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Field Artillery Target Acquisition

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This publication supersedes FM 3-09.12, *Tactics, Techniques, and Procedures for Field Artillery Target Acquisition* dated 21 June 2002.

Headquarters, Department of the Army

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Preface

This publication contains the techniques used to employ and manage field artillery (FA) target acquisition systems. It updates and replaces information formerly contained in field manual (FM) 3-09.12 and incorporates emerging techniques on new equipment such as the AN/TPQ-50 and AN/TPQ-53 radars. It also introduces the new Army Structure of the division artillery (DIVARTY) and the field artillery brigade (FAB). The material contained in this Army techniques publication (ATP) applies to all personnel involved in the target acquisition process.

The principal audience for ATP 3-09.12 is maneuver commanders and staffs, FA commanders and staffs, and target acquisition personnel.

Commanders, staffs, and subordinates ensure their decisions comply with applicable United States (U.S.), international, and, in some cases, host-nation laws and regulations. Commanders at all levels ensure their Soldiers operate in accordance with the law of war and the rules of engagement (See FM 27-10).

ATP 3-09.12 uses joint terms where applicable. Selected, joint and Army terms and definitions appear in both the glossary and the text. Terms for which ATP 3-09.12 is the proponent publication (the authority) are marked with an asterisk (*) in the glossary. Definitions for which ATP 3-09.12 is the proponent publication are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

ATP 3-09.12 applies to the Active Army, the Army National Guard, Army National Guard of the United States, and United States Army Reserve unless otherwise stated.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

The proponent of ATP 3-09.12 is the United States Army Fires Center of Excellence. The preparing agency is the Directorate of Training and Doctrine, United States Army Fires Center of Excellence. Send comments and recommendations on a Department of the Army (DA) Form 2028 (*Recommended Changes to Publications and Blank Forms*) directly to Directorate of Training and Doctrine, 700 McNair Avenue, Suite 128 ATTN: ATSF-DD, Fort Sill, OK 73503; by e-mail to usarmy.sil.fcoe.mbx.dotd-doctrine-inbox@mail.mil; or submit an electronic DA Form 2028.

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Introduction

This is a complete revision to Field Manual (FM) 3-09.12, *Tactics, Techniques, and Procedures for Field Artillery Target Acquisition*, which updates doctrine, techniques, and deletes obsolete information. ATP 3-09.12 contains the fundamental techniques and guidance required for planning, coordinating, and employing FA target acquisition assets. It provides current information on how to train and conduct operations. It describes the techniques currently being used and known to be effective. The doctrine is consistent with joint, multi-Service, or other Army doctrine.

The goal of FA target acquisition is to identify and provide an accurate target location to the supported maneuver commander to allow for immediate counterfire operations against the target.

This publication describes current and emerging fires target acquisition systems. Target acquisition systems include the following assets— weapon locating radars (WLR), counterfire operations, and target processing. It explains the techniques for employing radars, counterfire operations, and target processing. This publication describes techniques in non-prescriptive ways to accomplish the mission as stated in the operations order and to employ, maintain, and operate the WLR to locate the enemy indirect weapon systems.

ATP 3-09.12 is divided into seven chapters and seven appendices:

- Chapter 1 Introduction to Field Artillery Target Acquisition.
- Chapter 2 Counterfire.
- Chapter 3 Technical Aspects of Weapon Locating Radar Employment.
- Chapter 4 Employment of Target Acquisition Systems.
- Chapter 5 AN/TPQ-36/37 Weapon Locating Radar Systems Characteristics.
- Chapter 6 AN/TPQ-53 Weapon Locating Radar System Characteristics.
- Chapter 7 AN/TPQ-50 Weapon Locating Radar System Characteristics.
- Appendix A Automated Target Data Processing.
- Appendix B Friendly Fire Log.
- Appendix C Field Exercise Mode and Embedded Training.
- Appendix D Mask Considerations.
- Appendix E Support Requirement.
- Appendix F Tools and Procedures.
- Appendix G Rocket Artillery Mortar (RAM) Warn

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Chapter 1

Introduction to Field Artillery Target Acquisition

This chapter introduces target acquisition, the term counterfire, and the organizations necessary to perform counterfire operations. Counterfire operations are an integral part of the commander's overall concept of operations. Offensive and defensive missions cannot be accomplished without an effective counterfire fight. An effective counterfire fight allows for freedom of maneuver by destroying or neutralizing enemy indirect fire weapons systems.

SECTION I – INTRODUCTION

1-1. *Target acquisition* is the detection, identification, and location of a target in sufficient detail to permit the effective employment of weapons (Joint Publication [JP] 3-60). FA weapons locating radars (WLR) are located in the target acquisition platoons (TAP) of the field artillery brigade (FAB), division artillery (DIVARTY), and all brigade combat team (BCT) field artillery (FA) battalions. These assets are a crucial element in the commander's counterfire fight. The WLR is the commander's primary means for collecting real time information on the location of the enemy indirect fires systems and is used to produce targeting intelligence. BCTs, DIVARTYs and Field Artillery Brigades will each have two organic Q-53s and four (BCT's) or two (DIVARTY and FAB's) organic Q-50's. Incorporating these sensors into the ISR collection plan using Reinforcing and General Support Reinforcing echeloned employment enhances the overall coverage capability of the force. This redundant capability allows for one system to provide coverage while another systems moves, conducts maintenance or repair activities. If radar coverage can be provided to a BCT through their organic systems, through the reinforcing DIVARTY systems or through the General Support Reinforcing systems assigned to the Field Artillery Brigade, operational effectiveness has been achieved. Q-53s are not intended to work independently, but as a system of systems providing a tactical capability to the force.

1-2. The target processing sections of the FAB and DIVARTY, and the counterfire operations sections of the FA battalions, are responsible for managing the commander's counterfire fight through the integration and synchronization of target acquisition assets. These two sections focus on priority intelligence requirements and answer the commander's critical information requirements concerning the enemy indirect weapons systems. The information gathered is to be disseminated timely and accurately to the unit commander, staff, and echelons above and below.

1-3. Current fielded target acquisition WLR consist of the AN/TPQ-36, AN/TPQ-37, AN/TPQ-50 and AN/TPQ-53 systems. The TAPs of the FAB and DIVARTY will consist of 2ea AN/TPQ-53 sections and 2ea AN/TPQ-50 radar teams. The TAP of all FA battalions will consist of 2ea AN/TPQ-53 sections and 4ea AN/TPQ-50 radar teams.

SECTION II – FIELD ARTILLERY BRIGADE AND DIVISION ARTILLERY TARGET ACQUISITION PLATOONS

FIELD ARTILLERY BRIGADE AND DIVISION ARTILLERY TARGET ACQUISITION PLATOONS

1-4. The FAB and DIVARTYs primary task is to support the corps and division commander's scheme of maneuver by coordinating, integrating, synchronizing and employing fires to achieve the commander's objectives. The FAB and DIVARTY TAPs provide continuous WLR support in support of the commander's counterfire operations and gather information on enemy indirect fires systems. In addition the

DIVARTY or FAB can provide coverage for BCT(s) when organic BCT radars are moving, performing maintenance or repair. The TAP of the FAB and DIVARTY are identical in structure and are comprised of a platoon headquarters, WLR sections, target processing section, and a survey team.

- The TAP provides WLR support to—
  - Detect, locate, classify, report, and communicate the point of origin, predicted point of impact, radar cross section, and velocity of indirect fire systems for the counterfire fight.
  - Provide general support radar coverage for units operating within the area of search.
  - Provide radar maintenance support.
  - Confirm the actual burst/impact location of friendly fires.
- Survey support to—
  - Ensure common survey for the supported command.
  - Establish declination stations.
- Target processing support to—
  - Recommend and coordinate sectors of search within the supported headquarters area of operations and adjust coverage by FA target acquisition resources as the situation develops.
  - Monitor the operation of organic and augmenting FA target acquisition resources.
  - Develop targets and suspect targets and refine target locations.
  - Pass targets to the fire support (FS) cell or fire control for action.
  - Maintain the target production map and the artillery target intelligence file in automated targeting systems.
  - Request battle damage assessment on targets produced and passed to the fire control element for action.

WEAPONS LOCATING RADAR SECTIONS AND TEAMS

1-5. The FAB and DIVARTY TAP radar sections are almost identical in structure. The TAP currently contains 3ea AN/TPQ-37 radar section's and 2ea Lightweight countermortar radars (LCMR) teams. Once fielded the FAB TAPs will contain 2ea AN/TPQ-53 sections and 4ea AN/TPQ-50 radar teams. The DIVARTY TAPs will contain 2ea AN/TPQ-53 sections and 2ea AN/TPQ-50 radar teams. The radar personnel of target acquisition platoons are trained to conduct radar operations on all WLRs.

SURVEY

1-6. The survey team provides a common grid that will permit the massing of fires, establishes survey control point as directed, and near stake and far stake data for the WLR for transmission of target data from one element to another. The survey capabilities consist of an improved position and azimuth determining system global positioning system team.

1-7. The survey team consists of 1ea E5 surveyor computer improved position and azimuth determining system (IPADS) team chief, and 1ea E4 surveyor IPADS vehicle driver.

TARGET PROCESSING SECTION

1-8. The FAB and DIVARTY target processing section consists of six FA personnel. The target processing section consists of 1ea assistant counterfire officer, 1 ea senior FA targeting noncommissioned officer (NCO), 2ea targeting NCOs, and 2ea target processing specialists. The section is responsible for locating enemy indirect fires systems, sensor management of the WLRs, and maintaining the current maintenance status of the WLRs. The target processing section assists with integrating and synchronizing the target acquisition assets in accordance with the commander's intent and concept of operations.

SECTION III – FIELD ARTILLERY BATTALION TARGET ACQUISITION PLATOON

1-9. Each brigade combat team has an organic FA battalion. The target acquisition assets are located in the TAP.

FIELD ARTILLERY BATTALION TARGET ACQUISITION PLATOON

1-10. The FA battalion TAP has a counterfire operations section instead of a target processing section and has 4ea AN/TPQ-50 radars instead of 2ea in the FAB and DIVARTY. The TAP organic to the FA battalion supports all 3 types of brigade combat teams. The TAP includes a platoon headquarters, counterfire operations, radar sections and teams, and survey. Currently the TAP consists of a mix of AN/TPQ-37 and AN/TPQ-36 WLRs and LCMRs. Once fielded, all TAPs at the FA battalion will consist of 2ea AN/TPQ-53 sections and 4ea AN/TPQ-50 radar teams.

COUNTERFIRE OPERATIONS SECTION

1-11. Each BCT FA battalion TAP has an organic counterfire operations section responsible for providing responsive and accurate counterfire. Counterfire serves as a countermeasure and a support multiplier for the supported commander.

1-12. The counterfire operations section consists of the following personnel—a targeting officer, the senior Field Artillery Non-Commissioned Officer, 2ea targeting NCOs and 2ea target processing specialists. These individuals work together with the battalion intelligence officer and staff. These personnel have the responsibility to perform counterfire operations and to satisfy information requirements.

SECTION V – TARGET ACQUISITION PERSONNEL

1-13. Target acquisition personnel’s primary responsibility is operating and managing the WLRs for the commander. This includes synchronizing and integrating WLRs with the concept of operations. Target acquisition personnel are also the primary executers of the commander’s counterfire fight.

1-14. The target acquisition personnel located in the radar, counterfire operations, and target processing sections develop a WLR common operational picture by collaborating, sharing, and refining relevant information. The commander utilizes the operations process, intelligence preparation of the battlefield (IPB), targeting, detection, verification, and location methodology to help with controlling operations and providing a command presence.

PLATOON HEADQUARTERS

1-15. The TAP headquarters consists of the TA platoon leader and the TA platoon sergeant. Their duties are listed in the following two paragraphs.

TARGET ACQUISITION PLATOON LEADER

1-16. The TA platoon leader is responsible for the training, readiness, and maintenance of the platoon. The platoon leader supervises the movement, positioning, and emplacement of the WLRs. The TA platoon leader develops the platoon into an effective fighting force capable of performing its combat mission. Other duties include:

- Performs necessary tactical and technical coordination for FA radars and data collection systems, including communications, security, force protection, positioning, logistics and administration.
- Maintains a status of FA WLRs and informs the commander and counterfire officer when necessary.

- Advises the commander and staff on the technical considerations affecting the employment of target acquisition radars and recommends the general locations of radar sites and search azimuths.
- Monitors the mission support requirements of all WLRs within the supported area.
- Assists the senior FA targeting NCO or radar section chief in the reconnaissance and selection of radar sites.
- Commands and directs the TAP's operations.
- Reviews and consolidates requisitions for tools, repair parts, supplies, and equipment.
- Inspects maintenance of platoon vehicles and equipment.
- Monitors the terrain management plan for the positions of each section.
- Maintains communications between the section, battalion and the counterfire headquarters.
- Performs necessary tactical coordination for WLRs in the area of operations.
- Assists in the development of the radar deployment order (RDO).

TARGET ACQUISITION PLATOON SERGEANT

1-17. The TA platoon sergeant is the senior enlisted advisor to the platoon leader and must be prepared to assume the duties and responsibilities of the platoon leader in his absence. The platoon sergeant ensures that radar personnel are trained to perform all procedures used during combat operations. The platoon sergeant is responsible for the maintenance, logistics, and discipline of the platoon. The platoon sergeant works in close coordination with the platoon leader to ensure unity of effort. Other responsibilities consist of the following:

- Mentors and evaluates each radar senior FA NCO and section chief.
- Coordinates survey support for the platoon.
- Coordinates and recommends general position areas and search areas in accordance with the commander's guidance and intent.
- Supervises maintenance and training of the WLR sections.
- Participates in the development of RDO.
- Maintains the target acquisition capabilities chart.
- Manages all administrative actions for the radar platoon in conjunction with the senior FA targeting NCO and section chief.
- Reconnoiters and selects the site for the radars.
- Prepares and maintains accountability charts for all essential repair parts stockage list.
- Coordinates higher level maintenance for unserviceable equipment.

RADAR SECTION PERSONNEL

1-18. The radar sections for each radar are different. The radar personnel that make up the different radar sections and their duties are listed as follows.

SECTION CHIEF (AN/TPQ-36, AN/TPQ-37, AN/TPQ-50 AND AN/TPQ-53)

1-19. The radar section chief is responsible for the training, discipline, and tactical employment of the WLR section. The section chief executes the selection and emplacement procedures for the WLR within the general area for positioning during operations. The section chief coordinates for supplies and or maintenance support through the platoon sergeant or the counterfire operations section. The section chief is responsible for the maintenance of all assigned equipment. Other responsibilities consist of the following:

- Reconnoiters and selects the site for the radar.
- Performs hasty survey.
- Supervises -10 and -20 level maintenance of radar equipment.
- Ensures compliance with safety procedures.
- Coordinates and supervises hasty survey.

- Instructs personnel in all aspects of radar operations and associated techniques.
- Organizes and maintains security and defense of his position area.

Senior Radar Operator (AN/TPQ-36, AN/TPQ-37, AN/TPQ-50 and AN/TPQ-53)

1-20. The senior radar operator performs the duties of the section chief when he is absent and also performs these additional duties:

- Operates and supervises the operation of the radar set.
- Assists in the emplacement and concealment of the radar position.
- Assists the section chief in all of his duties.
- Provides technical guidance to radar operators.
- Troubleshoots, adjusts, aligns, and repairs using built-in-test routines, measurement, and diagnostic equipment authorized by the maintenance allocation chart.
- Uses fault-isolation-test, replaces cards, modules, components, and selected parts.

Radar Operator (AN/TPQ-36, AN/TPQ-37, AN/TPQ-50 and AN/TPQ-53)

1-21. The duties of the radar personnel are essentially the same for all WLRs regardless of organizational structure of the assigned radar section. Their responsibilities consist of the following—

- Emplaces and displaces the radar and ancillary equipment.
- Initializes and operates all radar and ancillary equipment.
- Determines and corrects the altitudes of weapon locations from a contour map, when required.
- Transmits the point of origin to the counterfire operations section or as directed by the RDO.
- Maintains record of transmitted locations.
- Operates and performs maintenance on the radar's prime movers.
- Performs unit maintenance using built-in-test/built-in-test-equipment, fault detection, and isolation.
- Isolates failures to a line replaceable unit or shop replaceable unit that can be replaced by a crewmember.
- Provides local security.
- Performs other duties assigned by the section chief.

Radar Repairer (AN/TPQ-36, AN/TPQ-37, AN/TPQ-50 and AN/TPQ-53)

1-22. The radar repairer performs field-level maintenance and resides in the brigade support battalion. He provides the following duties as needed:

- Performs unit maintenance using built-in-test and built-in-test-equipment, fault detection, and isolation.
- Isolates failures to a line replaceable unit or shop replaceable unit that can be replaced by a crewmember.
- Uses fault-isolation-test, replaces cards, modules, components, and selected parts.
- Troubleshoots, adjusts, aligns, and repairs using built-in-test routines, measurement, and diagnostic equipment authorized by the maintenance allocation chart.
- Replaces or forwards unserviceable equipment to higher level maintenance.
- Performs connector repair on certain specified cables.

Power Generation Equipment Repairer (AN/TPQ-36, AN/TPQ-37, AN/TPQ-50 and AN/TPQ-53)

1-23. The generator equipment repairer repairs and maintains tactical utility and precise power generation equipment. The mechanic is part of the brigade support battalion and is sent to work on the radar as needed. The generator mechanic performs the following duties:

- Troubleshoots mechanical and electrical systems and components; diagnoses and isolates malfunctions; tunes engine, and replaces components.
- Maintains repaired equipment.

OTHER TARGET ACQUISITION PERSONNEL

1-24. Other target acquisition personnel provide valuable input to the target acquisition process. The personnel and their duties follow.

COUNTERFIRE OFFICER

1-25. The counterfire officer is located in the current operations and counterfire section at the FAB or DIVARTY, corps, and division main command post. Duties of the counterfire officer include:

- Supervises the counterfire section at the FAB.
- Provides target location error (TLE) information on available WLRs to the fires cell or fire support coordinator (FSCOORD) as a basis for their recommendations to the targeting team.
- Acts as the principal advisor on counterfire and the employment WLRs.
- Writes the target acquisition tab to operations order.
- Develops and issues the RDO.
- Coordinates target acquisition planning and execution with the FAB operations officer, and the TA platoon leader.
- Recommends search azimuth, radar zones, and cueing schedules.
- Manages and positions WLRs.
- Uses automated systems to ensure that WLRs are properly oriented, cued, and targets are expeditiously attacked.

ASSISTANT COUNTERFIRE OFFICER

1-26. The assistant counterfire officer at the FAB and DIVARTY is in charge of the target processing section of the TAP. He is positioned to assist the FAB or DIVARTY counterfire officer. Duties of the assistant counterfire officer include:

- Supervises the target processing section of the FAB or DIVARTY TAP.
- Recommends and updates WLR coverage.
- Acts as counterfire officer in the absence of the counterfire officer.
- Ensures enemy indirect fire targets are passed to fire control and operations elements for action.
- Follows the target selection standards when developing enemy targets and suspected targets.
- Acts as the principal advisor to the intelligence officer on the integration of WLR.
- Assists in the development of the target acquisition tab portion of the operations order.
- Conducts coordination of target acquisition assets with the intelligence, operations, and targeting personnel.
- Ensures information from shelling reports and mortar bombing reports are integrated into the target development process.
- Provides additional recommendations on the following—
  - General position areas for the WLR.
  - WLR coverage and cueing schedule.
  - Additional target acquisition assets.
  - Target development.
  - Targeting information from other sources.

SENIOR FIELD ARTILLERY TARGETING NCO

1-27. The senior FA targeting NCO assigned to the FAB or DIVARTY, target processing section or the FA battalion TAP, counterfire operations section assists the counterfire or targeting officer. In addition, the senior FA targeting NCO performs the following duties:

- Supervises the activities of the counterfire cell.
- Reviews and consolidates requisitions for tools, repair parts, technical supplies, publications, and equipment.
- Coordinates technical support, to include meteorological (MET) and survey.
- Coordinates logistics and security requirements and liaises with the supported unit.
- Assumes the duties of the TA platoon sergeant in his absence.
- Collects and disseminates information provided by the intelligence section.
- Monitors the operations, status, and current and proposed locations of all target acquisition assets.
- Participates in military decisionmaking process (MDMP)
- Provides the counterfire officer with recommendations for positioning of WLRs, to include establishing sectors of search and radar zones.
- Maintains a counterfire database.
- Assists in the development of cueing guidance for WLRs.

TARGETING OFFICER

1-28. The FA battalion targeting officer is located in the counterfire operations section in the BCT FA battalion. He supervises the counterfire operations section personnel and his duties include:

- Serves as the FA battalion counterfire officer.
- Recommends and updates WLR coverage.
- Ensures enemy indirect fire targets are passed to fire control and operations elements for action.
- Follows the target selection standards when developing enemy targets and suspected targets.
- Conducts coordination of target acquisition assets with the battalion and BDE operations officers and intelligence officers.

TARGETING NONCOMMISSIONED OFFICERS

1-29. The two targeting NCOs assigned to the field artillery brigade target acquisition platoon target processing section or the FA battalion TAP counterfire operations section are responsible for counterfire operations. The targeting NCO duties are:

- Establishes and maintains all counterfire or targeting databases, maps, charts, and records.
- Establishes and maintains communications using the advanced field artillery tactical data system (AFATDS).
- Ensures enemy indirect fire targets are passed to the fires cell or fire control elements for action.
- Ensures tracking of information from shelling reports and mortar bombing reports are integrated into the target development process.
- Assists with maintaining the counterfire database.

TARGETING SPECIALISTS

1-30. The targeting specialist is responsible for assisting the targeting NCO, and other duties, which include:

- Sets up and maintains all targeting element or counterfire operations databases, maps, charts, and records.
- Initializes the AFATDS, which is used in conjunction with the targeting information from the target production map and other sources to produce targets.

- Passes targets generated by WLRs to the fires cell or fire control element for action.
- Assists in the tracking of crater analysis results and ensures assessments are integrated into the target development process.
- Assists with maintaining the counterfire database.

Chapter 2

Counterfire

This chapter discusses techniques for conducting counterfire operations. Section I breaks down what is counterfire operations. Section II covers counterfire in support of decisive action. And Section III details the execution of counterfire.

SECTION I – COUNTERFIRE OPERATIONS

2-1. *Counterfire* is fire intended to destroy, neutralize or suppress enemy indirect fire weapons (JP 3-09). Counterfire gains freedom for maneuver by destroying or neutralizing the enemy indirect fire capabilities. Counterfire can be accomplished by using different fire support assets to include joint fires. Counterfire must be synchronized and integrated with the current and future scheme of maneuver. Counterfire is proactive, reactive, or a combination of both.

2-2. Proactive counterfire is the specific targeting of enemy indirect fire systems, including their command and control, sensors, platforms, and logistics before they engage friendly forces. The proactive measures consists of zone management, site analysis, and position survivability considerations. Proactive counterfire process begins with targeting during the MDMP and continues throughout the operation. The intelligence officer and the targeting officer develop named areas of interest and target areas of interest where the enemy indirect fire assets are expected.

2-3. Reactive counterfire provides immediate indirect fires to neutralize, destroy, and suppress enemy indirect fire weapons once acquired. The fire support systems respond primarily to enemy mortar and artillery fires during or immediately following enemy engagements and actions directly or indirectly focused against friendly forces. Reactive counterfire usually requires quick response capabilities for optimum effectiveness and can benefit from the establishment of quickfire channels.

2-4. A quickfire channel can be established using digital (preferred) or voice communications. A quickfire channel allows for rapid engagement of radar acquisitions by streamlining the acquisition of target to shooter link. For example the radar can send its acquisitions straight to a battery AFATDS. Positive controls must be established when using a quickfire channel to ensure all clearance of fires procedures are executed.

2-5. All intelligence and target acquisition assets to include WLRs must be prioritized to accurately locate targets. Attack assets (such as artillery, mortars, close air support, attack helicopters, naval gunfire, and electronic warfare) must be dedicated to attacking the enemy’s total fire support system. Counterfire is the supported commander's responsibility.

2-6. The FSCOORD or the fire support officer (FSO) is the primary advisor and executor of counterfire. The FA WLRs are positioned to support the supported commander’s scheme of maneuver during the offense and provide radar coverage for his most vulnerable assets during the defense.

SECTION II – COUNTERFIRE IN SUPPORT OF DECISIVE ACTION

2-7. Counterfire in support of decisive action consists of supporting offensive, defensive, and stability tasks. Target acquisition planners must plan for the advantage of range to reduce or attrite enemy capabilities to aid in preserving our maneuver combat power while providing freedom of movement.

COUNTERFIRE IN SUPPORT OF OFFENSIVE TASKS

2-8. The primary role of the WLRs in the offense is to locate enemy targets for attack by friendly fire support systems. During the offense, particular attention must be given to planning WLR moves to ensure continuous operations as the attack progresses.

2-9. Target acquisition planners must ensure a smooth transition from one phase to the next by providing continuous radar coverage across the area of operations. Requirements for radar positioning and movement are identified during MDMP and tied to specific events. This allows continuous coverage by facilitating mutually supporting coverage between radars. The field artillery commanders monitor this process closely to ensure that the use of terrain, movements, and radar zones are properly coordinated.

2-10. A method for providing continuous radar coverage is to leapfrog radars forward. This is done by moving one or more radars forward while another radar covers the moving radars sector of search. This can be enhanced by the FAB or DIVARTY radars assisting the BCT radars by providing coverage while they move. Triggers for initiating this movement can be based on phase lines, events, or time determined during the planning process. The movement of radars must be synchronized with the scheme of maneuver.

2-11. The first consideration for radar zones in the offense is call for fire zones (CFFZ). Establishing CFFZs facilitates immediate counterfire to suppress, neutralize, or destroy enemy artillery that may disrupt the scheme of maneuver. Critical friendly zones (CFZ) may be planned along the axis of advance and over critical friendly forces determined by the supported commander. Special consideration should be given to gap crossings, breaching forces, choke points, or other vulnerable areas.

2-12. Control of WLRs will generally be more decentralized to facilitate command, control, movement, and cueing. The FSCOORD at all levels designates cueing agents. This is necessary to streamline the counterfire effort when committed maneuver forces may be particularly vulnerable to enemy indirect fire.

COUNTERFIRE IN SUPPORT OF DEFENSIVE TASKS

2-13. The primary role of WLRs in the defense is to provide target data and information to allow for counterfire mission processing. Target acquisition planners must also consider transitions to offensive tasks such as counterattacks. Positioning, task organization, and on-order missions should facilitate transitions.

2-14. The first consideration is the use of the radar's zone capabilities to provide coverage for critical units or installations using CFZs. The supported commander should indicate the assets that are deemed essential to ensure mission accomplishment. If the commander does not identify these assets, the FSCOORD or FSO must query the commander for the necessary guidance. Once the guidance is obtained, the information is passed to the fires cell for implementation.

2-15. CFFZs are planned on suspected or known enemy indirect fire systems. The intent is to suppress, neutralize, or destroy enemy indirect fire systems before they start their preparatory fires. CFFZs are planned based off of intelligence preparation of the battlefield (IPB) and other target indicators. CFFZs are used to monitor suspect areas from which enemy indirect fires may jeopardize the mission.

2-16. Artillery target intelligence zones (ATIZ) may be established in areas where we are not sure about enemy indirect fires and need to develop the situation. They can also be used in areas of suspected enemy indirect fires that the commander wishes to monitor closely but are out of friendly indirect fire range.

2-17. Consider the use of AN/TPQ-50 radars to cover battalion area battle positions and or strong points.

COUNTERFIRE IN SUPPORT OF STABILITY TASKS

2-18. Counterfire operations conducted in support of stability tasks are essentially the same as those conducted for offensive and defensive tasks. Counterfire is an essential combat multiplier during stability tasks. Due to the nature of stability tasks it is extremely important to have an accurate location of enemy indirect weapons systems. WLRs are usually positioned in static locations and rarely moved once established. During stability operations the use of WLRs to provide 6400mils coverage becomes an essential factor in the counterfire fight. Due to the nature of stability tasks, it can be assumed that the enemy will have freedom of maneuver and the ability to initiate contact at the time and location of his choosing. Target acquisition planners must weigh the advantages and disadvantages of WLRs operating in 6400mil mode. Planners must be able to properly advise the commander and staff on the loss in probability of detection and range while operating in the 6400 mils mode versus the advantages of operating in a directional mode and gaining range and probability of detection. Target acquisition planners must understand the system and how to properly coordinate, integrate, and synchronize this system with the capabilities of all WLRs. Proper planning for use of WLRs in the 6400 mils for the counterfire fight begins with targeting during MDMP and continues throughout the operation.

POSITIONING

2-19. The operations and counterfire officers determine the general positioning areas for WLRs. The radar section chief selects the final radar site based on Radar Position Analysis System (RPAS) and visual sighting. Often, WLRs require a position that permits 6400 mils coverage. During MDMP, target acquisition planners need to factor in the proximity of WLRs operating in 6400 mils mode in order to adhere to the strict separation requirements. The tactical situation may require positioning of the radar within a static location, which requires careful consideration of site improvement.

2-20. The radar section chief coordinates site improvement or hardening directly with supporting engineers or contracted support. Site improvement normally includes survivability of the radar, safety, and line of site. The engineer unit improves the position or constructs berms to enhance the survivability of the radar and section personnel. Berms should be constructed to the height of shelter and vehicles. The antenna should be bermed to the height of the antenna trailer. This provides protection for antenna transceiver group (ATG) electronics while providing a clear line of sight for the antenna. The engineer unit clears obstacles to provide a clear line of site.

2-21. Safety for friendly forces in the vicinity of the WLR is a major concern during the planning and implementation process. The heat and radiation generated by the radar poses a personnel hazard. These hazards are minimized by positioning the radar a safe distance from friendly forces. Elevating the antenna above the level of personnel and vehicles can mitigate the clutter and radiation hazard. Figures 2-1 and 2-2 depict improved radar positions.

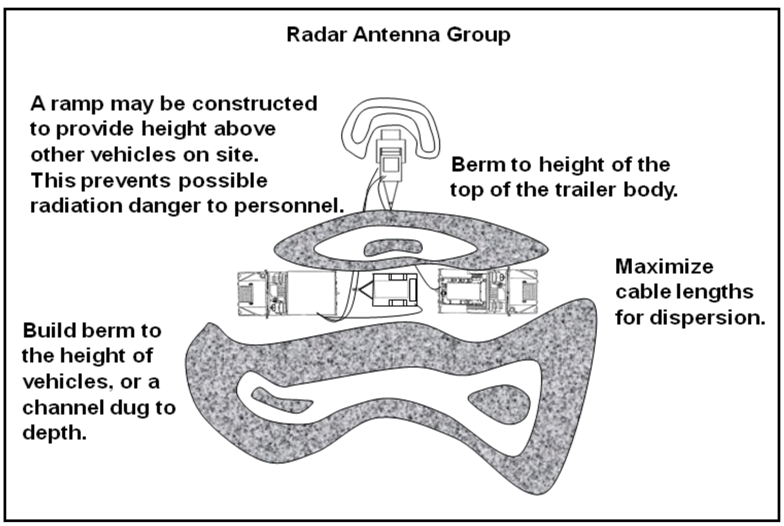


Figure 2-1. AN/TPQ-36 site enhancement (top view)

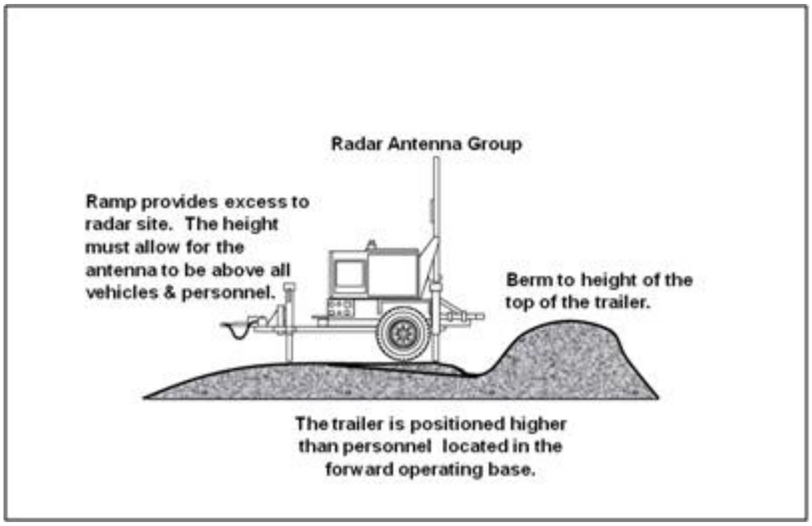


Figure 2-2. AN/TPQ-36 site enhancement (side view)

SECTION III – EXECUTION OF COUNTERFIRE

2-22. There are several options for conducting counterfire at any echelon. There is centralized counterfire where the commander executes his counterfire fight through a single headquarters. Typically this is accomplished by designating a FAB or a Division Artillery (DIVARTY) as a force field artillery headquarters. Decentralized counterfire is where the commander does not designate a single headquarters to execute counterfire operations. The commander may also choose to have a mixture of both centralized and decentralized counterfire operations based on mission variables.

2-23. Counterfire is fire intended to destroy or neutralize enemy weapons. Delivery means for counterfire encompasses many systems such as FA, close air support, close combat attack, maneuver elements, mortars, and electronic attack. Destruction of enemy fires capabilities that could disrupt and hinder operations is critical to ensure freedom of action for friendly forces. Counterfire can neutralize or destroy all or portions of the enemy's fires capabilities including delivery systems, control nodes, support systems, and logistics or sustainment areas. Counterfire is a function the force commander must address and is not solely the function of the FSCOORD. All of the elements of the combined arms team must be integrated to neutralize the enemy's total fires system.

PROACTIVE COUNTERFIRE

2-24. Proactive counterfire aggressively seeks to eliminate the enemy's weapon systems before the systems are employed against friendly forces. Proactive counterfire is nothing more than targeting. Examples of target sets include cannon, rocket, and missile delivery units, artillery ammunition storage facilities, fire direction centers, WLRs, forward observers, ground and air reconnaissance assets and airfields to include unmanned aircraft system launch sites, ground station controllers, electronic attack and communications infrastructure. The FAB/DIVARTY fires cell and its target processing section or the BCT fires cell and its counterfire operations section uses organic target acquisition and allocated fires capabilities, as well as allocated corps, or joint assets to acquire and disable components of the enemy's weapon systems. Proactive counterfire shapes the battle for future operations.

REACTIVE COUNTERFIRE

2-25. The counterfire headquarters uses a variety of target acquisition assets to accurately locate actively firing enemy weapons systems. The counterfire headquarters establishes the necessary quickfire links to all types of delivery assets to rapidly attack the enemy systems. Establishing and managing radar zones is a critical part of reactive counterfire.

CENTRALIZED COUNTERFIRE OPERATIONS

2-26. During centralized counterfire operations the controlling headquarters (usually the force field artillery headquarters) executes both proactive and reactive counterfire. The force field artillery commander executes proactive counterfire through targeting using a mixture of collection assets (to include WLRs) and delivery systems. The force field artillery commander executes reactive counterfire by conducting positioning authority over WLRs, and designating specific field artillery units as counterfire firing units.

DECENTRALIZED COUNTERFIRE OPERATIONS

2-27. During decentralized counterfire operations there is no single headquarters orchestrating the commander's counterfire fight. Each subordinate unit is responsible for their own counterfire. For example the FA battalion in a BCT is responsible for counterfire in the BCT's area of operations. WLRs and firing units are positioned by their organic headquarters instead of the force field artillery headquarters.

DIVISION COUNTERFIRE OPERATIONS

2-28. Although the DIVARTY has no organic firing units, it can be provided a variety of FA battalions (rocket and cannon) and other assets as required to execute the counterfire fight for the commander. The DIVARTY works with the division fires cell to achieve coordination, integration, and synchronization of all fires. Effective control of fire support is as critical as control of maneuver forces. The DIVARTY headquarters, through its target processing section, is responsible for the synchronization of all sensors that have a command or support relationship with the DIVARTY. The division commander assigns the DIVARTY its mission and coordinates its actions with the BCTs and other support brigades of the command. The DIVARTY is the force field artillery headquarters for the division. Counterfire in the division's area of operations becomes the responsibility of the DIVARTY. The DIVARTY target processing section manages counterfire operations. This includes the positioning and control of the WLRs within the division's area of operations. The target processing section will recommend and coordinate sectors of search within the division area of operations and adjust coverage by WLRs as the situation develops. At the division level, this translates to positioning, zone management, looking for gaps in coverage between BCT boundaries, as well as tracking and assisting with WLR maintenance issues.

2-29. If the division does not have a supporting FAB, the decentralized method for conducting counterfire operations is preferred. The division fires cell monitors the counterfire actions of the subordinate BCTs and conducts targeting for future engagements of enemy indirect fire weapon systems. Without a supporting FAB or other allocated assets the division fires cell does not have the required assets (indirect weapon systems) necessary to perform counterfire without pulling those assets from a BCT.

BRIGADE COMBAT TEAM COUNTERFIRE OPERATIONS

2-30. The FA battalion organic to all BCTs has the ability to conduct counterfire operations. The FA battalion has an organic counterfire operations section to execute the counterfire fight for the BCT commander. For an example of a BCT counterfire battle drill see figure 2-3. The FSCOORD advises the BCT commander on whether to use centralized or decentralized counterfire. The counterfire operations section can remain at the main command post of the FA battalion and conduct the counterfire fight for the BCT, or it can collocate with the fires cell at the BCT. The counterfire operations section pulls information from all available sensor feeds and turns that information into targeting data. The counterfire operations section then passes that targeting data to the appropriate weapons system based on the approved attack guidance matrix.

2-31. The BCT conducts centralized counterfire operations by keeping control of its WLRs and executing battalion level fire missions. Acquisitions can be sent to the fires cell or the counterfire operations section under centralized control. The FSCOORD directs the acquisition routing. Centralized control provides for positive clearance of both ground and air before executing a fire mission.

