time to conduct training on all of these tasks. The present step will permit you to determine what tasks you can cover in the training time you have available.

First, determine how much training time you have available. Estimate the total number of training hours that will be available within your particular training context. If training is occuring in a school, estimate the total number of classroom and hands-on training hours. If you are planning unit training, estimate the number of hours that will be available on a weekly basis and multiply this by the number of weeks your training will cover.

TABLE 15

RESULTS OF APPLYING STEP 1
(TANK COMMANDER TASKS)

Task Order	Criticality Subscores: Assistance	Consequence	Frequency	Task Description
1	4.5	3.5	13	Engage moving targets from tank commander's station with main gun in normal mode
2	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in normal mode
3	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in degraded mode
4	4.0	4.0	13	Engage moving targets from tank commander's station with main gun in degraded mode
5	4.0	3.5	12	Issue a fire command
6	4.0	3.5	12	Issue subsequent fire command
7	4.0	4.0	12	Direct main gun engagement in normal mode
8	4.0	4.0	12	Direct main gun engagement in degraded mode
9	4.0	4.0	7	Control movement
10	4.0	3.5	13	Adjust fire from tank commander's station using reengagement technique with main gun
11	4.0	3.5	13	Adjust fire from tank commander's station using standard adjustment with main gun
12	4.0	3.5	13	Adjust fire from tank commander's station using target form adjustment with main gun
13	4.0	3.5	9	Direct machinegun engagements
14	4.0	3.5	9	Engage area targets with M85
15	4.0	3.5	9	Engage moving targets with M85
16	4.0	3.5	3	Load/unload M85 caliber .50 machinegun
17	4.0	3.5	9	Perform misfire procedures with M85
18	4.0	3.0	9	Engage aerial targets with M85
19	4.0	3.0	3	Fire M239 smoke grenade launchers
20	3.5	3.5	9	Select tank firing positions
21	3.5	4.0	2	Establish tank firing positions
22	3.5	3.5	13	Perform misfire procedures with main gun
23	3.5	3.5	4	Prepare commander's station for operation
24	3.5	3.5	3	Troubleshoot fire control system
25	3.5	3.0	2	Clear M85 caliber .50 machinegun
26	3.5	3.0	1	Engage targets with range card data
27	3.5	3.0	1	Establish, enter, or leave radio net
28	3.0	3.0	1	Install/remove M85 caliber .50 machinegun
29	3.0	3.5	1	Perform tank commander's prepare-to-fire checks and services
30	3.0	3.5	1	Troubleshoot turret
31	3.0	3.5	1	Maintain M85 caliber .50 machinegun
32	3.0	3.0	2	Prepare range card
33	3.0	3.0	1	Boresight M85 caliber .50 machinegun
34	3.0	3.0	1	Zero M85 caliber .50 machinegun
35	3.0	2.5	2	Power down and secure commander's weapon station
36	3.0	2.0	1	Boresight tank searchlight (non-TTS tank)
37	3.0	2.0	1	Operate tank searchlight (non-TTS tank)
38	2.5	3.0	1	Supervise before-operation PMCS
39	2.5	2.5	3	Supervise personnel handling ammunition
40	2.5	2.0	1	Inspect DA form 2408-4 weapons data card

Next, estimate the number of hours that would be required to conduct training on each of the tasks on your task list. Enter these numbers beneath the Training time column on the list you prepared at the end of Step 2.

Add up the total number of hours required for doing training on all of the tasks on the list. If this number is greater than the total number of training hours, drop as many tasks from the bottom of the list as necessary to reduce the required training time to fit your available time.

This final step does not involve task prioritization, per se. Rather, it uses task priority as the basis for excluding tasks from the list for training.

TABLE 16

RESULTS OF APPLYING STEP 1
(GUNNER TASKS)

Task Order	Criticality Subscores: Assistance	Consequence	Frequency	Task Description
1	4.0	4.5	14	Engage stationary targets from gunner's station with main gun in normal mode
2	4.0	4.0	14	Engage moving targets from gunner's station with main gun in normal mode
3	4.0	4.0	14	Adjust fire from gunner's station using reengagement technique with main gun
4	4.0	4.0	14	Engage stationary targets from gunner's station with main gun in degraded mode
5	4.0	4.5	14	Engage moving targets from gunner's station with main gun in degraded mode
6	4.0	4.0	14	Adjust fire from gunner's station using standard adjustment with main gun
7	4.0	4.5	14	Adjust fire from gunner's station using target form adjustment with main gun
8	4.0	3.5	10	Engage stationary targets from gunner's station with M240 in normal mode
9	4.0	3.5	10	Engage moving targets from gunner's station with M240 in normal mode
10	4.0	3.5	10	Engage stationary targets from gunner's station with M240 in degraded mode
11	4.0	3.5	10	Engage moving targets from gunner's station with M240 in degraded mode
12	3.5	4.0	14	Perform misfire procedures with main gun
13	3.5	3.5	3	Perform gunner's during firing checks and services
14	3.5	4.0	3	Troubleshoot main gun
15	3.5	4.0	3	Troubleshoot fire control system
16	3.5	3.5	2	Operate M28E2 Azimuth indicator (range card)
17	3.5	3.5	2	Engage targets with range card data
18	3.0	3.5	1	Perform gunner's before-operation PMCS
19	3.0	3.5	1	Perform gunner's prepare-to-fire checks and services
20	3.0	4.0	4	Prepare gunner's station for operation
21	3.0	3.5	1	Maintain main gun and breechblock assembly
22	3.0	4.0	1	Prepare to boresight
23	3.0	4.0	1	Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
24	3.0	3.5	1	Troubleshoot turret
25	3.0	3.5	1	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)
26	3.0	3.0	2	Operate M13A3 elevation quadrant (range card)
27	3.0	3.0	2	Prepare range card
28	3.0	30	2	Perform gunner's after-firing checks and services
29	3.0	2.5	2	Power down and secure gunner's station
30	2.5	2.0	1	Install/remove tank searchlight (non-TTS tank)

TABLE 17

RESULTS OF APPLYING STEP 2 (TANK COMMANDER TASKS TRAINING PRIORITY)

Training Priority	Criticality Subscores: Assistance	Consequence	Frequency	Task Description
1*	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in normal mode
2	4.5	3.5	13	Engage moving targets from tank commander's station with main gun in normal mode
3	4.0	4.0	13	Engage stationary targets from tank commander's station with main gun in degraded mode
4	4.0	4.0	13	Engage moving targets from tank commander's station with main gun in degraded mode
5	4.0	3.5	12	Issue a fire command
6	4.0	3.5	12	Issue subsequent fire command
7	4.0	4.0	12	Direct main gun engagement in normal mode
8	4.0	4.0	12	Direct main gun engagement in degraded mode
9	4.0	4.0	7	Control movement
10	4.0	3.5	13	Adjust fire from tank commander's station using reengagement technique with main gun
11	4.0	3.5	13	Adjust fire from tank commander's station using standard adjustment with main gun
12	4.0	3.5	13	Adjust fire from tank commander's station using target form adjustment with main gun
13	4.0	3.5	9	Direct machinegun engagements
14	4.0	3.5	9	Engage area targets with M85
15	4.0	3.5	9	Engage moving targets with M85
16	4.0	3.5	3	Load/unload M85 caliber .50 machinegun
17	4.0	3.5	9	Perform misfire procedures with M85
18	4.0	3.0	9	Engage aerial targets with M85
19	4.0	3.0	3	Fire M239 smoke grenade launchers
20	3.5	3.5	9	Select tank firing positions
21	3.5	4.0	2	Establish tank firing positions
22	3.5	3.5	13	Perform misfire procedures with main gun
23*	3.0	3.0	1	Install/remove M85 caliber .50 machinegun
24*	3.0	3.5	1	Perform tank commander's prepare-to-fire checks and services
25	3.5	3.5	4	Prepare commander's station for operation
26	3.5	3.5	3	Troubleshoot fire control system
27	3.5	3.0	2	Clear M85 caliber .50 machinegun
28	3.5	3.0	1	Engage targets with range card data
29	3.5	3.0	1	Establish, enter, or leave radio net
30	3.0	3.5	1	Troubleshoot turret
31	3.0	3.5	1	Maintain M85 caliber .50 machinegun
32	3.0	3.0	2	Prepare range card
33	3.0	3.0	1	Boresight M85 caliber .50 machinegun
34	3.0	3.0	1	Zero M85 caliber .50 machinegun
35	3.0	2.5	2	Power down and secure commander's weapon station
36	3.0	2.0	1	Boresight tank searchlight (non-TTS tank)
37	3.0	2.0	1	Operate tank searchlight (non-TTS tank)
38	2.5	3.0	1	Supervise before-operation PMCS
39	2.5	2.5	3	Supervise personnel handling ammunition
40	2.5	2.0	1	Inspect DA form 2408-4 weapons data card

*Training priority after Step 9 is higher than task order after Step 8 for these tasks.

Assessment

Developing the prioritization methodologies was the most challenging task performed during this project. Unlike the task selection or training definition methodologies, both of which derive from similar methodologies in use in the Army, there was no model for task prioritization.

While the purpose of task prioritization differs from that of task selection, our goals in developing the two methodologies were similar. First, we wanted to develop methodologies that were both objective and reliable. Second, we wanted to develop methodologies that could be effectively employed by Army training developers. The first goal requires a methodology that is rigorous, comprehensive, and systematic; these requirements have implications in terms of personnel and time resources. The second goal requires simplicity and a minimum demand on these same resources. In short, the two goals are not complementary, but competing. In developing the task selection methodology, we were able to meet both goals reasonably well because the task selection methdology is simple.

However, task prioritization is much more complex, and it was impossible to meet both goals in one methodology. The result was two different prioritization methodologies.

The first prioritization methodology is the most objective and reliable. It requires the training developer to create questionnaires, administer them, collect and analyze data, develop task dependency networks, and then derive training orders. Three questionnaires must be developed--task assistance, consequence, and training dependency (i.e., prerequisite relationships among tasks). The first two questionnaires must be administered to approximately 50 subjects and the last to about 15. The first two questionnaires are easy to score. Total SME time to complete the questionnaires is approximately 130 man-hours. Questionnaires must be analyzed and task dependency networks developed by training analysts. The analysis procedure is rule-based and reliable. However, without computer assistance, it is time-consuming. For example, approximately 20 man-hours were required to develop the dependency networks for the tank commander and gunner questionnaires analyzed during this project. The analysis procedure could be simplified through computerization. If it were, then analysis would be a simple matter of feeding questionnaire data into a computer program and having it, in turn, generate task dependency networks and training orders. Performing the analysis does not require great computing power; a microcomputer such as the Apple II could do the job adequately.

TABLE 18

RESULTS OF APPLYING STEP 2
(GUNNER TASKS TRAINING PRIORITY)

Task Priority	Criticality Subscores: Assistance	Consequence	Frequency	Task Description
1	4.0	4.5	14	Engage stationary targets from gunner's station with main gun in normal mode
2	4.0	4.0	14	Engage moving targets from gunner's station with main gun in normal mode
3	4.0	4.0	14	Adjust fire from gunner's station using reengagement technique with main gun
4	4.0	4.0	14	Engage stationary targets from gunner's station with main gun in degraded mode
5	4.0	4.5	14	Engage moving targets from gunner's station with main gun in degraded mode
6	4.0	4.0	14	Adjust fire from gunner's station using standard adjustment with main gun
7	4.0	4.5	14	Adjust fire from gunner's station using target form adjustment with main gun
8	4.0	3.5	10	Engage stationary targets from gunner's station with M240 in normal mode
9	4.0	3.5	10	Engage moving targets from gunner's station with M240 in normal mode
10	4.0	3.5	10	Engage stationary targets from gunner's station with M240 in degraded mode
11	4.0	3.5	10	Engage moving targets from gunner's station with M240 in degraded mode
12	3.5	4.0	14	Perform misfire procedures with main gun
13*	3.0	3.5	1	Perform gunner's before-operation PMCS
14*	3.0	3.5	1	Perform gunner's prepare-to-fire checks and services
15	3.5	3.5	3	Perform gunner's during firing checks and services
16	3.5	4.0	3	Troubleshoot main gun
17	3.5	4.0	3	Troubleshoot fire control system
18	3.5	3.5	2	Operate M28E2 Azimuth indicator (range card)
19	3.5	3.5	2	Engage targets with range card data
20	3.0	4.0	4	Prepare gunner's station for operation
21	3.0	3.5	1	Maintain main gun and breechblock assembly
22	3.0	4.0	1	Prepare to boresight
23	3.0	4.0	1	Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
24	3.0	3.5	1	Troubleshoot turret
25	3.0	3.5	1	Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)
26	3.0	3.0	2	Operate M13A3 elevation quadrant (range card)
27	3.0	3.0	2	Prepare range card
28	3.0	3.0	2	Perform gunner's after-firing checks and services
29	3.0	2.5	2	Power down and secure gunner's station
30	2.5	2.0	1	Install/remove tank searchlight (non-TTS tank)

*Training priority after Step 9 is higher than task order after Step 8 for these tasks.

