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M1 Tank Gunnery: A Detailed Analysis of Conditions, Behaviors, and Processes

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This report establishes the domain of M1 tactical gunnery at the crew level. It categorizes the conditions that affect crew behavior in each of the segments of the gunnery process, with particular attention to the processes directly related to firing the tank weapons systems. The report presents a three-step model of tank gunnery, identifies fifteen sets of variables in the engagement process, and lists all possible engagement patterns. The results can be used by the Armor School to develop tactical gunnery training and testing programs for the M1 tank.

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M1 Tank Gunnery: A Detailed Analysis of Conditions, Behaviors, and Processes

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FOREWORD

The development of an effective training and testing program for tactical gunnery at the crew level, in contrast to pure marksmanship, requires that the domain of tactical gunnery be established and that the effects of battlefield conditions on this domain be identified. The establishment of the domain of tactical gunnery was initiated in a previous report. This report refines and expands upon this earlier effort by (a) identifying and categorizing the conditions that affect tactical gunnery at the crew level, (b) identifying variables affecting gunnery engagements, and (c) identifying the domain of engagement patterns.

This research is a part of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) task entitled "Application of Technology to Meet Armor Skills Training Needs." The task is performed under the auspices of ARI's Armor Research and Development Activity at Fort Knox.

The information presented in this report was provided to the Gunnery Division of the Weapons Department, U.S. Army Armor School, for use in developing future gunnery training programs. The information was also provided to the Operational Research Systems Analysis Division of the Directorate of Training and Doctrine for use in the development of new scoring procedures for Tank Table XII.

The proponent for this research is Training and Doctrine Command (TRADOC), and the user is U.S. Army Armor Center (USAARMC).

EDGAR M. JOHNSON
Technical Director

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M1 TANK GUNNERY: A DETAILED ANALYSIS OF CONDITIONS, BEHAVIORS, AND PROCESSES

EXECUTIVE SUMMARY

Requirement:

The effectiveness of tank gunnery training in the U.S. Army is dependent upon an accurate assessment of battlefield conditions and upon the identification of performance requirements placed upon crews as a result of those same battlefield conditions. There have been several efforts in the past to identify the domain of tank gunnery. These prior efforts have analyzed tank gunnery as it applied to older main battle tanks and within the gunnery-pure training environment. The concept of tactical gunnery was addressed by Hoffman and Morrison (1988), but their work did not fully identify the domain of tank gunnery as it applies to the M1 tank. The purpose of the present analysis is to revise the analysis of tactical gunnery performed by Hoffman and Morrison (1988), to formulate a model of M1 tactical gunnery, and to identify the domain of M1 tactical gunnery.

Procedure:

The project began with a review of gunnery conditions. These conditions were identified and sorted into three temporal categories, each of which corresponds to an operational level. The next step was to analyze gunnery behaviors and to align correct behavioral responses with the conditions that had been identified. A model of tank gunnery was developed, dividing gunnery into three segments: the target acquisition procedure, the engagement sequence, and the assessment procedure. The conditions and behaviors associated with each segment were examined, and the interrelationships were described. The engagement sequence itself was isolated and the crew duties associated with firing each weapon on the tank were analyzed to discover the common pattern and variable behaviors within the pattern. The different crew behaviors were then clustered. Fifteen clusters of variable behaviors were identified. The variables were sequenced logically, and impossible or highly improbable combinations of variables were eliminated. Finally, a list of all remaining variable patterns was developed.

Findings:

The three sets of conditions affecting tactical gunnery were categorized as pre-existing conditions, situation-specific conditions, and engagement-specific conditions. Within each of these, conditions were further subcategorized as internal or external to the tank or crew. The conditions related to the effectiveness of the tank system make it necessary for the crew to modify their behavior within engagements in response to system malfunctions (degraded mode gunnery). The temporal categories of conditions indicate whether the crew is responding to a condition that was identified before the start of the mission, during the mission itself, or during an engagement.

Target acquisition is the first of the three steps in the gunnery model. The analysis determined that target acquisition is a hierarchy of steps ranging from searching for targets to a decision to engage a particular target. The search process is ongoing throughout a combat mission. An engagement occurs only when criteria within the other steps of the hierarchy are satisfied. The process of target acquisition is strongly affected by the conditions within the tactical environment.

The second step of the gunnery model is the engagement sequence. Fifteen behavioral variables were identified. Eight of the fifteen involve alternative behaviors that are directly related to system failures. The analysis produced a list of 4,618 possible engagement patterns. A total of 4,068 of these patterns are fired by the gunner. Most of these are attributable to degraded mode conditions, since only 66 of the 4,068 gunner engagements do not involve one or more responses appropriate to an equipment failure.

The assessment process is the third segment in the gunnery model. The assessment examines the effectiveness of the preceding engagement and considers the changes within the engagement-specific conditions to determine whether the crew should enter another engagement or not, and if a new engagement is to be conducted, what behaviors are to be modified.

Utilization of Findings:

The research provides information that should be useful to the Armor training community. Of particular interest is the systematic identification of crew behavioral variables associated with various battlefield conditions and specific tank subsystem failures. The results can be used by the Armor School to develop tactical gunnery training and testing programs for the M1 tank and by the Armor School to develop tactical gunnery training and testing programs for the M1 tank.

M1 TANK GUNNERY: A DETAILED ANALYSIS OF CONDITIONS, BEHAVIORS, AND PROCESSES

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M1 TANK GUNNERY: A DETAILED ANALYSIS OF CONDITIONS, BEHAVIORS, AND PROCESSES

Introduction and Overview

Background

The introduction of the M1 Abrams family of tanks has provided the U.S. Army Armor Force the potential to achieve a major improvement in battlefield maneuverability and firepower. To realize this potential, each crew must be able to properly operate the tank's weapon systems. Thus, an adequate gunnery training program is necessary if the M1 family of tanks is to have its greatest impact. In addition, a valid testing program is necessary to diagnose training needs and to assess crew qualification. Before an adequate training and testing program can be developed, the performance requirements for tank gunnery must be identified. That is, it is necessary to identify the domain of tank gunnery. The performance domain should specify all of the ways that a tank can be fired and the conditions under which each behavior pattern is appropriate.

There have been several efforts in the past to identify the domain of tank gunnery. Kraemer, Boldovici, and Boycan (1975) suggested that the domain could be identified by analyzing the conditions that affect crew gunnery. Implementing this procedure, they first identified four conditions that affect crew performance on the M60A1AOS tank: the weapon that was fired, the fire-delivery method, the crew member who fired the weapon, and the fire control instrument. They then identified seven additional factors that affected the ability of the crew to operate the weapon systems: firing vehicle motion, target motion, target type, target visibility, target range, ammunition, and day-night firing. By multiplying the various levels of each of the eleven conditions, they determined that there were 1,679,616 combinations of conditions that could possibly affect crew gunnery. Most of these combinations, fortunately, represented impossible situations. For example, it was obviously not possible to fire main gun ammunition using a machine gun. By eliminating all combinations that were impossible or impractical, the number of combinations was reduced to 225. During later research performed by Wheaton, Fingerman, and Boycan (1978), the number of combinations was increased to 266. Although the studies conducted by Kraemer et al. (1975) and by Wheaton et al. (1978) were highly innovative since they attempted to identify the domain of tank gunnery in terms of conditions, the focus during both studies was on "pure" gunnery or marksmanship. That is, neither investigation examined the

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influence of tactical factors on gunnery or considered multiple targets.

Hoffman and Morrison (1988) revised the approach used by Kraemer et al. (1975) and by Wheaton et al. (1978) and applied it to incorporate multiple target conditions and to identify the domain of tactical gunnery for the M1 tank. They identified eleven different gunnery activities (e.g., acquire target, assess results of engagement) and found that these activities could be further subdivided into smaller behavioral units (e.g., "search for target" as a part of "acquire targets"). They further demonstrated that there are many branches and loops in the sequencing of gunnery activities and that there are many options in the behaviors that occur during gunnery. They concluded from their investigation that the particular branches or loops that are followed and the particular options that are selected are determined by the set of conditions under which a gunnery engagement takes place.

Although Hoffman and Morrison (1988) examined M1 tank gunnery from the tactical perspective and identified how gunnery conditions affect the gunnery process, they did not actually attempt to identify the complete domain of M1 gunnery. Moreover, their analysis was incomplete since some aspects of tank gunnery were not included, e.g., loader's machine gun engagements, the main gun immediate action procedure, and the employment of smoke grenades.

Purpose

Given that the performance requirements for M1 tank gunnery must be identified before an effective program for training and testing M1 crew gunnery can be developed, and given the current status of our knowledge of M1 tank gunnery, it is apparent that there is still a need to identify the domain of tank gunnery from a tactical perspective. The procedure developed initially by Kraemer et al. (1975) provides a method for making this identification, and the analysis of M1 tank gunnery performed by Hoffman and Morrison (1988) provides an understanding of the variables affecting tactical gunnery.

To identify the domain of M1 tactical gunnery, it will first be necessary to revise the earlier analysis performed by Hoffman and Morrison (1988). The revision of this analysis will generate a more complete list of the conditions affecting tactical gunnery. Once this list is revised, it will then be necessary to develop a comprehensive model of M1 tactical gunnery. The model will provide the framework needed to organize the complex interrelationship among the conditions affecting the gunnery process and to relate these conditions to appropriate gunnery behaviors. More specifically, a model

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of tactical gunnery will be needed to reduce the number of condition combinations that will be created when combining all possible gunnery conditions. While most combinations will be extremely unlikely or impossible, a model of the gunnery process will be necessary to identify the combinations that can be discarded. In addition, the model will be needed to provide a framework for identifying the options, loops, and sequences that comprise the gunnery process. Once the model has been developed, the final step in identifying the domain of tank gunnery will be to eliminate the highly unlikely or impossible combinations of gunnery conditions and to cluster the remaining combinations in a way that will facilitate the development of an adequate training and testing program for tactical gunnery.

It is the purpose of the present study to revise the analysis of tactical M1 gunnery performed by Hoffman and Morrison (1988), to formulate a model of M1 tactical gunnery, and to combine the results of the analysis, the model of tactical gunnery, and the author's personal experience to identify the domain of M1 tactical gunnery.

Conditions Affecting the Gunnery Process

The first step in the identification of the domain of M1 tactical gunnery will be to identify the conditions that affect the gunnery process. Since there are a large number of conditions affecting tactical gunnery, it would be helpful to organize these conditions into meaningful clusters. One way of clustering conditions is by temporal categories. Some conditions are present at the start of a mission and provide a baseline that will affect all engagements throughout the mission unless these conditions are changed. Other conditions are the result of tactical circumstances that are not present at the start of the mission, but occur during the execution of the mission. These conditions provide a baseline that will affect only those engagements that take place within the immediate tactical context. Finally, some conditions occur only during the engagement itself. They are the result of enemy contact and the immediate outcome of a direct fire exchange. These three categories, which are illustrated in Figure 1, are termed pre-existing conditions, situation-specific conditions, and engagement-specific conditions. Each category is described in more detail below.

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SCOPE: MISSION
CONDITIONS: PRE-EXISTING

Tank Status   Terrain
Crew Status   Weather
Enemy Situation   Light Conditions
Friendly Situation

SCOPE: MISSION-PHASE
CONDITIONS: SITUATION-SPECIFIC

Current Battle Position   Pre-planned Indirect Fires
Current Objective   Changes to Enemy Situation
Current Route   Changes to Friendly Situation

SCOPE: MACRO-ENGAGEMENT
CONDITIONS: ENGAGEMENT-
                   SPECIFIC

Target Array (# Targets, move-
    ment, type, etc.)
Friendly units engaged
Standing orders
Fragementary orders
Friendly/Enemy Combat losses

SCOPE

TIME

Figure 1.   Categories of tank gunnery conditions.

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Pre-Existing Conditions

The category of conditions related to the mission as a whole will be referred to as the "pre-existing conditions" throughout the remainder of this report. These conditions are addressed in detail in the section dealing with crew gunnery conditions, and include the operational status of the tank as the mission begins, the crew's mental and physical status, the natural environment, the friendly unit mission, and the general enemy situation.

Situation-Specific Conditions

The category of conditions related to the mission-phase or the specific tactical situation will be referred to as the "situation-specific conditions" throughout the remainder of this report. The terms "mission-phase" and "specific tactical situation" will be used interchangeably to describe a segment of the overall mission in which a set of situation-specific conditions apply. Situation-specific conditions consist of changes to the pre-existing conditions as a result of the ongoing tactical operation, whether related to the tank and its crew (such as equipment failures), to the enemy and friendly situations, or to the terrain in the immediate area. Situation-specific conditions will be addressed in greater detail in the section dealing with crew gunnery conditions.

Engagement-Specific Conditions

The category of conditions specifically related to enemy contact will be referred to throughout the remainder of this report as the "engagement-specific conditions." The term "macro-engagement" will be used in conjunction with this category of conditions to represent the direct fire exchange. More information on the macro-engagement is presented in the discussion of the gunnery model. Engagement-specific conditions are addressed in the section dealing with the macro-engagement.

A Model of M1 Tactical Gunnery

A model of M1 tactical gunnery was developed from information presented in the M1 tank gunnery training manual (FM 17-12-1, with change (w/c) 2, 1988). The first step in the development of the model was to analyze the descriptions of normal and degraded mode gunnery actions in order to identify the individual steps involved in the gunnery process. Once these steps were identified, they were closely examined to determine the specific sequence of activities common to all types of engagements. The steps were analyzed further to determine the effects of using different weapon systems or sights and to identify the branching that occurs in the

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gunnery process as a result of different conditions or decisions. Technical details were confirmed by cross-reference with the M1 operator's manual (TM 9-2350-255-10-2, 1981).

The Gunnery Sequence

The term "engagement" is applicable to several levels of direct fire tasks in common usage. It may be used to describe anything from a unit engagement of a large target array, to a single tank/single target confrontation. At the individual crew level, three types of engagements are recognized: (a) the single engagement, (b) the multiple engagement, and (c) the simultaneous engagement. The single engagement is fairly straight forward: one tank firing any one of its weapons systems at one target. The term "multiple engagement" infers the engagement of two or more targets by one tank. This would suggest any multiple target situation, without an apparent distinction between the sequential engagement of multiple targets with one of the tank's weapons systems (e.g., two enemy tanks engaged with the main gun), and the simultaneous engagement of multiple targets with multiple weapons systems (e.g., the engagement of an enemy tank with the main gun at the same time that a troop array is engaged with the Caliber .50 machine gun. As used in FM 17-12-1 w/c 2 (1988), however, the multiple engagement specifically refers to the sequential engagement of two or more targets by one tank, using one of its weapons systems. A simultaneous engagement is the concurrent engagement of two (or more) targets by a single tank using two (or more) of its weapons systems. The term "engagement," as commonly used, also includes the subsequent rounds fired at the same target. If the crew behaviors associated with these situations were diagrammed, a series of loops would be drawn to illustrate the repetitive processes performed by the crew (see Figure 2). It is these loops that this report seeks to isolate and describe. Despite the imprecision represented by the term "engagement" in light of these multiple engagement-specific conditions, "engagement" is the single term that best describes the individual loop. For this report, therefore, the term engagement will refer to the specific process of shooting one main gun round or a machine gun burst at one target. By this definition, the situation in which the single tank fires on multiple targets either sequentially or simultaneously, as well as the firing of two or more rounds at one target exceeds the scope of the term "engagement. To accommodate the larger context, the term "macro-engagement is introduced.

The term "macro-engagement" will be used to refer to the multiple target situation and the presence of other friendly forces in the battle. Each individual engagement occurs within the macro-engagement. For typical single tank training

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exercises at the intermediate skill level, multiple target situations are exercised, but the existence of other friendly forces and arrays of more than three targets are not. In section and larger unit gunnery training exercises, each gunnery event involves multiple tanks firing at multiple targets (a macro-engagement). This latter condition more closely resembles the common expectation of the nature of combat. Thus, the macro-engagement is important to unit gunnery. Its importance to the individual tank gunnery process is that the macro-engagement encompasses the engagement-specific conditions related to target acquisition, the conditions that transcend the engagement process, and the conditions resulting from all engagements in progress.

The gunnery sequence is segmented into three conceptually distinct processes: (a) the target acquisition procedure, (b) the engagement procedure, and (c) the assessment procedure, as illustrated in Figure 2.

In target acquisition, the TC selects a target from the macro-engagement and makes the decision to engage. The target acquisition procedure and engagement-specific conditions are addressed in the section of this report dealing with the macro-engagement. The engagement sequence follows a specific pattern among fifteen behavioral variables in the conduct of a single gunnery engagement. These variables are addressed in detail in the section of this report dealing with the engagement sequence and are supported by the tables in Appendixes A through C. The crew uses the assessment procedure to determine its subsequent actions. The assessment feeds back to the target acquisition process or the engagement sequence. The assessment procedure is analyzed in the section of this report dealing with post-engagement behaviors.

Methods Used in the Present Model and Conventional Task Analysis

In some respects, the present analysis resembles a conventional task analysis. Certainly, the identification of task conditions and behaviors is in keeping with conventional techniques. Furthermore, the macro-engagement can be seen as analogous to a "task," which is defined as a " . . . distinct activity carried about for a distinct purpose" (Cascio, 1978). In the present case, the purpose of the macro-engagement is to destroy an entire target array. In contrast, the purpose of an engagement is to engage one of the targets within the array. In that sense, a single tank/single target engagement may be viewed as a subtask, which is defined as a meaningful division of a task.

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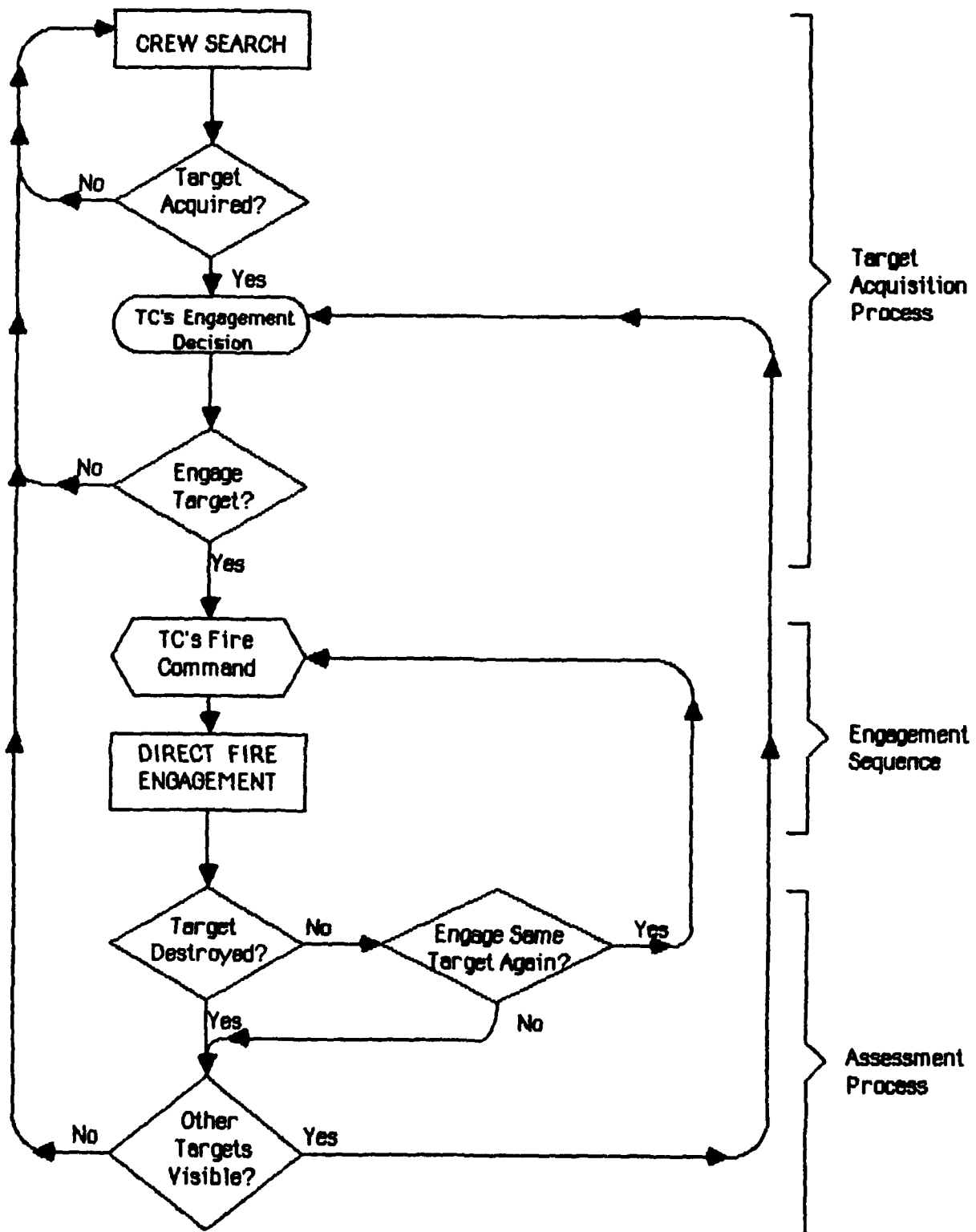
Figure 2.   The gunnery model.

Despite some superficial analogies of the current model to traditional task analysis methods, there are some important differences. One of the most important differences is that in task analysis the emphasis is on identifying the steps. Such descriptions are sufficient to describe simple procedural tasks that are typical of many jobs in industry and in the military. As can be seen in the previous illustrations, the process of gunnery is quite complex and does not necessarily proceed in a linear fashion. Hence, the present analysis emphasizes the relationship between conditions and behaviors and the temporal flow of actions. The result is a more coherent description of performance. However, some of the techniques used in this description are necessarily unconventional. To the extent possible, each technique is described where it is presented.

Identification of Crew Gunnery Conditions

Tank gunnery is complex because of the large number of mission-specific, situation-specific and engagement-specific conditions that affect the gunnery process. No analysis of tank crew gunnery behaviors can be complete without a thorough consideration of these conditions.

Various conditions affect the engagement. These are the stimuli related to the environmental situation, the tactical situation, equipment status, and personnel status that influence the capability of the tank to shoot, move, and communicate. These conditions can change in both predictable and unpredictable ways. As stated in the introduction, the environment in which the tank and its crew operate was separated into three categories of conditions in support of this gunnery analysis. The categories correspond to different levels of operation in both scope and time.

The first category is the set of pre-existing conditions that are established at the start of the mission and remain in effect until the mission is completed, unless modified in the ongoing tactical situation. For example, the predominant weather is a pre-existing condition that may not change over the course of a mission. There are two types of pre-existing conditions: internal and external. Internal conditions are those relating to the crew and the tank system, while external conditions are those relating to the general tactical scenario and environment.

The second category of conditions is the set of conditions resulting from the specific tactical situation. Like pre-existing conditions, situation-specific conditions are established before the engagement. However, the effects of situation-specific conditions are typically more spontaneous and are much more subject to change than the pre-existing

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conditions. For example, the employment of smoke during an operation modifies the visibility range in a limited area for a limited period of time. The presence of smoke is a temporary condition that affects the way the crew searches for targets, and also may affect where the crew moves the tank in a mobile situation. The internal and external sub-categories of conditions also apply within the context of situation-specific conditions.

The third category of conditions, those related to the macro-engagement, includes the visible enemy array, the friendly weapons systems engaged with the enemy array, and the direct fire exchange itself. Because of their direct relationship with the target acquisition process, the discussion of engagement-specific conditions will be presented in the section of this report dealing with the macro-engagement.

These categories and sub-categories of conditions are outlined in Table 1.

Table 1

Summary of Crew Gunnery Conditions

| | | SUB-CATEGORY OF CONDITIONS | |
CATEGORIES OF CONDITIONS	OPERATIONAL SCOPE	INTERNAL	EXTERNAL
PRE-EXISTING	Mission	Crew status System status	Enemy Situation Friendly situation Environment
SITUATION-SPECIFIC	Mission-phase or Specific tactical situation	System malfunctions Crew casualties	Changes to: --Enemy situation --Friendly situation Local environment
ENGAGEMENT-SPECIFIC	Macro-engagement	Misfires Ammo consumption Crew coordination	Target array Friendly fires Standing orders Smoke, chemicals

Pre-Existing Conditions

There are two types of pre-existing conditions: those that are internal and those that are external to the tank. Internal pre-existing conditions reflect the status of the tank and its crew, and are unlikely to be modified by the specific tactical situation. External pre-existing conditions reflect the baseline set of tactical and environmental conditions within the general situation or scenario. They are more general and more subject to modification by the specific tactical situation than are the internal pre-existing conditions. Table 2 shows the categories of pre-existing conditions and summarizes their impact on the gunnery process. Many of the system-specific parameters are limited to a small set of conditions. Other parameters are subject to a very large number of conditions, either along a continuum (e.g., collective crew knowledge) or among variables that are specific to a tactical situation (e.g., known or anticipated enemy positions). These types of conditions are shown as a continuum or as situation-specific under the conditions column in the table.

Internal Conditions

System status. Conditions pertaining to the tank crew and tank systems transcend the tactical situation from start to finish. System status conditions are dynamic. That is, they are subject to change at any point in the operation because of the influence of factors such as the degree of enemy activity, length of the battle, and losses incurred by both sides. Some of these changes are predictable, e.g., ammunition expenditure and fuel consumption. Some factors that affect the operational status of the tank are determined at the start of an operation and continue throughout, although they may be modified by malfunctions and combat results.

The operational status of the tank is determined during the before operations preventive maintenance checks and services and prepare-to-fire checks. Six categories of internal conditions may influence gunnery behavior: the main armament systems, auxiliary weapons systems, automotive systems, the NBC protection system, the communication system, and the status of on-board supplies.

a. Main armament systems. (See Table 2, pages 12-13, internal category 1.a.) The turret is the fighting compartment of the tank. It houses the main gun, coaxial machine gun, ready ammunition, fire control systems, communications system, and crew personnel that operate the weapons. For this report, the phrase "main armament systems" will refer to the main gun, the coaxial machine gun, and the fire control system components associated with those weapons.

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Table 2

Crew Gunnery Pre-existing Conditions

CATEGORY OF CONDITIONS	CONDITIONS	EFFECTS ON BEHAVIOR

INTERNAL CONDITIONS

1. SYSTEM STATUS.

   a. Main Armament Systems (Main gun, coax, and fire control system components).

(1) Traverse and elevation power.	A. Power operation. B. Manual operation.	Manual operation bypasses the stabilization system and ballistic computer.
(2) Stabilization.	A. Stabilization normal. B. Stabilization inoperative (emergency mode).	An inoperative stabilization system defeats the tank's ability to fire on the move, and the lead angle function.
(3) Ballistic computer.	A. Operational. B. Non-operational.	An inoperative computer requires use of the Gunner's Auxiliary Sight (GAS).
(4) Cant sensor.	A. Operational. B. Non-operational.	An inoperative cant sensor requires the gunner to apply a manual adjustment when firing a non-level position.
(5) Lead angle sensor. (LAS)	A. Operational. B. Non-operational.	An inoperative LAS requires the gunner to apply standard lead when engaging moving targets.
(6) Laser range finder (LRF).	A. Operational. B. Loss of symbology. C. Non-operational.	An inoperative LRF requires the crew to estimate and manually input range to the computer, or to use the GAS. Loss of symbology precludes range input evaluation by the crew.
(7) Sights.	A. Boresighted. B. Not boresighted.	Sights must be re-boresighted frequently to ensure main gun accuracy.
(a) Gunner's Primary Sight GPS)/ Gunner's Primary Sight Extension (GPSE)	A. Fully operational.	Either GPS channel may be used as a an alternative in place of the other, visibility and illumination permitting. Loss of both GPS channels requires switching to the GAS.
- Daylight channel (only)	B. Inoperative.	
- Thermal Imaging System (TIS) only	C. Inoperative.	
- Both	D. Inoperative.	

(table continues)

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Table 2 (Continued)

CATEGORY OF CONDITIONS	CONDITIONS	EFFECTS ON BEHAVIOR
(b) Gunner's Auxiliary Sight (GAS).	A. Operational. B. Non-operational.	An inoperative GAS requires the use of the primary sight. If both sighting systems are inoperative, the tank's primary weapons become ineffective.
(c) Muzzle reference system.	A. Aligned. B. Not aligned.	Failure to align the system can adversely affect the tank's accuracy.
(7) Firing circuitry. - Gunner's triggers (only). - TC's trigger (only). - Emergency manual firing device (only). - Complete system.	A. Fully operational. B. 1 or 2 triggers inoperative. C. All inoperative. D. Inoperative. E. Inoperative. F. Inoperative.	The failure of any electrical trigger is overcome using alternate triggers at the gunner's or TC's position. If all electrical triggers fail, the emergency manual firing device (blasting machine) may be used. A complete system failure disables the main gun.
b. Auxiliary weapons. (1) Cal .50.	A. Fully operational. B. Degraded capability. C. Inoperative.	System failure degrades the tank's overall capability, and eliminates the capability to conduct simultaneous engagements, but does not disable the tank. Degraded operations reduce the accuracy of the Cal .50.
(2) Smoke grenades.	A. Operational. B. Non-operational.	System failure increases the tank's vulnerability to enemy direct fires, but does not disable the tank.
(3) Loader's M240.	A. Operational. B. Non-operational.	Failure reduces tank's overall capability, but does not disable the tank.
c. Automotive systems.	A. Operational. B. Non-operational.	The tank can fight with an automotive system failure, but only from a stationary position. Otherwise, an automotive system failure disables the tank.
d. NBC protective system.	A. Operational. B. Non-operational.	Failure of the NBC protective system is a minor problem on the M1. The crew can use the portable filter canisters with their masks.
e. Communications. -Radio (only). -Intercom (only).	A. Fully operational. B. Inoperative. C. Inoperative. D. Non-operational.	Radio failure reduces the tank's ability to comply with the unit's fire distribution and movement plans. Intercom failure inhibits the crew's ability to interact. A complete system failure reduces the tank to emergency operations, only.

(<u>table continues</u>)

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Table 2 (Continued)

CATEGORY OF CONDITIONS	CONDITIONS	EFFECTS ON BEHAVIOR
f. Supply status.		
(1) Main gun ammunition.	A. Green[a] B. Amber. C. Red. D. Black.	The amount of main gun ammunition on board affects how long the tank can continue in sustained combat and when the tank needs to reload. The mix of main gun and machine gun ammunition available also affects weapon/
(2) Machine gun ammunition.	A. Green. B. Amber. C. Red. D. Black.	ammunition selection. A shortage of machine gun ammunition limits the tank's ability to provide suppressive fires and to reconnoiter by fire.
(3) Fuel.	A. Green. B. Amber. C. Red. D. Black.	The amount of fuel on board also affects the tank's ability to engage in sustained operations.
2. CREW STATUS.		
a. Number of crewmen.	A. Four. B. Three. C. Two. D. One.	A three man crew must either sacrifice mobility or simultaneous main gun/coax and Cal .50 engagements, by choosing to vacate either the driver's, gunner's, or loader's position. The optimum choice is to vacate the gunner's position, with the TC firing the main gun from his position. A two man crew can operate the turret from a static position, or move and fire the Cal .50 or one main gun round, in an emergency situation. A single crew member may conduct surveillance from the TC's position, fire the Cal .50 or one main gun round, or drive the vehicle, in an emergency situation.
b. Knowledge (individual/collective.)	(Continuum)	Individual knowledge and experience contributes to the crew's overall capability. Collective performance is dependent upon individual knowledge and teamwork.
c. Physical capability.	(Continuum)	Physical strength and fatigue affect the (Strength/fatigue.)loader's performance more than any of the other crew positions, under normal conditions. Physical fatigue will also affect the gunner if he must operate without turret power for any sustained period. Fatigue slows reaction times and reduces the crew's overall performance.
d. Psychological state.	(Situation dependent)	Psychological factors (mental fatigue, "shell shock," depression) can affect the crew's overall performance.

[a]The precise percentage of basic load for ammunition and fuel associated with the color ratings may vary among units. The following criteria corresponds with that suggested by the Armor School: Green = 90% +; Amber = 80 to 89%; Red = 60 to 79%; Black < 60%.

(table continues)

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Table 2 (Continued)

CATEGORY OF CONDITIONS	CONDITIONS	EFFECTS ON BEHAVIOR

EXTERNAL CONDITIONS

1. ENEMY SITUATION.

a. Most likely target type(s).	A. Tanks. B. APCs. C. Light-skinned vehicles. D. Troops.	Used in determining the type ammunition for the battle carry configuration and target engagement priorities.
b. Known/suspected locations.	(Situation dependent)	Used to establish tactical plans.
c. Known/anticipated capabilities.	(Situation dependent)	Used to establish tactical plans.
d. Anticipated actions.	(Situation dependent)	Used to establish tactical plans.

2. FRIENDLY SITUATION.

a. Mission/operation.	(Situation dependent)	May affect weapon/ammunition selections, formations, movement techniques, position selection, and engagement techniques throughout the operation.
b. Standing orders. (1) SOPs.	(Situation dependent)	Establishes tank's position in formation and sectors of responsibility for target acquisition and engagement.
(2) Engagement priorities.	(Situation dependent)	Modifies target classification criteria, increasing the priority for certain targets.
c. Adjacent unit missions/operations.	(Situation dependent)	Location, mission, capabilities, and actions of adjacent units affect target identification, fire distribution and movement plans of a subject crew's own unit.

3. ENVIRONMENT[b]

a. Terrain. (1) Cover.	(Continuum)	Good natural cover affords sufficient hull defilade positions. The distance between terrain features affects engagement ranges, tactical dispositions, and distances covered in each bound (offense).
(2) Concealment.	(Continuum)	Good concealment denies observation and limits target acquisition and engagement ranges. Concealment interacts with cover, but does not provide as much protection from enemy fires.

[b]Aspects of the environment affect both friendly and opposing forces capabilities. The affect varies between the attacker and defender. For example, good cover and concealment provides an initial advantage to the defender while good trafficability general provides an advantage to the attacker.

Table 2 (Continued)

CATEGORY OF CONDITIONS	CONDITIONS	EFFECTS ON BEHAVIOR
(3) Trafficability.	A. Good. B. Fair C. Poor.	Poor trafficability may slow or deny cross-country movement, increasing vehicle exposure times (friendly and enemy). Use of roads can increase movement rates, but canalizes the moving force, making it vulnerable to mines and preplanned indirect fires.
b. Light conditions.	A. Daylight. B. Night. C. Transitional (dusk/dawn).	Low light conditions require the use of night observation devices and/or illumination.
c. Weather.	A. Clear. B. Cloudy. C. Fog. D. Rain. E. Falling snow.	Cloudy conditions may reduce the amount of light available during transitional periods and at night. Fog, rain and falling snow reduce visibility (daylight and TIS, to degrees), and defeat the LRF.

The main armament system represents the majority of the tank's combat power. The operational status of the fire control systems defines the pre-existing conditions within the main armament system. These are listed in Table 2 (pages 12 and 13, internal sub-categories 1.a.(1) through 1.a.(7)), and the effect of sub-system failures are noted. Crew tasks associated with the before operations maintenance of the tank and the prepare to fire checks are essential in identifying the internal pre-existing conditions of the main armament systems.

b. Auxiliary weapons. (See Table 2, page 13, internal category 1.b.) The M2HB Caliber .50 machine gun, the loader's M240 machine gun, and the smoke grenade launchers are important auxiliary systems since they supplement the tank's overall combat power. The operational status of auxiliary systems is established during before operations maintenance checks and services and defines the set of pre-existing conditions relevant to them.

The failure of one or more of the auxiliary systems will affect how the crew fights. Failure of either the caliber .50 or M240 machine gun increases the importance of the coaxial machine gun in subsequent operations. The failure of the smoke grenade launchers reduces the tank's ability to screen itself with smoke.

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c. Automotive systems. (See Table 2, page 13, internal category 1.c.) Although automotive systems are only indirectly related to the firepower of the tank, they are extremely important in determining the tank's overall combat effectiveness. The before operations checks and services for the automotive system determine the tank's ability to move about the battlefield. This pre-existing condition is critical to the employment of the tank in the tactical operation.

d. NBC protective system. (See Table 2, page 13, internal category 1.d.) On the M1 tank, the NBC system is an air filtration system which connects to the crewman's protective mask by means of a hose. The mask normally contains a filter element that is connected to the end of the hose. The collective protection system of the tank supplements this system with additional filters.

The M1A1 tank employs an overpressure protection system that allows the crew to operate without protective masks and clothing in a contaminated environment. The operational status of the collective protection system on the M1A1 is therefore more significant than that of the basic M1. Under certain conditions, the crew may be required to don traditional protective gear in the M1A1, but this is a reaction to requirements to exit the vehicle or to protect the crew against hazards which may occur within the tank.

e. Communications. (See Table 2, page 13, internal category 1.e.) The status of a tank's communications system is important in a combat situation. The radio facilitates coordination among the tanks, increasing the potential combat effectiveness of the tank unit. The intercommunications system is essential in directing and coordinating the crew's activities. This pre-existing condition is also established in the before operations maintenance procedure.

f. Supply status. (See Table 2, page 14, internal category 1.f.) The tank carries a variety of supplies into battle so that the crew may operate for extended periods of time away from their supply base. The most critical categories of supply are ammunition and fuel. These pre-existing conditions jointly establish a limit on how long and how hard the crew can fight before being resupplied. Fuel and ammunition consumption can be predicted based on the anticipated level of enemy contact and the distances involved in the operation.

Crew status. The capabilities of the crew affect the operation of the tank. Several aspects of the crew status must be considered as pre-existing conditions. Table 2 outlines the crew-specific factors that can be considered

internal pre-existing conditions in the tank gunnery context. The factors of crew status are: the number of crewmen, the individual knowledge of each crew, the physical capability of the crew, and the crew's psychological state.

a. Number of crewmen. (See Table 2, page 14, internal category 2.a.) The number of crewman available to operate the tank can limit the tank's effectiveness. A three man crew has fewer choices regarding how to engage various targets. For example, simultaneous Cal .50 and main gun engagements are not possible without three crewmen in the turret. If short one crewman, the gunner's position is typically left vacant, and the TC conducts engagements from his position.

b. Knowledge (individual/collective). (See Table 2, page 14, internal category 2.b.) The operation of the tank is also affected by the training status of its crew, including both (a) technical knowledges and skills and (b) crew coordination. Each crewman possesses certain knowledges and skills, establishing the limits of that crewman's capability. The ability of the crew to work as a team may act to overcome some of the shortcomings of the individual crewman.

c. Physical capability (strength/fatigue). (See Table 2, page 14, internal category 2.c.) The physical status of the crew can affect their performance. Physical strength itself is most critical in the loader's position because of the physical demands associated with manipulating large caliber ammunition in close quarters (inside the tank). Other isolated tasks among the other crewmen involve some physical strength, but it is the loader who has the most physically demanding routine. Physical capability can be degraded by participating in sustained operations without sufficient rest, lack of food, intensity of combat, and so on.

d. Psychological state. (See Table 2, page 14, internal category 2.d.) The psychological state of the crew can also affect their collective performance. The psychological state may interact to some extent with the physical state, increasing fatigue. Other factors, such as internalized perceptions of combat (e.g., shell shock, feelings about the loss of fellow unit members) may also affect the crew's mental state and their subsequent performance.

External Conditions

There are three general categories of external pre-existing conditions: the enemy situation, the friendly situation, and the environment. The external conditions are outlined in Table 2, beginning on page 15.

Enemy situation. The overall enemy situation is a pre-existing condition that can affect both the designation of a battlecarry configuration and target engagement priorities.

The battlecarry configuration is selected based on the most likely or most dangerous type of enemy equipment to be encountered. (See Table 2, page 15, external category 1.a.) For example, if the friendly force anticipates contact with a tank-heavy enemy, the primary armor defeating ammunition would be loaded in the main gun, and the battlesight range[1] would be indexed into the computer. Ammunition selection switches would be preset to allow the fastest possible engagement sequence. Target engagement priorities reflect the types of targets the tank might encounter that offer the greatest pay-off when destroyed. For example, the destruction of command vehicles affects the enemy's ability to coordinate the battle and react to the dynamics of battle. The evaluation of potential targets is indicated by the designation of target engagement priorities.

Opposing force (OPFOR) positions, capabilities, and their anticipated actions are pre-existing conditions to the extent that they influence friendly mission planning. (Table 2, page 15, external categories 1.b. through 1.d.) Since known and suspected enemy locations and capabilities are considered in operational planning, they can dictate specific engagements or engagement options. Suppose, for example, that the company team is preparing for an offensive operation. Reconnaissance patrols have reported an enemy position on a given hillock. The company team commander's plan calls for one of the tank platoons to take up an overwatch position approximately 1,000 meters from the suspected position and to suppress the enemy while the remainder of the company team maneuvers to assault the position. In his operations order to the TCs, the platoon leader may direct that the tanks reconnoiter the position by fire (Fire on the position with machine guns, and if any armored targets are identified, engage them with main gun). This plan dictates the engagements that each tank commander will conduct at that point of the battle. In this case, the pre-existing condition is very specific and strongly affects what happens at that point in the attack.

Friendly situation. The mission or operation of the larger friendly unit (e.g., company/team, battalion/task force) is also a pre-existing condition. (Table 2, page 15, external category 2.a.) The commander's intent and scheme of

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[1]Factors used to select battlesight range include the most likely engagement range, the trajectory of the round selected and the size of the target. The most likely engagement range is the most important of these factors.

maneuver establish the background for the engagements to be conducted during the operation. These factors dictate the manner in which subordinate units will support each other by fire and movement, as illustrated in the previous example. Carrying the concept of the operation to the individual crew level, the plan specifies the proximity of friendly elements and their missions (Table 2, page 15, external category 2.c.), the points at which direct fires will be massed on enemy target arrays or positions, and how the arrays will be subdivided. To the tank commander, this translates into when he must increase the emphasis on identification (friend or foe) and what portion of the sector or target array he must cover or engage.

Standing Operating Procedures (SOPs) (Table 2, page 15, external sub-category 2.b.(1)) designate the tank's position in formation, sector of responsibility, and techniques of engagement to be employed when specific orders are not given. Because these are the routine procedures to be employed by the unit, they must be considered pre-existing conditions.

The designation of target engagement priorities at a superior command level (Table 2, page 15, external sub-category 2.b.(2)) requires tank commanders to consider certain types of enemy vehicles as dangerous targets even though they do not meet the normal criteria for that target classification. FM 17-12-1, Tank Combat Tables M1 w/c 2 (1988) defines a dangerous target as one that has an armor defeating capability (e.g., a tank or anti-tank guided missile launcher), but is not preparing to engage. A target without an armor defeating capability is normally classified "least dangerous." The implication for a multiple target engagement is that all dangerous targets are destroyed before least dangerous targets are engaged. For example, the command variant of the BTR-80 armored personnel carrier is, by definition, a least dangerous target because it does not have an armor-defeating capability. However, if enemy command vehicles are given a target engagement priority, those vehicles are treated as dangerous targets, and engaged accordingly. A target engagement priority is a pre-existing condition which dictates a modification of the target classification criteria.

Environment. The predominant terrain, weather, and light conditions influence both friendly and enemy capabilities. The identification of environmental pre-existing conditions pertinent to tank operations in Table 2 begins on page 15.

a. Terrain. (Table 2, page 15, external category 3.a.) The amount of cover (protection from enemy direct fires) and concealment (protection from enemy direct observation) in an area influence the operation in the selection of battle

positions, routes of movement, movement formations and techniques, and methods of supporting the operation. Trafficability is also important because of its effect on the ability of the tanks to move cross country. The characteristics of the terrain in an area of operations also help predict the range of options available in certain situations. For example, when enemy contact occurs, a contact drill is best in some types of terrain, while an action drill is better in others. Consideration of the predominant terrain conditions before the operation begins allows leaders to predict what courses of action will probably be most effective in given situations.

 b. Light conditions. (Table 2, page 16, external category 3.b.) Reduced light conditions dictate the employment of night observation devices and limit the crew's target acquisition capability. An overcast reduces the amount of available light, reducing the available illumination during transitional periods (dusk and dawn) and at night.

 c. Weather. (Table 2, page 16, external category 3.c.) The predominant weather conditions influence the effectiveness of the crew and fire control systems. Rain, fog, and falling snow reduce visibility throughout the daylight sights, and reduce the laser range finder's effectiveness. The crew can still acquire targets beyond visible range (unaided vision) with the thermal channel, but the range would have to be estimated and indexed manually.

Situation-Specific Conditions

The specific tactical scenario and immediate environment affect the gunnery engagement by modifying both external and internal pre-existing conditions. Whereas the external pre-existing conditions are general in nature, the specific situation refines those conditions, resulting in a more spontaneous effect on the crew's performance and a more detailed description of the tactical conditions relevant to gunnery.

Internal Situation-Specific Conditions

As the tactical situation progresses, the effects of operating the equipment and fighting the battle may modify the system and crew status. Fuel and ammunition are consumed, equipment malfunctions may occur, and the crew may undergo a change in their mental and physical state. Lulls in the operation may allow rest, redistribution of fuel and ammunition within the tank and between tanks, resupply from service support elements (e.g., refueling by the battalion service platoon), and repairs of minor malfunctions.

External Situation-Specific Conditions

   <u>Enemy situation</u>. The specific enemy situation modifies
the general enemy situation (pre-existing condition) and has
an immediate impact on the actions of the crew and platoon.
Whereas the pre-existing condition represents the enemy's
disposition, capabilities, and intentions when the operation
begins, the specific situation represents a refinement of the
situation that evolves from the pre-existing condition as a
result of the ongoing interaction between the two opposing
forces. For example, the effectiveness of indirect and
overwatching fires may force the friendly unit to adjust its
immediate position or plans. Unless specific targets are
identified, the tank platoon and crew cannot shoot back. This
may foster apprehension and frustration among the crew,
reducing their overall effectiveness. Known enemy activity
outside the tank's range of direct observation and fires also
influences the unit's actions. The friendly unit may be
repositioned to engage the enemy, or may be left in their
current position to await further developments. Other aspects
of the enemy situation which may modify the conditions at this
point include the introduction of nuclear, biological or
chemical weapons.

   <u>Friendly situation</u>. The specific friendly situation is
the immediate phase of the tactical scenario or operation. In
the defense, this translates to the current battle position
and the plan for defending it. In the offense, the specific
situation equates to the current overwatch position or bound.
Specifically, the differences between the pre-existing
conditions and the situation-specific conditions include
modifications to the friendly unit's plan necessitated by the
terrain, the enemy situation, losses from enemy action and
from equipment failures throughout the unit, and other
unforeseen problems. For example, a rapid change in the
weather such as an unexpected rain storm might reduce the
trafficability on the floor of a valley and cause the unit to
select a different avenue of approach in an offensive
operation. Inherent to the specific situation is the
proximity of friendly forces that can directly influence the
battle.

   <u>The environment</u>. The environment in which the tank is
operating limits the options available to the crew should they
become engaged. The immediate availability of cover and
concealment, including man-made enhancements (e.g.,
survivability efforts), present options that are not available
in open terrain. The relative trafficability of the terrain
may limit the routes available when moving, as illustrated in
the previous example. The introduction and dissipation of
battlefield smoke modifies the range of options available for
target acquisition and engagement.

The Macro-Engagement, Engagement-Specific Conditions, and the Target Acquisition Process

The macro-engagement[2] is the fire fight in which the tank crew is a participant. The individual tank engagement is but a single element within the macro-engagement. The macro-engagement is comprised of all friendly and enemy troops, vehicles, equipment, and weapons systems in contact with each other in a particular area, the exchange of fires within that area, and the outcome of each individual engagement therein. The macro-engagement begins when either force detects the other, and ends when either force is destroyed or captured, or when one of the forces disengages from the other. Throughout the course of a macro-engagement, participants may enter or leave the battle. All tactical tank gunnery engagements take place within a macro-engagement.

Engagement-specific conditions are those conditions present during a macro-engagement, but not prior to it, that interact with relevant pre-existing and situation-specific conditions, to affect the gunnery process. There are nine categories and several subcategories of engagement-specific conditions. These categories and sub-categories are listed in Table 3. The categories of engagement-specific conditions include details about the target or group of targets, and fire distribution and controls.

The target acquisition process consists of the covert perceptual and cognitive processes and overt behaviors involved in detecting and reacting to a target or group of targets during a macro-engagement. In effect, the engagement-specific conditions provide the stimuli that elicit responses from crew members. Target acquisition is the first of these responses and includes search, detection, location, recognition, identification, classification, and the decision whether or not (and what) to engage. Target acquisition is the initial step in the gunnery process. The engagement does not occur without target acquisition.

This section seeks to describe the macro-engagement, categorize the engagement-specific conditions, explain the target acquisition process, and demonstrate the inter-relationship among and between these elements.

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[2]The reader is reminded that the macro-engagement is an operational term within the context of this report, used to differentiate between the large scale engagement of two opposing forces and the smaller scale engagement of one target by one tank crew.

Table 3

Engagement-Specific Conditions

PARAMETER	CONDITIONS		COMMENTS
1. Number of targets.	Absolute value, ranging from 0 to some finite number limited by OPFOR resources, tactics, the terrain, and the intervisibility conditions.		Existence of multiple targets relates to parameters 3 and 4, below, and the decision to conduct sequential and/or simultaneous engagements.
2. Target Type(s).	a.	Tanks.	Influences ammunition/weapon selection and target classification.
	b.	Armored personnel carriers.	
	c.	Unarmored vehicles.	
	d.	Helicopters.	
	e.	Fixed wing aircraft.	
	f.	Personnel.	
	g.	Anti-tank weapons.	
	h.	Machine gun team.	
	i.	Other.	
3. Array.	a.	Lateral.	Related to parameter 4, below.
	b.	Depth.	
	c.	Mixed.	
4. Platoon fire plan(s) or pattern(s)			May be preplanned or specified by a fragmentary order when the targets are acquired.
-- Fire pattern.	a.	Frontal.	Generally conforms to the pattern of the target array.
	b.	Cross.	
	c.	Depth.	
	d.	Special.	
-- Firing technique.	a.	Simultaneous.	Specifies whether the tanks within the platoon will support each other with observations, and if so, how.
	b.	Alternating.	
	c.	Observed.	
5. Range to target.	a.	Effective main gun range.	Affects hit and kill probabilities for all weapons systems. For any type target, the range of viable options for weapon and ammunition choices and the range of options in engagement technique increase as range decreases.
		(1) Precision engagement range (<=4000 m).	
		(2) Battlesight engagement range. (Varies by situation.)	
	b.	Effective Cal .50 range. (1800 m.)	
	c.	Effective 7.62-mm range. (900 m.)	
6. Target	a.	Apparent movement.	Affects gunner's engagement behaviors. See Table 6, variable 13.
	b.	No apparent movement.	
7. Target aspect.	a.	Frontal.	Orientation of primary armor protection. Affects hit and kill probabilities, and influences ammunition and platoon fire pattern selection.
	b.	Oblique.	
	c.	Flank.	

(table continues)

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Table 3 (Continued)

PARAMETER	CONDITIONS	COMMENTS
8. Target orientlation.	a. Toward firing (friendly) tank. b. Toward other friendly units. c. Away from friendly units.	Orientation of primary weapons system. Affects target classification, and in turn, the sequence of engagement.
9. Target engagement priorities.	Situation-specific.	Affeclts target classification, and lconsequently, the sequence of 111lengagement.

In the introduction to this report, the single tank/single target engagement was established as the focus of this analysis and the gunnery model was introduced based on the individual engagement. The isolation of the individual engagement allows a convenient means of describing and analyzing the gunnery pattern. All "gunnery pure" behaviors can be examined and explained in relation to the gunnery model, whether in a single engagement, a concurrent engagement, or a sequence of engagements. The existence of other visible targets and other friendly units are extraneous to the individual engagement once a specific target has been designated. Since the decision to engage is concerned, in part, with the evaluation, selection, and sequencing of targets, and since the decision to engage is the last step of the acquisition process, these factors must be considered in the examination of the target acquisition process.

Engagement-Specific Conditions

The external stimuli to target acquisition are those aspects over which the tank commander has no direct control. They represent the salient aspects of the pre-existing conditions, the situation-specific conditions, and the engagement-specific conditions to which the crew must attend. The categories of pre-existing conditions, which were described in the previous section, are outlined in Table 2. The categories of engagement-specific conditions are outlined in Table 3 and are explained in detail in the text that follows.