2-32. The BCT conducts decentralized counterfire operations by assigning a direct support relationship between a WLR and a subordinate firing unit. The counterfire operations section or the BCT fires cell monitors the WLR but does not control the WLR. Decentralized control streamlines the process of acquisition to fire time however it is critical that procedures are in place for clearance of fires.

2-33. Deconfliction of radar coverage during decentralized operations may be more difficult due to the variety of target acquisition assets at brigade level. Possible control methodologies may include the use of common sensor boundaries, brigade combat team forward boundaries, phase lines, or designating specific target sets or coverage areas.

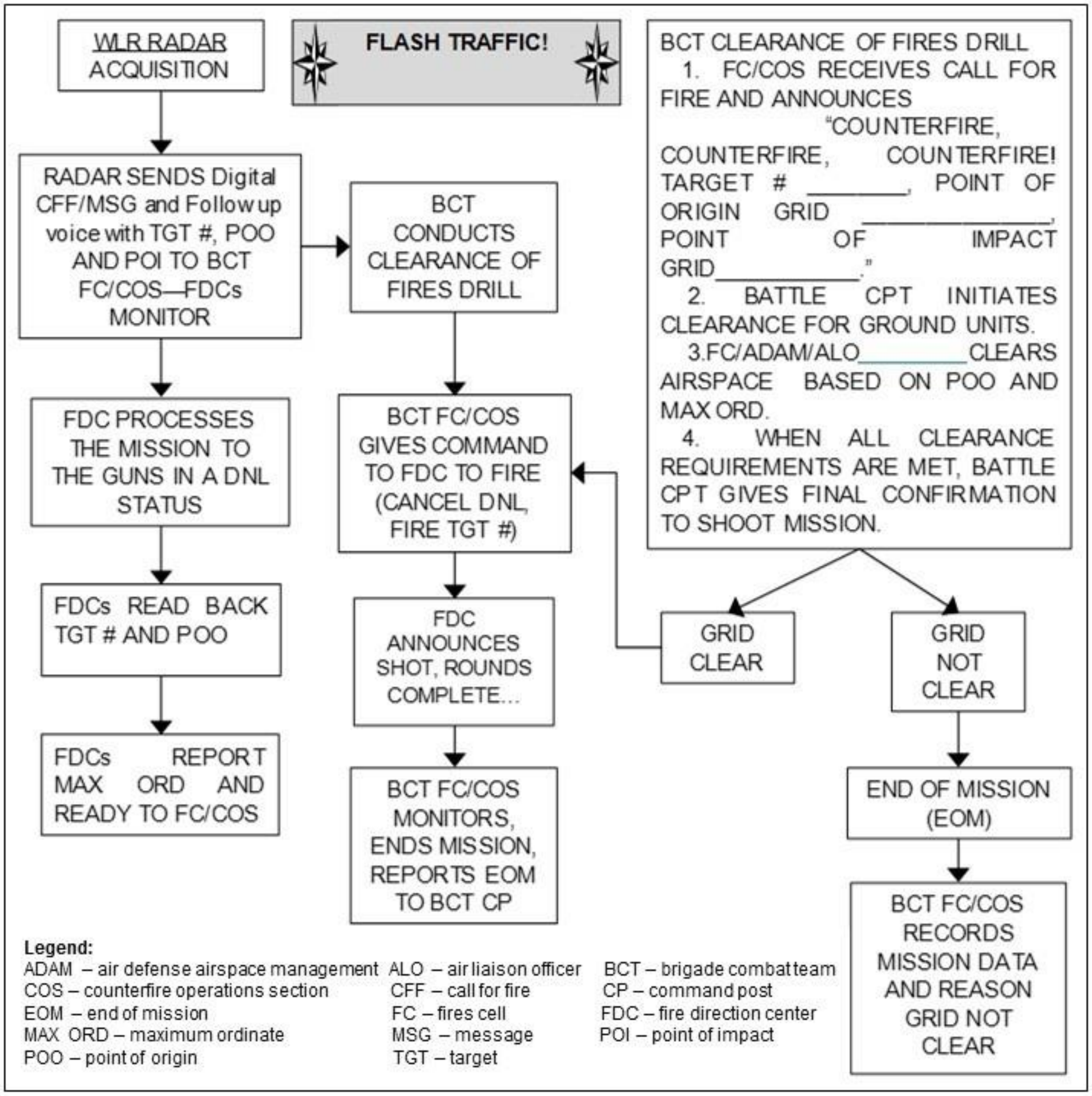


Figure 2-3. Example of a BCT counterfire drill

NOTE. This is just an example of a counterfire battle drill. Units can adjust as necessary based on their tactical standard operating procedures or mission variables of mission, enemy, terrain and weather, troops and support available, time available, civil considerations (METT-TC).

Chapter 3

Technical Aspects of Weapons Locating Radar Employment

This chapter provides an overview of the technical aspect of WLR. The technical aspects are the system characteristics and the parameters for acquiring targets. The standard is to provide timely and accurate information to enhance the attack of specified targets and provide relevant information. Target acquisition is an integral part of targeting and requires interaction among many cells.

TECHNICAL ASPECTS OF SELECTION, POSITIONING, AND OPERATIONS

3-1. The radar section must consider the technical aspects of selection and positioning to enhance and perform radar operations. Those considerations using the mission variables are listed in the following paragraphs.

MISSION

3-2. WLRs must be positioned where they can best accomplish their mission. Several factors drive positioning in relation to mission considerations. The commander's guidance regarding the effects to be achieved by the radar is a major factor in determining where WLRs must be positioned. The requirements to conduct hostile and friendly operations add specificity to positioning requirements. Further, the requirements to establish priority zones are considered when positioning the WLR.

ENEMY

3-3. The enemy situation and capabilities greatly influence where the WLR must be positioned within the area of operations. IPB influences positioning of systems in two ways. First, the process identifies the areas where enemy systems are anticipated. This information and the commander's targeting guidance dictate the positioning and orientation of the antenna. Secondly, IPB identifies threats that must be considered when positioning the WLR. These threats may include suspected locations of ground threats or special purpose forces, electronic warfare threats, major ground and air avenues of approach, and anticipated requirements for repositioning.

TERRAIN AND WEATHER

3-4. Terrain effects movement, cover, concealment, communications, and positioning. In mountainous terrain, identifying positions that maximize the WLR's range and capabilities is difficult. A position with an optimum screening crest may be difficult if not impossible to find. Terrain may also narrow the search sector because of inadequate electronic line of sight. On the other hand, flat or open terrain makes concealment difficult. Heavy rains, snow, sand storms, and dust storms can attenuate the WLR signal and degrade the probability of location. Heavy rains and snow can make some terrain impassable or the soil unstable. The effects of terrain and weather upon positioning must be considered or mission accomplishment will be jeopardized.

TROOPS

3-5. The size of the area to be covered and the number of WLRs available affect both positioning and employment. When multiple WLRs are available to support a unit, smaller search sectors may be assigned to specified WLRs. Further, positions should be selected that facilitate mutual support between WLRs. This allows one WLR to assume all of or part of a WLR section search sector and priority zones during displacement and movement. The number of crewmembers assigned to a WLR section can also affect positioning. Sections manned at less than authorization may require additional support to accomplish the mission. This support may include security or maintenance above normal levels. Occupying the WLR in the vicinity of another unit may be required.

TIME AVAILABLE

3-6. The time available for reconnaissance, liaison, movement, occupation, and position improvement must be considered. Mission requirements and the amount of time available to position WLRs may entail that a WLR initially position in a less than optimum position, then reposition at a later time as mission requirements dictate.

CIVIL CONSIDERATIONS

3-7. Civilians in the area of operations may impact positioning and WLR operations. Positioning requirements may include additional security considerations when there is a potentially hostile local populace. In addition to direct threats, movement routes may become blocked, or congested by the local populace, refugees, or obstacles. However, a cooperative or friendly populace may enhance positioning options. Fixed facilities or other civil structures may become available for use by the radar personnel.

OTHER CONSIDERATIONS

3-8. There are many considerations when employing the radars. A breakdown of other considerations is listed in the following paragraphs.

COVER

3-9. When possible, section equipment should be placed in a defilade, hardened structure, or prepared position to protect the antenna and crew. This provides the crew and some equipment with coverage from hostile fire. Even so, the antenna cannot be completely covered. The antenna can only be placed in a location that provides cover to the top. This provides protection for the antenna electronics while providing an unobstructed line of sight. Placing the WLR in a covered position also helps dissipate noise from the antenna and power distribution group (PDG), lowers susceptibility to direct observation, and reduces the WLR's thermal and infrared signatures.

3-10. In situations where a defilade or prepared position is unavailable, the WLR crew should bury the WLR data and power cables when possible. The data cable is one of the most vulnerable components of the WLR system. It is susceptible to damage by indirect fires or by a vehicle driving over the cable. One broken or damaged wire in the cable can render the cable useless. The power and data cables should be buried in trenches six inches deep, 12 inches deep when crossing roads. The trench should be free of rock and debris, as should the soil used to fill the trench. Engineer equipment should not be used to fill the trench because damage may occur to the cables and excess soil compaction may prevent recovery of the cables during WLR displacement.

CONCEALMENT

3-11. Maximum use of natural concealment, such as trees and shrubs, should be considered in selecting a site for the WLR. The section should make maximum use of their radar transparent camouflage nets and radar scattering nets. Care should be taken to avoid obstructions in front of the antenna that might attenuate the beam. Buildings and other manmade structures can be used to conceal some section equipment. Concealment is also affected by where the position site is located. The unit's IPB should identify likely enemy observation points. When possible, all sites should be selected that avoid direct observation from templated enemy observation points.

COMMUNICATIONS

3-12. Communications between the WLR and the supported unit will normally be conducted using digital and voice communications. WLRs must be adequately positioned in order to facilitate frequency modulation communications with the supported unit.

RECONNAISSANCE

3-13. The reconnaissance will normally include a map reconnaissance, a site analysis using RPAS, and a ground or air reconnaissance if time permits. At a minimum, a map reconnaissance and RPAS analysis should be conducted. RPAS is an excellent planning tool; however, it cannot replace the information gained from an actual ground or air reconnaissance. An actual reconnaissance is invaluable in determining the conditions in the position area and along movement routes.

MAP RECONNAISSANCE

3-14. The map reconnaissance is conducted by the leadership of the TAP. The map reconnaissance can be conducted using a paper map, aerial photographs, or a digital map. A good technique is to use a digital mission command system such as command post of the future (CPOF), Force XXI Battle Command Brigade and Below (FBCB2), or AFATDS because it includes the common operational picture. The map reconnaissance is used to determine the following:

- Known or suspected enemy locations, known or suspected contaminated areas, and friendly units operating in the vicinity.
- Routes of access and departure from the WLR site.
- Identifying landmarks that can aid in hasty survey and navigation.
- Bridges, fords, and bypasses leading into and out of the position area.
- Possible ambush and controlling terrain sites.
- Tentative sites for ground reconnaissance.
- Inter-visibility lines that may provide screening crests.
- Contour lines to provide information about ground slope.
- Significant terrain features that may enhance survivability or degrade performance.
- Possible alternate positions.

RADAR POSITION ANALYSIS SYSTEM

3-15. Once tentative sites are determined, RPAS is used to analyze the suitability of the site. RPAS provides the following information:

- Screening crest.
- Mask angle.
- Electronic line of sight.
- Optimum search fence.
- Estimated performance.
- Slope of the terrain.

GROUND RECONNAISSANCE

3-16. The radar section does not have an organic vehicle available to conduct the ground reconnaissance. A ground reconnaissance should follow the map reconnaissance to determine possibility of movement routes, validate position suitability, and facilitate the rapid occupation of the position. The ground reconnaissance is based on the factors of METT-TC and the technical and tactical considerations that influence WLR operations. A ground reconnaissance accomplishes the following:

- Conduct security sweep.
- Determine routes of ingress and egress to the position area.
- Search and mark the area for obstacles and mines.

- Determine alternate positions and rally points.
- Determine the exact locations for the system components.
- Select a location for the PDG that minimizes its affects on operations.
- Determine vehicle locations that facilitate displacement.
- Measure and evaluate the screening crest.
- Obtain modular azimuth and global positioning requirements from the survey team.

SURVIVABILITY CONSIDERATIONS

3-17. Survivability must be considered when selecting positions for WLR. Systems are susceptible to enemy ground attack, air attack, indirect fires, and electronic warfare. IPB assists with identifying possible threats. Radar sections are not manned or equipped to defend themselves from enemy attacks. When determining the proper amount of security required to defend the radar and crew, the likely threat must be identified and analyzed.

GROUND AND AIR ATTACK

3-18. The radar personnel can take precautions to protect against ground and air attacks. The best protection against a direct attack is to select areas that prevent direct observation by enemy forces. This is important since most attacks by indirect fire or special purpose forces are initiated as a result of direct observation. Security measures may include dedicated maneuver forces or military police to provide on-site security, or mutual support provided by units in the vicinity. Mutual support arrangements might consist of early warning or incorporation in the supporting unit's defense plan. In addition, the radar personnel can protect themselves by using cover and concealment. Selecting positions with natural or existing manmade cover and concealment is best. Engineer assets may also be tasked to provide prepared positions.

ELECTRONIC WARFARE

3-19. The WLRs electromagnetic signature makes it susceptible to electronic attack and radio direction finding. Standard signal security procedures can reduce the WLR vulnerability to radio direction finding. Detection by air and ground-based electronic warfare (EW) systems may present a greater problem. IPB identifies known and possible EW enemy systems. Selecting sites that lower the WLR's electronic signature helps protect the WLR against electronic countermeasures threats.

Occupy Optimum Sites

3-20. The best countermeasure to enemy EW is to occupy optimum sites. An optimum site is one in which the WLR is emplaced on level terrain having a gentle downward slope for the first 200-300m in front of the WLR then a sharp rise to a screening crest.

Screening Crest

3-21. The use of a screening crest is critical when an enemy has, or is suspected to have, electronic countermeasures capabilities. The screening crest diffracts the WLR beam making it difficult to determine the direction of the WLR beam.

Double Screening Crest

3-22. The use of two screening crests makes the WLR more difficult for the enemy to locate. The second crest further diffracts the WLR beam making it more difficult to accurately locate the WLR. The second screening crest is located approximately 1000m in front of the radar.

Tunneling

3-23. Tunneling is the technique of reducing the side, top, and back lobes of radiation through careful site selection. Tunneling is accomplished by sighting the WLR where terrain, vegetation and structures will be located to the sides and rear of the WLR antenna. Tunneling may also be accomplished by digging-in or sandbagging the position. The use of tunneling will reduce vulnerability to direction finding of side lobe radiation.

Orient on Soft Background

3-24. If there are no terrain features or vegetation to reflect or absorb the WLR beam beyond the target area, the background is open. Unrestricted access to non-reflected WLR beams is an ideal situation for enemy direction finding operators. Orienting on a soft background such as foliage, tree lines, or brush reflects the WLR beam and makes it more difficult to direction finding. Hard backgrounds such as rock, buildings, bunkers, or other structures also reflect WLR beams. However, soft backgrounds are better than hard backgrounds, due to the reflection of WLR beams causing a phenomenon known as the multipath effect. During reflection, the beam is bent and phase shifting occurs. This results in the same signal being received from multiple directions and out of phase, making the signal less susceptible to direction finding. The optimum background is an open background above a screening crest.

Reduce Radiating Time

3-25. The shorter time the WLR transmits, the lower the probability that the enemy will conduct direction finding and obtain a fix on the WLR. Transmission time should be reduced based on the enemy's detection capabilities to prevent being acquired. As a general rule, continuous radiation time should not exceed two minutes when the enemy has electronic detection capabilities. The WLR survivability matrix in table 3-1 can be used as quick reference to determine the total amount of radiation time from a position.

Table 3-1. Survivability matrix

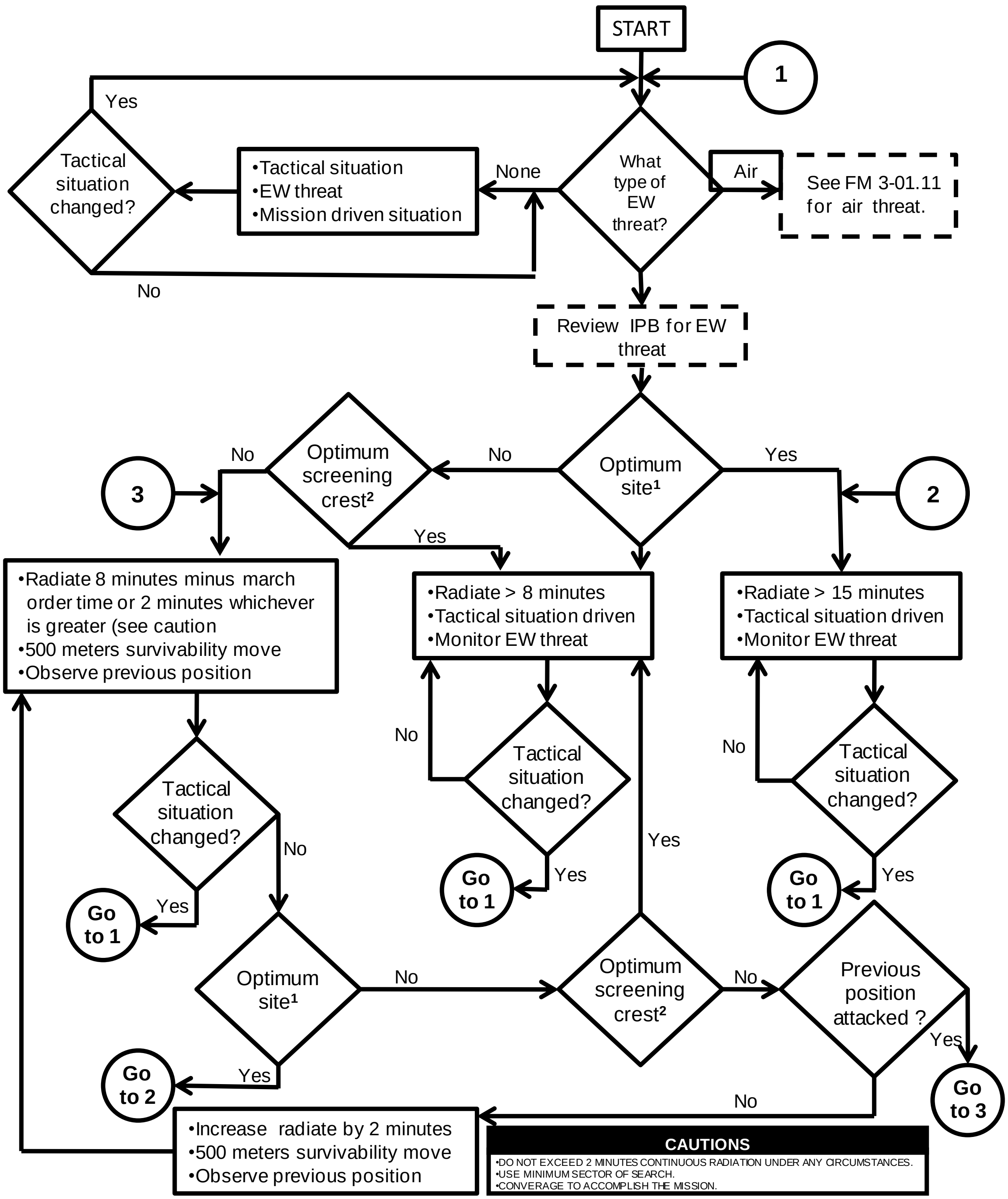
<table>
<tr><th>System</th><th>Screening crest</th><th>Tunneling</th><th>Electronic warfare threat</th><th>Position has screening crest and tunneling</th><th>Position screening crest only</th><th>Position has neither screening crest nor tunneling</th></tr>
<tr><td rowspan="2">AN/TPQ-36/37

AN/TPQ-53 in 90 degree mode</td><td rowspan="2">Less than 1 kilometer of the position in friendly territory 15–30 mils.</td><td rowspan="2">The use of foliage, berm, or buildings to reduce side lobe radiation.</td><td rowspan="3">Counterfire officer provides the current electronic warfare status for their area of operations.

Continuous radiation time should not exceed two minutes when the enemy has electronic detection capabilities</td><td>>15 minutes of accumulation</td><td>>15 minutes of accumulation</td><td>>8 minutes of accumulation</td></tr>
<tr><td colspan="3">Continuous radiation criteria—
• Tactical situation
• Electronic threat (high, medium, low)
• Mission driven situation (close air support)</td></tr>
<tr><td>AN/TPQ-50

AN/TPQ-53 in 360 degree mode</td><td>Mask angel not greater than 100 mils.</td><td>Any building or vehicle less than 20m distance may degrade operation of or damage equipment.</td><td>Never position in a deep depression or valley between hills. The performance will be severely degraded.</td><td></td><td></td></tr>
<tr><td colspan="7">m-meters</td></tr>
</table>

3-26. Total radiation time should be adjusted based on the tactical situation. In situations with no electronic detection threat, continuous radiation should be the norm. The survivability flow chart in figure 3-1 provides a detailed process for evaluating the electronic threat and determining total radiating time.



[1] Optimum radar site definition: AN/TPQ-36 screening crest 15 to 30 mils: AN/TPQ-37 screening crest 5 to 15 mils: good tunneling effect in foliage to reduce side lobe radiation.

[2] Optimum screening crest definition: within 1,000 meters of your position and in friendly territory: no crest in enemy territory higher then yours that is within the enemy's normal direction finding operating range.

Legend: EW – electronic warfare FM – field manual IPB - intelligence preparation of the battlefield

Figure 3-1. Survivability flowchart

Note. Optimum radar site definition: AN/TPQ-36 screening crest is 15 to 30 mils. AN/TPQ-37 screening crest is 5 to 15 mils. Good tunneling effect is foliage to reduce side lobe radiation.

Note. Optimum screening crest is within 1,000 m from your site and located in friendly territory. No screening crest in enemy territory is higher than your screening crest.

COMPLEMENTARY SYSTEMS

3-27. The following systems currently cannot provide targeting data with adequate TLE to engage targets with indirect fires. However, they can help focus radar assets and mitigate the lack of 6400 mil coverage beyond the WLR range.

UNATTENDED TACTICAL ACOUSTIC MEASURING & SIGNATURE INTELLIGENCE SYSTEM

3-28. The Unattended Tactical Acoustic Measuring and Signal Intelligence System was developed by the Army research laboratory to detect mortar and rocket launches and impacts. It is comprised of three to five acoustic arrays, each with four microphones, a processor, radio link, and power source. Interface is via laptop.

RAPID AEROSTAT INITIAL DEPLOYMENT-AEROSTATS

3-29. Rapid aerostat initial deployment-aerostats are being deployed as part of the Persistent Surveillance and Dissemination Systems. Basically, each sensor is monitored by a payload operator, but in locations controlling several sensors, more advanced monitoring systems are required. When connected to Army Battle Command Systems (ABCS), the system can display a comprehensive operational picture, depicting all participating friendly forces locations, and supporting such forces with live streaming video being broadcast on the military intranet, as events unfold. Such service provides quick-reaction forces and first responders at an event scene with live perspective on the operational area. Streaming video is automatically compressed to fit the capacity of each user's communication links.
PSDS2 uses an advanced efficient and intuitive interface to support operator's multi-tasking and focus. The visualization tools used enable the presentation of multiple video feeds as thumbnails, or ortho-rectified footprints superimposed on a terrain map or satellite image, clearly depicting the sensor coverage and orientation. 3-dimensional terrain features and building models are also displayed to improve orientation. This, in-context perspective view shows the scene from any desirable viewing angle or elevation, to optimize the employment of sensors such as unmanned aircraft systems (UAS) and ground observations. This capability can aid in the counterfire fight by providing real-time imagery of a point of origin of enemy indirect firing platforms. PSDS2 can also be used to look at the point of impact, particularly if the point of impact is masked or outside the range of the camera.

UNMANNED AIRCRAFT SYSTEMS

3-30. UAS consists of the air vehicle, sensors, payloads, mission command data links, the operator station, as well as the ground support equipment required for launch/recovery, operations, and maintenance. UAS can provide near-real-time targeting information for counterfire. UAS can be used in the proactive counterfire fight by flying over suspected enemy indirect firing locations identified during MDMP. UAS can be used in the reactive counterfire fight to confirm or deny radar acquisitions.

OPERATIONS

3-31. During radar operations there are many considerations, functions, and tools for the radar operator to use to conduct the mission. These considerations, functions, and tools are listed in the following paragraphs.

OPERATING THROUGH ELECTRONIC COUNTERMEASURES

3-32. Operating through electronic countermeasures consists of detecting the presence of jamming or interference and performing actions to minimize or eliminate the effects of jamming.

ANTIRADIATION MISSILES

3-33. Antiradiation missiles (friendly or enemy) can pose a significant threat to any radar. Capabilities of other countries must be taken into consideration, as multinational forces are capable of employing antiradiation missiles. Antiradiation missiles are of particular concern because friendly aircraft may inadvertently attack a radar (or "emitter") if unaware of its presence, azimuth of search, and operating frequencies. For example, if aircrews are unaware that an AN/TPQ-36 is radiating in the aircraft's area of operations it may be engaged as enemy radar. Further, multinational aircraft may not have the ability to discriminate between enemy and friendly radar signatures, exacerbating the risk to friendly radars. Danger to friendly radars may occur during situations where joint suppression of enemy air defense is employed in support of forward maneuver operations, aerial interdiction, or when receiving close air support.

3-34. Coordination of WLR information during the planning process can reduce the risk to friendly radars. The counterfire officer ensures that location is constantly updated and this information is passed to the battlefield coordination detachment through the brigade fires cell. The corps electronic warfare officer must be cognizant of all emitters across the range of military operations. The electronic operations order must include all emitters and be constantly updated to prevent a fratricide incident. It is imperative that the planners ensure that all radar locations are identified and disseminated.

3-35. Pertinent information about radars in the area operations can be submitted with the air support request (ASR) for preplanned missions and passed directly to the aircraft by the air liaison officer (ALO) during terminal control of close air support (CAS). Information submitted for preplanned missions is analyzed at the air operations center (AOC) and aircraft rules of engagement are developed and published in the airspace control order (ACO) and the special instructions (SPINS) of the air tasking order (ATO). The following information, as a minimum, must be passed to air operations center via the battlefield coordination detachment (BCD) to deconflict WLR operations and antiradiation missile employment:

- Radar type and purpose.
- Radar location.
- Azimuth of search
- Radar search mode (90 or 360 degree)
- On-air and off-air times.
- Site specific patterns.
- Physical site set-up.
- Communications capabilities.
- Coordination frequencies and call signs.

3-36. If the WLR and antiradiation missiles missions cannot be deconflicted, emitter shut down techniques must be used during antiradiation missiles employment. This process can be tedious and time consuming. Preplanned CAS missions normally allow sufficient time to coordinate shutdown. However, during immediate CAS missions this may not be the case. The supported ground commander must balance the risk of fratricide with the need for suppression of enemy air defense to support immediate CAS. In some cases, the ground commander may decide it is neither tactically sound, nor possible, to quickly and effectively shut down friendly emitters.

LOCATION AVERAGING

3-37. Location averaging is a functional part of the radar operational program that eliminates duplicate targets and prevents the loss of targets by eliminating backlogs in the radar's temporary display queue. This function is automatically turned on when the radar's operational program is loaded. Nonetheless, location averaging can be turned off if a requirement exists to identify target locations in close proximity to one another.

3-38. A target is placed in the temporary queue pending operator action. Targets remain in the temporary queue until the operator stores or transmits the target. Storing or transmitting the target removes the target from the temporary queue and places the target in permanent storage, which frees space in the temporary queue. If the temporary queue becomes full, all further target acquisitions are lost until space is freed in the temporary queue. Location averaging automatically frees space in the temporary queue by averaging new targets with targets in permanent storage. If a new target is within 200m of a target in permanent storage, the radar will automatically average its location with the target in permanent storage, update the stored target's location, and remove the new target from the temporary input queue. This saves space in the input queue, eliminates duplicate targets, and saves permanent storage space. If the new target does not correlate with a stored target, it is placed in the temporary input queue pending operator action.

Note. When location averaging is turned on, the software averages all detections within 200m radius into a point of origin. This function prevents overloading the radar storage queue with detections from the same location.

AUTOMATIC HEIGHT CORRECTION

3-39. Height correction is an essential function that must be performed to accurately locate enemy weapons. Height correction is required because the radar thinks the altitude of the target is the same as the high or low datum plane depending on which was used to initialize the radar's computer. Without height correction, the radar will locate a hostile weapon by backtracking the trajectory until it intersects the datum plane used during initialization instead of using the actual terrain altitude. This can cause a significant error in target location. Lack of height correction can also result in target misclassification or possible lack of target location.

3-40. The radar automatically performs height correction when digital terrain data is available, accurate, and loaded into the system. In the absence of digital terrain, manual height correction must be used.

Note. The Army is moving away from paper map displays so it is essential that the unit maintains an updated copy of digital terrain elevation data (DTED) for the operational area.

3-41. In the example shown in figure 3-2, the initial height in the height display is 1000 feet (ft) (the height of the low datum plane) whereas the actual weapon location height is 1500 ft. Therefore, the weapon location indicated on the site map will be incorrect, and the height of this location will not agree with the height indicated by the height display. If the correct weapon location height of 1500 ft is known, it can be entered directly. When the new height is entered, the backtracking solution moves along the projectile trajectory to the intersection with the new height and that new point becomes the displayed weapon location. When the height of the location indicated on the site map and that indicated by the height display agree, no further height correction is required and the displayed location is correct.

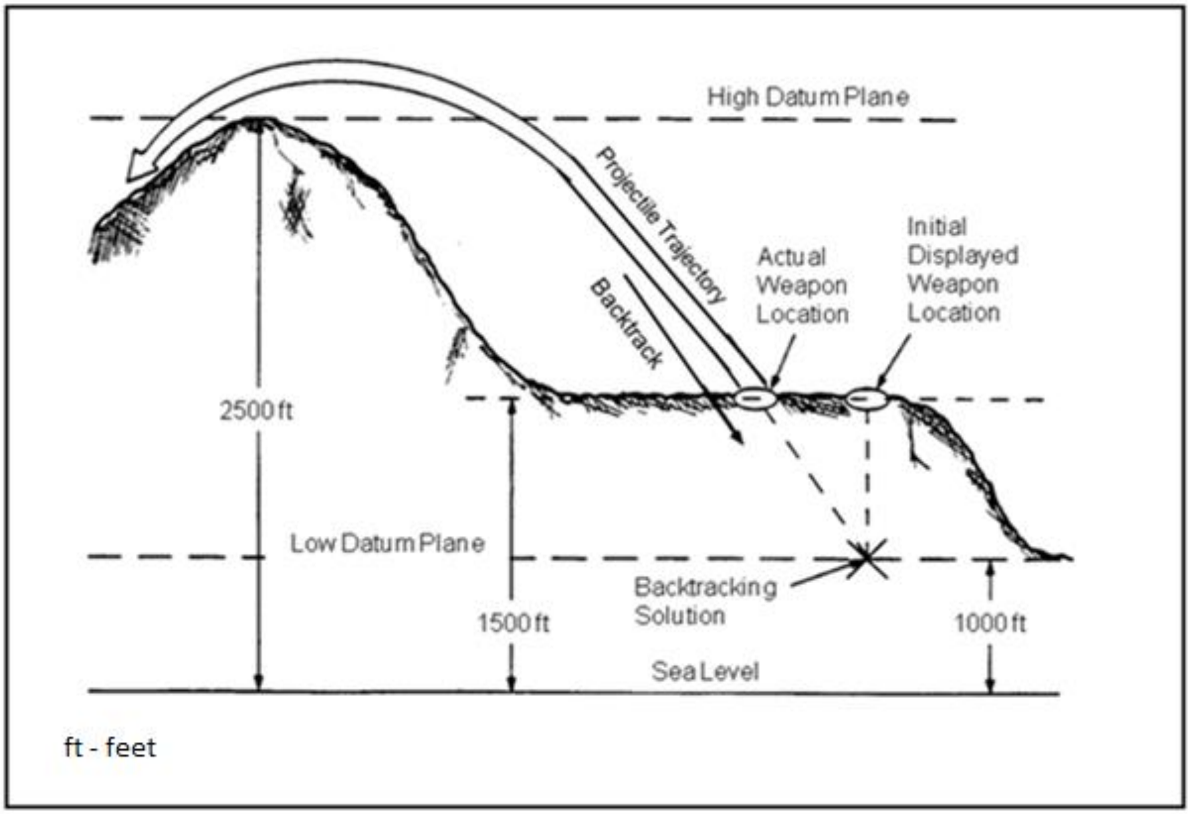


Figure 3-2. Height correction example

AUTO CENSORING

3-42. The radar's auto censoring function is used during anticipated periods of heavy enemy fire or when the radar begins locating more than 10 targets per minute. Auto censoring maximizes the radar's ability to locate new firing positions, saves computer processing time, and saves space in the permanent target list. It accomplishes this by eliminating duplicate target tracks that exceed a specified threshold count. When auto censoring is on, the radar examines each new track for proximity to an existing weapon location. If the new track is within 500m of a known target, and exceeds the established threshold count, the track is dropped. The threshold count is the maximum number of tracks allowed from a known location. It can be set from 2-16 tracks. Normally, a lower threshold count is established during periods of higher enemy fire. Use care when using auto censoring since this function causes the radar to ignore acquisitions.

RADAR POSITION ANALYSIS SYSTEM (RPAS)

3-43. RPAS is a computer tool that facilitates the sighting and setup of radars. RPAS determines radar coverage at a particular location by assessing the radar's ability to locate different types of enemy weapons. RPAS is capable of performing, in minutes, calculations that require significantly more time when done manually. The rapid analyses capability of this computer-based system allows the TA platoon leader the ability to quickly analyze alternative sites and evaluate potential radar coverage. RPAS significantly reduces the time required to perform a detailed radar site analysis. Care must be taken when conducting the analysis in or near urban areas or areas with dense vegetation as RPAS uses DTED to calculate track volume, omitting clutter and line of sight issues derived from structures and non-terrain features.

SITE ANALYSIS

3-44. The radar site is evaluated by specifying the position in the terrain database. The radar operator positions the radar in RPAS by specifying the position's easting, northing, and local reference datum on a pop-up menu. On a second menu, the antenna's azimuth of search, left and right sector scan limits, and minimum and maximum coverage ranges are specified. This information is used to construct a terrain plot. Figure 3-3 shows an example terrain plot.

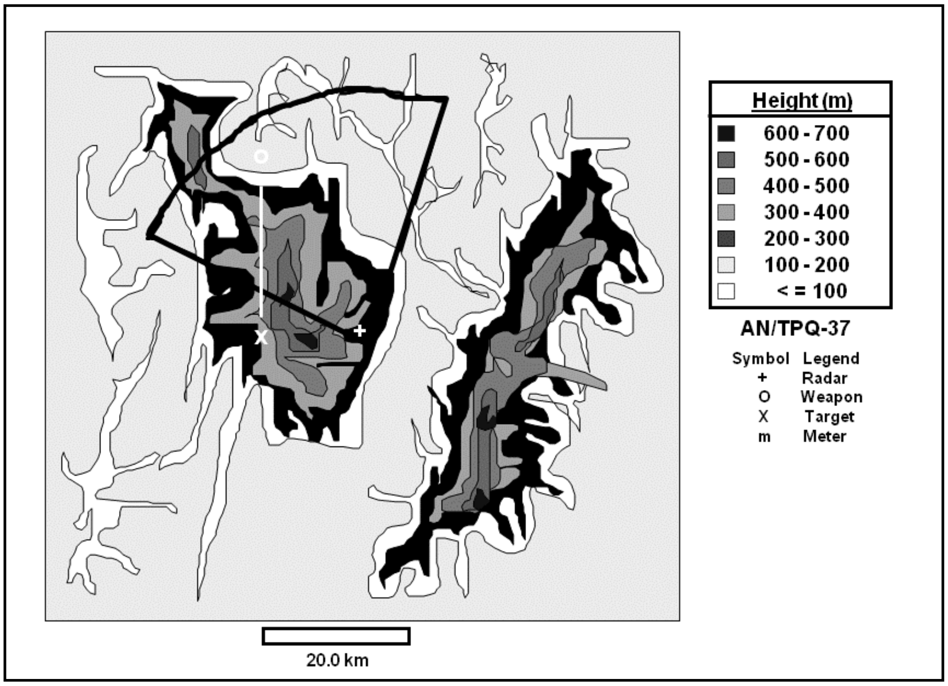


Figure 3-3. RPAS terrain plot

3-45. The white "+" at the center of this figure denotes the radar location, while the annular wedge depicts the radar coverage zone for the selected site. The terrain plot provides the operator with a topographic map of the area around the radar. The color code can be quickly changed to match the height characteristics of the local terrain or those of a small area on the terrain plot.

3-46. The easting, northing, and altitude of a point are displayed to the operator by clicking on a particular area. The operator can magnify a region of this plot by placing a rectangle zoom box around a desired area. The operator is able to produce several additional plots to evaluate the radar sighting, any or all of which can be active simultaneously.

3-47. Figure 3-4 shows a clutter plot. This plot shows where radar returns from stationary objects can degrade radar performance.