The second prioritization methodology is much simpler in the sense that it relies primarily on SME judgments. The first two steps of the prioritization methodology--collecting task assistance and consequence data--remain the same. However, task dependency data are not collected or used. Rather, the methodology depends upon the training developer's knowledge of the task dependencies rather than upon objective data. A small group of SMEs is provided with a task list and they apply their subjective criteria in a group setting to arrive at a training order. This methodology has the advantage that it is much less time- and labor-intensive. The drawback is its lack of objectivity and reliability. One does not really know what criteria SMEs use to prioritize tasks.

Which prioritization method is best?

The answer to this question depends upon what evaluation criteria are invoked. If objectivity and replicability are the main criteria, then Method One is the best. If minimum demand on resources is the main criterion, then Method Two is the best.

Both methods have technical shortcomings and could stand improvement. For example, the task dependency questionnaire used in Method One does not make an adequate distinction between "necessary" and "efficient" training orders. As a result, when data are analyzed, the results tend to show certain tasks as prerequisites of other tasks when there is a limited dependency between them. In simple terms, it may be "efficient" to train task A before task B, but not actually "necessary." The result of this shortcoming is evident in the prioritized tank commander task list (see Table 11), where the highest-priority tasks are those in which the tank commander engages targets from his own station. In actual practice, training is seldom conducted in this way. Nonetheless, SME responses to the task dependency questionnaire indicated that most SMEs thought that this would lead to the most efficient training.

What is wrong with prioritization Method Two? We cannot really identify technical shortcomings such as those pointed out above. The biggest problem with this method is that it reduces task prioritization to a sort of art whose practice is limited to a select few. No matter how carefully we word the procedure, when the SMEs get together and start prioritizing the task lists, they will be heavily influenced by their own preconceived biases.

A promising approach to prioritization is to take prioritization Method One a step further. Its most serious shortcoming is the amount of time and effort required to administer questionnaires and analyze them. By developing a micro computer program, it would be possible to shortcut the analysis required to develop the dependency networks and prioritized task lists. This requires additional research and development. Developing the software is feasible, and it would simplify analysis. The major payoff is that it would make prioritization an objective process.

TRAINING DEFINITION METHODOLOGY

Introduction

The objective of this task was to develop a methodology to define the scope, content, and methods to employ in unit-level individual training of armor crewmen. The methodology was subsequently applied to develop training plans and to identify the basic structure of a training regime for M60A3 tank commanders and gunners.

The training definition methodology focused on two training contexts: (1) garrison, and (2) pre-deployment training. Garrison training occurs on a continuing basis when a unit is not under pressure to prepare for combat in the short term. If the unit is alerted and about to go into action, it shifts into a pre-deployment mode of training--with very little time to train. The difference between these two contexts is one of time.

The project focused on two specific types of training: (1) training up the tank commander or gunner in his assigned crew position, and (2) cross-training gunners for the tank commander's position and other tank crewmen for the gunner's position. The methodology had to take into account several factors that influence training. First, the constraints on training at unit level had to be defined such that training could be designed to operate within them. The entry-level skills of tank crew members had to be known so that training could be set at the proper level. It was necessary to determine what training resources were available at unit level, and determine which ones could be used for training delivery. The tasks on which training would be delivered had to be analyzed and appropriate learning activities selected for use in conducting training on each task. Training modules had to be developed to support training delivery. Procedures and written guides had to be developed to permit effective training management and evaluation by unit leaders.

All of the foregoing influence the design, development, and conduct of unit-level training. Work on this task culminated in the development of several training products, including training modules for tank commanders and gunners, a trainer's guide, and a training manager's guide. The training modules were the main product of this work; their development is discussed in the final section of this report, and they are included in Volume 2. This section addresses these issues as they relate to the research objectives of the project. They are discussed in terms of the four subtasks that were performed:

1. Determine unit-level training constraints.
2. Identify training resources.
3. Select learning activities and resources.
4. Plan training products.

Determine Unit-Level Training Constraints

The objective of this subtask was to define unit constraints under both garrison and pre-deployment conditions. These constraints set the boundaries on how training could be conducted at unit level in terms of the availability of trainers, training time, outside demands on unit personnel, and training resources. The following constraints were of primary concern to the project:

- **NCO constraints**--NCO manning levels, availability, experience, skill level, training experience.

- **Time factors**--Training time availability, training scheduling, typical use of training time, projections concerning pre-deployment training time availability.

- **Outside demands on unit personnel**--Guard duty, required classes, leave, other taskings.

- **Training resources**--Types available, use, user preferences, training sites available.

- **Equipment and materials available for training**--Tanks, ammunition, ranges available.

Information concerning training constraints was obtained by conducting a field survey at a CONUS installation. An Army post was chosen that had two M60A3-equipped armor battalions. We had initially planned to visit several armor battalions in both CONUS and USAREUR. However, arrangements could not be made and our analysis is based on information obtained at one post.

During our data collection visit, project staff interviewed 84 personnel in two armor battalions. Separate questionnaires were prepared for Bn Cdr/XO, S3, Co Cdr/XO, Plt Ldr/Sgt/Master Gunner, and tank crew. Interviews were conducted based on these questionnaires, and responses were recorded on the questionnaires. Personnel were interviewed individually, with the exception of tank crews; each crew was interviewed as a group.

A detailed description of the survey was reported in Simpson, McCallum, and Fuller (1983, TR 518-3-1). The conclusions of this survey were as follows:

- **Unit strength for armor crew MOSs is adequate, but there is a significant shortage of more experienced supervisory personnel** -- It follows from this that training must often be delivered by personnel who are not fully qualified technically or as trainers, and that training modules must be detailed and highly prescriptive.

- **The availability of personnel to participate in training is quite good when the unit is in the field, but much worse in garrison** -- These two training environments are different both physically and in terms of the potential for successful training. The garrison environment is not particularly good for conducting individual training because of disruptions and personnel absences. Training modules must be usable on an individual basis without requiring full personnel availability.

- **Units appear to be very event and "crisis" oriented and show little evidence of being able to carry out a training program that is not mandated by immediate requirements** -- A complex training program with long-term training goals and substantial support requirements would have little chance of success. Portable, stand-alone training modules could be used when the time allows.

- **There will be little or no time to conduct individual training once the unit is ordered to deploy** -- For planning purposes, we should anticipate a two-week training period, and assume that the unit will have some advance notice that it will be deployed.

- **The typical unit trainer (tank commander or platoon sergeant) is unaware of the requirements for conducting effective performance-oriented training** -- The performance-oriented training formula must be built into training modules. Trainers will not necessarily know how to conduct such training.

Identify Training Resources

The objective of this subtask was to identify the training resources for unit-level individual training that were currently available, those that would be available during the next five years, and any advanced technology resources that will be available in the foreseeable future. Training resources are any written, graphic, audio-visual, or other materials or objects, excluding the M60A3 itself, that can be used to support training. Specific examples of training resources are Army Field Manuals (FM), Training Extension Courses (TEC), and the M55 laser.

The primary means of identifying training resources was via a literature review. Several dozen documents were reviewed, including FMs, TMs, ARTEPs, DAPams, and programs of instruction and supporting materials used in courses taught at the U.S. Army Armor School (USAARMS). We prepared a fact sheet for each resource, identifying the resource title, type resource, date available for field use, summary description of the resource, and the reference through which the resource was identified. During subsequent work, we prepared a task/resource cross-reference listing for gunner tasks and tank commander tasks. This cross-reference listing identified the training resources available for use in conducting training on the gunner and tank commander tasks identified during project task 1.

The resource fact sheets, cross-reference listings, and the glossary of acronyms are described in detail in Simpson et al. (1983).

Select Learning Activities and Resources

The objective of this subtask was to develop a simple and practical methodology for selecting learning activities and resources for use in armor crew training. The work performed and results obtained during this subtask are summarized in this section. This work is described in greater detail in Simpson et al (1983); Simpson, McCallum, and Fuller (1983a); and Simpson, McCallum, and Fuller (1983b).

During training development, the selection of learning activities and resources is usually made either in an informal and somewhat arbitrary way, or by following the complex and labor-intensive procedures described in the Instructional Systems Development (ISD) model.[2]

The ISD model is general, and applicable to a wide range of jobs, duties, and tasks that are performed in a variety of contexts. ISD procedures must therefore be comprehensive to encompass all training possibilities. The focus of the current project was upon two tank crewmen jobs (tank commander and gunner) and a specific training environment (armor combat unit) that permitted the use of a limited number of learning activities and resources. The ISD model could be considerably streamlined when applied in this context.

The overall objective described above was broken down into two sub-objectives. The first was to develop a procedure for translating task statements into appropropriate learning activities, using available training resources. We did this by tailoring the ISD model to the armor training context.

The second objective was to define a set of learning principles and activities that is common across all (or most) of the tasks for which training modules had to be developed. These principles and activities emerged, in part, from meeting the first objective. By looking at the various crew position tasks that had to be covered in training, we could determine what learning principles and activities applied to most training situations. In addition, performance-oriented training by its nature imposed certain specific learning activities, e.g., statement of training objectives, demonstration by trainer, hands-on practice by trainee, and performance evaluation.

In adapting the ISD model to the needs of the project, we made several assumptions about unit training constraints and the way that training would be delivered. These assumptions were as follows:

- The primary mode of training delivery would be for the supervisor to train his subordinates, acting in the role of a trainer. Gunners would be trained by tank commanders, and tank commanders by platoon sergeants or master gunners. Training would be managed by the platoon leader.

- The primary training resource would be training modules developed on this project. Other training resources would be used during training to the extent that they were readily available at unit level, supported accomplishment of training objectives for a particular module, and could be employed with minimum preparation and personnel support.

- During most garrison training, trainers would have very limited access to small- or large-caliber ranges or to geography that would permit use of the laser rangefinder. Most such garrison training would occur in the tank park or nearby. Most training would therefore occur in a simulated or "dry fire" mode.

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[2]The ISD model is described in a number of different documents, most notably TRADOC pamphlet 350-30 (Interservice Procedures for Instructional Systems Development). We based our analysis of ISD primarily on that document and on ARI Research Product 80-18 (Job Aid Manuals for Phase III (Develop): The Instructional Systems Development Model).

- Most training would be performance-oriented, following the schema: Statement of objectives, demonstration, hands-on practice, performance evaluation.

The procedure for selecting learning activities and resources was developed by adapting key elements of the ISD model to the unit-level individual training context. The resulting procedure led to the systematic identification of the unique learning activities and resources required for training on specific individual tasks. In addition, we identified certain individual training constants--learning activities that need to be part of most individual training. These training constants emerged both from Army doctrine concerning performance-oriented training and from previous research concerning learning and cognition.

The learning activity and resource selection process is illustrated in Figure 8. There are four inputs to this process, as shown on the left of the figure:

- **Individual tasks**--The set of tank commander and gunner individual tasks selected during project task 1 (task selection). These tasks comprise the scope of training coverage. They may be thought of as the basic units in which training will be delivered. Task order and emphasis were determined during project task 2 (task prioritization).

- **Training resources**--The training resources available for use in unit-level training.

- **Training constraints**--The factors limiting what learning activities are possible and what training resources can be used.

- **Armor crew skills**--The entry-level skills of soldiers who will participate in training.

The selection process (Steps 1-4) is shown in the center of the figure.