Number of Targets (Table 3, parameter 1)

The number of targets affect the crew in several ways. First, the existence of a multiple target array implies that a number of friendly units and weapons systems (e.g., tanks, anti-tank guided missile (ATGM) systems) will divide the array among themselves, each unit or system taking responsibility for a certain portion of the array. This is reflected in the fourth parameter, the platoon fire plan or pattern. Second, if the individual tank is responsible for more than one target within the array, each target must be classified according to the degree of danger it (the target) presents to the firing tank. The target classification influences the TC's decision to conduct sequential and/or simultaneous target engagements and affects the sequence of target engagements.

Target Type(s) (Table 3, parameter 2)

The target types influence ammunition and weapon selections and affect target classification. For example, tanks and anti-tank weapons present a greater danger to the tank than does a machine gun team since tanks and anti-tank weapons are armor-defeating systems and a machine gun is not. Heavy armor targets would be engaged with SABOT,[3] while the machine gun team would be engaged with a machine gun.

Target Array (Table 3, parameter 3)

The enemy formation or target array also affects selection of the platoon fire pattern. The platoon fire pattern, in turn, influences what targets the individual tank will engage. This factor interacts with range (parameter 5) and target classification to influence the order in which multiple targets are engaged.

There are three patterns of target arrays: lateral, depth, and mixed. A lateral array is one in which the targets are generally on line, with little dispersion in range. A column moving directly across a tank's front is an example of a lateral target array. An array in depth is one in which the targets are dispersed in range, but not laterally. A column moving directly toward the firing tank is an example of a

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[3]Sabot is the short designation for "armor piercing, fin stabilized, discarding sabot (APFSDS-T)," or "armor piercing, discarding sabot (APDS-T)" ammunition, the primary armor defeating ammunition. The fin stabilized version is the more recent development, and is preferred over the other variant, which is spin stabilized.

depth target array. A mixed array is dispersed both laterally and in depth. For example, a Soviet or Warsaw Pact motorized rifle battalion in classic deliberate attack formation has several ranks of armored vehicles arrayed in depth. Each rank represents a lateral array, while the depth of the formation represents a mixed array.

Platoon Fire Plan(s) or Pattern(s) (Table 3, parameter 4)

The platoon fire plan or pattern divides the target array between the tanks that are to engage. A fire plan is used in a defensive situation to specify patterns and techniques of engagement. A fire pattern may also be specified in a platoon fire command, or a particular pattern may be established as the "default" pattern for an operation. That is, all unit engagements will conform to a pre-designated pattern unless modified by a fragmentary order. A tank crew makes its own decisions regarding target sequencing within its sector of responsibility.

The standard types of fire patterns are frontal, cross, and depth. A frontal fire pattern represents a generally parallel arrangement of tank to target lines. In other words, the left most tank in the platoon fires at the left most target, while the right most tank engages the target furthest to the right. This pattern is appropriate for the long-range engagement of a lateral target and the engagement of a mixed array. A cross fire pattern is exactly the opposite of a frontal fire pattern. In a cross fire pattern, the tank on the platoon's left engages the target on the far right, and so on. This is appropriate against lateral targets at close range because the pattern affords more shots against the flanks of the target vehicles (see parameter 7, below). A depth fire pattern divides the array according to range and is appropriate for a depth target array. Special patterns may be generated based on local conditions related to the terrain or the enemy array. For example, the terrain may preclude certain tanks from engaging targets in conformance with a standard fire pattern, or the platoon leader may divide a mixed array in depth by section[4] with each section engaging in a frontal fire pattern.

The firing technique is also pertinent to the platoon fire command since it specifies whether the tanks within the platoon will support each other by observation and, if so, how. The three firing techniques are simultaneous fires, alternating fires and observed fires. Simultaneous fire affords the highest volume of fire with each tank engaging

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[4]The normal organization of a tank platoon is two sections of two tanks each.

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independently according to the specified pattern. Alternating fire requires one tank in each section to observe while the other tank engages, and then the two tanks alternate roles with the first tank firing and the second observing. This continues until both tanks are hitting targets, at which time the sections proceed to simultaneous fires in order to maximize their volume of fires. Observed fires are used against a smaller target array when volume of fire is not as critical. In observed fires, one tank in the section fires while the second observes. The observing tank only engages if the firing tank cannot adjust onto the target after several attempts. Otherwise, the observing tank refrains from exposing itself by firing its weapons. See the section on post-engagement behaviors for an explanation of direct fire observation.

Range (Table 3, parameter 5)

The range to the target interacts with the other stimuli already indicated. Although range is a continuum, engagement ranges can be divided according to certain practical break points.

The accuracy of the main gun is a function of round to round dispersion, target movement, environmental conditions, system error, and gunner error. For each round fired, these errors may compound or counteract each other, but the result will be some angular deviation from the optimum point of aim. Range and muzzle velocity interact to compound the angular errors present when the round is fired. Because of the relative size of the target, a great deal more error can be tolerated at close range than at long range. Thus, probability of hit is influenced by range.[5]

Angular dispersion, whether by random or gunner error, is greater for slower velocity munitions. Since SABOT has a higher muzzle velocity than the secondary armor defeating ammunition (high-explosive, anti-tank, or HEAT), SABOT is considered the more accurate round.

The accuracy of machine guns is primarily a function of the gunner's ability to adjust the rounds onto the target. The existence of tracers in one of every five rounds fired

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[5]The ballistic computer processes ballistic data for ranges from 200 to 4000 meters, and automatically provides solution data to the fire control system. Hits and kills are possible beyond 2500 meters, but due to the composite effect of the environment, system and gunner errors, and probability of kill against most targets at extended ranges, 2500 meters is generally considered the effective range of the main gun.

enables the gunner to observe where the rounds are impacting and to adjust his aim accordingly. The tracer element burns only for a few moments and, once gone, is no longer of use in trying to observe the path of the rounds. Thus, the range at which the tracers burn out for a type round limits the effective range of that weapon.

Range also influences the probability of kill (given a hit) for all types of ammunition fired by the tank except HEAT. Since SABOT and machine gun ammunition achieve penetration by kinetic energy, their terminal velocity affects kill probability. Drag (friction) reduces the velocity of a round as it travels through the air, reducing the amount of energy available at the point of impact. The amount of kinetic energy available at the point of impact, and therefore, the probability of kill, is inversely proportional to range. For example, a SABOT round loses approximately eleven per cent of its initial velocity by the time it travels 2500 meters (FT 105-A-3, 1982).

HEAT ammunition uses chemical energy to penetrate the target's armor shell. The amount of energy available is determined by a chemical reaction that is initiated when the round strikes the target. Since this reaction is totally independent of the projectile's terminal velocity, the kill probability (given a hit) for HEAT ammunition is constant with respect to range.

These factors, taken together, determine the effective range of the tank's weapons systems. The main gun is considered effective to 2500 meters. The Caliber .50 machine gun is effective to a range of 1800 meters, and the M240 coaxial and loader's station machine guns are effective to 900 meters.

Another practical break point for the main gun and the coax is the battlesight range. The battlesight range and ammunition are established before an operation, and that range is indexed into the computer. If a target appears within battlesight range, the firing tank may accelerate the engagement sequence without sacrificing hit probability by using the battlesight gunnery technique.

To summarize the effect of range on gunnery behaviors, the number of viable engagement options for all target types increase as range decreases.

Target Movement (Table 3, parameter 6)

The target's movement and direction of movement with respect to the firing tank also affect the gunner's behavior. The primary fire control system automatically applies lead if

the gunner is tracking a moving target. If engaging more than one target, the gunner must remember to purge any lead data which may have been fed into the computer while traversing the turret from one target to the next. If the lead angle function is inoperable, the gunner must apply lead manually to engage a moving target (see Table 6, variable 13).

Movement is a relative concept in gunnery applications. A target moving directly at the firing tank on flat terrain has no apparent movement. The gunner need not traverse the turret to maintain his sight reticle on the target. Similarly, if both the target and the firing tank are moving in the same direction at the same speed on parallel paths, there is no apparent movement between the two. It is apparent movement that causes the gunner to traverse the turret in order to maintain a sight picture on the target.

Target Aspect (Table 3, parameter 7)

The target's aspect (the orientation of its primary armor protection) is also important. Flank shots are preferred to frontal shots for two reasons. First, the flank silhouette of an armored vehicle is generally larger than the frontal silhouette, providing a greater hit probability. Second, flank armor is generally not as thick as frontal armor, offering a higher probability of penetration and damage if a flank shot results in a hit. The consideration of target aspect is also related to the question of target movement since a flank target is more likely to have apparent movement than a frontal target.

Target Orientation (Table 3, parameter 8)

The target's orientation (i.e., the orientation of its primary weapons system) is also relevant to the acquisition process, specifically with regard to target classification. The difference between a dangerous target and a most dangerous target is the orientation of the target's armor-defeating weapons system. An explanation of target classifications begins on page 35.

Target Engagement Priorities (Table 3, parameter 9)

A target engagement priority assigns a value to certain types of targets in an array or potential array. For example, The ZSU-23/4 is a self-propelled anti-aircraft weapon system that is routinely found accompanying Soviet and Warsaw Pact armored vehicle formations. Its normal target classification

is "least dangerous".[6] Because of the threat the ZSU-23/4
presents to any friendly aircraft entering the battle, the
unit's leadership may assign it a target engagement priority.
Tank crews within the unit must then classify this type of
target as dangerous rather than least dangerous. If this type
of target appears in an enemy array within the firing tank's
sector of responsibility, and if no "most dangerous" targets
exist within the sector, the crew is expected to shoot the
ZSU-23/4.

Internal Target Acquisition Processes

The internal processes of target acquisition are the
crew's responses to the engagement-specific conditions.
These internal processes interact with the pre-exis⁺i.1g
conditions and the situation-specific conditions to influence
the engagement sequence. The processes of target acquisition
are outlined in Table 4. A detailed explanation of each step
follows the table.

Steps 1 through 7, as outlined in Table 4, represent a
hierarchy with 7 being the most advanced step. Progression
through the steps is a mental process with both perceptual and
cognitive components. Progression may occur either in a
systematic, step-wise manner through all seven steps, or may
bypass one or more of the steps. The following examples
demonstrate this contrast. Suppose a tank commander is
searching his sector (step 1) and observes movement in a tree
line about 2000 meters to the front (detection and location--
steps 2 and 3). He traverses the turret and directs the
gunner to make a detailed search of the immediate area. Using
his three power (3X) sight, the gunner determines that there
is a wheeled vehicle moving just inside the tree line
(recognition--step 4), but cannot yet identify the type of
vehicle or its status as friend or foe. Switching to the ten
power (10X) sight, the gunner identifies the vehicle (step 5)
as an OPFOR ATGM system, classifies the target as dangerous
(step 6), and the TC decides to engage (step 7). In another
case, a friendly tank exiting a defile encounters an enemy
tank at 500 meters. Identification, classification, and the
decision to engage (steps 5 through 7) are instantaneous, and
steps 2 through 4 in the acquisition process are bypassed. In
yet another case, the tank is involved in an offensive
operation. The platoon occupies an overwatch position as the
lead element in the company. The company is conducting a
movement to contact, and only enemy units are presumed to be
to the front. A piece of terrain to the front is suspected of
containing some enemy forces, but the exact location and type

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[6]See the explanation of target classification beginning
on page 35.

Table 4

The Target Acquisition Process

Acquisition Step	Outcome
1. Search	Determine if any evidence of a potential target exists.
2. Detect	Evidence of a potential target exists.
3. Locate	Physical location of the known or suspected target. (Sufficient for suppressive fires and/or reconnaissance by fire.)
4. Recognize	Number and type of targets, aspect, movement, orientation, approximate range.
5. Identify	Verify friend or foe, identify by model/ variant. (Determine if engagement priority applies.)
6. Classify	Establish priorities of engagement within sector of responsibility: most dangerous first, dangerous second, least dangerous last. (Sectors per platoon fire pattern.)
7. Decide to engage	A decision to engage results in the issuance of a fire command. A decision to not engage results in a return to step one as regards the acquisition process. The crew will continue to monitor targets already acquired. A "no" decision may also be accompanied by other crew actions such as disengaging and moving the tank to an alternate position.

of targets is undetermined. Some movement on the position is discernable. The platoon leader orders the platoon to reconnoiter the position by fire. In this case, the decision to engage (step 7) is based on information only through step 3 of the acquisition process. Steps 4 through 6 are bypassed.

Search (Table 4, step 1)

The first step in the acquisition process is continuous. Whenever a crew is involved in combat operations, they are assigned a sector of observation. The sector may be defined as a portion of the terrain the tank sees from a static position, or a specific arc with respect to the tank's orientation in a mobile situation. Each member of the crew has an area of responsibility relative to the tank, and the tank crew has a sector of responsibility within the platoon. For example, suppose a tank is in a static defensive position. Within the platoon, the tank is responsible primarily for the sector between ten and two o'clock relative to the tank's position. The tank is in a turret defilade position, and the driver cannot observe anything beyond the higher ground to his immediate front. The gunner would scan for targets within the tank's primary sector through his sights. The loader is responsible for the left half of the tank, from six to twelve o'clock. The tank commander is responsible for the right half of the tank, from twelve to six o'clock. Thus, within the crew, the entire perimeter is covered with an overlap existing in the tank's primary sector. Each crew member can define his area by a landmark at the right and left limit of the sector.

The crew uses the best available system to search for targets given the environmental conditions. During periods of darkness, night observation devices are used. The thermal imaging system is used by the gunner and/or tank commander in most environmental conditions because it affords a higher probability of target detection than the daylight channel. If visibility is clear and illumination is good, the TC or loader may use binoculars or the naked eye to search from the open hatch. Crew members are not only interested in the appearance of an actual target, but in any indication that a target exists, e.g., smoke, dust, lights, or movement.

Detect (Table 4, step 2)

Target detection is the realization that a potential target exists, but without more detailed information about the target. The indicators listed in the previous paragraph are tantamount to the detection of a target. While providing no definitive information of the target's nature, detection serves to focus the continued acquisition effort.

Locate (Table 4, step 3)

Target location is essential to the target acquisition process, particularly when it is inappropriate for the crew member who detects the target to engage it. For example, if the loader detects a tank target, he must be able to designate its location for the TC and gunner. The TC normally indicates the location of a target by pointing the main gun in the target's direction so that the gunner may see it through his sights. With a reliable location, the gunner can scan the designated area with fire control optics. Given the improved magnification and resol tion of the gunner's sights, he has a much better chance of recognizing and identifying the target. Within the crew, use of reference points and the clock method may be sufficient ways to specify target location. When the TC must report the target to someone outside the crew (e.g., the platoon leader), the TC must be able to locate the target by map grid reference.

In certain situations, a crew may engage a target area with machine guns to suppress any enemy personnel expected to be in that area, or it may reconnoiter the area by fire. If the machine gun rounds strike metal, a flash will result allowing the crew to acquire a suspected armored vehicle (recognition--step 4, below). This type of engagement bypasses the higher levels of the acquisition process. It is based on the assumption that enemy forces are located in a given area and that these forces are legitimate targets.

Recognize (Table 4, step 4)

Target recognition implies confirmation that a possible target is observed without sufficient detail to determine its nationality or model. Recognition does imply a sense of the type of target (e.g., tank, armored personnel carrier, anti-tank gun, truck), movement, aspect, orientation, approximate range, and the number of targets. In other words, a possible target is seen, but the observable image is too indistinct to verify its identity as friend or foe, or as a specific vehicle model (e.g., type of tank).

Identify (Table 4, step 5)

The next step is to identify the target as friendly or enemy, and if possible, to determine the specific model and variant. Although the thermal imaging system is the preferred channel for acquisition, the factors used in target identification are easier to confirm with the daylight channel. Therefore, it is often necessary to use the daylight channel to identify the target. Identification as friend or foe and identification by model and variant are both important pieces of information, but the former is clearly the more

critical. The presumption that any target in a given area is
a legitimate enemy target satisfies the intent of this step
without visual confirmation of target identity.
Identification by vehicle model is important when target
engagement priorities specify a certain model and variant.
Knowledge of vehicle variants is useful in assessing the
target's capabilities. For example, there are many variants
of the BRDM-2. Some are used in reconnaissance roles, others
as ATGM launchers, and still others as anti-aircraft missile
launchers. The ATGM variant presents a clear and direct
danger to the tank crew, while the other variants are less
dangerous. Identification by model and variant is also useful
to intelligence collection activities at battalion and higher
command echelons.

Classify (Table 4, step 6)

The classification of targets is essential in determining
the sequence in which targets are engaged. The three
classifications are most dangerous, dangerous, and least
dangerous. A target with an armor defeating weapon system
that is engaging, preparing to engage, or oriented toward the
firing tank is classified "most dangerous." A target with an
armor defeating weapon system that is neither engaging,
preparing to engage, nor oriented on the firing tank is
classified as "dangerous." All other targets are classified
as least dangerous. Target engagement priorities (engagement-
specific parameter 9 in Table 3) require the tank crew to
consider specified least dangerous target types as dangerous.[7]

When the target array is being shared among several firing
vehicles, each firing tank concerns itself with the targets in
its sector of responsibility. Targets within the sector are
engaged in order of classification with the most dangerous
target being engaged first.[8]

Decide to Engage (Or Not to Engage) (Table 4, step 7)

The final step in the acquisition process is the decision
whether or not to engage. At this point, the TC considers all
the conditions relevant to the situation and makes his
decision. As previously explained, the decision may be made
once steps 2 and 3 have been satisfied if the tactical
situation and standing orders so warrant. The decision to

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[7]A "least dangerous" target with a target engagement
priority cannot be further promoted in classification to "most
dangerous," because it lacks an armor defeating weapon system.

[8]See also the discussion of range on page 29 and the
section on target sequencing on page 36.

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engage is not always automatic, even if the target is a legitimate, confirmed target. The standing orders or specific tactical situation may still preclude engagement. For example, suppose that a unit is in a defensive position and has not yet been in contact. A single enemy reconnaissance vehicle appears, travelling through the unit's engagement area. All acquisition steps are satisfied, but a standing order precludes engagement for most of the unit. One specific tank is to engage the reconnaissance vehicle from a special, ambush position away from the unit's defensive position, to avoid exposing the unit positions to observation by other enemy forces in the area.

Target Sequencing

The sequencing of targets is based first on target classification, then on range. FM 17-12-1 w/c 2 (1988) states that the crew should engage the nearer target first when two targets of the same classification (representing the same degree of danger to the firing tank) appear at different ranges.

When the firing tank encounters a multiple target situation where two or more targets of the same classification appear at or near the same range, the TC makes his decision based on other factors. For example, suppose two most dangerous targets appear at about the same range. The firing tank's gun tube is oriented to the right of both targets. The quickest and most appropriate way to engage both would be from right to left. In another case, suppose the tank observes three BMP-2 armored personnel carriers and a ZSU-23/4 travelling in a group across its sector of responsibility. No other targets are visible. The BMPs each mount an ATGM, all are oriented away from the firing tank, and all are classified "dangerous." A target engagement priority is designated for the ZSU-23/4, so it is also classified "dangerous." There is a stiff crosswind from right to left. The tank has a SABOT round chambered, which would be most effective against the ZSU-23/4. The TC decides to engage the ZSU first with the SABOT round, then the BMPs from right to left with HEAT. If one of the targets is set afire, the smoke will drift across the line of fire of the other vehicles, spoiling their aim. The firing tank's thermal sights are expected to penetrate the smoke, giving the firing tank the advantage. If necessary, the tank's smoke grenade launchers can also be employed in self-protection, and the TC can conduct a simultaneous engagement with the caliber .50 to suppress the remaining targets until the gunner can engage them with the main gun.

The Engagement Sequence: The Fire Command and
Crew Gunnery Engagement Behavioral Patterns

The Fire Command

The immediate result of target acquisition (assuming a
decision to engage) is the fire command. The fire command is
an order issued cue to the other crew members specifying a
pattern of crew behaviors the tank commander intends for an
engagement or engagement sequence. That is, the tank
commander issues his initial fire command to direct and
coordinate the efforts of the crew. The fire command may
specify single or multiple targets.   In the case of multiple
targets, the fire command specifies whether simultaneous or
sequential engagements will take place.   In the simultaneous
engagement, separate fire commands are issued for each
separate weapon system. If sequential targets are specified,
the TC indicates the sequence in which he wants them engaged.
Some of the elements of the command are optional in certain
situations. The description of elements below paraphrases the
content of FM 17-12-1 w/c 2 (1988) and is included to enhance
the continuity of this report. Exceptions to current doctrine
and to the content of FM 17-12-1 w/c 2 (1988) are suggested in
the sections dealing with the ammunition/weapon element and
the range element of the fire command.

Alert

The alert, the initial element of the fire command, warns
the crew of an impending engagement. The alert normally
specifies the crew member who will conduct the engagement
(variable 1 of the gunnery engagement sequence). The standard
alert for a main gun or coax engagement with a four-man crew
is "GUNNER."[9] For M240 engagements the alert is "LOADER."
For TC engagements with the Caliber .50, the weapon element
doubles as the alert. For the TC's main gun engagements with
a three man crew, the alert is "LOAD."

The alert is an optional element. It may be omitted
without a degradation of crew communication in many
situations. If the tank is operating with a four man crew,
the gunner will normally conduct main gun and coax
engagements. Omission of the alert does not modify this
trend. If it is understood that the gunner will attempt to
identify and engage any main gun or coax targets, that the

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[9]Throughout the remainder of this report, fire commands will
be shown in upper case and quotation marks. Variable elements of
a fire command will be shown in parentheses. If more than one
option is indicated for a particular element, the options are
separated with a slash (/).

loader will load the required round, or engage targets designated for the M240, and that the TC will conduct Cal .50 engagements, the omission of the alert does not degrade intra-crew communication or coordination. The alert is used to get the crew members' attention when necessary or when there is the chance of a misunderstanding.

Ammunition or Weapon

The ammunition or weapon element of the fire command specifies the type main gun round or the particular machine gun to be used in the engagement (see variable 4 of the gunnery engagement sequence). For a battlesight engagement, "BATTLESIGHT" is announced as the weapon or ammunition element of the fire command. This specifies that the predetermined battlesight range/ammunition and the battlesight engagement technique (variable 3, alternative b of the gunnery engagement sequence) are to be used.

The weapon/ammunition element is optional according to current doctrine. Various targets are normally engaged with certain weapon/ammunition combinations (e.g., tanks with SABOT, PCs with HEAT, troops with coax). In circumstances where these combinations are standardized, the target description implies the weapon and ammunition to be used. If there is the chance of a misunderstanding, or if no one round is understood as appropriate for a given type target, the TC should include the weapon/ammunition combination.

Current doctrine specifies that the precision engagement technique will be used when the laser range finder (LRF) is operational. If the LRF is not operational, or if it is ineffective due to the battlefield environment, the battlesight technique affords a quick, reliable means of engaging targets within the effective battlesight range. Normally, the term "BATTLESIGHT" is used to specify that the battlesight technique is to be used. If the LRF is ineffective, and if both the TC and gunner are aware of this fact, then the TC may omit the weapon/ammunition element in the fire command for battlesight engagements as well. The following examples illustrate this point.

The first example is of a battlesight engagement using the gunner's primary sight. Based on the understanding that the gunner is to use the battlesight technique, the TC gives the reduced fire command, "TANK . . . ," as opposed to "GUNNER-BATTLESIGHT-TANK" or "BATTLESIGHT-TANK". The gunner proceeds with a battlesight engagement, making no attempt to range. If the TC is confident that the target is within battlesight range, he gives the execution command. If the TC estimates the target to be outside the battlesight range, the TC may

index the estimated range, and then give the execution command.

The second example is of a battlesight engagement using the gunner's auxiliary sight. The same understanding applies. If the TC gives only the description and execution commands ("TANK . . . FIRE"), the gunner uses the range line in the GAS reticle corresponding to the predesignated battlesight range. If the TC announces a range element as noted on page 41, the gunner uses that range line instead.

In the third case, the TC has previously directed the gunner to use battlesight gunnery until he is told to do otherwise. The LRF is operational, but most of the recent engagements have been within battlesight range, and battlefield smoke has been degrading the effectiveness of the LRF. The gunner is using his primary sight. The TC acquires a tank target beyond battlesight range, and the visibility is relatively clear at the moment. The TC commands "TANK-LASE . . . FIRE." The modified command signals that the gunner is to lase in order to obtain a precision range solution.[10]

Description

The description element specifies the target in brief terms for the individual who is engaging. The target descriptions in Table 5 may be modified to indicate moving targets (e.g., "MOVING TANK") or to indicate multiple targets and specify the engagement sequence (e.g., "THREE TANKS, LEFT TANK FIRST").

Direction

The direction element of the fire command is optional. The normal procedure is for the TC to lay the turret with the commander's power controls (override). This procedure replaces the need to state a direction to the target. If the turret power is inoperative, the TC uses one of three methods of indicating the direction to the target. The three methods of announcing the direction are the traverse method, the reference point and deflection method, and the marking target method. If designating a target for the loader's M240, the TC may use the reference point and deflection method, the marking target method, or some other means. Other techniques include

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[10]In this non-standard fire command, "LASE" actually falls in sequence as the range element. This information is presented here to show how the weapon/ammunition element might still be omitted when switching from battlesight back to precision gunnery. If the standard fire command were used, the TC would command ". . . SABOT-TANK . . . FIRE."

Table 5

Target Descriptions Used in Fire Commands

TYPE TARGET	ANNOUNCED AS
Tank or tank-like target	"TANK"
Unarmored vehicle	"TRUCK"
Armored personnel carrier	"PC"
Helicopter	"CHOPPER"
Fixed-wing aircraft	"PLANE"
Personnel	"TROOPS"
Machine gun	"MACHINE GUN"
Antitank gun, antitank missile, or towed artillery piece	"ANTITANK"
Other targets	Briefest possible terms that clearly describe target.

the clock method, a general direction (e.g., "LEFT-FRONT"), or adjusting on the loader's tracers (the loader begins firing and the TC directs him to adjust left or right).

Traverse method. The TC announces "TRAVERSE (LEFT/RIGHT)." The Gunner traverses in the direction specified. As the gunner traverses the turret near the target in deflection, the TC announces "STEADY . . . ." The Gunner continues to traverse, and attempts to identify the target through the 3X sight. When the TC judges that the main gun is on line with the target, the TC announces "ON." The target should be in the gunner's field of view. If not, the TC may direct the gunner to elevate or depress the main gun to acquire the target, or the TC may look through the GPSE and attempt to acquire the target.

Reference point and deflection. The TC announces "REFERENCE POINT (DESCRIPTION), TRAVERSE (RIGHT/LEFT)." The Gunner traverses to the specified reference point, and then continues to traverse in the direction specified from the reference point. Additional directions, as needed, conform to the traverse method.

Marking target method. The TC announces the alert, ammunition/weapon, and description elements of the fire command, followed by, "WATCH MY TRACERS." The TC then proceeds with a normal caliber .50 engagement. The gunner observes the tracers from the caliber .50 and attempts to identify the target.

Range

The range element of the fire command is optional. Under normal operations, the gunner lases to the target, eliminating the need for the tank commander to announce the range. The range is announced if the gunner is using the auxiliary sight (GAS), or if the LRF is ineffective and the TC wants the gunner to index the range. The TC may also announce a range for loader engagements with the M240. (See behavioral variables 10 and 11 in Table 6.)

Current doctrine does not officially recognize the command "LASE" as a range element. Nevertheless, when used as suggested previously, this command would serve the same purpose as the range element of the fire command.

Execution

The normal execution command is "FIRE." If the TC wants to delay firing, he will announce "AT MY COMMAND," and then "FIRE," when he is ready. If the TC is engaging from his position with the main gun or coax, he will announce, "FROM MY POSITION . . . ON THE WAY."[11] If the TC is going to conduct a simultaneous engagement, he relinquishes control of the main gun/coax engagement (Table 6, variable 7, alternative b) with the command "FIRE AND ADJUST."

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[11]If operating with a three man crew, all engagements are conducted by the TC, therefore the phrase "FROM MY POSITION" is omitted.

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Crew Gunnery Engagement Behaviors

As stated in the introduction, the purposes of this research are to complete the analysis performed by Hoffman and Morrison (1988) and to provide a detailed description of the gunnery domain in terms of all possible engagements. Tank gunnery is extremely complex. The interaction of the crew and the behaviors of the crew members vary in response to the conditions influencing an engagement. FM 17-12-1 w/c 2 (1988) simplifies the description of different engagement patterns by using a matrix of five variables. These variables are combined to yield 64 possible permutations. However, a careful reading of the manual clearly suggests that degraded-mode gunnery and the various tank-target relationships cannot be adequately characterized by these 64 basic combinations of 5 variables. In fact, it was determined during the present analysis of the gunnery process that 15 variables, not 5, modify crew behaviors in the engagement sequence. This section presents the description of those fifteen variables and the crew behaviors associated with each.

The procedure employed to identify the variables was as follows:

(1) The model of tank gunnery contained in FM 17-12-1, Tank Combat Tables M1, w/c 2 (1988), was examined. The model, which describes the domain of tank gunnery in terms of five factors, was judged incomplete, particularly in the treatment of degraded mode gunnery.

(2) A detailed analysis was performed of degraded mode gunnery. The first step in the analysis was to identify each component of the weapon system that could fail to operate properly. Each component failure was then examined in depth to determine how it would affect the behavior of the crew, if at all.

(3) The description of crew duties contained in FM 17-12-1, Tank Combat Tables M1 (1986) was examined to identify the crew member behaviors that are variable (e.g., loading different types of ammunition, using different weapon sights).

(4) The behaviors associated with degraded mode gunnery that do not occur within the context of an engagement (e.g., reprogramming the ballistic computer due to a crosswind sensor failure) were eliminated from the model.

(5)   The variable behaviors identified in Steps 2 and 3
      (less those eliminated in step 4) were clustered.
      Eleven clusters of variable behaviors were
      identified.

(6)   Where the behavior in one of the eleven variables
      limited the possible alternatives within another,
      the behaviors were sequenced to introduce the
      independent variable before the dependent variable.[12]

(7)   After eliminating illogical combinations of these
      variables (e.g., firing main gun ammunition from a
      machine gun), all remaining combinations of the
      eleven variables were identified.

(8)   The clusters and the subsequent combinations of
      variables were subjected to staff review. The list
      was subsequently modified as a result of this
      review. Certain behavioral variables were
      eliminated while others were added. The final list
      contained 15 clusters of variables with each cluster
      corresponding to one of the 15 behavioral variables
      incorporated into the gunnery model described in
      this report.

For this analysis, an engagement is defined as (a) the
actions that the crew or crewmember takes to aim and fire the
main gun one time, or (b) the actions the crew or crew member
takes to aim and fire a single machine gun burst. Although
acquisition of the target is a prerequisite to the engagement,
it can be ignored when considering the specific crew actions
that constitute firing the tank's weapon systems. In fact,
all actions that have been performed prior to target
acquisition become moot at the point of engagement. In
multiple target situations, the determination of who conducts
and who controls each specific engagement divides multiple
target engagements into either sequential or simultaneous
engagements, and each engagement can be examined separately
from the others. The adjustment of fires after the first
round or burst constitutes a new engagement with respect to
the gunnery sequence.

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[12]For example, a battlesight engagement restricts the tank
commander's and gunner's ranging actions. For the TC,
battlesight engagements are not applicable to the Caliber .50
machine gun, therefore limiting the weapon/ammunition
combination as well. In practical application, the employment
of battlesight gunnery also limits the weapon/ammunition
combination to the predesignated round. Engagement technique
is therefore sequenced prior to weapon/ammunition combination
and ranging actions.

By this definition of an engagement, misfire procedures are also removed from the specific engagement sequence. The analysis of behavioral patterns within the engagement sequence revealed that the misfire procedures are actually a series of engagements where alternative actions (behaviors) are performed. The misfire procedure is addressed in detail in the section of this report dealing with post-engagement behaviors.

Fifteen behavioral variables were identified in the analysis. The crew duties associated with the simplest form of main gun engagement are outlined at Appendix A and establish a baseline for subsequent descriptions. The duties associated with each variable and alternative behavior are detailed at Appendix B. A complete enumeration of all single engagements is listed at Appendix C.

The engagements enumerated in Appendix C can be coded numerically using a fifteen-digit code. Each digit of the code corresponds to one of the fifteen behavioral variables in the engagement sequence. More specifically, the value assigned to each digit of the code specifies which alternative applies to a behavioral variable in the engagement sequence. The code number assigned to each alternative associated with the fifteen behavioral variables is shown in Table C-1 of Appendix C. For example, it can be seen by examining Table C-1 that there are three alternatives associated with Behavioral Variable 1, crew member engaging the target: gunner, tank commander, and loader. The numerical values 1, 2, and 3 have been assigned respectively to these alternatives.

All individual engagements within the macro-engagement can be depicted using the fifteen-digit code. To simplify the use of the code, the fifteen digits have been clustered into four groups of digits. The first four digits of the task number indicate the crew member to engage, the target dispersion, the engagement technique, and the weapon/ammunition combination. The second group of digits identifies the target's movement and the firing tank's movement. The third group of digits indicate the crew member controlling the engagement, the sight being used, whether the thermal imaging system (TIS) is being used, and the ranging actions of the TC and gunner. The last four digits indicate the method of traversing and elevating the weapon system, whether standard lead is being applied, whether any other adjustments to the sight picture are being applied, and whether the electrical or manual trigger or firing device is being used.

As an example of how the code can be used to identify an engagement, consider the engagement coded as task number 1122-00-11100-1000. The first group of digits (digits 1 through 4: 1122) indicate a gunner's engagement (1122) of a

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point target (1122) using battlesight technique (1122) and HEAT (1122) ammunition. The second cluster (digits 5 and 6: -00) specifies that neither the target (-00) nor the firing tank (-00) are moving. The third group of digits (digits 7 through 11: -11100) indicate that the TC is controlling the engagement (-11100), the gunner is using the GPS (-11100), the TIS is on (-11100), and that neither the TC nor the gunner perform any ranging action (-11100). The group of digits (digits 12 through 15: -1000) specify that the gunner is traversing and elevating the main gun with the turret power (-1000), no adjustment is made for standard lead (-1000), no other adjustments are made to the sight picture (-1000), and that the gun is being fired with the manual firing device (-1000).

If each of the fifteen variable categories were mutually exclusive from all the others, there would be over two million possible permutations.[13] However, most combinations of variables are either impossible or very improbable. Because of the large number of alternatives, a computer program was sued to eliminate improbable and impossible combinations. The computer output listed the remaining combinations, resulting in 4,618 possible engagements. The computer-generated enumeration is reproduced in Appendix C, Table C-2.

The variables and alternative behaviors are listed in Table 6. A detailed explanation of the variables and alternatives is presented in the text following the table, and diagrams of the decision logic for thirteen of the fifteen variables are also included. Within the flow charts, decision points that reflect prior variables in the engagement pattern are indicated by the corresponding variable number in parentheses (e.g., in Figure 4, one of the decision point is crew member to engage (1). The (1) indicates the first variable in the gunnery pattern). These illustrations are not necessarily indicative of the cognitive processes that actually occur among the tank crew members. In fact, most of the decisions suggested by the flow charts become almost automatic through training and require little, if any, thought. The diagrams do, however, represent all the logical decision points that lead to the selection of a particular engagement pattern.

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[13]To determine the unlimited number of possible variables, multiply the number of alternatives for each variable by all the number of alternatives for every other variable, as follows: 3 X 2 X 2 X 5 X 2 X 2 X 3 X 5 X 2 X 4 X 3 X 2 X 2 X 4 X 2 = 2,764,800.

Table 6

Crew Gunnery Behavioral Variables

Variable	Alternatives	Comments
1. Crew member engaging target	a. Gunner b. TC c. Loader	Specifies which crew member tracks the target, performs the final lay, and fires. Limited by number of crew members in the turret.
2. Engage point or area target	a. Point target b. Area target	Dictates how engaging crew member covers the target area. Ammunition selection for area targets limited to machine guns.[a]
3. Engagement technique	a. Precision b. Battlesight	Precision is the default situation. Battlesight limits the engagement to a preset primary turret wpn/ ammo and range combination. Either the TC or gunner can conduct a battlesight engagement.
4. Weapon/ Ammunition Combination	a. Main Gun/Sabot b. Main Gun/HEAT c. Coax d. Cal .50 e. Loader's M240	Limited by who will engage. Predetermined if Battlesight engagement is specified. Also dictated by variable 2 since SABOT is not effective against area targets, and a HEAT engagement of an area target is actually a sequence of engagements.

[a]See the detailed explanation of area target engagements beginning on page 51.

Table 6 (Continued)

Variable	Alternatives	Comments
5. Fire on the move?	a. No b. Yes	Dictated by the operational status of the turret power and stabilization systems, and the specific tactical situation.
6. Track target?	a. No b. Yes	Dictated by apparent movement of the target with respect to the firing tank.
7. Crewman controlling the engagement	a. TC b. Gunner c. Loader	Dictated by specific tactical situation. Limited by weapon/ammo combination for gunner and loader.
8. Sight selection	a. GPS b. GAS c. GPSE d. CWS e. Iron sights	Limited by crewman who engages and by weapon/ammo combination.
9. Employ TIS?	a. No b. Yes	Only available in conjunction with the GPS and GPSE. May be dictated by intervisibility conditions.
10. TC's ranging actions	a. None b. Lases c. Indexes/applies range d. Announces range.	Dictated by engagement technique; limited by crewman conducting engagement, weapon/ammo and sight.

(table continues)

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Table 6 (Continued)

Variable	Alternatives	Comments
11. Gunner's ranging actions	a. None b. Lases c. Indexes/ applies range	Dictated by engagement technique; limited by crewman conducting engagement, weapon/ ammo, sight, and TC's ranging actions/ decisions.
12. Traverse and elevation method	a. Power b. Manual	Dictated by system status, wpn/ammo, and crewman engaging.
13. Apply standard lead?	a. No b. Yes	Dictated by system status, wpn/ammo, sight, and whether target is being tracked manually or electrically.
14. Sight picture adjustment	a. None b. For cant c. Standard adjustment d. Per subsequent fire command	Dictated by system status, tank's firing position (cant), observations of prior rounds fired, or standard adjustments.
15. Fire with	a. Electrical trigger b. Manual trigger/firing device.	Dictated by system status, wpn/ammo, sight.

Variable 1. Crew Member Engaging Target

The tank commander specifies who is to conduct each engagement when he issues the initial fire command. This may be clearly stated in the alert element of the fire command, or implied by the other elements of the fire command if the alert is omitted. The decision logic for this parameter is illustrated in Figure 3. The tank commander may:
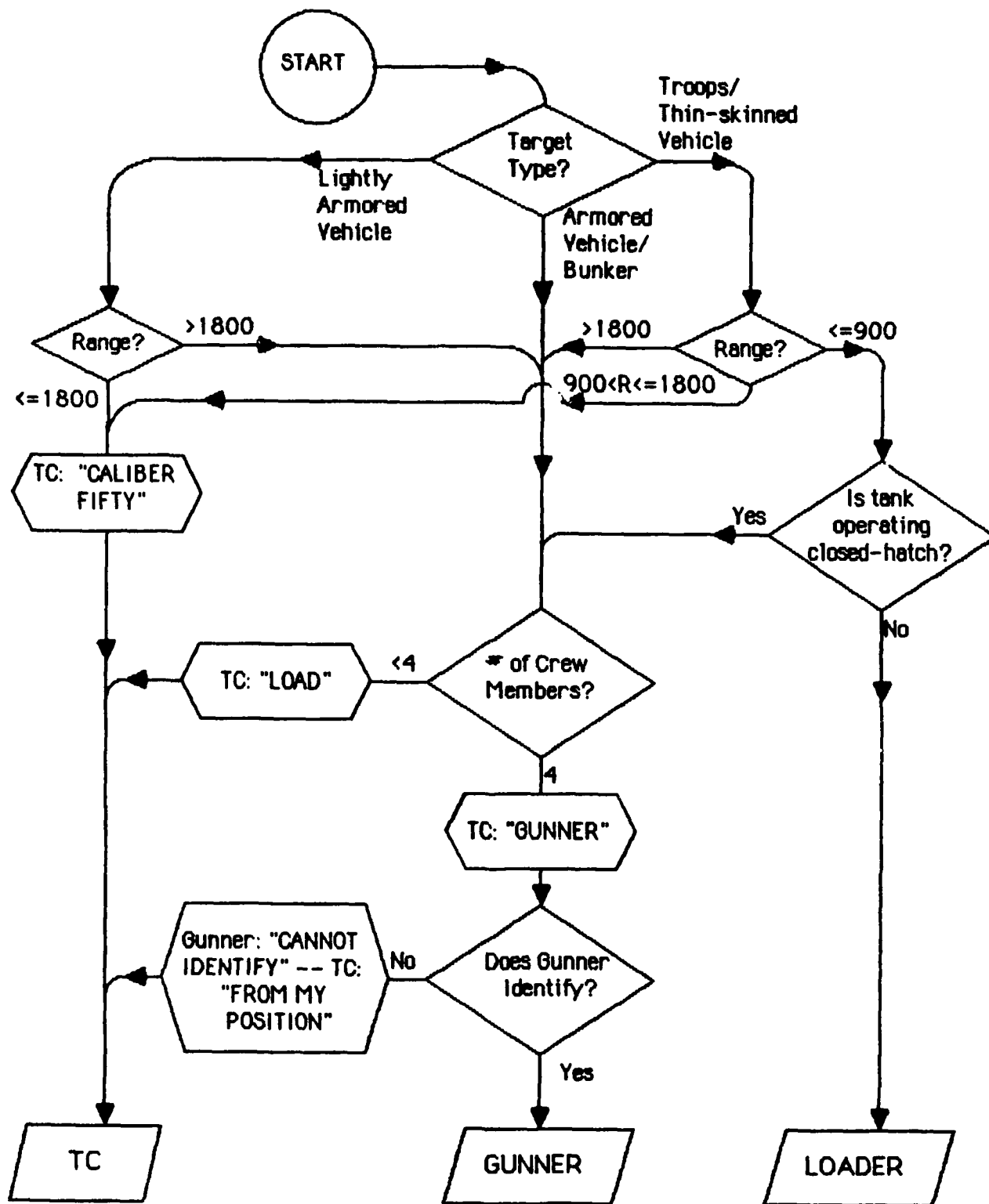
Figure 3. Crew member to engage decision logic.

(a) direct the gunner to engage,
(b) conduct the engagement himself (tank commander),
    - or -
(c) direct the loader to engage.

Gunner. For normal main gun and coaxial machine gun engagements, the gunner conducts the engagement. The alert associated with a gunner's engagement is "GUNNER . . ."

Tank commander. The TC will fire the main gun or coax from his position if the tank is operating with a three-man crew or if the gunner cannot identify the target (the TC announces, "FROM MY POSITION . . ."). If fighting with a three-man crew, the TC will direct the loader to load a particular round (alert: "LOAD . . ."). The TC will then engage the target from his position. The cal .50 machine gun is also fired from the TC's station.

Loader. The loader will conduct engagements with the M240 machine gun at his position. The alert for a loader's engagement is "LOADER . . ."

Variable 2. Engage a Point or Area Target

Target dispersion is a target condition that necessitates an appropriate behavioral response. The two behavioral alternatives are:

(a) engage a point target
    - or -
(b) engage an area target.

The behavioral difference between the engagement of point and area targets is that area targets require the manipulation of the weapon system in azimuth and elevation in order to achieve target coverage.

Point targets. A point target is a single target mass that can be effectively engaged with a single main gun round, e.g. tanks, armored personnel carriers, bunkers, and anti-tank guns. Heavily armored point targets are usually engaged with the main gun. Lightly armored and thin-skinned point targets (e.g., trucks) can be engaged with machine guns if their armor can be pierced by the smaller caliber ammunition. In some cases, machine guns may be used against heavily armored targets to suppress the target's crew until the main gun can be fired. The normal aiming point for a point target engagement is the center of the visible target mass, except as modified by conditions addressed under variables 13 and 14.

<u>Area targets</u>. An area target is one in which a number of individual targets are dispersed in range and/or deflection, e.g. dismounted troops. Machine guns are generally better suited than the main gun to engage area targets. In a machine gun area target engagement, the aiming point must be moved from one edge of the target to the other. This is done as the machine gun burst is being fired. It is this action of moving the weapon around the target while the trigger is depressed that differentiates an area target engagement from a point target engagement.

The blast produced when a HEAT round detonates on impact is effective against area targets. However, the coverage is limited in comparison to that provided by a machine gun. HEAT ammunition is used against area targets primarily when these targets are beyond effective machine gun range. On the other hand, HEAT ammunition is more critical than machine gun ammunition and ordinarily should be conserved for use against armored vehicles. Only in a predominantly infantry environment would the crew be likely to use main gun ammunition against a dismounted threat.

There are no behavioral differences between the use of HEAT against area targets and its use against point targets. In either case, the target is treated as a single mass when the first round is fired. The aiming point for subsequent rounds (if fired) are adjusted according to Variable 14, whether the target is a. area a point target. Since the engagement of an area target with HEAT ammunition is behaviorally indistinct from the engagement of a point target, all main gun engagements are coded as point target engagements.

Variable 3.   Engagement Technique

Engagement technique is applicable only to main gun and coax engagements. The TC designates (or implies) the technique to be used in his initial fire command to the gunner. The choices are:

(a) precision gunnery technique
     - or -
(b) battlesight gunnery technique.

The technique is specified in the ammunition or weapon element of the fire command. If the TC announces, "BATTLESIGHT," a battlesight engagement will be conducted. If he announces a weapon (e.g., "COAX") or a type main gun round (e.g., "SABOT"), a precision engagement will be conducted. The decision logic is illustrated in Figure 4.
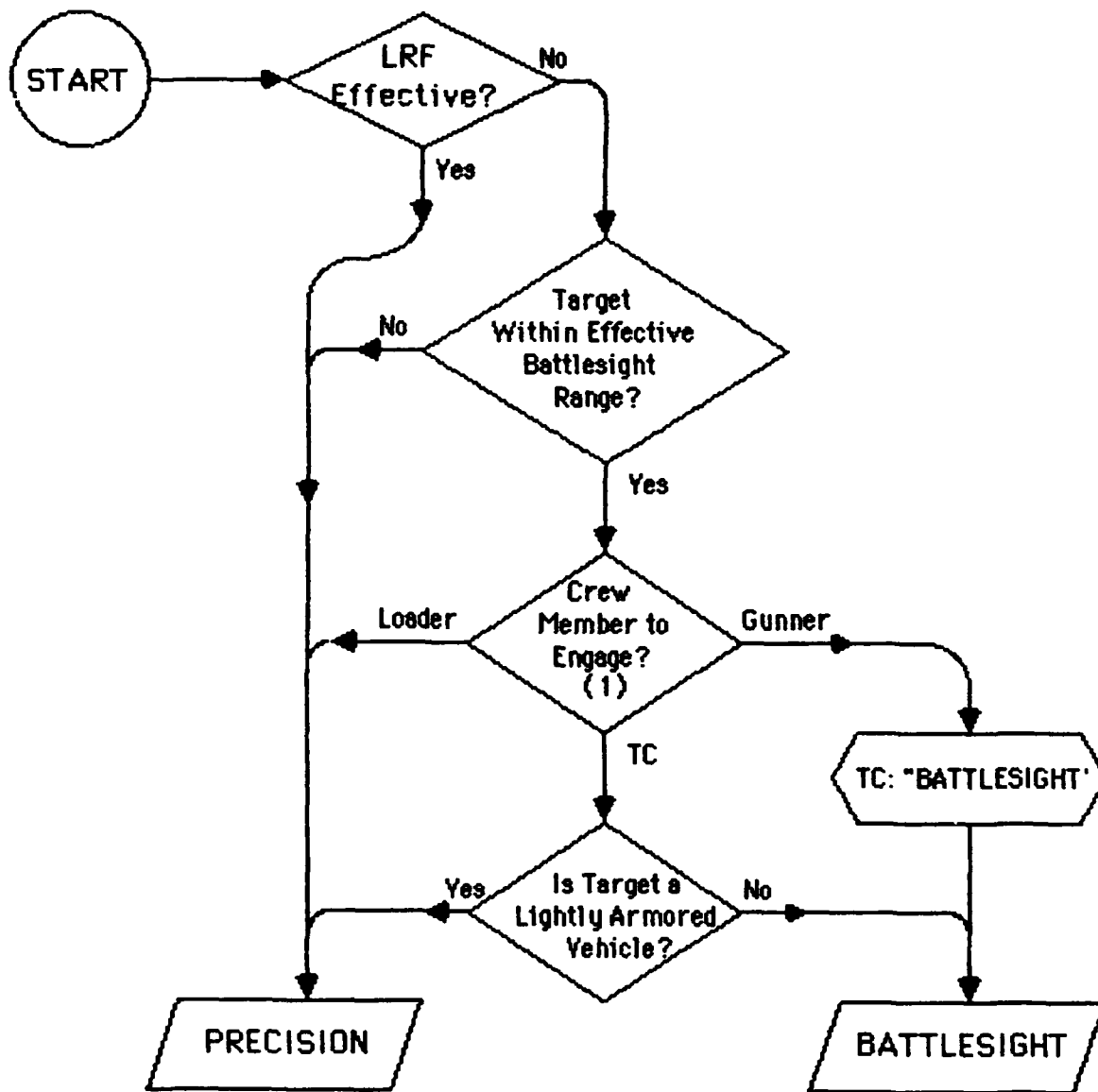
Figure 4. Engagement technique decision logic.

Precision gunnery. Under most conditions, precision gunnery is the preferred technique for engagements from a fully operational M1/M1A1 tank. Precision gunnery takes full advantage of the Abrams fire control system and affords the highest probability for a hit and kill. A precision engagement involves a measured or estimated tank to target distance that is entered into the fire control system (also referred to as a range solution) for each engagement. The preferred means of determining the range on an Abrams tank is by using the laser range finder (LRF). When the LRF and ballistic computer are functioning properly, the range data is automatically fed to the computer, and the computer automatically establishes an angle between the gunner's primary sight (GPS) reticle and the axis of the main gun (superelevation) to account for the round's trajectory. An estimated tank to target range may also be manually indexed into the computer, or the gunner's auxiliary sight (GAS) may be used (see variables 10 and 11).

Battlesight gunnery. Battlesight gunnery is an accelerated technique which affords high hit and kill probabilities against targets at or near the predetermined battlesight range. It is used when the laser range finder is either inoperable or ineffective due to battlefield conditions. A crew can fire in less time using battlesight than degraded-mode precision gunnery. The battlecarry configuration (i.e., range and ammunition) is determined by pre-existing conditions. The predominant intervisibility range and the most likely or most dangerous type target are considered when choosing the ammunition and range. For example, the most common battlesight ammunition and range setting is SABOT at 1200 meters. A typical Warsaw Pact main battle tank is about 2.3 meters high (FM 100-2-3, 1984). If the OPFOR tank exposes only 1.5 meters of its total height to engage, the battlesight solution will be effective to 1600 meters. Assuming that the gunner aims at the center of visible target mass, the trajectory of the round itself will reach its maximum height above the gunner's line of sight at about 605 meters. The vertical distance above the line of sight at that point is .8 meters. If the target were at that range, the round would strike the target at or near the top of its turret. From that point to the designated battlesight range of 1200 meters, the round will fall back to the gunner's line of sight. If the target is at 1200 meters, the round will strike at or near the point of aim. Beyond 1200 meters, the round continues to fall below the gunner's line of sight, but still has a good chance of hitting the target out to 1600 meters.

The selected type round is chambered in the main gun, and the range and ammunition are indexed into the computer prior to enemy contact. Switches are preset to reduce the

engagement time. If engaging with the primary sight, the gunner makes no attempt to lase or perform any ranging functions. If firing from the auxiliary sight, the gunner uses the range line corresponding to the predesignated battlesight range. A battlesight range (500 meters, unless changed by the unit SOP) is also preset for the coax.