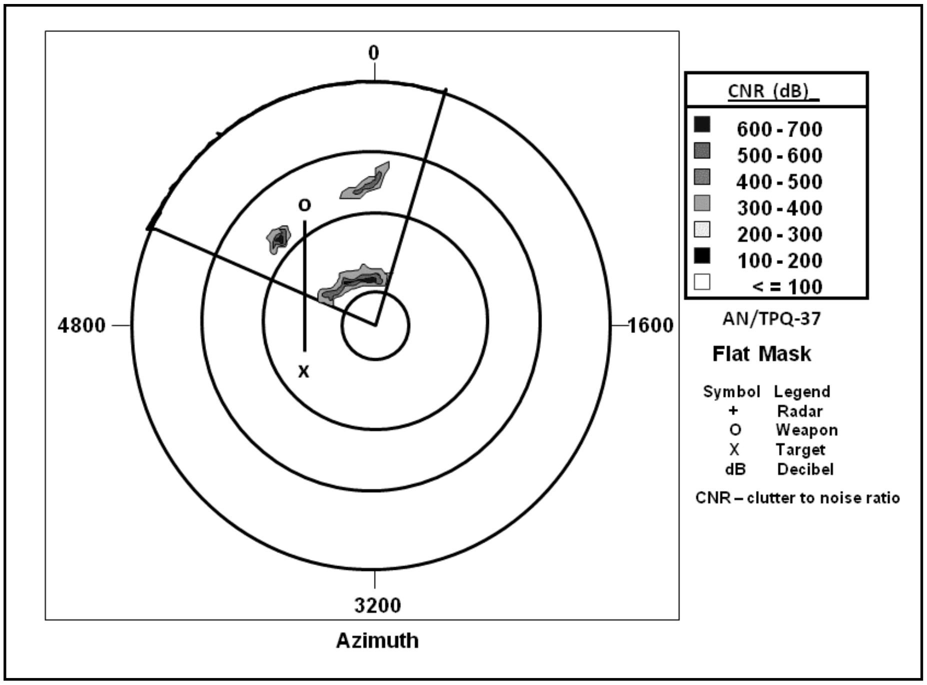


Figure 3-4. Clutter plot

3-48. The screen angle plot shown in figure 3-5 shows a terrain profile. The screening crest, as a function of range, can be obtained directly from this plot. The range to the terrain is color-coded. The rectangular box on this plot denotes the left and right azimuth scan limits and the upper and lower elevation scan limits.

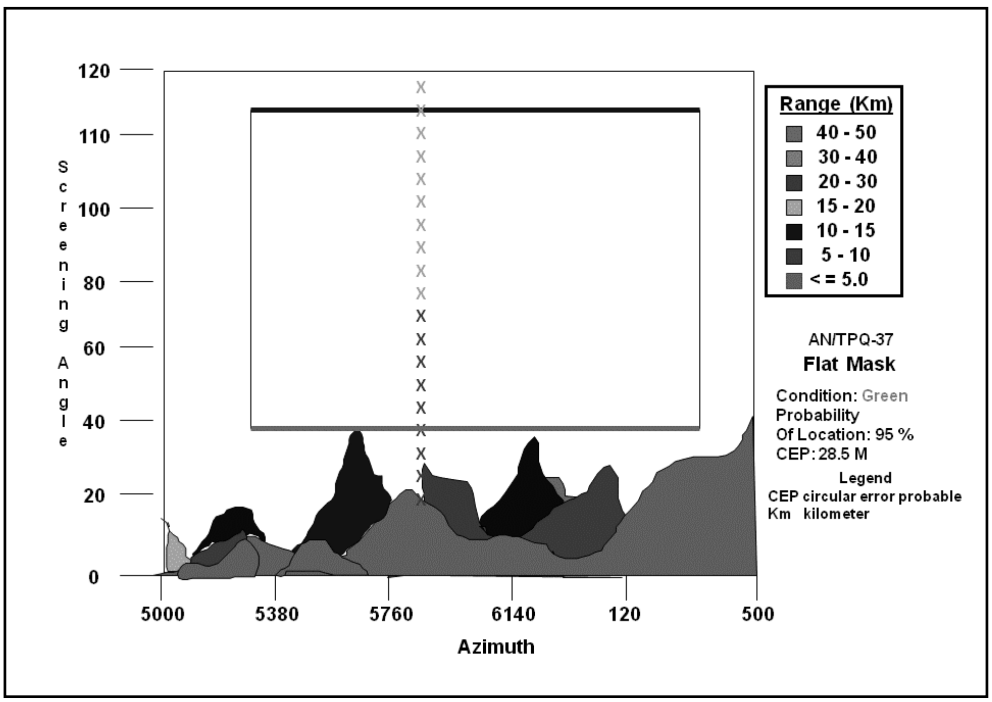


Figure 3-5. Screen angle plot

Weapon Location Analysis

3-49. RPAS provides the ability to perform a computer analysis of the radar's performance against probable enemy weapon location and aim points. This allows the operators to assess the radar's sighting and set-up based on information in a variety of scenarios. RPAS accomplishes this task by first allowing the user to specify the weapon type, location, and aim point, and both the quadrant elevation (QE) and muzzle velocity for a shot, and then by estimating the ability of the radar to determine the location of the weapon.

3-50. RPAS models several generic weapon types, including mortars; light, medium, and heavy artillery; and both light and heavy rockets. In addition, specific weapon types can easily be included in the system. RPAS will inform the operator if the shot parameters that have been input are not within the capabilities of the weapon. The relevant data is displayed for achievable shots include the following:

- Distance from the point of origin to the impact point.
- Range from the site to both the point of origin and point of impact.

3-51. The system automatically computes the minimum QE values. The operator may then change the muzzle velocity or the QE value to analyze other firing conditions. The maximum QE may be selected by the operator (or something like that).

3-52. The weapon model parameters used in RPAS include the allowable range of values for muzzle velocity, atmospheric drag coefficients, and the radar cross-sectional area of the projectile as a function of its aspect angle. This ensures the projectile's trajectory is correctly modeled and the radar signal strength is accurately determined. Once a shot has been specified, it can be overlaid onto all RPAS plots.

3-53. Listed below are four additional pieces of information provided to the operator on RPAS plots:

- P (Solution) - The probability that the radar will collect a sufficient amount of data with a suitable target to interference ratio to solve weapon location equations.
- The circular error probable for the weapon location estimate.
- P (Location) - The probability that the circular error probable will be within the radar's specification.
- Condition Color - A simple means for characterizing the radar performance through a green, yellow, red and black color code. The condition color has been designed to give the user a rapid means of assessing the sighting evaluation, especially under stressful conditions. A thorough assessment of the results can then be performed when time permits.

3-54. In addition to the data above, RPAS provides tabular data describing the radar characteristics for both the projectile and the environment for each point along the simulated trajectory.

SAFETY CONSIDERATIONS

3-55. Safety is an important consideration when operating and working around the WLR. Possible safety concerns include radiation, wind, noise, and electrical hazards.

Radiation

3-56. The antenna transceiver generates a microwave radiation when energized. The radiation is a hazard to radar personnel. It is recommended that the radiation warning sign be placed at least 6.4m from the WLR antennas.

Hazards of Electromagnetic Radiation to Personnel

3-57. The built-in-test scan is zero meters. The built-in-test scan refers to the self-test mode of the radar where it transmits a low amount of energy to test hardware functionality. The safe distance is zero meters for fuel.

Hazards of Electromagnetic Radiation to Ordnance

3-58. If the radar is to be emplaced near an airfield or ammunition site, liaison should be made with the organizations responsible for the operations of those facilities. A safe planning consideration for WLR located near ordnance is 1600° scanning at 268m.

OTHER HAZARDS

3-59. Other hazards include noise and electrical hazards. Using hearing protection when working around power generation equipment can mitigate noise hazards. Overhead power lines and improper grounding of radar equipment can cause safety problems. Radio antennas should be tied down during movement and position areas should be selected that eliminate overhead electrical hazards. Finally, section equipment must be properly grounded during operations.

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Chapter 4

Employment of Target Acquisition Systems

This chapter discusses concepts and procedures pertinent to the tactical employment of FA WLRs. The techniques contained in this chapter are applicable to the brigade combat team's tangible tactical actions.

SECTION I – METHODS OF CONTROL

4-1. There are three types of controls to consider for employment of the target acquisition systems. They are centralized, decentralized, and a combination of controls.

CENTRALIZED CONTROL

4-2. Target acquisition assets may be held under the centralized control of the field artillery brigade if it is designated as the force field artillery headquarters. If there is no force field artillery headquarters designated the BCT commander can use the centralized control option for his assigned WLRs. Centralized control optimizes coverage to support the commander's intent. The command authority performs the following tasks:

- Designates a general position area, sector of search, and zones.
- Establishes cueing guidance.
- Designates cueing agents.
- Controls radar movement.
- Designates who receives WLR acquisitions.

DECENTRALIZED CONTROL

4-3. Decentralized control can be accomplished by adjusting command and support relationships of WLRs to modify control and employment of the target acquisition assets. The operations officer, with support from the target processing section or the counterfire operations section, manages the WLRs.

COMBINATION OF CONTROLS

4-4. Any combination of centralized and decentralized control of WLRs is situational driven and may be used to support any operation. For example, one or more of the AN/TPQ-50s or AN/TPQ-53s may be attached, while the remaining WLRs are kept under centralized control.

COMMAND AND SUPPORT RELATIONSHIPS

4-5. There are command and support relationships to consider when it comes to employment of the target acquisition systems. The command and support relationships are listed in the following paragraphs.

COMMAND

4-6. The WLRs are organic to the TAPs in the FAB, DIVARTY, and the TAP of the BCT's FA battalions. The following paragraphs briefly describe command and support relationships.

4-7. Target acquisition elements may be placed under the control another unit using one of the following command relationships: attached, operational control (OPCON), or tactical control (TACON). Command responsibilities are service support and authority, which include the task of organizing and reassigning target acquisition assets to support the remaining force, higher headquarters, or parent unit.

SUPPORT

4-8. Support relationships for target acquisition elements consist of the following—direct, reinforcing, general support reinforcing, and general support. Support relationships define specific relationships and responsibilities between supporting and supported units. Normally, only direct support and general support relationships are established for radars. Additional information on command and support relationships can be found in FM 3-09.

SECTION II – WEAPON LOCATING RADAR EMPLOYMENT

4-9. This section lists the tasking document for employment of the weapons locating radars. These documents include the radar deployment order and the radar execution matrix and are discussed in the following paragraphs.

TASKING DOCUMENTS

4-10. There is more than one method of specifying WLR coverage for the radar sections. These include the RDO and the radar execution matrix. Both methods provide the required information for conducting radar operations. However, the primary method for orienting radars is digitally using the AFATDS RDO.

RADAR TASKING PROCEDURES

4-11. The DA Form 5957 (Radar Deployment Order) is an enclosure to the target acquisition tab. The RDO provides the information required to deploy the radar section and begin operations.

4-12. Figure 4-1 is an example of a completed RDO.

4-13. Instructions are listed in table 4-1 for completing the form and using this information to begin the detection, verification, and location methodology.

RADAR DEPLOYMENT ORDER
For use of this form see ATP 3-09.12; the proponent agency is TRADOC.

SECTION: Cobra 92 Q-53			MISSION: Hostile Fire	
LOCATION PRIMARY: 11SQS763469			ALTERNATE: 1SQS737/480	
GUN LOCATION:				
SEARCH SECTOR 360/90				
360 DEGREE MODE	LEFT EDGE	RIGHT EDGE	MINIMUM RANGE	MAXIMUM RANGE
PRIMARY AZIMUTH	mls	mls	meters	meters
ALTERNATE AZIMUTH	mls	mls	meters	meters
BLANKED SECTOR				
90 DEGREE MODE	LEFT EDGE	RIGHT EDGE	MINIMUM RANGE	MAXIMUM RANGE
PRIMARY AZIMUTH	4000 mls	5600 mls	[illegible]500 meters	50000 meters
ALTERNATE AZIMUTH	2400 mls	4000 mls	[illegible] meters	50000 meters
EW THREAT ASSESMENT				
EW THREAT ☒ Yes ☐ No	AFFECTING FRIENDLY ASSETS ☒ [illegible] ☐ [illegible]		TYPE OF THREAT Ground	
NOTE: Use the Survivability flowchart in A[illegible]12 [illegible]ermine emission limits				
CUEING AGENTS (CALL SIGN [illegible]GNATION) IN PRIORITY				
Vanguard 40 (Div Fires Cell)	Vanguard 95 (Division Fires [illegible]		Cobra 40 (BCT Fires Cell)	
Cobra 95 (BCT Fies Cell)				
[illegible] CHANNELS				
[illegible]ZONE DATA				

TYPE AND NUMBER	DESCRIPTION AND/OR COMMAND PRIORITY	GRID COORDINATES OF ZONE CORNER POINTS				

DA FORM 5957, JUN 2015 THIS FORM SUPERSEDES DA FORM 5957-R, OCTOBER 2013 APD LC v1.00

SAMPLE

Figure 4-1. DA Form 5957 example

Table 4-1. Instructions for DA Form 5957

Heading
In the first block Section, list the radar section number, and list the type of radar involved. In the second block, enter the mission (hostile, general, direct support, or friendly). If the section is direct support, list the supported unit; for example, 3/A/1-30 FA direct support (DS) to 3-90 FA. Limited command and support relationships are not listed on the RDO; for example, when the section is attached for administrative and logistics support only.
Location
Enter a primary and an alternate general position area for the section. The radar section chief selects the actual site and reports the location. Enter a gun location if providing friendly support.
Search Sector
In this section, describe the search sector. Select a primary azimuth only, and then determine the left and right sector edges or 6400 mil coverage. Range search limits can be specified.
Electronic Warfare Threat Assessment
In this section, indicate the electronic warfare threat. Specify whether an electronic warfare threat exists, if it is affecting friendly assets, and the type of threat. If there is an EW threat, you may use the survivability flow chart in conjunction with the commander's risk assessment and mission, enemy, terrain and weather, troops and support available, time available, civil considerations (METT-TC) to determine emission limits.
Cueing Agents
List in priority by call sign, agents that can cue the WLR.
Reporting Channels
List the communications nets on which the radar is to operate. Include the call sign for each.
Zone Data
In this section, include zone data. List the type of zone and zone number (for example CFZ1), and coordinates of the zones (minimum of three points and maximum of six points). In the description column, list the description of the activity (if any) in the zone. Also, list the command priority for CFFZs when upgraded from priority 2.
CFZ-critical friendly zone, CFFZ-call for fire zone DS-direct support FA-field artillery RDO-radar deployment order WLR-weapons locating radar

AZIMUTH SEARCH SECTOR

4-14. Sectors of search are areas within the area of operations where WLRs focus their capabilities. Sectors of search are determined during IPB and refined in the decide function of targeting. During the decide function, decisions are made concerning what target systems should be acquired and engaged, where and when targets are likely to be found, and what assets can locate the target. Doctrinal employment considerations, in conjunction with templates and intelligence produced during IPB, dictate the areas in which the WLR search should be focused. The location of friendly boundaries and fire support coordination measures may also affect the assignment of search sectors.

ZONES

4-15. Zones are a means of prioritizing acquisitions within the radar sectors of search. Zones focus radar acquisitions on the supported commander's priorities. A zone is a geometric figure placed around an area that designates the area as more, or less, important. There are Four zones that can be entered into the radar but they a broken down into 2 types of zones, Priority and Censor.

- Critical friendly zone (CFZ).
- Call-for-fire zone (CFFZ).

- Artillery target intelligence zone (ATIZ).
- Censor zone (CZ).

Critical Friendly Zone

4-16. A critical friendly zone is an area, usually a friendly unit or location, which the maneuver commander designates as critical to the protection of an asset whose loss would seriously jeopardize the mission (FM 3-09). When the computer predicts a round will impact in a CFZ, the radar generates a call for fire on the location from which the round was fired. This happens automatically unless overridden by the radar operator. A call for fire message priority 1 is transmitted to the fires cell. The CFZ provides the most responsive submission of targets to the fire support system. The CFZ does not have to be within the radar’s sector of search.

Call for Fire Zone

4-17. A CFFZ designates a search area that covers a suspected or from which the commander wants to attack hostile firing systems. A CFFZ would be placed around an enemy fire support position identified as a high-payoff target. A target identified in a CFFZ generates a call for fire priority 2 message. The commander may upgrade the priority, to priority 1, for certain CFFZs. A CFFZ must be in the radar’s sector of search.

Artillery Target Intelligence Zone

4-18. An ATIZ is an area in enemy territory that the commander wishes to monitor closely. Any weapon detected in an ATIZ will be reported ahead of all acquisitions other than those from CFZs or CFFZs. Detections from an ATIZ generate an artillery target intelligence message.

Censor Zone

4-19. CZ is an area from which the radar is prohibited from reporting acquisitions. A CZ is normally placed around friendly weapon systems to prevent them from being acquired by friendly WLRs. The CZ is most often used in noncontiguous situations or during cross forward line of troops (FLOT) raids or infiltration. Care must be used when employing a CZ since the WLR ignores all acquisitions coming from the CZ. This remains true even if the hostile weapon is firing at a unit inside a CFZ. A CZ is two dimensional window placed above ground level, which does not correlate to surface grids. Extremely careful consideration and characteristic understanding must be employed if the zone is to be used. Figure 4-2 depicts the use of a CZ.

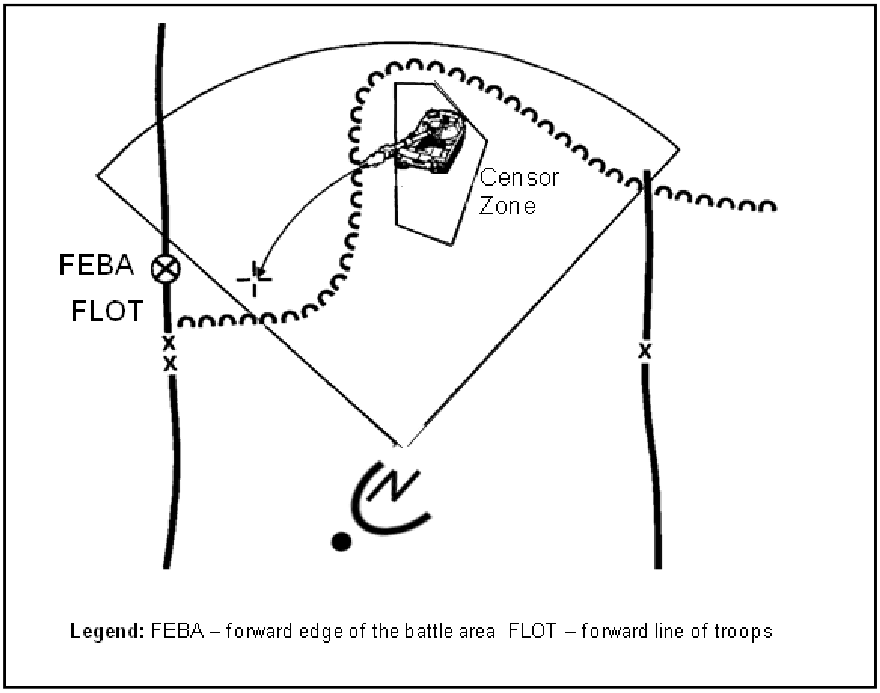

Figure 4-2. Censor zone

DEVELOPING ZONE DATA

4-20. Zone data must support the tactical plan and satisfy the radars requirements for data input. The targeting officer, and counterfire officer develop zone data. The data is entered and transmitted from the fires cell to the radar using the automated RDO. The following considerations apply when developing zone data:

- Up to 1000 zones can be entered. Zones may be any combination of types.
- A zone (including circular and ring zones) must be defined by a minimum of three and a maximum of six coordinates.
- A radar zone cannot intersect or touch another zone.
- Grid coordinates must be listed and entered sequentially.
- Zone coordinates cannot fall outside the sector of search (except for CFZ).

Note. An azimuth should not intersect the boundary of a zone more than two times as shown in figure 4-3.

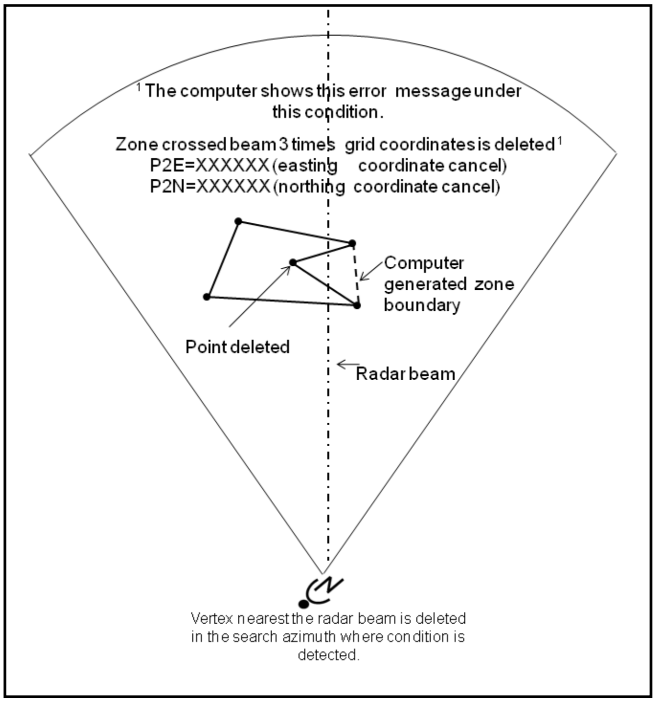

Figure 4-3. Zone gird coordinates

ZONE MANAGEMENT

4-21. Radar zones are managed to comply with the commander's guidance and intent, and the prioritization of fire support efforts. Understanding the commander's plan, and integrating FSOs into the development, refinement, and triggering are key to successful radar zone management. Planning guidance may be found in a number of different documents. These locations include the fires paragraph, tasks to subordinate units, and coordinating instructions of the operations plan or order, and the fire support annex. Information from these sources provides the necessary guidance and information to initiate zone planning.

4-22. The counterfire and targeting officer are directly involved in the planning, refinement, and triggering of zones. The planning for and availability of redundant radar coverage is critical to the commander's successful counterfire operations. This coverage must be included in planning guidance and coordinated as early as possible.

4-23. The counterfire or targeting officer is responsible for employing the WLRs. This involves planning the counterfire operations and fully understanding the target acquisition support requirements.

4-24. Basic guidelines for zone planning include:

- Allocate a certain amount of zone nominations to subordinate units.
- Conduct bottom up refinement that reflects the developed situation template, and scheme of maneuver.
- Develop triggers to activate and deactivate zones.
- Manage zones by resolving duplication.
- Time phasing zones by priority.
- Include zones in the fire support execution and synchronization matrices.
- Include zones in the RDO or radar execution matrix.
- Radar section chief performs technical zone management.
- Refine and update zones as operations progress.

ZONE MANAGEMENT PLANNING SEQUENCE

4-25. The following procedure provides a list of activities essential for successful zone planning:

- Prioritize area of operations and scheme of maneuver events for zone planning based on the commander's guidance.
- Develop zones during course of action development and the wargaming (COA analysis) process.
- Approve and allocate zones to subordinate fires cells that support the scheme of maneuver, meet the commander's priorities, and facilitate the engagement of high-payoff targets.
- Develop and assign decision points as triggers for the execution of planned zones.
- Incorporate decision points (triggers) for planned zones and radar movement into the appropriate decision support template, synchronization and execution matrices, and information collection plan.
- Rehearse planned zones during combined arms, FA technical, and fire support rehearsals.
- Refine zones during execution as IPB develops or the scheme of maneuver changes.
- Develop positioning guidance for the radar that optimizes the probability of acquisition and supports the coverage of planned zones.

ZONE MANAGEMENT RESPONSIBILITIES

4-26. Responsibilities for radar employment and zone management must be a fixed responsibility to focus the planning process and execution. The supported commander is ultimately responsible for counterfire. Usually the FSCOORD is the executive agent for executing the counterfire operations. Zone management responsibilities include:

- FSCOORD
  - Translates the commander's intent for engagement of enemy indirect fire weapons.
  - Ensures counterfire priorities are articulated in the fires paragraph to the operations order.
- Fires cell:
  - Synchronizes all target acquisition assets and zone development to facilitate targeting.
  - Ensures planned zones are synchronized with the applicable elements of the high-payoff target list.
  - Allocates, verifies, and updates zones to ensure the commander's intent for engagement is met.
  - Assigns cueing agents corresponding to named areas of interest, target areas of interest, priority intelligence requirements, and information requests associated with planned zones.
- Targeting and counterfire officer:
  - Provides guidance to lower echelon targeting and counterfire officers.
  - Ensures priorities and triggers are developed for the activation and inactivation of zones.
  - Integrates planned triggers into the appropriate decision and synchronization matrices.
  - Incorporates planned zones into the combined arms and fire support rehearsals.
  - Incorporates decision points, planned zones, and radar movement into the decision support template and synchronization matrix.
  - Monitors range capabilities of both the radars and engagement systems to ensure positioning and movement supports the counterfire plan.
- Operations officer:
  - Ensures the target acquisition portion of the FA battalion operations order includes coordination measures for zone development and radar positioning.
  - Ensures land management for the radars is coordinated with maneuver elements.
  - Recommends attack guidance and firing unit assignment to support the responsive engagement of WLR acquisitions.
- FSO:
  - Recommends priority zones to support the operations plan.

  - Nominates zones to the brigade commander for approval and priority.
  - Develops precise triggers along with identifying and recommending cueing agents for priority zones.
  - Ensures the developed triggers are incorporated into the supported unit decision support template and synchronization matrix.
  - Establishes ownership for the zones.
  - Ensures any changes to the scheme of maneuver are compared against the planned zones.
- Brigade or Battalion intelligence officer:
  - Recommends CFFZs based on the template of enemy artillery positions and known intelligence data.
  - Recommends zones as information collection plan develops or the scheme of maneuver changes.
- TA Platoon leader :
  - Ensures the capabilities and limitations of the radar system are considered during the planning process.
  - Selects radar positions that support the coverage of the planned zones and facilitates movement to support the scheme of maneuver.
  - Performs technical zone management of the radar employment plan.

AUTOMATED TARGET MANAGEMENT

4-27. Advancements in automated mission command systems have changed target management. Current automated systems have the capability to merge, correlate and deconflict multiple radar tracks of a single event. This allows all sensors to report at their full potential without loss in coverage. This advancement allows the WLR to act as a true sensor and not only report known targets, but also report suspect targets unrestricted to the proper analysis teams for integration into the collection plan.

CUEING

4-28. Cueing is the process designed to prompt or notify the radar to begin radiating to acquire indirect fire. The Cueing agent is a command and control element that has the authority to direct the radars search area and search time. Cueing authority should be limited with a clear chain of succession to eliminate multiple cueing agents trying to direct the radar which can cause confusion or conflict of mission. Determining when and how to best cue the radar is one of the most difficult planning decisions. There are as many different methods to cue radar as there are situations when it should be cued. The targeting and intelligence officers' recommendation of cueing guidance to the commander is based on the enemy's ELINT threat capability. Both authority to cue and priority for cueing requirements must be clearly understood and documented.

4-29. Planned random schedules based solely on hours of the day are not recommended and are usually ineffective. Unnecessary cueing subjects the radars to enemy direction finding. Therefore, cueing should be event driven to provide maximum support during critical phases of the battle.

4-30. The cueing of radars may be centralized or decentralized. Centralized cueing routes all cueing requests through the radar controlling headquarters. Centralized cueing may be less responsive based on the level of activity on communications nets and the number of nets the request to cue must go through. During decentralized cueing, the controlling headquarters establishes cueing guidance, to include authorized cueing agents, communication links, and conditions under which the radar may be cued. Radar cueing instructions are listed in the radar deployment order. When cueing agents, other than FA assets are designated, cueing guidance should be given in the base order as coordinating instructions or tasks to subordinate units.

4-31. The critical factor when planning radar cueing is responsiveness. Cueing should allow the radar to locate enemy positions during initial volleys of fire, preferably the first rounds. There are two techniques for cueing; situational (proactive) and demand (reactive). Situational and demand cueing may be used separately or in combination.

Situational Cueing

4-32. Situational cueing is the preferred technique for cueing WLRs and is the most responsive. This method ties cueing to events or triggers that are determined during IPB and the planning process. For example, during the execution of offensive tasks an event or trigger may be a breaching or air-assault operation. When executing defensive tasks, cueing may be tied to suspected enemy phases of fire depicted on the decision support template. Situational cueing focuses the radar on the commander’s intent and what is critical.

Demand Cueing

4-33. Demand cueing is the activation of WLR once the enemy is known to have begun firing. For demand cueing to be effective, cueing agents must be designated and a responsive communication system between the cueing agents and radar established. Specific cueing guidance must also be established to fully exploit the radars capabilities and minimize or eliminate unnecessary radiation. The situation will dictate who best can cue the radar and the specific conditions under which it should be cued. Possible cueing agents may include:

- Forward observers.
- Aerial observers.
- Brigade or division-level electronic warfare systems.
- Scouts.
- Intelligence officers.
- FSOs.
- Counterfire officers and targeting officers.

4-34. Cueing must be based on real-time information so that the radar has a high probability of tracking projectiles. Consider the situation where a task force FSO is designated as a cueing agent. The following events occur:

- 1 – The task force assembly area receives hostile artillery fires.
- 2 – The task force FSO immediately cues the radar.
- 3 – The radar responds and locates the hostile artillery firing on the task force.
- 4 – The radar transmits a call for fire to the FA battalion.
- 5 – The FA battalion executes the call for fire.

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Chapter 5

AN/TPQ-36/37 Weapon Locating Radar System Characteristics and Employment

This chapter discusses characteristics and employment techniques for the AN/TPQ-36/37 WLRs. The WLRs are designed to enhance the detection, verification, and location methodology.

The AN/TPQ-36 is optimized to locate shorter range, high-angle and lower velocity weapons, mortars, and shorter range artillery. It also can locate longer range cannons and rockets within its maximum range. While detecting mortars and artillery, the AN/TPQ-36's higher probability of detection extends to approximately 14,500m for artillery and 18,000m for mortars. Rockets can be detected with reasonable probability out to 24,000m. The AN/TPQ-36 can search up to 6400 mils (not simultaneously) by using the extended azimuth search function in which the computer automatically traverses the antenna from two to four positions and performs target location.

The AN/TPQ-37's greater range of 50,000m, increased accuracy, and ability to track mortar rounds provide the required radar coverage. The AN/TPQ-37 classifies and locates faster moving, low-angle projectiles from cannon and rocket launcher firing locations. To maximize this capability, the AN/TPQ-37 filters out all other radar tracks. The greater threat comes from high-angle and slow-moving mortars. A software solution was developed to enable the AN/TPQ-37 to replicate the AN/TPQ-36 radar's capabilities and acquire mortars with acceptable target location errors. The primary risk is that the software eliminates part of the filtering process, resulting in higher clutter images in a period of high volumes of fire. Crew training negates this risk.

SECTION I – CHARACTERISTICS AND EMPLOYMENT

5-1. The AN/TPQ-37 consists of an operations control group (OCG), antenna transceiver group (ATG), PDG, trailer power distribution unit, vehicle, and a family of medium tactical vehicles for transporting the trailer power distribution unit. The AN/TPQ-37 system major components consist of the following:

- Generator truck.
- Generator group.
- Prime power cable set.
- ATG.
- Transporter flatbed medium trailer.
- Shelter cable set.
- OCG.
- Shelter vehicle.

OPERATIONS CONTROL GROUP

5-2. The OCG is the focal point for operating the radar. It consists of the shelter mounted on a vehicle with the shelter cable set. The shelter cable set consists of two 50-foot cables. These cables connect the shelter to the ATG. One cable is a power cable that provides power from the ATG to the shelter. The second cable is a data cable that allows data exchange between the antenna and the shelter. The cables are stored on cable spools attached to the back of the shelter during movement. An alternate method of storing the cables is to place them in the utility vehicle bed under the shelter. This allows the cables to remain connected to the shelter during movement. This technique is often used since it shortens the emplacement time for the radar.

ANTENNA TRANSCEIVER GROUP

5-3. The ATG consists of the antenna, modular azimuth positioning system-hybrid (MAPS-H), a modified antenna trailer, radiating elements and associated feed, receiver preamplifiers, receiver protectors, azimuth and elevation positioning circuits, beam steering circuits, tilt sensor, and boresight telescope. The antenna is erected to the vertical position during operations and lowered to the horizontal position for transport. The OCG vehicle tows the ATG during movement. The modified trailer is equipped with the medium track suspension system. The medium track suspension system is designed to improve the mobility of the trailer when traveling over soft soil, sand, mud, and snow covered terrain. MAPS-H is a GPS aided, inertial surveying system, designed for use in the ground mobile environment. It provides the radar with an on-board position location and survey capability. MAPS-H uses a vehicle motion system to determine the location of the radar antenna.

POWER DISTRIBUTION GROUP

5-4. The PDG consists of generator mounted on a vehicle, and the prime power cable. The generator is a 400 hertz, 60 kilowatt, precise power tactical quite generator mounted on a special pallet. The prime power cable is contained on a spool that is mounted on the left rear of the generator pallet. The prime power cable is a 32m cable that connects the PDG generator to the ATG via a power distribution box with an eight-meter cable. This allows the PDG to be positioned up to 30m from the ATG, given the requirement for 10m of slack in the cable.

TRAILER POWER DISTRIBUTION UNIT

5-5. The trailer power distribution unit is a PU-806, or 400 hertz, 60 kilowatt generator, mounted on a M200A1 trailer. The medium tactical vehicle tows the trailer during movement. Based on the cable lengths in table 5-1, the AN/TPQ-37 OCG can be placed 40m from the ATG. The PDG can be placed up to 30m from the ATG given the combined lengths of the prime power and ATG power cable.

Table 5-1. AN/TPQ-37 cable lengths

Cable	*Length*
Prime Power Cable	32m (104 ft)
Control Display Terminal Power and Data Cable (x2)	50m (164 ft)
Shelter Power Cable	50m (164 ft)
Shelter Data Cable	50m (164 ft)
ft - feet m - meters	

SITE REQUIREMENTS

5-6. The technical aspects and characteristics of WLRs determine the requirements for site selection. The section chief selects the actual WLR site from the general area for positioning established by the FAB, DIVARTY, or battalion operations officer. These positions are recommended by the counterfire officer during MDMP. The technical considerations for site selection and emplacement include:

- Slope.
- Area in front of the antenna.
- Screening crest.
- Aspect angle.

- Electronic line of sight.
- Track volume.
- Proximity of other radars.
- Cable lengths.

SLOPE

5-7. Slope is an important consideration for the proper positioning of the WLR. The slope of the terrain must be 7 degrees (120 mils) or less to ensure proper leveling of the ATG. The ATG will not operate properly without leveling. Safety is a consideration when positioning the WLR on slopes greater than recommended. Some slope is advantageous and enhances radar functioning. Slope also provides drainage to the radar site that can help prevent WLR components from becoming stuck during periods of heavy or continuous rainfall.

AREA IN FRONT OF THE RADAR

5-8. The area in front of the ATG should be clear of foliage that extends above the bottom of the antenna. WLR signals can be attenuated by more than 1 decibel per meter if operating within heavy foliage. A few meters of foliage can severely reduce the detection effectiveness. A clear area in front of the ATG minimizes attenuation of the radar beam. This area should extend 200 - 300m in front of the ATG. The ideal site will have a clear area in front of the ATG that has a gentle downward slope for approximately 200-300m and then gradually rises up to the screening crest. The downward slope reduces multipath errors. Multipath errors are created when the computer controlled signal processor transmits or receive signals traveling by more than one path during detection.

SCREENING CREST

5-9. A screening crest increases the survivability of the AN/TPQ-36 and AN/TPQ-37 WLRs by serving as a defense against enemy observation (visual and infrared), direct fire, and electronic countermeasures. The screening crest also helps attenuate sound. Ideally, the screening crest should be in friendly territory and located approximately 1000m in front of the WLR, perpendicular to the WLR's azimuth to center sector. When possible, the WLR should utilize a dual screening crest. The first screening crest should be approximately 250m and the second screening crest at 1000m from the radar site.

5-10. The vertical angle to the screening crest should be between 15-30 mils for the AN/TPQ-36 and 5-15 mils for the AN/TPQ-37. The optimum vertical angle is 10 mils. The difference between the highest and lowest points on the screening crest should not exceed 30 mils for the AN/TPQ-36. A difference of more than 30 mils reduces the ability of the AN/TPQ-36 to produce enough track volume to compute a point of origin or point of impact. The AN/TPQ-37 screening crest should not have a difference of more than 54 mils between the highest and lowest points. The vertical angle between the ATG and the top of the screening crest is called a mask angle. Appendix D contains a detailed discussion of mask angle.

MASKING

5-11. The radar section chief must consider visibility and masking (for example, varied elevations, dense trees or foliage, and high buildings). This assumes a greater importance when the WLR covers a 6400 mil sector. RPAS is used to conduct site analysis and determine the optimum initialization data. Blind spots in the radar's coverage can be determined and reported to the counterfire section for appropriate action.

ELECTRONIC LINE OF SIGHT

5-12. The overriding consideration in the selection for a WLR site is electronic line of site. All radar systems must have an electronic line of sight to the projectile being detected to acquire the weapon. However, electronic line of site to the weapon is not required. The section chief verifies electronic line of sight before occupying the site. This can be done manually or with RPAS. Verifying the electronic line of sight before occupying the site can save valuable time by eliminating untenable sites.

TRACK VOLUME

5-13. Track volume is determined by the vertical scan of the WLR. The vertical scan can be reduced because of the terrain contour or screening crest in front of the WLR. WLRs require 50 mils of track volume to detect a projectile. The difference between the high and low mask angles should not exceed 30 mils for the AN/TPQ-36 and 54 mils for the AN/TPQ-37. A detailed discussion of track volume is contained in Appendix D.

TACTICAL CONSIDERATIONS

5-14. The tactical position areas are selected based on IPB, the range capabilities of the WLR, and METT-TC. A complete analysis of METT-TC will dictate which factors are most important. Generally, in a traditional area of operations, WLRs are positioned far enough from the FLOT to acquire enemy weapons and to prevent loss of personnel and equipment to enemy action. Avoiding unnecessary moves supports maximizing coverage and cueing time. The tactical considerations for positioning each radar system are listed below:

- AN/TPQ-36 is usually located 3-6km behind the FLOT.
- AN/TPQ-37 is usually located 8-12km behind the FLOT.