Step 1 is to develop a task/resource cross-reference listing which identifies the training resources available for conducting training on each task. This listing is used both during Step 4 and later in the project, during training module development.

During Step 2, the task is divided into its procedural steps. Training activities and resources are selected at this level, rather than at the more global level of the task.

During Step 3, task steps are analyzed and assigned to learning categories/subcategories, based upon the nature of each step. Consistent with the ISD model, three main learning categories are used--mental, physical, and attitudinal. Each category has a number of subcategories.

During Step 4, learning activities are identified for each learning category/subcategory. Available training resources, training constraints, and crew skills are considered in choosing the learning activities.

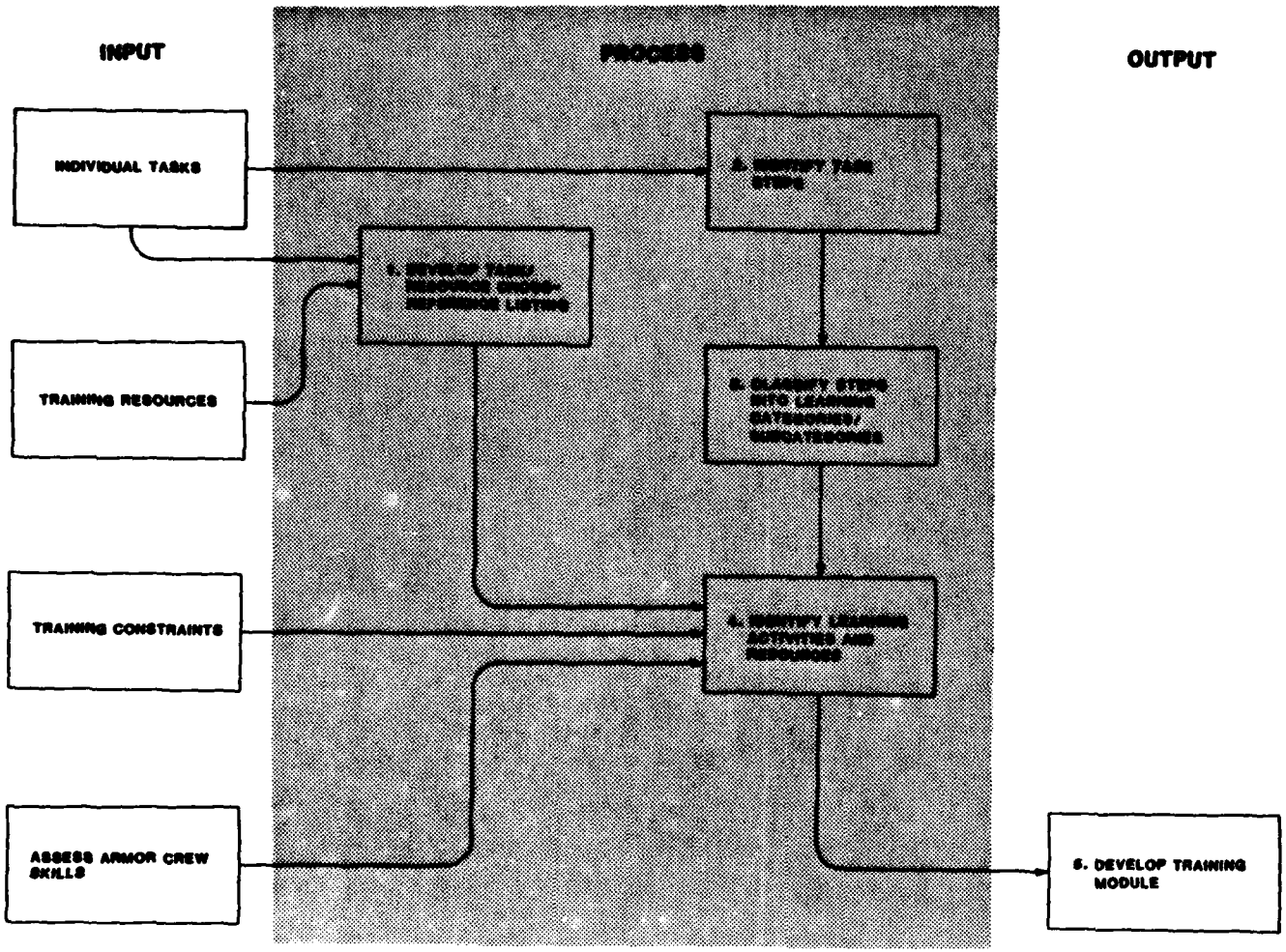


Figure 8. Learning activity and resource selection process.

The output of the process is obtained during Step 5. This output consists of a training module, which contains a step-by-step description of how training should be delivered in terms of specific learning activities and training resources.

Plan Training Products

The objective of this subtask was to plan the training products that would be used to deliver training. Planning these products required that assumptions be made about unit training constraints and the abilities of unit personnel to manage and conduct training. In addition, decisions had to be made concerning who would deliver training, where and in what manner, and how much time would be allowed for training delivery. All of these factors had an influence on the shape that training products eventually took. The work described in this section was reported in Simpson, Fuller, and McCallum (1983). For the sake of brevity, this section highlights key points.

The design of the training products was based on several assumptions about unit training constraints and the capabilities of unit personnel to manage and conduct training. These assumptions are as follows:

- In general, Armor units lack adequate training programs to sustain the individual skills of armor crewmen on a continuing basis. For example, instead of running a continuous program to sustain gunnery skills, unit training is characterized by crash programs prior to tank gunnery exercises and the absence of individual skill training for the months between gunnery exercises. Thus, training products had to provide a plan that specified what tasks to cover in training, on a scheduled basis, and the schedule had to cover tasks in the order of their priority.

- Many tank commanders lack the technical and training skills necessary to develop and deliver effective training to their subordinates. They also lack the time and aptitude to prepare effective learning activities. Training modules for this audience had to be complete, require minimal trainer preparation, and give specific guidance for training delivery.

- The garrison training environment is characterized by unpredictable, last-minute demands on personnel, frequent absences, changes in schedule, and personnel turbulence. These factors combine to make it impossible to carry out training according to a rigid schedule and require that training products be capable of use on short notice.

Decisions had to be made concerning who would deliver training. According to Army doctrine, a soldier's immediate supervisor is responsible for his individual training. Following this logic, the supervisor responsible for training the gunner is the tank commander, and the supervisor responsible for training the tank commander is the platoon sergeant. We assumed that training of tank commanders would be centralized at platoon level. Tank commanders could not train themselves and had to be trained by other qualified personnel. The primary trainer would be the platoon sergeant. He would also be the primary orchestrator of platoon-level training. In addition to him, other qualified trainers, such as the company master gunner, an expert tank commander, or a training specialist from outside the platoon might be designated to conduct training.

Training modules had to support the trainer's presentation. These modules had to contain a detailed lesson plan that described what to cover in training and how the training session should be conducted.

Gunner training would be conducted by tank commanders, using modules like those used for tank commander training. Tank commanders would prepare for training by using their training modules, and then administer a gunner lesson to their gunner, driver, and loader. This would permit train-up of the gunner in his designated crew position, and simultaneous cross-training of the loader and driver for the gunner crew position. Similarly, platoon sergeants would train both tank commanders and gunners on tank commander tasks, enabling simultaneous train-up of tank commanders and cross-training of gunners.

The primary method of training delivery would be for the trainer to conduct performance-oriented training, using operational equipment. He would prepare for his presentation by using training modules and references cited in those modules. Each module had to include a set of learning objectives and a performance test. The performance test would require the soldier to demonstrate to his trainer that he could perform the task, to standard, under appropriate conditions. Based on this test, the trainer will give the soldier a "go" or "no-go" on the task.

In addition to training modules, it was necessary to plan two additional training products: a Trainer's Guide and a Training Manager's Guide. The Trainer's Guide would be a trainer-oriented document that explained the trainer's role in individual training, the content and use of the training modules, and provided "how to train" guidance. The Training Manager's Guide would be an analogous document, but for the platoon leader, i.e., the person responsible for managing unit-level individual training. The Training Manager's Guide would explain the platoon leader's role in managing individual training, provide a brief description of the training modules, and offer guidance for training management and evaluation.

Thus, three basic types of training products were envisioned: training modules, a Trainer's Guide, and a Training Manager's Guide. These products were eventually developed. Their development, and a more detailed description of their content, are given in final section of this report.

DEVELOPMENT OF TRAINING PRODUCTS

Introduction

This section describes the format and content of the three types of training products developed during the project. These training products are:

- Training Modules
- Trainer's Guide
- Training Manager's Guide

Training modules were developed for use by the trainer both to prepare for conducting training and to use as a training prescription--telling how to train and what to cover--during training delivery. A trainer's guide was developed to explain the trainer's role, the content and use of the training modules, and to give general "how to train" guidance. A training manager's guide was prepared for training managers (i.e., platoon leaders) to explain their role in training, describe the training modules, and provide guidance for training management and evaluation.

These training products were developed in an iterative fashion, and with much interaction between personnel at Anacapa and ARI. The general content requirements for these products were determined quite early in the project, and were described fairly accurately in the technical proposal. As work proceeded, these requirements evolved, and prototype training products were developed. All training products were first submitted as drafts, reviewed by ARI, revised, reviewed again, and so on.

The format and content of the most current versions of each of the training products are described below.

Training Modules

Training modules were prepared for training both tank commanders and gunners. The platoon sergeant uses tank commander modules to train personnel for the tank commander crew position. Tank commanders would use gunner modules to train their crew members as gunners. The format of tank commander and gunner modules is identical. Each module covers a specific task. Tank commander tasks covered are listed in Table 19. Gunner tasks covered are listed in Table 20.

Two modules were prepared for each task. One is a "short" module and the other is a "long" module. Each short module consists of a single card (about 4¼" x 6¼"). Long modules are usually three or four pages long, arranged in a booklet with a hinge at the top. The first and last page of each long module duplicate the content of a short module. However, the middle pages contain additional technical and how-to-train information. The following discussion describes a long module. Examples of training modules will be found in Volume 2 of this report.

The first page of each training module contains identification and training preparation information at the top, and a training plan at the bottom. Consider first the box at the top.

CREW POSITION: GUNNER	TRAINING MODULE NO. 4
TASK: ENGAGE STATIONARY TARGETS WITH THE MAIN GUN USING PRECISION GUNNERY	
PREREQUISITE TASKS: GUNNER MODULES NO. 1 AND 3	
TRAINING REFERENCES: FM 17-12-3; SM 171-129-1020; TC 17-15-13, TEC 020-171-5360 E,F	
SUPPORT REQUIREMENTS: STOPWATCH; M60A3 TANK OR TURRET TRAINER; M55 LASER (OPTIONAL); 5 TARGET SILHOUETTES AT CLOSE (1,000 M) AND FAR (2,000 M) RANGES.	

CREW POSITION tells whom the module is for, i.e., gunner or tank commander.

TASK is the task that the module covers. It will be one of the tasks listed in either Table 19 or 20.

PREREQUISITE TASKS are the modules that should be completed before the current module.

TRAINING REFERENCES are references with information that will help the trainer prepare to train with the module.

SUPPORT REQUIREMENTS are the equipment, materials, ranges, and so forth required for conducting training. Some of these are optional and others are required. Optional items will make training more effective, but they are not always available. Training can be conducted without them, if necessary.

The bottom of the module contains the training plan. This plan describes the decisions and procedures involved in conducting training. The top of this plan consists of a decision-action diagram.

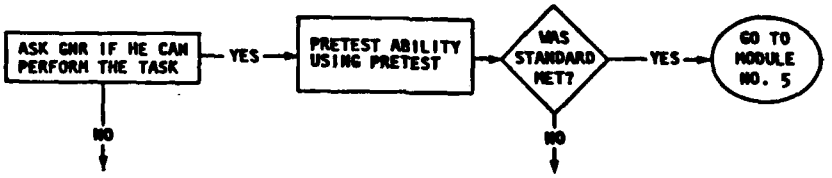


TABLE 19

TANK COMMANDER TASKS COVERED IN TRAINING MODULES

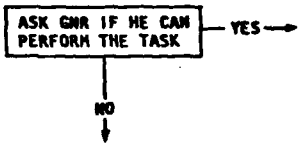
Module No.	Task
1	Prepare station and conduct LRF self-test.
2	Boresight a caliber .50 M85 machinegun.
3	Issue fire commands.
4	Respond to multiple LRF returns.
5	Direct main gun engagement in normal mode.
6	Engage stationary targets from TC's station using precision gunnery.
7	Engage moving targets from TC's station using auto-lead.
8	Issue subsequent fire command.
9	Engage targets with M85.
10	Direct main gun engagement using range card data.
11	Power down and secure TC station.