Variable 4. Select Weapon/Ammunition Combination

The weapon and/or ammunition to be used for an engagement is announced in the TC's initial fire command. The alternatives are:

(a) Main gun: Sabot (APFSDS-T),
(b) Main gun: HEAT (HEAT-T),
(c) Coaxial machine gun,
(d) Caliber .50 machine gun,
    - or -
(e) Loader's M240 machine gun.

For precision main gun engagements, the TC announces only the type ammo. For battlesight engagements, he announces "BATTLESIGHT," and the ammunition is understood to mean the battlesight round (or weapon).[14] For machine gun engagements, he specifies the weapon. Changes between rounds in a battlesight engagement (e.g., from SABOT to HEAT) are signaled by the command "FIRE (HEAT)" immediately after the execution command for the first round. The round in the tube is fired first; then the new type round is loaded, and the gunner changes his ammunition setting.

The two primary types of main gun ammunition are Armor Piercing, Fin Stabilized, Discarding Sabot (APFSDS-T, or SABOT), and High Explosive, Anti-Tank (HEAT-T, or HEAT). Under certain conditions, tank main gun fire can be effective out to and beyond 3000 meters. For planning purposes, 2500 meters is regarded as the maximum effective range for the main gun.

The weapon/ammunition decision logic is illustrated in Figure 5.

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[14]If the battlecarry configuration for the tank specifies coax, then the gun select switch is preset to coax. In that case, the command "BATTLESIGHT" would only be used in a coax engagement.
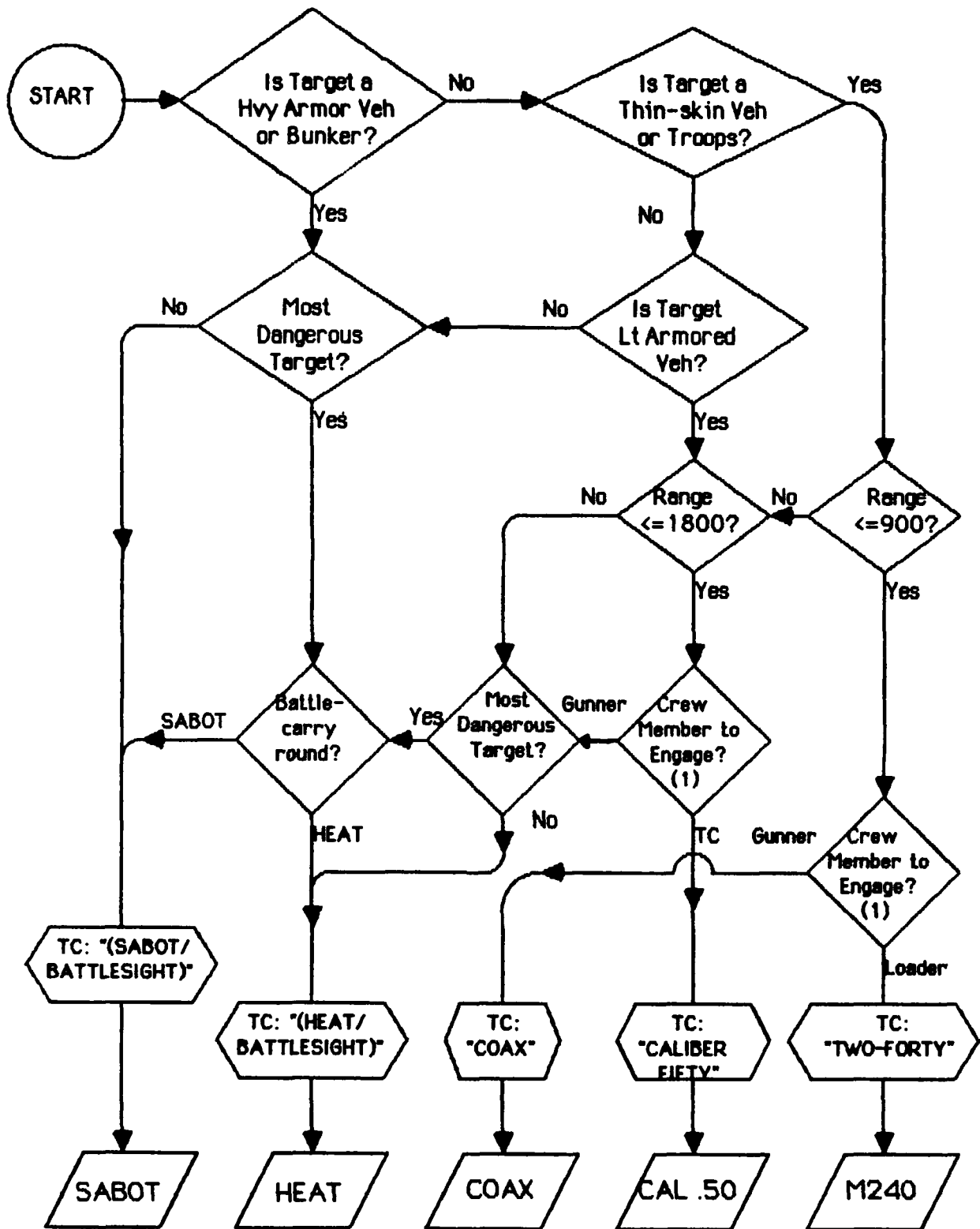
Figure 5. Weapon/ammunition decision logic.

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Main gun: Sabot (APFSDS-T). Sabot is a kinetic energy round that is normally used against heavily armored targets (e.g., tanks). It features a higher muzzle velocity, a flatter trajectory, and is generally regarded as more accurate than HEAT. Because it relies on kinetic energy to defeat enemy armor, its penetrative capability decreases as its velocity falls off. Since the velocity of the SABOT round is reduced by friction as it travels through the air, it is less effective in terms of penetration at longer ranges.

Main gun: HEAT (HEAT-T). HEAT (High Explosive, Anti-Tank) is a chemical energy round, employing a shaped charge to achieve penetration. It is normally used against less heavily armored targets (e.g., armored personnel and weapon carriers). The blast and shrapnel produced by an exploding HEAT round may also be effective in suppressing enemy troops at extended ranges. Unlike SABOT, HEAT is as effective at long range as it is at short range in defeating a given amount of armor protection since the chemical energy is not effected by muzzle or terminal velocity. Only the degree of accuracy is dependent upon the trajectory of the round.

The tank has three machine guns: the coax, the caliber .50, and the loader's M240.

Coaxial machine gun. The coaxial machine gun (abbreviated coax) is mounted coaxially with the main gun, and the line of fire is nearly parallel to that of the main gun. It is an M240 machine gun and fires the 7.62 mm NATO round. The gunner uses the same sights and controls to aim and fire the coax as he does for the main gun. The effective range of the coax is 900 meters. It is useful against troops and thin-skinned vehicles.

Caliber .50 machine gun. The Cal. .50 is mounted atop the tank at the TC's station and is normally aimed using the Commander's Weapon Station Sight (CWS). It can be fired either from the open or closed hatch. It is effective to a range of 1800 meters against lightly armored and thin skinned targets. It is also an extremely effective weapon for suppressive fires.

Loader's M240 machine gun. The loader's M240 is mounted atop the tank at the loader's weapon station. Its characteristics are similar to those of the coax except that it can only be fired open-hatch with its own integral (iron) sights. If the coax becomes inoperative, the loader's M240 can be moved to the coax position. Similarly, the M240 can be mounted in the commander's weapon station in place of the Cal. .50. Since the loader cannot load the main gun when firing the M240, simultaneous main gun/loader's machine gun engagements are improbable.

Variable 5. Fire On the Move/From the Halt

The stabilization system for the Abrams tank makes it possible for the crew to effectively engage targets while the tank is moving. Crew behaviors differ based on whether the tank is stationary or moving. Certain equipment malfunctions limit the crew's choices regarding movement while firing, as illustrated in Figure 6. The alternative behaviors are:

(a) Fire on the move
    - or -
(b) Fire from the halt.
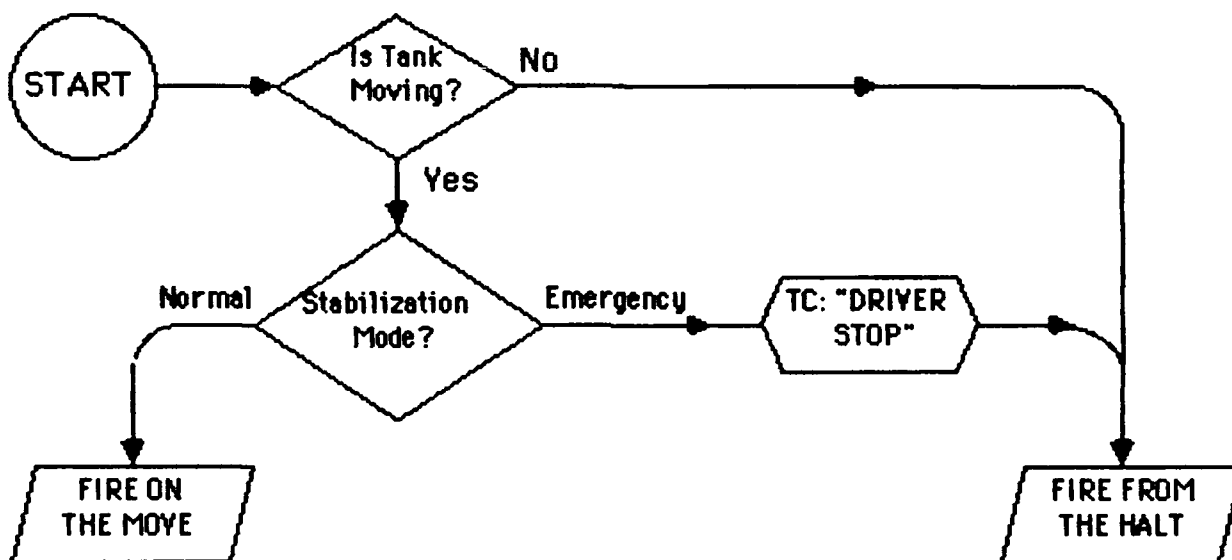
Figure 6. Fire on the move/fire from the halt decision logic.

Fire on the move. The stabilization system for the Abrams tank allows the gunner to track and engage ta　　ets effectively with the main gun and coax while the tank is r　　ving by counteracting the pitch and yaw of the tank's ull. A moving tank that is fully functional will normally continue to move during an engagement. When an engagement is in progress, the driver must avoid erratic changes in direction or speed.

When firing on the move, the loader operates the elevation uncouple (EL UNCPL) switch to steady the main gun while loading. The EL UNCPL switch disconnects the main gun from the sights when the spent case ejection guard is placed in the SAFE position. This allows the gunner to continue tracking the target while the gun remains still for loading. Once the switch is returned to its normal setting or the spent case ejection guard is placed in the ARMED position, the gun drive is again coupled to the sights.

Fire from the halt. If the stabilization system fails, a moving tank will normally fire the main gun from the short halt. The fire control mode switch is placed in the emergency position. This slaves the sights to the gun tube, defeating the elevation uncouple mode and the lead angle sensor function.[15] Machine guns may be fired without stabilization from a moving platform, but a degradation in effectiveness is recognized and accepted.[16] The stabilization system may fail independent of other systems, or it may be disabled due to a general turret electrical power failure. Stabilization only effects the main gun and coaxial machine gun.

A tank in a defensive position will usually fire from the halt. If the tank is in a turret down position, it will move to a hull down position before firing a main gun or coax engagement. In a turret down position, the caliber .50 and M240 machine guns (atop the turret) protrude above the terrain mask and can be fired without moving the tank.

Variable 6. Track Target?

Target movement can be a relatively complex parameter considering the direction of movement, bearing, and speed of the target relative to the firing tank. Target movement is primarily two dimensional, but can be three dimensional in hilly terrain or when the target is an aircraft. The relationship between a moving target and the firing tank will change in azimuth (left or right), in range (closer or further

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[15]Note that when using emergency mode gunnery against a moving target, lead must be applied manually. The aspects of moving target gunnery and manual lead are addressed in the sections on variables 6 and 13.

[16]Machine guns are area fire weapons. The dispersion between rounds in a well-aimed burst falls into an area referred to as "the beaten zone." Firing a machine gun from a moving tank (not stabilized) will enlarge the beaten zone, and reduce the density of rounds within the zone. If the target can be suppressed despite the reduction in effectiveness, there is no need to stop the tank.

away), and/or in elevation (up or down) in hilly terrain or in
the case of aircraft. Furthermore, these changes may result
from the movement of either the target or the firing tank, or
of both in combination. The tank's sights are two
dimensional, with the vertical axis of the sight accounting
for both the vertical aspect of a target and for range. If
the ground is level between the firing tank and the target,
there is no vertical movement, only lateral movement and/or a
change in range. Reduced to the two axes of movement, two
conditions are relevant to either firing tank or target:
moving laterally, or moving toward or away from each other.
In this comparison, the null condition, a stationary firing
tank or target, is also part of the universe and must be
considered. Table 7 compares the combination of target and
firing tank movement in the three, pure conditions related to
movement, given flat terrain.

Table 7

Tank and Target Movement Matrix

FIRING TANK MOVEMENT CONDITIONS	TARGET MOVEMENT CONDITIONS		
	Stationary	Toward/ Away from Firing Tank	Moving Laterally
Stationary	No tracking.	No tracking, change in range only.	Track lateral movement only.
Moving toward or away from target	No tracking, change in range only.	No tracking, change in range only.	Track lateral movement, change in range.
Moving laterally	Track lateral movement, no range change.	Track lateral movement, change in range.	Track lateral movement only. If firing tank and target moving in same direction at same speed: no tracking.

Considering any factor of the relative movement between tank and target, that factor only becomes critical when the movement is sufficient to cause a miss. When a round is fired, it will leave the gun tube on the axis of the gun tube, and then change direction based on environmental factors. These factors, taken together, are known as ballistics. The ballistic properties of main gun rounds are reduced to tabular form in the firing tables for the M1 (FT 105-A-3, 1979). The most critical ballistic variable for a moving target is the time of flight of the round to the target. If the round is fired at a given point in space, and the target is not there when the round arrives (x seconds later), the round will miss the target. Time of flight is one of the variables provided in the firing table.

For a relative movement situation where only range is changing, the relative movement of target, firing tank and round fired are reduced to the vertical axis. The angle of fall for a particular type round at a given range is also provided in the firing tables. This variable is expressed in the distance that the round falls (in meters) for a 100 meter change in range. Comparing this parameter to the height of a target (extracted from The Soviet Army: Troops, Organization and Equipment, FM 100-2-3, 1984), the time of flight of the round to the target, and the distance the target travels in that time yields the data in Table 8.

Explanation of Table 8. Each of the four engagements under investigation is represented in columns A-D. The data regarding target and ammunition type, target height, and target speed are shown for each column. For each tank-target range, three items are reported:

(a) The first item reported is the vertical deviation of the round (in meters) from the point of aim that occurs as a result of the target's movement between the time the round is fired and the time it reaches the target.

(b) The second item reported is whether the round would hit (H) or miss (M) the target if no other factors intervened.

(c) The third item reported is the vertical distance the target would have to move in hilly terrain to avoid being hit if item two reports a hit, or the vertical error if item two reports a miss. The figure applies equally to engagements involving decreasing or increasing ranges. A positive number (+x) shows that the target must move the indicated distance to avoid a hit. A negative number (-x) shows the vertical

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Table 8

Effect of Firing Tank and Target Movement Involving a Change in Range Only

TARGET TYPE:	T-80	BMP	T-80	BMP
TGT HEIGHT (meters):	2.3	1.7	2.3	1.7
AMMUNITION:	APFSDS-T M774	HEAT-T M456A2	APFSDS-T M774	HEAT-T M456A2
SPEED:	30 KMPH	30 KMPH	60 KMPH	60 KMPH
RANGE (meters) ENG:	A	B	C	D
500	>0.01=H +1.15	>0.01=H +0.84	>0.01=H +1.14	0.02=H +0.83
1000	0.01=H +1.14	0.04=H +0.81	0.02=H +1.13	0.08=H +0.77
1500	0.03=H +1.12	0.13=H +0.72	0.07=H +1.08	0.26=H +0.58
2000	0.06=H +1.09	0.32=H +0.53	0.12=H +1.03	0.65=H +0.20
2500	0.09=H +1.06	0.72=H +0.13	0.18=H +0.18	1.44=M -0.59
3000	0.14=H +1.01	1.53=M -0.68	0.28=H +0.87	3.09=M -2.24
3500	0.19=H +0.96	3.24=M -2.39	0.38=H +0.77	6.52=M -5.67
4000	0.26=H +0.89	6.87=M -6.02	0.53=H +0.62	13.8=M 13.0

distance by which a target is missed. The signs do not necessarily correspond to upward or downward motion.

As can be seen from the table, the predominant target types will probably be hit within the effective range of the tank's main gun (2500 meters) when the range is decreasing or increasing at a rate of up to 60 KMPH.[17] Given the fact that there are other possible sources of error that are also a function of range,[18] the significance of changing tank-target ranges during an engagement is very small. At extended ranges where the probability of a miss due to the target's relative movement becomes high, the probability that other types of errors will intervene is also high.

The question of the target's lateral movement is much more significant. For example, a BMP moving laterally at a rate of 30 KMPH will travel 8.3 meters in one second. The time of flight for a HEAT round (HEAT-T, M456A2) at a range of 1000 meters (FT 105-A-3, 1979) is one second. The length of a BMP is 5.4 meters (FM 100-2-3, 1984). If the aiming point is exactly center of mass and if no adjustment is made for the target's lateral movement (i.e., lead), a round fired will intersect the target's path 5.6 meters behind the target.[19]

The question of oblique movement is a combination of lateral movement and a change in range. The lateral movement in this situation is the more critical element. When the relative movement of the target is reduced to the two axes, the data in Table 8 clearly suggests that the changing range is not significant, while the information just presented reinforces the importance of an adjustment for lateral movement. In recognition of these factors, the concept of apparent movement is used in tank gunnery. Apparent movement is only concerned with the lateral movement of the target. For this reason, the requirement to track a target and to adjust for target movement is reduced to the following alternatives:

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[17]30 KMPH is considered a realistic battlefield speed according to current Army doctrine. 60 KMPH is included in this comparison to show the effect of target and firing tank closing at 30 KMPH each.

[18]See the discussion of range as an engagement-specific condition on page 41 of this report,

[19]The center of the target moves 8.3 meters while the round travels 1000 meters. 2.7 meters of the target's linear dimension is between the target's new center of mass and the point of aim. 8.3 m - 2.7 m = 5.6 m.

(a) engage a target with no apparent movement (no tracking)
    - or -
(b) track and engage a target with apparent movement.

Engage a target with no apparent movement (no tracking). If the target has no apparent movement, it is treated as a stationary target for gunnery purposes. Table 7 showed five conditions that result in a no tracking situation:

(a) Both firing tank and target are stationary.

(b) The firing tank is stationary and the target tank is moving directly toward or away from the firing tank.

(c) The target is stationary and the firing tank is moving directly toward or away from the target.

(d) The firing tank and target are moving directly toward or away from each other.

(e) Both tanks are moving on parallel or oblique paths at the same relative speed.

Track and engage a target with apparent movement. A target with apparent movement is one that must be tracked in azimuth during the engagement. Under normal conditions, the automatic lead function in the M1's fire control system induces the correct amount of lead in the Gunner's Primary Sight. The only difference between a moving (apparent movement) and a stationary (no apparent movement) target engagement is that the gunner must track the target correctly in the moving target engagement. He assumes the exact same sight picture in both cases, and his ranging actions are exactly the same.

If the firing tank has a stabilization system or Lead Angle Sensor (LAS) failure, or is in emergency mode, and if the crew is engaging a target with apparent movement, the gunner or tank commander must apply lead manually as explained under Variable 13. The stabilization failure affects the lead angle function even if the firing tank is stationary, since the LAS is actually a subsystem of the stabilization system.

Variable 7. Crew Member Controlling the Engagement

The tank commander normally supervises the conduct of all engagements. However, if he is conducting an engagement with the caliber .50 machine gun, he may direct another crew member to conduct and control a simultaneous engagement, as illustrated in Figure 7. The alternatives are:

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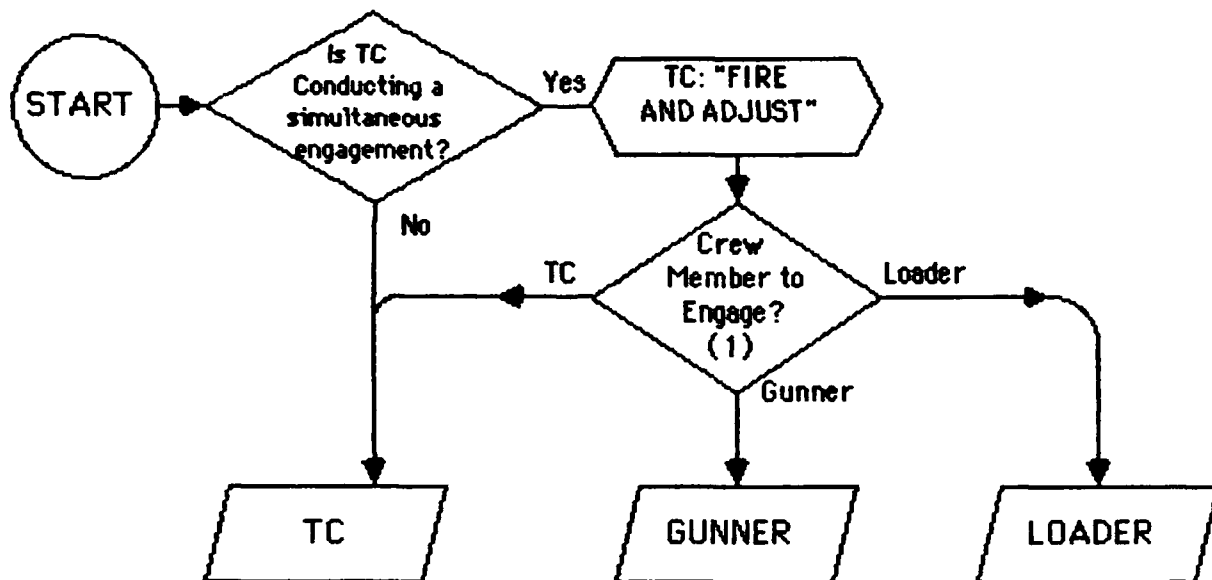
Figure 7. Crew member controlling the engagement decision
           logic.

(a) tank commander,
(b) gunner,
     - or -
(c) loader.

Tank commander. The TC controls all engagements unless he
is conducting a simultaneous engagement or is preoccupied for
some other reason (e.g., if the TC is also the tank platoon
leader, he may be controlling and distributing the platoon's
fires). The TC controls all caliber .50 engagements and all
main gun/coax engagements fired from his position.

Gunner. If the gunner is engaging a target with the main
gun or coax, and if the TC announces "FIRE AND ADJUST," the
gunner assumes control of the main gun/coax engagement. The
gunner reports his progress in the engagement over the
intercom. This cues the loader and keeps the TC aware of how
the main gun or coax engagement is proceeding. The loader
continues to load the round specified by the TC until he hears
"CEASE FIRE" or until the gunner commands him to load a
different round (e.g., "LOAD HEAT"). The gunner does not wait

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for execution commands ("FIRE") for each main gun round when he is controlling the engagement.

If the gunner destroys all targets specified in the original fire command, and if no other targets are visible in the tank's sector, he announces, "TARGET, GUNNER COMPLETE." If he was firing a machine gun engagement against a troop concentration, he may omit the word "TARGET."

Loader. The TC may direct the loader to control an engagement on the M240 in similar fashion.

Variable 8. Select Weapon Sight

The sight selection is dictated by the weapon and ammunition to be used and by the status of the tank's subsystems. The decision logic is illustrated in Figure 8. The five sights available are:

(a) the Gunner's Primary Sight (GPS),
(b) the Gunner's Auxiliary Sight (GAS),
(c) the Gunner's Primary Sight Extension (GPSE),
(d) the Commander's Weapon Station Sight (CWS),
      - or -
(e) iron sights.

The Gunner's Primary Sight (GPS). The GPS is the primary sight for most main gun and coax engagements. Given a fully functional fire control system, all computer solutions are automatically applied to the GPS reticle to assure high hit and kill probabilities.

The GPS has two magnification settings. The three-power (3X) setting, which is used for target acquisition and initial identification, features a wider field of view than the higher power setting. The ten-power (10X) setting is used for target engagement. The gunner's sight reticle (cross-hairs) are superimposed on the 10X sight. The GPS reticle is non-ballistic. That is, there are no graduated range lines in the reticle. The proper amount of superelevation appropriate to the tank-to-target range is automatically computed and applied by the ballistic computer.

The Gunner's Auxiliary Sight (GAS). The GAS is the preferred direct fire sight in various degraded gunnery modes (when system malfunctions reduce the effectiveness of the ballistic computer and GPS in combination). The GAS has a ballistic reticle. It is graduated with range lines and indexed at 400 meter intervals, thereby facilitating target engagement when the ballistic computer is not functional. The
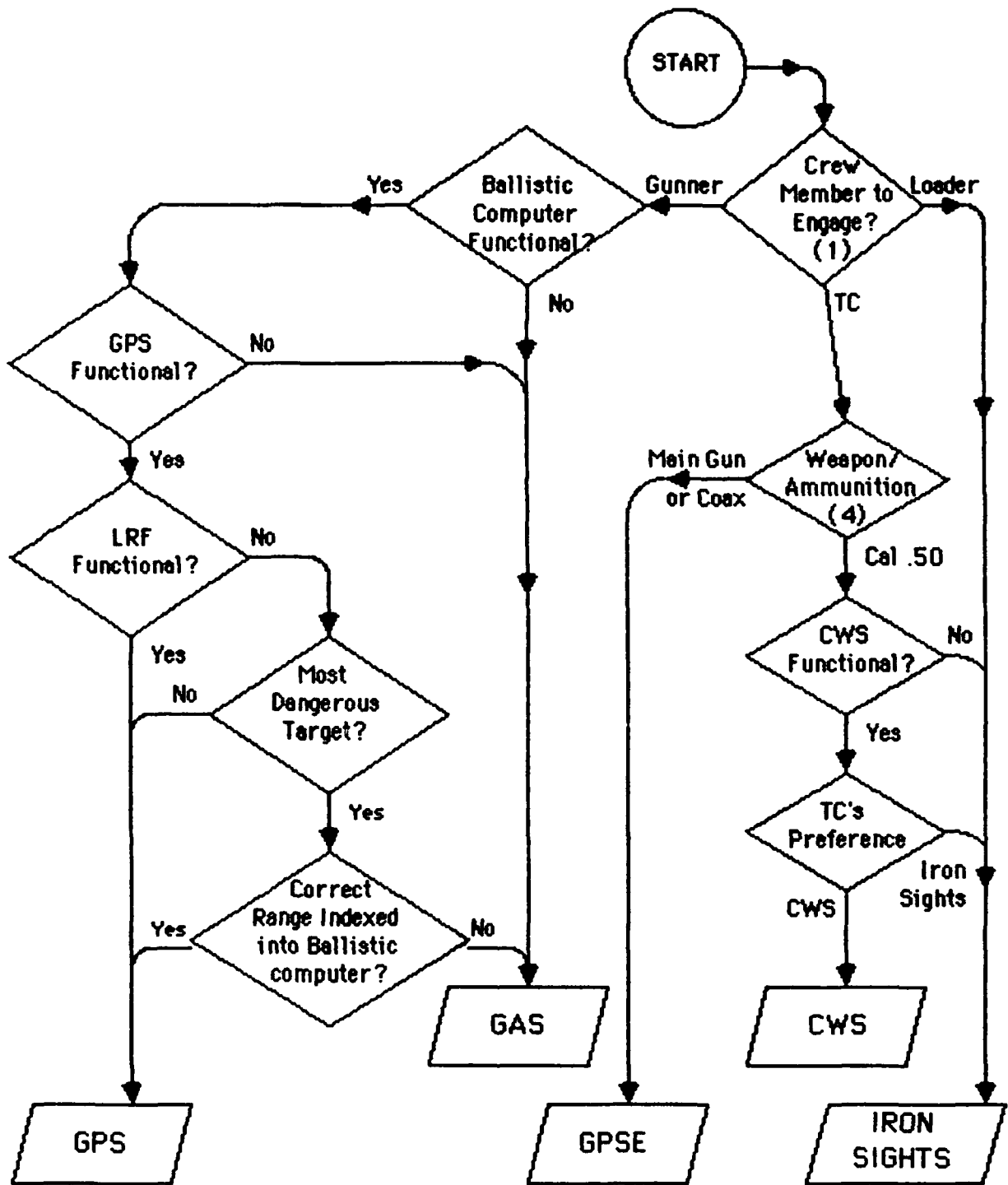
Figure 8. Select weapon sight decision logic.

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gunner must know the range to the target when using the GAS in order to select the proper range line. (Note: see variables 10 and 11, below.) The GAS has separate reticles for SABOT and HEAT. The gunner must select the proper reticle for the specified ammunition. Since the GAS reticle does not interface with the ballistic computer, corrections for lead or cant must be introduced manually. (Note: see variables 13 and 14, below.)

The GAS is also used to verify terrain mask clearance when the tank enters a hull defilade position. The Gunner's Auxiliary Sight is a telescope that projects through the turret alongside the main gun, while the Gunner's Primary Sight is a periscope that extends through the top of the turret. This means that the line of sight from the GPS may afford a clear view of a target to the front when the muzzle of the gun tube is pointing into the ground (the terrain mask). A clear field of view through the GAS verifies that the main gun is clear of the terrain mask.

The Gunner's Primary Sight Extension (GPSE). The GPSE reproduces the gunner's GPS sight picture and reticle at the tank commander's position. It is the sight the TC uses when firing the main gun and coax. Since the controls used to select the viewing magnification are at the gunner's station, the TC would have to reach the gunner's control panel to change the magnification when fighting with a three man crew. Due to the difficulty of reaching the gunner's control panel from the TC's position, the TC would probably leave the magnification at 10X indefinitely.

The Commander's Weapon Station Sight (CWS). The CWS is a ballistic sight that is used with the cal .50. Range must be applied manually in all engagements, and lead must be applied manually when tracking moving targets.

Iron sights. The loader's M240 has only the iron sights integral to the weapon itself. The rear sight is a leaf sight, graduated with range lines. The loader estimates the range to the target (or uses the range provided by the TC) and aligns the rear leaf sight and front blade sight. If necessary, he makes a lead adjustment and commences firing. He observes where the tracers impact with respect to the target, and then adjusts his aim accordingly.

Under certain conditions, the tank commander may elect to fire the cal .50 "from the hip" (i.e., open hatch), sighting along the top of the weapon. He may also fire from the closed hatch by using the iron sights along the bottom of the weapon and sighting through the unity periscope in the cupola in lieu of the CWS. Either of these is a means of aiming the cal .50

with iron sights. The CWS is the preferred sight for the caliber .50 because it allows a more precise initial lay.

Variable 9. Employ Thermal Imaging System/Daylight Channel

The GPS and GPSE have two channels of operation. The choice is made with a switch on the gunner's control panel. The alternatives are:

(a) employ daylight channel
- or -
(b) employ Thermal Imaging System (TIS).

The other sights only have a daylight capability. The decision logic is illustrated in Figure 9.

Employ daylight channel. The daylight channel of the GPS or GPSE is used when necessary to confirm target identity, or when the TIS is inoperable. It is only effective when visibility is clear and light conditions allow target acquisition without image intensification. For the GAS, the CWS, and iron sights, only the daylight channel is available.

Employ Thermal Imaging System (TIS). The thermal sight is the preferred channel for acquisition and engagements in all conditions. It is required for engagements under reduced visibility conditions from an M1 series tank. The image is projected through the GPS and GPSE, replacing the daylight channel.

The thermal sight can be used to detect targets night or day and through various environmental conditions which obscure unaided vision and other types of night observation devices. A failure of the GPS daylight channel will not normally affect the thermal channel. In those conditions where the daylight channel might be preferred, the thermal channel is a viable alternative. Note, however, that current doctrine specifies that the thermal channel is the preferred mode of operation for target acquisition and engagement.

The TIS has two polarity settings, a sensitivity and a contrast control. The polarity switch allows the gunner to reverse the image and background fields of the TIS. The two polarity settings (white hot and black hot) are analogous to the positive and negative images produced when conventional photographic film is processed. The sensitivity and contrast knobs are used to vary the absolute and relative brilliance of the image.

Target identification with the thermal image is generally more difficult than with the daylight channel. This is due to the loss of resolution within the target silhouette. "Hot
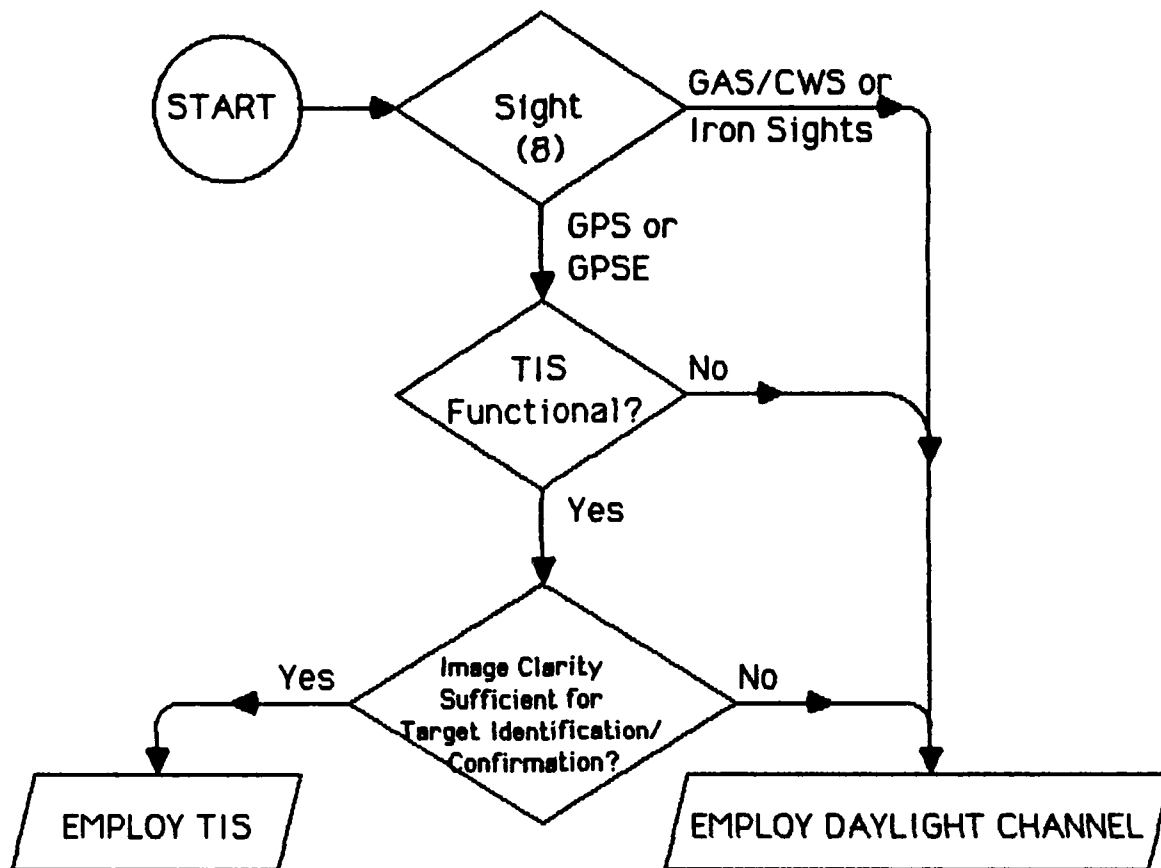
Figure 9.   Employ thermal imaging system/daylight channel
            decision logic.

spots," which are identified by varying shades of light on the
thermal image, do not follow the same patterns as recognition
factors visible in daylight.   The gunner will normally
experiment with the polarity, sensitivity and contrast
controls to achieve the best possible image.

    Operating the TIS is accomplished with the THERMAL MODE
switch on the gunner's control panel.   Since the TC cannot
change the settings easily when fighting with a three man
crew, he would leave the switch and other TIS controls in one
position indefinitely.   The THERMAL MODE switch has three
position selections--On, Off and Standby.   In the "off"
position, no power is supplied to the TIS, and it is not
operational.   When switched from "off" to "stand-by," the

system begins to "cool down."[20] Once it is cooled down, "stand-by" continues to power the system, but the thermal image is not projected to the sight. In the "on" position, the thermal image is projected to both the GPS and the GPSE. Switching between "on" and "stand-by" allows the gunner to select between thermal and daylight channels at will.

Variable 10. TC's Ranging Actions

The ranging actions performed by the TC for main gun and coax engagements interact with those performed by the gunner. Certain actions by the TC preclude or dictate certain actions by the gunner, and vice versa. Cal .50 engagements and TC main gun and coax engagements also require specific actions as illustrated in Figure 10. The alternatives are:

(a) the TC does not range,
(b) the TC lases,
(c) the TC indexes or applies the range,
      - or -
(d) the TC announces the range.

TC does not range. Under normal circumstances, the TC performs no overt ranging function. He does, however, estimate the range to the target and evaluate the range read out in a precision engagement to verify that the range return is correct. In a battlesight engagement, the TC has no overt ranging responsibility since the predetermined, pre-indexed range is assumed to be sufficiently correct.

TC lases. If the TC is firing the main gun or coax from his position, he will normally lase and evaluate the return as a normal sequence of the engagement. If the gunner has already lased, and if the TC is not satisfied with the return, he may direct the gunner to relase, index the battlesight range, or re-lase from his position.

TC indexes/applies the range. If the TC is not satisfied with the range return, or if the LRF is ineffective due to environmental conditions or a malfunction (e.g., loss of symbology), he may index the range to target manually from his position. To do so, the TC indexes the battlesight range with the MANUAL RANGE BATTLESIGHT button on the commander's control

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[20]The operating temperature of the TIS is well below environmental temperatures. When left off, the system will take on heat. When switched to stand-by, the system temperature is reduced until it reaches the operating temperature. This is referred to as "cooling down." It is analogous to warming up the tubes in older television or radio sets.
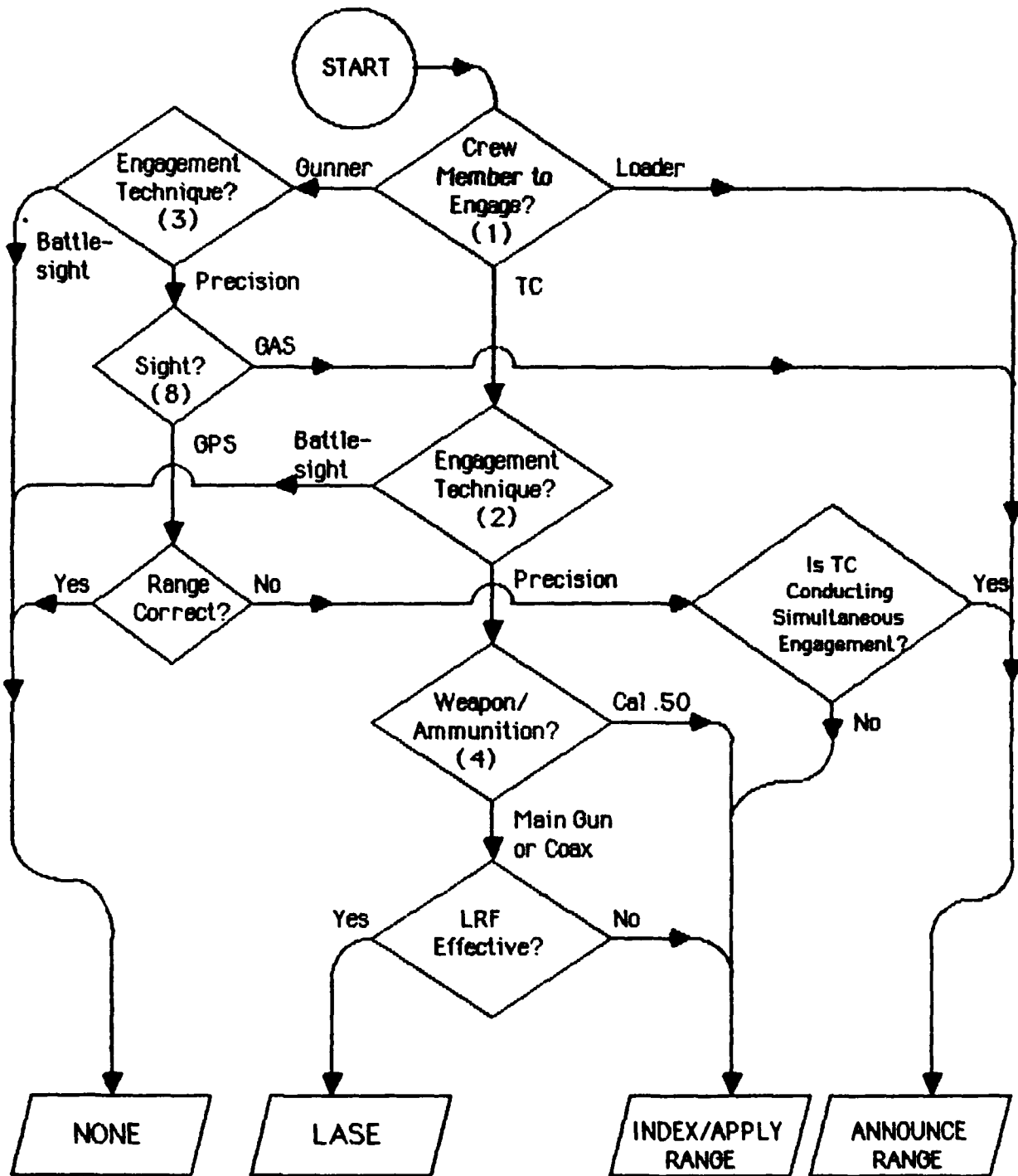
Figure 10. TC's ranging actions decision logic.

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panel, then uses the MANUAL RANGE BATTLE SGT ADD/DROP toggle switch to adjust the indexed range, if necessary. If he estimates that the target is within effective battlesight range, he does not need to adjust the range with the ADD/DROP toggle switch.[21]

When firing the cal .50 from the CWS, the commander applies the estimated range to the target using the range lines in the sight reticle.

TC announces the range. If the gunner is performing a precision engagement with the GAS, the TC must announce the range element in the fire command. If the LRF is ineffective and the gunner is using the GPS, the TC may require the gunner to manually index the range. In either of these cases, the TC must announce the range the gunner is to apply or index.

If the LRF is ineffective, the TC may use the cal .50 to determine the range to targets within 1800 meters of the firing tank. This method yields a fairly accurate range, designates the target for the gunner, and suppresses the target simultaneously. There is a drawback with this method, however, since it exposes the tank's position. Once he has determined the range by this method, the TC announces the range for the gunner.

Variable 11. Gunner's Ranging Actions

The gunner's ranging actions are dependent on a number of factors in the overall situation, but they are primarily determined by the TC's ranging actions and other commands. Figure 11 illustrates the decision logic for the Gunner's ranging actions. The alternative behaviors are:

(a) Gunner does not range,
(b) Gunner lases,
   - or -
(c) Gunner indexes/applies range.

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[21]Three possible actions are appropriate in the event that range symbology is lost. The first is to engage on the assumption that the LRF is working and that the correct range is indexed in the fire control system. The second is to engage using the battlesight setting, which is indexed by the TC with the MANUAL RANGE BATTLE SGT button. The TC cannot verify the adjustment of the range if he uses the ADD/DROP toggle, because he would need the range symbology read out in the sight to verify the adjustment. The third option is to announce the range and to require the gunner to index the range manually (variable 11).
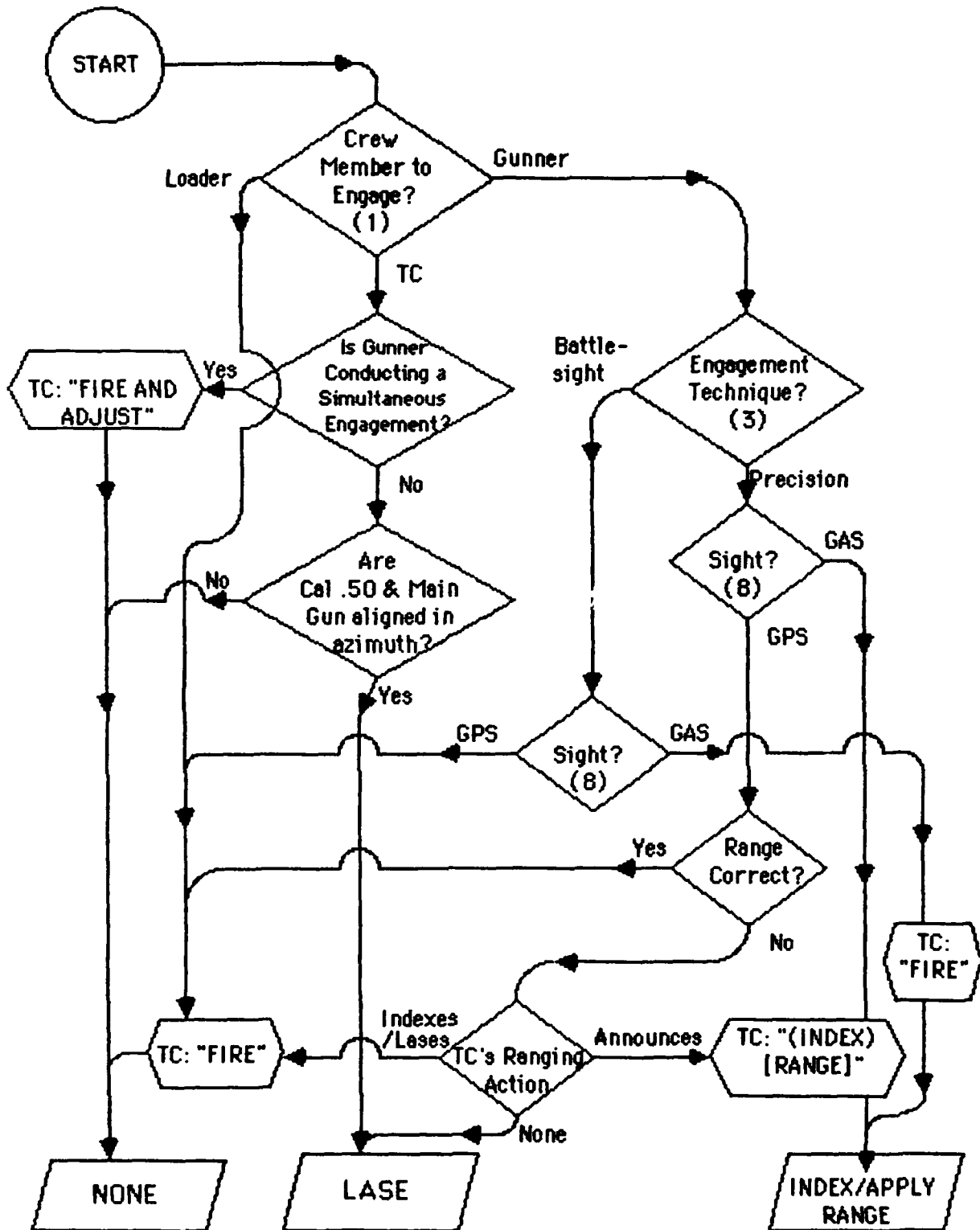
Figure 11. Gunner's ranging actions decision logic.

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Gunner does not range. The gunner will not lase if he is using the GPS in a battlesight engagement or if he is performing a precision engagement with an inoperable LRF. If the TC indexes the range, the gunner will continue to track the target and will fire on command.

Gunner lases. The gunner normally lases in all precision engagements. Exceptions occur only as a result of equipment failures or environmental effects. In a normal engagement, the gunner lays on target center of visible mass, lases, and then evaluates the range read out to determine if multiple returns exist. If multiple returns exist and if he is not satisfied with the read-out, the gunner switches the RANGE logic setting (from ARM FIRST to ARM LAST RETURN, or vice versa) to select the better solution. Once he is satisfied that the range is correct, he re-lays on target center of visible mass and fires.

When the TC is preparing to engage a target with the caliber .50, and if the gunner is not involved in a separate engagement, the gunner may lase and announce the range return. This will allow the TC to use a precise range solution in his initial burst.

Gunner indexes/applies range. If the TC directs the gunner to index a range, the gunner opens the Computer Control Panel (CCP) door and turns on the CCP. Next, he depresses the RANGE key, enters the range, and depresses the ENTER key. Depressing the RANGE key again indexes the range into the computer.

If the GAS is used, the gunner applies the range to the target using the range lines on the sight reticle. This is true whether he uses the predesignated battlesight range or the announced range. If the gunner is using the GAS, and if the T, fails to specify the range, the gunner requests a range to the target.

Variable 12. Select Traverse and Elevation Method

The behavioral alternatives for aiming the tank's weapons systems are:

(a) traverse and elevate electrically
    - or -
(b) traverse and elevate manually.

The decision logic for this parameter is illustrated in Figure 12.
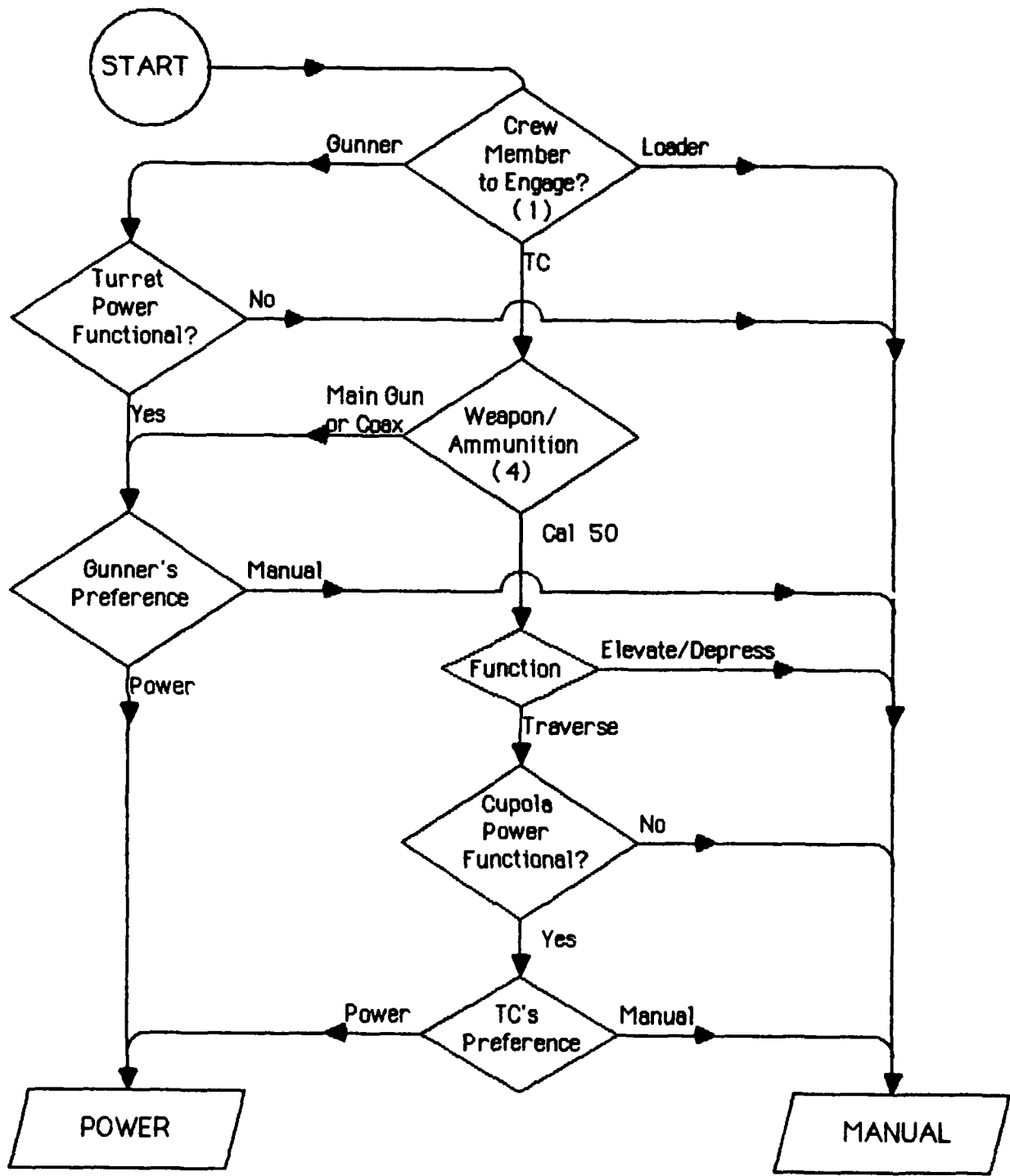
Figure 12. Select traverse and elevation method decision
            logic.