5-15. Positioning may change based on the tactical situation.

PROXIMITY OF OTHER RADARS

5-16. Other WLR systems or active emitters can interfere with WLR coverage by attenuating or jamming the WLR beam. WLRs and emitters close in proximity or azimuth of search may cause jamming. Inadvertent jamming can be avoided by careful planning of WLR positions.

5-17. When two or more AN/TPQ-36s or AN/TPQ-37s are operating in the same area they must be separated by at least 250m.

CABLE LENGTHS

5-18. Cable lengths must be considered when selecting a WLR site. The cables determine the maximum extent to which the components of the WLR can be dispersed. The location of system components is determined by terrain contour, foliage, site access, and threat. Ideally, the WLR components should be positioned to take advantage of naturally available cover and concealment. Nonetheless, cable lengths may dictate the actual positions.

5-19. Based on these lengths, the AN/TPQ-36's OCG can be placed up to 40m from the ATG and 30m from the PDG. The remote control display terminal can be located up to 90m from the shelter when using both control display terminal cables. Emplacement of system components must allow for 10m of slack in the cables to prevent damage to cable heads and connectors.

5-20. The AN/TPQ-37 OCG can be placed 40m from the ATG. The PDG can be placed up to 30m from the ATG given the combined lengths of the prime power and ATG power cable. The requirement for 1 m of cable slack also applies to the AN/TPQ-37.

SITE ACCESS

5-21. The WLR site should have more than one route of approach. Routes of approach should be accessible by section vehicles, free from enemy observation, and capable of being guarded by a minimum number of personnel. The quality of access must also be considered. Some essential considerations include:

- *Accessibility during poor weather conditions*. Can the position be accessed during periods of rain and snow? Positions that may deteriorate during inclement weather should be avoided to prevent stranding the WLR.

- *Overhead clearance.* Avoid locations where trees, power lines, or telephone lines may damage WLR components when entering and exiting the position. Check the clearance requirements for tunnels and overpasses to ensure section equipment does not exceed requirements.
- *Bridges.* Check the bridge classifications on routes to WLR positions. Ensure the bridge classification of section equipment does not exceed the load bearing capabilities of the bridge.
- *Fords.* Check fords to ensure they are passable to the WLR section equipment. The ATG for the AN/TPQ-36 and AN/TPQ-37 can only ford 30 inches of water. If heavy rains are expected, some positions may become untenable because of fording restrictions.
- *Obstacles.* Check routes for current and planned obstacles. These obstacles may include road craters, tank ditches, abates, or wire obstacles. Also, check for natural obstacles such as fallen trees and rockslides. Ensure the access is sufficient to allow egress after combat has occurred. Rubble from buildings, utilities, and fallen trees should not prevent the WLR section from displacing.

SAFETY CONSIDERATIONS

5-22. Safety is an important consideration when operating and working around the WLR. Possible safety concerns include radiation, wind, noise, and electrical hazards.

Hazards of Electromagnetic Radiation to Personnel

5-23. The hazard ranges are summarized below for WLRs:

- The AN/TPQ-36 radar extends 5m in front of the antenna within a 1600 mils fan about the boresight for all transmitting operations. For narrow-sector azimuth scan angles less than 400 mils, an additional sector must be controlled to a distance of 30m from the antenna. For fixed-beam mode, the hazard area extends to a distance of 75m in front of the radar. The narrow-scan hazard sector usually applies to friendly fire mode operations and fixed-beam to certain maintenance operations.
- The AN/TPQ-37 extends 7m in front of the antenna within a 1600 mils fan about the boresight for all transmitting operations. For narrow-sector scan, an additional sector must be controlled out to 40m. For fixed-beam mode, the hazard area extends out to 100m in front of the radar.

WIND

5-24. Because of the large surface area of the AN/TPQ-36 antenna, high wind velocity can cause serious safety hazards. When wind velocity reaches a constant 52 miles per hour (mph) (45 knots) or gusts up to 75 mph (65 knots) during operations, the antenna must be placed in the stowed position. When non-operational, the radar must be stowed when winds reach 65 mph (56 knots) with gusts to 100 mph (88 knots). Camouflage nets also should be lowered or removed to prevent damage to equipment or injury to personnel.

5-25. The same hazards exist for the AN/TPQ-37. However, the radar should be stowed when the wind velocity reaches a constant 40 mph (35 knots) with gusts up to 75 mph (65 knots) during operations. When non-operational, the antenna must be stowed when winds reach 80 mph (70 knots) with gusts up to 119 mph (103 knots).

SECTION II – DETECTION, VERIFICATION, AND LOCATION METHODOLOGY

5-26. The AN/TPQ-37 is designed to detect mortars artillery and rockets. The AN/TPQ-37 is optimized to locate longer-range, low-angle, higher velocity weapons such as long-range artillery and rockets. However, it will also locate short-range, high-angle, lower velocity weapons thus complementing the AN/TPQ-36. The AN/TPQ-37 has a minimum range of 3km and a maximum range of 50km. For artillery, the higher probability of detection extends out to approximately 30km. Minimum and maximum detection ranges can be established for the AN/TPQ-37. However, there must be at least 900m difference in maximum and minimum ranges.

5-27. The AN/TPQ-37 sector of search is 300-1600 mils. The AN/TPQ-37 is not equipped with the extended azimuth search function, and can traverse a full 6400 mils. The AN/TPQ-37 is normally deployed 8-12km behind the FLOT and can be emplaced, ready for operation within 30 minutes, and march-ordered within 15 minutes during daylight hours. Emplacement and march-order times do not include the time needed to set up or take down camouflage nets.

5-28. The AN/TPQ-36 and AN/TPQ-37 systems use a search, verify, track approach to achieve an acquisition on all suspected targets. Search, verify, track requires that the radar respond very quickly to every detection reported during search, by inserting a verify beam into the search frame.

5-29. Establishing the search fence is the first step performed by the WLR for detecting an object. The WLR accomplishes this by transmitting a series of beams that conform to the terrain. Once an object penetrates the search fence, the software determines the object's speed, elevation, range, and azimuth. The software uses this information to predict the object's next location and to send out verification beams to determine if the object has a ballistic trajectory.

5-30. If a ballistic trajectory is verified, the software sends out a series of tracking beams. These beams provide the WLR with the information required to mathematically extrapolate a predicted launch and impact point. The WLR stops sending out tracking beams when the following conditions exist:

- A solution is computed for the acquisition.
- Three sequential misses happen for the AN/TPQ-36.
- Five sequential misses for the AN/TPQ-37.
- The predicted azimuth for the next track update is outside the left or right limit of the WLR's search sector.
- The predicted elevation of the next track is above or below the WLR's minimum or maximum search elevation.

5-31. Figure 5-1 depicts how the AN/TPQ-36 and AN/TPQ-37 track a projectile. .

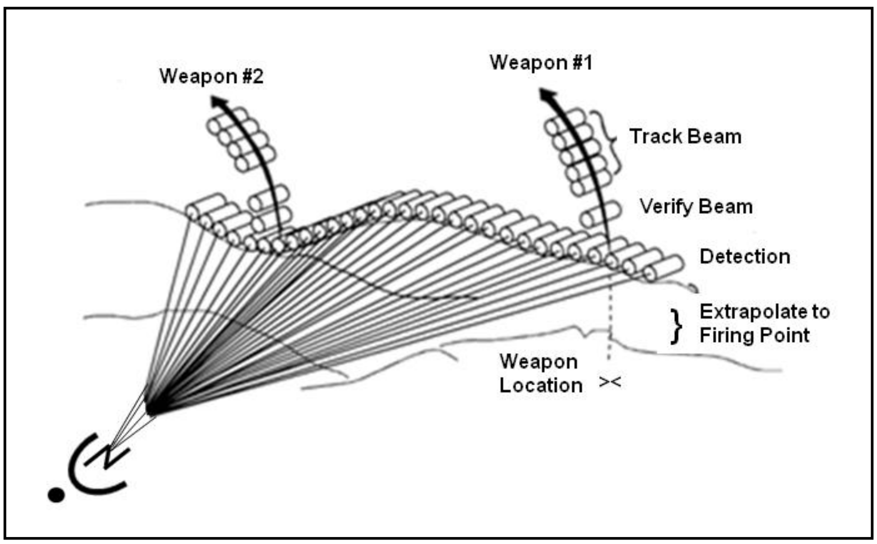

Figure 5-1. AN/TPQ-36/37 Detection, verification, and location methodology

> ***Note.*** Search beam on the screening crest verifies penetration of projectiles. Verification and tracking beams transmit automatically. Computer determines point of origin and point of impact.

AN/TPQ-36 AND Q-37 DETECTION AREA

5-32. The possible detection area is a three dimensional space defined by the minimum and maximum range, search sector, and the vertical scan of the WLR. Planning ranges are used for the purposes of this discussion; however, the maximum planning range for the WLR is not an absolute. A system's actual maximum effective range is the range at which the probability of detection becomes low enough to be unsuitable for planning purposes. Nonetheless, objects may be detected beyond the maximum planning range. Conversely, objects within the planning ranges may not be detected. Listed below are the planning ranges for the following WLR:

- AN/TPQ-36 – 14.5km for artillery, 18km for mortars, and 24km for rockets.
- AN/TPQ-37 – 30km for artillery and mortars, 50km for rockets.

AN/TPQ-36/37 SEARCH SECTOR AND RANGES

5-33. The search sector is the area left and right of the radar's azimuth of search where the WLR can locate targets. The maximum search sector for the AN/TPQ-36/37 is plus or minus 800 mils from the azimuth of search for a total of 1600 mils. The search sector can be narrowed based on the tactical situation.

5-34. Figure 5-2 illustrates possible AN/TPQ-36/37 search sector and associated range limits.

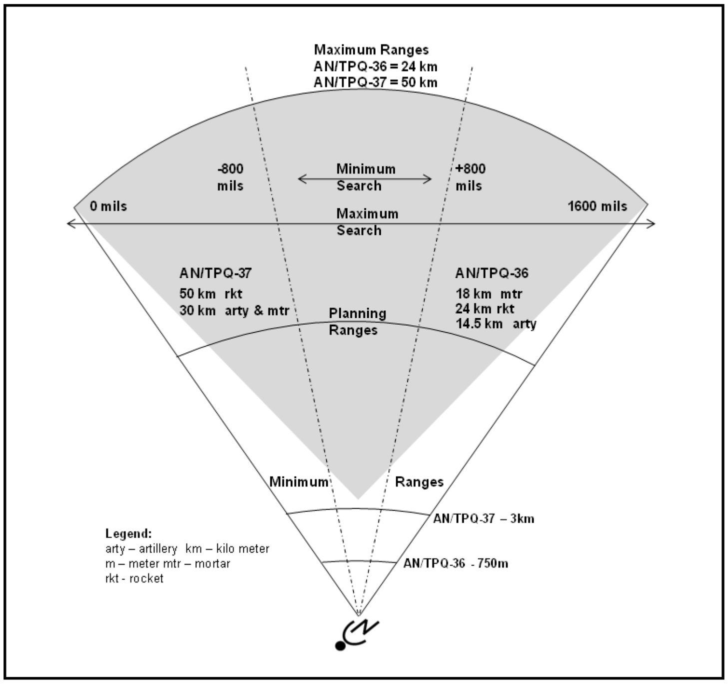

Figure 5-2. Q-36/37 Search sector and ranges

Note. Both AN/TPQ-36 and AN/TPQ-37 must have a minimum of 900m difference between minimum and maximum ranges.

AN/TPQ-36/37 VERTICAL SCAN

5-35. The vertical component of the detection area is vertical scan. This area extends vertically from the search fence to the maximum scan elevation of the radar. The vertical scan for the AN/TPQ-36 and AN/TPQ-37 is listed below:

- Maximum vertical scan for the AN/TPQ-36 radar is approximately 80 mils with all 32 scanning frequencies enabled. (Each frequency disabled results in a loss of approximately 2.5 mils of vertical scan.) A minimum of 20 frequencies are needed to track a round.
- Maximum vertical scan for the AN/TPQ-37 radar is approximately 104 mils. The AN/TPQ-37 uses phase scanning so no vertical scan is lost when any of the 15 frequencies are disabled. A minimum of 1 frequency is needed to track a round.

5-36. Figure 5-3 shows the vertical scan capabilities of the AN/TPQ-36 and AN/TPQ-37. The three dimensional area shown in the diagram is the area where an object can be detected and tracked. There must be a sufficient amount of vertical scan at the points where an object passes through the detection area for the WLR to track the object and compute a solution. The amount of available vertical scan is called track volume.

Note. AN/TPQ-36 and AN/TPQ-37 Radars require a minimum of 50 mils of track volume to track a round for long enough to achieve a solution.

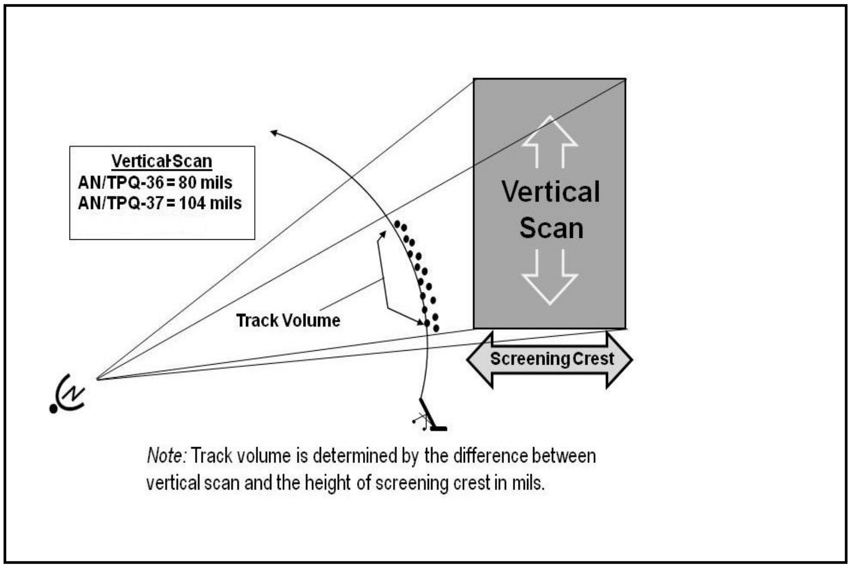

Figure 5-3. Vertical scan

5-37. There are two other major factors that affect the AN/TPQ-36 and AN/TPQ-37 radars' ability to detect, verify, and locate. These factors are aspect angle and speed of the object. The aspect angle is the angle measured from antenna to the target path of the object. The aspect angle must be greater than 1600 mils. This means the object must be traveling toward the antenna. An objects approaching at 1600 mils may not be detected by the radars.

5-38. The velocity of the object is a critical element. The velocity must be within the minimum and maximum velocity thresholds for the all radar systems.

Note. The aspect angle is the distance in mils between the radar antenna and the path of the projectile.

AN/TPQ-36/37 VELOCITY REQUIREMENTS

5-39. Most mortar, artillery, and rockets have a velocity greater than 80m per second. The velocity requirements for the AN/TPQ-36 and AN/TPQ-37 WLRs are listed below:

- AN/TPQ-36. Tracks objects *moving toward* the radar at ground surface speeds of at least 50m per second and no greater than 1500m per second. Tracks objects *moving away* from the radar at ground surface speeds no greater than 80m per second.
- AN/TPQ-37. Tracks objects *moving toward* the radar with ground surface speeds of at least 130m per second and no greater than 1500m per second. Tracks objects *moving away* from the radar at ground surface speeds up to 80m per second.

AN/TPQ-36/37 RADAR BEAMS

5-40. A radar beam is actually composed of four individual beams that comprise a track cluster. The track cluster is simply identified as a radar beam.

5-41. Figure 5-4 shows a cross section of a radar track beam used to track an object traveling through the detection area.

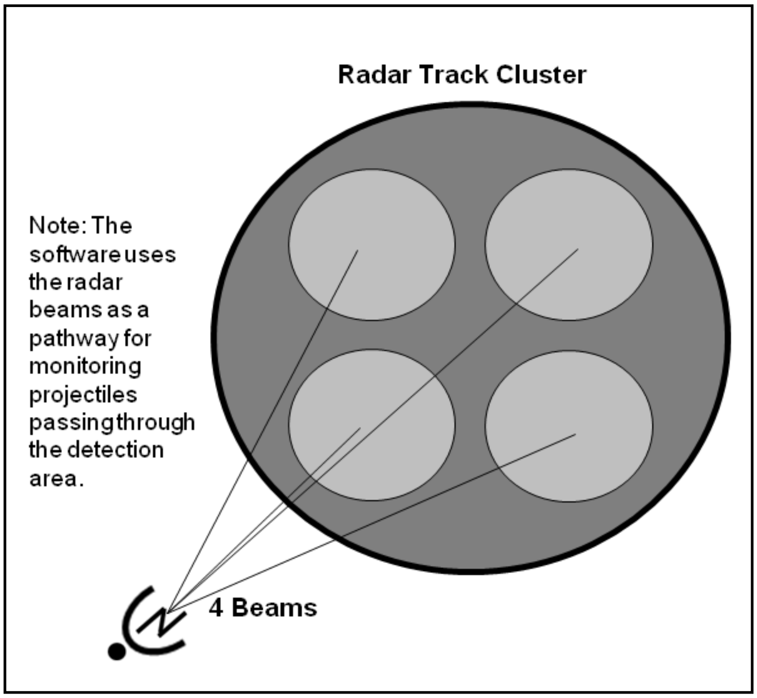

Figure 5-4. Radar track beam cross section

5-42. There are three possible outcomes when an object passes through the search fence and the radar transmits the verification or tracking beam. The outcomes are miss, hit, or plot. A miss occurs when the projectile strikes none of the individual beams in the track cluster. A hit is indicated when at least one beam in the track cluster is struck, but not all. A plot occurs when the following conditions happen:

- All four beams of the track cluster detect the object.
- The detected range of the object is within 75m of the predicted range.
- The detected azimuth is within 20 mils of the predicted azimuth for the AN/TPQ-36 or 15 mils for the AN/TPQ-37.
- The detected elevation is with 15 mils of the predicted elevation for the AN/TPQ-36 and 10 mils for the AN/TPQ-37.

5-43. When the software achieves an adequate number of plots it computes a solution for the point of origin and point of impact. The number of plots required to achieve a solution varies based on WLR type, which include the initial detection range and the tracking time. In general, the AN/TPQ-36 needs between 3-15 plots depending on the reasons for track termination. The AN/TPQ-37 requires 5-12 plots at ranges less than 30km and a minimum of 15 plots at ranges greater than 30km.

5-44. Figure 5-5 summarizes the tracking process:

- Step 1. Object breaks the radar’s search fence.
- Step 2. Radar verifies that object has ballistic characteristics.
- Step 3. Radar tracks object along its predicted trajectory.
- Step 4. Computer extrapolates the point of origin and point of impact.

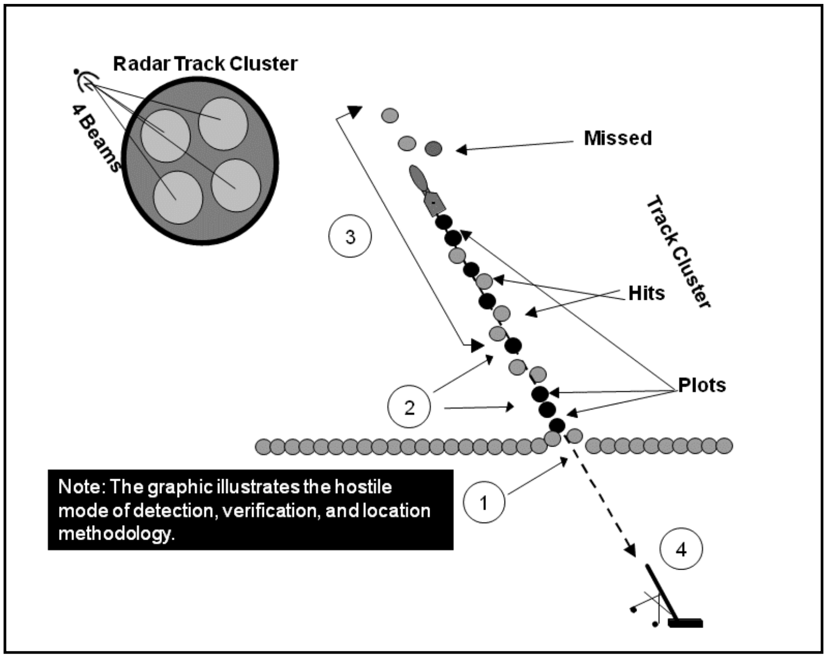

Figure 5-5. Hostile mode process example

AN/TPQ-36/37 VIDEO INTEGRATION

5-45. Video integration improves the radar's probability of detecting objects beyond 3km, but reduces the probability of detection short of 3km (see figure 5-6 through figure 5-9 on pages 5-12 and 5-13, accordingly). A radar beam looks at a spot for a given amount of time, and can consist of 1, 2, or 4 dwells. A dwell consists of 16 radar pulses, resulting in a target being illuminated up to 16 times in a single dwell. The AN/TPQ-36, with video integration on, uses the 2 or 4 dwell mode, rather than 1 dwell. The number of times a target can be illuminated increase to 32 or 64 with video integration off.

Note: Whether or not to use video integration needs to be decided during planning, targeting, threat assessment and in accordance with the priority intelligence requirements.

5-46. In noncontiguous or static position operations, if the radar is located in the middle of the static position and it is more than 3km to the edge of the static position perimeter, it could be beneficial to turn video integration "ON," depending on the nature of the threat.

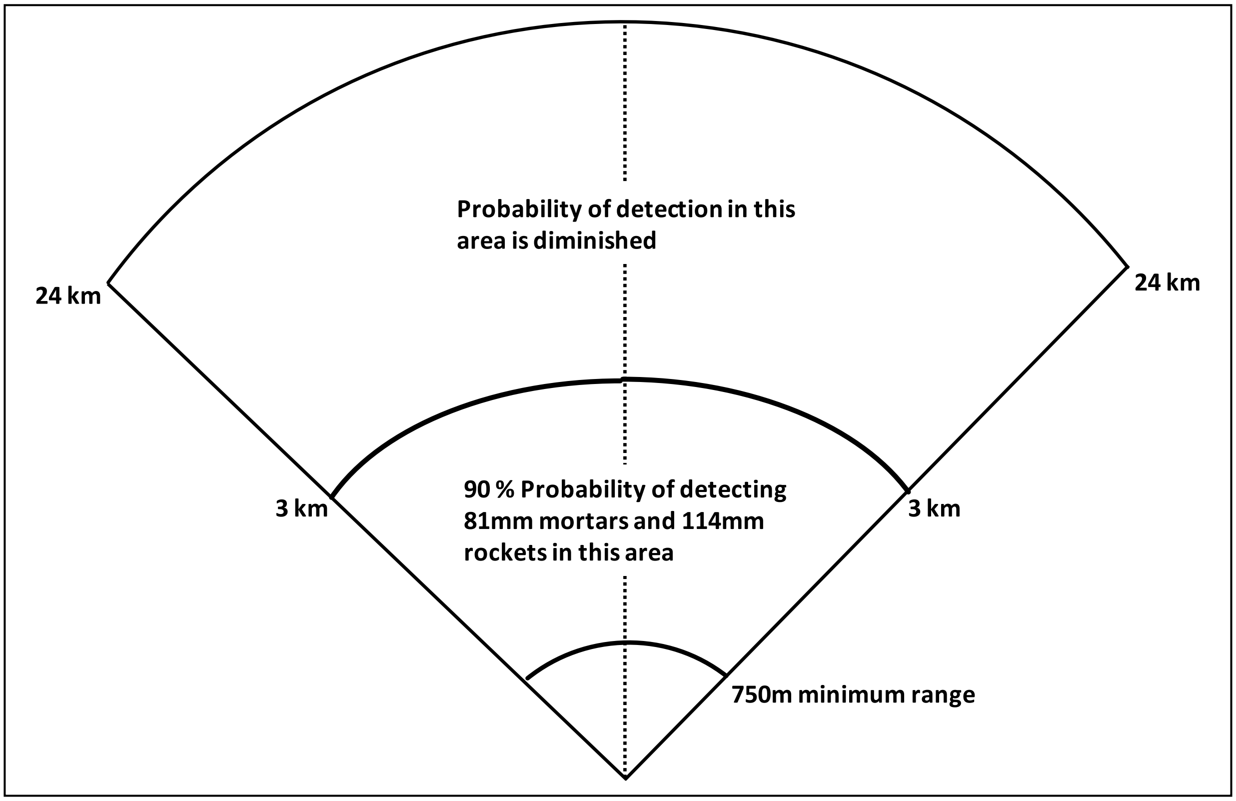

Figure 5-6. AN/TPQ-36 probability of detection, video integration "OFF"

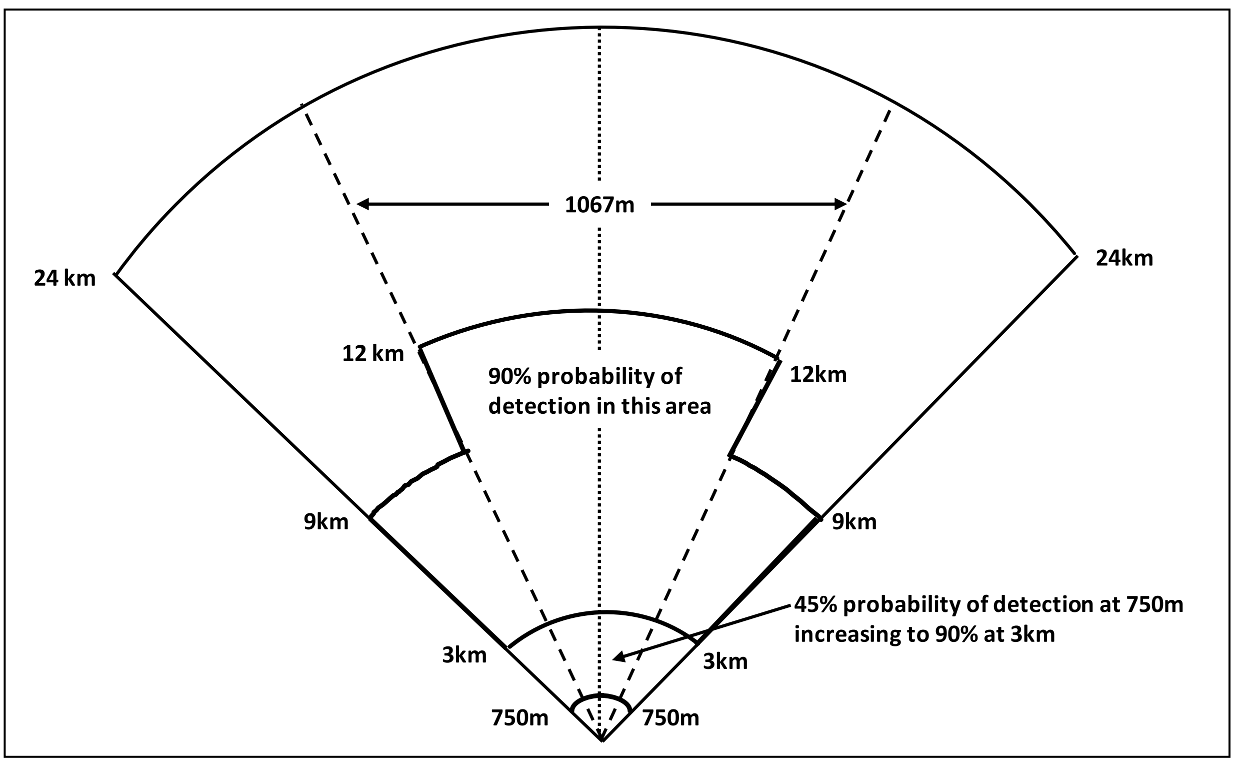

Figure 5-7. AN/TPQ-36 probability of detecting mortars, video integration "ON"

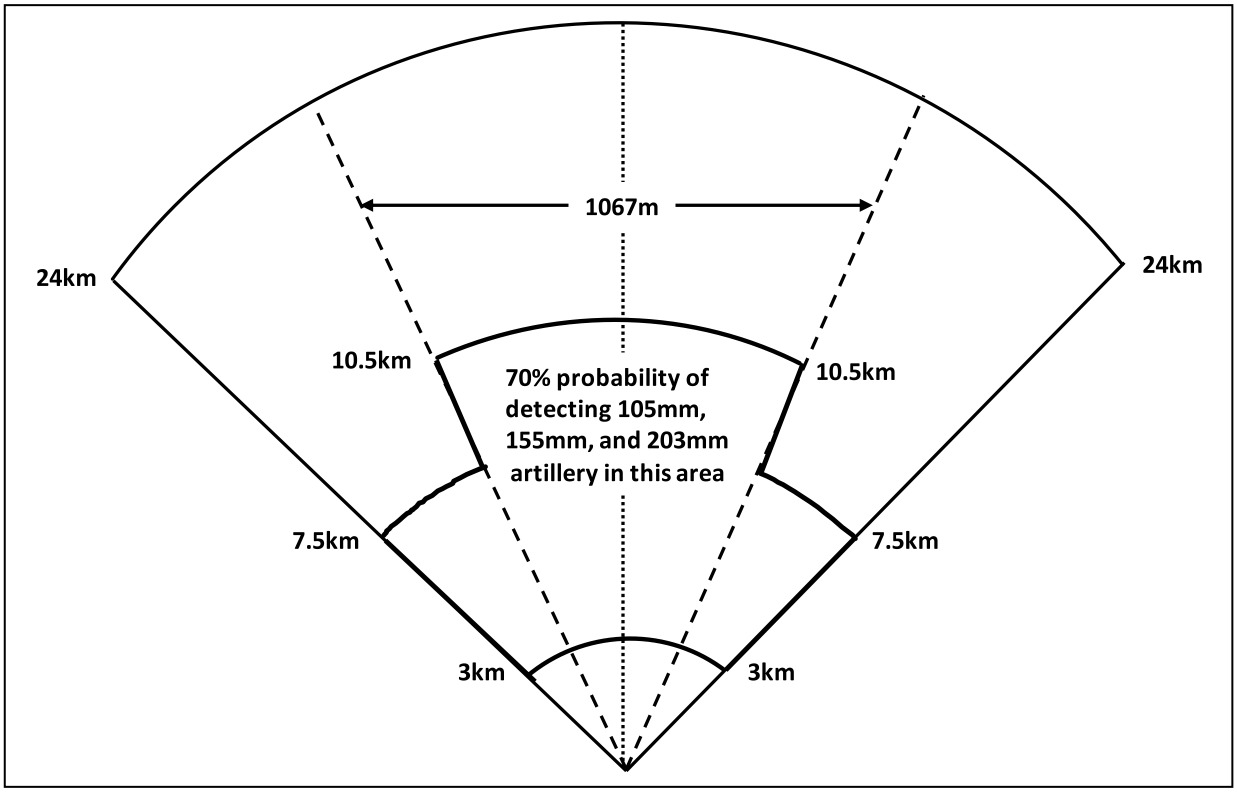

Figure 5-8. AN/TPQ-36 probability of detecting artillery, video integration "ON"

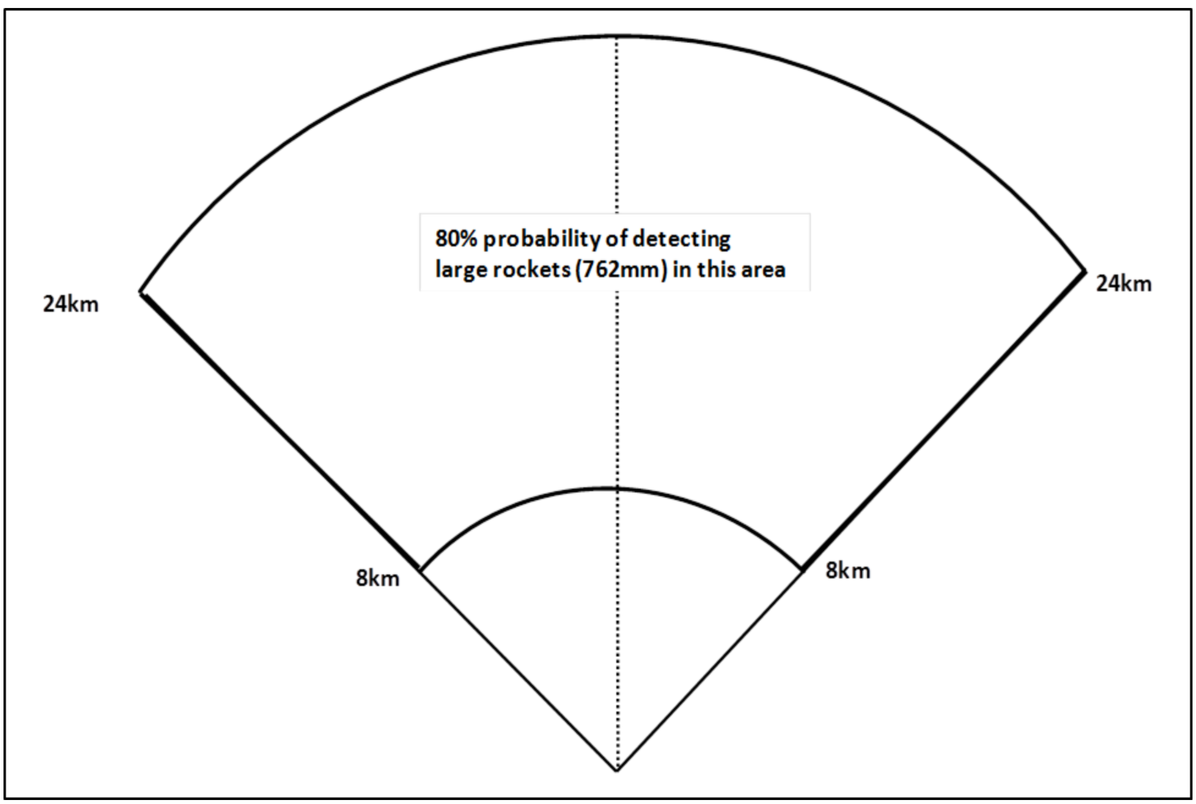

Figure 5-9. AN/TPQ-36 probability of detecting rockets, video integration "ON"

AN/TPQ-36/37 HOSTILE MODE

5-47. It is important to understand how these systems acquire and track projectiles in flight and extrapolate weapons location from this information. The AN/TPQ-36 and AN/TPQ-37 WLRs perform these basic steps to determine a point of origin:

- Establishes the search fence.
- Verifies penetration of the search fence.
- Validates the trajectory.
- Tracks the projectile.
- Extrapolates the firing location and determines the point of origin.

5-48. Several conditions must exist for the WLR to achieve a solution and provide a point of origin. First, the range to the projectile must be such that the radar beam strikes the object on the ascending branch of the trajectory. In hostile mode, the WLR will only detect objects on the ascending branch of their trajectory. The size and speed are critical when identifying an object in the hostile mode. Once the software identifies the object, it determines the trajectory of the object. The object must display a ballistic trajectory or the software rejects it. There must be sufficient time for the software to achieve a solution on a ballistic trajectory. The tracking times are as listed below by WLR:

- AN/TPQ-36: 3-5 seconds.
- AN/TPQ-37: 5-8 seconds.

5-49. The WLR can only determine locations from objects presenting characteristics within the technical capabilities of the software. The object must pass through the detection area of the search sector. It is important to understand the detection area in which the radar can detect an object.

TARGET CLASSIFICATION

5-50. The AN/TPQ-37 classifies acquisitions as three distinct target types: artillery, mortar, rocket or missile. The AN/TPQ-37 does not differentiate subtypes for these target types and defaults to unknown. The target classifications generated by the AN/TPQ-37 for transmission to AFATDS are mortar, artillery, and rocket unknowns. The algorithm used to locate mortars is a post-fielding software patch designed to provide an addition capability for operation needs. The mortar functionality has not been fully tested, so probability and accuracy data is not available. The acquisition ranges for mortars are the same as the ranges for artillery.

PROBABILITY OF LOCATION

5-51. The factors affecting the AN/TPQ-37's probability of location are the same as the AN/TPQ-36. In general, the AN/TPQ-37 can locate up to ten simultaneously firing weapons with QEs greater than 300 mils without degradation in probability of location. This is true when no more than two projectiles are being tracked or new firings do not occur at ranges less than 6km, or greater than three-quarters of the specified range for a specific projectile type. When both of these conditions occur, the probability of location may decrease to a probability of detection no lower than 50%. Wind and rain do not degrade the performance of the radar when the following conditions exist:

- Winds do not exceed 40 mph with gusts to 75 mph.
- Rain does not exceed 5 inches per hour with horizontal wind gusts of 40 mph.

5-52. The probability of locating a cannon projectile is 85% or greater at ranges from 4 -30km when weapon QEs are greater than 200 mils at ranges less than 10km and 300 mils at ranges greater than 10km. The ranges vary depending on the size of the projectile. The range fan for detecting light cannon is from 4-20km over the entire search sector. For medium cannon, the range fan is from 4-25km over the center 1067 mils of the search sector and 4-20km over the outside sector of the search sectors. The range fan for heavy cannon is from 4-30km over the center 1067 mils of the search sector and 4-22km over the outside search sectors. Figure 5-10 shows the higher probability coverage areas for cannons.