TABLE 20

GUNNER TASKS COVERED IN TRAINING MODULES

Module No.	Task
1	Prepare gunner's station for operation and conduct computer self-test.
2	Boresight.
3	Basic gunnery skills: aiming, tracking, ranging, firing.
4	Engage stationary targets with main gun using precision gunnery.
5	Engage moving targets with main gun using precision
6	Engage stationary targets with M105D telescope (degraded).
7	Engage moving targets with M105D telescope (degraded).
8	Adjust main gun fire.
9	Perform main gun misfire procedures.
10	Operate M28E2 azimuth indicator.
11	Operate gunner's quadrant.
12	Power down and secure gunner's station.

The words in the top left box say, ASK GUNNER (OR TANK COMMANDER) IF HE CAN PERFORM THE TASK.



The trainer asks the soldier this question before starting training. What the trainer does next depends upon the soldier's answer. If the soldier answers "no," then the trainer follows the arrow that goes straight down, to a box labeled **EXPLAIN.** If the soldier answers "yes," the trainer follows the arrow to the box to the right, which directs him to PRETEST ABILITY USING PRETEST FORM.

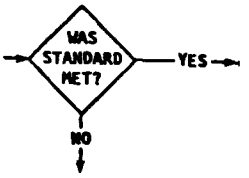
The pretest is on the back of the first page of the module. There are three blocks of information on the pretest: (1) objectives, (2) guidelines, and (3) pretest form. The objectives are the objectives of the pretest. These define the purpose of the pretest and give the performance standard. The trainer states these to the soldier before conducting the pretest. Guidelines are general directions for conducting the pretest. They describe procedures to follow during testing. The pretest form is the actual test. This test is based on the task that is being covered during training. It requires the soldier to demonstrate the basic skills and knowledge required to perform the task. The pretest form has three columns, as shown below.

PRETEST FORM

TC	GUNNER	GO	NO GO
Begin Exercise: Command: "GNR-SABOT-TANK," lay the main gun, start the stopwatch.	1. Set fire control switches. Locate target and get into TTS.		

The left column contains directions for the trainer. The middle column tells what the soldier should do. The right column contains GO/NO GO boxes. The directions tell the trainer what to do at each step. The trainer works his way through the pretest, step by step. He assesses the soldier's performance on each step, giving him a GO or NO GO and marking it in the right column.

After the pretest, the trainer determines whether or not the soldier met the standard and makes a decision (see decision diamond). He then takes the appropriate path, based on the soldier's performance. The trainer follows the arrow that corresponds to the answer to the question WAS STANDARD MET?

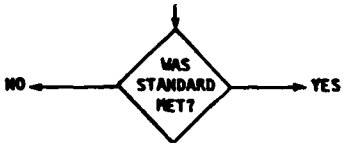


If the answer is "no" (standard not met), he follows the arrow for "no" straight down to box labeled **EXPLAIN.** If the answer is "yes," he follows the arrow to the right to the oval box with words directing him to the next module (i.e., the soldier does not have to receive training on the current module, and the trainer can proceed to a more advanced module).

Typically, the trainer will proceed with the training exercise in the current module. This exercise is contained in the four boxes labeled EXPLAIN, DEMONSTRATE, SUPERVISE PRACTICE, and EVALUATE. To conduct the exercise, the trainer follows the direction in each box, in turn.

He starts with the EXPLAIN box. This requires him to describe in words each step in the particular task. Next, he goes to the DEMONSTRATE box. This lists the points to cover during the demonstration. Additional information on the demonstration will be contained within long modules. After completing the demonstration, the supervisor continues to the SUPERVISE PRACTICE box. This gives instructions for supervision. Additional information will be contained within long modules. Finally, the supervisor moves to the EVALUATE box. This refers him to the PRACTICE/EVALUATION form on the last page of the module. This form is similar to the pretest form and is used in the same way. It lists each step in the procedure, and requires the supervisor to evaluate the soldier's performance and keep track of GOs and NO GOs.

At the conclusion of this process, the trainer must decide whether or not the soldier met the standard (see decision diamond at bottom), and take the appropriate action.



If the standard was met, then training is over. If not, then the soldier is given additional practice, and his performance is evaluated again. This cycle continues until the soldier meets the performance standard.

Individual modules differ in content, but all have the form just described, and all are used in the same way.

Trainer's Guide

The training concept developed during this project placed heavy emphasis on training modules. As described above, these modules were to be used both for training preparation by the trainer and during the actual delivery of training. A basic requirement of these modules was that they had to be concise and compact. This meant that they could only include the essentials. If training were to be conducted by more sophisticated trainers, in a more congenial context (e.g., a school), then the training modules might have taken on a more elaborate form. However, the form they did take meant that compromises had to be made, and certain information left out.

The Trainer's Guide was developed to fill in this missing information. More specifically, the Trainer's Guide was designed to provide information on the following topics:

- A description of the training program in which the modules were to be used.
- The trainer's role in training.
- An explanation of the training modules--what tasks they covered, differences between short and long modules, module organization.
- How to conduct training--who must be trained, what to train them on, where to train them, and when to train.
- How to train--trainer preparation, how to conduct a training session, evaluation of soldier performance

Consistent with the general guidelines followed when developing the training modules, the Trainer's Guide was written as concisely as possible. The guide totals 26 pages. It is written in a simple, clear style, addresses the reader in the second person singular, and provides explicit directions for performing specific training activities, i.e., is directive in nature rather than providing general guidelines that can be broadly interpreted. Also like the training modules, the Trainers' Guide was prepared in compact form for convenient storage and transport.

Training Manager's Guide

The Training Manager's Guide fills for the training manager (i.e., platoon leader) the same role that the Trainer's Guide does for the trainer. It provides the information the training manager needs in order to manage and evaluate training efficiently. This is information that would be out of place in training modules or in the Trainer's Guide.

The Training Manager's Guide is similar in certain respects to the Trainer's Guide. It is concise and compact (15 pages long), written in a simple and clear

style, and is explicit and directive in nature. This guide was designed to provide information on the following topics:

- A description of the training program in which the training modules were to be used.
- The training manager's role in managing and evaluating training.
- Description of tasks covered by training modules.
- Description of a module and the correct way of using it during training.
- Training procedures--who to train, what to train, when to train, and where to train.
- Training management procedures--planning training, controlling training, evaluating training.

REFERENCES

Jarosz, C.J. **Armor training in combat units: Armor crew task selection products (preliminary).** Santa Barbara, California: Anacapa Sciences, Inc., December 1982.

Fuller, R.G., Jarosz, C.J., and Simpson, H. **Armor training in combat units: Selection of tasks for armor crew training.** Santa Barbara, California: Anacapa Sciences, Inc., Technical Report 518-1, January 1983.

Simpson, H., Fuller, R.G., and McCallum, M.C. **Armor training in combat units: Concept for individual training at unit level (preliminary).** Santa Barbara, California: Anacapa Sciences, Inc., Technical Memorandum 518-1, February 1983.

McCallum, M.C. **Armor training in combat units: Task prioritization methodology (preliminary).** Santa Barbara, California: Anacapa Sciences, Inc., Technical Memorandum 518-2, March 1983a.

Simpson, H., McCallum, M.C., and Fuller, R.G. **Armor training in combat units: Procedure for selecting training activities and resources (preliminary).** Santa Barbara, California: Anacapa Sciences, Inc., Technical Memorandum 518-3, March 1983.

McCallum, M.C., Simpson, H., and Goldberg, S.L. **Armor training in combat units: Prioritization of tasks for training. Volume 1: Development of methodology.** Santa Barbara, California: Anacapa Sciences, Inc., Technical Report 518-2-1, May 1983.

McCallum, M.C., Fuller, R.G., and Simpson, H. **Armor training in combat units: Prioritization of tasks for training. Volume 2: User's Guide.** Santa Barbara, California: Anacapa Sciences, Inc., Technical Report 518-2-2, May 1983.

Simpson, H., McCallum, M.C., and Fuller, R.G. **Armor training in combat units: Definition of armor crew training. Volume 1: Development of methodology.** Santa Barbara, California: Anacapa Sciences, Inc., Technical Report 518-3-1, May 1983.

Simpson, H., McCallum, M.C., and Fuller, R.G. **Armor training in combat units: Definition of armor crew training. Volume 2: User's Guide.** Santa Barbara, California: Anacapa Sciences, Inc., Technical Report 518-3-2, May 1983b.

Simpson, H. **Armor training in combat units: Training manager's guide.** Santa Barbara, California: Anacapa Sciences, Inc., Technical Memorandum 518-4-2, September 1983.

APPENDIX A

TASK ASSISTANCE AVAILABILITY QUESTIONNAIRE

This questionnaire provides examples of the instructions and questionnaire items used to obtain SME estimates of the availability of task assistance during combat operations. The order of tasks in this example has been randomized. Four different orders of items were used for this questionnaire. This technique reduces any systematic effect of item order on the results of subsequent analyses.

QUESTIONNAIRE FOR ARMOR TRAINING IN COMBAT UNITS:
TASK ASSISTANCE DURING COMBAT, M60A3 GUNNER TASKS

PURPOSE

The U.S. Army Research Institute for the Behavioral and Social Sciences has been working to identify the importance of different armor tasks for training tank crews in combat units. Lists of armor tasks will be developed for each duty position. These lists will specify the order in which armor tasks should be trained to quickly bring crew members "up to speed" on tasks that are important to the success of a combat mission.

In this questionnaire we want to find out how often you think assistance will be available during combat to M60A3 gunners who must complete certain tasks. We will analyze your answers and use them along with other data to identify the importance for training of each M60A3 gunner task included in this questionnaire.

Please complete the following questions before starting the questionnaire.

1. Months experience in armor: _____

2. Your rank: _____

3. Duty position (check all applicable):
   - ( ) Platoon Sergeant
   - ( ) Gunner
   - ( ) Tank Commander
   - ( ) Master Gunner
   - ( ) Platoon Leader
   - ( ) Company Commander

4. Times fired Table VIII: _____

5. Times qualified on Table VIII: _____

INSTRUCTIONS

Consider the following situation when making your judgments about how often assistance will be available during combat to M60A3 gunners who must complete certain tasks.

GENERAL SITUATION

USAREUR forces are engaged in a conventional war with OPFOR forces on the European battlefield. The European battlefield consists of rolling farmland, numerous hills, streams, small forests, and villages. In the rolling farmland, fields of fire sometimes stretch for 5,000 meters or more, but fog, snow, or rain may reduce the field of view. OPFOR forces consist of an extremely modern, highly mobile, and well balanced combined arms force. The tactical conditions of this general situation are as follows:

- OPFOR forces outnumber USAREUR forces at all battlefields.
- OPFOR attacks are carried out to the front, flanks, and rear of battalions, brigades, divisions, and corps.
- OPFOR is using chemical weapons sometimes and there is the possibility that tactical nuclear weapons will also be used.
- USAREUR operations are often conducted day and night without letup for extended periods.
- USAREUR communications are often inoperable. Battles and skirmishes are fought at all levels--platoon, company, battalion, and brigade.

SPECIFIC SITUATION

You are stationed with a USAREUR division as a platoon leader or platoon sergeant. Your battalion has been alerted to deploy immediately. You have been informed that your platoon may be operating independently for periods of time. You are confident of your leadership skills, but concerned about the technical competence of the gunners in your platoon. Sometimes they need help from others or must refer to technical manuals before they can do a task correctly. Assistance has usually been available during training, but actual combat is another matter. If a gunner needs help in completing some tasks during combat, his tank and your platoon may be in trouble. For other tasks, assistance can be provided during combat. Each M60A3 gunner task can be put into one of five categories, based on whether the gunner can get help from others or technical manuals **without threatening combat success:**

1. **Not applicable** -- the task is so easy that even an untrained soldier can do the task without help.