Traverse and elevate electrically. The gunner and tank commander normally use the power control handles to traverse and elevate the turret armament, i.e., main gun and coax. The TC may also traverse the caliber .50 electrically using the Commander's Weapon Station control handle when the POWER/MANUAL lever is in the POWER position.

·Traverse and elevate manually. The turret manual controls, which exist only at the gunner's station, serve as a back-up system. The turret manual controls are normally used in a combat situation only when the turret power is inoperative. They may be used as a primary system in certain situations where they provide finer adjustments than are possible with the power controls.

It is possible that the power controls may fail independently of the ballistic computer system, but this is not likely. If the ballistic computer system is still operational, the gunner should use the GPS. If the ballistic computer goes down as well, the gunner should use the GAS.

The stabilization system and the lead angle sensor are bypassed when the manual controls are used. Tracking a moving target with the manual controls will therefore require the application of standard lead as addressed in variable 13, below. If the ballistic computer is disabled, other adjustments to the sight picture may be necessary as outlined in variable 14, below.

If turret power is lost, the TC must direct the gunner to traverse and/or elevate in order to identify targets. This is accomplished in the direction element of the fire command, as outlined in a previous section of this report.

Variable 13. Gunner/TC Applies (Does Not Apply) Standard Lead

The requirement to apply lead manually is dependent upon the apparent movement of the target, the weapon and sight selection, and the operational status of selected fire control system components. These factors are illustrated in Figure 13. The gunner or TC may:

(a) engage with no lead adjustment or with   system-
    induced lead,
    - or -
(b) apply standard lead.

Engage with no lead adjustment or with system-induced lead. No lead solution is required when the target has no apparent movement. A moving target presents target solution problems which are automatically resolved on a fully operational Abrams tank (assuming the gunner manipulates the

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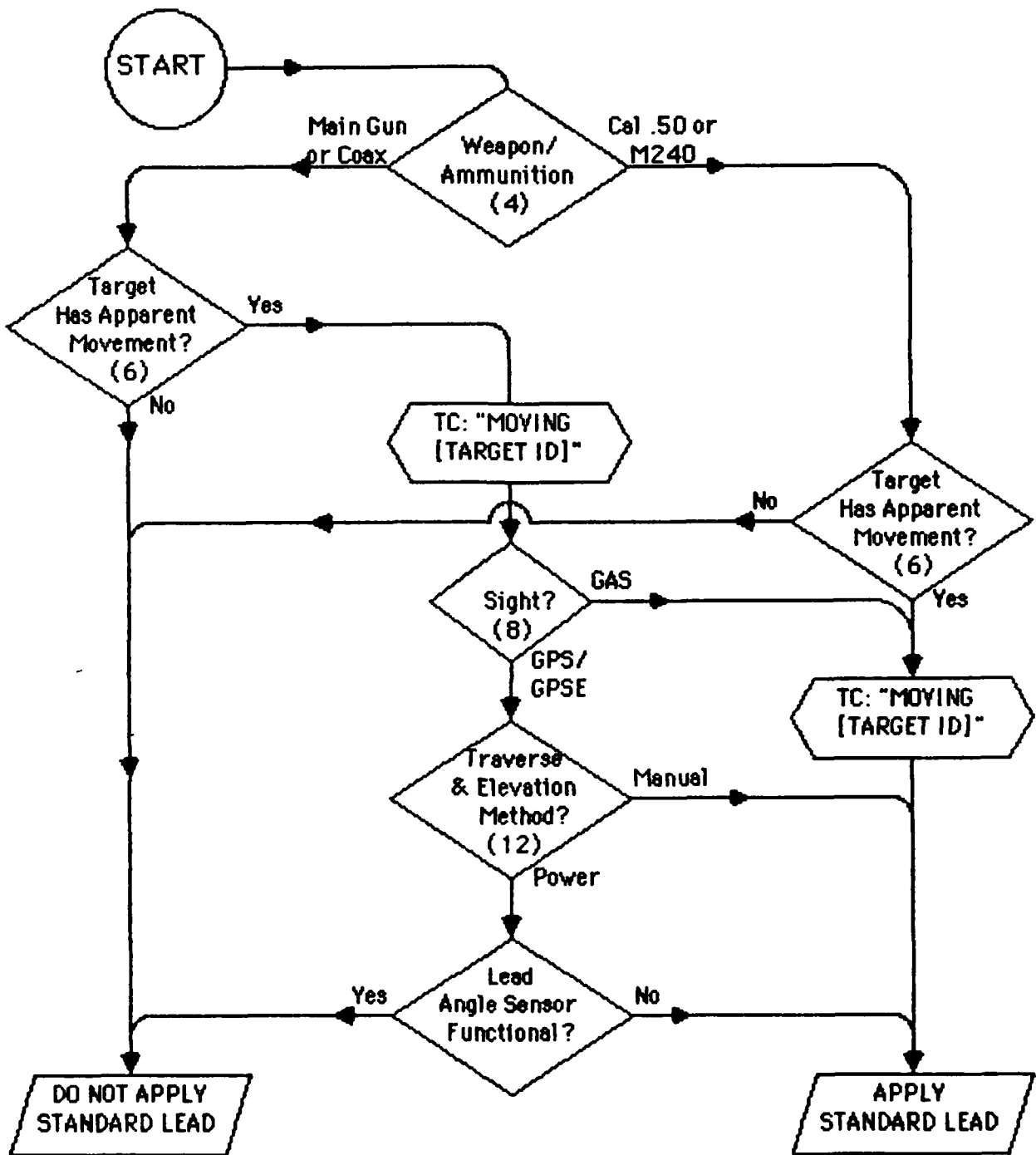
Figure 13. Gunner/TC applies (does not apply) standard lead
decision logic.

controls properly). A sensor determines the turret slew rate regulated through the gunner's (or TC's) control handles, and provides that information to the ballistic computer. The ballistic computer determines the precise amount of lead necessary to hit the target, and induces the solution angle in the gunner's primary sight. The gunner aims center of visible mass and fires. This behavior is the same for any target as long as the lead angle function is operational.

The lead angle sensor (LAS) is slaved to the stabilization system. When the tank is engaging on the move, the sensor differentiates between the turret's counter-rotation in response to the driver's directional inputs and the gunner's inputs in target tracking.

Apply standard lead. The LAS may be disabled independently (as indicated during a computer self-test), or it may become inoperative as the result of a stabilization system failure, ballistic computer failure, or turret power failure. Since the stabilization system is activated by the palm switches on the gunner's and TC's power control handles, automatic lead will not be processed by the computer if the target is tracked with the manual traversing and elevation handles.

If the stabilization system is working, but the LAS is not, and if the turret must be traversed by the gunner to track the target, then lead must be applied. This condition may occur if the firing tank is moving laterally with respect to a stationary target.

A standard lead increment has been established for each weapon and for both types of main gun round. Special standard lead increments also apply to aircraft and to troops descending by parachute. The standard lead increment is to be used in the initial engagement when appropriate to the conditions. If the first round misses, subsequent engagements are made by adjustments to the sight picture according to Variable 14, below.

Variable 14. Adjust the Sight Picture

Besides the application of range when using ballistic sights and the application of standard lead, other adjustments may be appropriate because of system malfunctions or in subsequent engagements against the same target. The four categories of adjustments are:

(a) no adjustment,
(b) adjust for cant,
(c) apply standard adjustment,
    - or -
(d) adjust per subsequent fire command.

Note that any of these adjustments are cumulative. If more than one of the conditions applies, the adjustments accumulate to determine the final aiming point except when one adjustment overrules another. For example, when the TC issues a subsequent fire command, that overrules the gunner's standard adjustment. Subsequent adjustments (alternatives (c) and (d), below) are made from the previous point of aim. For example, if the initial engagement involved a cant adjustment, the subsequent adjustment would be made from the aiming point used after the cant adjustment was applied. The logic associated with these miscellaneous sight adjustments is illustrated in Figure 14.

No adjustment. In the initial engagement sequence with a fully operational Abrams tank, the gunner will make his final lay on the target's center of visible mass and then fire. The ballistic computer corrects for all predictable factors affecting main gun accuracy.

If a target is not destroyed with the first round, the gunner has three options. The first is to reengage. This method is no different from an initial engagement. All steps remain exactly the same with no adjustment being made to the sight picture. If the gunner observed a hit, but intends to engage the same target again, he assumes the exact same sight picture a second time, but does not re-lase.

Reengagement is preferred if all fire control sub-systems are operational. The assumption is that any error on the first round was either a gunner error or a random error. The other two methods of adjustment are used in degraded mode gunnery and involve modifications to the gunner's sight picture. These options (alternatives (c) and (d)) are addressed below. These methods may be used in normal mode gunnery only if the gunner was missing the target repeatedly and the round was consistently falling in the same place with respect to the target.

Adjust for cant. If the ballistic computer is disabled or if the Cant Sensor fails (as indicated by the computer self-test), and if the tank occupies a non-level firing position, the gunner adjusts for cant. He does so by laying the cross hairs on the target's center of visible mass and lasing. The gunner then aims 1 mil high and 1 mil opposite the direction of cant (or "uphill") for each 1000 meters of
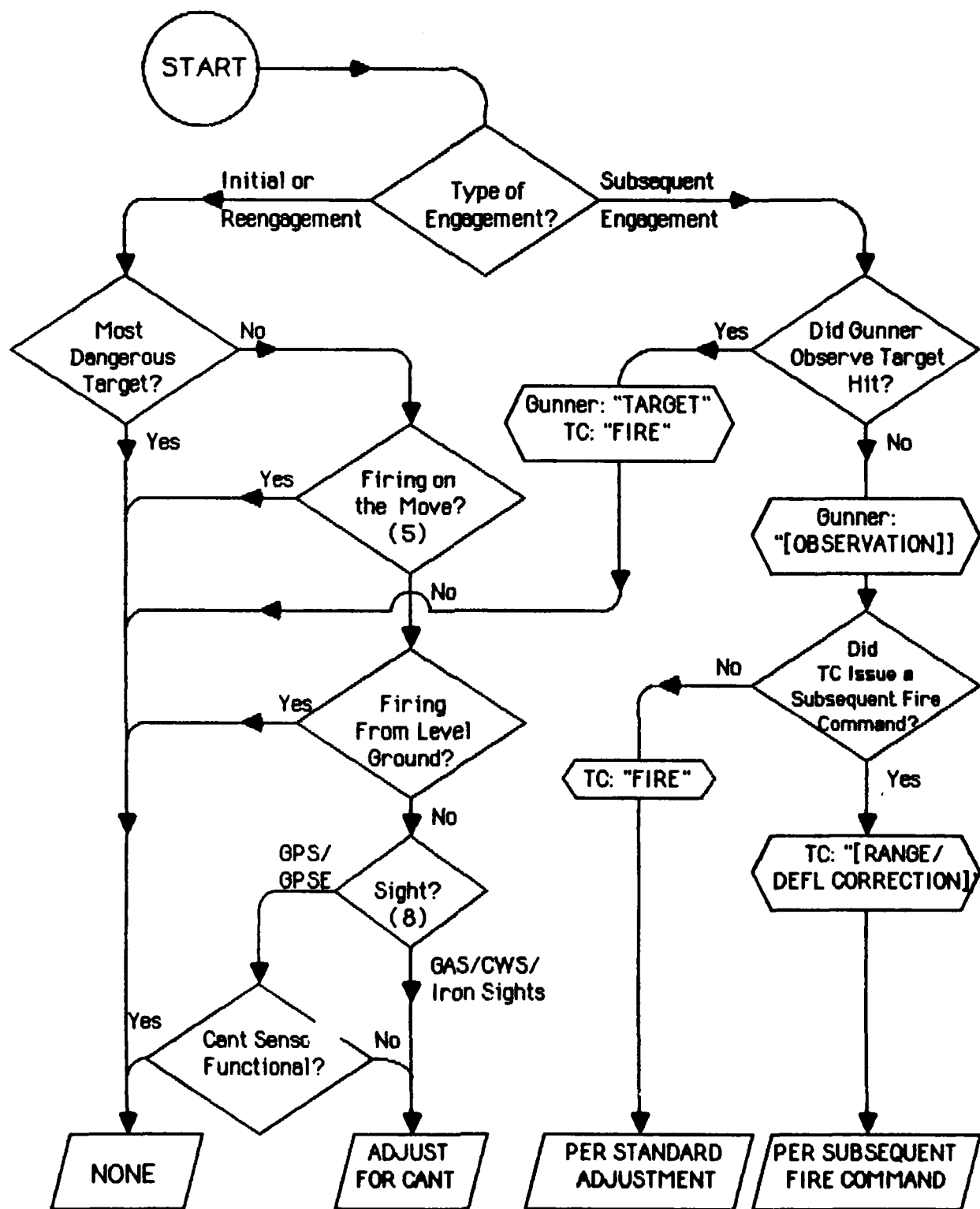
Figure 14. Adjust the sight picture decision logic.

range.[22] Cant must always be considered when using the GAS because the GAS does not benefit from the solutions generated by the ballistic computer.

Apply standard adjustment. The gunner's standard adjustment is the first adjustment technique. In this case, the gunner adjusts his sight picture based on his observation of the previous round. On the assumption that any errors in his initial range solution will be offset by the adjusted sight picture, he does not re-lase. His adjustment is incremental, to avoid over adjusting.

Adjust per subsequent fire command. The second adjustment technique is based on a subsequent fire command from the TC. When the gunner receives the subsequent command, he will apply the adjustment specified by the TC. A more detailed description of the direct fire adjustment procedures (alternatives (c) and (d)) is provided in the explanation of post-engagement behaviors.

Variable 15. Fire with Electrical/Manual Trigger/Firing Device

The use of electrical or manual triggers or firing devices is dependent upon the weapon being fired and the status of the firing circuitry, as illustrated in Figure 15. The alternatives are:

(a) fire with an electrical trigger
- or -
(b) fire with a manual trigger or firing device.

Fire with an electrical trigger. The main gun, coax and caliber .50 are normally fired with electrical triggers. For the main gun and coax, two triggers are located on the gunner's power control handles, one is located on the manual elevation crank handle, and another is located on the TC's power control handle (override). The electrical trigger for the caliber .50 is part of the manual elevation crank mechanism.

Fire with a manual trigger or firing device. In case of an electrical power failure in the tank, all the tank's weapons may be fired manually. The manual firing device for the main gun is a small electrical generator mounted at the

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[22]If engaging a most dangerous target, no adjustment for cant is made with the first round. If the first round misses, the standard adjustment or subsequent fire command adjustment is made, or the target is reengaged.
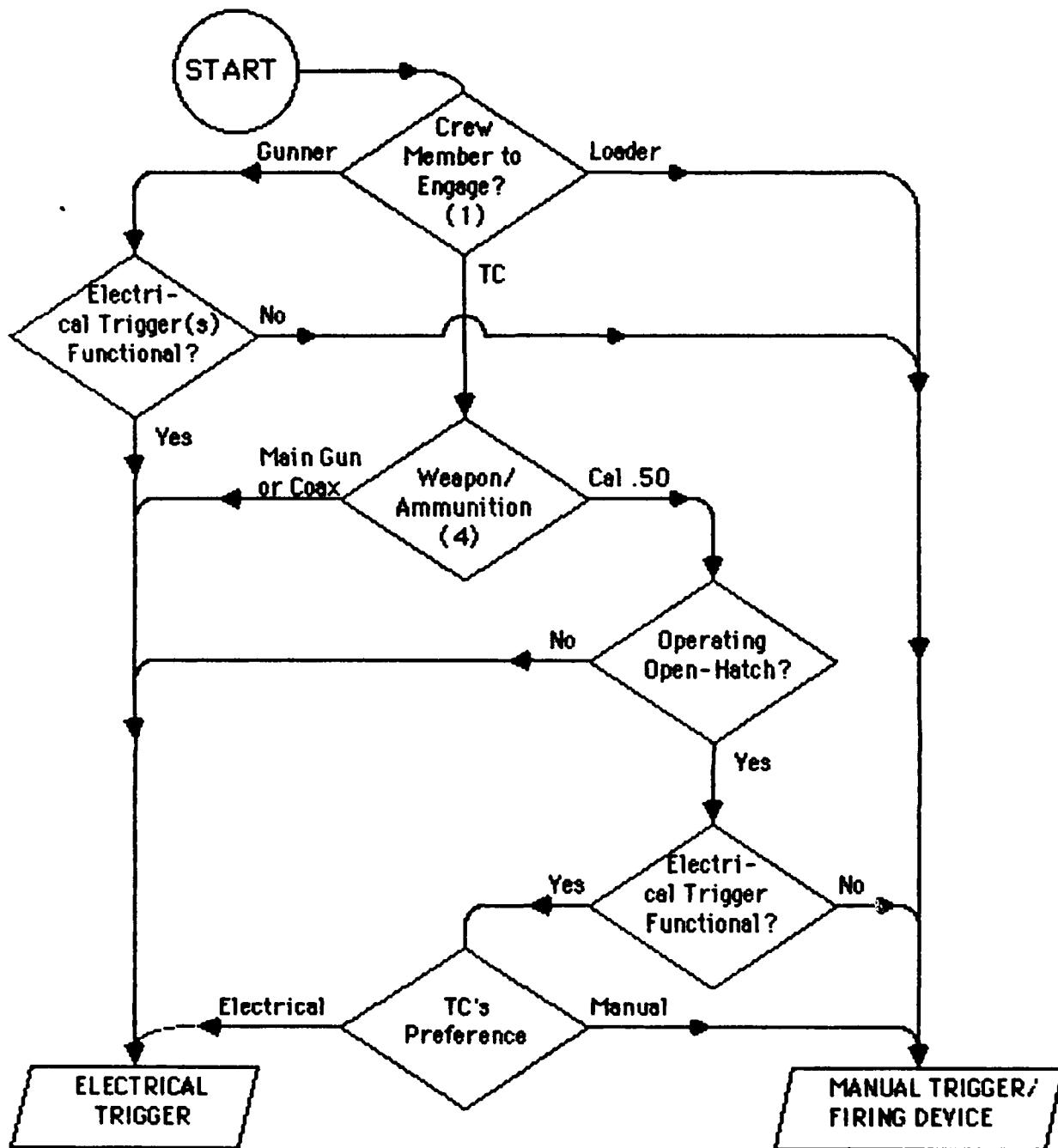
Figure 15. Fire with electrical/manual trigger/firing device decision logic.

gunner's station. The device is operated by rapidly twisting the handle clockwise up to four times.

The coax has a solenoid attached to the machine gun's receiver (the rear of the gun) that is linked to the mechanical trigger. The gunner may manually fire the coax by pressing a button on the back of the solenoid. The caliber .50 may be fired manually by depressing the butterfly trigger on the back of the receiver. The loader's M240 only has a manual trigger.

Summary of the Engagement Sequence

In this section of the report, the engagement sequence has been addressed in detail. The engagement sequence is the second of the three steps of the gunnery model introduced in this report. The engagement sequence is further sub-divided into the fire command and the direct fire engagement. The basic fire command consists of six elements: the alert, ammunition or weapon, description, direction, range, and execution. Some elements of the fire command may be omitted when their omission does not cause confusion among the crew. The direct fire engagement conforms to a pattern of fifteen variables, each consisting of from one to five alternative behaviors. The variables and alternatives are outlined in Table 6, and discussed in detail throughout the remainder of this section. The crew duties associated with the direct fire engagement are outlined in Appendices A and B. Appendix C lists all possible alternative engagement patterns.

Crew Gunnery Assessment and
Post-Engagement Behaviors and Processes

The actions of a crew following an engagement respond to the crew's shared perception of the overall situation (the macro-engagement). Both the tank commander and gunner individually assess the outcome of the prior engagement. The tank commander also reevaluates the progress of the macro-engagement. To the extent possible, the driver and loader also contribute their observations to the remainder of the crew. These assessments reflect the shared perception of the battle among the crew. The outcomes of all the individual engagements modify the conditions within the macro-engagement. Some of the ways the conditions change are:

(a) The number of targets is reduced by friendly fires.

(b) The friendly tanks that have fired have exposed their positions. Enemy systems will acquire the friendly tanks and attempt to return fire. This upgrades the target classifications applicable to the enemy weapon systems.

(c) The friendly force may have sustained losses, increasing the number of targets that each surviving friendly tank must destroy to survive the battle (except as modified by condition (b), above.

(d) Other forces (friendly and/or enemy) may enter or leave the macro-engagement.

(e) The unit leader or commander may issue new orders that require the crew to modify its subsequent actions.

The assessment is an internal process, with perceptual and cognitive components, that leads to post-engagement behaviors. The purpose of this section is to analyze and explain the post-engagement processes and behaviors.

There are two types of assessment that occur simultaneously following any engagement. The first type is concerned with the observation of the main gun round or machine gun burst fired and its effect on the target. The second type of assessment is concerned with the conditions comprising the macro-engagement. The second type of assessment will be referred to throughout the remainder of this section as the reevaluation, while the unmodified term, "assessment," will refer uniquely to the first type of assessment.

The Reevaluation and Appropriate Responses

The reevaluation is a general assessment of the macro-engagement that includes the effects of the just-completed engagement within the greater context. The reevaluation requires the TC to update his classification of all targets in his sector and to analyze the effect of enemy fires on his own unit. It may include the receipt of radio messages that require some particular action on the part of the crew or that alert the crew to new developments.

Effective friendly fires will reduce the number of targets in the array, while friendly losses will increase the number of targets each surviving friendly tank must destroy. The manner in which the situation develops dictates subsequent actions. An outline of reevaluation stimuli and responses is shown in Table 9. The information in the table is amplified in the subsequent text.

Table 9

Reevaluation Stimuli and Responses

Stimulus	Alternative Responses
1. Changing battlefield situation (stationary).	a. Continue engagement. b. Disengage and move to alternate firing position. c. Disengage and move to subsequent battle position.
2. Changing battlefield situation (moving).	a. Continue engagement on the move. (1) Action drill (2) Contact drill b. Disengage and move to covered/concealed position. c. "Pop smoke."
3. Platoon leader's FRAGO.	Comply, issue appropriate crew commands.
4. Adjacent tank's observation.	Evaluate and: a. Allow gunner to apply standard adjustment based on external observation. b. Issue subsequent fire command based on external observation. c. Issue subsequent fire command based on own observation. d. Direct the gunner to reengage.

Changing Battlefield Situation (Stationary)

Continue to engage from current position. In a defensive situation, a crew can theoretically deliver its greatest sustained volume of fires when it does not move. However, every time the tank fires, it exposes its own position. There is a direct correlation between the amount of time that a tank is exposed and the likelihood that the tank will be engaged and destroyed by an enemy system. The decision to stay in position therefore must be balanced against the risk of destruction against the benefit of destroying more targets.

Disengage and move to alternate firing position. The second alternative in a defensive situation is to maneuver within the battle position to an alternate firing position.

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This affords the tank protection from observation and direct fires once it clears the initial position. The tank can then move into its alternate position and reengage at a reduced level of risk. However, in the time it takes to reposition, the enemy array can also move. If that movement decreases the engagement range significantly, the probability that the enemy will acquire the friendly tank as it enters its new fighting position will increase. If the enemy array is significantly larger than the friendly unit, the friendly force can easily become overwhelmed.

Disengage and move to subsequent battle position. The third alternative in a defensive situation is to move to a subsequent battle position. This is a decision made at a higher command echelon. It is also possible for a unit to be forced off of its current position by superior enemy forces. Depending upon the proximity of the enemy, the friendly unit may (a) disengage from the enemy entirely, (b) fight back in echelon (part of the unit stays in position while the rest of the unit moves back; then the forward element moves back under the overwatching fires of the rearward element), or (c) become involved in a running battle as it withdraws. Each of these alternatives implies certain gunnery-related behaviors on the part of the individual tank crew. Specifically, because of ongoing enemy activity, the crew must continue to search for targets when none are visible and to engage targets as they appear. After each subsequent engagement, the crew must reassess the situation and act accordingly.

Changing Battlefield Situation (Moving)

In offensive operations, engagements may be conducted on the move during a bound or from overwatch positions. In many ways, firing from overwatch is analogous to fighting from a battle position. Sustained fires from a single fighting position involve an increased risk of being engaged and destroyed by return fires.

Continue engagement on the move. When engaging on the move during a bound or an assault, the tank crew must consider several courses of action with each engagement. When the unit is moving, the chances are greater that an engagement will be initiated by a stationary enemy force. This requires the friendly unit to perform actions on contact (return fire, conduct a battle drill or seek cover and concealment, report, and develop the enemy situation). The two types of battle drills that may be used are (1) the action drill and (2) the contact drill. Both of these drills dictate crew engagements. The difference between the two is the direction of movement.

If the platoon leader commands an action drill in the enemy's direction, the unit transitions into a hasty attack.

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The crew begins to engage with machine guns to suppress enemy infantry. If armored targets or bunkers are identified, they are engaged with the main gun.

If the platoon leader commands a contact drill, the crew engages the enemy location with suppressive fires as it continues to move in the original direction. Once again, if armored targets or bunkers are identified, they are engaged with main gun.

Disengage and move to covered/concealed position. Seeking cover and concealment allows the unit to escape the enemy's fires and to reassess the situation. As the tank moves to the covered position, it continues to engage. Once in a covered position, tanks may move up into hull defilade positions and reengage. The unit can begin to employ fire and maneuver to assault the enemy position or to bypass it. The nature of the terrain, the enemy's disposition and the friendly situation all influence the subsequent actions of the crew at this point.

"Pop smoke". The tank has two on-board smoke systems: the smoke grenades and the vehicle exhaust smoke screen system. Either of these might be used to screen the tank's location and movement, spoiling the enemy's aim. Smoke may be used in conjunction with the other actions taken by the unit. Since the thermal sights can penetrate the smoke screen, the tank can continue to engage.

Platoon Leader's FRAGO

The situations described above encompass most of the ways the platoon leader may influence the tank's subsequent engagements or other actions. The platoon leader may also use fragmentary orders (FRAGOs) to change the platoon's fire pattern, individual tank sectors of responsibility, or target engagement priorities, or to order individual tanks to disengage for rearming or refueling.

Adjacent Tank's Observation

When possible, the tanks in a section or platoon interact to assist one another in direct fire adjustment. This is done by transmitting observations of each other's fires. The three firing techniques and the inter-tank communication prescribed by each technique are described in a previous section of this report. A detailed explanation of direct fire adjustment is presented below.

Assessment and Direct Fire Adjustments[23]

The reevaluation of the overall situation is primarily the responsibility of the Tank Commander. The gunner's attention is focused on the target that he just engaged and on the subsequent actions dictated by the results of the engagement.[24] The gunner makes an assessment of the effects of the round on the intended target.

(a) If the target was hit and destroyed, the TC may direct the gunner to cease fire or to engage a new target.

(b) If the target was hit, but may not have been destroyed, the basic assumption is that the target vehicle is at least disabled as an effective weapon system. If other dangerous targets exist, the gunner engages them. If not, the gunner may reengage the same target to ensure its destruction. If the hit was against the suspension, and if there is a strong likelihood that the target still presents a danger, the gunner conducts a subsequent engagement against that target.

(c) If the last round missed the target, and if the TC does not command some other response, the gunner continues to engage the same target according to the direct fire adjustment procedure.

Direct fire assessment procedures are illustrated in flow chart form in Figures 17 through 19. Figure 16 indicates which of the figures is applicable based on the number of targets and type of multiple engagement being conducted.

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[23]The description of direct fire adjustments paraphrases the content of Tank Combat Tables M1 (FM 17-12-1, 1986). It is included here to enhance continuity of this report.

[24]The material that follows is primarily concerned with main gun engagements. In a machine gun engagement, the adjustment of fires may occur during the burst, in which case a new engagement is not required, or between bursts, in which case each burst is essentially a new engagement and adjustments are made in a manner similar to main gun adjustments. The increments specified in this chapter for direct fire adjustments apply specifically to main gun. Larger adjustments may be made in machine gun applications because the gunner's observation is usually more reliable than it is in a main gun engagement.
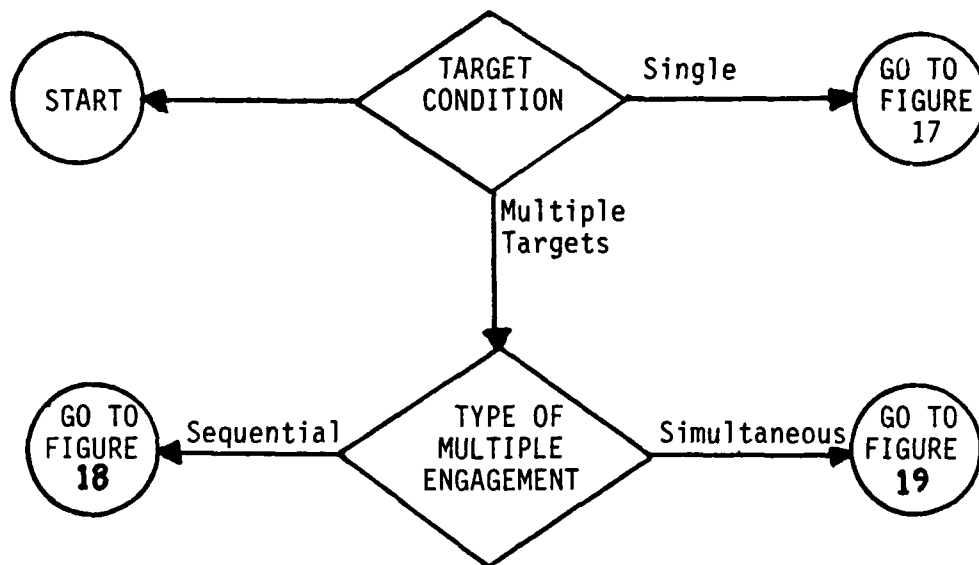
Figure 16. Application logic for direct fire assessment
procedures.
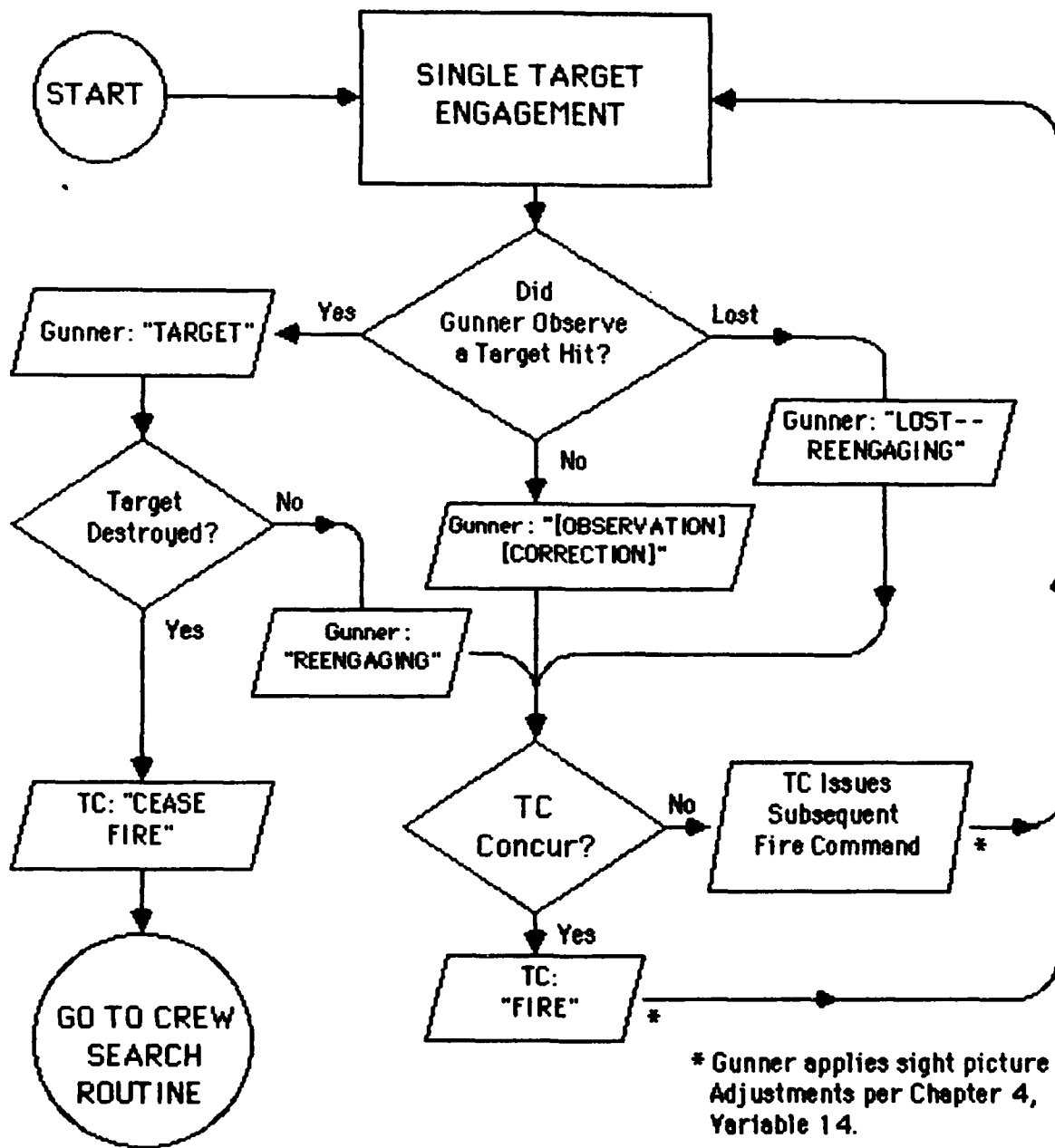
Figure 17. Single target engagement direct fire assessment procedure.
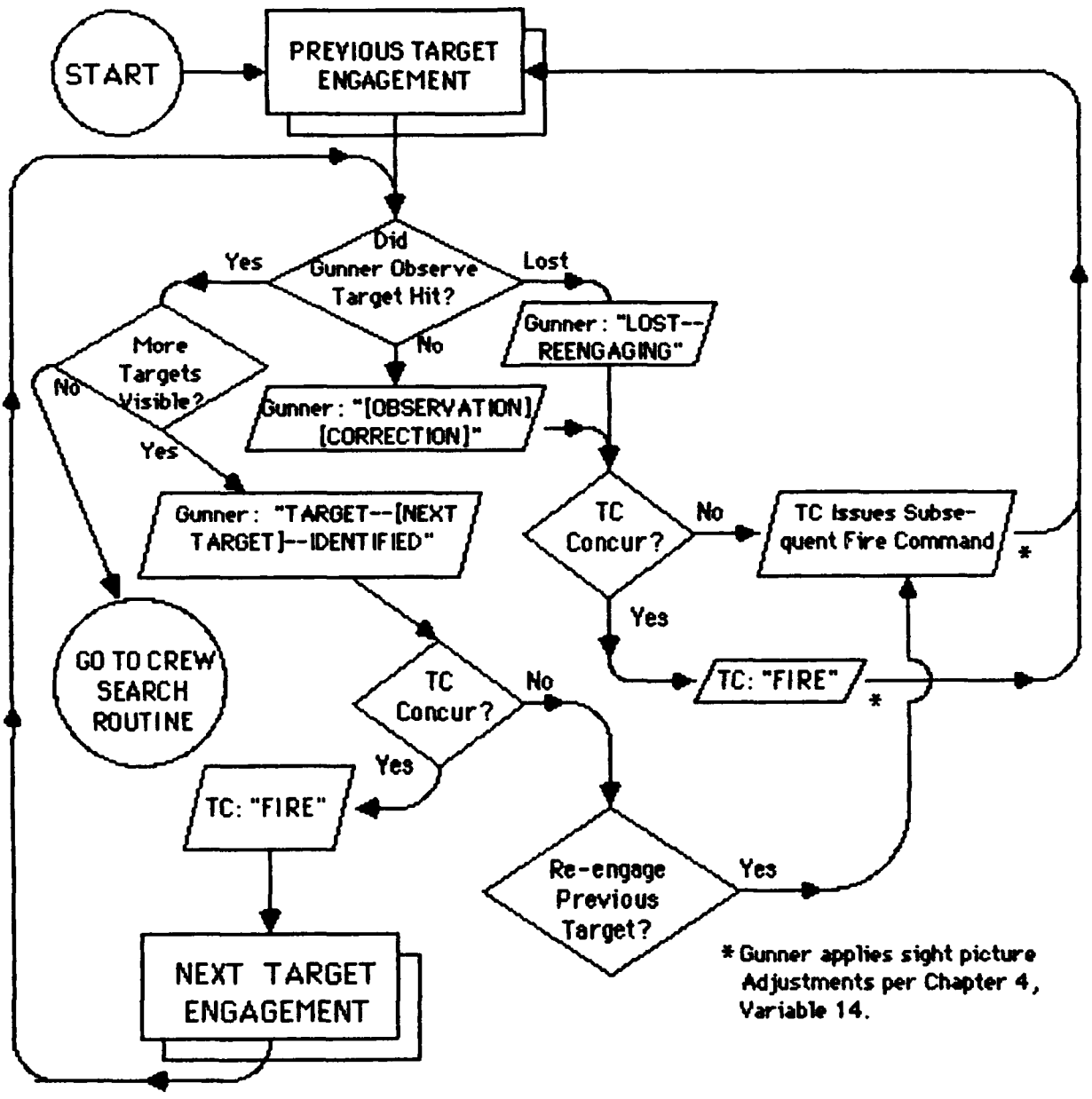
Figure 18. Sequential target engagement direct fire assessment procedure.
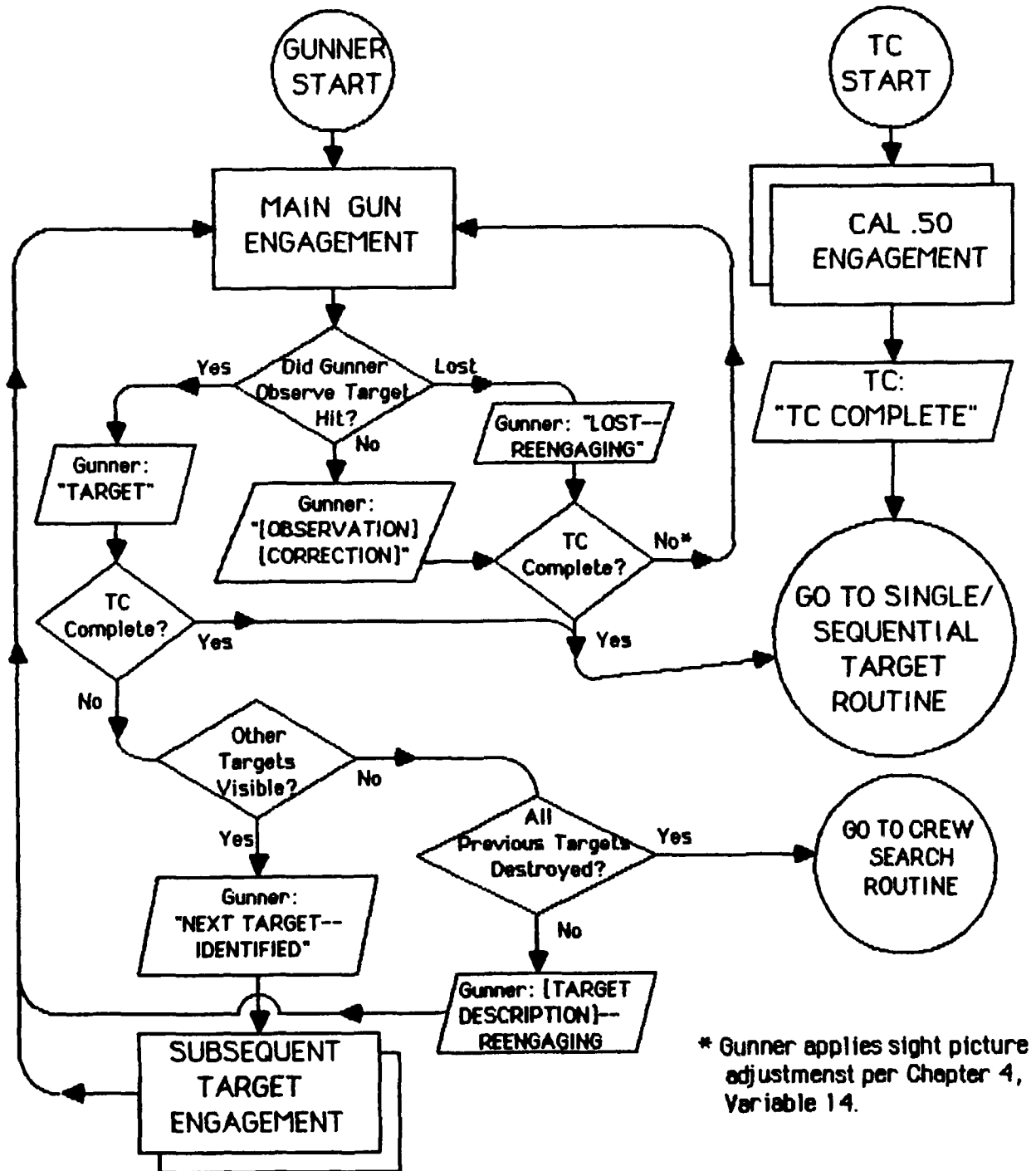
Figure 19. Simultaneous target engagement direct fire assessment procedure. (Gunner's assessment in simultaneous main gun/caliber .50 machine gun engagement illustrated.)

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Direct Fire Observations

The gunner attempts to observe the result of each engagement. Due to the main gun blast and the high velocity of main gun ammunition and the obscuration caused by the muzzle blast of the main gun, it is unlikely that the gunner will observe the flight of the round. Nevertheless, he can infer the round's effect in most situations. A target hit will usually result in a bright flash that may be sensed through the muzzle blast. If the round strikes the ground in the vicinity of the target, a splash of earth or debris may be sensed.[25] A round may be completely unobserved (lost) if it goes over the target.

In a fully operational tank, the preferred method of engaging a target after a first round miss is to reengage. That is, to perform all actions as if the target was being engaged for the first time. This doctrine assumes that the miss was caused either by round-to-round dispersion or by gunner error, and that the application of the proper procedure by the gunner, coupled with a new solution from the ballistic computer will result in a target hit. In this case, the intended correction is announced as "REENGAGING." If the tank is operating in degraded mode, the gunner keeps the palm switches depressed to maintain any solution data from the first round, and announces and intended correction consistent with his observation and the standard adjustment (see below).

Given a reliable observation, the gunner announces his observation and intended correction, makes any necessary adjustments in azimuth and elevation to his sight picture, and engages a second time (without ranging, if in degraded mode). An explanation of direct fire observations is contained in Table 10.

If no reliable observation was made, the gunner may reengage by performing all steps as they were performed in the initial engagement sequence. The gunner's observation is "LOST." He announces "REENGAGING" and proceeds as with an entirely new engagement unless the TC countermands the gunner's proposed action.

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[25]The term, "sensed" is used in this context because the observation is made through the muzzle blast, and is not as reliable as a direct observation. The sensory perception is similar to that experienced when one observes something out of the corner of one's eye. The sensation is sufficient to infer that something was seen, but is not sufficient to support a detailed description of what is seen.

Table 10

Direct Fire Observations

Observation	Explanation
TARGET	Any part of the target is hit by direct fire.
LOST	Neither the round nor its effects were observed.
OVER	The tracer was observed passing over the target, or the effects of the round were observed beyond the target.
SHORT	The round, tracer, or its effects fall between the firing tank and its target.
DOUBTFUL	The round or tracer are observed passing to the right or left of the target, or the effects of the round appear to either side of the target. The range solution appears to be correct.

Deflection observations are not normally voiced in order to preclude confusion between the observation and correction. However, the following terms have been used in the past to indicate observations in deflection.

LINE	Usually used with "short" or "over" to indicate that the deflection was correct but the range was in error.
RIGHT, LEFT	Usually used with "doubtful" to indicate the relationship of the round to the target.

If the gunner observed a target hit, his observation and intended correction is "TARGET, (NEXT TARGET), IDENTIFIED." Unless the TC overrules him, he proceeds to engage the next target in the predesignated sequence of engagement. Current Armor School doctrine assumes that a non-catastrophic target hit will sufficiently disrupt the target's systems and crew so that it no longer poses an immediate threat. When a combat

vehicle is struck by either a kinetic energy or chemical energy round, there is likely to be collateral damage to fire control and automotive components, even if the armor shell is not penetrated. It is presumed that this damage would disable the target for at least the short term, although the length of the disability is unpredictable. The target cannot be dismissed altogether, therefore, but should be reengaged at a later time after all other more dangerous targets have been shot.

When observations are received from adjacent vehicles, the gunner may apply the standard adjustment in the directions indicated (one mil increments), or the TC may give a subsequent fire command to increase the adjustment or override it.

The Gunner's Standard Adjustment

When the gunner misses the target with the first round in a fully operational M1 tank, the first assumption is that the miss was due to random or gunner error. In this event, the preferred response is to reengage. That is, to conduct what is behaviorally indistinct from the initial engagement, and to take advantage of the tank's sophisticated fire control system.

If the crew is operating with known degradations to the fire control system, and if the gunner believes he has made a reliable observation of a round that missed the target, he will use the gunner's standard adjustment in the subsequent engagement. The gunner's standard adjustment is a specified increment the gunner uses when adjusting his sight picture.[26] He does not relase. Any sight picture corrections are cumulative. For instance, if he had applied 2.5 mils standard lead against a moving target and missed behind the target, he would add the standard adjustment to the standard lead increment, leading the target by 3.5 mils for the subsequent engagement. The gunner's standard adjustment increments are shown in Table 11.

Subsequent Fire Commands

The tank commander is also expected to observe the effect of an engagement, if possible. If he disagrees with the gunner's observation or wants the gunner to apply a larger adjustment, he issues a subsequent fire command. For example, suppose the TC observes the round impacting the ground well beyond and two and one-half mils to the left of the target. The gunner also observes that the round missed to the left,

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[26]See Variable 14 on page 78.

Table 11

Direct Fire Adjustments[27]

SIGHT	GUNNER'S STANDARD ADJUSTMENTS		TC'S ADJUSTMENTS	
	ADD OR DROP	LEFT OR RIGHT	ADD OR DROP	LEFT OR RIGHT
Primary	1 mil	1 mil	1/2 to 2 mils	1/2 to 3 mils
GAS	200 meters	1 mil	100 to 400 meters	1/2 to 3 mils

but that the range was correct. Both agree that the round was off-line to the left, but there is a disagreement on the range observation. The gunner's observation and proposed correction is "DOUBTFUL, RIGHT ONE." The TC is concerned that the correction the gunner proposes will result in a second miss since the lateral correction is too small and since the gunner has not indicated a range correction. The TC announces "OVER, RIGHT TWO AND ONE HALF, DROP TWO." The gunner takes up a sight picture with the cross hairs of the non-ballistic reticle two and one half mils to the right and two mils below the target's center of visible mass for the next round.

If the TC agrees with the gunner's observation, he merely gives the execution command when he is sure that it is safe to fire. If the gunner is using the GAS, the TC announces range corrections in hundreds of meters rather than mils.

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[27] The standard adjustments shown are for SABOT and HEAT. Appendix E, FM 17-12-1 (1986) specifies gunner's standard adjustments for High Explosive Plastic (HEP-T) and White Phosphorous (WP-T). These types of ammunition are in limited use in certain areas, and are only available for use on M1 tanks with 105mm guns. The gunners standard adjustment for targets out to 2000m is: add or drop 2 mils (200m), and left or right 2 mils. The increment is increased to 5 mils on each axis for targets beyond 2000m. No standard adjustment is specified for the third type of limited use ammunition, Anti-PERSonnel (APERS-T). Instead, the TC is expected to establish the standard adjustment for APERS.

When the TC decides to terminate an engagement, he announces "CEASE FIRE."[28] All weapons and switches are then returned to the battlecarry configuration.

Minimum and maximum TC's adjustments, as specified in FM 17-12-1 w/c 2 (1988), are .5 to 3 mils in deflection, and .5 to 2 mils (for the GPS) or 100 to 400 meters (for the GAS) in range. These limits are reproduced in Table 11.

Misfire Procedure

If the main gun fails to fire, the gunner announces "MISFIRE," and the crew follows the misfire procedure outlined at Table 12. This procedure is essentially a sequence of failed engagements. Every time the gunner attempts to fire, he is engaging the target anew with alternative triggers, and finally with a new round.

Summary and Conclusions

Summary

This report has presented a model of tactical gunnery that can be used in the development of systematic training and testing programs for the M1 tank. The model is based on three premises. The first premise is that M1 tactical gunnery cannot be adequately viewed in terms of pure marksmanship, but must be considered as a set of variable behaviors that occur as responses to specific combat conditions. The model, therefore, identifies and categorizes combat conditions and relates these conditions to the appropriate set of crew behaviors. The second premise is that tactical gunnery can be analyzed as a series of discrete one-tank/one-target engagements that are conducted within an overall tactical engagement, the macro-engagement, that includes other weapons systems and targets. As a consequence, an engagement is considered to be the set of behaviors in which a single main gun round or a single machine gun burst is fired by a crew at a single target. The third premise is that the discrete one-tank/one-target engagements can be defined in terms of behaviors that vary across engagements. The complete set of engagements, defined in terms of these behavioral variables, would constitute the domain of tank gunnery.

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[28]If firing machine guns in an independent engagement, the TC, gunner or loader may indicate completion of the engagement by announcing "(TC/GUNNER/LOADER) COMPLETE." If the gunner is engaging with the main gun during a simultaneous engagement, and if the main gun target is destroyed, the gunner announces, "TARGET, CEASE FIRE."

Table 12

Main Gun Misfire Procedures

TANK COMMANDER	GUNNER	LOADER	DRIVER
	Upon main gun failure to fire, announces "MISFIRE."		
Continues to observe.	Verifies that gun select switch is in main gun position. Continues to track target. Announces "ON THE WAY."	Verifies ejection guard is to the rear and gun is armed.	Continues to If tank is moving, continues on present course.
Braces.	Waits one second and attempts to fire with alternate electrical trigger on gunner's power control handles.	Braces.	Braces.
	Upon main gun failure to fire, announces "MISFIRE."		
Continues to observe.	Continues to track target, announces "ON THE WAY."		Continues to observe/drive.
Braces.	Waits one second and attempts to fire with electrical trigger on manual elevation crank.[a]	Braces.	Braces.
	Upon main gun failure to fire, announces "MISFIRE."		
Announces, "FROM MY POSITION." Sights through GPSE. Lays on target. Announces "ON THE WAY."	Observes through GPS or GAS. Braces.	Braces.	Continues to observe/drive. Braces/

[a]If original attempt was made with the trigger on the manual elevation crank, the gunner attempts to fire with an alternate trigger on the power control handles on the third attempt.

Table 12 (Continued)

TANK COMMANDER	GUNNER	LOADER	DRIVER
Attempts to fire with TC's power control handle (TC's override.) Upon failure of main gun to fire, announces "MISFIRE."			
Continues to observe. TRIGGER SAFE.	Sets GUN SELECT switch Announces, "ON THE WAY."	observe/drive.	Continues to to
Braces.	Waits one second and attempts to fire using manual firing handle ("blasting machine"). Upon failure of main gun to fire, announces "MISFIRE."	Braces.	Braces.
Continues to observe.[b]	Continues to track.	Waits two minutes for possible hang fire. Opens breach manually, rotates round 180 degrees on its axis, and rechambers the round. Insures that the ejection guard is to the rear and that the main gun is armed. Clears the path of the recoil and announces "UP."	Continues to observe.
Insures the path of recoil is clear and that it is safe to fire. Announces "FIRE."	Sets the GUN SELECT to MAIN. Lays on the target. Announces "ON THE WAY."		