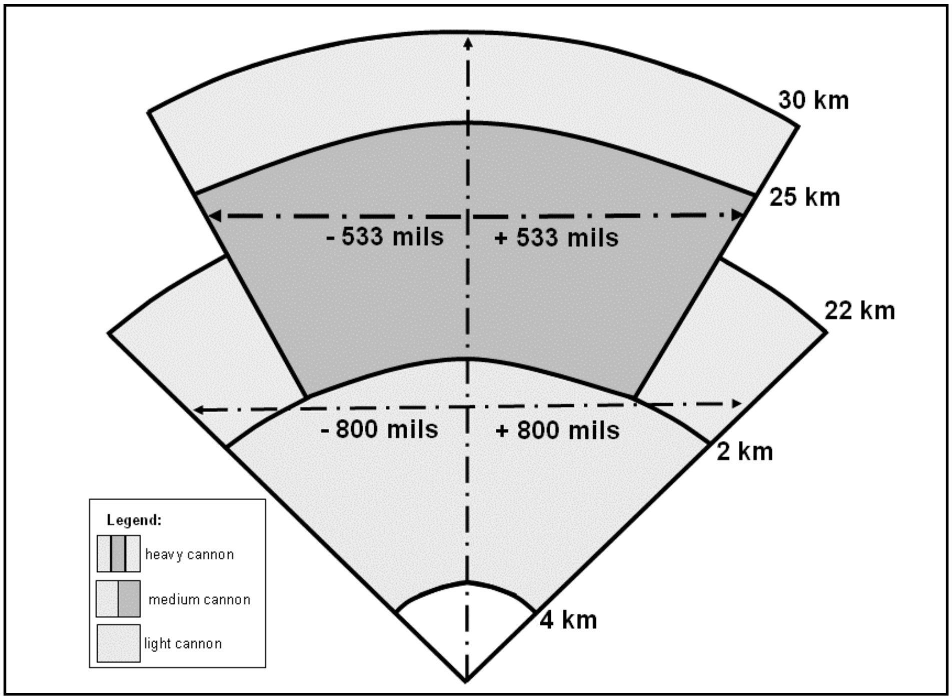

Figure 5-10. AN/TPQ-37 cannon artillery coverage areas

5-53. The probability of locating long-range rockets up to 762mm in diameter is at least 85% for QEs greater than 300 mils. The detection ranges are between 4-50km over the center 1067 mils of the search sector and 4-37km across the entire search sectors. Figure 5-11 depicts the coverage area for long-range rockets.

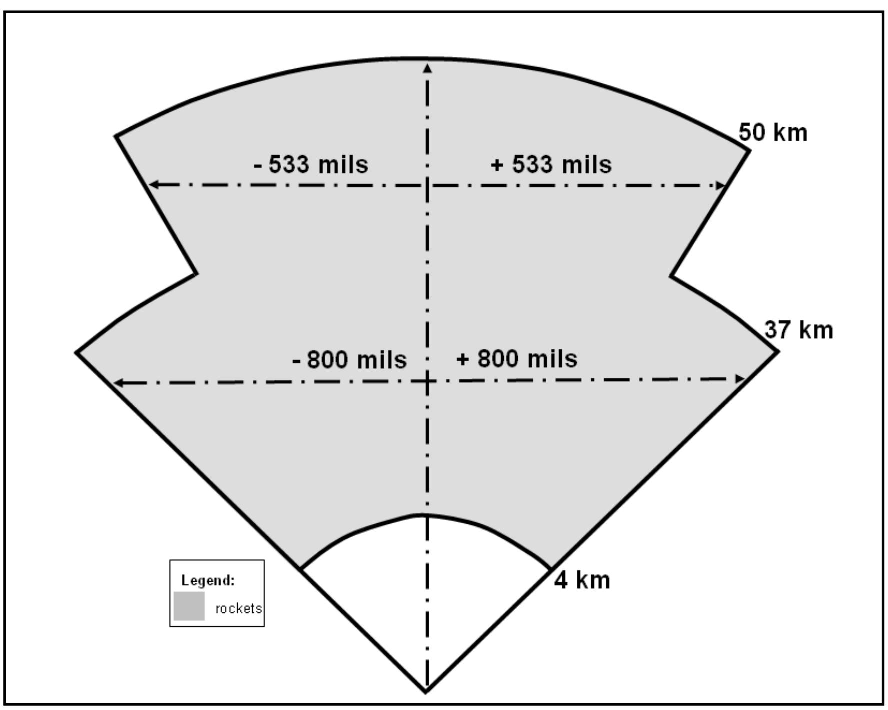

Figure 5-11. AN/TPQ-37 rocket coverage areas

ACCURACY

5-54. The accuracy and target location error have the same characteristics for both radars—

- The maximum 50% target location errors by projectile type are:
  - All cannon – 35m or .35% of range, whichever is greater.
  - Long-range rocket – 70m or .4% of range, whichever is greater.
- The maximum 90% target location errors by projectile type are:
  - All cannon – 90m or .9% of range, whichever is greater.
  - Long-range rocket – 175m or 1% of range, whichever is greater.

5-55. Table 5-2 (50%) and table 5-3 (90%) target location error data.

Table 5-2. AN/TPQ-36/37 maximum 50% target location error

Target Category	*4km*	*10km*	*20km*	*Ranges 22km*	*25km*	*30km*	*37km*	*50km*
Mortar	N/A	N/A	N/A	N/A	N/A	N/A		
Cannon	35m	35m	70m	77m	88m	105m		
Rocket	70m	70m	80m	88m	100m	120m	148m	200m
km – kilometer m – meter								

Table 5-3. AN/TPQ-36/37 maximum 90% target location error

Target Category	*4km*	*10km*	*20km*	*Ranges 22km*	*25km*	*30km*	*37km*	*50km*
Mortar	N/A	N/A	N/A	N/A	N/A	N/A		
Cannon	90m	90m	180m	198m	225m	270m		
Rocket	175m	175m	200m	220m	250m	300m	370m	500m
km – kilometer m – meter								

AN/TPQ-36/37 FRIENDLY MODE

5-56. The AN/TPQ-36 and AN/TPQ-37 systems require separate modes to conduct friendly fire. Hostile and friendly fire cannot be performed simultaneously with these systems.

5-57. The methodology used by the AN/TPQ-36/37 to search, verify, and track an impact or burst location in the friendly mode is the same as that for the hostile mode. The major differences are the size of the search fence, angle-T, and orientation of the detection area. In friendly fire mode, the WLR tracks projectiles as they travel away from the WLR. Therefore, the WLR detects and tracks the projectile on the descending leg of its trajectory. The detection area in the friendly mode is significantly smaller since the search sector must be narrowed to approximately 440 mils.

5-58. When operating in friendly fire mode, the WLR sets up a horizontal "window" through which the projectile must pass. The window is referred to as the friendly fire search fence. The narrowed search fence provides the best probability of detecting and tracking friendly rounds fired. The radar tracks projectiles until an airburst is detected, the selected datum plane altitude is intersected, or the radar has enough data to predict the point of impact.

5-59. In the optimum friendly fire radar-tracking situation for the AN/TPQ-36 and AN/TPQ-37, the angle (angle-T) made by the radar-orienting point (radar-target) line and the gun-orienting point (gun-target) line is from 800 to 1200 mils (see figure 5-12).

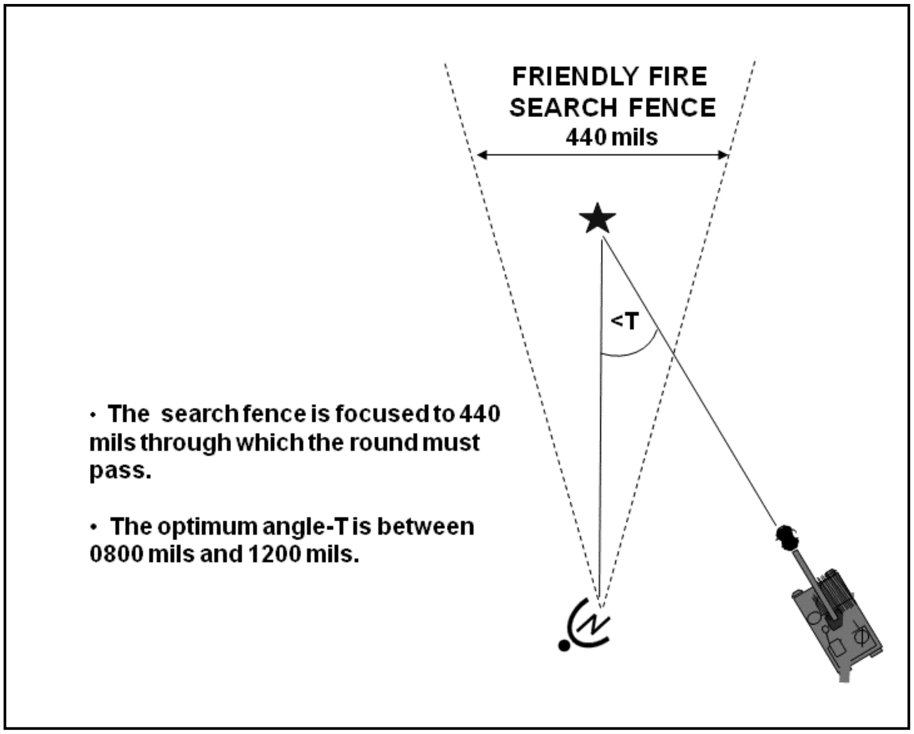

Figure 5-12. Angle-T

5-60. Orienting data required for the friendly fire buffer and the actual fire mission can be sent from the battery computer system by voice or digital transmission. The data entered into the computer will either accept the search fence or reject it by displaying an error message. The radar operator must then coordinate with the battery fire direction center for adjustments to the firing data or orienting point that will allow the radar to observe the rounds in the friendly fire mode. In friendly fire mode, the AN/TPQ-36 and AN/TPQ-37 radars can perform three types of missions:

- Observe a high-burst registration (artillery airburst mode).
- Predict impact locations (artillery impact-predict mode).
- Observe a datum-plane registration (artillery datum-plane mode).

5-61. These friendly fire mode missions support the two types of registrations conducted by the fire direction center. The radar high-burst registration provides “did hit” observations for the fire direction center high-burst registration. The radar impact-predict and datum-plane registrations provide “did hit” observations for the fire direction center mean-point-of-impact registration. The mean-point-of-impact calculations by the fire direction center differ for the two types of radar observation, because they correspond to different orienting points. All of these calculations are discussed in detail in FM 3-09.21.

5-62. When operating in friendly fire mode the radar provides friendly units with accurate actual burst, datum-plane, or predicted-impact location data. It has five mission sub-modes that are used to provide this data. The mission sub-modes are listed below:

- Mortar datum plane.
- Mortar impact prediction.
- Artillery airburst.
- Artillery datum plane.
- Artillery impact prediction.

5-63. The radar can also observe adjust fire missions. The observation functions performed by the radar to observe an adjust fire mission are the same as an impact predict registration.

HIGH-BURST REGISTRATION

5-64. For a high-burst registration, the high-burst altitude above the registration point is the actual orienting point for the radar. The high-burst altitude is located two probable errors in height above the registration point expressed up to the next 10m. The radar must be able to observe this point and begin tracking the trajectory of the round at least 350m before the burst. This ensures the radar can track the round to the burst point. If the radar cannot observe the orienting point, the radar operator will be notified by an error message.

5-65. The radar section chief must then coordinate with the firing unit to select a new high-burst altitude (or orienting point for the radar) that meets the technical tracking criteria of the radar. The radar operator passes the grid coordinates and altitude of each observed burst to the firing unit. The firing unit must then determine registration corrections as it would for a regular high-burst registration.

IMPACT-PREDICT REGISTRATION

5-66. In an impact-predict mission, the radar uses friendly fire mode to track the round on its descending trajectory toward the registration point and to predict where the round will impact without actually observing the ground burst. To provide data, the radar must track the round along its trajectory for a sufficient distance above the radar's screening crest. If the radar cannot track the round far enough along its trajectory, it will notify the operator that it has limited track coverage.

5-67. Coordination must then be made with the firing unit to end the mission or to continue it by selecting a new registration point. The predicted burst locations are reported to the fire direction center, which then averages them as "did hit" data and compares them to the fired "should hit" data of the registration point to obtain the mean point of impact registration corrections.

DATUM-PLANE REGISTRATION

5-68. The datum-plane registration is a lesser-used capability of radars. During a datum-plane registration, the fire direction center selects a registration point, for example, a grid intersection. The altitude for the datum-plane registration is the altitude of a selected horizontal datum plane above the registration point through which all rounds will pass. The radar must be able to observe the rounds in flight as they pass through this altitude. In calculating firing data, the fire direction center uses the altitude of the datum plane as the altitude of the registration point. If the radar cannot track along the trajectory for a sufficient distance to its datum-plane orienting point, the same error messages will be displayed to the operator as for a high-burst registration.

5-69. The firing unit must then adjust the altitude of the target. When the radar observes the registration rounds, the coordinates reported to fire direction center are those of each penetration or intersection point of the datum plane at the datum plane altitude rather than the predicted location of impact. The fire direction center corrects the "should hit" data by the altitude difference between the datum plane and the actual registration point. The fire direction center must then compute registration corrections in the same way it would to obtain "did hit" data for a mean point of impact registration. Detailed procedures for the conduct of all friendly fire missions, digital formats, and voice communications are outlined FM 3-09.21. Procedures for manually recording fire mission data are provided and outlined under the friendly fire log.

5-70. The computer either accepts or rejects all parameters entered as search fence data. See figure 5-13, friendly fire search fence parameters.

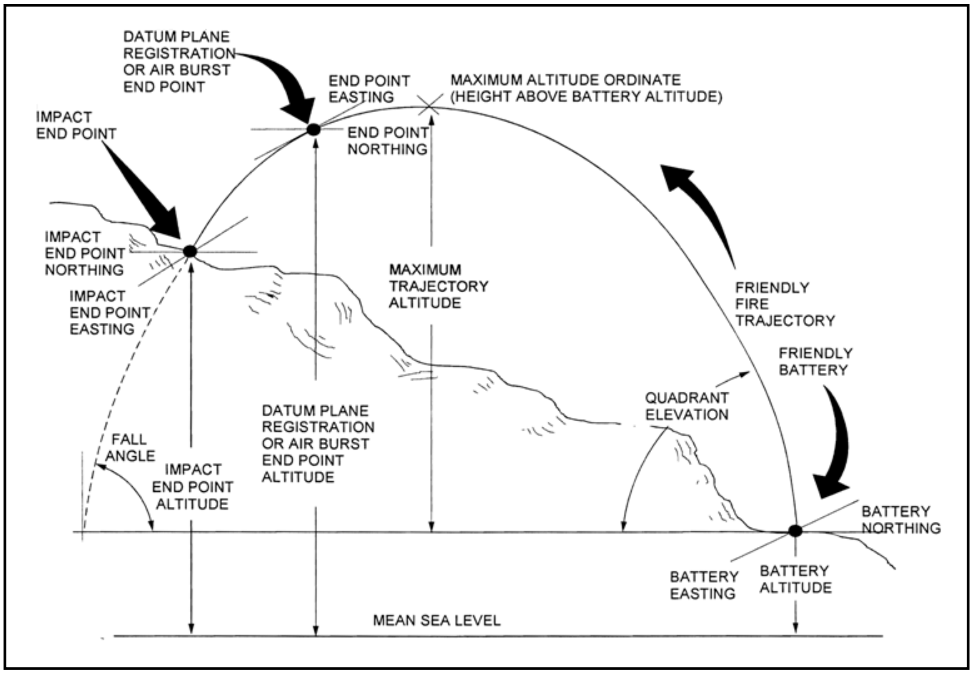

Figure 5-13. Friendly fire search fence

5-71. The AN/TPQ-36 and AN/TPQ-37 friendly fire mode logging procedures are described in Appendix B.

OPERATING THROUGH ELECTRONIC COUNTERMEASURES

5-72. Operating through electronic countermeasures consists of detecting the presence of jamming or interference and performing actions to minimize or eliminate the effects of jamming.

AN/TPQ-36

5-73. The WLR indicates jamming by displaying a vertical line at the jamming azimuth on the operational display, printing a jam strobe message, the interference/jamming indicator being lit on the operations screen, or for some types of jamming, displaying many short duration tracks on the monitor. To avoid degradation of WLR performance the following tactics may be used:

- Turn on the WLR's electronic counter countermeasures feature.
- Avoid operation within line of sight or in the same sector as the jammer.
- Operate on a different frequency than the jammer.
- Use deception.

5-74. Turning on the WLR's electronic counter countermeasures function allows the operator to activate the jam strobe and pulsed interference rejection functions. The jam strobe identifies jamming and identifies the azimuth of the jamming while pulsed interference rejection helps filter out interference from the jammer. If pulsed interference rejection does not work, the other tactics can be implemented. Line of sight issues can be avoided by selecting optimal WLR sights. Relocating the WLR to avoid jamming may or may not be possible based on the tactical situation. Changing WLR frequencies will sometimes help avoid the jammer's operating frequency. Increment frequencies one at a time and determine from the jam strobe indicator if the jammer is still present. Increase the frequency, starting at the lowest frequency, the least amount necessary to avoid degrading the WLR's performance. If these steps do not work, it may be possible to fool the jammer by ceasing to radiate for a few minutes.

AN/TPQ-37

5-75. The tactics for working through electronic counter countermeasures for the AN/TPQ-36 are applicable to the AN/TPQ-37. Further, the AN/TPQ-37's jam strobe and pulsed interference rejection functions are similar to the AN/TPQ-36. In addition, the AN/TPQ-37 has a clear channel sensing function. Clear channel sensing is automatically turned on when the WLR's operational program is entered. Clear channel sensing passively scans the WLR's 49 search beam positions using all 15 frequencies of each beam position and determines which frequencies are free of jamming or interference. A frequency report is provided to the operator. During operations, the clear channel sensing function disables frequencies and provides operator alerts based on the WLR frequency mode in use. Listed below are the three frequency modes:

- Single frequency.
- Diversity (the normal operating mode).
- Electronic countermeasures avoidance.

5-76. In single frequency mode, the WLR operates on a single frequency for all beams. If jamming is detected on the frequency, clear channel sensing activates the degraded performance warning light indicating the WLR is operating in a degraded mode. In diversity mode, a different frequency is used for each beam position. Up to five frequencies can be selected by the operator for each beam position. When operating in diversity mode, clear channel sensing disables individual frequencies within beam positions to avoid jamming. When only one frequency remains and it is not clear, clear channel sensing activates the degraded performance warning light. Finally, the WLR can be operated in the electronic countermeasures avoidance frequency mode. This mode is used to combat electronic countermeasures when these measures are seriously degrading the WLR's performance. It should only be used under this condition because electronic countermeasures avoidance mode degrades the WLRs performance. In this mode, WLR frequencies and beam positions are selected at random.

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Chapter 6

AN/TPQ-53 Weapon Locating Radar System Characteristics and Employment

This chapter discusses characteristics and employment techniques for the AN/TPQ-53 WLRs. The WLRs are designed to enhance the detection, verification, and location methodology.

The AN/TPQ-53 is a highly mobile fire finding/fire support radar system. The AN/TPQ-53 is capable of locating hostile mortar, artillery, and rocket fire in a clutter environment, and provides friendly artillery registration and adjustment. The system was designed to supply 90 degree coverage against all threats at industry-leading ranges and accuracies, 360 degree azimuth coverage against mortars at ranges up to 15km and against artillery and rockets at ranges up to 20km, battlefield tested man machine interfaces, ease of programmability, and built-in capacity for future growth. The principle functions of the system are to detect, track, classify, and accurately determine the point of origin and point of impact of enemy indirect fires. The AN/TPQ-53 provides the Soldier continuous and responsive counter-battery target acquisition for all types and phases of military operations. The AN/TPQ-53 is designed to meet ongoing mission requirements and provide a solution that can meet full operational capability in a single C-130 cargo aircraft sortie.

SECTION I – CHARACTERISTICS AND EMPLOYMENT

6-1. The AN/TPQ-53 can be operated in either mission essential configuration or sustained operations configuration. Figure 6-1 depicts the AN/TPQ-53 in its mission essential configuration; consisting of the AN/TPY-3 target acquisition subsystem, which contains the following sub-systems:

- Prime mover.
- Antenna Transceiver Group (ATG).
- Prime power group.
- Communications group (digital and voice).
- Remote control and display unit.

6-2. The sustained operations configuration of the AN/TPQ-53 consists of the AN/VPC-95, which includes the prime mover and the operations control shelter (OCS). The AN/VPC-95 incorporates a cockpit like control center for the crew to conduct operations. The OCS may be powered from an external source, or from an on-board 10kW generator, which eliminates external power connections. Use of the generator frees the crew from heavy power cable deployment and allows separation from the ATG at distances up to 1km, enhancing Soldier survivability. The AN/TPQ-53 can also use commercial power and can automatically or manually switch between tactical and commercial power or between primary and backup tactical power without system interruption

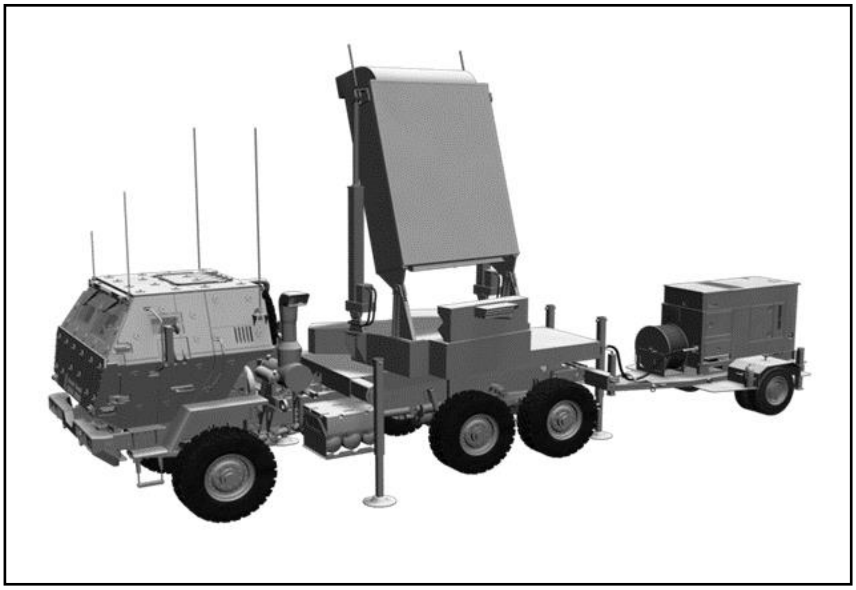

Figure 6-1. Mission essential configuration

6-3. In its sustained operations configuration, the system combines an AN/TPY-3 with the additional capabilities of the AN/VPC-95 Communication Subsystem (see figure 6-2).

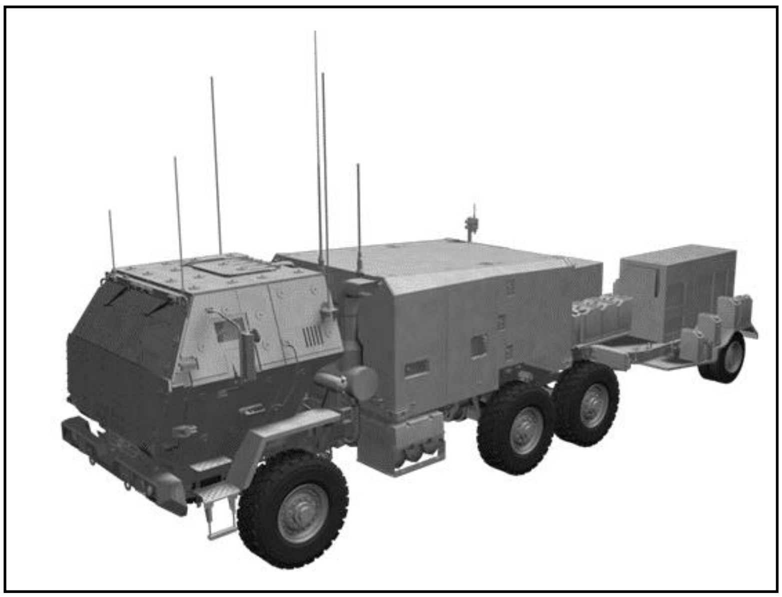

Figure 6-2. Sustained operations configuration

REMOTE OPERATIONS

6-4. Operators can remotely operate the AN/TPQ-53 using wireless and fiber optic connectivity to a distance of 1000m. Figure 6-3 displays each remote configuration.

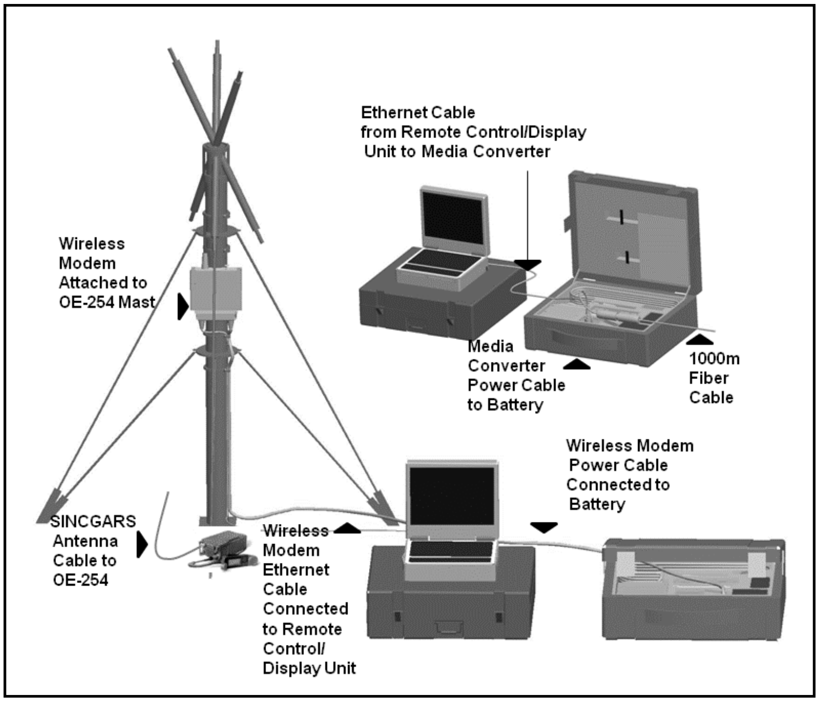

Figure 6-3. Remote operations configuration

SITE REQUIREMENTS

6-5. The choice of a site for the radar set is dictated primarily by the tactical situation, the area to be observed, and the terrain restrictions. Generally, the site selected should have adequate drainage and have a ground slope of less than or equal to 5 degrees.

6-6. There are no restrictions on the location of the shelter except that it must be within 1000m (3281 ft) of the Mission Essential Group (MEG) because of the length of the OCS-to-ATG cables or wireless capabilities. The OCS can be entrenched, sandbagged, or located among trees. The OCS should be located in a protected area and never in the line-of-sight of the antenna.

6-7. Generally, the following should be considered when selecting a site for the MEG:

- The slope of the ground (must be ≤ 5 degrees) with the prime mover positioned facing down slope.
- The ground should be of adequate strength and consistency.
- The area in front of the antenna.
- The terrain mask angle.
- The height and density of foliage or trees relative to the antenna.
- Other radar sets operating in the area.

6-8. The slope of the ground should be such that the prime mover and the antenna transceiver group can be leveled. The bubble level located on the prime mover dashboard must indicate that the truck is on ground that falls within the capabilities of the leveling system. The area in front of the antenna should be clear of nearby clutter that will weaken (attenuate) the radar beam. Solid objects and heavy foliage should not extend above the bottom of the antenna within 300m (984 ft) of the antenna. The bottom of the antenna is a line at the bottom on the antenna that is at right angles to the antenna face and parallel to antenna broadside. The slope of the ground should be such to minimize possible multipath errors. Multipath errors are caused mainly by ground reflections. To minimize multipath errors, the terrain should not exceed 2-3m (7-10 ft) in height from the terrain height at the antenna for a distance of 200-250m (656-820 ft).

6-9. The system should be emplaced on man-made or natural ground which provides adequate strength for stability. Such man-made surfaces include, but are not limited to: concrete, asphalt, dirt roads, and gravel pads. Acceptable natural ground conditions should be of consistency and moisture content that does not allow the soil to noticeably flow under the sand pads during emplacement. The ground should be as free of organic content for example logs, branches, peat as possible, as this can lead to settling. Care should also be taken to prevent washout conditions from eroding soil from beneath emplaced sand pads.

6-10. The angle from the antenna to the top of the nearest obstruction, above which the radar set provides search coverage is the terrain mask angle. Two conflicting requirements influence mask angle: enemy radar jamming and direction finders; and detection of enemy projectiles. To be effective, radar jamming and direction finders generally require a line-of-sight to the antenna of the radar.

6-11. A high mask angle is useful against ground-based jamming and direction finders because the jamming must be located at a point above the mask angle. As the jammer or direction finder is forced up in height, the number of suitable sites is generally reduced. Also, because the radar set detects projectiles to determine the weapon location, the radar set does not require a line-of-sight to the weapon emplacements. Therefore, a mask angle that masks off the line-of-sight to the weapons location reduces the effectiveness of enemy jamming and direction finding located in the vicinity of the weapons.

6-12. Enemy weapon locations generally tend to require lower radar mask angles. Maximum allowable mask angles decrease with increasing weapon location range, lower weapon location elevations, and lower weapon velocity. However, the radar set does not require a line-of-sight to the weapon location. The radar set must track the enemy projectile for a sufficient elevation arc before the projectile reaches the highest points of its trajectory (apogee). Considering the requirements for effectiveness against jamming, while maintaining adequate detection capability of projectiles, a lower mask angle (dependent upon the QE and velocity of the rounds fired) will provide the specified performance when the radar and the weapons are at the same altitude.

6-13. Another factor which influences site selection is the height and density of foliage or trees relative to the radar antenna and the area of interest. Radar signals may be weakened (attenuated) by more than 1 decibel per meter of heavy foliage. Therefore, foliage more than a few meters deep can severely reduce or inhibit the radar effectiveness. The radar effectiveness is evident when the operator looks at the area of interest with the clutter map function enabled and raw video displayed. If the remote control display unit shows a lot of white area, then the radar beams are being blocked by the foliage (screening crest) in front of the radar. For this reason, it is important to place the trailer well back from trees in the direction of radar search, if operation in a forest environment is required. The angle to the top of the nearest tree is the mask angle, ideally about 10 mils.

6-14. The site can be camouflaged, but the camouflage must provide clearance for 360-degree antenna rotation. The camouflage must be of a radar transparent type.

6-15. If other radar sets are operating in the area, consideration for radar site location should be taken into account in order to minimize the common illumination volume between radar sets.

6-16. When a site location has been selected, the site grid coordinates and a boresight reference have to be established and marked to properly orient the radar during occupation. A fifth-order survey is required to determine the site grid coordinates. This survey is performed by a survey team prior to the arrival of the radar set and will not be done by the installation team. When the position has been determined, it is marked by the primary stake (near stake). A near stake is not required if utilizing Inertial Navigation Unit or a Global Positioning System.

6-17. For the boresight reference, a second stake (far stake) is preferably located more than 250m away in any convenient direction from the primary stake. A far stake is not required if utilizing inertial navigation unit or a global positioning system.

6-18. The minimum acceptable distance is 100m. The azimuth angle (AZ Ø) formed by the intersection of the line between the two stakes and grid north is then measured by the survey team. The measured azimuth, along with the site grid coordinates, is recorded for subsequent use during initialization of the weapons location program.

TACTICAL CONSIDERATIONS

6-19. The tactical position areas are selected based on IPB, the range capabilities of the WLR, and METT-TC. A complete analysis of METT-TC will dictate which factors are most important. Generally, in a traditional area of operations, WLRs are positioned far enough from the FLOT to acquire enemy weapons and to prevent loss of personnel and equipment to enemy action. Avoiding unnecessary moves supports maximizing coverage and cueing time.

6-20. The AN/TPQ-53 is usually located 3-6km behind the FLOT, but the system was designed to provide capability from .5-60km with the flexibility to optimize coverage with a variety of operational modes and sub-modes.

6-21. Q-53's are not intended to work independently, but as a system of systems providing a tactical capability to the force. This redundant capability allows for one system to provide coverage while organic systems move, conduct maintenance or repair activities.

6-22. Positioning may change based on the tactical situation.

PROXIMITY OF OTHER RADARS

6-23. Other WLR systems or active emitters can interfere with WLR coverage by attenuating or jamming the WLR beam. WLRs and emitters close in proximity or azimuth of search may cause jamming or false locations. Inadvertent jamming and false locations can be avoided by careful planning of WLR positions.

6-24. The following positioning guidelines are provided to ensure non-degraded performance of the AN/TPQ-53 radar systems when co-located:

- Two AN/TPQ-53 arrays operating in one of the 90 degree modes must be separated by 5km and facing in the same general direction with a maximum angle of 889 mils (50°) formed by the intersection of the boresight axes of the 2 arrays. Each will electronically scan up to 800 mils (45°) from their respective mechanical azimuth of search. Figure 6-4 shows the geometric orientation of the two collocated systems. The systems should be operating on separate frequencies [25 megahertz (MHz) separation] and the transmitting and receiving systems will be asynchronously operating.

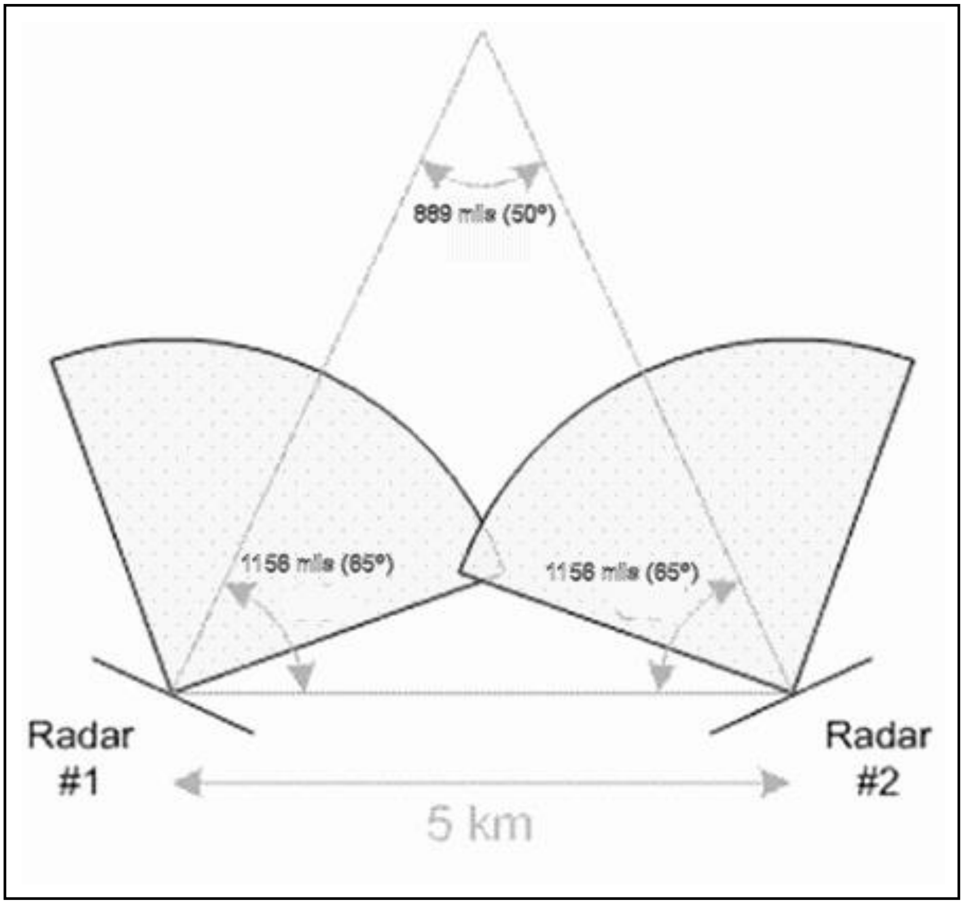

Figure 6-4. Collocated systems - 90 degree mode

- Two AN/TPQ-53 arrays operating in one of the 360 degree modes must be separated by 20km. Both systems will be rotating at 30 revolutions per minute asynchronously and will eventually electronically scan towards each simultaneously. The systems should be operating on different frequencies (25 MHz separation) and both systems have an active sector of 6222 mils (350°) with at least a 178 mil (10°) inactive region being centered on the azimuth angle towards the other AN/TPQ-53 system. This coordinated azimuth sector control assures that neither system forms transmit or receive beams within ±89 mils (5°) in azimuth of the other system. Figure 6-5 shows the geometric orientation of the two collocated systems in 360 degree mode.

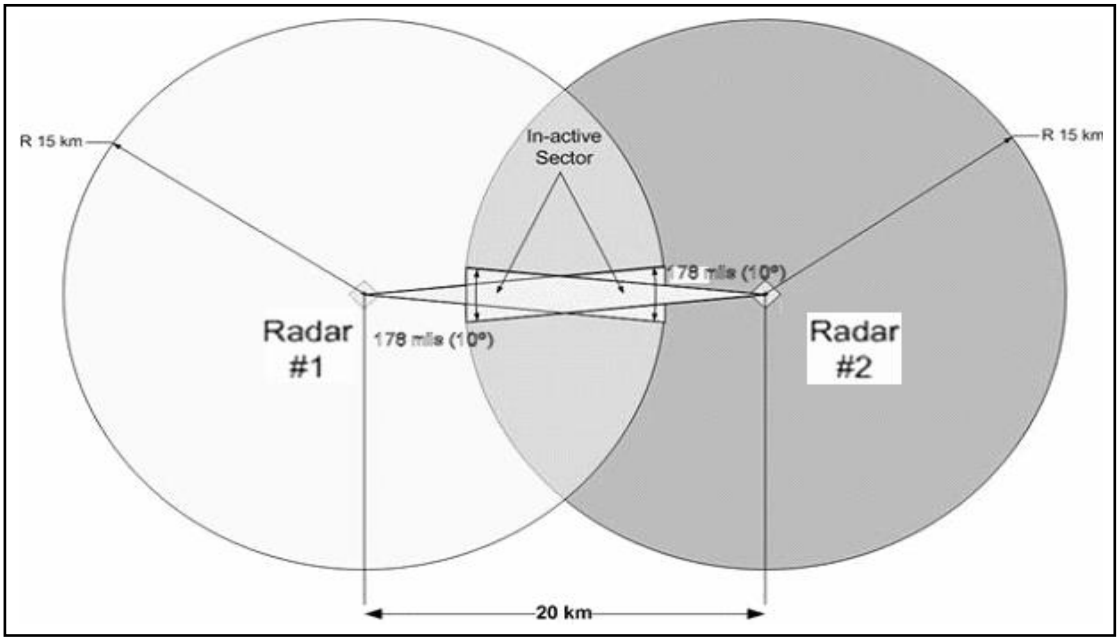

Figure 6-5. Collocated systems - 360 degree mode

- When one AN/TPQ-53 radar is operating in a 360 degree mode and a second AN/TPQ-53 radar is operating in a 90 degree mode, the systems must be separated by 20km. The systems should be operating on different frequencies (at least 25 MHz separation, more is better). The system in 360 degree mode should have an active sector of at most 6222 mils (350°) with at least a 178 mils (10°) inactive region being centered on the azimuth angle towards the other AN/TPQ-53 system. The system in 90 degree mode should be oriented such that the other AN/TPQ-53 radar in 360 degree mode is at least 5 degrees outside of the operating sector. This coordinated azimuth sector control ensures that neither system forms transmit or receive beams within ±89 mils (5°) in azimuth of the other system. Collocated Systems - 360 degree mode, above, shows the geometric orientation of the two co-located systems in 360 deg mode.