2. There is **always** time for help on the task. Combat success is never threatened when help is needed on the task.

3. **Most of the time** combat conditions allow time for help, but once in a while the task must be performed as quickly as possible.

4. **Some of the time** combat conditions allow time for help on the task, but usually there isn't any time.

5. There is **never** time to get help in doing the task. The task must be performed as second nature.

QUESTIONNAIRE COMPLETION

You are to classify the availability of help for each of the M60A3 gunner tasks on the following pages. A sample questionnaire item looks like this.

EXAMPLE

M60A3 Gunner Task	Gunner Can Get Help During Combat Without Threatening Combat Success: Not Applicable*	Always	Most of the Time	Some of the Time	Never
Perform after-operation PMCS on turret	( )	( )	( )	( )	( )

In completing this item, **check the one alternative** that best indicates how often **during combat** a gunner can get help on a task without threatening combat success. A completed item will look like the one shown below. Always is checked because there is not an immediate threat when this task is done and it is more important that the task be done correctly than quickly.

EXAMPLE

M60A3 Gunner Task	Gunner Can Get Help During Combat Without Threatening Combat Success: Not Applicable*	Always	Most of the Time	Some of the Time	Never
Perform after-operation PMCS on turret	( )	(X)	( )	( )	( )

M60A3 Gunner Task	Not Applicable*	Gunner Can Get Help During Combat Without Threatening Combat Success: Always	Most of the Time	Some of the Time	Never
12. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)	( )	( )	( )	( )	( )
41. Engage moving target from gunner's station with main gun using automatic lead	( )	( )	( )	( )	( )
32. Operate M28E2 azimuth indicator (range card)	( )	( )	( )	( )	( )
4. Prepare gunner's station for operation	( )	( )	( )	( )	( )
22. Check sight stability (boresight)	( )	( )	( )	( )	( )
24. Check ballistic solution (boresight)	( )	( )	( )	( )	( )
16. Adjust laser rangefinder (boresight)	( )	( )	( )	( )	( )
27. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)	( )	( )	( )	( )	( )
18. Adjust TTS (boresight)	( )	( )	( )	( )	( )
13. Prepare to boresight	( )	( )	( )	( )	( )
33. Engage targets from gunner's station with M240 coax machinegun	( )	( )	( )	( )	( )
31. Operate M13A3 elevation quadrant (range card)	( )	( )	( )	( )	( )
2. Perform gunner's prepare-to-fire checks and services	( )	( )	( )	( )	( )

*Task is so easy that even an untrained soldier can do the task without help.

M60A3 Gunner Task	Not Applicable*	Gunner Can Get Help During Combat Without Threatening Combat Success: Always	Most of the Time	Some of the Time	Never
43. Engage target from gunner's station with main gun using battlesight	( )	( )	( )	( )	( )
11. Zero M240 coax machinegun	( )	( )	( )	( )	( )
49. Engage targets from range card data	( )	( )	( )	( )	( )
6. Troubleshoot fire control system	( )	( )	( )	( )	( )
26. Check elevation backlash (boresight)	( )	( )	( )	( )	( )
38. Engage targets with suppressive fire from gunner's station with M240	( )	( )	( )	( )	( )
45. Adjust fire from gunner's station using standard adjustment with main gun	( )	( )	( )	( )	( )
35. Engage area targets from gunner's station with M240 in degraded mode	( )	( )	( )	( )	( )
5. Perform gunner's during firing checks and services	( )	( )	( )	( )	( )
19. Check zero pressure (boresight)	( )	( )	( )	( )	( )
37. Engage point targets from gunner's station with M240 in degraded mode	( )	( )	( )	( )	( )
8. Troubleshoot turret	( )	( )	( )	( )	( )
47. Adjust fire from gunner's station using burst-on-target with main gun	( )	( )	( )	( )	( )

*Task is so easy that even an untrained soldier can do the task without help.

M60A3 Gunner Task	Not Applicable*	Gunner Can Get Help During Combat Without Threatening Combat Success: Always	Most of the Time	Some of the Time	Never
39. Engage targets from gunner's station with main gun	( )	( )	( )	( )	( )
25. Check computer system lead circuit (boresight)	( )	( )	( )	( )	( )
28. Power down and secure gunner's station	( )	( )	( )	( )	( )
23. Check boresight knob backlash, linearity, and repeatability (boresight)	( )	( )	( )	( )	( )
30. Prepare range card	( )	( )	( )	( )	( )
44. Adjust fire from gunner's station using reengagement technique with main gun	( )	( )	( )	( )	( )
42. Engage target from gunner's station with main gun in degraded mode	( )	( )	( )	( )	( )
15. Adjust M105D telescope (boresight)	( )	( )	( )	( )	( )
36. Engage point targets from gunner's station with M240 in normal mode	( )	( )	( )	( )	( )
20. Check sight parallax (boresight)	( )	( )	( )	( )	( )
40. Engage target from gunner's station with main gun in normal mode	( )	( )	( )	( )	( )
21. Check manual elevation, power elevation, and power cylinder (boresight)	( )	( )	( )	( )	( )
3. Install/remove tank searchlight	( )	( )	( )	( )	( )

*Task is so easy that even an untrained soldier can do the task without help.

M60A3 Gunner Task	Not Applicable*	Gunner Can Get Help During Combat Without Threatening Combat Success: Always	Most of the Time	Some of the Time	Never
1. Perform gunner's before-operation PMCS	( )	( )	( )	( )	( )
29. Perform gunner's after-firing checks and services	( )	( )	( )	( )	( )
46. Adjust fire from gunner's station using target form adjustment with main gun	( )	( )	( )	( )	( )
17. Adjust passive sight (boresight)	( )	( )	( )	( )	( )
14. Adjust M35E1 sight (boresight)	( )	( )	( )	( )	( )
9. Maintain main gun breechblock assembly	( )	( )	( )	( )	( )
34. Engage area targets from gunner's station with M240 in normal mode	( )	( )	( )	( )	( )
10. Boresight M240 coax machinegun	( )	( )	( )	( )	( )
48. Perform misfire procedures with main gun	( )	( )	( )	( )	( )
7. Troubleshoot main gun	( )	( )	( )	( )	( )

*Task is so easy that even an untrained soldier can do the task without help.

APPENDIX B

CONSEQUENCES OF INADEQUATE PERFORMANCE OF TASK QUESTIONNAIRE

This questionnaire provides examples of the instructions and questionnaire items used to obtain SME estimates of the consequence of inadequate task performance during combat operations. Note that the term "incorrect" was substituted for "inadequate." The order of tasks in this example has been randomized. Four different orders of items were used for this questionnaire. This technique reduces any systematic effect of item order on the results of subsequent analyses.

QUESTIONNAIRE FOR ARMOR TRAINING IN COMBAT UNITS: CONSEQUENCES OF INCORRECT PERFORMANCE OF TASK M60A3 GUNNER TASKS

PURPOSE

The U.S. Army Research Institute for the Behavioral and Social Sciences has been working to identify the importance of different armor tasks for training tank crews in combat units. Lists of armor tasks will be developed for each duty position. These lists will specify the order in which armor tasks should be trained to quickly bring crew members "up to speed" on tasks that are important to the success of a combat mission.

In this questionnaire we want to find out what you think would happen during combat if M60A3 gunners did certain tasks incorrectly. We will analyze your answers and use them along with other data to identify the importance for training of each M60A3 gunner task included in this questionnaire.

Please complete the following questions before starting the questionnaire.

1. Months experience in armor: _____

2. Months experience with M60A3 tanks: _____

3. Your rank: _____

4. Previous and current duty positions (check all applicable):
   - ( ) Platoon Sergeant
   - ( ) Gunner
   - ( ) Tank Commander
   - ( ) Master Gunner
   - ( ) Platoon Leader
   - ( ) Company Commander
   - ( ) Other (specify): _____

5. Times fired Table VIII: _____

6. Times qualified on Table VIII: _____

INSTRUCTIONS

Consider the following situation when making your judgments about what would happen during combat if M60A3 gunners performed certain tasks poorly.

GENERAL SITUATION

USAREUR forces are engaged in a conventional war with OPFOR forces on the European battlefield. The European battlefield consists of rolling farmland, numerous hills, streams, small forests, and villages. In the rolling farmland, fields of fire sometimes stretch for 5,000 meters or more, but fog, snow, or rain may reduce the field of view. OPFOR forces consist of an extremely modern, highly mobile, and well balanced combined arms force. The tactical conditions of this general situation are as follows:

- OPFOR forces outnumber USAREUR forces at all battlefields.
- OPFOR attacks are carried out to the front, flanks, and rear of battalions, brigades, divisions, and corps.
- OPFOR is using chemical weapons sometimes and there is the possibility that tactical nuclear weapons will also be used.
- USAREUR operations are often conducted day and night without letup for extended periods.
- USAREUR communications are often inoperable. Battles and skirmishes are fought at all levels--platoon, company, battalion, and brigade.

SPECIFIC SITUATION

You are stationed with a USAREUR division as a platoon leader or platoon sergeant. Your battalion has been alerted to deploy immediately. You have been informed that your platoon may be operating independently for periods of time. You are confident of your leadership skills, but concerned about the gunners in your platoon. Sometimes they do a task too slowly or simply don't know how to do it correctly. A basic question you ask yourself is: **If a task is performed incorrectly, what will be the effect on combat mission success?**

All of the tasks performed by the gunner during combat support the success of a combat mission. But poor performance of some tasks will result in combat mission failure more often than others. Each task can be classified into one of five categories, using the key on the following page.

Key to Task Classification

What will be the effect on combat mission success if a task is performed incorrectly?

1: Combat mission success will not be affected.
2: Sometimes incorrect task performance will result in combat mission failure.
3: Incorrect task performance will result in combat mission failure about half the time.
4: Most times incorrect task performance will result in combat mission failure.
5: Incorrect task performance will always result in combat mission failure.

QUESTIONNAIRE COMPLETION

You are to classify the effect of incorrect task performance on combat mission success for each of the M60A3 gunner tasks included in this questionnaire. A sample questionnaire item looks like this.

EXAMPLE

	If this task is performed incorrectly, what will be the effect on combat mission success?				
M60A3 Gunner Task	1	2	3	4	5
Perform after-operation PMCS on turret	( )	( )	( )	( )	( )

In completing these items, **check the one alternative** that best indicates how often poor gunner performance on the task will result in mission failure. A completed item will look like the one below. Category 2 is checked because sometimes poor performance of this task will result in combat mission failure.

EXAMPLE

	If this task is performed incorrectly, what will be the effect on combat mission success?				
M60A3 Gunner Task	1	2	3	4	5
Perform after-operation PMCS on turret	( )	(X)	( )	( )	( )

For your convenience in completing the questionnaire, the KEY TO TASK CLASSIFICATION is on the top of each page of this questionnaire.

Key to Task Classification

What will be the effect on combat mission success if a task is performed incorrectly?

1: Combat mission success will not be affected.
2: Sometimes incorrect task performance will result in combat mission failure.
3: Incorrect task performance will result in combat mission failure about half the time.
4: Most times incorrect task performance will result in combat mission failure.
5: Incorrect task performance will always result in combat mission failure.

M60A3 Gunner Task	If this task is performed incorrectly, what will be the effect on combat mission success? 1	2	3	4	5
9. Maintain main gun breechblock assembly	( )	( )	( )	( )	( )
23. Engage point targets from gunner's station with M240 in normal mode	( )	( )	( )	( )	( )
10. Boresight M240 coax machinegun	( )	( )	( )	( )	( )
37. Adjust fire from gunner's station using standard adjustment with main gun	( )	( )	( )	( )	( )
11. Zero M240 coax machinegun	( )	( )	( )	( )	( )
24. Engage point targets from gunner's station with M240 in degraded mode	( )	( )	( )	( )	( )
4. Prepare gunner's station for operation	( )	( )	( )	( )	( )
7. Troubleshoot main gun	( )	( )	( )	( )	( )
6. Troubleshoot fire control system	( )	( )	( )	( )	( )
32. Engage moving target from gunner's station with main gun in stabilization mode	( )	( )	( )	( )	( )

Key to Task Classification

What will be the effect on combat mission success if a task is performed incorrectly?