[b]The tank commander may interrupt the normal misfire procedure if he believes it is justified by the tactical situation. This is particularly true for the portions of the procedure that require waiting periods. In making such a decision, the TC accepts the risk of a hang-fire or cook-off rather than remaining in an exposed firing position.

Table 12 (Continued)

TANK COMMANDER	GUNNER	LOADER	DRIVER
Braces.	Waits one second and attempts to fire with any trigger. Upon failure of main gun to fire, announces "MISFIRE."	Braces.	Braces.
Continues to observe.	Continues to track target.	Opens breach manually Removes round. If possible, removes round from the tank.[c] Reloads main gun, insures that the ejection guard is to the rear and that the main gun is armed. Clears the path of recoil and announces "UP."	Continues to observe/drive.
Insures the path of recoil is clear. Evaluates the range return. Insures it is safe to fire. Announces "FIRE."	Re-lays on the target. Lases. Evaluates range return. Announces "ON THE WAY."		
Braces.	Waits one second. Attempts to fire with any trigger.[d]	Braces.	Braces.

[c]If the gun is hot, and loader cannot remove the round within one minute after the last misfire attempt, the crew exits the vehicle, takes cover, and waits two hours for the weapon to cool.

[d]If the main gun fails to fire with the new round, the misfire procedure is repeated from the beginning. If the second round does not fire through the entire misfire procedure, the crew should test the firing circuitry.

The combat conditions affecting tactical gunnery were classified as pre-existing, situation-specific, and engagement-specific. Pre-existing conditions are those conditions that are present prior to the mission and that can affect gunnery performance at any time throughout the mission. Two types of pre-existing conditions were identified: internal and external. Internal conditions relate to the operational status of the tank and the mental, emotional, psychological, and physical status of the crew. External conditions relate to the environment, the enemy situation, and the friendly situation as they are known or predicted prior to the start of the mission. Situation-specific conditions are conditions affecting gunnery performance throughout a particular phase of the operation that were not present at the start of the mission. Situation-specific conditions also conform to the external/internal categories described above, but differ from pre-existing conditions in that less time is available to react to and respond to the new condition. Engagement-specific conditions are those conditions that affect crew behaviors during the macro-engagement. Because of the dynamics present during a direct-fire exchange, the engagement-specific conditions are constantly modified as the two opposing forces engage and destroy their targets. Therefore, within the tactical environment, the set of engagement-specific conditions will change before, during, between, and after each individual engagement.

The model of tactical gunnery separates gunnery activities into three segments: the target acquisition process, the engagement sequence, and the assessment process. The activities in each segment are affected by pre-existing, situation-specific, and engagement-specific conditions.

A gunnery engagement begins with target acquisition. The target acquisition process was treated as a hierarchy of seven steps involving both perceptual and cognitive activities. These activities could be performed discretely as separate events or simultaneously depending upon the target(s) and other aspects of the tactical situation. Ways that pre-existing conditions influence the target acquisition process include: prescribing sectors the crew is to search, establishing target engagement priorities that affect target classification, and establishing the operational status of sights and equipment essential to the target acquisition process. Situation-specific conditions may modify the predesignated search sectors, cause closer scrutiny of particular areas where enemy activity is expected as a result of the ongoing tactical situation, or cause the crew to use different equipment as they continue to search. Engagement-specific conditions allow the crew to gather, process, and share information used in the decision to engage (the last step of the acquisition process).

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The engagement sequence depicts the many different ways in which engagements can be conducted on an M1 tank. Engagements were defined in the model as combinations of fifteen different behavioral variables. Each behavioral variable consists of certain activities. An alternative activity performed as part of one variable (e.g., firing SABOT ammunition), combined with the activities performed as part of all the other variables (e.g., using the gunner's auxiliary sight, firing on the move) define an engagement. Pre-existing conditions affect the engagement process by establishing the equipment-based limits for many of the variables, and by allowing the crew to determine how given degradations are to be accommodated. Situation-specific conditions affect the gunnery process in the same manner, but the actions of the crew in isolating a suspected failure and adjusting for it are typically conducted under more critical time constraints. Engagement-specific conditions affect the engagement process by prescribing the optimal and acceptable behaviors based on the target that is engaged, in combination with the pre-existing and situation-specific conditions. There are 4,618 engagement patterns, 4,068 of which are gunner's engagements.[29] All but 66 of these possible gunner engagements feature one or more alternative behaviors associated with an equipment failure in some component of the fire control system.

Each gunnery engagement is concluded by the assessment process. The assessment examines the effectiveness of the preceding engagement and considers the changes among the engagement-specific conditions to determine whether the crew should enter another engagement or not, and if a new engagement is to be conducted, what behaviors are to be modified. The only pre-existing or situation-specific conditions that affect the assessment process are those which establish standing procedures or orders applicable to the assessment process.

Conclusions

The description of tank gunnery presented in this paper is an attempt to integrate the processes involved in tactical gunnery in a single model. By integrating the various activities involved in tactical gunnery, including the perceptual and cognitive components of gunnery, the development of an adequate training and testing program should be facilitated. Moreover, by treating gunnery as a set of activities performed in a combat situation and influenced by

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[29]See Appendix C for an enumeration of possible combinations.

events occurring in that situation, it should be possible to overcome the focus on pure marksmanship.

It should be noted that the validity of the model depends on the reasonableness of the premisses that underlie its development. It should also be noted that the model does not take criticality into account. Although application of the model can lead to the identification of all types of tactical engagements, it cannot be used to identify the frequency with which the different engagements are performed or the likelihood that they will result in successful accomplishment of the unit mission.

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APPENDIX A

Baseline Gunnery Engagement Sequence

Comment. The following is an illustration of a normal, precision main gun engagement. The behavioral variable alternatives (see Chapter 4, Table 4-2) reflected in this example are:

1. Crew member engaging target: a. Gunner.
2. Target dispersion: a. Point.
3. Engagement technique: a. Precision.
4. Weapon/ammunition combination: a. Main Gun/Sabot.
5. Fire on the move: a. No.
6. Track moving target: a. No.
7. Crewman controlling the engagement: a. TC.
8. Sight selection: a. GPS.
9. Employ TIS: a. No.
10. TC's ranging actions: a. None.
11. Gunner's ranging actions: b. Lases.
12. Traverse and elevation method: a. Power.
13. Apply standard lead: a. No.
14. Sight picture adjustment: a. None.
15. Fire with: a. Electrical
                                          Trigger.

This engagement corresponds with task number 1111-00-11001-1001 in Appendix C, Table C-2. The explanation of crew duties in Appendix B will refer back to this Appendix as a baseline.

Conditions. Fully operational M1 tank in hull-down position, with SABOT round chambered (battlecarry). One enemy tank appears within effective main gun range, no apparent movement. Engagement occurs under daylight conditions, with no obscuration.

TC	GUNNER	LOADER	DRIVER
Announces "GUNNER, SABOT, TANK." (Alert, ammo, and description elements of fire command.) Lays gun for direction using TC's power control handle. (Over-ride.)	Ensures FIRE CONTROL MODE switch is in NORMAL position and LRF is in ARM 1ST RTN. Ensures AMMUNITION SELECT SWITCH is set on SABOT and GUN SELECT switch is in MAIN. Looks through GPS in 3X magnification and attempts to acquire the target.	Checks the turret ring. Ensures GUN/TURRET DRIVE switch is in POWERED. Ensures the ejection guard is in the ARMED position and that the yellow ARMED light is on. Clears the path of recoil. Announces "UP."	Observes.

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APPENDIX A.   BASELINE GUNNERY ENGAGEMENT SEQUENCE

TC	GUNNER	LOADER	DRIVER
	Acquires the target and announces, "IDENTIFIED."	Remains clear of the path of recoil.	
Releases override.	Centers the target in the GPS and switches to 10X magnification. Lays on target center of mass, lases, evaluates range return. Continues to track target.		
Evaluates range return, verifies that the target is hostile, ensures that it is safe to fire, announces, "FIRE." (Execution element.)	Makes final lay on target center of mass, confirms that target is hostile, announces, "ON THE WAY."		
Braces and observes.	Waits one second and fires.	Braces.	Braces.

APPENDIX B

Gunnery Behaviors

CONTENTS

APPENDIX B.   GUNNERY BEHAVIORS

CONTENTS (Continued)

APPENDIX B.   GUNNERY BEHAVIORS

This appendix outlines the crew duties associated with
each alternative of the fifteen behavioral variables
identified in Chapter 4.   The material in this appendix is
illustrative of the primary situations related to each
variation of the gunnery engagement pattern.   The material is
organized into 15 sections corresponding to the 15 behavioral
variables.   Each section identifies the behavioral variable
and alternatives associated with the behavioral variable and
the primary conditions associated with each particular
alternative.   Cases are presented as a sub-division of
alternatives to illustrate events where the pattern is
modified based on other variables.   For example, variable 1,
alternative b (Tank Commander engagement) has two cases.   The
first is a main gun or coax engagement; the second is a
Caliber .50 machine gun engagement.   Since the differences
between the crew duties are significant enough to list as
separate patterns, each case is presented separately.

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable 1.   Specify Crew Member to Conduct Engagement

Alternative.   a.   Gunner.

Conditions.   Four-man tank crew is preparing to engage with main gun/coax.

TC	GUNNER	LOADER	DRIVER
Announces "GUNNER" as alert element of fire command.	Proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative.   b.   Tank Commander.
Case.   (1) Main gun/coax.

Conditions.   Three-man tank crew is preparing to engage with main gun/coax.

TC	GUNNER	LOADER	DRIVER
Announces "LOAD . . ." as alert element of fire command. Omits description, direction and range elements.		Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative.   b.   Tank Commander.
Case.   (2) Cal .50

Conditions.   TC is preparing to engage a target with the Cal .50 machine gun.

TC	GUNNER	LOADER	DRIVER
Omits alert element of fire command.	Proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 1. Specify Crew Member to Engage

Alternative. c. Loader.

Conditions. The tank is participating in combat operations, a target appears. The TC intends to have the loader engage with the M240.

TC	GUNNER	LOADER	DRIVER
Announces "LOADER."	Observes.	Prepares to engage with M240.	Proceeds per normal engagement.

Behavioral Variable. 2. Engage point or Area Target

Alternative. a. Engage point target.
Case. (1) Main gun.

Conditions. Tank crew is engaging a point target with main gun.

TC	GUNNER	LOADER	DRIVER
Crew proceeds per baseline gunnery sequence. (See Appendix A.)			

Alternative. a. Engage point target.
Case. (2) Machine guns.

Conditions. Tank commander, gunner or loader is preparing to engaging a point target with Cal .50, coax, or M240 machine gun (respectively).

TC	GUNNER	LOADER	DRIVER
(CAL .50 ENGAGEMENT) Aims at target center of mass and fires.	(COAX ENGAGEMENT) Aims at target center of mass and fires.	(M240 ENGAGEMENT) Aims at target center of mass and fires.	Proceeds per normal engagement.

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APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   2.   Engage Point or Area Target

Alternative.   b.   Engage area target.

Conditions.   Tank commander, gunner, or loader is engaging an
area target with the Cal .50, coax, or M240 machine gun
(respectively).

TC	GUNNER	LOADER	DRIVER
(CALIBER .50) Aims at nearest corner of the target array, commences firing. Traverses through the front of the array to the opposite flank. Traverses through the center of the array to the far edge of the near flank. Finally, traverses along the back of the array to the opposite flank, forming a "Z" pattern. Fires bursts of 10 to 15 rounds each.	(COAX) Same as TC's engagement, except fires bursts of 20 to 30 rounds each.	(M240) Same as coax engagement.	Proceeds per normal engagement.

Behavioral variable.   3.   Engagement Technique

Alternative.   a.   Employ precision gunnery technique.

Conditions.   Tank crew is engaging a target within effective main
gun or coax range.   Target is not preparing to engage the tank,
battlecarry configuration may or may not be appropriate for
engagement.

TC	GUNNER	LOADER	DRIVER

Crew proceeds per baseline gunnery sequence.   (See appendix A.)

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   3.   Engagement Technique

Alternative.   b.   Employ battlesight gunnery technique.
Case.   (1) Initial battlesight engagement.

Conditions.   The tank is participating in combat operations.   A most dangerous target appears within battlesight range.   The LRF is ineffective.

TC	GUNNER	LOADER	DRIVER
Announces "BATTLE-SIGHT," as ammunition element; makes no attempt to evaluate range. Proceeds per normal engagement.	Acquires target, and announces "IDENTI-FIED." Omits lasing and range evaluation. Proceeds per normal engagement. If using GAS, applies predetermined battlesight range for prechambered round.	Proceeds per normal engagement. Prepares to reload with battlesight round.	Proceeds per normal engagement.

Alternative.   b.   Employ battlesight gunnery technique.
Case.   (2) Change ammunition for subsequent round.

Conditions.   The tank is engaging a most dangerous target using battlesight technique.   The prechambered battlesight round is SABOT, but HEAT is more appropriate to the target.   The tank commander has directed a battlesight engagement, and has just given the execution command.

TC	GUNNER	LOADER	DRIVER
Announces, "FIRE HEAT."	After firing first (SABOT) round, resets AMMUNITION SELECT switch to HEAT. Proceeds per battlesight engagement.	Loads HEAT round. Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable.   4.   Select Weapon/Ammunition Combination

Alternative. a. Main gun: SABOT (APFSDS-T).

Conditions. Tank is engaging a heavily armored target.

TC	GUNNER	LOADER	DRIVER
Announces "SABOT," as ammunition element of the fire command.	Sets GUN SELECT switch to MAIN GUN. Sets AMMUNITION SELECT switch to SABOT. Proceeds per normal engagement.	Loads SABOT round. Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative. b. Main gun: HEAT (HEAT-T).

Conditions. Tank is engaging a less heavily armored target or an area target beyond machine gun range.

TC	GUNNER	LOADER	DRIVER
Announces "HEAT," as ammunition element of the fire command. Proceeds per normal engagement.	Sets GUN SELECT switch to MAIN GUN. Sets AMMUNITION SELECT switch to HEAT. Proceeds per normal engagement.	Loads HEAT round. Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative. c. Coaxial machine gun.

Conditions. Tank is engaging a thin skinned vehicle or troop array, or suppressing a known/suspected enemy location within 900 meters.

TC	GUNNER	LOADER	DRIVER
Announces "COAX," as ammunition element of the fire command. Proceeds per normal engagement.	Sets GUN SELECT switch to COAX. Proceeds per normal engagement.	Observes.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 4. Select Weapon/Ammunition Combination

Alternative. d. Caliber .50 machine gun.

Conditions. TC is engaging a thin skinned vehicle or troop array, or suppressing a known/suspected enemy location within 1800 meters.

TC	GUNNER	LOADER	DRIVER
Announces "CALIBER FIFTY." Omits description, direction, range and execution elements. At end of engagement, announces "TC COMPLETE."	Attempts to observe tracers and assist TC to adjust on target.	Observes.	Proceeds per normal engagement.

Alternative. e. Loader's M240 machine gun.

Conditions. Loader is engaging a point or area target.

TC	GUNNER	LOADER	DRIVER
Announces "TWO-FORTY," as ammunition element of fire command. Proceeds per normal engagement.	Observes.	Mans weapon and prepares to engage.	Performs per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 5. Fire on the Move/From the Halt

Alternative. a. Fire on the move.

Conditions. The tank is moving and acquires a target. The FIRE
CONTROL MODE switch is set to NORMAL and stabilization is
functional.

TC	GUNNER	LOADER	DRIVER
Proceeds per normal engagement.	Proceeds per normal engagement.	Pushes ejection guard forward, insures MAIN GUN STATUS -- SAFE light comes on. Sets GUN/TURRET DRIVE switch to EL UNCPL, insures EL UNCPL light comes on.	Continues to drive, avoiding abrupt changes in speed or direction, if possible. Selects the smoothest available route in the general direction of travel.
		Loads main gun.	
		Moves ejection guard to rear, insures MAIN GUN STATUS -- ARMED light comes on. Clears path of recoil and announces "UP."	

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   5.   Fire on the Move/From the Halt

Alternative. b. Fire from the halt.
Case.   (1) Engagement initiated on the move, stabilization inoperative.

Conditions. The tank is moving and acquires a target. The FIRE CONTROL MODE switch is set to EMERGENCY and stabilization is not functional.

TC	GUNNER	LOADER	DRIVER
Issues initial fire command then announces "DRIVER STOP." -OR- Orders, "DRIVER STOP," then issues initial fire command. Proceeds per normal engagement.	Proceeds per normal engagement, EXCEPT sights through GAS when tank stops to verify terrain mask clearance. If not clear, directs driver forward to hull-down position. Proceeds per normal engagement.	Proceeds per normal engagement.	Brakes vehicle smoothly, prepares to move again on order.
Upon completion of engagement, orders "DRIVER MOVE OUT."			Releases brake and accelerates rapidly along original direction of travel.

Alternative. b. Fire from the halt.
Case.   (2) Engagement initiated from turret defilade position.

Conditions. The tank is stationary, in a turret down position, and a target is acquired.

TC	GUNNER	LOADER	DRIVER
Issues initial fire command.	Identifies target.	Proceeds per normal engagement.	Prepares to move tank.
Orders "DRIVER MOVE OUT, GUNNER TAKE OVER."	Sights through GAS.		Releases brakes, and drives tank forward to the hull-down position.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 5. Fire on the Move/From the Halt

Alternative b, Case (2), engagement initiated from turret
defilade position, continued.

TC	GUNNER	LOADER	DRIVER
	When main gun clears terrain mask, orders "DRIVER, STOP."		Brakes smoothly, shifts tank into reverse while holding brakes, and stands by.
When engagement is complete, orders "DRIVER, BACK UP."			Releases brakes and drives tank out of hull-down position per TC's directions.

Alternative. b. Fire from the halt.
Case. (3) Engagement initiated from a hull defilade or exposed
position (from the halt).

Conditions. The tank is in a hull-down position, and a target is
acquired.

TC	GUNNER	LOADER	DRIVER

Crew proceeds per baseline gunnery sequence. (See appendix A.)

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   6.   Track Moving/Stationary Target

Alternative.   a.   Engage stationary target.

Conditions. The tank is engaging a stationary target from the
halt, -OR- the target is moving directly at the firing tank (no
apparent movement), -OR- the tank is moving, stabilization is
functioning properly, and a target is acquired moving parallel to
the firing vehicle at the same speed (no apparent movement).

TC	GUNNER	LOADER	DRIVER
Crew proceeds per baseline gunnery sequence (see appendix A) except as modified by behavioral variable 5, alternative b.			

Alternative.   b.   Engage moving target.
Case.   (1) Stationary firing tank, moving target.

Conditions. The tank acquires a target with apparent movement,
and engages from the halt.

TC	GUNNER	LOADER	DRIVER
Inserts "MOVING" in target description. If engaging from his position, tracks target with override (main gun/coax), cupola power, or manual controls (Cal .50).	Gunner tracks target with power or manual controls.	Proceeds per normal engagement (main gun). If engaging with M240, tracks target manually.	Proceeds per normal engagement.

NOTE: If in emergency mode, if LAS is not functional, or if
using manual controls, gunner must conform with Behavioral
Variable 13, alternative b.

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   6.   Track Moving/Stationary Target

Alternative.   b.   Engage moving target.
Case.   (2) Firing tank is moving, target is moving or stationary.

Conditions.   The tank is moving.   A stationary target is acquired.   The target has apparent speed due to the motion of the firing tank.   Stabilization is operational, set to NORMAL mode.

TC	GUNNER	LOADER	DRIVER
Proceeds per normal engagement.	Manipulates power control handles to keep crosshairs on target.	Proceeds per stabilized gunnery engagement (Behavioral variable 5, alternative b).	Proceeds per stabilized gunnery engagement (Behavioral variable 5, alternative b).

Behavioral Variable.   7.   Specify Who is to Control Engagement

Alternative.   a.   Tank commander.

Conditions.   The crew is engaging a single (or multiple) main gun or machine gun target(s).

TC	GUNNER	LOADER	DRIVER

Crew proceeds per baseline gunnery sequence (see appendix A).

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 7. Specify Who is to Control Engagement

Alternative. b. Gunner.

Conditions. The crew has acquired multiple targets. The TC
intends to conduct simultaneous engagements.

TC	GUNNER	LOADER	DRIVER
Issues initial fire command, then announces "FIRE AND ADJUST." Proceeds with caliber .50 engagement. Upon completion of caliber .50 engagement, announces "TC COMPLETE," and resumes control of main gun/ coax engagement.	Proceeds per normal engagement EXCEPT does not wait for TC's execution command. Upon completion announces "TARGET, CEASE FIRE" (Main gun), OR- "GUNNER COMPLETE" (coax).	Proceeds per normal engagement, taking loading commands from the gunner.	Proceeds per normal engagement.

Alternative. c. Loader.

Conditions. The TC has issued an initial fire command for the
loader to engage a target with the M240. The TC is going to
conduct a simultaneous engagement against a second target with
the Cal .50 (or Coax).

TC	GUNNER	LOADER	DRIVER
Announces "FIRE AND ADJUST." Proceeds with other engagement.	Assists loader or TC, as required.	Engages target, once target has been defeated, announces "LOADER COMPLETE."	Proceeds per normal engagement.

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   8.   Select Weapon Sight

Alternative.   a.   Gunner's Primary Sight (GPS).

Conditions. The gunner is engaging a target with the primary
fire control system operational. The engagement is conducted day
or night, with visibility clear or obscured.

TC	GUNNER	LOADER	DRIVER
Crew proceeds per baseline gunnery sequence (see appendix A).			

Alternative.   b.   Gunner's Auxiliary Sight (GAS).

Conditions. The gunner is engaging a target with main gun or
coax. The GPS is inoperative. The engagement takes place under
daylight or night/illuminated conditions, visibility clear.

TC	GUNNER	LOADER	DRIVER
Issues initial fire command to include estimated range, per behavioral variable 10, alternative d. Otherwise, proceeds per normal engagement.	Selects GAS reticle corresponding to ammunition specified in fire command, sights through GAS. Applies range per behavioral variable 10, alternative c. Otherwise, proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 8. Select Weapon Sight

Alternative. c. Gunner's Primary Sight Extension (GPSE).

Conditions. The tank commander is engaging a target from his position with the main gun or coax. The Primary Fire Control system is operational.

TC	GUNNER	DRIVER	LOADER
Sights through GPSE. Proceeds with precision/battlesight gunnery sequence with appropriate modifications.		Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative. d. Commander's Weapon Station Sight (CWS).

Conditions. Tank commander is engaging a target with the Caliber .50 from inside the vehicle.

TC	GUNNER	LOADER	DRIVER
Sights through CWS. Applies range per behavioral variable 10, alternative c. Proceeds with Cal .50 engagement.			Proceeds per normal engagement.

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APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   8.   Select Weapon Sight

Alternative.   e.   Iron sights.

Conditions.   Tank commander or loader is engaging a target with
the Cal .50 or M240 machine gun (respectively) from the open
hatch, or the TC is sighting through the CWS unity periscope from
inside the tank.

TC	GUNNER	LOADER	DRIVER
(CAL .50) Sights along top of weapon. Estimates range, lead, and other adjustments. -OR- Sights through unity periscope using iron sights along bottom of weapon.		(M240) Aims weapon using rear leaf and front blade sights.	

Behavioral Variable.   9.   Employ Thermal Imaging System/Daylight
Channel

Alternative.   a.   Employ daylight channel.

Conditions.   The crew is engaging a target with main gun/coax
using any sight.   The thermal mode switch is in stand-by or off.

TC	GUNNER	LOADER	DRIVER

Crew proceeds per baseline gunnery sequence.   (See appendix A.)

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 9. Employ Thermal Imaging System/Daylight Channel

Alternative. b. Employ thermal imaging system.

Conditions. The crew is engaging a target with main gun/coax using either the GPS or GPSE. The thermal mode switch is in stand-by. The engagement occurs at night or under daylight conditions. Any obscuration (e.g., fog or smoke) present is penetrated by the thermal channel.

TC	GUNNER	LOADER	DRIVER
Proceeds per normal engagement.	Switches THERMAL MODE switch to ON. Adjusts POLARITY and SENSITIVITY as required to refine image.	Proceeds per normal engagement.	Proceeds per normal engagement.

Behavioral Variable. 10. TC's Ranging Actions

Alternative. a. TC does not range.

Conditions. The tank crew is engaging a target using precision gunnery. The LRF is operational, -OR- the tank crew is engaging a target using battlesight gunnery. The TC has estimated the range to the target.

TC	GUNNER	LOADER	DRIVER
(Precision) Proceeds per normal engagement. (Battlesight) Makes no attempt to range or evaluate range.	See behavioral variable 11.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 10. TC's Ranging Actions

Alternative. b. TC lases.

Conditions. The tank commander is conducting a precision
engagement from his position with the main gun or coax, -OR- the
gunner has lased, but the TC is not satisfied with the return(s).

TC	GUNNER	LOADER	DRIVER
Using commander's station power control handle and sighting through GPSE, lays on target center of mass and lases.		Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative. c. TC indexes/applies range.
Case. (1) Indexes range for main gun/coax engagement.

Conditions. The tank crew is conducting a precision engagement.
The gunner or TC has ranged. The TC evaluates the range return,
but is not satisfied with the return, -OR- the crew is conducting
a precision engagement and the LRF is ineffective.

TC	GUNNER	LOADER	DRIVER
Adjusts range with MANUAL RANGE ADD/DROP toggle switch on commander's control panel. Proceeds per normal engagement.	See behavioral variable 11.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 10. TC's Ranging Actions

Alternative. c. TC indexes/applies range.
Case. (2) Applies range for Cal .50 engagement.

Conditions. The TC is conducting a Cal .50 engagement.

TC	GUNNER	LOADER	DRIVER
(CWS) Takes up sight picture, centering target vertically on the range line corresponding with the range to target.	See behavioral variable 11, alternative b.	Proceeds per normal Cal .50 engagement.	Proceeds per normal engagement.

Alternative. d. TC announces range.
Case. (1) Gunner is using GAS.

Conditions. The crew is conducting a precision engagement. The LRF is ineffective. The gunner is using the GAS.

TC	GUNNER	LOADER	DRIVER
Announces range to target to nearest one hundred meters as range element of fire command.	See behavioral variable 11, alternative c.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 10. TC's Ranging Actions

Alternative. d. TC announces range.[1]
Case. (2) Gunner is using GPS, TC directs gunner to index range.

Conditions. The crew is conducting a precision engagement, the gunner is sighting through the GPS. The LRF is ineffective.

TC	GUNNER	LOADER	DRIVER
Announces "INDEX [RANGE]" as range element of fire command.	Indexes range per behavioral variable 11, alternative c.	Proceeds per normal engagement.	Proceeds per normal engagement.

Behavioral Variable. 11. Gunner's Ranging Actions

Alternative. a. Gunner does not range.

Conditions. The crew is conducting a battlesight engagement, the crew is conducting a precision engagement, the LRF is inoperative, and the TC has previously instructed the gunner that he (the TC) will index the range to the target manually (behavioral variable 10, alternative c), or the gunner is reengaging a target that was hit or near-missed with the previous round, in degraded mode.

TC	GUNNER	LOADER	DRIVER
Proceeds per behavioral variable 10.	Makes no attempt to range or evaluate range. Otherwise, proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

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[1]Range is rounded off to the nearest ten meters. If range is estimated at an even hundred or thousand, the term "HUNDRED" or "THOUSAND" is used. Otherwise, each digit is pronounced individually. E.g.: "EIGHT-SIX-ZERO," "ONE-FIVE-HUNDRED," or "TWO THOUSAND."

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   11.   Gunner's Ranging Actions

Alternative.   b.   Gunner lases.
Case.   (1) Precision main gun/coax engagement.

Conditions.   The crew is conducting a precision engagement with
the main gun or coax.   The LRF is operational.

TC	GUNNER	LOADER	DRIVER
Crew proceeds per baseline gunnery sequence (Appendix A), as modified by previous behavioral variables and alternatives.			

Alternative.   b.   Gunner lases.
Case.   (2) Gunner lases to determine range for Cal .50
engagement.

Conditions.   The TC is preparing to engage a target with the Cal
.50 machine gun.   The Cal .50 is aligned in azimuth with the main
gun.   No other engagements are in progress.

TC	GUNNER	LOADER	DRIVER
TC proceeds with engagement as outlined in prior behavioral variables and alternatives.	Lays on target center of mass, lases, evaluates range, and announces range.	Proceeds per normal Cal .50 engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 11. Gunner's Ranging Actions

Alternative. c. Gunner indexes/applies range.
Case. (1) Gunner indexes range, sights through GPS.

Conditions. The crew is conducting a precision engagement, the gunner is sighting through the GPS. The LRF is ineffective.

TC	GUNNER	LOADER	DRIVER
Issues fire command, to include range element: "INDEX [RANGE]." Proceeds per normal engagement.	Opens CCP door. Turns CCP on. Depresses RANGE key. Enters range. Depresses ENTER key. Depresses RANGE key again. Proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative. c. Gunner indexes/applies range.
Case. (1) Gunner is sighting through GAS.

Conditions. The crew is conducting a precision engagement, the gunner is sighting through the GAS; or the crew is conducting a battlesight engagement, the gunner is sighting through the GAS. The proper reticle for the type ammunition in use has been selected.

TC	GUNNER	LOADER	DRIVER
Proceeds per previous behavioral variables and alternatives.	Aligns specified range line with target's vertical center of visible mass. Proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 12. Select Traverse and Elevation Method

Alternative. a. Traverse and elevate electrically.

Conditions. The gunner or TC is engaging a target with the main gun, coax, or Cal .50. The turret/cupola power is operational and the POWER/MANUAL lever is in the POWER position.

TC	GUNNER	DRIVER	LOADER
(CAL .50) Tracks target using CWS Power control handle (traverse only). Elevates manually (see alternative b, below). (MAIN GUN/COAX) Tracks target with commander's power control handle. (Override.) Proceeds per normal engagement.	Tracks target with gunner's power control handles. Proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 12. Select Traverse and Elevation Method

Alternative. b. Traverse and elevate manually.
Case. (1) Main gun/coax.

Conditions. The tank is engaging a target with the main gun/coax. The turret power is inoperative.

TC	GUNNER	LOADER	DRIVER
Inserts direction element in fire command using traverse, reference point and deflection, or target marking method to direct gunner to target. Otherwise, proceeds per normal engagement.	Traverses using gunner's manual traverse crank. Elevates using gunner's manual elevation crank. When engaging moving targets, applies lead per behavioral variable 13, alternative b.	Proceeds per normal engagement.	Proceeds per normal Engagement.

Alternative. b. Traverse and elevate manually.
Case. (2) Caliber .50 engagement.

Conditions. The TC is engaging a target with the Cal .50 machine gun. The cupola power is inoperative or he chooses to traverse and elevate manually. The POWER/MANUAL lever is in the MANUAL position.

TC	GUNNER	LOADER	DRIVER
Traverses using the manual traverse ring. Elevates using the CWS elevation crank knob.	Proceeds per normal Cal .50 engagement.	Proceeds per normal Cal .50 engagement.	Proceeds per normal engagement.

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   12.   Select Traverse and Elevation Method

Alternative.   b.   Traverse and elevate manually.
Case (3) M240 engagement.

Conditions.   The loader is engaging a target with the M240.   The
machine gun is loaded and on safe.

TC	GUNNER	LOADER	DRIVER
		Pulls skate lock to center position, removes elevation lock pin. Grasps hand grips. Adjusts direction and elevation by moving receiver left/ right and up/down. For gross adjustments in direction, pushes skate along rail.	

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 13. Gunner/TC Applies Standard Lead (Does Not Apply Lead)

Alternative. a. Engage with no lead adjustment or with system induced lead.

Conditions. The crew is engaging with main gun/coax from a moving or stationary tank with fully operational stabilization system, turret power, and lead angle function, the gunner is sighting through the GPS, the target may or may not have apparent movement. -OR- The TC/gunner is engaging a target with Cal .50/main gun/coax, using any sight, target has no apparent movement, firing from the halt or on the move (stabilized main gun/coax).

TC	GUNNER	LOADER	DRIVER
(CAL .50, MAIN GUN OR COAX.) Centers target in sight horizontally. Proceeds per normal engagement.	(MAIN GUN, COAX) Centers target in sight. Momentarily releases palm switches before lasing. Re-lays on center of mass and tracks target per variable 6.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 13. Gunner/TC Applies Standard Lead

Alternative. b. Apply standard lead.
Case. (1) Main gun or coax engagement.

Conditions. The gunner or TC is engaging a target with the main gun or coax, using the GPS, GAS, or GPSE. The target has apparent movement and the firing tank's lead angle function is inoperative, or has been bypassed by the sight selection (GAS), the decision to traverse manually, or selection of emergency mode.

TC	GUNNER	LOADER	DRIVER
If firing from his position, applies standard lead as shown to right.	SABOT: Takes up a sight picture with the cross hairs 2.5 mils in front (with respect to the target's movement) of the target center or mass. HEAT, COAX: Takes up a sight picture with the cross hairs 5 mils in front of the target center of mass.	Proceeds per normal engagement.	Proceeds per normal engagement.

Alternative. b. Apply standard lead.
Case. (2) Cal .50 engagement.

Conditions. The TC is engaging a target with the Cal .50 using the CWS.[2] The target has apparent movement.

TC	GUNNER	LOADER	DRIVER
Aims 5 mils in front of the target center of mass.	Proceeds per normal Cal .50 engagement.	Proceeds per normal Cal .50 engagement.	Proceeds per normal engagement.

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[2]For engagements with the Cal .50 or M240 using the iron sights, lead is estimated by the TC/loader for the initial burst, then the tracers are "walked into" the target (tracers are observed and aim adjusted to strike target).

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   14.   Adjust the Sight Picture

Alternative.   a.   No adjustment.

Conditions.   The crew is engaging a target (precision or battlesight).   No adjustments are necessitated by equipment failures or the relative movement or positions of the target and the firing tank, -OR- an adjustment for cant is not applied because the tank is engaging a most dangerous target.

TC	GUNNER	LOADER	DRIVER

The crew proceeds per baseline engagement sequence (Appendix A), except as modified by previous behavioral variables and alternatives.

Alternative.   b.   Adjust for cant.

Conditions.   The crew is conducting a precision engagement against a dangerous or least dangerous target.   The tank is in a firing position with a noticeable cant to one side.   The cant sensor is inoperative.   The ballistic computer has been reprogrammed (during prepare-to-fire procedures) so that it makes no automatic adjustment for cant.

TC	GUNNER	LOADER	DRIVER
Proceeds per normal engagement. If engaging from his position, adjusts as shown at right.	Lases per behavioral variable 11, alternative b. For every 1000 meters of range, aims one mil high and one mil opposite the direction of cant (uphill). Proceeds per normal engagement.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 14. Adjust the Sight Picture

Alternative. c. Apply standard adjustment.

Conditions. The crew is conducting a precision (degraded) or
battlesight engagement. A prior round was observed to miss the
target. The loader has reloaded with the same type of round and
has announced "UP." An adjacent tank may have transmitted an
observation.

TC	GUNNER	LOADER	DRIVER
	Keeps palm switches depressed. Announces observation ("[OVER, SHORT],"), and intended correction in deflection and/or range. (Deflection: "[LEFT/ RIGHT] ONE. Range: "[ADD/DROP] ONE (GPS), or "[ADD/DROP] 200 (GAS).)	Proceeds per normal engagement.	Proceeds per normal engagement.
Announces, "FIRE." Braces and observes.	Adjusts aim per proposed correction.		

Alternative. d. Adjust per subsequent fire command.

Conditions. The crew is conducting a precision or battlesight
engagement. A prior round was observed to miss the target. The
loader has reloaded with the same type of round, and has
announced "UP." An adjacent tank may have transmitted an
observation.

TC	GUNNER	LOADER	DRIVER
	Keeps palm switches depressed. Announces observation and intended correction in deflection and/or range, as above.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   14.   Adjust the Sight Picture

Alternative d, continued.

TC	GUNNER	LOADER	DRIVER
Issues subsequent fire command, modifying the adjustment proposed by the gunner. (See Table 5-3.) Subsequent fire command consists of an alert [TC's OBSERVATION], deflection and range corrections and execution elements.	Applies deflection and range corrections dictated by TC. Proceeds per normal engagement.		

Behavioral Variable.   15.   Fire with Electrical/Manual Trigger/ Firing Device

Alternative.   a.   Fire with electrical trigger.
Case.   (1) Main gun/coax.

Conditions.   The gunner or tank commander is engaging a target with the main gun or coax.

TC	GUNNER	LOADER	DRIVER

(FIRING FROM HIS POSITION) Announces, "FROM MY POSITION, ON THE WAY." Waits one second and fires using trigger on commander's power control handle (override).	Announces "ON THE WAY." Waits one second and fires using:
	    (1) The electrical trigger on either hand of the gunner's power control handles,
	         -OR-
	    (2) The electrical trigger on the gunner's manual elevation crank.
		Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable. 15. Fire with Electrical/Manual Trigger/Firing Device

Alternative. a. Fire with electrical trigger.
Case. (2) Caliber .50 machine gun.

Conditions. The tank commander is engaging a target with the caliber .50 machine gun.

TC	GUNNER	LOADER	DRIVER
Sets safety switch to fire and pulls down on CWS elevation crank knob.	Proceeds per normal cal .50 engagement.	Proceeds per normal cal .50 engagement.	Proceeds per normal engagement.

Alternative. b. Fire with manual trigger/firing device.
Case. (1) Main gun.

Conditions. The crew is engaging a target with the main gun. The turret power is inoperative or the electrical triggers on the gunner's and commander's control handles and the manual elevation crank are inoperable.

TC	GUNNER	LOADER	DRIVER
Proceeds per normal engagement.	After announcing "ON THE WAY" and waiting one second, cranks the handle of the manual firing device (blasting machine) clockwise, rapidly, up to four times.	Proceeds per normal engagement.	Proceeds per normal engagement.

APPENDIX B.   GUNNERY BEHAVIORS

Behavioral Variable.   15.   Fire with Electrical/Manual Trigger/
Firing Device

Alternative.   b.   Fire with manual trigger/firing device.
Case.   (2) Coaxial machine gun.

Conditions.   The crew is engaging a target with the coax.   The
turret power is inoperative or the electrical triggers on the
gunner's and commander's control handles and the manual elevation
crank are inoperable.

TC	GUNNER	LOADER	DRIVER
Proceeds per normal engagement.	After announcing "ON THE WAY" and waiting one second, presses button on rear of solenoid.	Proceeds per normal coax engagement.	Proceeds per normal engagement.

Alternative.   b.   Fire with manual trigger/firing device.
Case.   (3) Caliber .50 machine gun.

Conditions.   The tank commander is engaging a target with the Cal
.50.   The electrical trigger is not functioning.

TC	GUNNER	LOADER	DRIVER
Fires using manual trigger on rear of receiver group.	Proceeds per normal Cal .50 engagement.	Proceeds per normal Cal .50 engagement.	Proceeds per normal engagement.

APPENDIX B. GUNNERY BEHAVIORS

Behavioral Variable.   15.   Fire with Electrical/Manual Trigger/
Firing Device

Alternative.   b.   Fire with manual trigger/firing device.
Case.   (4) Loader's M240 machine gun.

Conditions.   The loader is engaging a target with the M240.

TC	GUNNER	LOADER	DRIVER
Proceeds per normal M240 engagement.	Proceeds per normal M240 engagement.	Puts safety on "FIRE," fires weapon using trigger on rear of receiver group.	Proceeds per normal M240 engagement.

APPENDIX C

Engagement Task List

CONTENTS

APPENDIX C.   ENGAGEMENT TASK LIST

CONTENTS (Continued)

LIST OF FIGURES

APPENDIX C.   ENGAGEMENT TASK LIST

Explanation

This task list enumerates the possible engagement patterns that remain after eliminating all illogical, impossible, or extremely unlikely combinations of the fifteen behavioral variables identified and explained in Chapter 4. The variables identified in Table 4-2 are reproduced in Table C-1, below, and a numerical code is assigned for each alternative.

Table C-1

Crew Gunnery Behavioral Variables and Codes

VARIABLE		ALTERNATIVES	NUMERICAL CODE
1.	Crew member engaging target	a. Gunner	1
		b. TC	2
		c. Loader	3
2.	Engage point or area target	a. Engage a point target	1
		b. Engage an area target	2
3.	Engagement technique	a. Precision	1
		b. Battlesight	2
4.	Weapon/ammunition combination	a. Main Gun/SABOT	1
		b. Main Gun/HEAT	2
		c. Coax	3
		d. Caliber .50	4
		e. Loader's M240	5
5.	Fire on the move?	a. No	0
		b. Yes	1
6.	Track target?	a. Engage a target with no apparent movement	0
		b. Track and engage a target with apparent movement.	1
7.	Crew member controlling the engagement	a. TC	1
		b. Gunner	2
		c. Loader	3

(table continues)

C-3

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-1 (continued)

VARIABLE	ALTERNATIVES		NUMERICAL CODE
8. Sight selection	a.	GPS	1
	b.	GAS	2
	c.	GPSE	3
	d.	CWS	4
	e.	Iron sights	5
9. Employ TIS?	a.	No	0
	b.	Yes	1
10. TC's ranging actions.	a.	None	0
	b.	Lases	1
	c.	Indexes/applies range	2
	d.	Announces range	3
11. Gunner's ranging actions	a.	None	0
	b.	Lases	1
	c.	Indexes/applies range	2
12. Traverse and elevation method	a.	Power	1
	b.	Manual	0
13. Apply standard lead?	a.	No	0
	b.	Yes	1
14. Sight picture adjustment	a.	None	0
	b.	For cant	1
	c.	Standard adjustment	2
	d.	Per subsequent fire command	3
15. Fire with	a.	Electrical trigger	1
	b.	Manual firing device/trigger	0

APPENDIX C. ENGAGEMENT TASK LIST

Hierarchy of Tank Sub-systems

Several of the fire control system components are inter-connected so that a failure in one system may affect other subsystems. These relationships affect the selection of crew engagement behaviors, especially those involved in degraded mode gunnery.

Figure C-1 illustrates the components of and interconnections among the fire control system. A failure of any subsystem illustrated breaks the power or data flow affecting all down line systems. For example, a stabilization failure disables the lead angle sensor. This failure, in turn, affects the ballistic computer. Since the ballistic computer only depends on the lead angle sensor for a certain type of data input, the stabilization failure does not disable the computer. There is a degradation in the computer's effectiveness. Since a bypass exists for the electrical drive, the stabilization failure does not disable the turret power controls.

The primary fire control system depends upon the ballistic computer to insure accuracy of fires. The computer receives data from a number of different sensors, as illustrated. The crew makes manual entries through one of the three control panels. Based on the manual and automatic inputs, the computer adjusts the aiming point of the gunner's primary sight and gunner's primary sight extension with respect to the axis of the main gun. The gunner moves the turret with the turret electrical controls, and the sights follow. The ready-to-fire box in the GPS reticle (to the left of the range display) indicates that the gun is properly aligned with the sights, to properly offset the gun axis from the gunner's line of sight, based on all available data, and that the main gun is armed. Once the aiming point of the sight is on target center of visible mass, and the ready-to-fire box is displayed, the gunner fires. If all data are correct, the round should strike very close to the aiming point. Faulty data input or subsystem failures may reduce the computer's effectiveness.

The gunner's auxiliary sight is mechanically linked to the main gun and is totally independent of the ballistic computer. As the gunner moves the main gun with the turret controls, the sight follows, but none of the sophisticated ballistic corrections available in the primary fire control system are relayed to the auxiliary sight. If the stabilization system is operational and the gunner is using the turret electrical control handles, the stabilization system will counteract the movements of the tank (allowing the gunner to track the
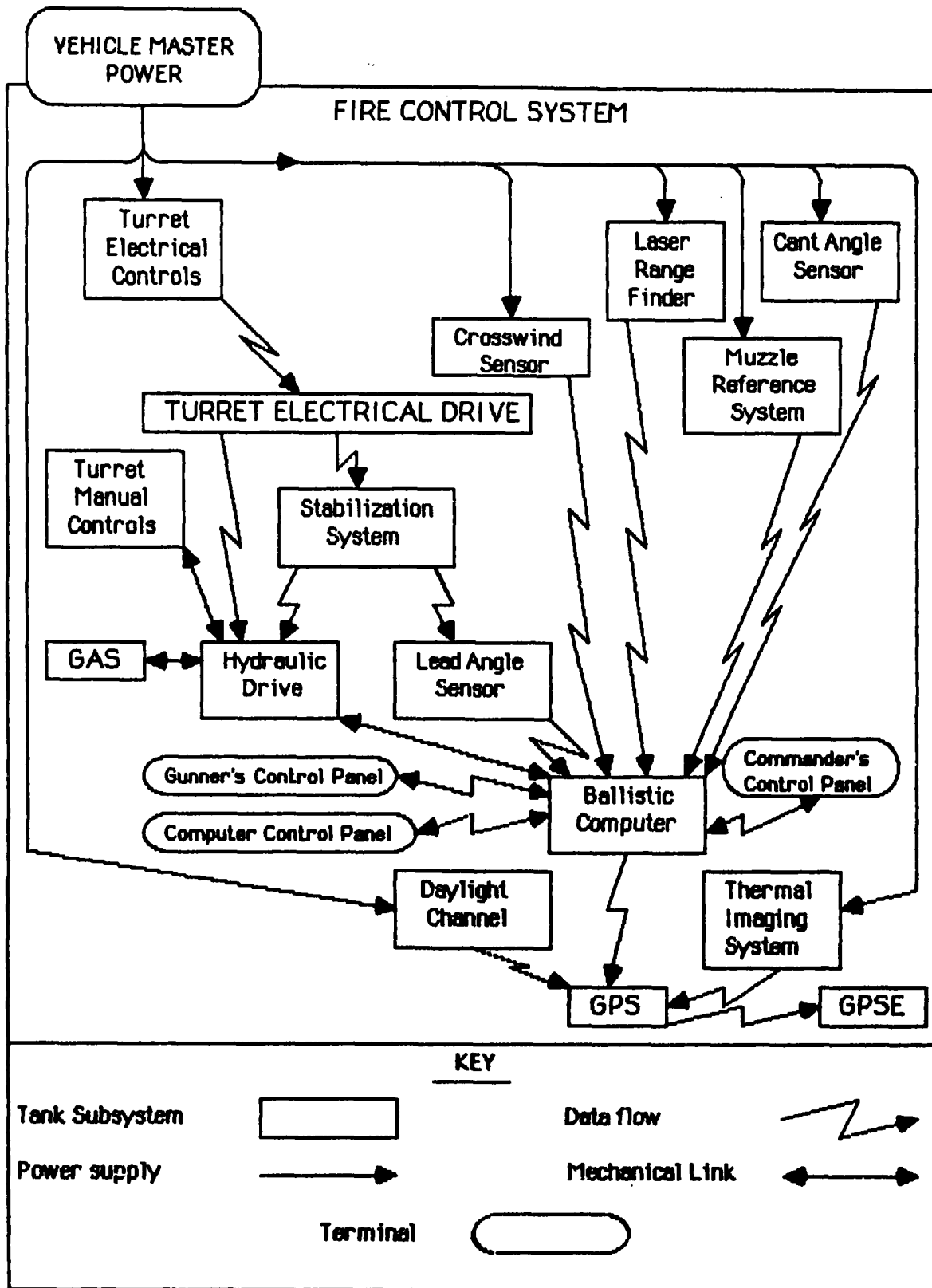
Figure C-1.   Fire control system schematic diagram.

target), but any other corrections (e.g.: lead if the lead angle sensor is inoperative) must be made manually.

The turret manual controls bypass the stabilization system and the lead angle function, but can be used in conjunction with the primary fire control system to benefit from all other ballistic corrections.

Engagement Task List

The task numbers in table C-2 represent each of the logical combinations of the fifteen behavioral variables in the engagement sequence. The fifteen digits are the codes associated with each behavioral variable. Any task number within Table C-2 can be interpreted by referencing each digit to the corresponding codes in Table C-1. Impossible or extremely unlikely variable combinations have been eliminated to show only the possible combinations.

Each task number is partitioned primarily for ease of interpretation, but the partitions also fall logically within the overall gunnery behavioral pattern. These partitions are explained below. Task number 1111-00-21120-1001 is used as an example. Note that the headings throughout the table identify the alternatives associated with the first six digits.

The first four digits refer to the crew member firing the engagement, the target's dispersion, the engagement technique and the weapon/ammunition combination. In the example, the first four digits (1111) represent a gunner's engagement of a point target, using precision gunnery, and firing SABOT. These same first four digits, in combination with any other pattern, will represent the same alternatives of these variables.

The next two digits (-00) relate to the movement of the firing tank and the target. In the example, the firing tank is stationary, and the target has no apparent movement.

The third group of five digits (-21120 in the example) indicate who is controlling the engagement, the sight and channel selection, and the ranging actions of the TC and gunner. In the example, the gunner is controlling the engagement, using the GPS, TIS on, TC lasing and gunner performing no ranging function. Although this arrangement of the last two variables in this group is abnormal, it is a viable pattern.

APPENDIX C.   ENGAGEMENT TASK LIST

The last set of four digits (1001) indicate the controls
being used, adjustments to the sight picture for lead and
other inputs, and whether a manual or electrical trigger is
used.   In the case sited, the gunner is using the power
control handles, is making no adjustments for lead or any
other reason, and is firing with an electrical trigger.