SITE ACCESS

6-25. The WLR site should have more than one route of approach. Routes of approach should be accessible by section vehicles, free from enemy observation, and capable of being guarded by a minimum number of personnel. The quality of access must also be considered. Some essential considerations include:

- *Accessibility during poor weather conditions*. Can the position be accessed during periods of rain and snow? Positions that may deteriorate during inclement weather should be avoided to prevent stranding the WLR.
- *Overhead clearance.* Avoid locations where trees, power or telephone lines may damage WLR components when entering and exiting the position. Check the clearance requirements for tunnels and overpasses to ensure section equipment does not exceed requirements.
- *Bridges.* Check the bridge classifications on routes to WLR positions. Ensure that the bridge classification of section equipment does not exceed the load bearing capabilities of the bridge.
- *Fords.* Check fords to ensure they are passable to the WLR section equipment. If heavy rains are expected some positions may become untenable because of fording restrictions.
- *Obstacles.* Check routes for current and planned obstacles. These obstacles may include road craters, tank ditches, abates, or wire obstacles. Also, check for natural obstacles such as fallen trees and rockslides. Ensure that the access is sufficient to allow egress after combat has occurred. Rubble from buildings, utilities, and fallen trees should not prevent the WLR section from displacing from a position.

SAFETY CONSIDERATIONS

6-26. Safety is an important consideration when operating and working around the WLR. Possible safety concerns include radiation, wind, noise, and electrical hazards.

WIND

6-27. Because of the large surface area of the AN/TPQ-53 antenna, high wind velocity can cause serious safety hazards. Camouflage nets also should be lowered or removed to prevent damage to equipment or injury to personnel.

6-28. For standard (un-armored) cab AN/TPQ-53 Systems:

6-29. Whenever wind velocity reaches a constant 55 mph (48 knots) or gusts up to 78 mph (68 knots) during operations, the antenna must be placed in the stowed position. When non-operational, the radar must be stowed when winds reach 60 mph (52 knots) with gusts to 85 mph (74 knots).

6-30. For armored Cab AN/TPQ-53 Systems:

6-31. Whenever wind velocity reaches a constant 76 mph (66 knots) or gusts up to 90 mph (78 knots) during operations, the antenna must be placed in the stowed position. When non-operational, the radar must be stowed when winds reach 85 mph (74 knots) with gusts to 100 mph (87 knots).

SECTION II – DETECTION, VERIFICATION, AND LOCATION METHODOLOGY

6-32. The AN/TPQ-53 Counterfire Target Acquisition Radar is a mobile, radar set that automatically locates single or multiple hostile mortar, artillery, and rocket launched weapons. The AN/TPQ-53 can detect, classify, track, and determine the location of enemy indirect fire such as mortars, artillery, and rockets. It provides a net ready system with increased range and accuracy throughout a 1600 mil search sector as well as 6400 mils coverage for locating mortar, artillery, and rocket firing positions. The AN/TPQ-53 systems use a track-while scan approach. Track-while scan uses a fixed timeline of search beams, which revisits every point within the radar coverage rapidly enough to establish and maintain a track on any target that enters the radar coverage without the need for any dedicated verify beams. A variation of track-while scan, called enhanced track-while scan foregoes the use of verify beams in the same manner as pure track-while scan, but allows the use of dedicated track beams on established targets while enabling a reduction in the overall track-while scan search volume (elevation). Enhanced track- while scan is the most efficient in terms of radar timeline used per number of targets, especially in a typical mission that sees weapons fired upward from the ground through a search fence. The AN/TPQ-53 uses either enhanced track-while scan or track-while scan for its search strategy, depending on mode. This extremely efficient use of radar resources increases the overall range coverage of the radar.

6-33. AN/TPQ-53 must collect information in its search fence before it begins to track. There are no verification beams for this radar in the 90 degree modes. A track is formed through revisits in the search fence. When a track appears to be a target of interest, the AN/TPQ-53 dynamically schedules periodic beams dedicated to tracking that specific target. In the 360 degree mode the AN/TPQ-53 is a “track while scan” radar, there are no dedicated track beams, but the extensive elevation coverage of the 360 degree search fence facilitates the location of mortars to 15km and artillery and rockets to 20km. A track can start at any height in the coverage.

6-34. Figure 6-6 depicts how the AN/TPQ-53 6400 mil azimuth coverage is achieved. Beams are steered electronically forward and backward of the center beam by 30º as shown, while the array is mechanically rotating at 30 revolutions per minute. This method illuminates the targets three times per scan. The system operates in a track-while-scan mode with a fixed radar timeline which allows for the volume search every scan.

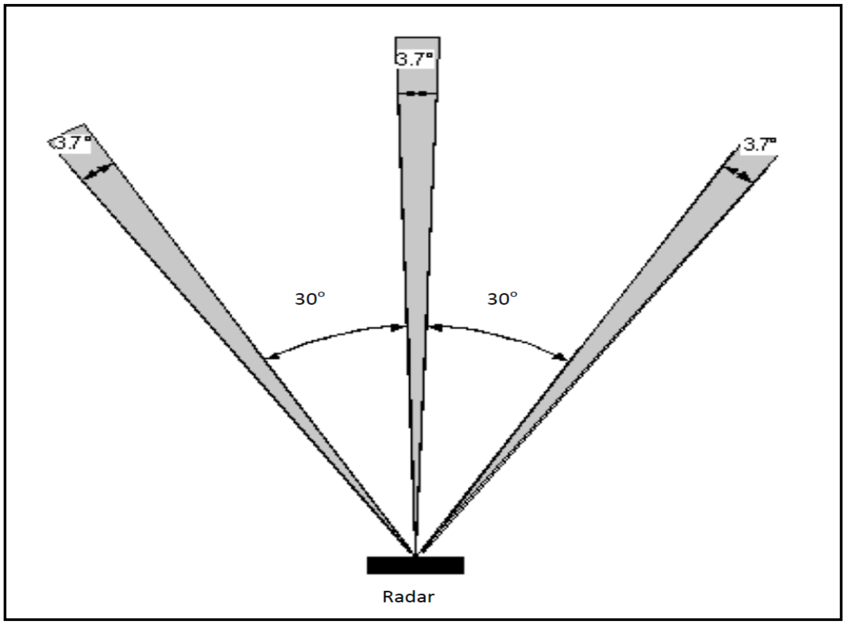

Figure 6-6. Azimuth coverage of the AN/TPQ-53 in 6400 mil mode

AN/TPQ-53 Detection Area

6-35. The possible detection area is a three dimensional space defined by the minimum and maximum range, search sector, and the vertical scan of the WLR. Planning ranges are used for the purposes of this discussion; however, the maximum planning range for the WLR is not an absolute. It is the range at which the probability of detection becomes low enough to be unsuitable for planning purposes. Nonetheless, objects may be detected beyond the maximum planning range. Conversely, objects within the planning ranges may not be detected. Listed below are the designed to planning ranges for the various operational modes of the AN/TPQ-53:

- 90 Degree Normal – 0.5 to 20km for mortars, 0.5 to 34km for artillery, and 0.5 to 50km for rockets
- 90 degree short range optimized mode – 0.5 to 20km for mortars, 0.5 to 25km for artillery, and 0.5 to 25km for rockets
- 90 Degree Long Range Optimized Mode – 0.5 to 20km for mortars, 0.5 to 34km for artillery, and 0.5 to 60km for rockets
- 90 Degree 107 millimeter (mm) Rocket – 25 to 34km for artillery, and 25 to 50km for rockets
- 360 Degree Normal – 3 to 15km for mortars, 5 to 25km for artillery, and 5 to 20km for rockets
- 360 Degree Weather – 3 to 15km for mortars, 5 to 25km for artillery, and 5 to 20km for rockets

Q-53 Search Sector and Ranges

6-36. The search sector for the AN/TPQ-53 is the azimuth coverage of the radar's search sector or sectors and the frequencies used. Each defined sector specifies the azimuth center, azimuth left and right boundaries, and the minimum and maximum range of the search area. It is possible to define up to 27 sectors in a full circle with a minimum value of 237 mils (13°) each, to total no more than 6400 mils.

6-37. The following table 6-1 describes the intended AN/TPQ-53 search sectors and associated range limits for each mode:

Table 6-1. AN/TPQ-53 search sector limits

Operating Mode	***Right/Left Sector Edges***	***Min/Max Range***
90 degree – normal	+/- 800 mils (+/- 45 degrees)	500m to 50km
90 degree – short range optimized mode	+/- 800 mils (+/- 45 degrees)	500m to 25km
90 degree - Long Range Optimized Mode	+/- 800 mils (+/- 45 degrees)	500m to 60km
90 Degree – 107mm Rocket	+/- 533 mils (+/- 30 degrees)	25km to 50km
360 Degree – Normal	0 to 6400 mils	3km to 20km
360 Degree – Weather	0 to 6400 mils	3km to 20km

MODE SELECTION CONSIDERATIONS

6-38. The AN/TPQ-53 is a versatile system that gives the commander multiple options using either 90 degree or 360 degree mode. Target acquisition planners use the mission variables of METT-TC, commander's guidance, and future operations to determine which mode to employ. The following is a list of possible considerations:

- The range of enemy indirect systems. If > 20km use direct azimuth mode.
- To reduce the number of moves in the offense use direct azimuth mode to maximize range.
- When there is not enough separation between two AN/TPQ-53 radars use direct azimuth mode.
- When IPB identifies templated location of enemy indirect fire systems use direct azimuth mode.
- When a more accurate TLE for the POO is required use direct azimuth mode.
- When the enemy electronic intelligence threat is high use direct azimuth mode.
- When IPB does not identify likely enemy indirect fire locations use 360 degree mode.
- When the enemy indirect fire systems range is <20km consider using 360 degree mode.
- To provide radar coverage over a large static location use 360 degree mode.
- Depending on the shape and size of the area of operations 360 degree maybe the optimal mode to maximize the coverage area.

AN/TPQ-53 VERTICAL SCAN

6-39. The maximum steerable elevation angle of the AN/TPQ-53 using 90 degree mode is 587 mils (33 degrees). In 360 degree normal mode, the AN/TPQ-53 has a fixed 373 mils (21 degrees) of elevation coverage. Figure 6-7 depicts how the AN/TPQ-53 elevation coverage is achieved in 6400 mil mode. One single three degree beam and three additional six degree beams cover from 1.5 degrees to 22.5 degrees above the horizon. A projectile could enter anywhere within the volume area and the radar system will identify and classify it.

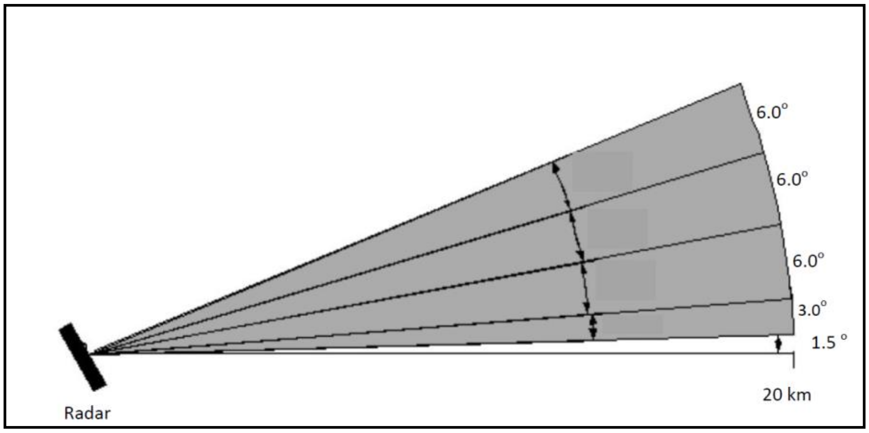

Figure 6-7. Elevation coverage of the AN/TPQ-53 in 6400 mil mode

Range and Accuracy Coverage Hostile Mode

6-40. The AN/TPQ-53 was designed to provide weapon locations at the ranges and accuracies specified in table 6-2 throughout a 1600 mil search sector.

Table 6-2. AN/TPQ-53 1600 mils coverage range and location accuracies

Weapon Type	***Range***	***Accuracy** (Circular Error Probable 50)*
Mortar light (60mm)	*0.5 to 15km*	30m *or .3% of range*
Mortar medium (81mm)	0.5 to 18km	30m or .3% of range
Mortar heavy (120mm)	0.5 to 20km	30m or .3% of range
Cannon light (105mm)	3 to 30km	30m or .3% of range
Cannon medium (155mm)	3 to 32km	30m or .3% of range
Cannon heavy (8 in)	3 to 34km	30m or .3% of range
Rocket light (80mm)	5 to 15km	30m or .3% of range
Rocket light (107mm)	8 to 50km	30m or .3% of range
Rocket medium (122mm)	8 to 50km	30m or .3% of range
Rocket heavy (240mm)	15 to 60km	30m or .3% of range

6-41. The AN/TPQ-53 was designed to provide weapon locations at the ranges and accuracies specified in table 6-3 throughout a 6400 mil search sector.

Table 6-3. AN/TPQ-53 6400 mils coverage range and location accuracies

Weapon Type	***Range***	***Accuracy (Circular Error Probable 50)***
Mortar light (60mm)	3 to 10km	50m or .5% of range
Mortar medium (81mm)	3 to 12km	50m or .5% of range
Mortar heavy (120mm)	3 to 15km	50m or .5% of range
Cannon light (105mm)	5 to 18km	75m or 1% of range
Cannon medium (155mm)	5 to 20km	75m or 1% of range
Cannon heavy (8 in)	5 to 20km	75m or 1% of range
Rocket light (107mm)	5 to 20km	75m or 1% of range
Rocket medium (122mm)	8 to 20km	75m or 1% of range

6-42. The operator can tailor the search sectors to enable coverage between 230 and 6400 mils in azimuth. The operator can select a maximum of 27 sectors, while in 360 degree mode, with a minimum of 1 sector. An individual sector can be no smaller than 230 mils (13 degrees). The radar can detect and acquire six or more projectiles within the search area at any given time.

6-43. The AN/TPQ-53 can acquire and track hostile and friendly mortar, cannon, and rocket projectiles throughout a 6400 mils search sector. The search sector can be being moved and steered throughout the 6400 mils coverage without repositioning the vehicle or trailer on which the antenna is mounted.

6-44. The AN/TPQ-53 is a multifaceted system which in 1600 mil modes has the ability to track mortars with a designed to range of 500m to 25km, and artillery or rockets out to a range of 60km. The TPQ-53 provides flexibility for optimizing the operational mode to the tactical situation by offering additional search modes tailored specifically for short range or long range capabilities. For example, short range optimized mode allows for optimized tracking of short range, high angle rate targets. Long range optimized mode has the ability to track rockets out to 60km at the expense of short range revisit time.

6-45. The AN/TPQ-53 also has the ability to operate over a 6400 mil azimuth search sector with a designed to minimum range of 3km and maximum range of 20km. It is imperative for mode use to be determined during MDMP and issued to the radar section through the RDO.

6-46. The AN/TPQ-53 software allows it to perform in 6 operating modes to include:

- 90 degree normal mode.
- 90 degree short range optimized mode.
- 90 degree long range optimized mode .
- 90 degree 107mm rocket mode.
- 360 degree normal mode.
- 360 degree weather mode.

6-47. The 90 degree normal search mode utilizes 4 distinct waveforms which allow it to provide coverage from 500m to 50km. These waveforms overlap to provide very high revisit rates at close range and lower revisit rates at long range, ensuring the system will accurately locate targets from 500m-50km.

6-48. The 90 degree short range optimized mode differs from the normal 90 degree mode, with that the coverage goes from 500m to 25km. This mode provides additional elevation coverage at short ranges (500m-12km) and even higher revisit rates to improve probability of location and resulting accuracy. This mode is optimized for locating high angle rate targets close in range and was designed to provide at least an 85% probability of locating targets down to 500m.

6-49. The 90 Degree long range optimized mode is derived from the 90 degree normal mode. This mode has been modified in order to locate 240mm rockets at 60km. This mode provides improved performance over 90° mode from 12-60km while retaining some very short range capability in to 500m.

6-50. The 90 Degree 107mm rocket mode was designed to enable performance against long range 107mm rockets out to 50km. It is derived from the 90 degree normal mode with all but the long range search fences removed, and all detections inside of 25km suppressed. This mode is intended to be operated over a 1067 mil (60 degree) sector when the threat is specifically very long range 107mm (light) rockets.

6-51. The 360 degree search mode allows coverage of 360 degrees or 6400 mils by rotating the antenna array at a rate of 30 RPMs. Through beam steering, a beam stack at both 30 degrees to the left and right of the main beam stack enables electronic scanning of the entire search sector covering 21 degrees of elevation three times in each mechanical rotation.

6-52. The 360 degree weather mode was designed to provide 360 degrees performance from 3-20km while operating in heavy rain clutter. This mode improves Doppler resolution to reduce the effects of clutter, but to offset this improvement; it reduces the search elevation coverage of the 360 degree normal mode. To counteract the reduction in search elevation coverage, this mode adds the ability to dynamically place beams on tracks of interest, maintaining performance while in rain clutter in a 6400 mil (360 degree) mode.

TARGET CLASSIFICATION

6-53. The AN/TPQ-53 classifies acquisitions as three distinct target types: mortar, artillery, or rocket. The AN/TPQ-53 does not differentiate subtypes for these target types and defaults to unknown. The target classifications generated by the AN/TPQ-53 for transmission to AFATDS are mortar, artillery, and rocket unknowns. Of significant importance in target type classification for the AN/TPQ-53 system is the low datum plane. Estimates of target dynamics at launch are the primary discriminators used in the system software to determine the target type classification. This launch state is based on extrapolation of the target track to the low datum plane. As such, the low datum plane must match the true low point of the sector of operations as closely as possible. Significant mismatch in the low datum plane and the true gun height may cause the AN/TPQ-53 to misclassify the target, inducing accuracy errors, or possibly even failure to locate as the track may no longer appear to be a target of interest.

PROBABILITY OF LOCATION

6-54. The AN/TPQ-53 was designed to achieve at least 85% probability of location for all targets at the ranges listed in tables 6-2 and 6-3. Optimal operational mode selection based on a-priori threat intelligence ensures targets are located with the highest probability.

AN/TPQ-53 FRIENDLY MODE

6-55. The AN/TPQ-53 does not have a dedicated friendly fire mode. Friendly fire missions can be executed while the system simultaneously performs its hostile weapon locating mission. The AN/TPQ-53 has the ability to perform friendly fire missions in both 90 degree modes and 360 degree modes.

AN/TPQ-53 FRIENDLY FIRE

6-56. In the 90 degree mode, unlike the AN/TPQ-36 and AN/TPQ-37 systems, the AN/TPQ-53 can track weapons for friendly fire registration while simultaneously tracking hostile targets. The AN/TPQ-53 can register at all impact ranges between 3km and 40km. The AN/TPQ-53 can perform friendly fire registration in both 90 and 360 degree modes.

6-57. When executing a friendly fire mission in 90 degree mode, the WLR sets up a horizontal “window” through which the projectile must pass. The window is referred to as the friendly fire search fence as shown in figure 6-8. The narrowed search fence provides the best probability of detecting and tracking friendly rounds fired. The radar tracks projectiles until it has enough data to predict the point of impact.

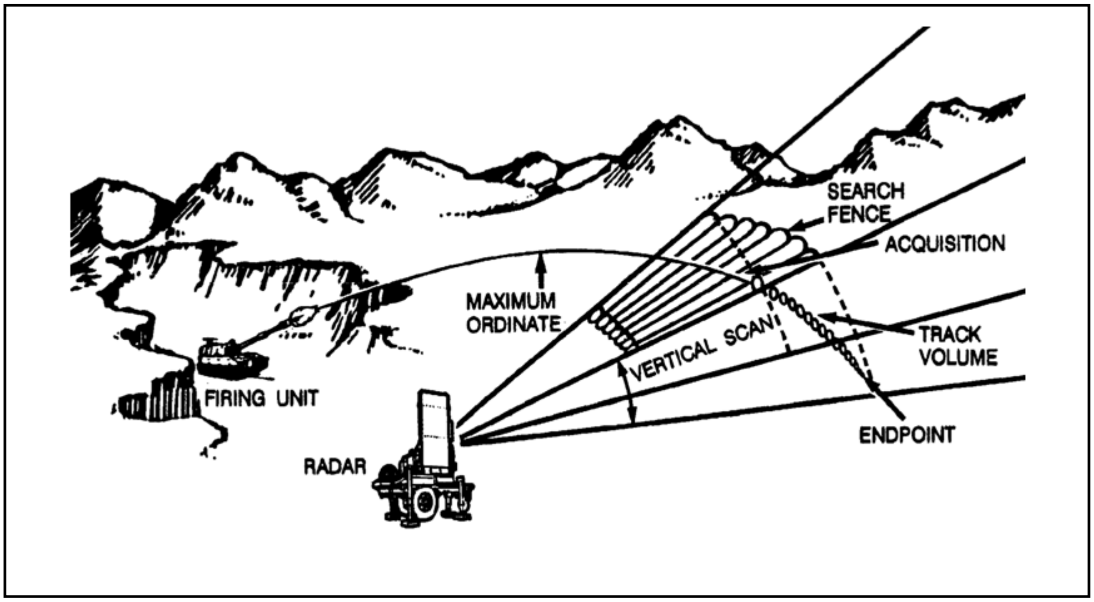

Figure 6-8. Friendly projectile tracking

6-58. When executing a friendly fire mission in 360 degree mode, the WLR utilizes the hostile search fence to perform friendly fire registration, identifying the friendly round based on the expected target trajectory.

6-59. When operating in the friendly fire mode the radar provides friendly units with accurate predicted-impact location data. The AN/TPQ-53 supports 3 missions that are used to provide this data. The missions are listed below:

- Mortar impact prediction.
- Artillery impact prediction.
- Rocket impact predication.

6-60. See the AN/TPQ-53 operator manuals for the correct friendly fire mission procedures.

OPERATING THROUGH ELECTRONIC COUNTERMEASURES

6-61. Operating through electronic countermeasures consists of detecting the presence of jamming or interference and performing actions to minimize or eliminate the effects of jamming.

AN/TPQ-53

6-62. The WLR can indicate jamming by any or all of the following: displaying a line at the jamming azimuth on the operational display, jam strobe message (azimuth, frequency, time) in the jammer database, the jammer indicator displaying the number of active jammers, or the electronic attack indicator indicating an Active status in the operations screen. To avoid degradation of WLR performance the following tactics may be used:

- Keep the WLR’s electronic attack countermeasures features enabled.
- Avoid operation within line of sight or in the same sector as the jammer.
- Operate on a different frequency than the jammer.
- Use deception.

6-63. Keeping the WLR’s electronic attack countermeasure functions enabled allows for activation of the jam strobe and electronic protection functions. The jam strobe identifies the azimuth of the jamming while the electronic protection functions serve to remove the effects of interference from the jammer. Line of sight issues can be avoided by selecting optimal WLR sights. Relocating the WLR to avoid jamming may or may not be possible based on the tactical situation. Changing WLR frequencies will sometimes help avoid the jammer's operating frequency. If these steps do not work, it may be possible to fool the jammer by ceasing to radiate for a few minutes. Change frequencies then resume operations. This may help prevent the jammer from staying on the WLR's.

6-64. The following bullets provide A concise summary of the AN/TPQ-53 capabilities:

- **Transportability.** The AN/TPQ-53 can be shipped worldwide by ground, rail, water, and air. The AN/TPQ-53 can be air transported by larger cargo airplanes and helicopters. The AN/TPQ-53, in its mission essential group configuration, can be air transportable in a single C-130 sortie without disassembly and with drive-on and drive-off capability. It can be placed in a travel configuration prepared to convoy within 2 minutes of off-load.
- **Emplacement and Displacement.** Four operators can emplace and put the system in to full operation (radiating) in 5 minutes. Four operators can displace the system into a travel configuration for full march within 2 minutes. The AN/TPQ-53 can perform self-leveling on a slope of up to 125 mils.
- **Self Surveying and Orientation.** The AN/TPQ-53 can perform self-location functions. Operators can also manually bore sight the radar and input location and orientating data in the event of automated systems failure.
- **Search Sector Tailorability.** An AN/TPQ-53 operator can tailor the search sectors to enable coverage between 230 and 6400 mils. An AN/TPQ-53 operator can select a maximum of 27 sectors with a minimum of 1 sector. Tailoring a search sector enables the sensor to scan that particular sector more often than it would if scanning the entire 6400 mil detection span. An option exists for search sectors to be automatically defined by the system based on the current operating mode or for the operator to override the automatically generated sectors and manually define them.
- **Digital Terrain and Elevation Data.** The system can download, store, and use Digital Terrain and Elevation Data (DTED) Level 1, DTED Level 2, and SRTM data.
- **Radar Terrain Following Data.** AN/TPQ-53 can implement and store electronic radar terrain following data. The operators can also manually input terrain data. The system defaults to the most accurate data. In 90 degree modes, search beams automatically follow the terrain mask in use.
- **Did–Hit-Data Capability.** The AN/TPQ-53 provides did-hit-data (projectile impact location) of friendly indirect fires in the 1600 mil mode to an accuracy of 30m or .3% of range. In the 6400 mils mode, the AN/TPQ-53 will achieve an impact location accuracy of 50m or 0.5% of range for mortars and an accuracy of 75m or 1% of range for cannons and rockets.
- **Impact Point Prediction.** For hostile fire, the projectile impact point accuracy is typically within 250m or 2% of range.
- **Locating non-standard munitions.** The system can track and locate projectiles launched with nonstandard QEs and high muzzle velocities.
- **False Location Rate.** The AN/TPQ-53 has a false location rate of no more than one every 6 hours in both modes. Combat experience and testing has demonstrated that similar radars and RF emitters of the same band, rotary and fixed wing aircraft can cause an increase in false locations.
- **Height Correction Automated or Manual. The radar automatica**lly height corrects all targets and/or provides the operator with the option to manually input corrections in order to achieve the actual firing location with the use of DTED Level 1, DTED Level 2, and SRTM data.
- **Transmit Targets on the Move.** The system can recall from system storage, process and digitally transmit targets previously acquired in position while on the move.
- **Sense and Warn.** Radar can provide an acquisition message set while in 1600 mils or 6400 mils mode to facilitate sense and warn mission.
- **Voice and Digital Communications.** The AN/TPQ-53 can communicate and pass data with multiple subscribers on multiple nets simultaneously operating on two digital and two voice communication nets.

- **State Vector Capability.** When an AN/TPQ-53 is working within an area protected by RAM-Warn activities, these WLRs sends state vector data for indirect fire munitions to the forward area air defense (FAAD) control node. The FAAD uses this data along with other sensor data to correlate the position of the incoming indirect fire munitions and forwards the data to warn Soldiers in the affected area quickly of the pending hazard.
- **Tactical Display.** The system can electronically display tactical maps and graphic overlays of friendly and enemy locations and boundaries and all fire support coordinating measures upon request. The operator must have the ability to display the operational area in sufficient detail and scale to make tactical decisions to support ongoing operations.
- **Prime Power.** The AN/TPQ-53 has an organic primary and a backup tactical power sources common to the U.S. military services. The AN/TPQ-53 can automatically or manually switch between tactical and commercial power or between primary and backup tactical power without system interruption.
- **Computer Backup.** All computer systems and data can retain their data via backup or auto-save capability for 60 minutes in the event of a power failure.
- **Survivability**. The AN/TPQ-53 has enhanced survivability against artillery primarily by a combination of deployment capabilities, rapid displacement, emission control, side lobe signature reduction, and reduced signatures.
- **Jam Strobe Reporting.** The AN/TPQ-53 provides jammer azimuth and frequency in the Intercept report format.
- **Audible Alarm.** An operator adjustable alarm (audio and visual) will alert the operator and differentiate between the following events:
  - A new location identified.
  - A received message.
  - A system fault.
  - An over temperature.
- **Target Track Capacity.** The AN/TPQ-53 can detect, verify, and locate at least 50 projectiles simultaneously in flight within the search area.
- **Locating Non-Standard munitions.** The system will track and locate projectiles launched with nonstandard QEs and high muzzle velocities.
- **Tracking through Clutter.** The system detects and tracks targets while minimizing the effects of clutter on system performance over the entire surveillance volume. The system can process targets in an urban, high relief, and low relief terrain clutter environment along with sea clutter.
- **Saturation Alleviation.** The AN/TPQ-53 automatically performs saturation alleviation of targets in a manner which is dependent on the primary mission the AN/TPQ-53 is conducting. The operator also has a limited manual control of system sensitivity.
- **Passive Interference Display.** The AN/TPQ-53 provides a display that informs the operator of interference levels over the entire range of AN/TPQ-53 operating frequencies, across the entire 6400 mil sector.
- **Data Recording.** The AN/TPQ-53 provides built-in or integral data recording of all key operational, system readiness, and technical data without system degradation or operator distraction, as well as playback and analysis at non-mission essential workstations. The AN/TPQ-53 will record data during electronic operations and synchronize it with the display data. The AN/TPQ-53 has the following data recording capabilities:
  - Data recording capacity for up to 72 hours.
  - Record equipment status, failure indication, diagnostic, fault isolation, and other typical sample data histories for a 200 hour operation period, onto removable storage devices.
  - Copying the recorded data media and archiving selected portions in a master database.
  - On-demand, off-line post-mission playback of recorded data enabling interaction with the recorded playback, that includes selective zooming, event focus, and editing of training data.
  - Provides a data port for accessing radar data for inner-platform networking growth.

Chapter 7

AN/TPQ-50 Weapon Locating Radar System Characteristics and Employment

This chapter discusses characteristics and employment techniques for the AN/TPQ-50 WLR. The WLRs are designed to enhance the detection, verification, and location methodology.

Short range mortars firing from all angles can be a challenge for the AN/TPQ-36 radars to track and calculate a firing solution for. While the AN/TPQ-36 has a capability to perform 6400 mils coverage using four 1600 mil blocks, this capability is slow and cumbersome. The AN/TPQ-50 provides automated 6400 mil coverage.

SECTION I – CHARACTERISTICS AND EMPLOYMENT

7-1. The AN/TPQ-50 has two different operating configurations: stand alone or on vehicle configurations (see figure 7-1). They each provide the capability to detect enemy indirect fire through 6400 mil azimuth coverage. At a minimum, the AN/TPQ-50 is designed to detect, track, and locate mortars, rockets, and artillery. It has a location range from 0.5-10km. The AN/TPQ-50 will classify each weapon located as a mortar, cannon, or rocket. The system further classifies mortars by light, medium, and heavy projectiles.

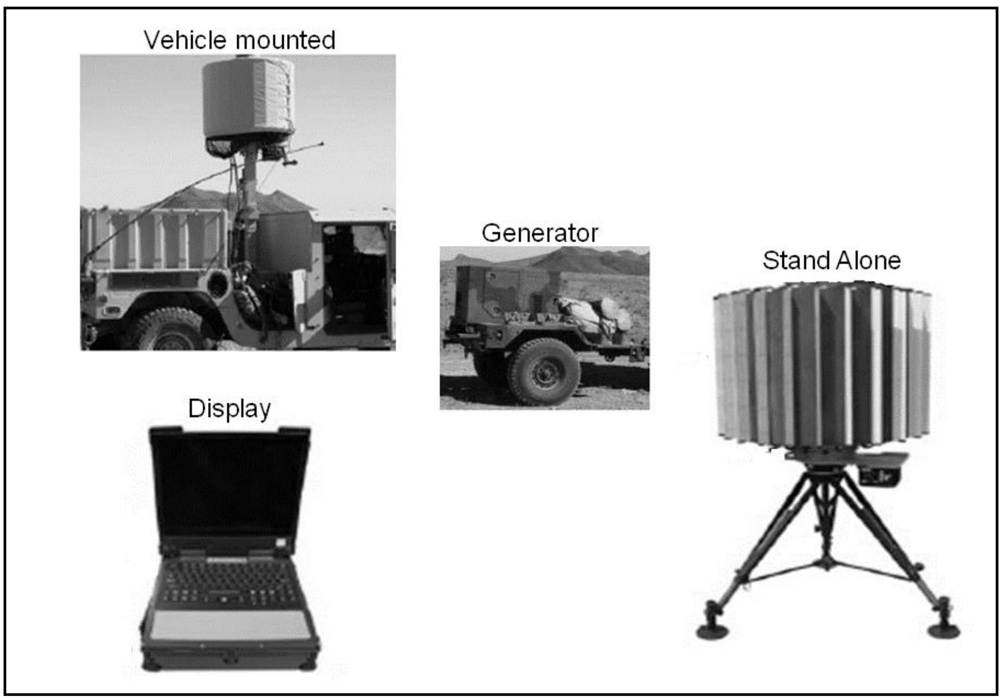

Figure 7-1. AN/TPQ-50 configurations

7-2. In nominal weather conditions the AN/TPQ-50 standalone system assembly, alignment, and initialization can be accomplished by two trained operators in less than 20 minutes. Disassembly can be accomplished by two trained operators in approximately 10 minutes. Care must be taken during assembly and disassembly to prevent damage to the equipment, especially the antenna columns.

7-3. Operators can remotely operate the AN/TPQ-50 using wireless connectivity to a distance of 1000m line of site.

SITE REQUIREMENTS

7-4. Emplacement and planning considerations for all versions of the AN/TPQ-50. The following factors should be taken into consideration when determining site selection and emplacement:

- Place the AN/TPQ-50 in an area with the clearest field of view possible because nearby buildings, trees, and other obstructions could seriously degrade system performance. The ideal location for the AN/TPQ-50 system is on a hill or roof top above the surrounding terrain with a clear field of view and a slope of 10° or less.
- Raising the emplacement height of the AN/TPQ-50 will result in better performance. The radar should be emplaced to minimize any obstructions, and should mask no more than 4 degrees of elevation in the area of interest.
- In the event that there are no physical obstructions in the local area, there is no advantage to emplacing the AN/TPQ-50 above ground level. The emplacement height above local terrain should be less than 15m.

7-5. When properly sited, the AN/TPQ-50 can provide continuous 6400 mil (360°) surveillance. However, the operator may choose to limit the azimuth coverage to less than 6400 mils (360°), but no less than 267 mils (15°), if obstructions such as buildings, vehicles, or trees are located near the AN/TPQ-50. Modifications to the search sector may also be adjusted if a 6400 mil (360°) search sector is not required.

7-6. Ensure the AN/TPQ-50 is positioned at least 20m from obstructions to prevent reflection damage. The AN/TPQ-50 can operate within 20m of an obstruction, but the system's receiver may be damaged and the performance may be degraded.

CAUTION

If obstructions are located within 20m of the AN/TPQ-50, the signal return strength may damage the system.

7-7. The AN/TPQ-50 performance can be degraded or the false location rate may increase due to radio frequency interference from other radars or communications equipment. Therefore, the AN/TPQ-50 emplacement and planning considerations should take into consideration any possible interference sources; high power emitters, such as air surveillance radars, can be a source of substantial interference since they operate in the same frequency band as the AN/TPQ-50, also any previous versions of the AN/TPQ-50, such as: AN/TPQ-48, AN/TPQ-49, and AN/TPQ-49 upgrade. There are also many jamming devices on the battlefield, both friendly and enemy. Friendly forces use different jamming devices such as the Duke and Warlock and many variances of these systems. This must be taken into consideration during all steps of MDMP for decisive action, especially during stability operations. If the AN/TPQ-50 is located within a tactical assembly area, "ON" and "OFF" procedures for these jamming devices must be taken into consideration as well as the area of effect for these systems.

7-8. Emplacement times are critical in all operations, especially early entry scenarios, when the initial force on the ground is extremely susceptible to enemy indirect fire. To minimize this risk, two operators can emplace the AN/TPQ-50 and bring it to full operational capability in twenty minutes. This is a very important consideration to keep in mind when considering phase lines and triggers during MDMP.

7-9. Analysis of combat operations has identified that a significant number of radar acquisitions occur at ranges between 2-10km and these fires may originate from all sectors of the defensive perimeter. The AN/TPQ-50 fills these short range, close support, and 6400 mil coverage capability gaps. The AN/TPQ-50 provides uniform continuous indirect coverage.

7-10. The AN/TPQ-50, as well as the AN/TPQ-53, can simultaneously locate weapons fired both in-bound and out-bound, in respects to the radar location. This capability is a definite combat multiplier and must be taking in consideration during the counterfire or targeting process.