1: Combat mission success will not be affected.
2: Sometimes incorrect task performance will result in combat mission failure.
3: Incorrect task performance will result in combat mission failure about half the time.
4: Most times incorrect task performance will result in combat mission failure.
5: Incorrect task performance will always result in combat mission failure.

M60A3 Gunner Task	If this task is performed incorrectly, what will be the effect on combat mission success? 1	2	3	4	5
28. Engage targets with suppressive fire from gunner's station with M240	( )	( )	( )	( )	( )
1. Perform gunner's before-operation PMCS	( )	( )	( )	( )	( )
18. Operate M13A3 elevation quadrant (range card)	( )	( )	( )	( )	( )
5. Perform gunner's during firing checks and services	( )	( )	( )	( )	( )
31. Engage moving target from gunner's station with main gun using automatic lead	( )	( )	( )	( )	( )
38. Adjust fire from gunner's station using target form adjustment with main gun	( )	( )	( )	( )	( )
21. Engage area targets from gunner's station with M240 in normal mode	( )	( )	( )	( )	( )
13. Prepare to boresight	( )	( )	( )	( )	( )
36. Adjust fire from gunner's station using reengagement technique with main gun	( )	( )	( )	( )	( )

Key to Task Classification

What will be the effect on combat mission success if a task is performed incorrectly?

1: Combat mission success will not be affected.
2: Sometimes incorrect task performance will result in combat mission failure.
3: Incorrect task performance will result in combat mission failure about half the time.
4: Most times incorrect task performance will result in combat mission failure.
5: Incorrect task performance will always result in combat mission failure.

M60A3 Gunner Task	If this task is performed incorrectly, what will be the effect on combat mission success? 1	2	3	4	5
30. Engage target from gunner's station with main gun in normal mode	( )	( )	( )	( )	( )
8. Troubleshoot turret	( )	( )	( )	( )	( )
19. Operate M28E2 azimuth indicator (range card)	( )	( )	( )	( )	( )
26. Engage moving targets with the M240 from the gunner's station using auto lead	( )	( )	( )	( )	( )
3. Install/remove tank searchlight (non-TTS tank)	( )	( )	( )	( )	( )
39. Adjust fire from gunner's station using burst-on-target with main gun	( )	( )	( )	( )	( )
12. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)	( )	( )	( )	( )	( )
34. Engage target from gunner's station with main gun in degraded mode	( )	( )	( )	( )	( )

Key to Task Classification

What will be the effect on combat mission success if a task is performed incorrectly?

1: Combat mission success will not be affected.
2: Sometimes incorrect task performance will result in combat mission failure.
3: Incorrect task performance will result in combat mission failure about half the time.
4: Most times incorrect task performance will result in combat mission failure.
5: Incorrect task performance will always result in combat mission failure.

M60A3 Gunner Task	If this task is performed incorrectly, what will be the effect on combat mission success? 1	2	3	4	5
2. Perform gunner's prepare-to-fire checks and services	( )	( )	( )	( )	( )
17. Prepare range card	( )	( )	( )	( )	( )
40. Perform misfire procedures with main gun	( )	( )	( )	( )	( )
29. Engage targets from gunner's station with main gun	( )	( )	( )	( )	( )
16. Perform gunner's after-firing checks and services	( )	( )	( )	( )	( )
14. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)	( )	( )	( )	( )	( )
33. Engage moving target from gunner's station with main gun using standard lead	( )	( )	( )	( )	( )
20. Engage targets from gunner's station with M240 coax machine-gun	( )	( )	( )	( )	( )
35. Engage target from gunner's station with main gun using battlesight	( )	( )	( )	( )	( )

Key to Task Classification

What will be the effect on combat mission success if a task is performed incorrectly?

1: Combat mission success will not be affected.
2: Sometimes incorrect task performance will result in combat mission failure.
3: Incorrect task performance will result in combat mission failure about half the time.
4: Most times incorrect task performance will result in combat mission failure.
5: Incorrect task performance will always result in combat mission failure.

M60A3 Gunner Task	If this task is performed incorrectly, what will be the effect on combat mission success? 1	2	3	4	5
41. Engage targets from range card data	( )	( )	( )	( )	( )
22. Engage area targets from gunner's station with M240 in degraded mode	( )	( )	( )	( )	( )
27. Engage moving targets with the M240 from the gunner's station using standard lead	( )	( )	( )	( )	( )
25. Engage moving targets with the M240 from the gunner's station in stabilization mode	( )	( )	( )	( )	( )
15. Power down and secure gunner's station	( )	( )	( )	( )	( )

APPENDIX C

TASK TRAINING ORDER QUESTIONNAIRE

This questionnaire provides the instructions and examples of questionnaire items used to obtain SME judgments on the most efficient order in which pairs of tasks should be trained. The example includes the first 10 questionnaire items from a questionnaire that consisted of 137 questionnaire items.

QUESTIONNAIRE FOR ARMOR TRAINING IN COMBAT UNITS:
TASK TRAINING ORDER
M60A3 GUNNER TASKS

PURPOSE

The U.S. Army Research Institute for the Behavioral and Social Sciences has been working to identify the importance of different armor tasks for training tank crews in combat units. Lists of armor tasks will be developed for each duty position. These lists will specify an order in which armor tasks could be trained to quickly bring crew members "up to speed" on tasks that are important to the success of combat missions.

In this questionnaire we want to find out what you think the order should be for training certain M60A3 gunners tasks in a unit. We will analyze your answers and use them along with other data to identify the importance and order for training of each M60A3 gunner task included in this questionnaire.

Please complete the following questions before starting the questionnaire.

1. Months experience in armor: _____

2. Months experience conducting armor school training: _____

3. Months experience conducting tank crew on-the-job training: _____

4. Your rank: _____

5. Current and past duty positions (check all applicable):
   - ( ) Platoon Sergeant
   - ( ) Tank Commander
   - ( ) Master Gunner
   - ( ) Other (specify): _____

6. Times fired Table VIII: _____

7. Times qualified on Table VIII: _____

INSTRUCTIONS

This questionnaire asks you to indicate the order that M60A3 gunner tasks should be trained. The basic question you should consider in completing the questionnaire is:

Will a soldier learn the skills needed to be a good gunner more efficiently if he is trained on tasks in a specific order?

Practical experience in training has led most of us to believe that the answer to this question is **yes.** But what is the best order? This questionnaire is designed to help us obtain the answer to this question.

There are several sections to this questionnaire. Each section deals with a different set of M60A3 gunner tasks. Each section contains several questions. To illustrate how to answer these questions, here is an example of what one part of a questionnaire will look like. (The tasks are for illustrative purposes only. They have to do with operating an automobile.) The tasks are:

- Operate ignition
- Operate air conditioner
- Shift gears
- Parallel park
- Back out of driveway

Four questionnaire items from this set of tasks would look like the ones below.

EXAMPLE

Task Pair	Task Description	Schedule Tasks for Training: Does Not Matter	Task A First	About Same Time	Task B First
1.	A. Shift gears B. Operate ignition	( )	( )	( )	( )
2.	A. Parallel park B. Shift gears	( )	( )	( )	( )
3.	A. Operate air conditioner B. Back out of driveway	( )	( )	( )	( )
4.	A. Back out of driveway B. Parallel park	( )	( )	( )	( )

In completing the items, **check the one alternative** that indicates how training for the two tasks should be scheduled to make gunner training most efficient. The example from the preceding page is completed below. Here is why the items are completed as shown.

Task Pair 1 -- About the Same Time: Drivers should learn basic skills, such as "shift gears" and "operate ignition," early in training, but learning one task doesn't make it easier to learn the other task.

Task Pair 2 -- Task B First: If a driver learns how to "shift gears" before he learns to "parallel park," training is more efficient, because he must know how to shift gears to parallel park.

Task Pair 3 -- Does not Matter: The efficiency of driver training would not be increased by training "operate air conditioner" and "back out of driveway" following any specific schedule.

Task Pair 4 -- Task A First: By training "back out of driveway" first, a driver could learn many of the basic skills required by the more difficult task, "parallel park."

EXAMPLE

Task Pair	Task Description	Schedule Tasks for Training: Does Not Matter	Task A First	About Same Time	Task B First
1.	A. Shift gears B. Operate ignition	( )	( )	(X)	( )
2.	A. Parallel park B. Shift gears	( )	( )	( )	(X)
3.	A. Operate air conditioner B. Back out of driveway	(X)	( )	( )	( )
4.	A. Back out of driveway B. Parallel park	( )	(X)	( )	( )

In completing this questionnaire, you should consider the order in which tasks **should** be trained. Do not simply answer according to Army doctrine. We know how tasks are currently trained. Your answers to this questionnaire should provide us with your expert suggestions for improving the order in which tasks are trained.

Because only a select group of experts will be completing this questionnaire, it is important that you consider each task pair carefully. Answer all items. You are training experts in this area. We need your input to determine the best order for task training.

Indicate the most efficient order for training the M60A3 gunner tasks listed below on the questionnaire pages that follow.

- Perform gunner's before-operation PMCS
- Perform gunner's prepare-to-fire checks and services
- Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)
- Prepare to boresight
- Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)

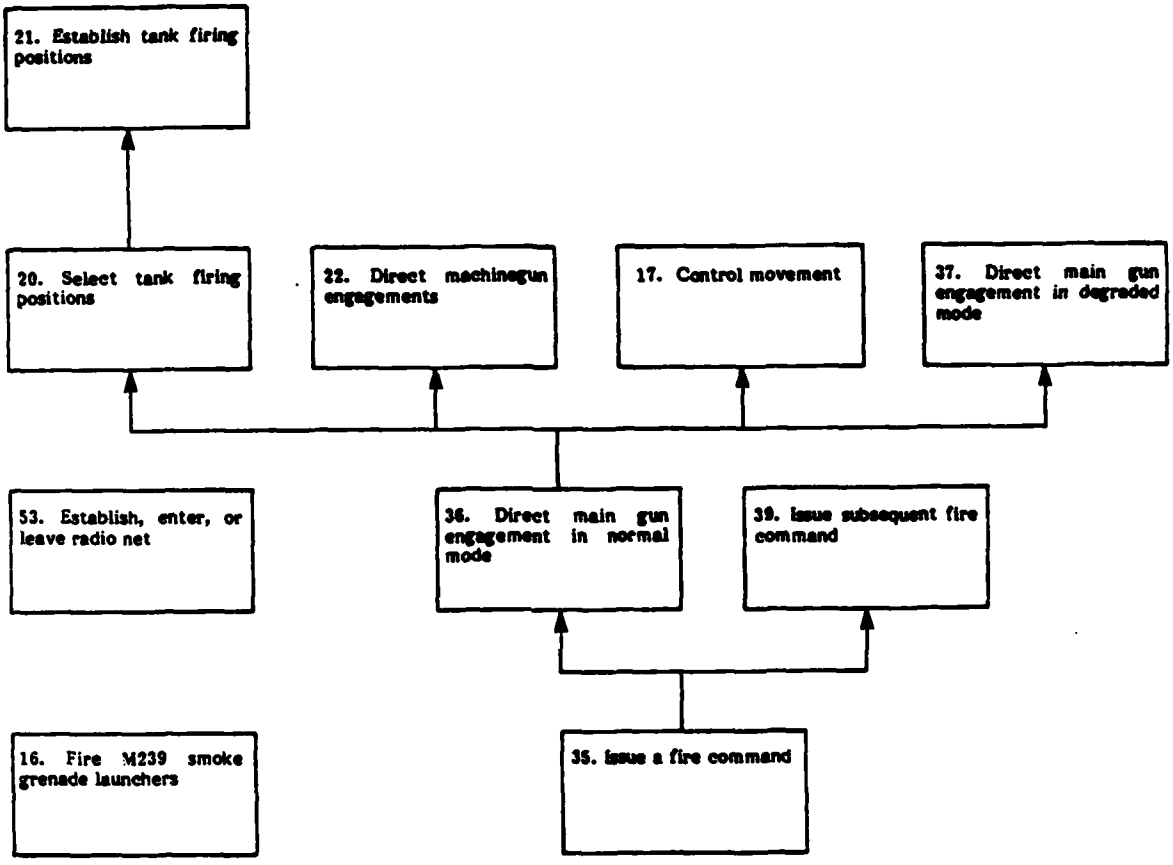
Task Pair	Task Description	Schedule Tasks for Training: Does Not Matter	Task A First	About Same Time	Task B First
1.	A. Perform gunner's before-operation PMCS B. Perform gunner's prepare-to-fire checks and services	( )	( )	( )	( )
2.	A. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson) B. Prepare to boresight	( )	( )	( )	( )
3.	A. Perform gunner's prepare-to-fire checks and services B. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson)	( )	( )	( )	( )
4.	A. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson) B. Perform gunner's before-operation PMCS	( )	( )	( )	( )
5.	A. Prepare to boresight B. Perform gunner's prepare-to-fire checks and services	( )	( )	( )	( )