APPENDIX C. ENGAGEMENT TASK LIST

Table C-2

Engagement Task List

Gunner's Engagements

Gunner engages stationary point target, precision, with SABOT, from the halt; enumeration:

1111-00-11000-1001	1111-00-11000-1020	1111-00-11000-0011	1111-00-11000-0030	1111-00-11001-1031
1111-00-11000-1000	1111-00-11000-1031	1111-00-11000-0010	1111-00-11001-1001	1111-00-11001-1030
1111-00-11000-1011	1111-00-11000-1030	1111-00-11000-0021	1111-00-11001-1000	1111-00-11001-0001
1111-00-11000-1010	1111-00-11000-0001	1111-00-11000-0020	1111-00-11001-1011	1111-00-11001-0000
1111-00-11000-1021	1111-00-11000-0000	1111-00-11000-0031	1111-00-11001-1010	1111-00-11001-0011
1111-00-11001-0010	1111-00-11010-1011	1111-00-11010-0010	1111-00-11011-0001	1111-00-11020-1000
1111-00-11001-0031	1111-00-11010-1010	1111-00-11011-1001	1111-00-11011-0000	1111-00-11020-1011
1111-00-11001-0030	1111-00-11010-0001	1111-00-11011-1000	1111-00-11011-0011	1111-00-11020-1010
1111-00-11010-1001	1111-00-11010-0000	1111-00-11011-1011	1111-00-11011-0010	1111-00-11020-0001
1111-00-11010-1000	1111-00-11010-0011	1111-00-11011-1010	1111-00-11020-1001	1111-00-11020-0000
1111-00-11020-0011	1111-00-11021-1010	1111-00-11032-1001	1111-00-11032-1030	1111-00-11032-0031
1111-00-11020-0010	1111-00-11021-0001	1111-00-11032-1000	1111-00-11032-0001	1111-00-11032-0030
1111-00-11021-1001	1111-00-11021-0000	1111-00-11032-1011	1111-00-11032-0000	1111-00-11100-1001
1111-00-11021-1000	1111-00-11021-0011	1111-00-11032-1010	1111-00-11032-0011	1111-00-11100-1000
1111-00-11021-1011	1111-00-11021-0010	1111-00-11032-1031	1111-00-11032-0010	1111-00-11100-1011
1111-00-11100-1010	1111-00-11100-0001	1111-00-11100-0020	1111-00-11101-1011	1111-00-11101-0000
1111-00-11100-1021	1111-00-11100-0000	1111-00-11100-0031	1111-00-11101-1010	1111-00-11101-0011
1111-00-11100-1020	1111-00-11100-0011	1111-00-11100-0030	1111-00-11101-1031	1111-00-11101-0010
1111-00-11100-1031	1111-00-11100-0010	1111-00-11101-1001	1111-00-11101-1030	1111-00-11101-0031
1111-00-11100-1030	1111-00-11100-0021	1111-00-11101-1000	1111-00-11101-0001	1111-00-11101-0030
1111-00-11110-1001	1111-00-11110-0000	1111-00-11111-1011	1111-00-11111-0010	1111-00-11120-0001
1111-00-11110-1000	1111-00-11110-0011	1111-00-11111-1010	1111-00-11120-1001	1111-00-11120-0000
1111-00-11110-1011	1111-00-11110-0010	1111-00-11111-0001	1111-00-11120-1000	1111-00-11120-0011
1111-00-11110-1010	1111-00-11111-1001	1111-00-11111-0000	1111-00-11120-1011	1111-00-11120-0010
1111-00-11110-0001	1111-00-11111-1000	1111-00-11111-0011	1111-00-11120-1010	1111-00-11121-1001
1111-00-11121-1000	1111-00-11121-0011	1111-00-11132-1010	1111-00-11132-0011	1111-00-12032-1000
1111-00-11121-1011	1111-00-11121-0010	1111-00-11132-1031	1111-00-11132-0010	1111-00-12032-1011
1111-00-11121-1010	1111-00-11132-1001	1111-00-11132-1030	1111-00-11132-0031	1111-00-12032-1010
1111-00-11121-0001	1111-00-11132-1000	1111-00-11132-0001	1111-00-11132-0030	1111-00-12032-1031
1111-00-11121-0000	1111-00-11132-1011	1111-00-11132-0000	1111-00-12032-1001	1111-00-12032-1030

(table continues)

Table C-2 (Continued)

Gunner engages stationary point target, precision, with SABOT,
from the halt; enumeration, continued:

1111-00-12032-0001	1111-00-12032-0030	1111-00-21000-1021	1111-00-21000-0010	1111-00-21001-1011
1111-00-12032-0000	1111-00-21000-1001	1111-00-21000-1020	1111-00-21000-0021	1111-00-21001-1010
1111-00-12032-0011	1111-00-21000-1000	1111-00-21000-0001	1111-00-21000-0020	1111-00-21001-0001
1111-00-12032-0010	1111-00-21000-1011	1111-00-21000-0000	1111-00-21001-1001	1111-00-21001-0000
1111-00-12032-0031	1111-00-21000-1010	1111-00-21000-0011	1111-00-21001-1000	1111-00-21001-0011
1111-00-21001-0010	1111-00-21010-0001	1111-00-21011-1000	1111-00-21011-0011	1111-00-21020-1010
1111-00-21010-1001	1111-00-21010-0000	1111-00-21011-1011	1111-00-21011-0010	1111-00-21020-0001
1111-00-21010-1000	1111-00-21010-0011	1111-00-21011-1010	1111-00-21020-1001	1111-00-21020-0000
1111-00-21010-1011	1111-00-21010-0010	1111-00-21011-0001	1111-00-21020-1000	1111-00-21020-0011
1111-00-21010-1010	1111-00-21011-1001	1111-00-21011-0000	1111-00-21020-1011	1111-00-21020-0010
1111-00-21021-1001	1111-00-21021-0000	1111-00-21032-1011	1111-00-21032-0010	1111-00-21100-1021
1111-00-21021-1000	1111-00-21021-0011	1111-00-21032-1010	1111-00-21100-1001	1111-00-21100-1020
1111-00-21021-1011	1111-00-21021-0010	1111-00-21032-0001	1111-00-21100-1000	1111-00-21100-0001
1111-00-21021-1010	1111-00-21032-1001	1111-00-21032-0000	1111-00-21100-1011	1111-00-21100-0000
1111-00-21021-0001	1111-00-21032-1000	1111-00-21032-0011	1111-00-21100-1010	1111-00-21100-0011
1111-00-21100-0010	1111-00-21101-1011	1111-00-21101-0010	1111-00-21110-0001	1111-00-21111-1000
1111-00-21100-0021	1111-00-21101-1010	1111-00-21110-1001	1111-00-21110-0000	1111-00-21111-1011
1111-00-21100-0020	1111-00-21101-0001	1111-00-21110-1000	1111-00-21110-0011	1111-00-21111-1010
1111-00-21101-1001	1111-00-21101-0000	1111-00-21110-1011	1111-00-21110-0010	1111-00-21111-0001
1111-00-21101-1000	1111-00-21101-0011	1111-00-21110-1010	1111-00-21111-1001	1111-00-21111-0000
1111-00-21111-0011	1111-00-21120-1010	1111-00-21121-1001	1111-00-21121-0000	1111-00-21132-1011
1111-00-21111-0010	1111-00-21120-0001	1111-00-21121-1000	1111-00-21121-0011	1111-00-21132-1010
1111-00-21120-1001	1111-00-21120-0000	1111-00-21121-1011	1111-00-21121-0010	1111-00-21132-0001
1111-00-21120-1000	1111-00-21120-0011	1111-00-21121-1010	1111-00-21132-1001	1111-00-21132-0000
1111-00-21120-1011	1111-00-21120-0010	1111-00-21121-0001	1111-00-21132-1000	1111-00-21132-0011
1111-00-21132-0010	1111-00-22032-1000	1111-00-22032-1010	1111-00-22032-0000	1111-00-22032-0010
1111-00-21132-1001	1111-00-22032-1011	1111-00-22032-0001	1111-00-22032-0011	

Permutations this subset: 284

(table continues)

Table C-2 (Continued)

Gunner engages moving point target, precision, with SABOT, from the halt; enumeration:

1111-01-11000-1001	1111-01-11000-1020	1111-01-11000-1111	1111-01-11000-1130	1111-01-11000-0121
1111-01-11000-1000	1111-01-11000-1031	1111-01-11000-1110	1111-01-11000-0101	1111-01-11000-0120
1111-01-11000-1011	1111-01-11000-1030	1111-01-11000-1121	1111-01-11000-0100	1111-01-11000-0131
1111-01-11000-1010	1111-01-11000-1101	1111-01-11000-1120	1111-01-11000-0111	1111-01-11000-0130
1111-01-11000-1021	1111-01-11000-1100	1111-01-11000-1131	1111-01-11000-0110	1111-01-11001-1001
1111-01-11001-1000	1111-01-11001-1101	1111-01-11001-1130	1111-01-11001-0131	1111-01-11010-1010
1111-01-11001-1011	1111-01-11001-1100	1111-01-11001-0101	1111-01-11001-0130	1111-01-11010-1031
1111-01-11001-1010	1111-01-11001-1111	1111-01-11001-0100	1111-01-11010-1001	1111-01-11010-1030
1111-01-11001-1031	1111-01-11001-1110	1111-01-11001-0111	1111-01-11010-1000	1111-01-11010-1101
1111-01-11001-1030	1111-01-11001-1131	1111-01-11001-0110	1111-01-11010-1011	1111-01-11010-1100
1111-01-11010-1111	1111-01-11010-0100	1111-01-11011-1001	1111-01-11011-1030	1111-01-11011-1131
1111-01-11010-1110	1111-01-11010-0111	1111-01-11011-1000	1111-01-11011-1101	1111-01-11011-1130
1111-01-11010-1131	1111-01-11010-0110	1111-01-11011-1011	1111-01-11011-1100	1111-01-11011-0101
1111-01-11010-1130	1111-01-11010-0131	1111-01-11011-1010	1111-01-11011-1111	1111-01-11011-0100
1111-01-11010-0101	1111-01-11010-0130	1111-01-11011-1031	1111-01-11011-1110	1111-01-11011-0111
1111-01-11011-0110	1111-01-11020-1011	1111-01-11020-1100	1111-01-11020-0101	1111-01-11020-0130
1111-01-11011-0131	1111-01-11020-1010	1111-01-11020-1111	1111-01-11020-0100	1111-01-11021-1001
1111-01-11011-0130	1111-01-11020-1031	1111-01-11020-1110	1111-01-11020-0111	1111-01-11021-1000
1111-01-11020-1001	1111-01-11020-1030	1111-01-11020-1131	1111-01-11020-0110	1111-01-11021-1011
1111-01-11020-1000	1111-01-11020-1101	1111-01-11020-1130	1111-01-11020-0131	1111-01-11021-1010
1111-01-11021-1031	1111-01-11021-1110	1111-01-11021-0111	1111-01-11032-1000	1111-01-11032-1101
1111-01-11021-1030	1111-01-11021-1131	1111-01-11021-0110	1111-01-11032-1011	1111-01-11032-1100
1111-01-11021-1101	1111-01-11021-1130	1111-01-11021-0131	1111-01-11032-1010	1111-01-11032-1111
1111-01-11021-1100	1111-01-11021-0101	1111-01-11021-0130	1111-01-11032-1031	1111-01-11032-1110
1111-01-11021-1111	1111-01-11021-0100	1111-01-11032-1001	1111-01-11032-1030	1111-01-11032-1131
1111-01-11032-1130	1111-01-11032-0131	1111-01-11100-1010	1111-01-11100-1101	1111-01-11100-1120
1111-01-11032-0101	1111-01-11032-0130	1111-01-11100-1021	1111-01-11100-1100	1111-01-11100-1131
1111-01-11032-0100	1111-01-11100-1001	1111-01-11100-1020	1111-01-11100-1111	1111-01-11100-1130
1111-01-11032-0111	1111-01-11100-1000	1111-01-11100-1031	1111-01-11100-1110	1111-01-11100-0101
1111-01-11032-0110	1111-01-11100-1011	1111-01-11100-1030	1111-01-11100-1121	1111-01-11100-0100
1111-01-11100-0111	1111-01-11100-0130	1111-01-11101-1031	1111-01-11101-1110	1111-01-11101-0111
1111-01-11100-0110	1111-01-11101-1001	1111-01-11101-1030	1111-01-11101-1131	1111-01-11101-0110
1111-01-11100-0121	1111-01-11101-1000	1111-01-11101-1101	1111-01-11101-1130	1111-01-11101-0131
1111-01-11100-0120	1111-01-11101-1011	1111-01-11101-1100	1111-01-11101-0101	1111-01-11101-0130
1111-01-11100-0131	1111-01-11101-1010	1111-01-11101-1111	1111-01-11101-0100	1111-01-11110-1001

(table continues)

Table C-2 (Continued)

Gunner engages moving point target, precision, with SABOT, from the halt; enumeration, continued:

1111-01-11110-1000	1111-01-11110-1101	1111-01-11110-1130	1111-01-11110-0131	1111-01-11111-1010
1111-01-11110-1011	1111-01-11110-1100	1111-01-11110-0101	1111-01-11110-0130	1111-01-11111-1031
1111-01-11110-1010	1111-01-11110-1111	1111-01-11110-0100	1111-01-11111-1001	1111-01-11111-1030
1111-01-11110-1031	1111-01-11110-1110	1111-01-11110-0111	1111-01-11111-1000	1111-01-11111-1101
1111-01-11110-1030	1111-01-11110-1131	1111-01-11110-0110	1111-01-11111-1011	1111-01-11111-1100
1111-01-11111-1111	1111-01-11111-0100	1111-01-11120-1001	1111-01-11120-1030	1111-01-11120-1131
1111-01-11111-1110	1111-01-11111-0111	1111-01-11120-1000	1111-01-11120-1101	1111-01-11120-1130
1111-01-11111-1131	1111-01-11111-0110	1111-01-11120-1011	1111-01-11120-1100	1111-01-11120-0101
1111-01-11111-1130	1111-01-11111-0131	1111-01-11120-1010	1111-01-11120-1111	1111-01-11120-0100
1111-01-11111-0101	1111-01-11111-0130	1111-01-11120-1031	1111-01-11120-1110	1111-01-11120-0111
1111-01-11120-0110	1111-01-11121-1011	1111-01-11121-1100	1111-01-11121-0101	1111-01-11121-0130
1111-01-11120-0131	1111-01-11121-1010	1111-01-11121-1111	1111-01-11121-0100	1111-01-11132-1001
1111-01-11120-0130	1111-01-11121-1031	1111-01-11121-1110	1111-01-11121-0111	1111-01-11132-1000
1111-01-11121-1001	1111-01-11121-1030	1111-01-11121-1131	1111-01-11121-0110	1111-01-11132-1011
1111-01-11121-1000	1111-01-11121-1101	1111-01-11121-1130	1111-01-11121-0131	1111-01-11132-1010
1111-01-11132-1031	1111-01-11132-1110	1111-01-11132-0111	1111-01-12002-1100	1111-01-12002-1131
1111-01-11132-1030	1111-01-11132-1131	1111-01-11132-0110	1111-01-12002-1111	1111-01-12002-1130
1111-01-11132-1101	1111-01-11132-1130	1111-01-11132-0131	1111-01-12002-1110	1111-01-12002-0101
1111-01-11132-1100	1111-01-11132-0101	1111-01-11132-0130	1111-01-12002-1121	1111-01-12002-0100
1111-01-11132-1111	1111-01-11132-0100	1111-01-12002-1101	1111-01-12002-1120	1111-01-12002-0111
1111-01-12002-0110	1111-01-12032-1101	1111-01-12032-1130	1111-01-12032-0131	1111-01-21000-1010
1111-01-12002-0121	1111-01-12032-1100	1111-01-12032-0101	1111-01-12032-0130	1111-01-21000-1021
1111-01-12002-0120	1111-01-12032-1111	1111-01-12032-0100	1111-01-21000-1001	1111-01-21000-1020
1111-01-12002-0131	1111-01-12032-1110	1111-01-12032-0111	1111-01-21000-1000	1111-01-21000-1101
1111-01-12002-0130	1111-01-12032-1131	1111-01-12032-0110	1111-01-21000-1011	1111-01-21000-1100
1111-01-21000-1111	1111-01-21000-0100	1111-01-21001-1001	1111-01-21001-1100	1111-01-21001-0111
1111-01-21000-1110	1111-01-21000-0111	1111-01-21001-1000	1111-01-21001-1111	1111-01-21001-0110
1111-01-21000-1121	1111-01-21000-0110	1111-01-21001-1011	1111-01-21001-1110	1111-01-21032-1001
1111-01-21000-1120	1111-01-21000-0121	1111-01-21001-1010	1111-01-21001-0101	1111-01-21032-1000
1111-01-21000-0101	1111-01-21000-0120	1111-01-21001-1101	1111-01-21001-0100	1111-01-21032-1011
1111-01-21032-1010	1111-01-21032-0101	1111-01-21100-1000	1111-01-21100-1101	1111-01-21100-1120
1111-01-21032-1101	1111-01-21032-0100	1111-01-21100-1011	1111-01-21100-1100	1111-01-21100-0101
1111-01-21032-1100	1111-01-21032-0111	1111-01-21100-1010	1111-01-21100-1111	1111-01-21100-0100
1111-01-21032-1111	1111-01-21032-0110	1111-01-21100-1021	1111-01-21100-1110	1111-01-21100-0111
1111-01-21032-1110	1111-01-21100-1001	1111-01-21100-1020	1111-01-21100-1121	1111-01-21100-0110

(table continues)

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages moving point target, precision, with SABOT, from
the halt; enumeration, continued:

1111-01-21100-0121	1111-01-21101-1010	1111-01-21101-0101	1111-01-21132-1000	1111-01-21132-1111
1111-01-21100-0120	1111-01-21101-1101	1111-01-21101-0100	1111-01-21132-1011	1111-01-21132-1110
1111-01-21101-1001	1111-01-21101-1100	1111-01-21101-0111	1111-01-21132-1010	1111-01-21132-0101
1111-01-21101-1000	1111-01-21101-1111	1111-01-21101-0110	1111-01-21132-1101	1111-01-21132-0100
1111-01-21101-1011	1111-01-21101-1110	1111-01-21132-1001	1111-01-21132-1100	1111-01-21132-0111
1111-01-21132-0110	1111-01-22002-1121	1111-01-22002-0110	1111-01-22032-0100	1111-01-22032-0110
1111-01-22002-1101	1111-01-22002-1120	1111-01-22002-0121	1111-01-22032-1111	
1111-01-22002-1100	1111-01-22002-0101	1111-01-22002-0120	1111-01-22032-1110	
1111-01-22002-1111	1111-01-22002-0100	1111-01-22032-1101	1111-01-22032-0101	
1111-01-22002-1110	1111-01-22002-0111	1111-01-22032-1100	1111-01-22032-0111	

Permutations this subset: 396

Gunner engages stationary point target, precision, with SABOT, on
the move; enumeration:

1111-10-11000-1001	1111-10-11000-1030	1111-10-11001-1031	1111-10-11010-1030	1111-10-11011-1031
1111-10-11000-1000	1111-10-11001-1001	1111-10-11001-1030	1111-10-11011-1001	1111-10-11011-1030
1111-10-11000-1021	1111-10-11001-1000	1111-10-11010-1001	1111-10-11011-1000	1111-10-11020-1001
1111-10-11000-1020	1111-10-11001-1021	1111-10-11010-1000	1111-10-11011-1021	1111-10-11020-1000
1111-10-11000-1031	1111-10-11001-1020	1111-10-11010-1031	1111-10-11011-1020	1111-10-11020-1031
1111-10-11020-1030	1111-10-11030-1001	1111-10-11031-1020	1111-10-11100-1001	1111-10-11100-1030
1111-10-11021-1001	1111-10-11030-1000	1111-10-11032-1001	1111-10-11100-1000	1111-10-11101-1001
1111-10-11021-1000	1111-10-11031-1001	1111-10-11032-1000	1111-10-11100-1021	1111-10-11101-1000
1111-10-11021-1021	1111-10-11031-1000	1111-10-11032-1021	1111-10-11100-1020	1111-10-11101-1021
1111-10-11021-1020	1111-10-11031-1021	1111-10-11032-1020	1111-10-11100-1031	1111-10-11101-1020
1111-10-11101-1031	1111-10-11110-1030	1111-10-11111-1031	1111-10-11120-1030	1111-10-11130-1001
1111-10-11101-1030	1111-10-11111-1001	1111-10-11111-1030	1111-10-11121-1001	1111-10-11130-1000
1111-10-11110-1001	1111-10-11111-1000	1111-10-11120-1001	1111-10-11121-1000	1111-10-11131-1001
1111-10-11110-1000	1111-10-11111-1021	1111-10-11120-1000	1111-10-11121-1021	1111-10-11131-1000
1111-10-11110-1031	1111-10-11111-1020	1111-10-11120-1031	1111-10-11121-1020	1111-10-11131-1021
1111-10-11131-1020	1111-10-12002-1001	1111-10-12032-1000	1111-10-21000-1021	1111-10-21001-1000
1111-10-11132-1001	1111-10-12002-1000	1111-10-12032-1031	1111-10-21000-1020	1111-10-21001-1021
1111-10-11132-1000	1111-10-12002-1021	1111-10-12032-1030	1111-10-21000-1031	1111-10-21001-1020
1111-10-11132-1021	1111-10-12002-1020	1111-10-21000-1001	1111-10-21000-1030	1111-10-21030-1001
1111-10-11132-1020	1111-10-12032-1001	1111-10-21000-1000	1111-10-21001-1001	1111-10-21030-1000

(<u>table continues</u>)

Table C-2 (Continued)

Gunner engages stationary point target, precision, with SABOT, on the move; enumeration, continued:

1111-10-21031-1001	1111-10-21032-1000	1111-10-21100-1021	1111-10-21101-1000	1111-10-21131-1001
1111-10-21031-1000	1111-10-21032-1021	1111-10-21100-1020	1111-10-21101-1021	1111-10-21131-1000
1111-10-21031-1021	1111-10-21032-1020	1111-10-21100-1031	1111-10-21101-1020	1111-10-21131-1021
1111-10-21031-1020	1111-10-21100-1001	1111-10-21100-1030	1111-10-21130-1001	1111-10-21131-1020
1111-10-21032-1001	1111-10-21100-1000	1111-10-21101-1001	1111-10-21130-1000	1111-10-21132-1001
1111-10-21132-1000	1111-10-22002-1001	1111-10-22002-1020	1111-10-22032-1021	
1111-10-21132-1021	1111-10-22002-1000	1111-10-22032-1001	1111-10-22032-1020	
1111-10-21132-1020	1111-10-22002-1021	1111-10-22032-1000		

Permutations this subset: 136

Gunner engages moving point target, precision, with SABOT, on the move; enumeration:

1111-11-11000-1001	1111-11-11000-1030	1111-11-11000-1131	1111-11-11001-1020	1111-11-11001-1121
1111-11-11000-1000	1111-11-11000-1101	1111-11-11000-1130	1111-11-11001-1031	1111-11-11001-1120
1111-11-11000-1021	1111-11-11000-1100	1111-11-11001-1001	1111-11-11001-1030	1111-11-11001-1131
1111-11-11000-1020	1111-11-11000-1121	1111-11-11001-1000	1111-11-11001-1101	1111-11-11001-1130
1111-11-11000-1031	1111-11-11000-1120	1111-11-11001-1021	1111-11-11001-1100	1111-11-11010-1001
1111-11-11010-1000	1111-11-11010-1131	1111-11-11011-1020	1111-11-11011-1121	1111-11-11020-1000
1111-11-11010-1031	1111-11-11010-1130	1111-11-11011-1031	1111-11-11011-1120	1111-11-11020-1031
1111-11-11010-1030	1111-11-11011-1001	1111-11-11011-1030	1111-11-11011-1131	1111-11-11020-1030
1111-11-11010-1101	1111-11-11011-1000	1111-11-11011-1101	1111-11-11011-1130	1111-11-11020-1101
1111-11-11010-1100	1111-11-11011-1021	1111-11-11011-1100	1111-11-11020-1001	1111-11-11020-1100
1111-11-11020-1131	1111-11-11021-1020	1111-11-11030-1001	1111-11-11031-1000	1111-11-11031-1121
1111-11-11020-1130	1111-11-11021-1101	1111-11-11030-1000	1111-11-11031-1021	1111-11-11031-1120
1111-11-11021-1001	1111-11-11021-1100	1111-11-11030-1101	1111-11-11031-1020	1111-11-11032-1001
1111-11-11021-1000	1111-11-11021-1121	1111-11-11030-1100	1111-11-11031-1101	1111-11-11032-1000
1111-11-11021-1021	1111-11-11021-1120	1111-11-11031-1001	1111-11-11031-1100	1111-11-11032-1021
1111-11-11032-1020	1111-11-11100-1001	1111-11-11100-1030	1111-11-11100-1131	1111-11-11101-1020
1111-11-11032-1101	1111-11-11100-1000	1111-11-11100-1101	1111-11-11100-1130	1111-11-11101-1031
1111-11-11032-1100	1111-11-11100-1021	1111-11-11100-1100	1111-11-11101-1001	1111-11-11101-1030
1111-11-11032-1121	1111-11-11100-1020	1111-11-11100-1121	1111-11-11101-1000	1111-11-11101-1101
1111-11-11032-1120	1111-11-11100-1031	1111-11-11100-1120	1111-11-11101-1021	1111-11-11101-1100

(table continues)

Table C-2 (Continued)

Gunner engages moving point target, precision, with SABOT, on the
move; enumeration, continued:

1111-11-11101-1121	1111-11-11110-1000	1111-11-11110-1131	1111-11-11111-1020	1111-11-11111-1121
1111-11-11101-1120	1111-11-11110-1031	1111-11-11110-1130	1111-11-11111-1031	1111-11-11111-1120
1111-11-11101-1131	1111-11-11110-1030	1111-11-11111-1001	1111-11-11111-1030	1111-11-11111-1131
1111-11-11101-1130	1111-11-11110-1101	1111-11-11111-1000	1111-11-11111-1101	1111-11-11111-1130
1111-11-11110-1001	1111-11-11110-1100	1111-11-11111-1021	1111-11-11111-1100	1111-11-11120-1001
1111-11-11120-1000	1111-11-11120-1131	1111-11-11121-1020	1111-11-11130-1001	1111-11-11131-1000
1111-11-11120-1031	1111-11-11120-1130	1111-11-11121-1101	1111-11-11130-1000	1111-11-11131-1021
1111-11-11120-1030	1111-11-11121-1001	1111-11-11121-1100	1111-11-11130-1101	1111-11-11131-1020
1111-11-11120-1101	1111-11-11121-1000	1111-11-11121-1121	1111-11-11130-1100	1111-11-11131-1101
1111-11-11120-1100	1111-11-11121-1021	1111-11-11121-1120	1111-11-11131-1001	1111-11-11131-1100
1111-11-11131-1121	1111-11-11132-1020	1111-11-12002-1101	1111-11-12032-1100	1111-11-21000-1021
1111-11-11131-1120	1111-11-11132-1101	1111-11-12002-1100	1111-11-12032-1131	1111-11-21000-1020
1111-11-11132-1001	1111-11-11132-1100	1111-11-12002-1121	1111-11-12032-1130	1111-11-21000-1031
1111-11-11132-1000	1111-11-11132-1121	1111-11-12002-1120	1111-11-21000-1001	1111-11-21000-1030
1111-11-11132-1021	1111-11-11132-1120	1111-11-12032-1101	1111-11-21000-1000	1111-11-21000-1101
1111-11-21000-1100	1111-11-21001-1001	1111-11-21001-1100	1111-11-21030-1101	1111-11-21031-1020
1111-11-21000-1121	1111-11-21001-1000	1111-11-21001-1121	1111-11-21030-1100	1111-11-21031-1101
1111-11-21000-1120	1111-11-21001-1021	1111-11-21001-1120	1111-11-21031-1001	1111-11-21031-1100
1111-11-21000-1131	1111-11-21001-1020	1111-11-21030-1001	1111-11-21031-1000	1111-11-21031-1121
1111-11-21000-1130	1111-11-21001-1101	1111-11-21030-1000	1111-11-21031-1021	1111-11-21031-1120
1111-11-21032-1001	1111-11-21032-1100	1111-11-21100-1021	1111-11-21100-1100	1111-11-21101-1001
1111-11-21032-1000	1111-11-21032-1121	1111-11-21100-1020	1111-11-21100-1121	1111-11-21101-1000
1111-11-21032-1021	1111-11-21032-1120	1111-11-21100-1031	1111-11-21100-1120	1111-11-21101-1021
1111-11-21032-1020	1111-11-21100-1001	1111-11-21100-1030	1111-11-21100-1131	1111-11-21101-1020
1111-11-21032-1101	1111-11-21100-1000	1111-11-21100-1101	1111-11-21100-1130	1111-11-21101-1101
1111-11-21101-1100	1111-11-21130-1101	1111-11-21131-1020	1111-11-21132-1001	1111-11-21132-1100
1111-11-21101-1121	1111-11-21130-1100	1111-11-21131-1101	1111-11-21132-1000	1111-11-21132-1121
1111-11-21101-1120	1111-11-21131-1001	1111-11-21131-1100	1111-11-21132-1021	1111-11-21132-1120
1111-11-21130-1001	1111-11-21131-1000	1111-11-21131-1121	1111-11-21132-1020	1111-11-22002-1101
1111-11-21130-1000	1111-11-21131-1021	1111-11-21131-1120	1111-11-21132-1101	1111-11-22002-1100
1111-11-22002-1121	1111-11-22032-1101	1111-11-22032-1131		
1111-11-22002-1120	1111-11-22032-1100	1111-11-22032-1130		

Permutations this subset: 256

(<u>table continues</u>)

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages stationary point target, precision, with HEAT, from the halt; enumeration:

1112-00-11000-1001	1112-00-11000-1020	1112-00-11000-0011	1112-00-11000-0030	1112-00-11001-1031
1112-00-11000-1000	1112-00-11000-1031	1112-00-11000-0010	1112-00-11001-1001	1112-00-11001-1030
1112-00-11000-1011	1112-00-11000-1030	1112-00-11000-0021	1112-00-11001-1000	1112-00-11001-0001
1112-00-11000-1010	1112-00-11000-0001	1112-00-11000-0020	1112-00-11001-1011	1112-00-11001-0000
1112-00-11000-1021	1112-00-11000-0000	1112-00-11000-0031	1112-00-11001-1010	1112-00-11001-0011
1112-00-11001-0010	1112-00-11010-1011	1112-00-11010-0010	1112-00-11011-0001	1112-00-11020-1000
1112-00-11001-0031	1112-00-11010-1010	1112-00-11011-1001	1112-00-11011-0000	1112-00-11020-1011
1112-00-11001-0030	1112-00-11010-0001	1112-00-11011-1000	1112-00-11011-0011	1112-00-11020-1010
1112-00-11010-1001	1112-00-11010-0000	1112-00-11011-1011	1112-00-11011-0010	1112-00-11020-0001
1112-00-11010-1000	1112-00-11010-0011	1112-00-11011-1010	1112-00-11020-1001	1112-00-11020-0000
1112-00-11020-0011	1112-00-11021-1010	1112-00-11032-1001	1112-00-11032-1030	1112-00-11032-0031
1112-00-11020-0010	1112-00-11021-0001	1112-00-11032-1000	1112-00-11032-0001	1112-00-11032-0030
1112-00-11021-1001	1112-00-11021-0000	1112-00-11032-1011	1112-00-11032-0000	1112-00-11100-1001
1112-00-11021-1000	1112-00-11021-0011	1112-00-11032-1010	1112-00-11032-0011	1112-00-11100-1000
1112-00-11021-1011	1112-00-11021-0010	1112-00-11032-1031	1112-00-11032-0010	1112-00-11100-1011
1112-00-11100-1010	1112-00-11100-0001	1112-00-11100-0020	1112-00-11101-1011	1112-00-11101-0000
1112-00-11100-1021	1112-00-11100-0000	1112-00-11100-0031	1112-00-11101-1010	1112-00-11101-0011
1112-00-11100-1020	1112-00-11100-0011	1112-00-11100-0030	1112-00-11101-1031	1112-00-11101-0010
1112-00-11100-1031	1112-00-11100-0010	1112-00-11101-1001	1112-00-11101-1030	1112-00-11101-0031
1112-00-11100-1030	1112-00-11100-0021	1112-00-11101-1000	1112-00-11101-0001	1112-00-11101-0030
1112-00-11110-1001	1112-00-11110-0000	1112-00-11111-1011	1112-00-11111-0010	1112-00-11120-0001
1112-00-11110-1000	1112-00-11110-0011	1112-00-11111-1010	1112-00-11120-1001	1112-00-11120-0000
1112-00-11110-1011	1112-00-11110-0010	1112-00-11111-0001	1112-00-11120-1000	1112-00-11120-0011
1112-00-11110-1010	1112-00-11111-1001	1112-00-11111-0000	1112-00-11120-1011	1112-00-11120-0010
1112-00-11110-0001	1112-00-11111-1000	1112-00-11111-0011	1112-00-11120-1010	1112-00-11121-1001
1112-00-11121-1000	1112-00-11121-0011	1112-00-11132-1010	1112-00-11132-0011	1112-00-12032-1000
1112-00-11121-1011	1112-00-11121-0010	1112-00-11132-1031	1112-00-11132-0010	1112-00-12032-1011
1112-00-11121-1010	1112-00-11132-1001	1112-00-11132-1030	1112-00-11132-0031	1112-00-12032-1010
1112-00-11121-0001	1112-00-11132-1000	1112-00-11132-0001	1112-00-11132-0030	1112-00-12032-1031
1112-00-11121-0000	1112-00-11132-1011	1112-00-11132-0000	1112-00-12032-1001	1112-00-12032-1030
1112-00-12032-0001	1112-00-12032-0030	1112-00-21000-1021	1112-00-21000-0010	1112-00-21001-1011
1112-00-12032-0000	1112-00-21000-1001	1112-00-21000-1020	1112-00-21000-0021	1112-00-21001-1010
1112-00-12032-0011	1112-00-21000-1000	1112-00-21000-0001	1112-00-21000-0020	1112-00-21001-0001
1112-00-12032-0010	1112-00-21000-1011	1112-00-21000-0000	1112-00-21001-1001	1112-00-21001-0000
1112-00-12032-0031	1112-00-21000-1010	1112-00-21000-0011	1112-00-21001-1000	1112-00-21001-0011

(table continues)

Table C-2 (Continued)

Gunner engages stationary point target, precision, with HEAT, from the halt; enumeration, continued:

1112-00-21001-0010	1112-00-21010-0001	1112-00-21011-1000	1112-00-21011-0011	1112-00-21020-1010
1112-00-21010-1001	1112-00-21010-0000	1112-00-21011-1011	1112-00-21011-0010	1112-00-21020-0001
1112-00-21010-1000	1112-00-21010-0011	1112-00-21011-1010	1112-00-21020-1001	1112-00-21020-0000
1112-00-21010-1011	1112-00-21010-0010	1112-00-21011-0001	1112-00-21020-1000	1112-00-21020-0011
1112-00-21010-1010	1112-00-21011-1001	1112-00-21011-0000	1112-00-21020-1011	1112-00-21020-0010
1112-00-21021-1001	1112-00-21021-0000	1112-00-21032-1011	1112-00-21032-0010	1112-00-21100-1021
1112-00-21021-1000	1112-00-21021-0011	1112-00-21032-1010	1112-00-21100-1001	1112-00-21100-1020
1112-00-21021-1011	1112-00-21021-0010	1112-00-21032-0001	1112-00-21100-1000	1112-00-21100-0001
1112-00-21021-1010	1112-00-21032-1001	1112-00-21032-0000	1112-00-21100-1011	1112-00-21100-0000
1112-00-21021-0001	1112-00-21032-1000	1112-00-21032-0011	1112-00-21100-1010	1112-00-21100-0011
1112-00-21100-0010	1112-00-21101-1011	1112-00-21101-0010	1112-00-21110-0001	1112-00-21111-1000
1112-00-21100-0021	1112-00-21101-1010	1112-00-21110-1001	1112-00-21110-0000	1112-00-21111-1011
1112-00-21100-0020	1112-00-21101-0001	1112-00-21110-1000	1112-00-21110-0011	1112-00-21111-1010
1112-00-21101-1001	1112-00-21101-0000	1112-00-21110-1011	1112-00-21110-0010	1112-00-21111-0001
1112-00-21101-1000	1112-00-21101-0011	1112-00-21110-1010	1112-00-21111-1001	1112-00-21111-0000
1112-00-21111-0011	1112-00-21120-1010	1112-00-21121-1001	1112-00-21121-0000	1112-00-21132-1011
1112-00-21111-0010	1112-00-21120-0001	1112-00-21121-1000	1112-00-21121-0011	1112-00-21132-1010
1112-00-21120-1001	1112-00-21120-0000	1112-00-21121-1011	1112-00-21121-0010	1112-00-21132-0001
1112-00-21120-1000	1112-00-21120-0011	1112-00-21121-1010	1112-00-21132-1001	1112-00-21132-0000
1112-00-21120-1011	1112-00-21120-0010	1112-00-21121-0001	1112-00-21132-1000	1112-00-21132-0011
1112-00-21132-0010	1112-00-22032-1000	1112-00-22032-1010	1112-00-22032-0000	1112-00-22032-0010
1112-00-22032-1001	1112-00-22032-1011	1112-00-22032-0001	1112-00-22032-0011	

Permutations this subset: 284

Gunner engages moving point target, precision, with HEAT, from the halt; enumeration:

1112-01-11000-1001	1112-01-11000-1020	1112-01-11000-1111	1112-01-11000-1130	1112-01-11000-0121
1112-01-11000-1000	1112-01-11000-1031	1112-01-11000-1110	1112-01-11000-0101	1112-01-11000-0120
1112-01-11000-1011	1112-01-11000-1030	1112-01-11000-1121	1112-01-11000-0100	1112-01-11000-0131
1112-01-11000-1010	1112-01-11000-1101	1112-01-11000-1120	1112-01-11000-0111	1112-01-11000-0130
1112-01-11000-1021	1112-01-11000-1100	1112-01-11000-1131	1112-01-11000-0110	1112-01-11001-1001

(**table continues**)

Table C-2 (Continued)

Gunner engages moving point target, precision, with HEAT, from the halt; enumeration, continued:

1112-01-11001-1000	1112-01-11001-1101	1112-01-11001-1130	1112-01-11001-0131	1112-01-11010-1010
1112-01-11001-1021	1112-01-11001-1100	1112-01-11001-0101	1112-01-11001-0130	1112-01-11010-1031
1112-01-11001-1020	1112-01-11001-1111	1112-01-11001-0100	1112-01-11010-1001	1112-01-11010-1030
1112-01-11001-1031	1112-01-11001-1110	1112-01-11001-0111	1112-01-11010-1000	1112-01-11010-1101
1112-01-11001-1030	1112-01-11001-1131	1112-01-11001-0110	1112-01-11010-1011	1112-01-11010-1100
1112-01-11010-1111	1112-01-11010-0100	1112-01-11011-1001	1112-01-11011-1030	1112-01-11011-1131
1112-01-11010-1110	1112-01-11010-0111	1112-01-11011-1000	1112-01-11011-1101	1112-01-11011-1130
1112-01-11010-1131	1112-01-11010-0110	1112-01-11011-1011	1112-01-11011-1100	1112-01-11011-0101
1112-01-11010-1130	1112-01-11010-0131	1112-01-11011-1010	1112-01-11011-1111	1112-01-11011-0100
1112-01-11010-0101	1112-01-11010-0130	1112-01-11011-1031	1112-01-11011-1110	1112-01-11011-0111
1112-01-11011-0110	1112-01-11020-1011	1112-01-11020-1100	1112-01-11020-0101	1112-01-11020-0130
1112-01-11011-0131	1112-01-11020-1010	1112-01-11020-1111	1112-01-11020-0100	1112-01-11021-1001
1112-01-11011-0130	1112-01-11020-1031	1112-01-11020-1110	1112-01-11020-0111	1112-01-11021-1000
1112-01-11020-1001	1112-01-11020-1030	1112-01-11020-1131	1112-01-11020-0110	1112-01-11021-1011
1112-01-11020-1000	1112-01-11020-1101	1112-01-11020-1130	1112-01-11020-0131	1112-01-11021-1010
1112-01-11021-1031	1112-01-11021-1110	1112-01-11021-0111	1112-01-11032-1000	1112-01-11032-1101
1112-01-11021-1030	1112-01-11021-1131	1112-01-11021-0110	1112-01-11032-1011	1112-01-11032-1100
1112-01-11021-1101	1112-01-11021-1130	1112-01-11021-0131	1112-01-11032-1010	1112-01-11032-1111
1112-01-11021-1100	1112-01-11021-0101	1112-01-11021-0130	1112-01-11032-1031	1112-01-11032-1110
1112-01-11021-1111	1112-01-11021-0100	1112-01-11032-1001	1112-01-11032-1030	1112-01-11032-1131
1112-01-11032-1130	1112-01-11032-0131	1112-01-11100-1010	1112-01-11100-1101	1112-01-11100-1120
1112-01-11032-0101	1112-01-11032-0130	1112-01-11100-1021	1112-01-11100-1100	1112-01-11100-1131
1112-01-11032-0100	1112-01-11100-1001	1112-01-11100-1020	1112-01-11100-1111	1112-01-11100-1130
1112-01-11032-0111	1112-01-11100-1000	1112-01-11100-1031	1112-01-11100-1110	1112-01-11100-0101
1112-01-11032-0110	1112-01-11100-1011	1112-01-11100-1030	1112-01-11100-1121	1112-01-11100-0100
1112-01-11100-0111	1112-01-11100-0130	1112-01-11101-1031	1112-01-11101-1110	1112-01-11101-0111
1112-01-11100-0110	1112-01-11101-1001	1112-01-11101-1030	1112-01-11101-1131	1112-01-11101-0110
1112-01-11100-0121	1112-01-11101-1000	1112-01-11101-1101	1112-01-11101-1130	1112-01-11101-0131
1112-01-11100-0120	1112-01-11101-1011	1112-01-11101-1100	1112-01-11101-0101	1112-01-11101-0130
1112-01-11100-0131	1112-01-11101-1010	1112-01-11101-1111	1112-01-11101-0100	1112-01-11110-1001
1112-01-11110-1000	1112-01-11110-1101	1112-01-11110-1130	1112-01-11110-0131	1112-01-11111-1010
1112-01-11110-1011	1112-01-11110-1100	1112-01-11110-0101	1112-01-11110-0130	1112-01-11111-1031
1112-01-11110-1010	1112-01-11110-1111	1112-01-11110-0100	1112-01-11111-1001	1112-01-11111-1030
1112-01-11110-1031	1112-01-11110-1110	1112-01-11110-0111	1112-01-11111-1000	1112-01-11111-1101
1112-01-11110-1030	1112-01-11110-1131	1112-01-11110-0110	1112-01-11111-1011	1112-01-11111-1100

(table continues)

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages moving point target, precision, with HEAT, from
the halt; enumeration, continued:

1112-01-11111-1111	1112-01-11111-0100	1112-01-11120-1001	1112-01-11120-1030	1112-01-11120-1131
1112-01-11111-1110	1112-01-11111-0111	1112-01-11120-1000	1112-01-11120-1101	1112-01-11120-1130
1112-01-11111-1131	1112-01-11111-0110	1112-01-11120-1011	1112-01-11120-1100	1112-01-11120-0101
1112-01-11111-1130	1112-01-11111-0131	1112-01-11120-1010	1112-01-11120-1111	1112-01-11120-0100
1112-01-11111-0101	1112-01-11111-0130	1112-01-11120-1031	1112-01-11120-1110	1112-01-11120-0111
1112-01-11120-0110	1112-01-11121-1011	1112-01-11121-1100	1112-01-11121-0101	1112-01-11121-0130
1112-01-11120-0131	1112-01-11121-1010	1112-01-11121-1111	1112-01-11121-0100	1112-01-11132-1001
1112-01-11120-0130	1112-01-11121-1031	1112-01-11121-1110	1112-01-11121-0111	1112-01-11132-1000
1112-01-11121-1001	1112-01-11121-1030	1112-01-11121-1131	1112-01-11121-0110	1112-01-11132-1011
1112-01-11121-1000	1112-01-11121-1101	1112-01-11121-1130	1112-01-11121-0131	1112-01-11132-1010
1112-01-11132-1031	1112-01-11132-1110	1112-01-11132-0111	1112-01-12002-1100	1112-01-12002-1131
1112-01-11132-1030	1112-01-11132-1131	1112-01-11132-0110	1112-01-12002-1111	1112-01-12002-1130
1112-01-11132-1101	1112-01-11132-1130	1112-01-11132-0131	1112-01-12002-1110	1112-01-12002-0101
1112-01-11132-1100	1112-01-11132-0101	1112-01-11132-0130	1112-01-12002-1121	1112-01-12002-0100
1112-01-11132-1111	1112-01-11132-0100	1112-01-12002-1101	1112-01-12002-1120	1112-01-12002-0111
1112-01-12002-0110	1112-01-12032-1101	1112-01-12032-1130	1112-01-12032-0131	1112-01-21000-1010
1112-01-12002-0121	1112-01-12032-1100	1112-01-12032-0101	1112-01-12032-0130	1112-01-21000-1021
1112-01-12002-0120	1112-01-12032-1111	1112-01-12032-0100	1112-01-21000-1001	1112-01-21000-1020
1112-01-12002-0131	1112-01-12032-1110	1112-01-12032-0111	1112-01-21000-1000	1112-01-21000-1101
1112-01-12002-0130	1112-01-12032-1131	1112-01-12032-0110	1112-01-21000-1011	1112-01-21000-1100
1112-01-21000-1111	1112-01-21000-0100	1112-01-21001-1001	1112-01-21001-1100	1112-01-21001-0111
1112-01-21000-1110	1112-01-21000-0111	1112-01-21001-1000	1112-01-21001-1111	1112-01-21001-0110
1112-01-21000-1121	1112-01-21000-0110	1112-01-21001-1011	1112-01-21001-1110	1112-01-21032-1001
1112-01-21000-1120	1112-01-21000-0121	1112-01-21001-1010	1112-01-21001-0101	1112-01-21032-1000
1112-01-21000-0101	1112-01-21000-0120	1112-01-21001-1101	1112-01-21001-0100	1112-01-21032-1011
1112-01-21032-1010	1112-01-21032-0101	1112-01-21100-1000	1112-01-21100-1101	1112-01-21100-1120
1112-01-21032-1101	1112-01-21032-0100	1112-01-21100-1011	1112-01-21100-1100	1112-01-21100-0101
1112-01-21032-1100	1112-01-21032-0111	1112-01-21100-1010	1112-01-21100-1111	1112-01-21100-0100
1112-01-21032-1111	1112-01-21032-0110	1112-01-21100-1021	1112-01-21100-1110	1112-01-21100-0211
1112-01-21032-1110	1112-01-21100-1001	1112-01-21100-1020	1112-01-21100-1121	1112-01-21100-0110
1112-01-21100-0121	1112-01-21101-1010	1112-01-21101-0101	1112-01-21132-1000	1112-01-21132-1111
1112-01-21100-0120	1112-01-21101-1101	1112-01-21101-0100	1112-01-21132-1011	1112-01-21132-1110
1112-01-21101-1001	1112-01-21101-1100	1112-01-21101-0111	1112-01-21132-1010	1112-01-21132-0101
1112-01-21101-1000	1112-01-21101-1111	1112-01-21101-0110	1112-01-21132-1101	1112-01-21132-0100
1112-01-21101-1011	1112-01-21101-1110	1112-01-21132-1001	1112-01-21132-1100	1112-01-21132-0111

(<u>table continues</u>)

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages moving point target, precision, with HEAT, from
the halt; enumeration, continued:

1112-01-21132-0110	1112-01-22002-1121	1112-01-22002-0110	1112-01-22032-1111	1112-01-22032-0110
1112-01-22002-1101	1112-01-22002-1120	1112-01-22002-0121	1112-01-22032-1110	
1112-01-22002-1100	1112-01-22002-0101	1112-01-22002-0120	1112-01-22032-0101	
1112-01-22002-1111	1112-01-22002-0100	1112-01-22032-1101	1112-01-22032-0100	
1112-01-22002-1110	1112-01-22002-0111	1112-01-22032-1100	1112-01-22032-0111	

Permutations this subset: 396

Gunner engages stationary point target, precision, with HEAT, on
the move; enumeration:

1112-10-11000-1001	1112-10-11000-1030	1112-10-11001-1031	1112-10-11010-1030	1112-10-11011-1031
1112-10-11000-1000	1112-10-11001-1001	1112-10-11001-1030	1112-10-11011-1001	1112-10-11011-1030
1112-10-11000-1021	1112-10-11001-1000	1112-10-11010-1001	1112-10-11011-1000	1112-10-11020-1001
1112-10-11000-1020	1112-10-11001-1021	1112-10-11010-1000	1112-10-11011-1021	1112-10-11020-1000
1112-10-11000-1031	1112-10-11001-1020	1112-10-11010-1031	1112-10-11011-1020	1112-10-11020-1031
1112-10-11020-1030	1112-10-11030-1001	1112-10-11031-1020	1112-10-11100-1001	1112-10-11100-1030
1112-10-11021-1001	1112-10-11030-1000	1112-10-11032-1001	1112-10-11100-1000	1112-10-11101-1001
1112-10-11021-1000	1112-10-11031-1001	1112-10-11032-1000	1112-10-11100-1021	1112-10-11101-1000
1112-10-11021-1021	1112-10-11031-1000	1112-10-11032-1021	1112-10-11100-1020	1112-10-11101-1021
1112-10-11021-1020	1112-10-11031-1021	1112-10-11032-1020	1112-10-11100-1031	1112-10-11101-1020
1112-10-11101-1031	1112-10-11110-1030	1112-10-11111-1031	1112-10-11120-1030	1112-10-11130-1001
1112-10-11101-1030	1112-10-11111-1001	1112-10-11111-1030	1112-10-11121-1001	1112-10-11130-1000
1112-10-11110-1001	1112-10-11111-1000	1112-10-11120-1001	1112-10-11121-1000	1112-10-11131-1001
1112-10-11110-1000	1112-10-11111-1021	1112-10-11120-1000	1112-10-11121-1021	1112-10-11131-1000
1112-10-11110-1031	1112-10-11111-1020	1112-10-11120-1031	1112-10-11121-1020	1112-10-11131-1021
1112-10-11131-1020	1112-10-12002-1001	1112-10-12032-1000	1112-10-21000-1021	1112-10-21001-1000
1112-10-11132-1001	1112-10-12002-1000	1112-10-12032-1031	1112 10-21000-1020	1112-10-21001-1021
1112-10-11132-1000	1112-10-12002-1021	1112-10-12032-1030	1112-10-21000-1031	1112-10-21001-1020
1112-10-11132-1021	1112-10-12002-1020	1112-10-21000-1001	1112-10-21000-1030	1112-10-21030-1001
1112-10-11132-1020	1112-10-12032-1001	1112-10-21000-1000	1112-10-21001-1001	1112-10-21030-1000
1112-10-21031-1001	1112-10-21032-1000	1112-10-21100-1021	1112-10-21101-1000	1112-10-21131-1001
1112-10-21031-1000	1112-10-21032-1021	1112-10-21100-1020	1112-10-21101-1021	1112-10-21131-1000
1112-10-21031-1021	1112-10-21032-1020	1112-10-21100-1031	1112-10-21101-1020	1112-10-21131-1021
1112-10-21031-1020	1112-10-21100-1001	1112-10-21100-1030	1112-10-21130-1001	1112-10-21131-1020
1112-10-21032-1001	1112-10-21100-1000	1112-10-21101-1001	1112-10-21130-1000	1112-10-21132-1001

(table continues)

Table C-2 (Continued)

Gunner engages moving point target, precision, with HEAT, from the halt, enumeration, continued:

1112-10-21132-1000	1112-10-22002-1021	1112-10-22002-1000	1112-10-22032-1031
1112-10-21132-1021	1112-10-22002-1020	1112-10-22032-1001	1112-10-22032-1030
1112-10-21132-1020	1112-10-22002-1001	1112-10-22032-1000	

Permutations this subset: 136

Gunner engages moving point target, precision, with HEAT, on the move; enumeration:

1112-11-11000-1001	1112-11-11000-1030	1112-11-11000-1131	1112-11-11001-1020	1112-11-11001-1121
1112-11-11000-1000	1112-11-11000-1101	1112-11-11000-1130	1112-11-11001-1031	1112-11-11001-1120
1112-11-11000-1021	1112-11-11000-1100	1112-11-11001-1001	1112-11-11001-1030	1112-11-11001-1131
1112-11-11000-1020	1112-11-11000-1121	1112-11-11001-1000	1112-11-11001-1101	1112-11-11001-1130
1112-11-11000-1031	1112-11-11000-1120	1112-11-11001-1021	1112-11-11001-1100	1112-11-11010-1001
1112-11-11010-1000	1112-11-11010-1131	1112-11-11011-1020	1112-11-11011-1121	1112-11-11020-1000
1112-11-11010-1031	1112-11-11010-1130	1112-11-11011-1031	1112-11-11011-1120	1112-11-11020-1031
1112-11-11010-1030	1112-11-11011-1001	1112-11-11011-1030	1112-11-11011-1131	1112-11-11020-1030
1112-11-11010-1101	1112-11-11011-1000	1112-11-11011-1101	1112-11-11011-1130	1112-11-11020-1101
1112-11-11010-1100	1112-11-11011-1021	1112-11-11011-1100	1112-11-11020-1001	1112-11-11020-1100
1112-11-11020-1131	1112-11-11021-1020	1112-11-11030-1001	1112-11-11031-1000	1112-11-11031-1121
1112-11-11020-1130	1112-11-11021-1101	1112-11-11030-1000	1112-11-11031-1021	1112-11-11031-1120
1112-11-11021-1001	1112-11-11021-1100	1112-11-11030-1101	1112-11-11031-1020	1112-11-11032-1001
1112-11-11021-1000	1112-11-11021-1121	1112-11-11030-1100	1112-11-11031-1101	1112-11-11032-1000
1112-11-11021-1021	1112-11-11021-1120	1112-11-11031-1001	1112-11-11031-1100	1112-11-11032-1021
1112-11-11032-1020	1112-11-11100-1001	1112-11-11100-1030	1112-11-11100-1131	1112-11-11101-1020
1112-11-11032-1101	1112-11-11100-1000	1112-11-11100-1101	1112-11-11100-1130	1112-11-11101-1031
1112-11-11032-1100	1112-11-11100-1021	1112-11-11100-1100	1112-11-11101-1001	1112-11-11101-1030
1112-11-11032-1121	1112-11-11100-1020	1112-11-11100-1121	1112-11-11101-1000	1112-11-11101-1101
1112-11-11032-1120	1112-11-11100-1031	1112-11-11100-1120	1112-11-11101-1021	1112-11-11101-1100
1112-11-11101-1121	1112-11-11110-1000	1112-11-11110-1131	1112-11-11111-1020	1112-11-11111-1121
1112-11-11101-1120	1112-11-11110-1031	1112-11-11110-1130	1112-11-11111-1031	1112-11-11111-1120
1112-11-11101-1131	1112-11-11110-1030	1112-11-11111-1001	1112-11-11111-1030	1112-11-11111-1131
1112-11-11101-1130	1112-11-11110-1101	1112-11-11111-1000	1112-11-11111-1101	1112-11-11111-1130
1112-11-11110-1001	1112-11-11110-1100	1112-11-11111-1021	1112-11-11111-1100	1112-11-11120-1001