7-11. The AN/TPQ-50 predicts the impact point for all hostile projectiles accurately enough to provide localized warning in sufficient time for personnel to properly react. This early warning provides enhanced force protection for US and allied personnel. The AN/TPQ-50 also provides friendly fire "did-hit data" to a 25m accuracy for mortars and 50m for cannon and rocket systems to assist in friendly fire adjustments, elimination of fratricide, and generating predictive enemy engagement battlefield damage assessment.

With the capability of being able to track both hostile and friendly impact predictions simultaneously, there needs to be consideration when developing zones, counterfire battle drills, and buffer data. One suggested approach to utilize this new capability to improve the counterfire battle drill would be, if you have a Call for Fire Zone in your area of operations, you should also have a buffer built for that specific zone as well. Since a zone is three to six points, treat these points like they were impact locations and calculate a mean point of impact for all the associated points. By using the calculated mean point of impact as your target location, lay your hot gun onto this target, with clearance of fires already established for that zone. The radar will be given specific instruction, if anything comes out of that zone to apply the buffer established for that zone. This will give real time did-hit data for the counterfire and assist with a more accurate battlefield damage assessment.

TACTICAL CONSIDERATIONS

7-12. The tactical position areas are selected based on IPB, the range capabilities of the WLR, and METT-TC. A complete analysis of METT-TC will dictate which factors are most important. Generally, in a traditional area of operations, WLRs are positioned far enough from the forward line of troops FLOT to acquire enemy weapons and to prevent loss of personnel and equipment to enemy action. Avoiding unnecessary moves supports maximizing coverage and cueing time.

7-13. The AN/TPQ-50 is usually located 1-2km behind the FLOT.

7-14. Positioning may change based on the tactical situation.

PROXIMITY OF OTHER RADARS

7-15. Other WLR systems or active emitters can interfere with WLR coverage by attenuating or jamming the WLR beam. WLRs and emitters close in proximity or azimuth of search may cause jamming or increase the false location rate. Inadvertent jamming can be avoided by careful planning of WLR positions.

7-16. The AN/TPQ-50 performance can be degraded due to radio frequency interference from other radars or communications equipment; therefore, site selection should take interfering sources into consideration. High power emitters, such as air surveillance radars, can be a source of substantial interference. The AN/TPQ-50 should be placed as far away as possible from this type of interference. All sources of information should be used to determine all possible emitters in the area of operations to avoid interference.

Note. Several air surveillance radars and Counter Radio-Controlled Electronic Warfare Systems operate in the same frequency band as the AN/TPQ-50.

7-17. If multiple AN/TPQ-50 systems are operating in the same area, each AN/TPQ-50 system is positioned a minimum of 1000m apart and on a different frequency from the other systems. Minimum frequency separation of 30 MHz for three or less AN/TPQ-50s and minimum frequency separation of 20 MHz with more than three AN/TPQ-50s. See figure 7-2 through figure 7-4 on pages 7-4 and 7-5 accordingly, for examples of operating two or more AN/TPQ-50s from the same area of operations.

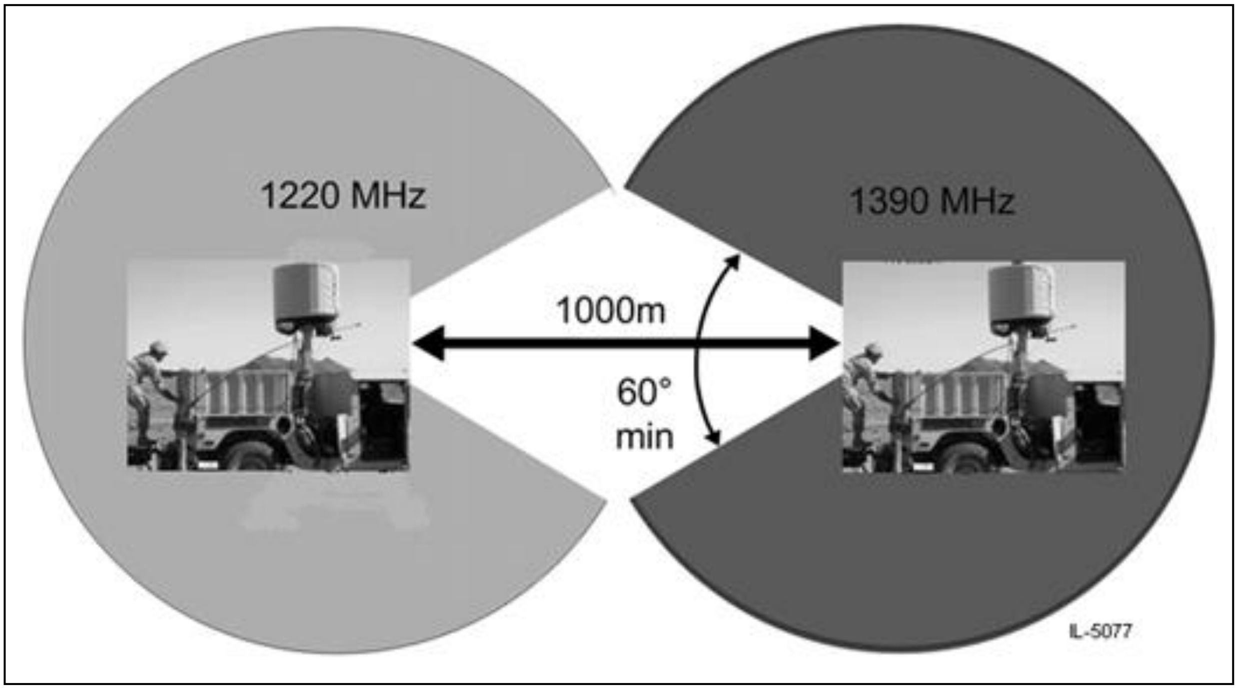

Figure 7-2. AN/TPQ-50 position considerations for two radars

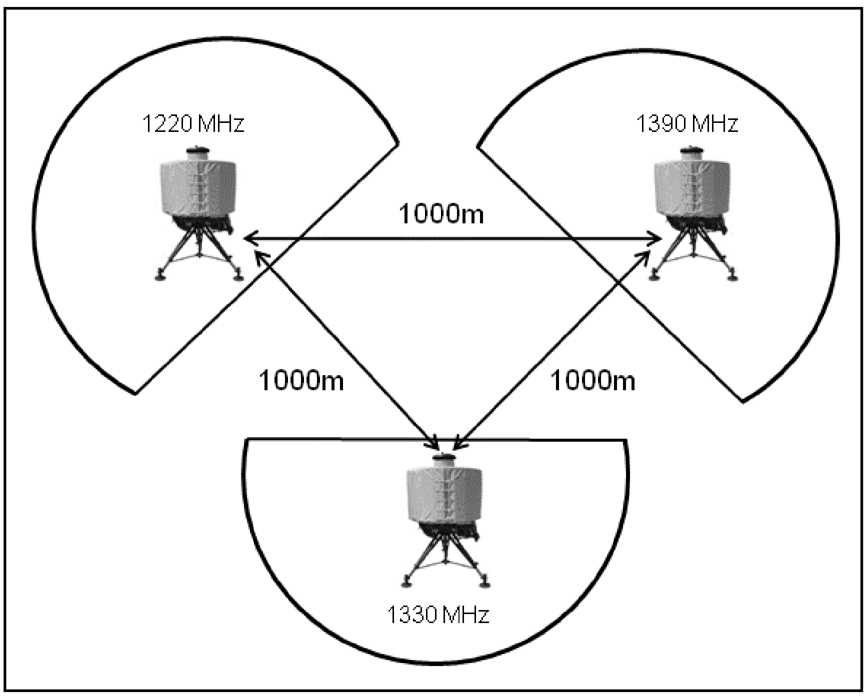

Figure 7-3. AN/TPQ-50 position considerations for three radars

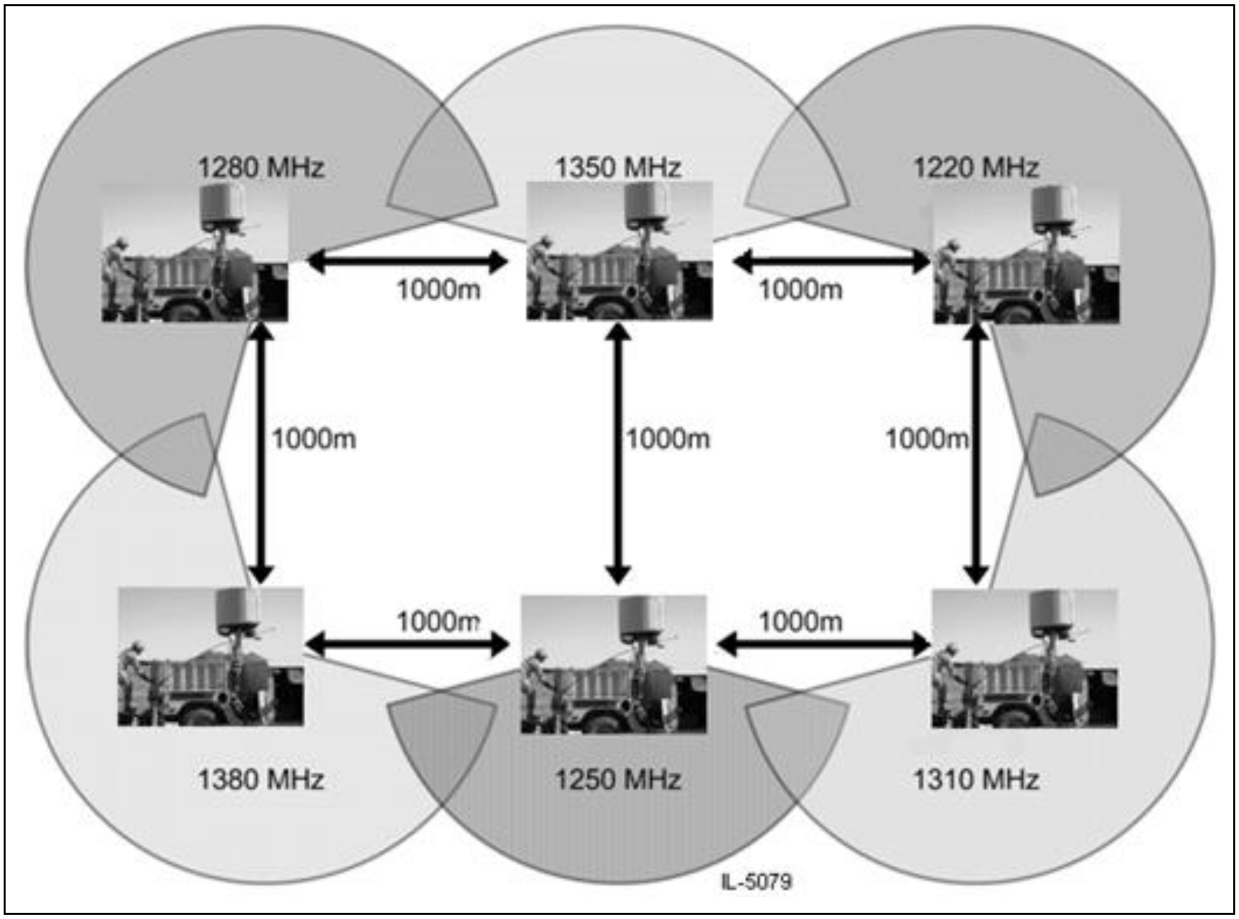

Figure 7-4. AN/TPQ-50 position considerations for more than three radars

> ***Note.*** All sectors facing the other AN/TPQ-50 systems are blanked, or turned off and the frequencies are separated as described above.

SITE ACCESS

7-18. The WLR site should have more than one route of approach. Routes of approach should be accessible by section vehicles, free from enemy observation, and capable of being guarded by a minimum number of personnel. The quality of access must also be considered. Some essential considerations include:

- *Accessibility during poor weather conditions*. Can the position be accessed during periods of rain and snow? Positions that may deteriorate during inclement weather should be avoided to prevent stranding the WLR.
- *Overhead clearance.* Avoid locations where trees, power or telephone lines may damage WLR components when entering and exiting the position. Check the clearance requirements for tunnels and overpasses to ensure section equipment does not exceed requirements.
- *Bridges.* Check the bridge classifications on routes to WLR positions. Ensure that the bridge classification of section equipment does not exceed the load bearing capabilities of the bridge.
- *Fords.* Check fords to ensure they are passable to the WLR section equipment. The ATG for the AN/TPQ-50 can only ford 30 inches of water. If heavy rains are expected some positions may become untenable because of fording restrictions.
- *Obstacles.* Check routes for current and planned obstacles. These obstacles may include road craters, tank ditches, abates, or wire obstacles. Also, check for natural obstacles such as fallen trees and rockslides. Ensure that the access is sufficient to allow egress after combat has

occurred. Rubble from buildings, utilities, and fallen trees should not prevent the WLR section from displacing from a position.

SAFETY CONSIDERATIONS

7-19. Safety is an important consideration when operating and working around the WLR. Possible safety concerns include radiation, wind, noise, and electrical hazards.

HAZARDS OF ELECTROMAGNETIC RADIATION TO PERSONNEL

7-20. The hazard ranges for the AN/TPQ-50 extends full 6400 mils scanning: 2.0m within 1600 mils of the stare sector, non-scanning: 6.4m, and more than 1600 mils outside of stare sector: 0.8m.

WIND

7-21. The AN/TPQ-50 system includes a weather cover that is placed over the radar assembly for protection from wind, rain, snow, or sand. The mesh at the bottom of the cover allows hot air to flow out when used in hot, dry temperatures. The weather cover's drawstrings and Velcro straps further protect the AN/TPQ-50 from conditions. The AN/TPQ-50 can operate in a 35 mph (30 knot) wind. However if the prevailing wind is 57 mph (50 knots) or more the system must be disassembled to avoid damage.

SECTION II – DETECTION, VERIFICATION, AND LOCATION METHODOLOGY

7-22. The AN/TPQ-50 is extremely proficient at detecting airborne objects, and aircraft are no exception. Even though an aircraft can provide a stable detection pattern for a track, it does not meet the expected velocity and trajectory profile of artillery, rockets, or mortars. Therefore, the aircraft may be displayed as a non-discrimination track or as a non-projectile track.

AN/TPQ-50 DETECTION AREA

7-23. The possible detection area is a three dimensional space defined by the minimum and maximum range, search sector, and the vertical scan of the WLR. Planning ranges are used for the purposes of this discussion. However, the maximum planning range for the WLR is not an absolute. It is the range at which the probability of detection becomes low enough to be unsuitable for planning purposes. Nonetheless, objects may be detected beyond the maximum planning range. Conversely, objects within the planning ranges may not be detected. Planning ranges for the AN/TPQ-50 are 0.5 to 10km for mortars, artillery, and rockets (see figure 7-5).

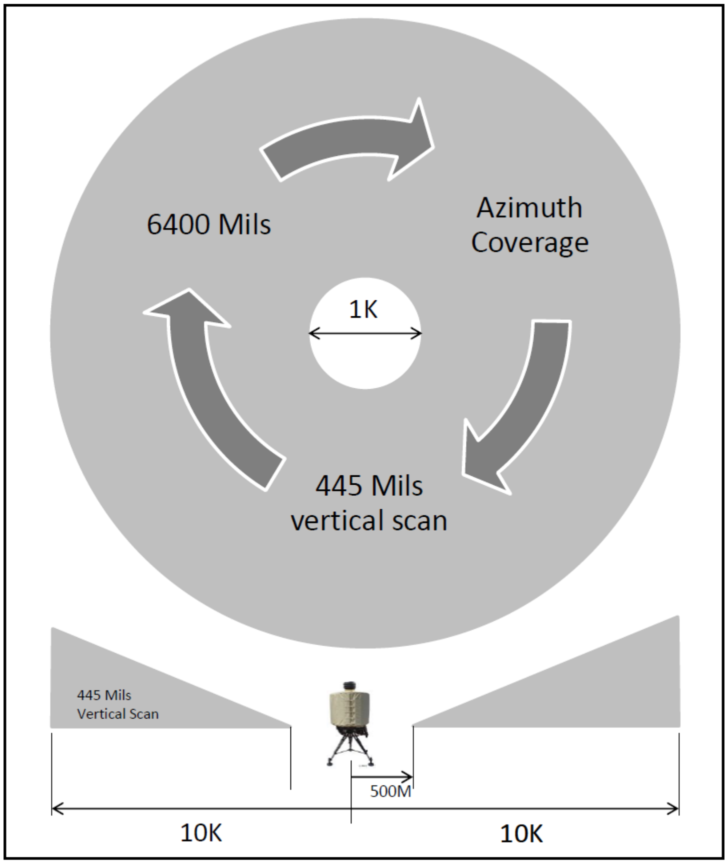

Figure 7-5. AN/TPQ-50 search sector and range

> ***Note.*** AN/TPQ-50 classifies each weapon as mortar, cannon, or rocket, to include mortar as light, medium, and heavy.

AN/TPQ-50 VERTICAL SCAN

7-24. The elevation coverage of the AN/TPQ-50 is 445 mils. This elevation coverage provides the required target tracking time to enable accurate weapon locations for projectiles between .5km and 10km.

TARGET CLASSIFICATION HOSTILE MODE

7-25. The AN/TPQ-50 has the capability of providing friendly fire "did-hit data" with a TLE50 CEP of 50m for mortars (see table 7-1 for other weapon TLEs). It has the capability of maintaining track on 20 simultaneous in-flight projectiles originating from separate sites uniformly distributed in the coverage area of the AN/TPQ-50.

Table 7-1. AN/TPQ-50 TLE

Weapon	***Range (Km)***	***TLE(m)****
Mortar 60mm	0.5km	50m
Mortar 81mm	0.5-8km	50m
Mortar 120mm	1-10km	50m
Cannon 155mm	1-6km	50m or 2% of range
Rocket 122mm	1-10km	100m or 3.5% of range
Rocket 240mm	1-10km	200m or 3.5% of range
m – meter mm – millimeter km – kilometer		

AN/TPQ-50 FRIENDLY MODE

7-26. The AN/TPQ-50 operates in hostile and friendly fire mode simultaneously and has the ability to conduct friendly fire missions through the use of buffers. This allows hostile tracking and friendly fire observation to be conducted simultaneously. The AN/TPQ-50 system utilizes friendly fire buffers to conduct friendly registrations while continuing the primary mission of hostile operations. See the respective operator manuals for the correct procedures.

7-27. The AN/TPQ-50 provides friendly fire ‘did-hit data’ with a TLE 50 CEP of 50m for mortars if the entire trajectory remains in radar coverage. The radar uses weapon data, such as QE, position, and weapon type, to accurately predict friendly fire impact. The data must be manually entered by the operator.

Note. If the projectile is outside specific tolerances, (see table 7-2) the track will display as hostile.

Table 7-2. Friendly fire gates

Variable	***Description***	***Value***
Time Delta	Maximum time until friendly fire track selection from the candidate list	Time till highest point for friendly fire shot based on General Trajectory Program
Time Gate	Maximum time between first detection in track and "Send to Radar" to become a candidate	+/- 5 seconds
Range Gate	Range gate maximum range delta between first detection in track and gun range from friendly fire message	1000m
Azimuth Gate	Maximum azimuth delta between first detection in track and gun azimuth from friendly fire message	7.5 degrees
Quadrant Elevation Gate	Maximum quadrant elevation delta between calculated quadrant elevation of candidate track, and quadrant elevation from friendly fire message	10 degrees
Velocity Gate	Maximum velocity delta between calculated muzzle velocity of candidate track and muzzle velocity from friendly fire message	75m/second

7-28. Unlike the AN/TPQ-36 and AN/TPQ-37, the AN/TPQ-50 can track weapons for friendly fire registration while simultaneously tracking hostile targets.

OPERATING THROUGH ELECTRONIC COUNTERMEASURES

7-29. Operating through electronic countermeasures consists of detecting the presence of jamming or interference and performing actions to minimize or eliminate the effects of jamming.

AN/TPQ-50

7-30. It is recommended to select a frequency that is not jammed. The TA platoon leader should consult with the frequency manager (usually within the S-6 section) through the target processing section/counterfire officer for operating frequency settings.

7-31. The following bullets provide a concise summary of the AN/TPQ-50 capabilities:

- The AN/TPQ-50 can perform self-location functions. Operators can also manually bore sight the radar and input location and orientating data in the event of automated systems failure.
- An AN/TPQ-50 operator can tailor the search sectors to enable coverage between 267 and 6400 mils. An AN/TPQ-50 operator can select a maximum of 18 sectors with a minimum of 1 sector. Establishing a priority enables the sensor to scan a particular sector more often than it would if scanning the entire 6400 mil detection span.
- The system can download, store, and use digital terrain and elevation data levels 1 through 5.
- The AN/TPQ-50 has a target track capacity that can detect and acquire a maximum of twenty projectiles within the search area at any given time.

- The system can recall from system storage, process and digitally transmit targets previously acquired in position while on the move.
- The radar can provide an acquisition message set to facilitate sense and warn mission.
- The AN/TPQ-50 can communicate and pass data with multiple subscribers on multiple nets simultaneously and interface through the AFATDS and battery computer system, operating on two digital and two voice communication nets.
- When an AN/TPQ-50 is working within an area protected by RAM-Warn activities, these WLRs sends state vector data for indirect fire munitions to the FAAD control node. The FAAD uses this data, along with other sensor data, to correlate the position of the incoming indirect fire munitions and forwards the data to warn Soldiers in the affected area of the pending hazard
- The system can electronically display tactical maps and graphic overlays of friendly and template enemy locations and boundaries and all fire support coordinating measures upon request. The operator must have the ability to display the operational area in sufficient detail and scale to make tactical decisions to support ongoing operations.
- The AN/TPQ-50 provides jammer azimuth which facilitates jam strobe reporting.
- The AN/TPQ-50 provides built-in or integral data recording of all key operational, system readiness, and technical data without system degradation or operator distraction, as well as playback and analysis at non-mission essential workstations. The AN/TPQ-50 will record data during electronic operations and synchronize it with the display data.

Appendix A
Automated Target Data Processing

This appendix explains how the AFATDS processes target indicators and suspect targets. It provides the detailed information necessary to effectively use AFATDS to manage the processing of targets and target indicators. This appendix includes AFATDS target generation functions, target indicator processing, suspect target processing, target damage assessment, file maintenance, and target purging.

GENERAL

A-1. The amount of processing required to develop a target varies extensively. In its simplest form, target data processing is the passing of a target from a known, accurate, and reliable source to the fires cells for attack within established attack guidance and target selection standards. In its most complex form, it is the collation of target indicators and suspect targets from diverse sources into a target identification and location accurate enough to justify attack.

A-2. Target data is transmitted and processed automatically according to the commander's guidance and target selection standards stored in the AFATDS computer.

A-3. AFATDS uses the target generation function to automate the tasks performed by the targeting and target processing elements. The target generation function consists of a series of processes that compare and combine target information to generate targets and update the suspect target list and target indicator file. Target generation takes suspect targets, artillery target intelligence targets, and target indicators (such as shell reports) as inputs, and through several processes eliminates duplication, determines and refines suspect target locations, and generates targets. The target generation function can be turned on or off based on the targeting needs in a given tactical situation. The outputs of this function are generated targets and an updated suspect target list and target indicator file. Some key definitions related to target generation are:

- Target indicators are directional information that forms a ray (line) from a given point, in a given direction, to a derived maximum distance along which a possible enemy target may be located. Examples of target indicators include shelling, flash, and jam strobe reports. A target indicator will have a target type.
- Target data is grid producing information received at AFATDS via a fire request or intelligence information. Target data is also produced by AFATDS. For example, AFATDS uses intersecting target indicator rays to determine a grid location, thereby generating target data.
- Target data that has passed target selection standards and meets the commander's criteria for reliability, accuracy and timeliness will be considered worthy of attack consideration. This target data will undergo further mission processing to determine if a fire mission will be initiated based on comparisons to additional targeting and attack guidance, relative value to other targets, and if attack systems are capable of engaging the target.
- A suspect target is target data that has failed target selection standards and may not be worthy of attacking because it does not meet the commander's criteria for reliability, accuracy, or timeliness. Suspect targets are further refined until they pass target selection standards and the operator initiates a fire mission on the suspect target, or the suspect target decays (based on target decay guidance) and is deleted from the suspect target list.

TARGET INDICATOR PROCESSING

A-4. The FA battalion fire cell receives a shelling report from one of the unit's observers. The FA battalion FSO may direct that the report be forwarded to the FAB or DIVARTY (or the designated counterfire headquarters).

AFATDS AUTOMATIC PROCESSING OF TARGET INDICATORS

A-5. AFATDS always performs certain functions when a target indicator is initially received, whether it was received from an observer or created through operator input. When AFATDS receives target indicator data, some of the information required to process the indicator may or may not be present. AFATDS automatically determines missing information based on the reporting observer's unit data and default data files. Missing information is determined as follows:

- Target Indicator Number - If the received target indicator does not have a target indicator number, one is assigned based on the next available target indicator number from the target indicator number block. The target indicator number must always begin with "II." If a target indicator is received with a number that does not begin with "II," the number will automatically be replaced with an "II" number. AFATDS maintains a target indicator numbering block, which the operator cannot edit. This block goes from II0000 to II9999.

Note. When you enter a target indicator into AFATDS do not enter a target number (AFATDS will automatically number the indicator).

- Target Indicator Decay date time group - If the target indicator decay date time group for the target indicator is not provided, AFATDS computes the date time group by adding target decay guidance for the target type to the date time group of acquisition or report. The date time group of the report will default to the current time if not provided.
- Target Type - If the received target indicator does not specify a target type, one is assigned based on the following rules. If the caliber of the mortar is reported, AFATDS will determine the target type as shown in table A-1.

Table A-1. Mortar caliber target type mapping

Report caliber	***Mortar type***
108 -150mm	Heavy
61-107mm	Medium
Less than 60mm	Light
Not given	Unknown

Note. The weapon type used for rockets or missiles is unknown. Any electronic warfare equipment will be described as an electronic emitter in the target type subfield.

- Sensor Directional Error - If the target indicator does not include the sensor directional error (mils) then it is determined based on the default value for the reporting sensor's unit data or unit type.
- Sensor Location - If the sensor location at time of report is not provided, then that sensor unit's most current location is used to determine this value. If no location for the reporting unit is available, the target indicator report is discarded.

TARGET SIMILARITY

A-6. AFATDS uses target similarity to determine if targets should be combined, or if target indicators are close enough to generate target data. The matrix number is the individual number for that target type. The matrix is also used for target duplication checks.

DIRECTION AND DISTANCE

A-7. The direction and distance of the target indicator ray is determined by:

- Direction of ray originating from the shell impact location.
- Length of ray is based on the following:

- Use length provided, if given.
- If a flash to bang is provided, use distance = 350 x time (seconds). The result is the length of ray in meters.
- If length or flash to bang time is not provided, the ray length is based on the target type.

DISPLAY

A-8. Target indicators are displayed as "fans" based on the sensor directional error. Figure A-1 shows a target indicator with a 10km length and a sensor directional error of 10 mils.

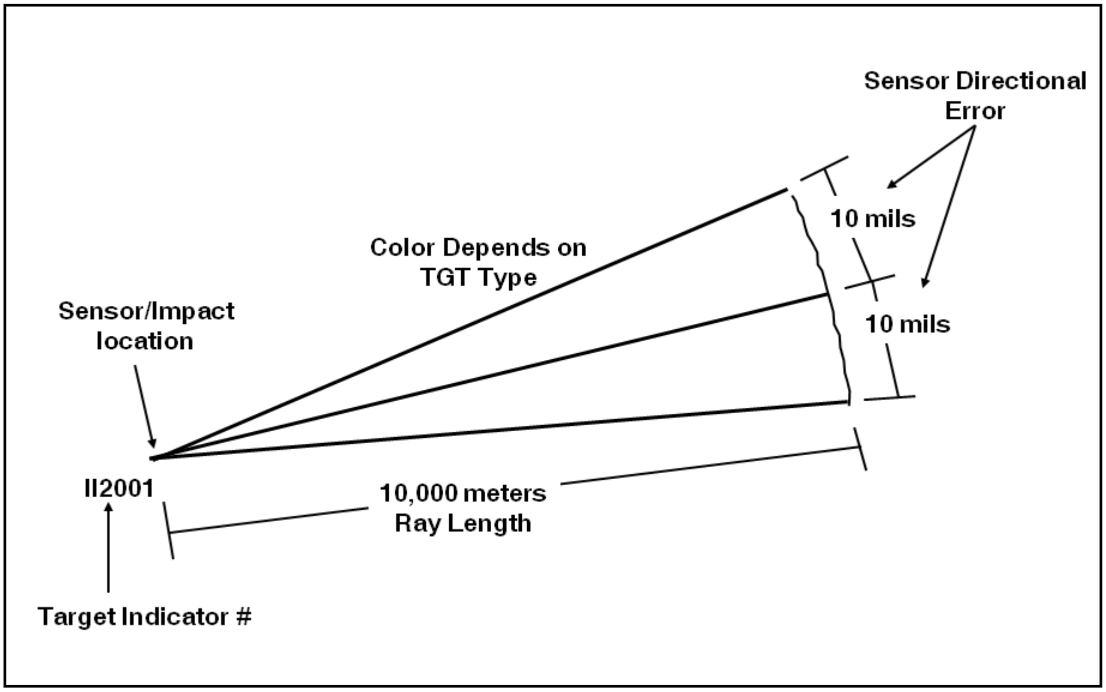

Figure A-1. Target indicator display

Note. Each target indicator ray has an assigned color based on target type.

TARGET INDICATOR FUNCTION

A-9. Based on the tactical situation, the AFATDS operator may or may not want the system to run the target indicator function. AFATDS allows the operator to turn target indicator processing on or off. When the target indicator processing is "off," AFATDS adds the target indicator to the target indicator list with no additional processing or comparisons. When target indicator processing is "on," AFATDS performs the following checks (in order):

- Compares the target indicator against the current (but non-active) target files (targets on the "On-call," "Suspect," "Planned," and "Inactive" target lists). If the indicator ray covers a similar target, the fires cell with target indicator processing duty is notified of the "Target Indicator Match" via an alert and reviews information on the target indicator and all matched targets. The operator may take various actions from this alert:
  - Selectively initiate fire mission(s) against the target(s) indicated as a match. This will open the initiate fire mission screen already filled out for the selected target.
  - Add selected matched target(s) to an existing fire plan. This will place the targets on the selected fire plan.
  - Display the target indicator fan-target comparison. This graphically displays the indicator fan and the associated matched target(s) on the map.

- Selectively update matched target(s) with a new "last updated" value based on the target indicator date time group of acquisition report.
- Delete the target indicator. This will discard the received target indicator data and will not add it to the target indicator list.
- Continue processing the target indicator. This will add the target indicator to the target indicator list for possible combination with existing target indicators.

- Compare the target indicator with other target indicators already on file. If the target indicator did not match a target or the operator selected "Process target indicator" from the target match window, AFATDS will add the new target indicator to the target indicator list and determine if it can be combined with existing target indicators. See Figure A-2 for an example of target comparison. The following rules are used in this comparison:
  - The new target indicator is compared against existing target indicators in the target indicator file that have a similar target type. Only target indicators that have not passed their decay date time group are considered.
  - When target indicator rays of three or more of the compared target indicators intersect to form a point or common area, and all points are located within 400m, AFATDS automatically combines the rays and generates a new target number and passes the target to the target selection standards check for further processing. Combined target indicators are deleted from the list.
  - If no match is found, the new target indicator is added to the target indicator file. The operator can purge the target indicator list of target indicators when their "decay time" date time group is passed. To do this simply select "automatically purge" option on the target indicator list window.

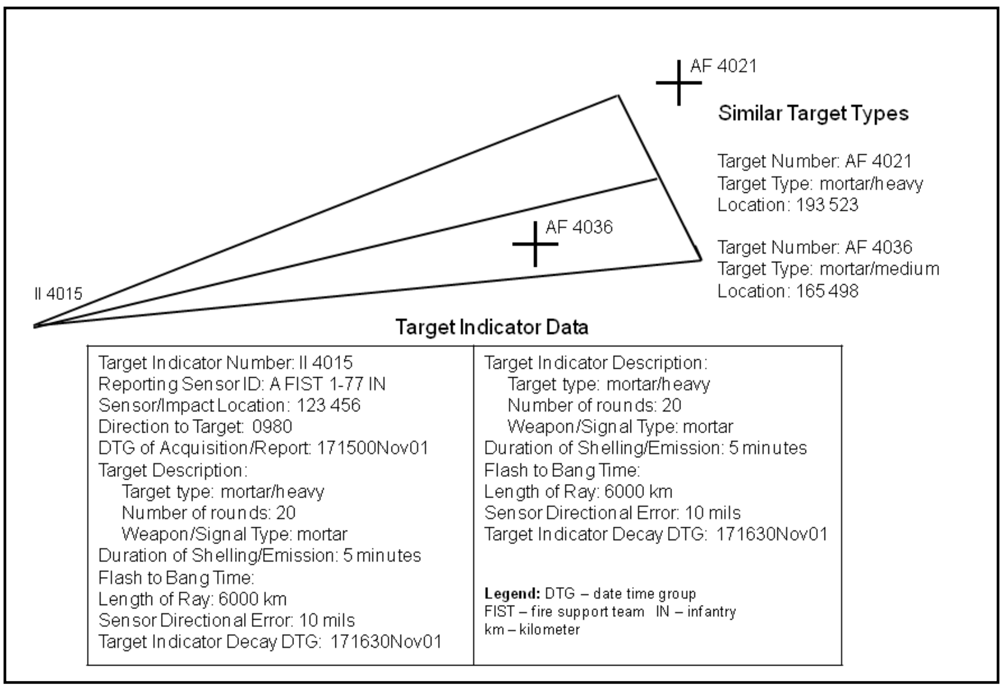

Figure A-2. Target comparison

A-10. Figure A-3 provides a summary of the possible results of target indicator processing.

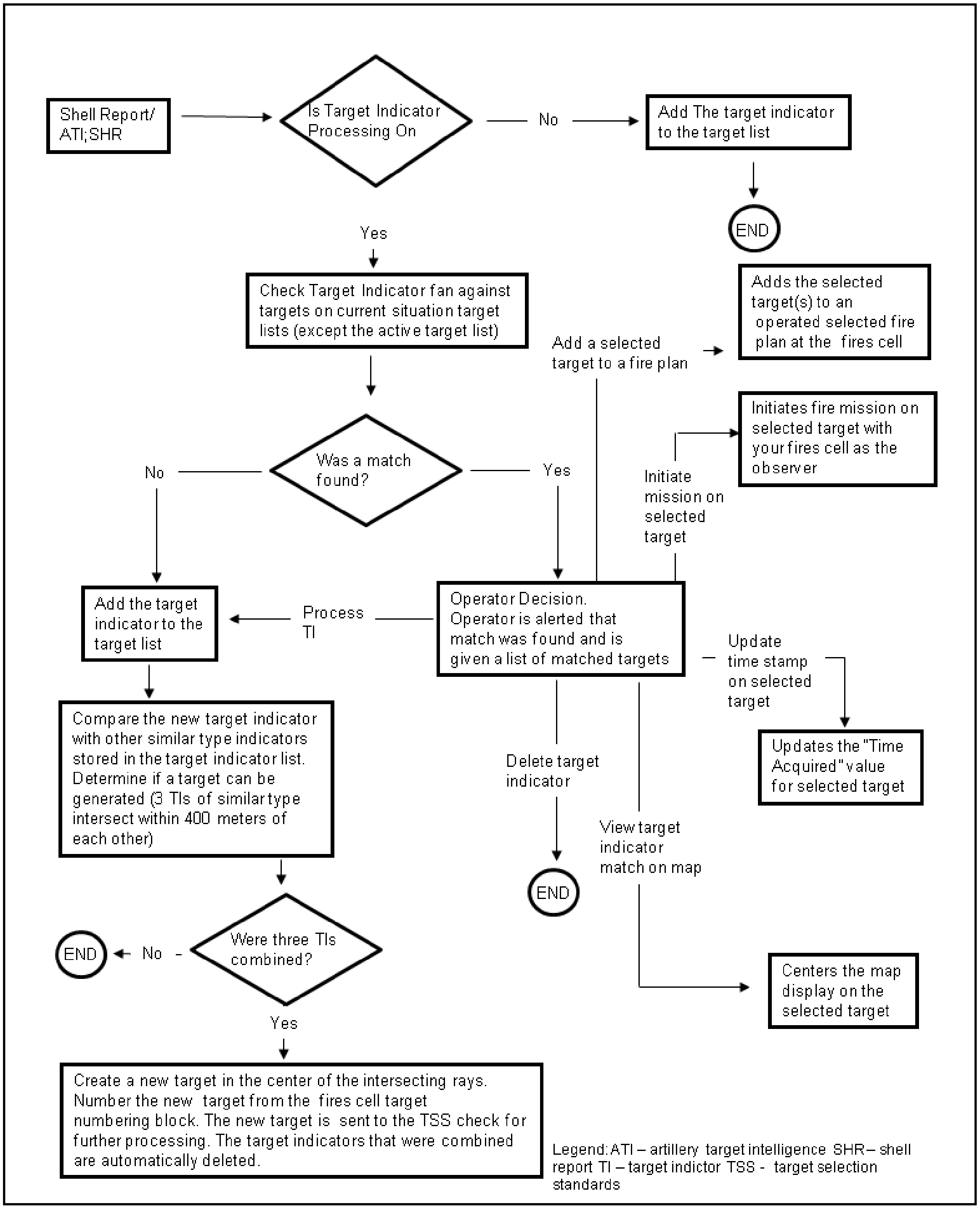

Figure A-3. Target indictor processing

SUSPECT TARGET PROCESSING

A-11. Suspect targets represent target information that has not passed target selection standards. This section discusses how AFATDS processes suspect targets after target selection standards failure. The operator may turn suspect target processing "on" or "off". When it is turned off, all suspect targets are simply added to the suspect target list with no further processing. When it is turned on, AFATDS evaluates each suspect target against other suspect targets to combine the new suspect target with an existing suspect target and generate a target with a better target location error and more current date time group. AFATDS applies the following considerations when identifying suspect targets for combination and applying the associated target data for the ”new” (combined) target:

- Decay Time. Only suspect targets that have not passed their decay date time group are considered for combination.
- Target Type. Only targets with a similar type will be considered for combination. For example, an “Artillery, Unknown” target would not be combined with a “Building, Metal” target.
- Target Size. The target size and TLE, for the new or extracted suspect targets, is used to determine overlap. If an overlap exists between the new target and a single existing target and the overlap area meets or exceeds the operator established percentage of overlap required, then the two targets match. Basically, the overlap percentage tells AFATDS how close two targets must be (considering the area and TLE of each target) in order to combine them. Figure A-4 shows some examples of this comparison.