Task Pair	Task Description	Schedule Tasks for Training: Does Not Matter	Task A First	About Same Time	Task B First
6.	A. Perform gunner's before-operation PMCS B. Prepare to boresight	( )	( )	( )	( )
7.	A. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair) B. Prepare to boresight	( )	( )	( )	( )
8.	A. Boresight and system calibrate an M60A3 tank using muzzle boresight device (Pye-Watson) B. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)	( )	( )	( )	( )
9.	A. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair) B. Perform gunner's prepare-to-fire checks and services	( )	( )	( )	( )
10.	A. Perform gunner's before-operation PMCS B. Boresight and system calibrate an M60A3 tank using two-point method (string crosshair)	( )	( )	( )	( )

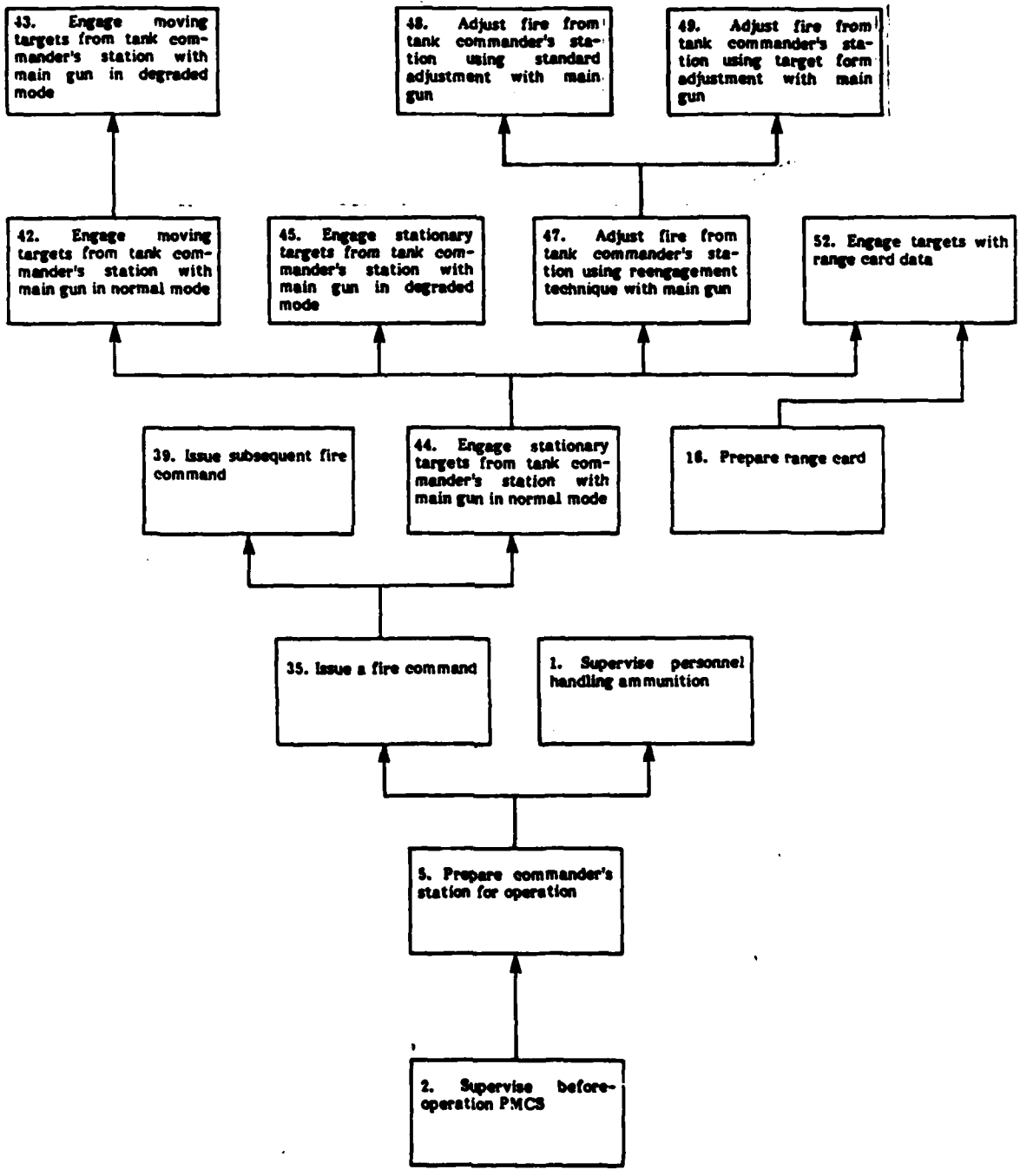
APPENDIX D

TRAINING ORDER NETWORKS

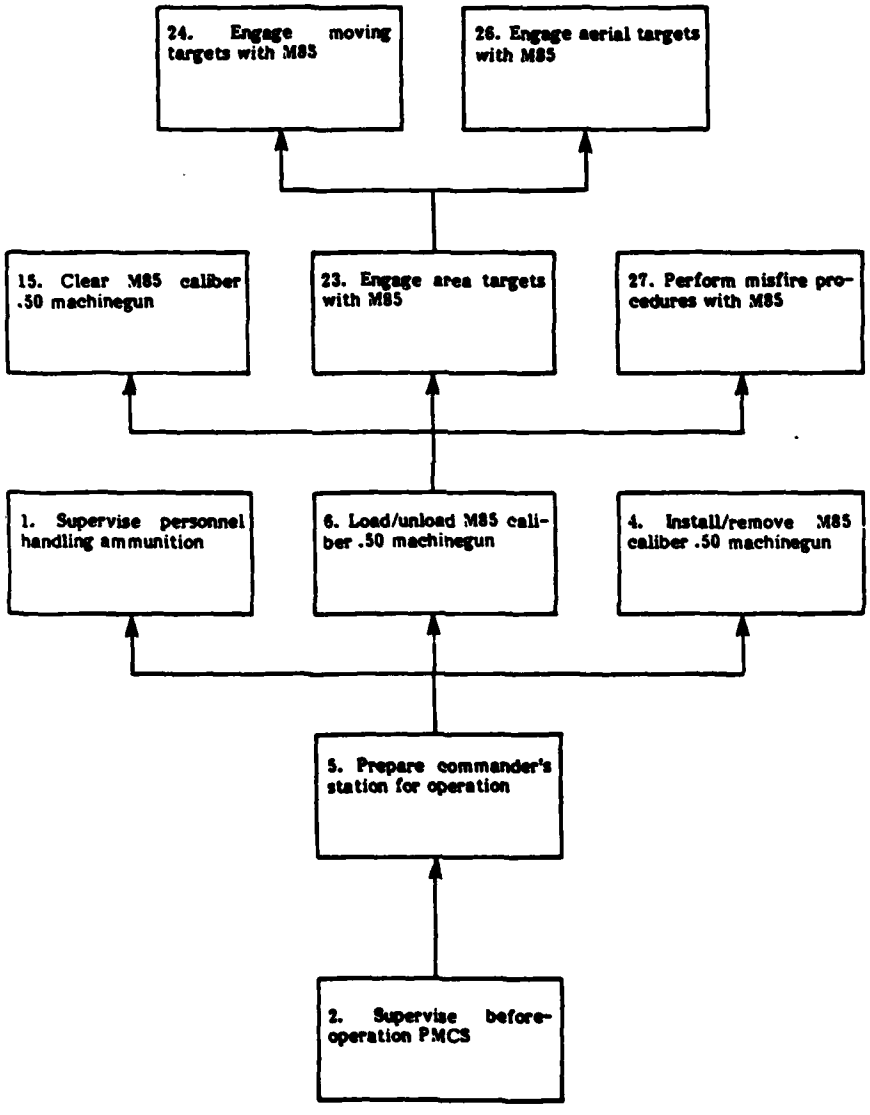
These training order networks resulted from analysis of the task training order questionnaire data described in this report. There are four separate models for tank commander tasks and five for gunner tasks. In three of the models, a number of tasks are not linked to other tasks. This result was obtained when a majority of SMEs did not judge that a specific task order would improve efficiency.