(<u>table continues</u>)

Table C-2 (Continued)

Gunner engages moving point target, precision, with HEAT, on the
move; enumeration, continued:

1112-11-11120-1000	1112-11-11120-1131	1112-11-11121-1020	1112-11-11130-1001	1112-11-11131-1000
1112-11-11120-1031	1112-11-11120-1130	1112-11-11121-1101	1112-11-11130-1000	1112-11-11131-1021
1112-11ᵃ11120-1030	1112-11-11121-1001	1112-11-11121-1100	1112-11-11130-1101	1112-11-11131-1020
1112-11-11120-1101	1112-11-11121-1000	1112-11-11121-1121	1112-11-11130-1100	1112-11-11131-1101
1112-11-11120-1100	1112-11-11121-1021	1112-11-11121-1120	1112-11-11131-1001	1112-11-11131-1100
1112-11-11131-1121	1112-11-11132-1020	1112-11-12002-1101	1112-11-12032-1100	1112-11-21000-1021
1112-11-11131-1120	1112-11-11132-1101	1112-11-12002-1100	1112-11-12032-1131	1112-11-21000-1020
1112-11-11132-1001	1112-11-11132-1100	1112-11-12002-1121	1112-11-12032-1130	1112-11-21000-1031
1112-11-11132-1000	1112-11-11132-1121	1112-11-12002-1120	1112-11-21000-1001	1112-11-21000-1030
1112-11-11132-1021	1112-11-11132-1120	1112-11-12032-1101	1112-11-21000-1000	1112-11-21000-1101
1112-11-21000-1100	1112-11-21001-1001	1112-11-21001-1100	1112-11-21030-1101	1112-11-21031-1020
1112-11-21000-1121	1112-11-21001-1000	1112-11-21001-1121	1112-11-21030-1100	1112-11-21031-1101
1112-11-21000-1120	1112-11-21001-1021	1112-11-21001-1120	1112-11-21031-1001	1112-11-21031-1100
1112-11-21000-1131	1112-11-21001-1020	1112-11-21030-1001	1112-11-21031-1000	1112-11-21031-1121
1112-11-21000-1130	1112-11-21001-1101	1112-11-21030-1000	1112-11-21031-1021	1112-11-21031-1120
1112-11-21032-1001	1112-11-21032-1100	1112-11-21100-1021	1112-11-21100-1100	1112-11-21101-1001
1112-11-21032-1000	1112-11-21032-1121	1112-11-21100-1020	1112-11-21100-1121	1112-11-21101-1000
1112-11-21032-1021	1112-11-21032-1120	1112-11-21100-1031	1112-11-21100-1120	1112-11-21101-1021
1112-11-21032-1020	1112-11-21100-1001	1112-11-21100-1030	1112-11-21100-1131	1112-11-21101-1020
1112-11-21032-1101	1112-11-21100-1000	1112-11-21100-1101	1112-11-21100-1130	1112-11-21101-1101
1112-11-21101-1100	1112-11-21130-1101	1112-11-21131-1020	1112-11-21132-1001	1112-11-21132-1100
1112-11-21101-1121	1112-11-21130-1100	1112-11-21131-1101	1112-11-21132-1000	1112-11-21132-1121
1112-11-21101-1120	1112-11-21131-1001	1112-11-21131-1100	1112-11-21132-1021	1112-11-21132-1120
1112-11-21130-1001	1112-11-21131-1000	1112-11-21131-1121	1112-11-21132-1020	1112-11-22002-1101
1112-11-21130-1000	1112-11-21131-1021	1112-11-21131-1120	1112-11-21132-1101	1112-11-22002-1100
1112-11-22002-1121	1112-11-22032-1101	1112-11-22032-1131		
1112-11-22002-1120	1112-11-22032-1100	1112-11-22032-1130		

Permutations this subset: 256

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages stationary point target, precision, with coax,
from the halt; enumeration:

1113-00-11000-1001	1113-00-11000-1020	1113-00-11000-0011	1113-00-11000-0030	1113-00-11001-1031
1113-00-11000-1000	1113-00-11000-1031	1113-00-11000-0010	1113-00-11001-1001	1113-00-11001-1030
1113-00-11000-1011	1113-00-11000-1030	1113-00-11000-0021	1113-00-11001-1000	1113-00-11001-0001
1113-00-11000-1010	1113-00-11000-0001	1113-00-11000-0020	1113-00-11001-1011	1113-00-11001-0000
1113-00-11000-1021	1113-00-11000-0000	1113-00-11000-0031	1113-00-11001-1010	1113-00-11001-0011
1113-00-11001-0010	1113-00-11010-1011	1113-00-11010-0010	1113-00-11011-0001	1113-00-11020-1000
1113-00-11001-0031	1113-00-11010-1010	1113-00-11011-1001	1113-00-11011-0000	1113-00-11020-1011
1113-00-11001-0030	1113-00-11010-0001	1113-00-11011-1000	1113-00-11011-0011	1113-00-11020-1010
1113-00-11010-1001	1113-00-11010-0000	1113-00-11011-1011	1113-00-11011-0010	1113-00-11020-0001
1113-00-11010-1000	1113-00-11010-0011	1113-00-11011-1010	1113-00-11020-1001	1113-00-11020-0000
1113-00-11020-0011	1113-00-11021-1010	1113-00-11032-1001	1113-00-11032-1030	1113-00-11032-0031
1113-00-11020-0010	1113-00-11021-0001	1113-00-11032-1000	1113-00-11032-0001	1113-00-11032-0030
1113-00-11021-1001	1113-00-11021-0000	1113-00-11032-1011	1113-00-11032-0000	1113-00-11100-1001
1113-00-11021-1000	1113-00-11021-0011	1113-00-11032-1010	1113-00-11032-0011	1113-00-11100-1000
1113-00-11021-1011	1113-00-11021-0010	1113-00-11032-1031	1113-00-11032-0010	1113-00-11100-1011
1113-00-11100-1010	1113-00-11100-0001	1113-00-11100-0020	1113-00-11101-1011	1113-00-11101-0000
1113-00-11100-1021	1113-00-11100-0000	1113-00-11100-0031	1113-00-11101-1010	1113-00-11101-0011
1113-00-11100-1020	1113-00-11100-0011	1113-00-11100-0030	1113-00-11101-1031	1113-00-11101-0010
1113-00-11100-1031	1113-00-11100-0010	1113-00-11101-1001	1113-00-11101-1030	1113-00-11101-0031
1113-00-11100-1030	1113-00-11100-0021	1113-00-11101-1000	1113-00-11101-0001	1113-00-11101-0030
1113-00-11110-1001	1113-00-11110-0000	1113-00-11111-1011	1113-00-11111-0010	1113-00-11120-0001
1113-00-11110-1000	1113-00-11110-0011	1113-00-11111-1010	1113-00-11120-1001	1113-00-11120-0000
1113-00-11110-1011	1113-00-11110-0010	1113-00-11111-0001	1113-00-11120-1000	1113-00-11120-0011
1113-00-11110-1010	1113-00-11111-1001	1113-00-11111-0000	1113-00-11120-1011	1113-00-11120-0010
1113-00-11110-0001	1113-00-11111-1000	1113-00-11111-0011	1113-00-11120-1010	1113-00-11121-1001
1113-00-11121-1000	1113-00-11121-0011	1113-00-11132-1010	1113-00-11132-0011	1113-00-12032-1000
1113-00-11121-1011	1113-00-11121-0010	1113-00-11132-1031	1113-00-11132-0010	1113-00-12032-1011
1113-00-11121-1010	1113-00-11132-1001	1113-00-11132-1030	1113-00-11132-0031	1113-00-12032-1010
1113-00-11121-0001	1113-00-11132-1000	1113-00-11132-0001	1113-00-11132-0030	1113-00-12032-1031
1113-00-11121-0000	1113-00-11132-1011	1113-00-11132-0000	1113-00-12032-1001	1113-00-12032-1030
1113-00-12032-0001	1113-00-12032-0030	1113-00-21000-1021	1113-00-21000-0010	1113-00-21001-1011
1113-00-12032-0000	1113-00-21000-1001	1113-00-21000-1020	1113-00-21000-0021	1113-00-21001-1010
1113-00-12032-0011	1113-00-21000-1000	1113-00-21000-0001	1113-00-21000-0020	1113-00-21001-0001
1113-00-12032-0010	1113-00-21000-1011	1113-00-21000-0000	1113-00-21001-1001	1113-00-21001-0000
1113-00-12032-0031	1113-00-21000-1010	1113-00-21000-0011	1113-00-21001-1000	1113-00-21001-0011

(table continues)

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APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages stationary point target, precision, with coax, from the halt; enumeration, continued:

1113-00-21001-0010	1113-00-21010-0001	1113-00-21011-1000	1113-00-21011-0011	1113-00-21020-1010
1113-00-21010-1001	1113-00-21010-0000	1113-00-21011-1011	1113-00-21011-0010	1113-00-21020-0001
1113-00-21010-1000	1113-00-21010-0011	1113-00-21011-1010	1113-00-21020-1001	1113-00-21020-0000
1113-00-21010-1011	1113-00-21010-0010	1113-00-21011-0001	1113-00-21020-1000	1113-00-21020-0011
1113-00-21010-1010	1113-00-21011-1001	1113-00-21011-0000	1113-00-21020-1011	1113-00-21020-0010
1113-00-21021-1001	1113-00-21021-0000	1113-00-21032-1011	1113-00-21032-0010	1113-00-21100-1021
1113-00-21021-1000	1113-00-21021-0011	1113-00-21032-1010	1113-00-21100-1001	1113-00-21100-1020
1113-00-21021-1011	1113-00-21021-0010	1113-00-21032-0001	1113-00-21100-1000	1113-00-21100-0001
1113-00-21021-1010	1113-00-21032-1001	1113-00-21032-0000	1113-00-21100-1011	1113-00-21100-0000
1113-00-21021-0001	1113-00-21032-1000	1113-00-21032-0011	1113-00-21100-1010	1113-00-21100-0011
1113-00-21100-0010	1113-00-21101-1011	1113-00-21101-0010	1113-00-21110-0001	1113-00-21111-1000
1113-00-21100-0021	1113-00-21101-1010	1113-00-21110-1001	1113-00-21110-0000	1113-00-21111-1011
1113-00-21100-0020	1113-00-21101-0001	1113-00-21110-1000	1113-00-21110-0011	1113-00-21111-1010
1113-00-21101-1001	1113-00-21101-0000	1113-00-21110-1011	1113-00-21110-0010	1113-00-21111-0001
1113-00-21101-1000	1113-00-21101-0011	1113-00-21110-1010	1113-00-21111-1001	1113-00-21111-0000
1113-00-21111-0011	1113-00-21120-1010	1113-00-21121-1001	1113-00-21121-0000	1113-00-21132-1011
1113-00-21111-0010	1113-00-21120-0001	1113-00-21171-1000	1113-00-21121-0011	1113-00-21132-1010
1113-00-21120-1001	1113-00-21120-0000	1113-00-21121-1011	1113-00-21121-0010	1113-00-21132-0001
1113-00-21120-1000	1113-00-21120-0011	1113-00-21121-1010	1113-00-21132-1001	1113-00-21132-0000
1113-00-21120-1011	1113-00-21120-0010	1113-00-21121-0001	1113-00-21132-1000	1113-00-21132-0011
1113-00-21132-0010	1113-00-22032-1000	1113-00-22032-1010	1113-00-22032-0000	1113-00-22032-0010
1113-00-22032-1001	1113-00-22032-1011	1113-00-22032-0001	1113-00-22032-0011	

Permutations this subset: 284

Gunner engages moving point target, precision, with coax, from the halt; enumeration:

1113-01-11000-1001	1113-01-11000-1020	1113-01-11000-1111	1113-01-11000-1130	1113-01-11000-0121
1113-01-11000-1000	1113-01-11000-1031	1113-01-11000-1110	1113-01-11000-0101	1113-01-11000-0120
1113-01-11000-1011	1113-01-11000-1030	1113-01-11000-1121	1113-01-11000-0100	1113-01-11000-0131
1113-01-11000-1010	1113-01-11000-1101	1113-01-11000-1120	1113-01-11000-0111	1113-01-11000-0130
1113-01-11000-1021	1113-01-11000-1100	1113-01-11000-1131	1113-01-11000-0110	1113-01-11001-1001

(table continues)

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APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages stationary point target, precision, with coax, from the halt; enumeration, continued:

1113-01-11001-1000	1113-01-11001-1101	1113-01-11001-1130	1113-01-11001-0131	1113-01-11010-1010
1113-01-11001-1021	1113-01-11001-1100	1113-01-11001-0101	1113-01-11001-0130	1113-01-11010-1031
1113-01-11001-1020	1113-01-11001-1111	1113-01-11001-0100	1113-01-11010-1001	1113-01-11010-1030
1113-01-11001-1031	1113-01-11001-1110	1113-01-11001-0111	1113-01-11010-1000	1113-01-11010-1101
1113-01-11001-1030	1113-01-11001-1131	1113-01-11001-0110	1113-01-11010-1011	1113-01-11010-1100
1113-01-11010-1111	1113-01-11010-0100	1113-01-11011-1001	1113-01-11011-1030	1113-01-11011-1131
1113-01-11010-1110	1113-01-11010-0111	1113-01-11011-1000	1113-01-11011-1101	1113-01-11011-1130
1113-01-11010-1131	1113-01-11010-0110	1113-01-11011-1011	1113-01-11011-1100	1113-01-11011-0101
1113-01-11010-1130	1113-01-11010-0131	1113-01-11011-1010	1113-01-11011-1111	1113-01-11011-0100
1113-01-11010-0101	1113-01-11010-0130	1113-01-11011-1031	1113-01-11011-1110	1113-01-11011-0111
1113-01-11011-0110	1113-01-11020-1011	1113-01-11020-1100	1113-01-11020-0101	1113-01-11020-0130
1113-01-11011-0131	1113-01-11020-1010	1113-01-11020-1111	1113-01-11020-0100	1113-01-11021-1001
1113-01-11011-0130	1113-01-11020-1031	1113-01-11020-1110	1113-01-11020-0111	1113-01-11021-1000
1113-01-11020-1001	1113-01-11020-1030	1113-01-11020-1131	1113-01-11020-0110	1113-01-11021-1011
1113-01-11020-1000	1113-01-11020-1101	1113-01-11020-1130	1113-01-11020-0131	1113-01-11021-1010
1113-01-11021-1031	1113-01-11021-1110	1113-01-11021-0111	1113-01-11032-1000	1113-01-11032-1101
1113-01-11021-1030	1113-01-11021-1131	1113-01-11021-0110	1113-01-11032-1011	1113-01-11032-1100
1113-01-11021-1101	1113-01-11021-1130	1113-01-11021-0131	1113-01-11032-1010	1113-01-11032-1111
1113-01-11021-1100	1113-01-11021-0101	1113-01-11021-0130	1113-01-11032-1031	1113-01-11032-1110
1113-01-11021-1111	1113-01-11021-0100	1113-01-11032-1001	1113-01-11032-1030	1113-01-11032-1131
1113-01-11032-1130	1113-01-11032-0131	1113-01-11100-1010	1113-01-11100-1101	1113-01-11100-1120
1113-01-11032-0101	1113-01-11032-0130	1113-01-11100-1021	1113-01-11100-1100	1113-01-11100-1131
1113-01-11032-0100	1113-01-11100-1001	1113-01-11100-1020	1113-01-11100-1111	1113-01-11100-1130
1113-01-11032-0111	1113-01-11100-1000	1113-01-11100-1031	1113-01-11100-1110	1113-01-11100-0101
1113-01-11032-0110	1113-01-11100-1011	1113-01-11100-1030	1113-01-11100-1121	1113-01-11100-0100
1113-01-11100-0111	1113-01-11100-0130	1113-01-11101-1031	1113-01-11101-1110	1113-01-11101-0111
1113-01-11100-0110	1113-01-11101-1001	1113-01-11101-1030	1113-01-11101-1131	1113-01-11101-0110
1113-01-11100-0121	1113-01-11101-1000	1113-01-11101-1101	1113-01-11101-1130	1113-01-11101-0131
1113-01-11100-0120	1113-01-11101-1011	1113-01-11101-1100	1113-01-11101-0101	1113-01-11101-0130
1113-01-11100-0131	1113-01-11101-1010	1113-01-11101-1111	1113-01-11101-0100	1113-01-11110-1001
1113-01-11110-1000	1113-01-11110-1101	1113-01-11110-1130	1113-01-11110-0131	1113-01-11111-1010
1113-01-11110-1011	1113-01-11110-1100	1113-01-11110-0101	1113-01-11110-0130	1113-01-11111-1031
1113-01-11110-1010	1113-01-11110-1111	1113-01-11110-0100	1113-01-11111-1001	1113-01-11111-1030
1113-01-11110-1031	1113-01-11110-1110	1113-01-11110-0111	1113-01-11111-1000	1113-01-11111-1101
1113-01-11110-1030	1113-01-11110-1131	1113-01-11110-0110	1113-01-11111-1011	1113-01-11111-1100

Table C-2 (Continued)

Gunner engages moving point target, precision, with coax, from
the halt; enumeration, continued:

1113-01-11111-1111	1113-01-11111-0100	1113-01-11120-1001	1113-01-11120-1030	1113-01-11120-1131
1113-01-11111-1110	1113-01-11111-0111	1113-01-11120-1000	1113-01-11120-1101	1113-01-11120-1130
1113-01-11111-1131	1113-01-11111-0110	1113-01-11120-1011	1113-01-11120-1100	1113-01-11120-0101
1113-01-11111-1130	1113-01-11111-0131	1113-01-11120-1010	1113-01-11120-1111	1113-01-11120-0100
1113-01-11111-0101	1113-01-11111-0130	1113-01-11120-1031	1113-01-11120-1110	1113-01-11120-0111
1113-01-11120-0110	1113-01-11121-1011	1113-01-11121-1100	1113-01-11121-0101	1113-01-11121-0130
1113-01-11120-0131	1113-01-11121-1010	1113-01-11121-1111	1113-01-11121-0100	1113-01-11132-1001
1113-01-11120-0130	1113-01-11121-1031	1113-01-11121-1110	1113-01-11121-0111	1113-01-11132-1000
1113-01-11121-1001	1113-01-11121-1030	1113-01-11121-1131	1113-01-11121-0110	1113-01-11132-1011
1113-01-11121-1000	1113-01-11121-1101	1113-01-11121-1130	1113-01-11121-0131	1113-01-11132-1010
1113-01-11132-1031	1113-01-11132-1110	1113-01-11132-0111	1113-01-12002-1100	1113-01-12002-1131
1113-01-11132-1030	1113-01-11132-1131	1113-01-11132-0110	1113-01-12002-1111	1113-01-12002-1130
1113-01-11132-1101	1113-01-11132-1130	1113-01-11132-0131	1113-01-12002-1110	1113-01-12002-0101
1113-01-11132-1100	1113-01-11132-0101	1113-01-11132-0130	1113-01-12002-1121	1113-01-12002-0100
1113-01-11132-1111	1113-01-11132-0100	1113-01-12002-1101	1113-01-12002-1120	1113-01-12002-0111
1113-01-12002-0110	1113-01-12032-1101	1113-01-12032-1130	1113-01-12032-0131	1113-01-21000-1010
1113-01-12002-0121	1113-01-12032-1100	1113-01-12032-0101	1113-01-12032-0130	1113-01-21000-1021
1113-01-12002-0120	1113-01-12032-1111	1113-01-12032-0100	1113-01-21000-1001	1113-01-21000-1020
1113-01-12002-0131	1113-01-12032-1110	1113-01-12032-0111	1113-01-21000-1000	1113-01-21000-1101
1113-01-12002-0130	1113-01-12032-1131	1113-01-12032-0110	1113-01-21000-1011	1113-01-21000-1100
1113-01-21000-1111	1113-01-21000-0100	1113-01-21001-1001	1113-01-21001-1100	1113-01-21001-0111
1113-01-21000-1110	1113-01-21000-0111	1113-01-21001-1000	1113-01-21001-1111	1113-01-21001-0110
1113-01-21000-1121	1113-01-21000-0110	1113-01-21001-1011	1113-01-21001-1110	1113-01-21032-1001
1113-01-21000-1120	1113-01-21000-0121	1113-01-21001-1010	1113-01-21001-0101	1113-01-21032-1000
1113-01-21000-0101	1113-01-21000-0120	1113-01-21001-1101	1113-01-21001-0100	1113-01-21032-1011
1113-01-21032-1010	1113-01-21032-0101	1113-01-21100-1000	1113-01-21100-1101	1113-01-21100-1120
1113-01-21032-1101	1113-01-21032-0100	1113-01-21100-1011	1113-01-21100-1100	1113-01-21100-0101
1113-01-21032-1100	1113-01-21032-0111	1113-01-21100-1010	1113-01-21100-1111	1113-01-21100-0100
1113-01-21032-1111	1113-01-21032-0110	1113-01-21100-1021	1113-01-21100-1110	1113-01-21100-0111
1113-01-21032-1110	1113-01-21100-1001	1113-01-21100-1020	1113-01-21100-1121	1113-01-21100-0110
1113-01-21100-0121	1113-01-21101-1010	1113-01-21101-0101	1113-01-21132-1000	1113-01-21132-1111
1113-01-21100-0120	1113-01-21101-1101	1113-01-21101-0100	1113-01-21132-1011	1113-01-21132-1110
1113-01-21101-1001	1113-01-21101-1100	1113-01-21101-0111	1113-01-21132-1010	1113-01-21132-0101
1113-01-21101-1000	1113-01-21101-1111	1113-01-21101-0110	1113-01-21132-1101	1113-01-21132-0100
1113-01-21101-1011	1113-01-21101-1110	1113-01-21132-1001	1113-01-21132-1100	1113-01-21132-0111

(table continues)

Table C-2 (Continued)

Gunner engages moving point target, precision, with coax, from
the halt; enumeration, continued:

1113-01-21132-0110	1113-01-22002-1121	1113-01-22002-0110	1113-01-22032-1111	1113-01-22032-0110
1113-01-22002-1101	1113-01-22002-1120	1113-01-22002-0121	1113-01-22032-1110	
1113-01-22002-1100	1113-01-22002-0101	1113-01-22002-0120	1113-01-22032-0101	
1113-01-22002-1111	1113-01-22002-0100	1113-01-22032-1101	1113-01-22032-0100	
1113-01-22002-1110	1113-01-22002-0111	1113-01-22032-1100	1113-01-22032-0111	

Permutations this subset: 396

Gunner engages stationary point target precision, with coax, on
the move; enumeration:

1113-10-11000-1001	1113-10-11000-1030	1113-10-11001-1031	1113-10-11010-1030	1113-10-11011-1031
1113-10-11000-1000	1113-10-11001-1001	1113-10-11001-1030	1113-10-11011-1001	1113-10-11011-1030
1113-10-11000-1021	1113-10-11001-1000	1113-10-11010-1001	1113-10-11011-1000	1113-10-11020-1001
1113-10-11000-1020	1113-10-11001-1021	1113-10-11010-1000	1113-10-11011-1021	1113-10-11020-1000
1113-10-11000-1031	1113-10-11001-1020	1113-10-11010-1031	1113-10-11011-1020	1113-10-11020-1031
1113-10-11020-1030	1113-10-11030-1001	1113-10-11031-1020	1113-10-11100-1001	1113-10-11100-1030
1113-10-11021-1001	1113-10-11030-1000	1113-10-11032-1001	1113-10-11100-1000	1113-10-11101-1001
1113-10-11021-1000	1113-10-11031-1001	1113-10-11032-1000	1113-10-11100-1021	1113-10-11101-1000
1113-10-11021-1021	1113-10-11031-1000	1113-10-11032-1021	1113-10-11100-1020	1113-10-11101-1021
1113-10-11021-1020	1113-10-11031-1021	1113-10-11032-1020	1113-10-11100-1031	1113-10-11101-1020
1113-10-11101-1031	1113-10-11110-1030	1113-10-11111-1031	1113-10-11120-1030	1113-10-11130-1001
1113-10-11101-1030	1113-10-11111-1001	1113-10-11111-1030	1113-10-11121-1001	1113-10-11130-1000
1113-10-11110-1001	1113-10-11111-1000	1113-10-11120-1001	1113-10-11121-1000	1113-10-11131-1001
1113-10-11110-1000	1113-10-11111-1021	1113-10-11120-1000	1113-10-11121-1021	1113-10-11131-1000
1113-10-11110-1031	1113-10-11111-1020	1113-10-11120-1031	1113-10-11121-1020	1113-10-11131-1021
1113-10-11131-1020	1113-10-12002-1001	1113-10-12032-1000	1113-10-21000-1021	1113-10-21001-1000
1113-10-11132-1001	1113-10-12002-1000	1113-10-12032-1031	1113-10-21000-1020	1113-10-21001-1021
1113-10-11132-1000	1113-10-12002-1021	1113-10-12032-1030	1113-10-21000-1031	1113-10-21001-1020
1113-10-11132-1021	1113-10-12002-1020	1113-10-21000-1001	1113-10-21000-1030	1113-10-21030-1001
1113-10-11132-1020	1113-10-12032-1001	1113-10-21000-1000	1113-10-21001-1001	1113-10-21030-1000
1113-10-21031-1001	1113-10-21032-1000	1113-10-21100-1021	1113-10-21101-1000	1113-10-21131-1001
1113-10-21031-1000	1113-10-21032-1021	1113-10-21100-1020	1113-10-21101-1021	1113-10-21131-1000
1113-10-21031-1021	1113-10-21032-1020	1113-10-21100-1031	1113-10-21101-1020	1113-10-21131-1021
1113-10-21031-1020	1113-10-21100-1001	1113-10-21100-1030	1113-10-21130-1001	1113-10-21131-1020
1113-10-21032-1001	1113-10-21100-1000	1113-10-21101-1001	1113-10-21130-1000	1113-10-21132-1001

(table continues)

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages stationary point target, precision, with coax, on
the move; enumeration, continued:

1113-10-21132-1000	1113-10-22002-1001	1113-10-22002-1021	1113-10-22032-1001	1113-10-22032-1031
1113-10-21132-1021	1113-10-22002-1000	1113-10-22002-1020	1113-10-22032-1000	1113-10-22032-1030
1113-10ª21132-1020				

Permutations this subset: 136

Gunner engages moving point target, precision, with coax, on the
move; enumeration:

1113-11-11000-1001	1113-11-11000-1030	1113-11-11000-1131	1113-11-11001-1020	1113-11-11001-1121
1113-11-11000-1000	1113-11-11000-1101	1113-11-11000-1130	1113-11-11001-1031	1113-11-11001-1120
1113-11-11000-1021	1113-11-11000-1100	1113-11-11001-1001	1113-11-11001-1030	1113-11-11001-1131
1113-11-11000-1020	1113-11-11000-1121	1113-11-11001-1000	1113-11-11001-1101	1113-11-11001-1130
1113-11-11000-1031	1113-11-11000-1120	1113-11-11001-1021	1113-11-11001-1100	1113-11-11010-1001

1113-11-11010-1000	1113-11-11010-1131	1113-11-11011-1020	1113-11-11011-1121	1113-11-11020-1000
1113-11-11010-1031	1113-11-11010-1130	1113-11-11011-1031	1113-11-11011-1120	1113-11-11020-1031
1113-11-11010-1030	1113-11-11011-1001	1113-11-11011-1030	1113-11-11011-1131	1113-11-11020-1030
1113-11-11010-1101	1113-11-11011-1000	1113-11-11011-1101	1113-11-11011-1130	1113-11-11020-1101
1113-11-11010-1100	1113-11-11011-1021	1113-11-11011-1100	1113-11-11020-1001	1113-11-11020-1100

1113-11-11020-1131	1113-11-11021-1020	1113-11-11030-1001	1113-11-11031-1000	1113-11-11031-1121
1113-11-11020-1130	1113-11-11021-1101	1113-11-11030-1000	1113-11-11031-1021	1113-11-11031-1120
1113-11-11021-1001	1113-11-11021-1100	1113-11-11030-1101	1113-11-11031-1020	1113-11-11032-1001
1113-11-11021-1000	1113-11-11021-1121	1113-11-11030-1100	1113-11-11031-1101	1113-11-11032-1000
1113-11-11021-1021	1113-11-11021-1120	1113-11-11031-1001	1113-11-11031-1100	1113-11-11032-1021

1113-11-11032-1020	1113-11-11100-1001	1113-11-11100-1030	1113-11-11100-1131	1113-11-11101-1020
1113-11-11032-1101	1113-11-11100-1000	1113-11-11100-1101	1113-11-11100-1130	1113-11-11101-1031
1113-11-11032-1100	1113-11-11100-1021	1113-11-11100-1100	1113-11-11101-1001	1113-11-11101-1030
1113-11-11032-1121	1113-11-11100-1020	1113-11-11100-1121	1113-11-11101-1000	1113-11-11101-1101
1113-11-11032-1120	1113-11-11100-1031	1113-11-11100-1120	1113-11-11101-1021	1113-11-11101-1100

1113-11-11101-1121	1113-11-11110-1000	1113-11-11110-1131	1113-11-11111-1020	1113-11-11111-1121
1113-11-11101-1120	1113-11-11110-1031	1113-11-11110-1130	1113-11-11111-1031	1113-11-11111-1120
1113-11-11101-1131	1113-11-11110-1030	1113-11-11111-1001	1113-11-11111-1030	1113-11-11111-1131
1113-11-11101-1130	1113-11-11110-1101	1113-11-11111-1000	1113-11-11111-1101	1113-11-11111-1130
1113-11-11110-1001	1113-11-11110-1100	1113-11-11111-1021	1113-11-11111-1100	1113-11-11120-1001

(<u>table continues</u>)

Table C-2 (Continued)

Gunner engages moving point target, precision, with coax, on the move; enumeration:

1113-11-11120-1000	1113-11-11120-1131	1113-11-11121-1020	1113-11-11130-1001	1113-11-11131-1000
1113-11-11120-1031	1113-11-11120-1130	1113-11-11121-1101	1113-11-11130-1000	1113-11-11131-1021
1113-11-11120-1030	1113-11-11121-1001	1113-11-11121-1100	1113-11-11130-1101	1113-11-11131-1020
1113-11-11120-1101	1113-11-11121-1000	1113-11-11121-1121	1113-11-11130-1100	1113-11-11131-1101
1113-11-11120-1100	1113-11-11121-1021	1113-11-11121-1120	1113-11-11130-1001	1113-11-11131-1100
1113-11-11131-1121	1113-11-11132-1020	1113-11-12002-1101	1113-11-12032-1100	1113-11-21000-1021
1113-11-11131-1120	1113-11-11132-1101	1113-11-12002-1100	1113-11-12032-1131	1113-11-21000-1020
1113-11-11132-1001	1113-11-11132-1100	1113-11-12002-1121	1113-11-12032-1130	1113-11-21000-1031
1113-11-11132-1000	1113-11-11132-1121	1113-11-12002-1120	1113-11-21000-1001	1113-11-21000-1030
1113-11-11132-1021	1113-11-11132-1120	1113-11-12032-1101	1113-11-21000-1000	1113-11-21000-1101
1113-11-21000-1100	1113-11-21001-1001	1113-11-21001-1100	1113-11-21030-1101	1113-11-21031-1020
1113-11-21000-1121	1113-11-21001-1000	1113-11-21001-1121	1113-11-21030-1100	1113-11-21031-1101
1113-11-21000-1120	1113-11-21001-1021	1113-11-21001-1120	1113-11-21031-1001	1113-11-21031-1100
1113-11-21000-1131	1113-11-21001-1020	1113-11-21030-1001	1113-11-21031-1000	1113-11-21031-1121
1113-11-21000-1130	1113-11-21001-1101	1113-11-21030-1000	1113-11-21031-1021	1113-11-21031-1120
1113-11-21032-1001	1113-11-21032-1100	1113-11-21100-1021	1113-11-21100-1100	1113-11-21101-1001
1113-11-21032-1000	1113-11-21032-1121	1113-11-21100-1020	1113-11-21100-1121	1113-11-21101-1000
1113-11-21032-1021	1113-11-21032-1120	1113-11-21100-1031	1113-11-21100-1120	1113-11-21101-1021
1113-11-21032-1020	1113-11-21100-1001	1113-11-21100-1030	1113-11-21100-1131	1113-11-21101-1020
1113-11-21032-1101	1113-11-21100-1000	1113-11-21100-1101	1113-11-21100-1130	1113-11-21101-1101
1113-11-21101-1100	1113-11-21130-1101	1113-11-21131-1020	1113-11-21132-1001	1113-11-21132-1100
1113-11-21101-1121	1113-11-21130-1100	1113-11-21131-1101	1113-11-21132-1000	1113-11-21132-1121
1113-11-21101-1120	1113-11-21131-1001	1113-11-21131-1100	1113-11-21132-1021	1113-11-21132-1120
1113-11-21130-1001	1113-11-21131-1000	1113-11-21131-1121	1113-11-21132-1020	1113-11-22002-1101
1113-11-21130-1000	1113-11-21131-1021	1113-11-21131-1120	1113-11-21132-1101	1113-11-22002-1100
1113-11-22002-1121	1113-11-22032-1101	1113-11-22032-1131		
1113-11-22002-1120	1113-11-22032-1100	1113-11-22032-1130		

Permutations this subset: 256

(table continues)

Table C-2 (Continued)

Gunner engages stationary point target, battlesight, with SABOT, from the halt; enumeration:

1121-00-11000-1001	1121-00-11100-1000	1121-00-12002-0001	1121-00-21000-0000	1121-00-22002-1001
1121-00-11000-1000	1121-00-11100-0001	1121-00-12002-0000	1121-00-21100-1001	1121-00-22002-1000
1121-00-11000-0001	1121-00-11100-0000	1121-00-21000-1001	1121-00-21100-1000	1121-00-22002-0001
1121-00-11000-0000	1121-00-12002-1001	1121-00-21000-1000	1121-00-21100-0001	1121-00-22002-0000
1121-00-11100-1001	1121-00-12002-1000	1121-00-21000-0001	1121-00-21100-0000	

Permutations this subset: 24

Gunner engages moving point target, battlesight, with SABOT, from the halt; enumeration:

1121-01-11000-1001	1121-01-11000-0100	1121-01-11100-0101	1121-01-12002-0100	1121-01-21000-0101
1121-01-11000-1000	1121-01-11100-1001	1121-01-11100-0100	1121-01-21000-1001	1121-01-21000-0100
1121-01-11000-1101	1121-01-11100-1000	1121-01-12002-1101	11?1-01-21000-1000	1121-01-21100-1001
1121-01-11000-1100	1121-01-11100-1101	1121-01-12002-1100	112i-01-21000-1101	1121-01-21100-1000
1121-01-11000-0101	1121-01-11100-1100	1121-01-12002-0101	1121-01-21000-1100	1121-01-21100-1101

1121-01-21100-1100	1121-01-21100-0100	1121-01-22002-1100	1121-01-22002-0100
1121-01-21100-0101	1121-01-22002-1101	1121-01-22002-0101	

Permutations this subset: 32

Gunner engages stationary point target, battlesight, with SABOT, on the move; enumeration:

1121-10-11000-1001	1121-10-11100-1000	1121-10-21000-1001	1121-10-21100-1000
1121-10-11000-1000	1121-10-12002-1001	1121-10-21000-1000	1121-10-22002-1001
1121-10-11100-1001	1121-10-12002-1000	1121-10-21100-1001	1121-10-22002-1000

Permutations this subset: 12

Gunner engages moving point target, battlesight, with SABOT, on the move; enumeration:

1121-11-11000-1001	1121-11-11100-1001	1121-11-12002-1101	1121-11-21000-1101	1121-11-21100-1101
1121-11-11000-1000	1121-11-11100-1000	1121-11-12002-1100	1121-11-21000-1100	1121-11-21100-1100
1121-11-11000-1101	1121-11-11100-1101	1121-11-21000-1001	1121-11-21100-1001	1121-11-22002-1101
1121-11-11000-1100	1121-11-11100-1100	1121-11-21000-1000		1121-11-21100-
1000	1121-11-22002-1100			

Permutations this subset: 20

(table continues)

Table C-2 (Continued)

Gunner engages stationary point target, battlesight, with HEAT, from the halt; enumeration:

1122-00-11000-1001	1122-00-11100-1000	1122-00-12002-0001	1122-00-21000-0000	1122-00-22002-1001
1122-00-11000-1000	1122-00-11100-0001	1122-00-12002-0000	1122-00-21100-1001	1122-00-22002-1000
1122-00-11000-0001	1122-00-11100-0000	1122-00-21000-1001	1122-00-21100-1000	1122-00-22002-0001
1122-00-11000-0000	1122-00-12002-1001	1122-00-21000-1000	1122-00-21100-0001	1122-00-22002-0000
1122-00-11100-1001	1122-00-12002-1000	1122-00-21000-0001	1122-00-21100-0000	

Permutations this subset: 24

Gunner engages moving point target, battlesight, with HEAT, from the halt; enumeration:

1122-01-11000-1001	1122-01-11000-0100	1122-01-11100-0101	1122-01-12002-0100	1122-01-21000-0101
1122-01-11000-1000	1122-01-11100-1001	1122-01-11100-0100	1122-01-21000-1001	1122-01-21000-0100
1122-01-11000-1101	1122-01-11100-1000	1122-01-12002-1101	1122-01-21000-1000	1122-01-21100-1001
1122-01-11000-1100	1122-01-11100-1101	1122-01-12002-1100	1122-01-21000-1101	1122-01-21100-1000
1122-01-11000-0101	1122-01-11100-1100	1122-01-12002-0101	1122-01-21000-1100	1122-01-21100-1101

1122-01-21100-1100	1122-01-21100-0100	1122-01-22002-1100	1122-01-22002-0100
1122-01-21100-0101	1122-01-22002-1101	1122-01-22002-0101	

Permutations this subset: 32

Gunner engages stationary point target, battlesight, with HEAT, on the move; enumeration:

1122-10-11000-1001	1122-10-11100-1000	1122-10-21000-1001	1122-10-21100-1000
1122-10-11000-1000	1122-10-12002-1001	1122-10-21000-1000	1122-10-22002-1001
1122-10-11100-1001	1122-10-12002-1000	1122-10-21100-1001	1122-10-22002-1000

Permutations this subset: 12

Gunner engages moving point target, battlesight, with HEAT, on the move; enumeration:

1122-11-11000-1001	1122-11-11100-1001	1122-11-12002-1101	1122-11-21000-1101	1122-11-21100-1101
1122-11-11000-1000	1122-11-11100-1000	1122-11-12002-1100	1122-11-21000-1100	1122-11-21100-1100
1122-11-11000-1101	1122-11-11100-1101	1122-11-21000-1001	1122-11-21100-1001	1122-11-22002-1101
1122-11-11000-1100	1122-11-11100-1100	1122-11-21000-1000	1122-11-21100-1000	1122-11-22002-1100

Permutations this subset: 20

(table continues)

Table C-2 (Continued)

Gunner engages stationary point target, battlesight, with coax, from the halt; enumeration:

1123-00-11000-1001	1123-00-11100-1000	1123-00-12002-0001	1123-00-21000-0000	1123-00-22002-1001
1123-00-11000-1000	1123-00-11100-0001	1123-00-12002-0000	1123-00-21100-1001	1123-00-22002-1000
1123-00-11000-0001	1123-00-11100-0000	1123-00-21000-1001	1123-00-21100-1000	1123-00-22002-0001
1123-00-11000-0000	1123-00-12002-1001	1123-00-21000-1000	1123-00-21100-0001	1123-00-22002-0000
1123-00-11100-1001	1123-00-12002-1000	1123-00-21000-0001	1123-00-21100-0000	

Permutations this subset: 24

Gunner engages moving point target, battlesight, with coax, from the halt; enumeration:

1123-01-11000-1001	1123-01-11000-0100	1123-01-11100-0101	1123-01-12002-0100	1123-01-21000-0101
1123-01-11000-1000	1123-01-11100-1001	1123-01-11100-0100	1123-01-21000-1001	1123-01-21000-0100
1123-01-11000-1101	1123-01-11100-1000	1123-01-12002-1101	1123-01-21000-1000	1123-01-21100-1001
1123-01-11000-1100	1123-01-11100-1101	1123-01-12002-1100	1123-01-21000-1101	1123-01-21100-1000
1123-01-11000-0101	1123-01-11100-1100	1123-01-12002-0101	1123-01-21000-1100	1123-01-21100-1101

1123-01-21100-1100	1123-01-21100-0100	1123-01-22002-1100	1123-01-22002-0100
1123-01-21100-0101	1123-01-22002-1101	1123-01-22002-0101	

Permutations this subset: 32

Gunner engages stationary point target, battlesight, with coax, on the move; enumeration:

1123-10-11000-1001	1123-10-11100-1000	1123-10-21000-1001	1123-10-21100-1000
1123-10-11000-1000	1123-10-12002-1001	1123-10-21000-1000	1123-10-22002-1001
1123-10-11100-1001	1123-10-12002-1000	1123-10-21100-1001	1123-10-22002-1000

Permutations this subset: 12

Gunner engages moving point target, battlesight, with coax, on the move:

1123-11-11000-1001	1123-11-11100-1001	1123-11-12002-1101	1123-11-21000-1101	1123-11-21100-1101
1123-11-11000-1000	1123-11-11100-1000	1123-11-12002-1100	1123-11-21000-1100	1123-11-21100-1100
1123-11-11000-1101	1123-11-11100-1101	1123-11-21000-1001	1123-11-21100-1001	1123-11-22002-1101
1123-11-11000-1100	1123-11-11100-1100	1123-11-21000-1000	1123-11-21100-1000	1123-11-22002-1100

Permutations this subset: 20

Table C-2 (Continued)

Gunner engages stationary area target, precision, with coax, from the halt; enumeration:

1213-00-11000-1001	1213-00-11000-1020	1213-00-11000-0011	1213-00-11000-0030	1213-00-11001-1031
1213-00-11000-1000	1213-00-11000-1031	1213-00-11000-0010	1213-00-11001-1001	1213-00-11001-1030
1213-00-11000-1011	1213-00-11000-1030	1213-00-11000-0021	1213-00-11001-1000	1213-00-11001-0001
1213-00-11000-1010	1213-00-11000-0001	1213-00-11000-0020	1213-00-11001-1011	1213-00-11001-0000
1213-00-11000-1021	1213-00-11000-0000	1213-00-11000-0031	1213-00-11001-1010	1213-00-11001-0011
1213-00-11001-0010	1213-00-11010-1011	1213-00-11010-0010	1213-00-11011-0001	1213-00-11020-1000
1213-00-11001-0031	1213-00-11010-1010	1213-00-11011-1001	1213-00-11011-0000	1213-00-11020-1011
1213-00-11001-0030	1213-00-11010-0001	1213-00-11011-1000	1213-00-11011-0011	1213-00-11020-1010
1213-00-11010-1001	1213-00-11010-0000	1213-00-11011-1011	1213-00-11011-0010	1213-00-11020-0001
1213-00-11010-1000	1213-00-11010-0011	1213-00-11011-1010	1213-00-11020-1001	1213-00-11020-0000
1213-00-11020-0011	1213-00-11021-1010	1213-00-11032-1001	1213-00-11032-1030	1213-00-11032-0031
1213-00-11020-0010	1213-00-11021-0001	1213-00-11032-1000	1213-00-11032-0001	1213-00-11032-0030
1213-00-11021-1001	1213-00-11021-0000	1213-00-11032-1011	1213-00-11032-0000	1213-00-11100-1001
1213-00-11021-1000	1213-00-11021-0011	1213-00-11032-1010	1213-00-11032-0011	1213-00-11100-1000
1213-00-11021-1011	1213-00-11021-0010	1213-00-11032-1031	1213-00-11032-0010	1213-00-11100-1011
1213-00-11100-1010	1213-00-11100-0001	1213-00-11100-0020	1213-00-11101-1011	1213-00-11101-0000
1213-00-11100-1021	1213-00-11100-0000	1213-00-11100-0031	1213-00-11101-1010	1213-00-11101-0011
1213-00-11100-1020	1213-00-11100-0011	1213-00-11100-0030	1213-00-11101-1031	1213-00-11101-0010
1213-00-11100-1031	1213-00-11100-0010	1213-00-11101-1001	1213-00-11101-1030	1213-00-11101-0031
1213-00-11100-1030	1213-00-11100-0021	1213-00-11101-1000	1213-00-11101-0001	1213-00-11101-0030
1213-00-11110-1001	1213-00-11110-0000	1213-00-11111-1011	1213-00-11111-0010	1213-00-11120-0001
1213-00-11110-1000	1213-00-11110-0011	1213-00-11111-1010	1213-00-11120-1001	1213-00-11120-0000
1213-00-11110-1011	1213-00-11110-0010	1213-00-11111-0001	1213-00-11120-1000	1213-00-11120-0011
1213-00-11110-1010	1213-00-11111-1001	1213-00-11111-0000	1213-00-11120-1011	1213-00-11120-0010
1213-00-11110-0001	1213-00-11111-1000	1213-00-11111-0011	1213-00-11120-1010	1213-00-11121-1001
1213-00-11121-1000	1213-00-11121-0011	1213-00-11132-1010	1213-00-11132-0011	1213-00-12032-1000
1213-00-11121-1011	1213-00-11121-0010	1213-00-11132-1031	1213-00-11132-0010	1213-00-12032-1011
1213-00-11121-1010	1213-00-11132-1001	1213-00-11132-1030	1213-00-11132-0031	1213-00-12032-1010
1213-00-11121-0001	1213-00-11132-1000	1213-00-11132-0001	1213-00-11132-0030	1213-00-12032-1031
1213-00-11121-0000	1213-00-11132-1011	1213-00-11132-0000	1213-00-12032-1001	1213-00-12032-1030
1213-00-12032-0001	1213-00-12032-0030	1213-00-21000-1021	1213-00-21000-0010	1213-00-21001-1011
1213-00-12032-0000	1213-00-21000-1001	1213-00-21000-1020	1213-00-21000-0021	1213-00-21001-1010
1213-00-12032-0011	1213-00-21000-1000	1213-00-21000-0001	1213-00-21000-0020	1213-00-21001-0001
1213-00-12032-0010	1213-00-21000-1011	1213-00-21000-0000	1213-00-21001-1001	1213-00-21001-0000
1213-00-12032-0031	1213-00-21000-1010	1213-00-21000-0011	1213-00-21001-1000	1213-00-21001-0011

Table C-2 (Continued)

Gunner engages stationary area target, precision, with coax, from
the halt; enumeration, continued:

1213-00-21001-0010	1213-00-21010-0001	1213-00-21011-1000	1213-00-21011-0011	1213-00-21020-1010
1213-00-21010-1001	1213-00-21010-0000	1213-00-21011-1011	1213-00-21011-0010	1213-00-21020-0001
1213-00-21010-1000	1213-00-21010-0011	1213-00-21011-1010	1213-00-21020-1001	1213-00-21020-0000
1213-00-21010-1011	1213-00-21010-0010	1213-00-21011-0001	1213-00-21020-1000	1213-00-21020-0011
1213-00-21010-1010	1213-00-21011-1001	1213-00-21011-0000	1213-00-21020-1011	1213-00-21020-0010
1213-00-21021-1001	1213-00-21021-0000	1213-00-21032-1011	1213-00-21032-0010	1213-00-21100-1021
1213-00-21021-1000	1213-00-21021-0011	1213-00-21032-1010	1213-00-21100-1001	1213-00-21100-1020
1213-00-21021-1011	1213-00-21021-0010	1213-00-21032-0001	1213-00-21100-1000	1213-00-21100-0001
1213-00-21021-1010	1213-00-21032-1001	1213-00-21032-0000	1213-00-21100-1011	1213-00-21100-0000
1213-00-21021-0001	1213-00-21032-1000	1213-00-21032-0011	1213-00-21100-1010	1213-00-21100-0011
1213-00-21100-0010	1213-00-21101-1011	1213-00-21101-0010	1213-00-21110-0001	1213-00-21111-1000
1213-00-21100-0021	1213-00-21101-1010	1213-00-21110-1001	1213-00-21110-0000	1213-00-21111-1011
1213-00-21100-0020	1213-00-21101-0001	1213-00-21110-1000	1213-00-21110-0011	1213-00-21111-1010
1213-00-21101-1001	1213-00-21101-0000	1213-00-21110-1011	1213-00-21110-0010	1213-00-21111-0001
1213-00-21101-1000	1213-00-21101-0011	1213-00-21110-1010	1213-00-21111-1001	1213-00-21111-0000
1213-00-21111-0011	1213-00-21120-1010	1213-00-21121-1001	1213-00-21121-0000	1213-00-21132-1011
1213-00-21111-0010	1213-00-21120-0001	1213-00-21121-1000	1213-00-21121-0011	1213-00-21132-1010
1213-00-21120-1001	1213-00-21120-0000	1213-00-21121-1011	1213-00-21121-0010	1213-00-21132-0001
1213-00-21120-1000	1213-00-21120-0011	1213-00-21121-1010	1213-00-21132-1001	1213-00-21132-0000
1213-00-21120-1011	1213-00-21120-0010	1213-00-21121-0001	1213-00-21132-1000	1213-00-21132-0011
1213-00-21132-0010	1213-00-22032-1000	1213-00-22032-1010	1213-00-22032-0000	1213-00-22032-0010
1213-00-22032-1001	1213-00-22032-1011	1213-00-22032-0001	1213-00-22032-0011	

Permutations this subset: 284

Gunner engages stationary area target, precision, with coax, on
the move; enumeration:

1213-10-11000-1001	1213-10-11000-1030	1213-10-11000-1131	1213-10-11001-1020	1213-10-11001-1121
1213-10-11000-1000	1213-10-11000-1101	1213-10-11000-1130	1213-10-11001-1031	1213-10-11001-1120
1213-10-11000-1021	1213-10-11000-1100	1213-10-11001-1001	1213-10-11001-1030	1213-10-11001-1131
1213-10-11000-1020	1213-10-11000-1121	1213-10-11001-1000	1213-10-11001-1101	1213-10-11001-1130
1213-10-11000-1031	1213-10-11000-1120	1213-10-11001-1021	1213-10-11001-1100	1213-10-11010-1001
1213-10-11010-1000	1213-10-11010-1131	1213-10-11011-1020	1213-10-11011-1121	1213-10-11020-1000
1213-10-11010-1031	1213-10-11010-1130	1213-10-11011-1031	1213-10-11011-1120	1213-10-11020-1031
1213-10-11010-1030	1213-10-11011-1001	1213-10-11011-1030	1213-10-11011-1131	1213-10-11020-1030
1213-10-11010-1101	1213-10-11011-1000	1213-10-11011-1101	1213-10-11011-1130	1213-10-11020-1101
1213-10-11010-1100	1213-10-11011-1021	1213-10-11011-1100	1213-10-11020-1001	1213-10-11020-1100

(table continues)

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

Gunner engages stationary area target, precision, with coax, on
the move; enumeration, continued:

1213-10-11020-1131	1213-10-11021-1020	1213-10-11030-1001	1213-10-11031-1000	1213-10-11031-1121
1213-10-11020-1130	1213-10-11021-1101	1213-10-11030-1000	1213-10-11031-1021	1213-10-11031-1120
1213-10-11021-1001	1213-10-11021-1100	1213-10-11030-1101	1213-10-11031-1020	1213-10-11032-1001
1213-10-11021-1000	1213-10-11021-1121	1213-10-11030-1100	1213-10-11031-1101	1213-10-11032-1000
1213-10-11021-1021	1213-10-11021-1120	1213-10-11031-1001	1213-10-11031-1100	1213-10-11032-1021
1213-10-11032-1020	1213-10-11100-1001	1213-10-11100-1030	1213-10-11100-1131	1213-10-11101-1020
1213-10-11032-1101	1213-10-11100-1000	1213-10-11100-1101	1213-10-11100-1130	1213-10-11101-1031
1213-10-11032-1100	1213-10-11100-1021	1213-10-11100-1100	1213-10-11101-1001	1213-10-11101-1030
1213-10-11032-1121	1213-10-11100-1020	1213-10-11100-1121	1213-10-11101-1000	1213-10-11101-1101
1213-10-11032-1120	1213-10-11100-1031	1213-10-11100-1120	1213-10-11101-1021	1213-10-11101-1100
1213-10-11101-1121	1213-10-11110-1000	1213-10-11110-1131	1213-10-11111-1020	1213-10-11111-1121
1213-10-11101-1120	1213-10-11110-1031	1213-10-11110-1130	1213-10-11111-1031	1213-10-11111-1120
1213-10-11101-1131	1213-10-11110-1030	1213-10-11111-1001	1213-10-11111-1030	1213-10-11111-1131
1213-10-11101-1130	1213-10-11110-1101	1213-10-11111-1000	1213-10-11111-1101	1213-10-11111-1130
1213-10-11110-1001	1213-10-11110-1100	1213-10-11111-1021	1213-10-11111-1100	1213-10-11120-1001
1213-10-11120-1000	1213-10-11120-1131	1213-10-11121-1020	1213-10-11130-1001	1213-10-11131-1000
1213-10-11120-1031	1213-10-11120-1130	1213-10-11121-1101	1213-10-11130-1000	1213-10-11131-1021
1213-10-11120-1030	1213-10-11121-1001	1213-10-11121-1100	1213-10-11130-1101	1213-10-11131-1020
1213-10-11120-1101	1213-10-11121-1000	1213-10-11121-1121	1213-10-11130-1100	1213-10-11131-1101
1213-10-11120-1100	1213-10-11121-1021	1213-10-11121-1120	1213-10-11131-1001	1213-10-11131-1100
1213-10-11131-1121	1213-10-11132-1020	1213-10-12002-1101	1213-10-12032-1100	1213-10-21000-1021
1213-10-11131-1120	1213-10-11132-1101	1213-10-12002-1100	1213-10-12032-1131	1213-10-21000-1020
1213-10-11132-1001	1213-10-11132-1100	1213-10-12002-1121	1213-10-12032-1130	1213-10-21000-1031
1213-10-11132-1000	1213-10-11132-1121	1213-10-12002-1120	1213-10-21000-1001	1213-10-21000-1030
1213-10-11132-1021	1213-10-11132-1120	1213-10-12032-1101	1213-10-21000-1000	1213-10-21000-1101
1213-10-21000-1100	1213-10-21001-1001	1213-10-21001-1100	1213-10-21030-1101	1213-10-21031-1020
1213-10-21000-1121	1213-10-21001-1000	1213-10-21001-1121	1213-10-21030-1100	1213-10-21031-1101
1213-10-21000-1120	1213-10-21001-1021	1213-10-21001-1120	1213-10-21031-1001	1213-10-21031-1100
1213-10-21000-1131	1213-10-21001-1020	1213-10-21030-1001	1213-10-21031-1000	1213-10-21031-1121
1213-10-21000-1130	1213-10-21001-1101	1213-10-21030-1000	1213-10-21031-1021	1213-10-21031-1120
1213-10-21032-1001	1213-10-21032-1100	1213-10-21100-1021	1213-10-21100-1100	1213-10-21101-1001
1213-10-21032-1000	1213-10-21032-1121	1213-10-21100-1020	1213-10-21100-1121	1213-10-21101-1000
1213-10-21032-1021	1213-10-21032-1120	1213-10-21100-1031	1213-10-21100-1120	1213-10-21101-1021
1213-10-21032-1020	1213-10-21100-1001	1213-10-21100-1030	1213-10-21100-1131	1213-10-21101-1020
1213-10-21032-1101	1213-10-21100-1000	1213-10-21100-1101	1213-10-21100-1130	1213-10-21101-1101

Table C-2 (Continued)

Gunner engages stationary area target, precision, with coax, on the move; enumeration, continued:

1213-1Q-21101-1100	1213-10-21130-1101	1213-10-21131-1020	1213-10-21132-1001	1213-10-21132-1100
1213-10-21101-1121	1213-10-21130-1100	1213-10-21131-1101	1213-10-21132-1000	1213-10-21132-1121
1213-10-21101-1120	1213-10-21131-1001	1213-10-21131-1100	1213-10-21132-1021	1213-10-21132-1120
1213-10-21130-1001	1213-10-21131-1000	1213-10-21131-1121	1213-10-21132-1020	1213-10-22002-1101
1213-10-21130-1000	1213-10-21131-1021	1213-10-21131-1120	1213-10-21132-1101	1213-10-22002-1100
1213-10-22002-1121	1213-10-22032-1101	1213-10-22032-1131		
1213-10-22002-1120	1213-10-22032-1100	1213-10-22032-1130		

Permutations this subset: 256

Gunner engages stationary area target, battlesight, with coax, from the halt; enumeration:

1223-00-11000-1001	1223-00-11100-1000	1223-00-12002-0001	1223-00-21000-0000	1223-00-22002-1001
1223-00-11000-1000	1223-00-11100-0001	1223-00-12002-0000	1223-00-21100-1001	1223-00-22002-1000
1223-00-11000-0001	1223-00-11100-0000	1223-00-21000-1001	1223-00-21100-1000	1223-00-22002-0001
1223-00-11000-0000	1223-00-12002-1001	1223-00-21000-1000	1223-00-21100-0001	1223-00-22002-0000
1223-00-11100-1001	1223-00-12002-1000	1223-00-21000-0001	1223-00-21100-0000	

Permutations this subset: 24

Gunner engages stationary area target, battlesight, with coax, on the move; enumeration:

1223-10-11000-1001	1223-10-11100-1000	1223-10-12002-0001	1223-10-21000-0000	1223-10-22002-1001
1223-10-11000-1000	1223-10-11100-0001	1223-10-12002-0000	1223-10-21100-1001	1223-10-22002-1000
1223-10-11000-0001	1223-10-11100-0000	1223-10-21000-1001	1223-10-21100-1000	1223-10-22002-0001
1223-10-11000-0000	1223-10-12002-1001	1223-10-21000-1000	1223-10-21100-0001	1223-10-22002-0000
1223-10-11100-1001	1223-10-12002-1000	1223-10-21000-0001	1223-10-21100-0000	

Permutations this subset: 24

(table continues)

Table C-2 (Continued)

Tank Commander's Engagements

TC engages stationary point target, precision, with SABOT, from the halt; enumeration:

2111-00-13000-1001	2111-00-13010-1001	2111-00-13020-1011	2111-00-13100-1021	2111-00-13120-1001
2111-00-13000-1011	2111-00-13010-1011	2111-00-13100-1001	2111-00-13110-1001	2111-00-13120-1011
2111-00-13000-1021	2111-00-13020-1001	2111-00-13100-1011	2111-00-13110-1011	

Permutations this subset: 14

TC engages moving point target, precision, with SABOT, from the halt; enumeration:

2111-01-13000-1001	2111-01-13000-1121	2111-01-13020-1001	2111-01-13100-1011	2111-01-13110-1001
2111-01-13000-1011	2111-01-13010-1001	2111-01-13020-1011	2111-01-13100-1021	2111-01-13110-1011
2111-01-13000-1021	2111-01-13010-1011	2111-01-13020-1101	2111-01-13100-1101	2111-01-13110-1101
2111-01-13000-1101	2111-01-13010-1101	2111-01-13020-1111	2111-01-13100-1111	2111-01-13110-1111
2111-01-13000-1111	2111-01-13010-1111	2111-01-13100-1001	2111-01-13100-1121	2111-01-13120-1001

2111-01-13120-1011	2111-01-13120-1101	2111-01-13120-1111

Permutations this subset: 28

TC engages stationary point target, precision, with SABOT, on the move; enumeration:

2111-10-13000-1001	2111-10-13010-1001	2111-10-13100-1001	2111-10-13110-1001
2111-10-13000-1021	2111-10-13020-1001	2111-10-13100-1021	2111-10-13120-1001

Permutations this subset: 8

TC engages moving point target, precision, with SABOT, on the move; enumeration:

2111-11-13000-1001	2111-11-13010-1001	2111-11-13100-1001	2111-11-13110-1001
2111-11-13000-1021	2111-11-13010-1101	2111-11-13100-1021	2111-11-13110-1101
2111-11-13000-1101	2111-11-13020-1001	2111-11-13100-1101	2111-11-13120-1001
2111-11-13000-1121	2111-11-13020-1101	2111-11-13100-1121	2111-11-13120-1101

Permutations this subset: 16

(<u>table continues</u>)

Table C-2 (Continued)

TC engages stationary point target, precision, with HEAT, from the halt; enumeration:

2112-00-13000-1001	2112-00-13010-1001	2112-00-13020-1011	2112-00-13100-1021	2112-00-13120-1001
2112-00-13000-1011	2112-00-13010-1011	2112-00-13100-1001	2112-00-13110-1001	2112-00-13120-1011
2112-00-13000-1021	2112-00-13020-1001	2112-00-13100-1011	2112-00-13110-1011	

Permutations this subset: 14

TC engages moving point target, precision, with HEAT, from the halt; enumeration:

2112-01-13000-1001	2112-01-13000-1121	2112-01-13020-1001	2112-01-13100-1011	2112-01-13110-1001
2112-01-13000-1011	2112-01-13010-1001	2112-01-13020-1011	2112-01-13100-102i	2112-01-13110-1011
2112-01-13000-1021	2112-01-13010-1011	2112-01-13020-1101	2112-01-13100-1101	2112-01-13110-1101
2112-01-13000-1101	2112-01-13010-1101	2112-01-13020-1111	2112-01-13100-1111	2112-01-13110-1111
2112-01-13000-1111	2112-01-13010-1111	2112-01-13100-1001	2112-01-13100-1121	2112-01-13120-1001

2112-01-13120-1011	2112-01-13120-1101	2112-01-13120-1111

Permutations this subset: 28

TC engages stationary point target, precision, with HEAT, on the move; enumeration:

2112-10-13000-1001	2112-10-13010-1001	2112-10-13100-1001	2112-10-13110-1001
2112-10-13000-1021	2112-10-13020-1001	2112-10-13100-1021	2112-10-13120-1001

Permutations this subset: 8

TC engages moving point target, precision, with HEAT, on the move; enumeration:

2112-11-13000-1001	2112-11-13010-1001	2112-11-13100-1001	2112-11-13110-1001
2112-11-13000-1021	2112-11-13010-1101	2112-11-13100-1021	2112-11-13110-1101
2112-11-13000-1101	2112-11-13020-1001	2112-11-13100-1101	2112-11-13120-1001
2112-11-13000-1121	2112-11-13020-1101	2112-11-13100-1121	2112-11-13120-1101

Permutations this subset: 16

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-2 (Continued)

TC engages stationary point target, precision, with coax, from
the halt; enumeration:

2113-00-13000-1001	2113-00-13010-1001	2113-00-13020-1011	2113-00-13100-1021	2113-00-13120-1001
2113-00-13000-1011	2113-00-13010-1011	2113-00-13100-1001	2113-00-13110-1001	2113-00-13120-1011
2113-00-13000-1021	2113-00-13020-1001	2113-00-13100-1011	2113-00-13110-1011	

Permutations this subset: 14

TC engages moving point target, precision, with coax, from the
halt; enumeration:

2113-01-13000-1001	2113-01-13000-1121	2113-01-13020-1001	2113-01-13100-1011	2113-01-13110-1001
2113-01-13000-1011	2113-01-13010-1001	2113-01-13020-1011	2113-01-13100-1021	2113-01-13110-1011
2113-01-13000-1021	2113-01-13010-1011	2113-01-13020-1101	2113-01-13100-1101	2113-01-13110-1101
2113-01-13000-1101	2113-01-13010-1101	2113-01-13020-1111	2113-01-13100-1111	2113-01-13110-1111
2113-01-13000-1111	2113-01-13010-1111	2113-01-13100-1001	2113-01-13100-1121	2113-01-13120-1001

2113-01-13120-1011	2113-01-13120-1101	2113-01-13120-1111

Permutations this subset: 28

TC engages stationary point target, precision, with coax, on the
move; enumeration:

2113-10-13000-1001	2113-10-13010-1001	2113-10-13100-1001	2113-10-13110-1001
2113-10-13000-1021	2113-10-13020-1001	2113-10-13100-1021	2113-10-13120-1001

Permutations this subset: 8

TC engages moving point target, precision, with coax, on the
move; enumeration:

2113-11-13000-1001	2113-11-13010-1001	2113-11-13100-1001	2113-11-13110-1001
2113-11-13000-1021	2113-11-13010-1101	2113-11-13100-1021	2113-11-13110-1101
2113-11-13000-1101	2113-11-13020-1001	2113-11-13100-1101	2113-11-13120-1001
2113-11-13000-1121	2113-11-13020-1101	2113-11-13100-1121	2113-11-13120-1101

Permutations this subset: 16

Table C-2 (Continued)

TC engages stationary point target, with cal .50, from the halt; enumeration:

2114-00-14020-1001	2114-00-14020-1020	2114-00-14020-0021	2114-00-14021-1010	2114-00-15020-1001
2114-00-14020-1000	2114-00-14020-0001	2114-00-14020-0020	2114-00-14021-0001	2114-00-15020-1000
2114-00-14020-1011	2114-00-14020-0000	2114-00-14021-1001	2114-00-14021-0000	2114-00-15020-1011
2114-00-14020-1010	2114-00-14020-0011	2114-00-14021-1000	2114-00-14021-0011	2114-00-15020-1010
2114-00-14020-1021	2114-00-14020-0010	2114-00-14021-1011	2114-00-14021-0010	2114-00-15020-1021
2114-00-15020-1020	2114-00-15020-0000	2114-00-15020-0010	2114-00-15020-0020	
2114-00-15020-0001	2114-00-15020-0011	2114-00-15020-0021		

Permutations this subset: 32

TC engages moving point target, with cal .50, from the halt; enumeration:

2114-01-14020-1101	2114-01-14020-1120	2114-01-14020-0121	2114-01-14021-1110	2114-01-14021-0111
2114-01-14020-1100	2114-01-14020-0101	2114-01-14020-0120	2114-01-14021-1121	2114-01-14021-0110
2114-01-14020-1111	2114-01-14020-0100	2114-01-14021-1101	2114-01-14021-1120	2114-01-14021-0121
2114-01-14020-1110	2114-01-14020-0111	2114-01-14021-1100	2114-01-14021-0101	2114-01-14021-0120
2114-01-14020-1121	2114-01-14020-0110	2114-01-14021-1111	2114-01-14021-0100	2114-01-15020-1101
2114-01-15020-1100	2114-01-15020-1121	2114-01-15020-0100	2114-01-15020-0121	
2114-01-15020-1111	2114-01-15020-1120	2114-01-15020-0111	2114-01-15020-0120	
2114-01-15020-1110	2114-01-15020-0101	2114-01-15020-0110		

Permutations this subset: 36

TC engages stationary point target, with cal .50, on the move; enumeration:

2114-10-14020-1001	2114-10-14020-1020	2114-10-14020-0021	2114-10-14021-1010	2114-10-14021-0011
2114-10-14020-1000	2114-10-14020-0001	2114-10-14020-0020	2114-10-14021-1021	2114-10-14021-0010
2114-10-14020-1011	2114-10-14020-0000	2114-10-14021-1001	2114-10-14021-1020	2114-10-14021-0021
2114-10-14020-1010	2114-10-14020-0011	2114-10-14021-1000	2114-10-14021-0001	2114-10-14021-0020
2114-10-14020-1021	2114-10-14020-0010	2114-10-14021-1011	2114-10-14021-0000	2114-10-15020-1001
2114-10-15020-1000	2114-10-15020-1021	2114-10-15020-0000	2114-10-15020-0021	
2114-10-15020-1011	2114-10-15020-1020	2114-10-15020-0011	2114-10-15020-0020	
2114-10-15020-1010	2114-10-15020-0001	2114-10-15020-0010		

Permutations this subset: 36

Table C-2 (Continued)

TC engages moving point target, with cal .50, on the move; enumeration:

2114-11-14020-1101	2114-11-14020-1120	2114-11-14020-0121	2114-11-14021-1110	2114-11-14021-0111
2114-11-14020-1100	2114-11-14020-0101	2114-11-14020-0120	2114-11-14021-1121	2114-11-14021-0110
2114-11-14020-1111	2114-11-14020-0100	2114-11-14021-1101	2114-11-14021-1120	2114-11-14021-0121
2114-11-14020-1110	2114-11-14020-0111	2114-11-14021-1100	2114-11-14021-0101	2114-11-14021-0120
2114-11-14020-1121	2114-11-14020-0110	2114-11-14021-1111	2114-11-14021-0100	2114-11-15020-1101
2114-11-15020-1100	2114-11-15020-1121	2114-11-15020-0100	2114-11-15020-0121	
2114-11-15020-1111	2114-11-15020-1120	2114-11-15020-0111	2114-11-15020-0120	
2114-11-15020-1110	2114-11-15020-0101	2114-11-15020-0110		

Permutations this subset: 36

TC engages stationary point target, battlesight, with SABOT, from the halt; enumeration:

2121-00-13000-1001   2121-00-13100-1001

Permutations this subset: 2

TC engages moving point target, battlesight, with SABOT, from the halt; enumeration:

2121-01-13000-1001   2121-01-13000-1101   2121-01-13100-1101   2121-01-13100-1001

Permutations this subset: 4

TC engages stationary point target, battlesight, with SABOT, on the move; enumeration:

2121-10-13000-1001   2121-10-13100-1001

Permutations this subset: 2

TC engages moving point target, battlesight, with SABOT, on the move; enumeration:

2121-11-13000-1001   2121-11-13000-1101   2121-11-13100-1101   2121-11-13100-1001

Permutations this subset: 4

(table continues)

Table C-2 (Continued)

TC engages stationary point target, battlesight, with HEAT, from the halt; enumeration:

2122-00-13000-1001   2122-00-13100-1001

Permutations this subset: 2

TC engages moving point target, battlesight, with HEAT, from the halt; enumeration:

2122-01-13000-1001   2122-01-13000-1101   2122-01-13100-1001   2122-01-13100-1101

Permutations this subset: 4

TC engages stationary point target, battlesight, with HEAT, on the move; enumeration:

2122-10-13000-1001   2122-10-13100-1001

Permutations this subset: 2

TC engages moving point target, battlesight, with HEAT, on the move; enumeration:

2122-11-13000-1001   2122-11-13000-1101   2122-11-13100-1001   2122-11-13100-1101

Permutations this subset: 4

TC engages stationary point target, battlesight, with coax, from the halt; enumeration:

2123-00-13000-1001   2123-00-13100-1001

Permutations this subset: 2

TC engages moving point target, battlesight, with coax, from the halt; enumeration:

2123-01-13000-1001   2123-01-13000-1101   2123-01-13100-1001   2123-01-13100-1101

Permutations this subset: 4

(table continues)

APPENDIX C. ENGAGEMENT TASK LIST

Table C-2 (Continued)

TC engages stationary point target, battlesight, with coax, on the move; enumeration:

2123-10-13000-1001   2123-10-13100-1001

Permutations this subset: 2

TC engages moving point target, battlesight, with coax, on the move; enumeration:

2123-11-13000-1001   2123-11-13000-1101   2123-11-13100-1001   2123-11-13100-1101

Permutations this subset: 4

TC engages stationary area target, precision, with coax, from the halt; enumeration:

2213-00-13000-1001   2213-00-13010-1001   2213-00-13020-1011   2213-00-13100-1021   2213-00-13120-1001
2213-00-13000-1011   2213-00-13010-1011   2213-00-13100-1001   2213-00-13110-1001   2213-00-13120-1011
2213-00-13000-1021   2213-00-13020-1001   2213-00-13100-1011   2213-00-13110-1011

Permutations this subset: 14

TC engages stationary area target, precision, with coax, on the move; enumeration:

2213-10-13000-1001   2213-10-13010-1001   2213-10-13100-1001   2213-10-13110-1001
2213-10-13000-1021   2213-10-13010-1101   2213-10-13100-1021   2213-10-13110-1101
2213-10-13000-1101   2213-10-13020-1001   2213-10-13100-1101   2213-10-13120-1001
2213-10-13000-1121   2213-10-13020-1101   2213-10-13100-1121   2213-10-13120-1101

Permutations this subset: 16

TC engages stationary area target, with caliber .50, from the halt; enumeration:

2214-00-14020-1001   2214-00-14020-1020   2214-00-14020-0021   2214-00-14021-1010   2214-00-15020-1001
2214-00-14020-1000   2214-00-14020-0001   2214-00-14020-0020   2214-00-14021-0001   2214-00-15020-1000
2214-00-14020-1011   2214-00-14020-0000   2214-00-14021-1001   2214-00-14021-0000   2214-00-15020-1011
2214-00-14020-1010   2214-00-14020-0011   2214-00-14021-1000   2214-00-14021-0011   2214-00-15020-1010
2214-00-14020-1021   2214-00-14020-0010   2214-00-14021-1011   2214-00-14021-0010   2214-00-15020-1021

2214-00-15020-1020   2214-00-15020-0000   2214-00-15020-0010   2214-00-15020-0020
2214-00-15020-0001   2214-00-15020-0011   2214-00-15020-0021

Permutations this subset: 32

(table continues)

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Table C-2 (Continued)

TC engages stationary area target, with caliber .50, on the move; enumeration:

2214-10-14020-1001	2214-10-14020-1020	2214-10-14020-0021	2214-10-14021-1010	2214-10-14021-0011
2214-10-14020-1000	2214-10-14020-0001	2214-10-14020-0020	2214-10-14021-1021	2214-10-14021-0010
2214-10-14020-1011	2214-10-14020-0000	2214-10-14021-1001	2214-10-14021-1020	2214-10-14021-0021
2214-10-14020-1010	2214-10-14020-0011	2214-10-14021-1000	2214-10-14021-0001	2214-10-14021-0020
2214-10-14020-1021	2214-10-14020-0010	2214-10-14021-1011	2214-10-14021-0000	2214-10-15020-1001
2214-10-15020-1000	2214-10-15020-1021	2214-10-15020-0000	2214-10-15020-0021	
2214-10-15020-1011	2214-10-15020-1020	2214-10-15020-0011	2214-10-15020-0020	
2214-10-15020-1010	2214-10-15020-0001	2214-10-15020-0010		

Permutations this subset: 36

TC engages stationary area target, battlesight, with coax, from the halt; enumeration:

2223-00-13000-1001   2223-00-13100-1001

Permutations this subset: 2

TC engages stationary area target, battlesight, with coax, on the move; enumeration:

2223-10-13000-1001   2223-10-13000-1101   2223-10-13100-1001   2223-10-13100-1101

Permutations this subset: 4

                                                            (table continues)

APPENDIX C. ENGAGEMENT TASK LIST

Table C-2 (Continued)

Loader Engagements

Loader engages stationary point target with M240, from the halt; enumeration:[a]

3115-00-15002-0000	3115-00-15002-0030	3115-00-15032-0020	3115-00-35002-0010	3115-00-35032-0010
3115-00-15002-0010	3115-00-15032-0000	3115-00-15032-0030	3115-00-35002-0020	3115-00-35032-0020
3115-00-15002-0020	3115-00-15032-0010	3115-00-35002-0000	3115-00-35032-0000	

Permutations this subset: 14

Loader engages moving point target with M240, from the halt; enumeration:

3115-01-15002-0100	3115-01-15002-0130	3115-01-15032-0120	3115-01-35002-0110	3115-01-35032-0110
3115-01-15002-0110	3115-01-15032-0100	3115-01-15032-0130	3115-01-35002-0120	3115-01-35032-0120
3115-01-15002-0120	3115-01-15032-0110	3115-01-35002-0100	3115-01-35032-0100	

Permutations this subset: 14

Loader engages stationary point target with M240, on the move; enumeration:

3115-10-15002-0000	3115-10-15002-0030	3115-10-15032-0020	3115-10-35002-0000	3115-10-35032-0000
3115-10-15002-0020	3115-10-15032-0000	3115-10-15032-0030	3115-10-35002-0020	3115-10-35032-0020

Permutations this subset: 10

Loader engages moving point target with M240, on the move; enumeration:

3115-11-15002-0100	3115-11-15002-0130	3115-11-15032-0120	3115-11-35002-0100	3115-11-35032-0100
3115-11-15002-0120	3115-11-15032-0100	3115-11-15032-0130	3115-11-35002-0120	3115-11-35032-0120

Permutations this subset: 10

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[a]The eleventh variable shows the value associated with "gunner applies range" for all loader engagements. The loader is the gunner for the M240, so this contingency behavior was noted as shown.

(table continues)

APPENDIX C. ENGAGEMENT TASK LIST

Table C-2 (Continued)

Loader engages stationary area target with M240, from the halt;
enumeration:

3215-00-15002-0000	3215-00-15002-0030	3215-00-15032-0020	3215-00-35002-0010	3215-00-35032-0010
3215-00-15002-0010	3215-00-15032-0000	3215-00-15032-0030	3215-00-35002-0020	3215-00-35032-0020
3215-00-15002-0020	3215-00-15032-0010	3215-00-35002-0000	3215-00-35032-0000	

Permutations this subset: 14

Loader engages stationary area target with M240, on the move;
enumeration:

3215-10-15002-0000	3215-10-15002-0030	3215-10-15032-0020	3215-10-35002-0000	3215-10-35032-0000
3215-10-15002-0020	3215-10-15032-0000	3215-10-15032-0030	3215-10-35002-0020	3215-10-35032-0020

Permutations this subset: 10

Recapitulation of Conditions Related to Engagement Pattern Selection

        The following table is a compilation of the conditions
affecting decisions regarding each of the fifteen behavioral
variables listed in Table C-1. The table also shows the
interrelationship among the fifteen behavioral variables within
the engagement sequence. More specifically, where one variable
serves as a condition for another variable, the initial variable
number is indicated in parentheses by number. For example, the
first variable, crew member to engage (1), is shown under Crew
Situation-/Engagement-Specific Conditions as a condition
affecting variable number three, engagement technique.

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Table C-3

Conditions Related to Engagement Pattern Selection.

BEHAVIORAL VARIABLE	PRE-EXISTING CONDITIONS Tank/Crew Status	SITUATION-/ENGAGEMENT-SPECIFIC CONDITIONS Tank	Target	Crew
1. Crew member to engage	# of Crew members.	Open or closed hatch.	Type, range.	Gunner identify target?
2. Target dispersion			Type.	
3. Engagement technique	LRF operational?	LRF effective?	Type, range.	Crew member to engage (1).
4. Weapon/ ammunition combination	Battlecarry configuration.		Type, range, classification.	Crew member to engage (1).
5. Fire on the move? (Y/N)	Stabilization operational?	Tank moving?		
6. Track moving target? (Y/N)			Apparent movement.	
7. Crew member to control engagement			Number, type(s).	Simultaneous engagement?
8. Sight	LRF operational? Ballistic computer and GPS functional (main gun/coax)? CWS functional (Cal .50)?	LRF effective? Indexed range correct? Weapon/ ammunition combination (4).	Classification.	TC's preference (Cal .50 only). Crew member to engage (1).
9. Daylight or thermal channel?	TIS functional?	Image clarity		Sight (8).

APPENDIX C.   ENGAGEMENT TASK LIST

Table C-3   (Continued)

BEHAVIORAL VARIABLE	PRE-EXISTING CONDITIONS Tank/Crew Status	SITUATION-/ENGAGEMENT-SPECIFIC CONDITIONS		
		Tank	Target	Crew
10. TC's ranging actions.	LRF operational?	LRF effective? Indexed range correct? Weapon/ammunition combination (4).	Number, type.	Simultaneous engagement? Crew member to engage (1). Engagement technique (3). Sight (8).
11. Gunner's ranging actions		Indexed range correct? Cal .50 and turret aligned? Weapon/ammunition combination (4).	Number, type.	Simultaneous engagement? Crew member to engage (1). Engagement technique (3). TC's ranging actions (10).
12. Traverse and elevation method	Turret (main gun/coax)/cupola (Cal .50) power functional?	Weapon/ammunition combination (4).		Gunner's (main gun/coax)/TC's (Cal .50) preference. Crew member to engage (1).
13. Apply lead manually (Y/N)?	LAS functional? T&E method (12)?	Weapon/ammunition combination (4).	Apparent movement (6).	Sight (8).
14. Sight picture adjustment	Cant sensor functional?	Firing on the move (5)? Tank halted on level ground?	Classification	Initial or subsequent engagement? Gunner/TC observe? TC issue subsequent fire command? Sight (8).
15. Electrical or manual trigger	Electrical trigger operational?	Open/closed hatch? Misfire. Weapon/ammunition combination (4).		TC's preference (Cal .50 only). Crew member to engage (1).

APPENDIX C. ENGAGEMENT TASK LIST

Summary of Engagement Patterns

Tables C-4 through C-17 show the total number of logical engagements associated with each of the alternatives connected with each variable. For example, Table C-4 shows that the total number of engagements (4,618) are comprised of 4,068 gunner engagements, 478 TC engagements, and 72 loader engagements. Each table also shows the distribution of engagements by weapon/ ammunition combination. For example, the total number of gunner engagements (4,068) are comprised of 1,160 main gun engagements with SABOT, 1,160 main gun engagements with HEAT, and 1,748 coaxial machine gun engagements.

Tables C-18 through C-26 show other distribution data that should be useful for training development. Note that these distributions are merely a count of different engagement patterns, not necessarily a reflection of the frequency that any given variable will assume any particular alternative in practice.

Table C-4

Crew Member to Engage by Weapon/Ammunition Combination
(Variables 1 and 4)

WEAPON/ AMMUNITION COMBINATION	CREW MEMBER TO ENGAGE			
	Gunner	TC	Loader	TOTAL
SABOT	1,160	78	0	1,238
HEAT	1,160	78	0	1,238
Total Main Gun	2,320	156	0	2,476
Coax	1,748	114	0	1,862
Cal .50	0	208	0	208
M240	0	0	72	72
Total Machine Gun	1,748	322	72	2,142
TOTAL	4,068	478	72	4,618

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Table C-5

Target Dispersion by Weapon/Ammunition Combination
(Variables 2 and 4)

WEAPON/ AMMUNITION COMBINATION	TARGET DISPERSION		
	Point	Area	TOTAL
SABOT	1,238	0	1,238
HEAT	1,238	0	1,238
Total Main Gun	2,476	0	2,476
Coax	1,238	624	1,862
Cal .50	140	68	208
M240	48	24	72
Total Machine Gun	1,426	716	2,142
TOTAL	3,902	716	4,618

Table C-6

Engagement Technique by Weapon/Ammunition
Combination (Variables 3 and 4)

WEAPON/ AMMUNITION COMBINATION	ENGAGEMENT TECHNIQUE		
	Precision	Battlesight	TOTAL
SABOT	1,138	100	1,238
HEAT	1,138	100	1,238
Total Main Gun	2,276	200	2,476
Coax	1,708	154	1,862
Cal .50	208	0	208
M240	72	0	72
Total Machine Gun	1,988	154	2,142
TOTAL	4,264	354	4,618

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Table C-7

Firing Tank Movement by Weapon/Ammunition Combination
(Variables 5 and 4)

WEAPON/ AMMUNITION COMBINATION	Fire from the Halt	Fire on the Move	TOTAL
SABOT	784	454	1,238
HEAT	784	454	1,238
Total Main Gun	1,568	908	2,476
Coax	1,108	754	1,862
Cal .50	100	108	208
M240	52	20	72
Total Machine Gun	1,260	882	2,142
TOTAL	2,828	1,790	4,618

Table C-8

Target Movement by Weapon/Ammunition Combination
(Variables 6 and 4)

WEAPON/ AMMUNITION COMBINATION	TARGET MOVEMENT		
	Stationary	Moving	TOTAL
SABOT	482	756	1,238
HEAT	482	756	1,238
Total Main Gun	964	1,512	2,476
Coax	1,106	756	1,862
Cal .50	136	72	208
M240	48	24	72
Total Machine Gun	1,290	852	2,142
TOTAL	2,254	2,364	4,618

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Table C-9

Crew Member to Control Engagement by Weapon/Ammunition
Combination (Variables 7 and 4)

WEAPON/ AMMUNITION COMBINATION	CREW MEMBER TO CONTROL ENGAGEMENT			
	TC	Gunner	Loader	TOTAL
SABOT	81	420	0	1,238
HEAT	818	420	0	1,238
Total Main Gun	1,636	840	0	2,476
Coax	1,202	660	0	1,862
Cal .50	208	0	0	208
M240	42	0	30	72
Total Machine Gun	1,452	660	30	2,142
TOTAL	3,088	1,500	30	4,618

Table C-10

Sight Selection by Weapon/Ammunition Combination
(Variables 8 and 4)

WEAPON/ AMMUNITION COMBINATION	SIGHT SELECTION					
	GPS	GAS	GPSE	CWS	Iron Sights	TOTAL
SABOT	1,036	124	78	0	0	1,238
HEAT	1,036	124	78	0	0	1,238
Total Main Gun	2,072	248	156	0	0	2,476
Coax	1,572	176	114	0	0	1,862
Cal .50	0	0	0	136	72	208
M240	0	0	0	0	72	72
Total Machine Gun	1,572	176	114	136	144	2,142
TOTAL	3,644	424	270	136	144	4,618

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Table C-11

Channel Selection by Weapon/Ammunition Combination
(Variables 9 and 4)

WEAPON/ AMMUNITION COMBINATION	CHANNEL SELECTION		
	Daylight	Thermal	TOTAL
SABOT	681	557	1,238
HEAT	681	557	1,238
Total Main Gun	1,362	1,114	2,476
Coax	1,019	843	1,862
Cal .50	208	0	208
M240	72	0	72
Total Machine Gun	1,299	843	2,142
TOTAL	2,661	1,957	4,618

Table C-12

TC's Ranging Action by Weapon/Ammunition Combination
(Variables 10 and 4)

WEAPON/ AMMUNITION COMBINATION	TC's RANGING ACTIONS				
	None	Lase	Index/ Apply	Announce	TOTAL
SABOT	546	214	202	276	1,238
HEAT	546	214	202	276	1,238
Total Main Gun	1,092	428	404	552	2,476
Coax	806	326	306	424	1,862
Cal .50	0	0	208	0	208
M240	36	0	0	36	72
Total Machine Gun	842	326	514	460	2,142
TOTAL	1,934	754	918	1,012	4,618

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Table C-13

Gunner's Ranging Action by Weapon/Ammunition Combination
(Variables 11 and 4)

WEAPON/ AMMUNITION COMBINATION	GUNNER's RANGING ACTIONS			
	None	Lase	Index/ Apply	TOTAL
SABOT	562	404	272	1,238
HEAT	562	404	272	1,238
Total Main Gun	1,124	808	544	2,476
Coax	846	620	396	1,862
Cal .50	144	64	0	208
M240	0	0	72	72
Total Machine Gun	990	684	468	2,142
TOTAL	2,114	1,492	1,012	4,618

Table C-14

Traverse and Elevation Method by Weapon/
Ammunition Combination (Variables 12 and 4)

WEAPON/ AMMUNITION COMBINATION	TRAVERSE AND ELEVATION METHOD		
	Power	Manual	TOTAL
SABOT	930	308	1,238
HEAT	930	308	1,238
Total Main Gun	1,860	616	2,476
Coax	1,394	468	1,862
Cal .50	104	104	208
M240	0	72	72
Total Machine Gun	1,498	644	2,142
TOTAL	3,378	1,260	4,618

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Table C-15

Gunner/TC Applies (Does not Apply) Standard
Lead by Weapon/Ammunition Combination
(Variables 13 and 4)

WEAPON/ AMMUNITION COMBINATION	STANDARD LEAD ADJUSTMENT?		
	No	Yes	TOTAL
SABOT	758	480	1,238
HEAT	758	480	1,238
Total Main Gun	1,516	960	2,476
Coax	1,238	624	1,862
Cal .50	136	72	208
M240	48	24	72
Total Machine Gun	1,422	720	2,142
TOTAL	2,938	1,680	4,618

Table C-16

Sight Picture Adjustment by Weapon Ammunition Combination
(Variables 14 and 4)

WEAPON/ AMMUNITION COMBINATION	SIGHT PICTURE ADJUSTMENT				
	None	Adjust for Cant	Per Standard Adjustment	Per Subsequent Fire Cmd	TOTAL
SABOT	576	274	190	198	1,238
HEAT	576	274	190	198	1,238
Total Main Gun	1,152	548	380	396	2,476
Coax	888	400	296	278	1,862
Cal .50	72	72	64	0	208
M240	24	12	24	12	72
Total Machine Gun	984	484	384	290	2,142
TOTAL	2,136	1,032	764	686	4,618

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Table C-17

Trigger Selection by Weapon/Ammunition
Combination (Variables 15 and 4)

WEAPON/ AMMUNITION COMBINATION	TRIGGER SELECTION		
	Electric	Manual	TOTAL
SABOT	658	580	1,238
HEAT	658	580	1,238
Total Main Gun	1,316	1,160	2,476
Coax	988	874	1,862
Cal .50	104	104	208
M240	0	72	72
Total Machine Gun	1,092	1,050	2,142
TOTAL	2,408	2,210	4,618

Relationship between target and firing tank movement, traversing and elevation method, lead requirement, and weapon/ ammunition combination. The requirement to apply standard lead is directly related to the question of the target's apparent movement. Since the primary fire control system has an automatic lead function, not all engagement patterns against moving targets require the manual application of lead. The weapon/ammunition combination is also pertinent since the standard lead increment is different for different ammunition types, and only the main armament is slaved to the primary fire control system.

Table C-18 shows the distribution of engagements by firing tank movement and target movement. Table C-19 shows the same data further broken down by five weapon/ammunition combination. Table C-20 shows the number of tasks related to the requirement to apply lead, based on target movement.

The method of traversing and elevating (power/manual) and of firing (electrical or manual trigger/firing device) a weapon is dependent upon the type of weapon in use, as further modified by the crew member engaging. The number of tasks from Table C-2 within each of these categories is shown in Table C-21. The data reported by weapon in the table is compiled from the data for weapon/ammunition combination.

By combining the data from Tables C-20 and C-21, a more complete understanding can be gained regarding the relationship

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between the weapon in use, the crew member engaging, the traversing and elevation method, the type of trigger being used, target movement, and the requirement to apply standard lead. All these factors are inter-related by the fire control system's configuration. These data are presented in Table C-22.

Table C-18

Target Movement by Firing Tank Movement
(Variables 6 and 5)

FIRING TANK MOVEMENT	TRACK TARGET WITH APPARENT MOVEMENT		
	No	Yes	TOTAL
Fire from the Halt	1,398	1,430	2,828
Fire on the Move	856	934	1,790
TOTAL	2,254	2,364	4,618

Table C-19

Firing Tank and Target Movement by Weapon/Ammunition Combination
(Variables 5, 6, and 4)

WEAPON/ AMMUNITION COMBINATION	FIRING TANK MOVEMENT/TARGET MOVEMENT				
	Stat/ Stat	Stat/ Mvg	Mvg/ Stat	Mvg/ Mvg	TOTAL
SABOT	324	460	158	296	1,238
HEAT	324	460	158	296	1,238
Total Main Gun	648	920	316	592	2,476
Coax	648	460	458	296	1,862
Cal .50	64	36	72	36	208
M240	28	14	20	10	72
Total Machine Gun	740	510	550	342	2,142
TOTAL	1,398	1,430	856	934	4,618

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Table C-20

Track Moving Target and Apply Standard Lead by Weapon/
Ammunition Combination (Variables 6, 13, and 4)

| WEAPON/
AMMUNITION
COMBINATION | TARGET MOVEMENT/
STANDARD LEAD REQUIREMENT | | | |
	Stat/ No Lead	Mvg/ No Lead	Mvg/ Lead	TOTAL
SABOT	482	278	478	1,238
HEAT	482	278	478	1,238
Total Main Gun	964	552	960	2,476
Coax	970	268	624	1,862
Cal .50	136	0	72	208
M240	48	0	24	72
Total Machine Gun	1,154	268	720	2,142
TOTAL	2,118	820	1,680	4,618

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Table C-21

Traversing and Elevation Method and Trigger/Firing Device by
Weapon and Crew Member to Engage (Variables 12, 15, 4, and 1)

CREW MEMBER	TRAV & ELEV METHOD/TRIGGER				
WEAPON	Power/ Electric	Power/ Manual	Manual/ Electric	Manual/ Manual	TOTAL
Gunner					
Main Gun	852	852	308	308	2,320
Coax	640	640	234	234	1,748
Sub-total	1,492	1,492	542	542	4,068
Tank Commander					
Main Gun	156	0	0	0	156
Coax	114	0	0	0	114
Cal .50	52	52	52	52	208
Sub-total	322	52	52	52	478
Loader					
M240	0	0	0	72	72
Sub-Totals by Weapon					
Main Gun	1,008	852	308	308	2,476
Coax	754	640	234	234	1,862
Cal .50	52	52	52	52	208
M240	0	0	0	72	72
Sub-Total Machine Gun	806	692	286	358	2,142
TOTAL	1,814	1,544	594	666	4,618

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Table C-22

Track Moving Target and Apply Standard Lead by Crew Member to
Engage, Weapon, Traversing and Elevation Method, and
Trigger/Firing Device (Variables 6, 13, 1, 4, 11, and 15)

CREW MEMBER WEAPON T&E METHOD TRIGGER	TARGET MOVEMENT/ STANDARD LEAD REQUIREMENT			
	Stat/ No Lead	Mvg/ No Lead	Mvg/ Lead	TOTAL
Gunner				
Main Gun				
Power/Electric	302	250	300	852
Power/Manual	302	250	300	852
Manual/Electric	154	0	154	308
Manual/Manual	154	0	154	308
Coax				
Power/Electric	294	126	220	640
Power/Manual	294	126	220	640
Manual/Electric	160	0	74	234
Manual/Manual	160	0	74	234
Sub-Total	1,820	752	1,496	4,068
Tank Commander				
Main Gun				
Power/Electric	52	52	52	156
Coax				
Power/Electric	62	16	36	114
Cal .50				
Power/Electric	34	0	18	52
Power/Manual	34	0	18	52
Manual/Electric	34	0	18	52
Manual/Manual	34	0	18	52
Sub-Total	250	68	160	478
Loader--M240				
Manual/Manual	48	0	24	72
Total by Weapon				
Main Gun				
Power/Electric	354	302	354	1,008
Manual/Manual	302	250	300	852
Manual/Electric	154	0	154	308
Manual/Manual	154	0	154	308
Total	964	552	960	2,476

(table continues)

Table C-22   (Continued)

CREW MEMBER WEAPON T&E METHOD TRIGGER	TARGET MOVEMENT/ STANDARD LEAD REQUIREMENT			
	Stat/ No Lead	Mvg/ No Lead	Mvg/ Lead	TOTAL
Coax				
Power/Electric	356	142	256	754
Power/Manual	294	126	220	640
Manual/Electric	160	0	74	234
Manual/Manual	160	0	74	234
Total	970	268	624	1,862
Cal .50				
Power/Electric	34	0	18	52
Power/Manual	34	0	18	52
Manual/Electric	34	0	18	52
Manual/Manual	34	0	18	52
Total	136	0	72	208
M240--Manual/Manual	48	0	24	72
TOTAL	2,118	820	1,680	4,618

Relationship between TC's and gunner's ranging actions. The
ranging actions of the gunner and TC interact based on several
variables. The most important is the crew member controlling the
engagement. Table C-23 shows the distribution of engagement
patterns within each TC and gunner ranging action combination,
broken down by crew member to engage, crew member to control
engagement, and weapon. Table C-24 shows the TC and gunner
ranging action combinations broken down by engagement technique
and weapon. Table C-25 isolates the TC and Gunner ranging action
combinations for main gun and coax engagements, and reports the
frequencies as a percentage within each logical combination of
crew member firing and crew member controlling the engagement.

Table C-23

TC's and Gunner's (Leader's) Ranging Actions by Crew Member Engaging, Crew Member Controlling Engagement, and Weapon (variables 10, 11, 1, 9 and 4).

Table C-24

TC's and Gunner's (Leader's) Ranging Actions by Engagement Technique and Weapon (variables 10, 11, 3, and 4).

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Table C-25

Frequency Distribution of TC's and Gunner's Ranging Actions by
Crew Member to Engage and Crew Member Controlling the Engagement
(Main Gun and Coax Engagements only)

GUNNER's RANGING ACTIONS	TC's RANGING ACTIONS				
	None	Lase	Index	Announce	TOTAL
Gunner fired/TC controlled engagements					
None	20.2%	10.0%	10.0%	1.7%	41.8%
Lase	12.9%	11.7%	10.0%	3.4%	38.0%
Index/Apply	4.6%	0	0	15.5%	20.2%
TOTAL	37.7%	21.7%	20.0%	20.6%	100.0%
Gunner-fired/gunner-controlled engagements					
None	30.0%	4.4%	4.4%	3.0%	41.7%
Lase	15.3%	4.4%	4.4%	6.0%	30.0%
Index/Apply	7.4%	0	0	21.0%	28.3%
TOTAL	52.6%	8.7%	8.7%	30.0%	100.0%
TC-fired/TC-controlled engagements					
None	54.1%	23.0%	23.0%	0	100.0%

The fact that either the TC or the gunner can control a main
gun or coax engagement interacts with the ranging action that
each can perform. Table C-25 shows a shift in both the gunner
and TC ranging actions in gunner-fired engagements as a function
of which crew member controls the engagement. With respect to
the TC's ranging action, there are relatively fewer engagement
patterns in which the TC lases or indexes the range if the gunner
is controlling the engagement. There is an increase in the
relative number of patterns in which the TC takes no action, or
in which he announces the range.[1] The distribution of gunner
ranging actions shifts away from lasing and toward indexing or
applying the range with his assumption of control. This can be
explained by the fact that the TC is not as likely to relase or
index an estimated range if he is conducting a simultaneous
engagement and the gunner receives multiple returns or a clearly
erroneous range return.

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[1]Gunner-controlled patterns showing the TC lasing or
indexing the range assume that the TC must temporarily abandon a
separate (simultaneous) engagement to assist the gunner in one of
those two ways.

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The first column (TC ranging action--none) and TOTAL column of Table C-25 for gunner fired/gunner controlled can be compared with the TC fired/TC controlled engagements to show the difference in distribution between these two categories of engagements. In all TC engagements, the gunner performs no ranging action. This should be compared directly with the column under Gunner fired/controlled engagements that shows no ranging action for the TC. In order to make the comparison valid, one must determine the percentage distribution of each gunner's ranging action within that column alone. Table C-26, shows the resultant distribution, and compares it to the other data.

Table C-26

Frequency Distribution of Firing Crew
Member's Ranging Actions in One-Man
Fired/Controlled Engagements

FIRING CREW MEMBER's RANGING ACTION	FREQUENCY DISTRIBUTION		
	Gnr/Gnr TC-No Action	Gnr/Gnr TC-All (Total)	TC/TC (Total)
None	57.0%	41.7%	54.1%
Lase	29.0%	30.0%	23.0%
Index/Apply	14.0%	28.3%	23.0%
TOTAL	100.0%	100.0%	100.0%

The engagement technique for main gun and coax engagements is also a factor in ranging actions, as shown in Table C-27.

Table C-27

Frequency Distribution of Firing Crew Member's Ranging Actions by Engagement Technique and Crew Member Engaging

		FIRING CREW MEMBER's RANGING ACTION			
CREW MEMBER ENGAGING	ENGAGEMENT TECHNIQUE	None	Lase	Index/ Apply	TOTAL
Gunner	Precision	39.6%	37.8%	22.6%	100.0%
	Battlesight	66.7%	0	33.3%	100.0%
TC	Precision	45.6%	27.2%	27.2%	100.0%
	Battlesight	100.0%	0	0	100.0%

Note that the gunner applies the range whenever he uses the GAS. If firing a battlesight engagement through the GAS, he will apply the predetermined battlesight range. This accounts for the 33.3% of Gunner's battlesight engagements in which range is applied. The TC has only one sight available at his position to fire the main gun or coax, and that sight (the GPSE) is a non-ballistic sight so he performs no ranging action in a battlesight engagement fired from his position.

Summary. The vast majority of the engagement patterns (4,068 of 4,618, or 88.1%) are Gunner's Engagements.[2] Compare these figures with the total of Main Gun and Coax engagements for the TC (270). Either the TC or Gunner can fire a main gun or coax engagement, but the gunner may employ over fifteen times the number of engagement patterns that the TC may employ for these two weapons. Several factors account for this situation. Taken in order, the variables which expand the Gunner's choices of engagement pattern are: Crew member controlling the engagement, sight selection, TC and Gunner ranging actions, traversing and elevation method, sight picture adjustment, and trigger selection. Each of these variables expands the range of options available to the gunner beyond those available to the Tank Commander.

A gunner engagement may be controlled by either the TC or the gunner, while a TC engagement will only be controlled by the TC. This factor roughly doubles the number of permutations for the gunner as compared to the TC.

Each Tank Commander engagement using the GPSE has a corresponding gunner engagement through the GPS. The availability of the Gunner's Auxiliary Sight (GAS) increases the choices available to the gunner beyond those accounted for by the other factors listed above. One-tenth (424 out of 4068, or 10.4%) of the gunner engagements are fired through the GAS.[3] Since both the GPS and GPSE access both the thermal and daylight channels, that variable is not an immediate factor. However, given the fact that the channel selection is on the gunner's control panel, the TC is practically limited to a single channel once a direct fire exchange commences, while the gunner can switch between channels. The availability of the GAS accounts for a 12% increase in gunner engagement patterns while the number of TC engagements is held constant.

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[2]See Table C-4.

[3]See Table C-11.

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The interaction of ranging behaviors between the TC and gunner also expand the number of total engagement patterns for the gunner. This trend is examined in the previous section, and the discussion will not be reviewed here. This interaction results in an 81% increase in gunner engagement patterns while the number of TC engagement patterns is held constant.

The traversing and elevation options for the main gun and coax also affect the number of engagement patterns for the gunner over those available to the TC. The gunner may use either manual or power controls to elevate and traverse the turret. The TC has only power controls available at his position. This factor roughly doubles the number of gunner's tasks over TC's main gun and coax tasks in all patterns fired from the halt. Only power controls are effective from a moving tank because the stabilization system is only activated when the power controls are used. Of the 4,068 gunner engagement patterns, 616 (15.1%) involve the use manual controls. Manual controls account for a 50% increase in gunner engagement patterns while TC engagement patterns are held constant. This increase seems disproportionate to the overall number of engagements, but the requirement to apply standard lead in moving target situations when using the manual controls (the next variable in the gunnery pattern) limits the effect.

The range of sight picture adjustments also differs between the gunner and TC. The gunner is subject to subsequent fire commands from the TC in most precision engagement patterns, while the TC is not. A total of 674 (16.6%) of the gunner's engagements respond to a subsequent fire command, increasing the number of gunner's engagement patterns by 20% over the number of TC's engagements.

Finally, trigger selection options also account for a large increase in gunner engagement patterns. The manual firing device for the main gun and the manual trigger for the coax are both at the gunner's station, providing twice the number of types of triggers available to the gunner for each primary weapon than are available to the TC. The analysis did not distinguish between the different electrical triggers available to the gunner. To do so would have doubled the options for gunner engagements again, because there are three electrical triggers at the gunner's station (two on the gunner's power control handles and one on the manual elevation crank handle).

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   An analysis of the engagement patterns that involve
precision gunnery techniques without any modifications for
degraded conditions shows that the vast majority of
engagements enumerated in Table C-2 involve alternative
behaviors appropriate to one or more equipment failures.   Only
66 of the 4,068 gunner's engagements are "normal" mode
engagements in this regard.