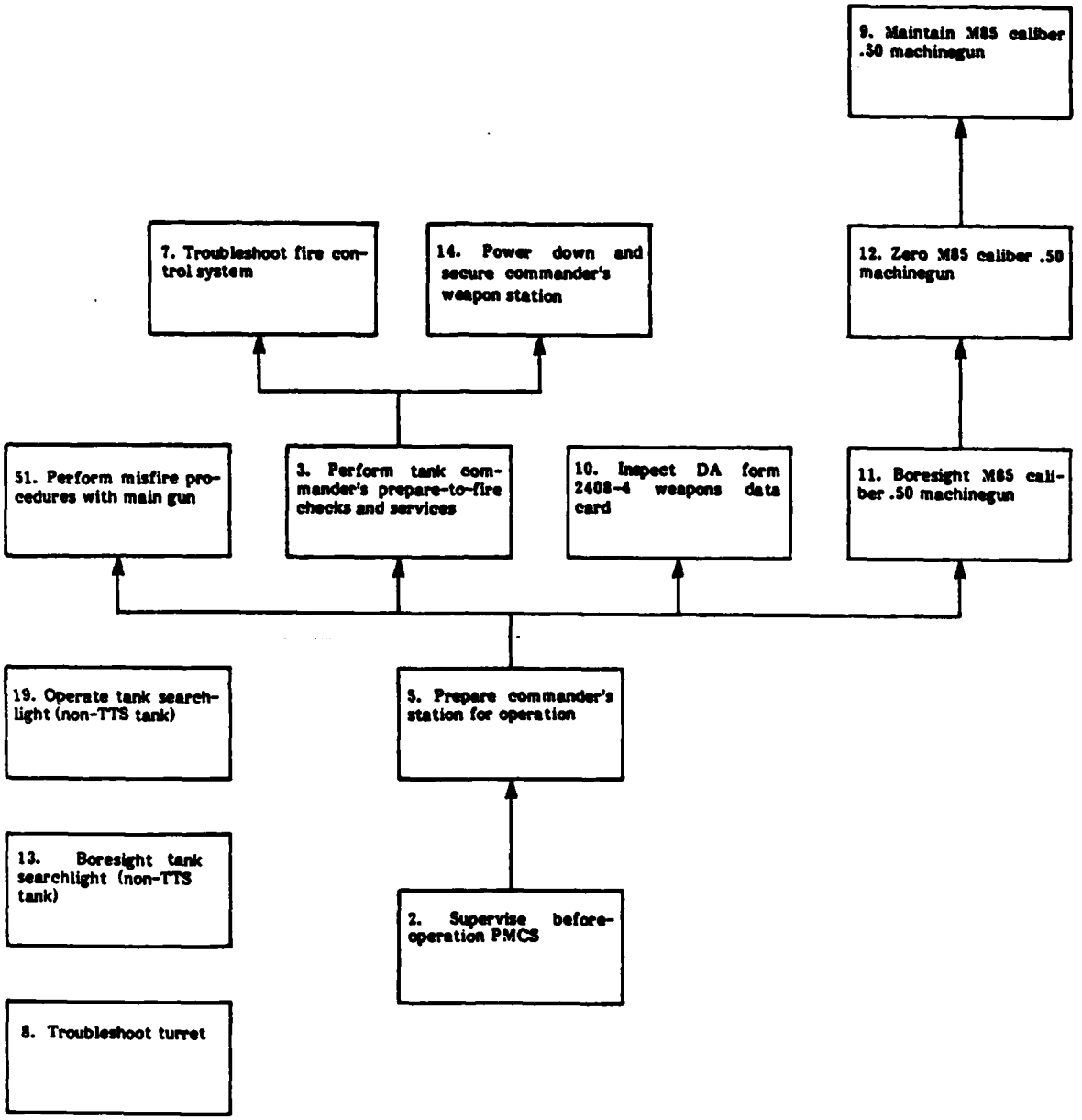
Tank Commander: Tactics and Command



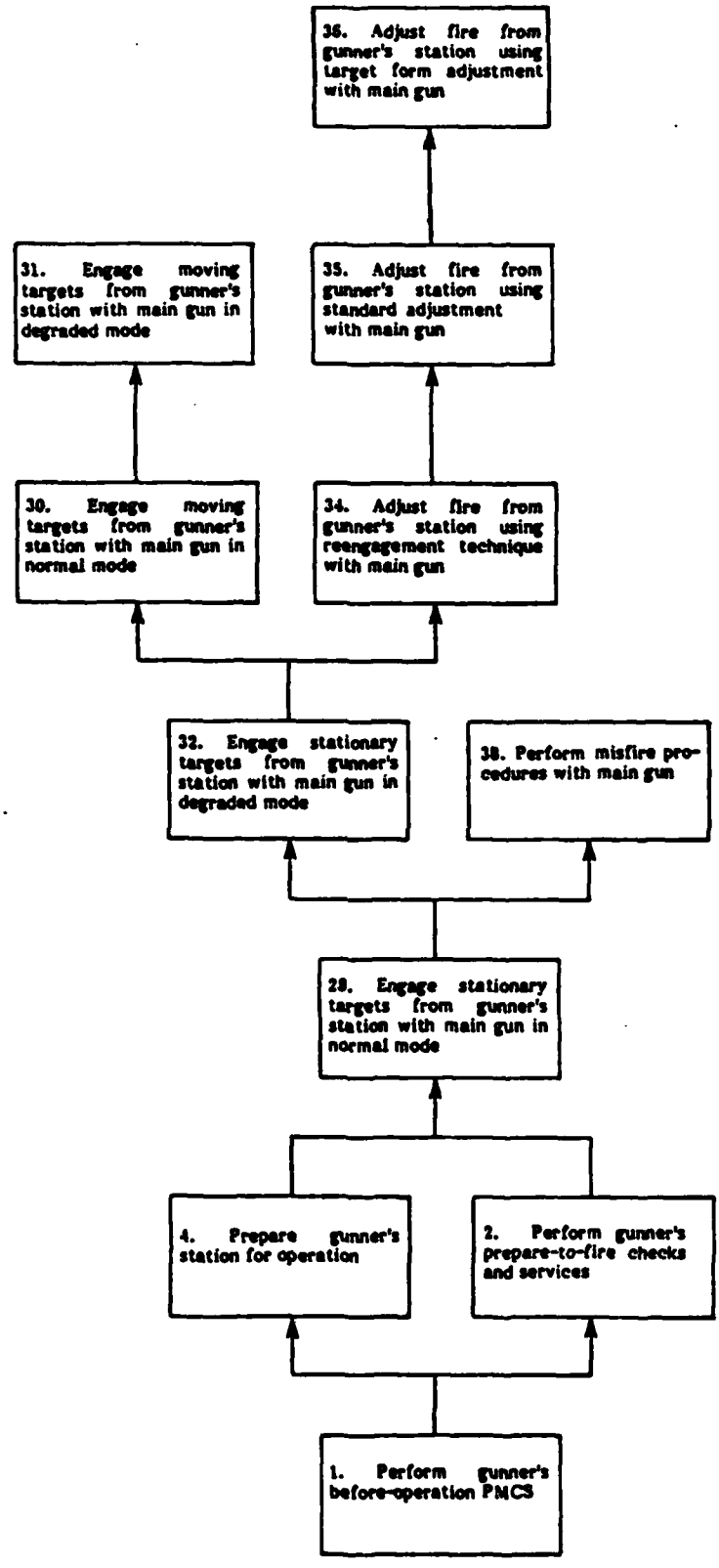
Tank Commander: Main Gun Engagement



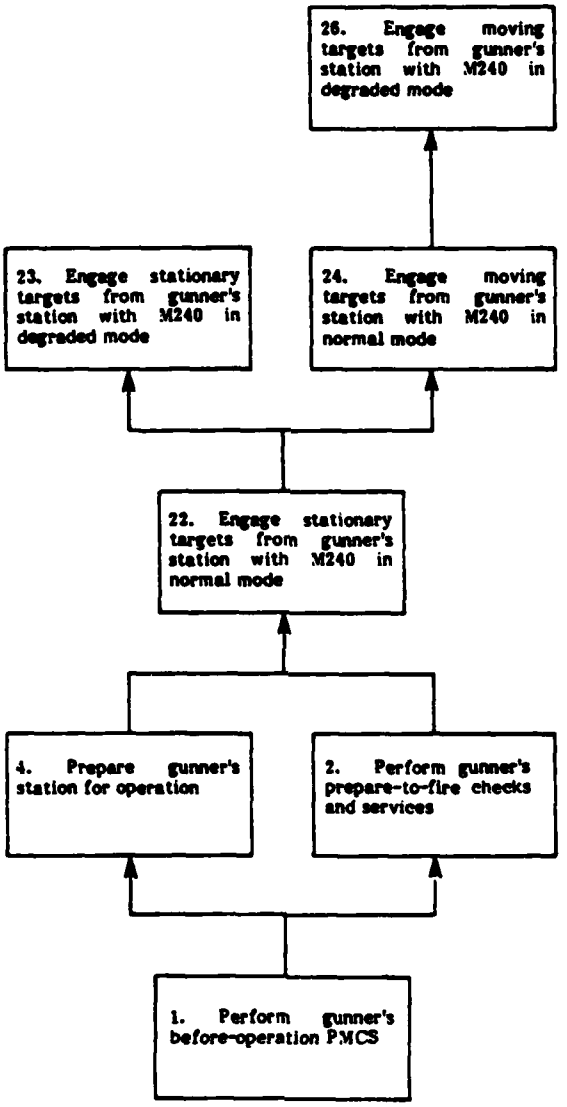
Tank Commander: M85 Machinegun Engagement



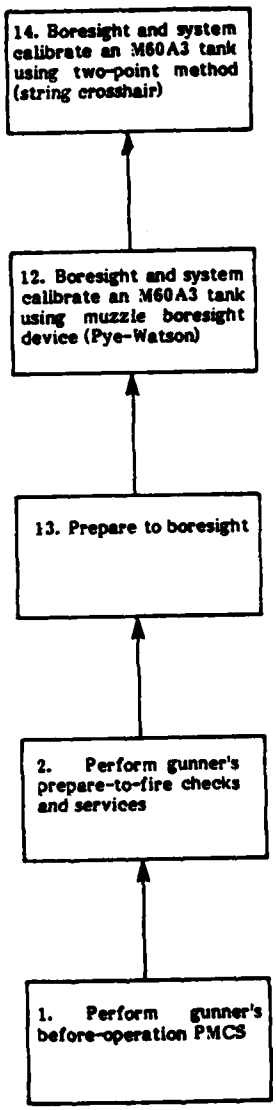
Tank Commander: Maintenance, Checks, and Services



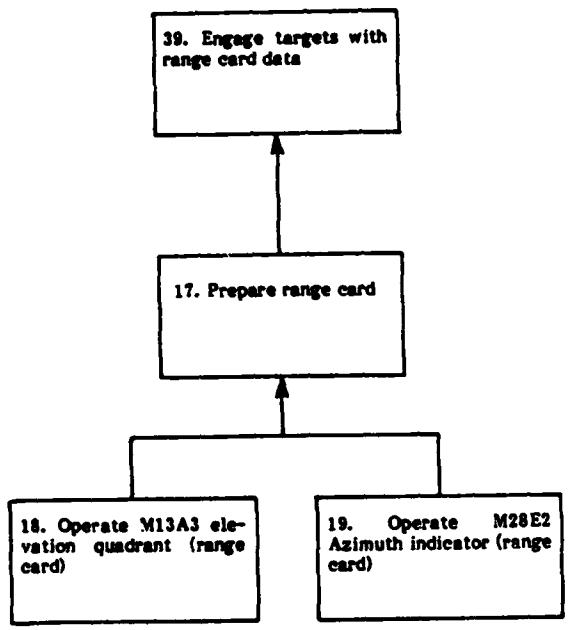
Gunner: Main Gun Engagement



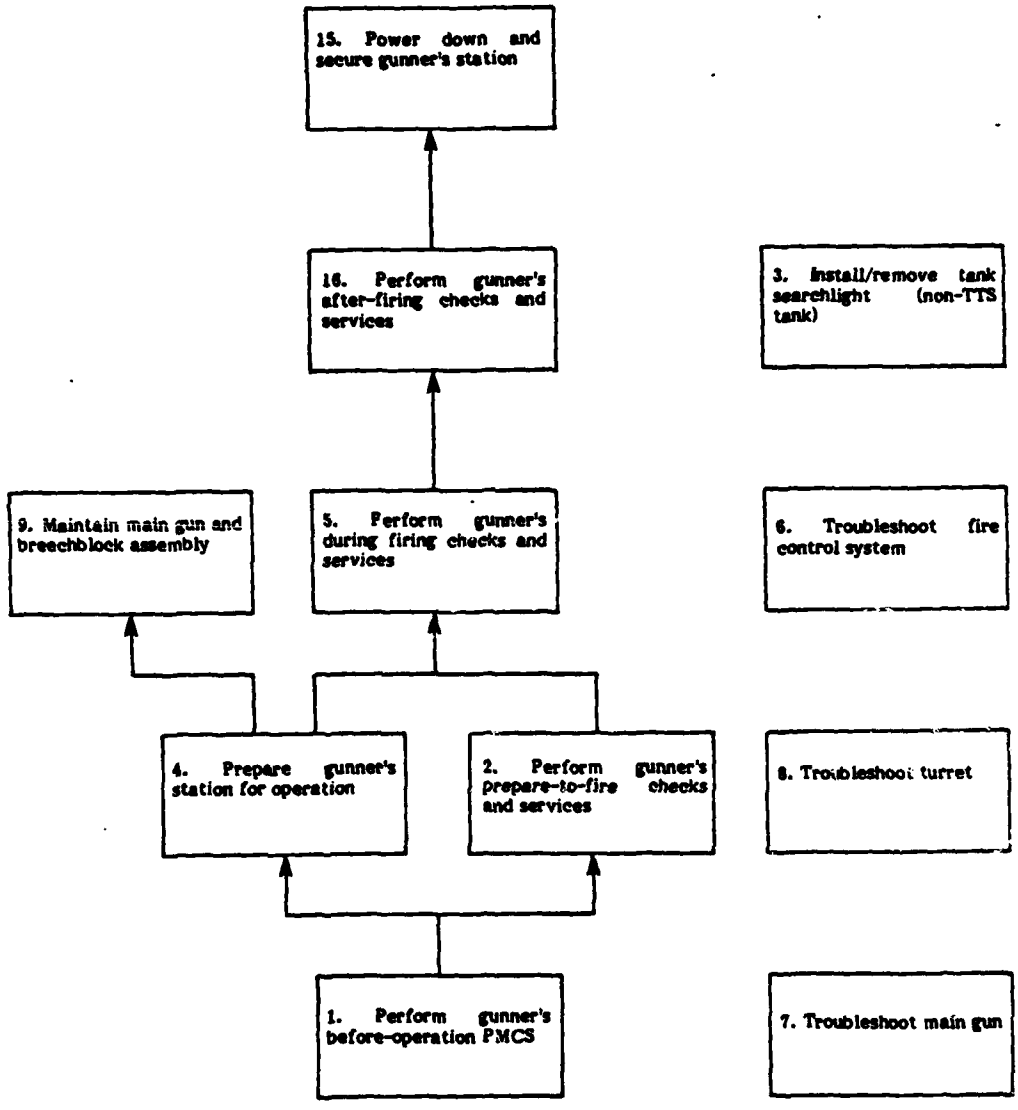
Gunner: M240 Machinegun Engagement



Gunner: Boresight



Gunner: Range Card



Gunner: Maintenance, Checks, and Services