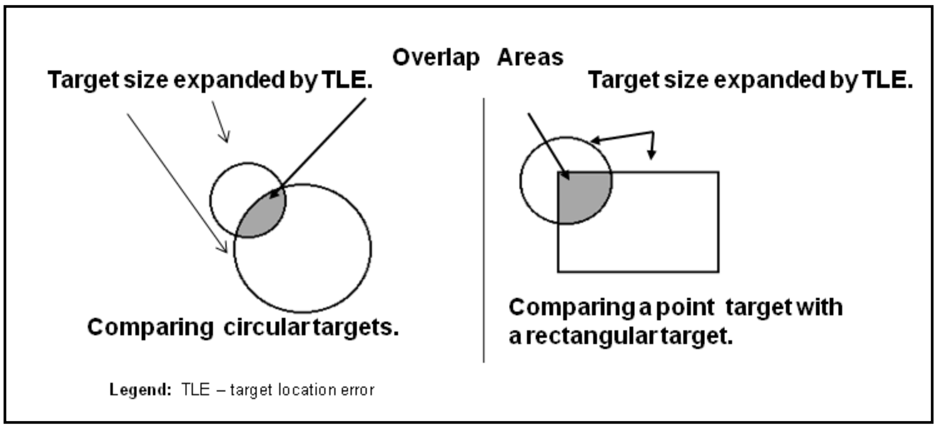

Figure A-4. Suspect target overlap

A-12. If multiple overlaps exists between the new suspect target and two or more existing suspect targets and each overlap area meets or exceeds the operator established percentage of overlap required, then the following rules apply:

- The suspect target with the greater degree of similarity to the new suspect target is combined with the new suspect target.
- If the degree of similarity is the same, the suspect target with the greater degree of overlap with the new suspect target is combined with the new suspect target.

A-13. When two targets are combined, the new target is sent to target selection standards for further processing. Both of the “parent” targets (the two that were combined) are removed from the suspect target list. The operator may specify the “Overlap %” to be used by the AFATDS when considering targets for combination. A larger percentage (like 75%) will result in fewer, but more accurate combinations than a smaller percentage (like 25%). As with the target indicator list, the operator may decide to have the suspect target list purged of targets when their decay time date time group is passed. To do this, simply select the “automatically purge” option on the suspect target list window. Finally, the operator may see the targets on the suspect target list that was generated by AFATDS (these will be the targets that have a “yes” in the “Combined” column of the list). There is an option to “not combine” a combined target if desired. Figure A-5 on page A-8 illustrates multiple target overlap.

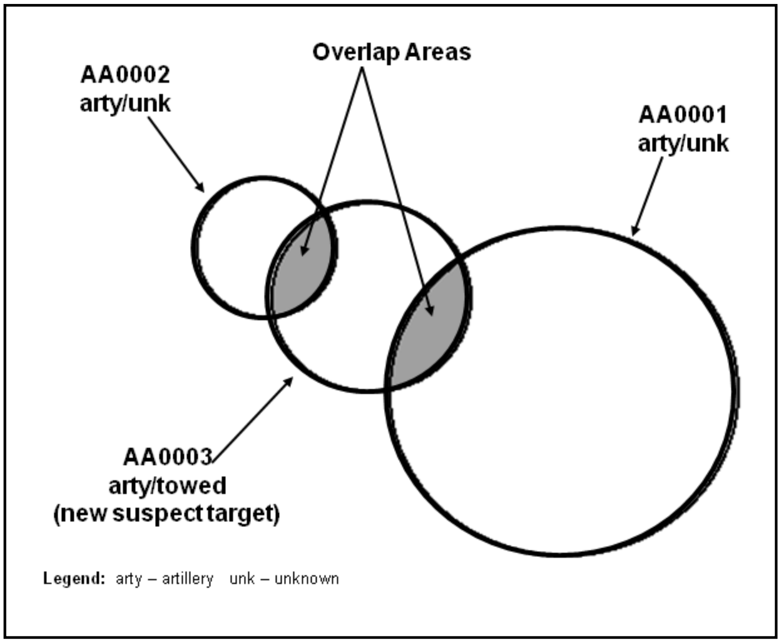

Figure A-5. Multiple targets overlap

TARGET DAMAGE ASSESSMENT

A-14. Target damage assessment is a function of AFATDS that allows target disposition to be entered by the observer on the mission fire request after the attack of a target. Target damage assessment can be flagged in the commander's guidance of AFATDS, causing targets to remain active until disposition is received from the observer for the particular target. Target damage assessment in AFATDS guidance is target type specific. Therefore, it is not very useful in the determination of target damage assessment on a particular target generated from the suspect target processing function. Flagging an individual target type in the target management matrix will cause that target type to remain active until the reporting sensor sends a mission fire request for that target that contains target damage. A target generated by the suspect target or target indicator processing function will have the processing AFATDS station as the observer, which seldom has eyes on the target.

FILE MAINTENANCE AND TARGET PURGING

A-15. File maintenance for suspect target and target indicator processing consists of purging targets that are no longer valid. This can be done manually or automatically. Manually deleting targets from the suspect target or target indicator list involves selecting the target list requiring maintenance and reviewing individual targets, and validating or deleting individual targets from the target list. The most effective method of performing file maintenance is to set target purging to automatic, which automatically purges targets based on the target decay time established in the target selection standards. This task is accomplished by selecting "Automatic Purge" on the suspect target or target indicator list.

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Appendix B
Friendly Fire Log

This appendix discusses the secondary mission of the AN/TPQ-36 and AN/TPQ-37 weapons locating radars to support friendly fire elements. It also provides an example of the radar friendly fire log and instructions for filling it out.

FRIENDLY MISSION

B-1. The secondary mission for the weapon locating radars (WLR) is to support friendly firing elements. For the AN/TPQ-36 and AN/TPQ-37 WLRs, this mission is performed only when the commander deems it absolutely necessary. The reason is that the secondary mission takes the radars away from its primary mission of locating hostile weapons. In addition, it exposes the WLR’s location to hostile electronic warfare systems. In the friendly fire mode, WLRs can provide accurate actual burst, datum-plane, or predicted-impact location data. The data allows firing elements to determine registration corrections for nonstandard conditions. Because the AN/TPQ-36 and AN/TPQ-37 WLRs cannot radiate in friendly fire mode and hostile fire mode at the same time, the commander must issue specific guidance as to when and how friendly fire mode will be used. This determination is made based on METT-TC, availability of observers, and the ability of the supported unit to meet the requirements for accurate fire. The AN/TPQ-53 WLR can perform hostile and friendly missions simultaneously.

FRIENDLY FIRE LOG

B-2. The radar operator uses DA Form 5310 (Radar Friendly Fire Log) to record all the pertinent data for any type of friendly fire mission. The form is designed for use with either a digital or a conventional fire direction center. However, it is not necessary to use DA Form 5310 when friendly fire missions are transmitted by digital means, since all messages transmitted and received by the radar are recorded on the radar’s printer. DA Form 5310 should be used anytime a friendly fire mission is sent by voice or when the printer is not operational. See figure B-1 for the radar friendly fire log.

RADAR FRIENDLY FIRE LOG
(TO BE USED WITH WEAPON LOCATING RADARS)
For use of this form see ATP 3-09.12; the proponent agency is TRADOC.

SECTION I. MESSAGE TO OBSERVER

BLOCK				
1	RADAR MODE (CHECK APPROPRIATE BOX) ☐ AA: ARTILLERY AIRBURST ☒ AI: ARTILLERY IMPACT PREDICT ☐ MI: MORTAR IMPACT PREDICT ☐ AD: ARTILLERY DATUM PLANE ☐ MD: MORTAR DATUM PLANE			
	UNIT 3/A/1-30 Field Artillery		DATE-TIME GROUP 070600JUN15	
2	UNIT LOCATION	EASTING 13555	NORTHING	ALTITUDE 605 (M ☒ / F)
3	TARGET LOCATION END POINT	EASTING 11250	NORTHING	ALTITUDE 605 (M ☒ / F)
4	MAXIMUM ORDINATE (HEIGHT ABOVE BATTERY ALTITUDE) 198.4 (M / F)		QUADRANT ELEVATION 181	
	TARGET NUMBER AA7000			
5	BUFFER NUMBER (CHECK ONE) X 2			
6	FRIENDLY FIRE SEARCH FENCE (FFSF) ERROR MESSAGES (CHECK APPROPRIATE BOX[ES]) ☐ END POINT BEYOND 50 KM (Q-53) 30 KM (Q-37)/24 KM (Q-36) 10 KM (Q-50) ☐ END POINT INSIDE 3 KM (Q-37)/1 KM (Q-36)/500 M (Q-53/Q-50) ☐ TRAJECTORY INCORRECT ☐ END POINT ABOVE MAXIMUM ORDINATE ☐ LIMITED TRACK COVERAGE ☐ END POINT ABOVE MAXIMUM ____ (M / F) ☐ END POINT BELOW MINIMUM ____ (M / F)			

SECTION II. MESSAGE TO FDC

(CHECK APPROPRIATE BOX)
☐ AT MY COMMAND ☒ REQUEST SPLASH ☐ READY TO OBSERVE
☐ REQUEST SHOT ☐ REPORT WHEN READY ☐ ONE GUN

SECTION III. RECORD AND REPORT TO FDC

ROUND NUMBER	EASTING a	NORTHING b	ALTITUDE (M / F) c	METHOD SENT d	TIME SENT e	ACKNOWLEDGED f
1	10950	49950	605	Voice	0605	yes
2	11500	49250	[illegible]	Voice	0615	yes
3	11350	49720	605	Voice	0625	yes
4	11250	49500	605	Voice	0635	yes
5						
6						
7						
8						
9						

REMARKS	TIME END OF MISSION RECEIVED	MISSION OBSERVED BY
	0645	Rank Last Name

DA FORM 5310, JUN 2015 THIS FORM SUPERSEDES DA FORM 5310-R, AUG 84 APD LC v1.00

Figure B-1. Radar friendly fire log example

B-3. Before the radars can conduct a mission in friendly fire mode, specific information must be stored in the friendly fire buffer of the radar computer. Instructions are listed in table B-1 below for completing DA Form 5310.

Table B-1. Instructions for DA Form 5310

Section 1 Message to Observer		
Block 1: Sub-mode type of mission Unit Designation: Date time group (DDHHMMJUN15, DD - is the day, HHMM - is the time, JUN – month, 15 – year).		
Block 2: Battery location (easting, northing, and altitude).		
Block 3: Registration point location (easting, northing, and altitude).		
Block 4: Maximum ordinate (max ord) of the trajectory to the nearest meter from the appropriate tabular firing table (max ord above gun). Quadrant elevation or fall angle from the Tabular Firing Table G (see figure B-2 below.) Target number.		
Block 5: Select a buffer.		
Block 6: Check the appropriate boxes for error messages.		
Section 2 Message to Fire Direction Center		
Always check boxes to request shot and splash from fire direction center. **(BTRY) fire direction center (FDC)** Request shot and splash, out. **(BTRY) FDC** (BTRY), Shot, over. **(RADAR)** (BTRY), Shot, out. **(BTRY) FDC** (BTRY), Splash, over. **(RADAR)** (BTRY), Splash, out. **(RADAR)** (BTRY FDC) Did hit grid __________, over. **(BTRY) FDC** Did hit grid _________, out		
Section 3 Record and Report to Fire Direction Center		
By round report did hit data by location (easting, northing, and altitude). (Battery FDC) this is (Radar), ready to observe, request shot and splash, over.		
Remarks	Record time end of mission	Radar operator rank & name
BTRY – battery FDC - fire direction center		

CHARGE 4G | TABLE G | FT 155-AM-2

SUPPLEMENTARY DATA | PROJ, HE, M107 FUZE, PD, M577

1	2	3	4	5	6	7	8	9	10	11	12	13
RANGE	ELEV	PROBABLE ERRORS					ANGLE OF FALL	COT ANGLE OF FALL	TML VEL	MO	COMP SITE FOR ANGLE OF SITE	
				FUZE M564								
		R	D	HB	TB	RB					+1 MIL SITE	-1 MIL SITE
M	MIL	M	M	M	SEC	M	MIL		M/S	M	MIL	MIL
0	0.0	4	0				0		316	0	0.000	0.000
500	25.4	4	0				26	39.4	308	0	0.001	0.000
1000	51.7	5	1	1	0.06	18	53	19.1	301	13	0.002	-0.002
1500	78.9	7	1	2	0.07	19	83	12.3	296	30	0.005	-0.005
2000	107.0	8	1	2	0.07	21	113	9.0	290	54	0.010	-0.010
2500	136.2	9	2	3	0.08	22	146	6.9	285	87	0.017	-0.016
3000	166.6	11	2	4	0.08	23	180	5.6	280	129	0.026	-0.024
3500	198.4	12	2	5	0.09	25	217	4.6	276	181	0.038	-0.035
4000	231.7	14	3	7	0.09	26	256	3.9	272	244	0.054	-0.049
4500	267.0	16	3	8	0.10	27	297	3.3	268	319	0.075	-0.068
5000	304.5	18	4	10	0.11	29	341	2.9	265	410	0.103	-0.093
5500	344.9	20	4	12	0.11	30	389	2.5	262	517	0.142	-0.125
6000	389.0	23	5	14	0.12	32	441	2.2	259	647	0.199	-0.171
6500	438.3	25	5	17	0.13	33	500	1.9	257	804	0.287	-0.238
7000	495.5	28	6	20	0.14	35	566	1.6	255	1002	0.445	-0.347
7500	566.7	31	7	24	0.15	37	647	1.4	254	1269	0.831	-0.553
8000	677.4	34	8	32	0.17	39	768	1.1	255	1714		-1.191
8000	886.8	37	9	46	0.19	38	977	0.7	260	2597		2.216
7500	996.2	35	10	53	0.21	35	1078	0.6	263	3042	-1.849	1.576
7000	1066.3	32	10	57	0.21	32	1142	0.5	265	3309	-1.461	1.367
6500	1122.3	30	9	60	0.22	30	1193	0.4	267	3508	-1.301	1.255
6000	1169.8	27	9	63	0.22	27	1238	0.4	268	3665	-1.208	1.183
5500	1211.6	24	9	65	0.22	24	1279	0.3	269	3793	-1.146	1.131
5000	1248.5	21	8	67	0.23	21	1317	0.3	269	3897	-1.101	1.092
4500	1280.7		8	69	0.23	18	1355	0.2	269	3980	-1.066	1.061

Figure B-2. Table G

Appendix C

Field Exercise Mode and Embedded Training

This appendix provides a brief overview of the field exercise mode and embedded training procedures. It also provides instructions on how to develop and implement scenarios.

APPLICATION OVERVIEW

C-1. Field exercise mode (FEM) and embedded training are off-line, separate computer programs that function with the WLR's existing operational programs to allow the system to be used in a training mode. These off-line training programs provide the operator with realistic operating scenarios for the purpose of evaluating and improving proficiency. The scenarios include real-time simulation of hostile and friendly weapons fire.

C-2. FEM and embedded training increases the radar operator's ability to process targets and communicate with other net subscribers. It allows radar operators to perform all normal mission processing functions. However, when the simulation is running, the WLR will not radiate when the radiate switch lamp is pressed. FEM and embedded training allows the section chief to develop scenarios that present radar operators with a high density of hostile and friendly targets and conduct real or simulated communications with other net subscribers.

SECTION AND PLATOON TRAINING

C-3. FEM and embedded training provides a vehicle for training a WLR section or an entire platoon in either a garrison or a field environment. The system's ability to simulate digital communications or communicate with actual tactical systems makes this possible. An individual section can train by itself and the scenario will replicate all digital communications. The section can send their acquisitions to a fires cell, which provides the opportunity to train the target processing section and targeting team members while providing realistic training for all WLR operators.

GUNNERY TEAM TRAINING

C-4. The entire gunnery team can benefit from the use of FEM and embedded training during rehearsals, before the conduct of actual operations, or during command post exercises, live-fire training, and maneuver exercises. These programs allow the development of scenarios that reflect the actual tactical situation or exercise event list. This facilitates training of the entire gunnery team and provides the capability to conduct fire support and technical rehearsals for actual situations.

SCENARIO DEVELOPMENT

C-5. The common steps for developing training using FEM and embedded training are:

- Step 1. Determine training goals (mission requirements for the exercise). These should include:
  - Mission-essential task list requirements.
  - Mission training plan requirements.
- Step 2. Analyze resources
- Step 3. Establish RDO data from the commander's targeting criteria in the operations order.
- Step 4.Identify simulation targets to be used on the basis of the scenario and targeting criteria.
- Step 5. Develop a plan for updating and changing the tactical situation and mission.
- Step 6. Develop the scenario target tables using the detailed procedures for selecting and loading target data into the FEM and embedded training.

Embedded Training

C-6. Planning and developing the embedded training scenario and simulation data should be a team effort with the intelligence section and fires cell. The team should follow these steps:

- Step 1. Review each phase of the tactical operation to determine and record probable enemy mortar, artillery, and rocket firing locations.
- Step 2. Sequence the phased firing locations into a simulation target table for the WLR.
- Step 3. Load the target table using the scenario generation screen.
- Step 4. The operator selects "ADD" on this screen and enters each target separately with the following elements of data— weapon type**,** weapon velocity, QE, weapon location, impact location, firing interval, time on and time off, and volley.
- Step 5. After entering each individual target, the operator must wait for a response to determine acceptability of the data entered. If the program accepts the target with no response, the data becomes a part of the scenario target file.
- Step 6. These targets are entered, numbered, and time sequenced.
- Step 7. After all targets from the target table have been entered and accepted, the scenario is saved for use in the training exercise.

Note. This is a lengthy and time-consuming process, and it must have the support and cooperation of the command elements to achieve success.

Implementing the Scenario

C-7. The command or exercise control element determines the commander's priority guidance for WLR, search data, cueing agents, and cueing guidance. These determinations are based on:

- Scenario.
- METT-TC.
- Intelligence estimates.
- Target value analysis.
- High-payoff target list.
- Commander's targeting guidance.
- Targeting priorities.
- FEM target overlay.
- FEM target table.

Cueing Agent

C-8. Cueing agents are designated and provided a copy of the scenario target tables by the command or control element. They must be able to identify the cueing criteria required and the method they are to use to cue the WLR section. When the cueing criteria are met during the exercise, the cueing agent sends the cue command to the WLR.

Weapon Locating Radar Section

C-9. After receiving the initial search data and commander's priority guidance, the radar section chief prepares the WLR to support the mission. When notified by the fires cell, the radar operator turns on the appropriate simulation targets. The radar operator waits for the cue command from the cueing agent. When the radar operator receives the cue command, the operator turns on the radar transmitter, processes the targets, and transmits them digitally to the fires cell.

Counterfire Cell

C-10. The counterfire cell processes targets received from the WLR according to the commander's criteria established in their tactical fire direction system. The commander's criteria should conform to the exercise guidance issued by the fires cell. Normally, fire missions are generated for priority targets. Artillery target intelligence reports are sent to the command posts or the targeting element where they will be entered in the tactical fire direction system.

Firing Element

C-11. Upon receipt of fire missions, the firing unit generates firing commands (live or dry fire).

> ***Note.*** Use of the FEM and embedded training during live-fire exercises can generate fire missions in an impact area if the proper search and zone data is entered into the WLR computer. The AFATDS must be set up to accept simulated targets or any acquisition sent from embedded training. Other targets will provide useful training for the fires cell.

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Appendix D

Mask Considerations

Appendix D explains how to calculate the track volume for the WLRs. It is intended for use by the radar section leader to enable him to determine whether a WLR site will provide enough track volume to locate hostile firing positions. It also provides procedures for correcting insufficient track volume.

DEFINITIONS

D-1. The following definitions are associated with mask and see figure D-1:

- Flat mask is a single mask angle or a default value in the radar when no mask angle is entered into the radar computer. Mask angl**e** is the vertical angle from the radar to the top of the mask or screening crest at a given azimuth. The lowest mask angle and the highest mask angle are calculated and entered in the radar's computer during initialization.
- Mask variation is the difference between the lowest and highest mask angles.
- Vertical scan is the maximum vertical scanning capability of a specific type of radar. Vertical scan for the AN/TPQ-36 radar is approximately 80 mils with all scanning frequencies enabled. Each frequency that is disabled results in a loss of approximately 2.5 mils of vertical scan.

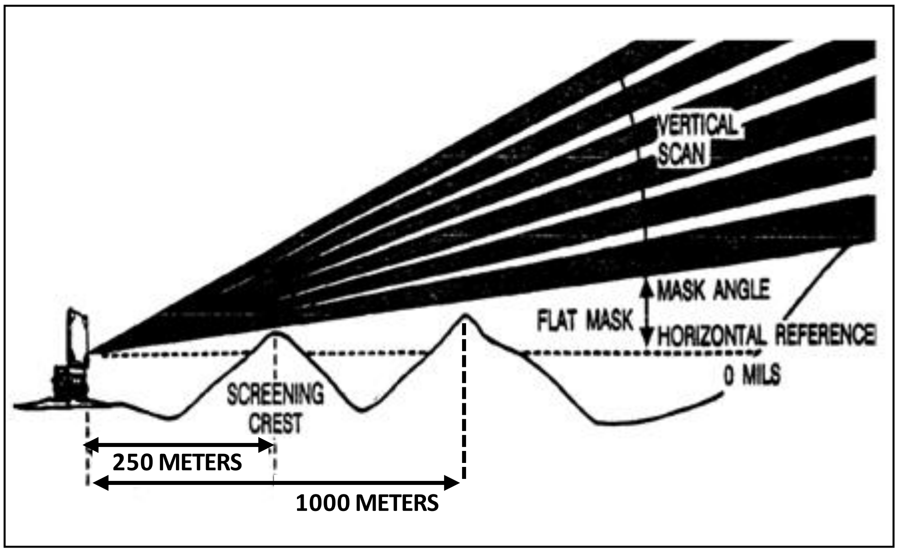

Figure D-1. Masking characteristics

TRACK VOLUME

D-2. The amount of track volume is determined by the vertical scan of the radar and the amount of vertical scan that is lost because of the terrain contour, or screening crest in front of the radar. From any radar position, the altitude of the screening crest along the terrain contour in front of the position will vary across the radar's sector of search. This varying screening crest altitude results in varying mask angles along the terrain contour. The variance between the smallest mask angle and the largest mask angle reduces the radar's vertical scan.

D-3. Sometimes this reduction is enough that the available scan coverage is less than the 50 mils track volume required by the radar to extrapolate weapon locations. When the track volume is reduced below 50 mils, the radar section leader must compensate by artificially adjusting the low mask angle, narrowing the search sector, or by moving the radar to a new position that provides adequate track volume.

D-4. Whenever possible, an aiming circle or other accurate measuring device should be used to determine mask angles along the terrain contour. These measured mask angles are entered in the computer to depict the terrain contour. Otherwise, the radar will radiate into hill masses that are higher than the flat mask default in the radar computer. Automatic terrain following can be used when digital terrain is available for the location of the radar site. This capability allows the radar section leader to compute mask angles before occupying a radar site.

TRACK VOLUME CALCULATION AND SUBSEQUENT ACTIONS

D-5. The radar search fence starts at the lowest mask angle entered in the radar computer (or at the flat mask default value if no lowest mask angle is entered) and goes to the highest point of the vertical scan. The first step in calculating track volume for the radar site and search sector is to subtract the low mask angle from the high mask angle. This difference must then be subtracted from the vertical scan of the radar. The result is the track volume for the radar site. Figure D-2 shows the procedure for calculating track volume.

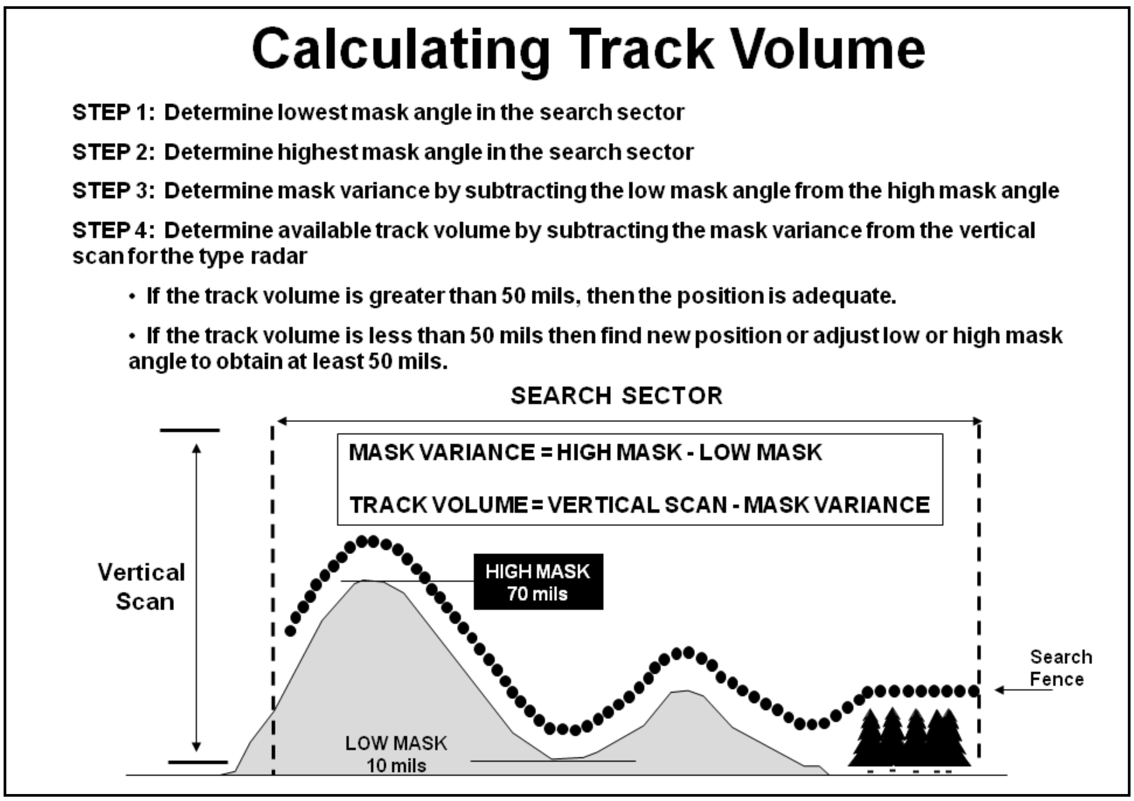

Figure D-2. Track volume

D-6. Although the ideal mask variation may be met, the maximum allowable mask variation for a WLR can be calculated by subtracting the 50 mils of track volume required for firing weapon location from the vertical scan of the radar. The maximum allowable mask variations are:

- AN/TPQ-36 – 30 mils.
- AN/TPQ-37 – 54 mils.
- AN/TPQ-50 – 395 mils.
- AN/TPQ-53 – No limitations on mask variations, however large variations very close to each other are undesirable.

D-7. Thus, any mask variation exceeding the allowable maximum variation would not allow enough track volume for the radar to determine firing weapon locations. In that event, some action must be taken to regain enough track volume to perform the radar mission. Possible actions include doing nothing, raising the low mask angle, narrowing the search sector, or moving the radar. If nothing is done, a dead space is created where projectiles cannot be detected. Figure D-3 depicts a dead space area.

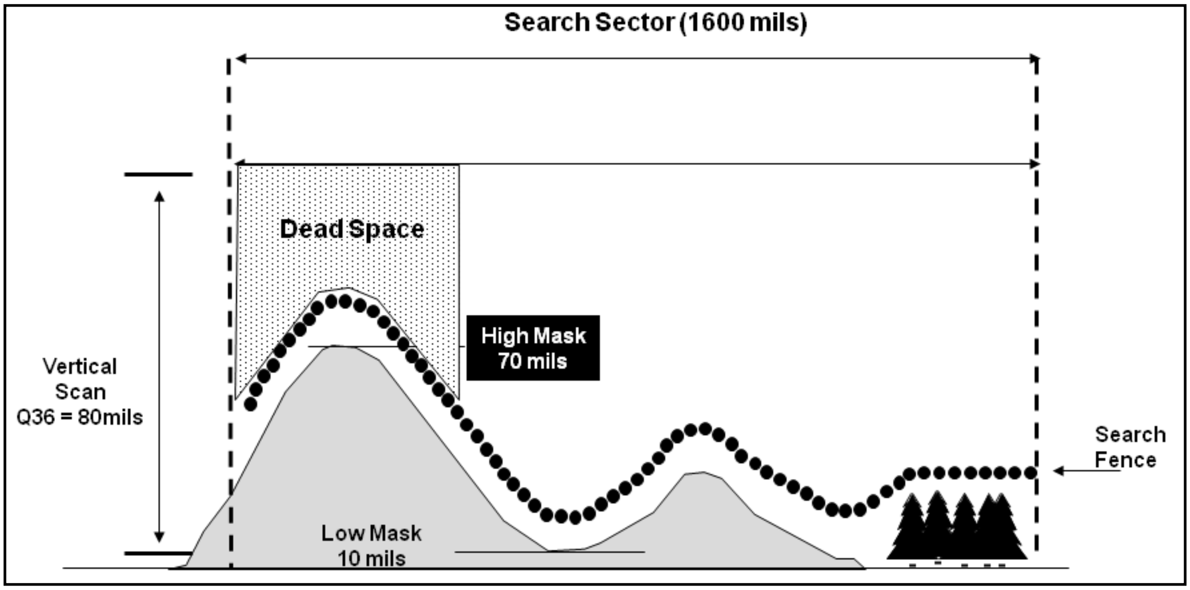

Figure D-3. Dead space area

D-8. Figure D-3 gives an example of no action taken with a mask variation of 60 mils. This allows 20 mils of track volume over portions of the search sector. This creates a dead space area. The result is an area where hostile weapons cannot be detected. Figure D-4 shows the possible adverse effects of a dead space.

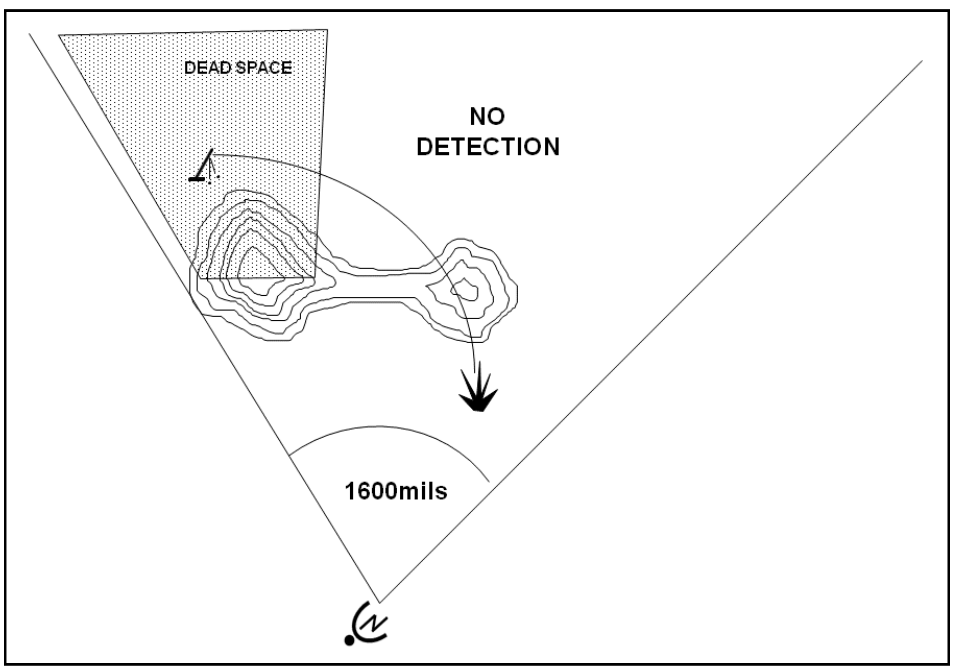

Figure D-4. Effects of dead space area

D-9. The first solution is to raise the low mask angle. This will provide enough track volume to eliminate the large dead space area. Nonetheless, this solution will produce a small dead space area under the low mask area. This may or may not be acceptable. Figure D-5 shows the result of raising the low mask angle.

Note. If WLR must occupy this position, you must adjust the mask variance in order to obtain 50 mils of track volume.

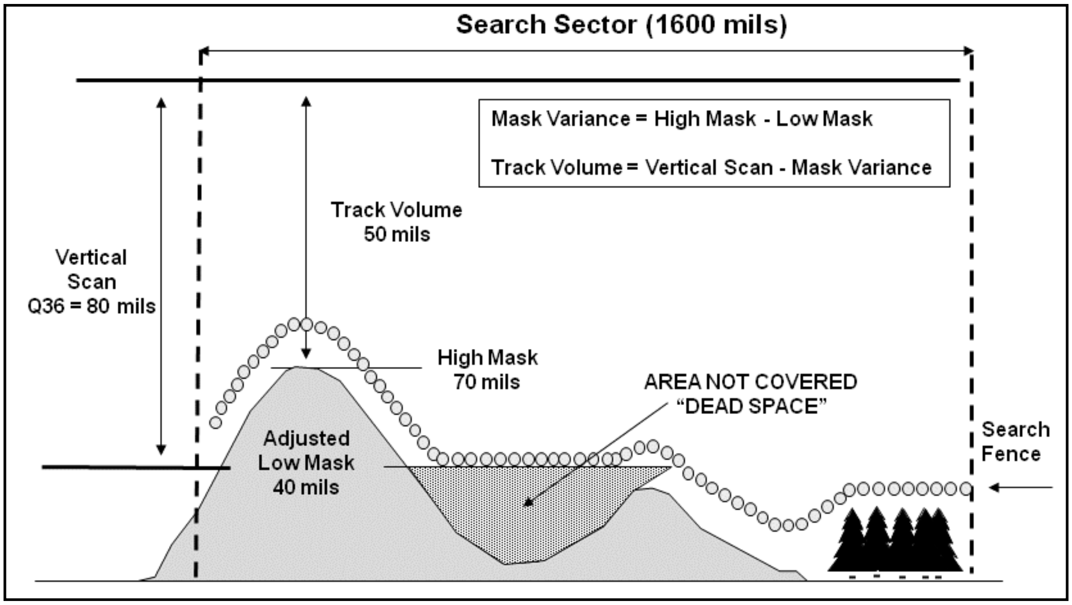

Figure D-5. Raising the low mask angle

D-10. The next solution might be to narrow the search sector or move the search sector. This will lower the mask variation and eliminate the dead space in the search sector. This still leaves an area with no radar coverage. Narrowing the search may not be acceptable based on the tactical situation. Figure D-6 depicts narrowing the search sector.

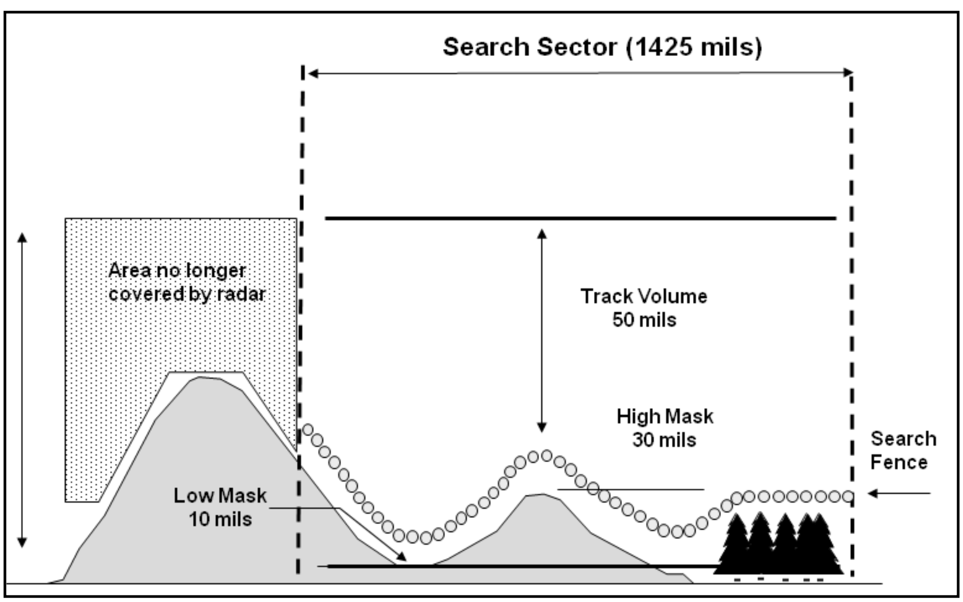

Figure D-6. Modifying the search sector

D-11. If none of these solutions are acceptable, the radar must be moved to another site to provide the required coverage. The radar section chief computes mask angles and track volume again at the new location.

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Appendix E
Support Requirements

WLRs are widely dispersed across the area of operations and require support from units that may not be familiar with the support requirements for the WLR. Appendix E outlines the support requirements.

SURVEY

E-1. Common datum and common survey is critical for successful employment of target acquisition assets as well as all other operating systems. The specific survey data required for each WLR radar system is described below:

- Survey data
  - Grid zone.
  - Site location (universal transverse mercator coordinates within 10m circular error probable).
  - Distance from near stake (radar location) to far stake (orienting point). This distance between near and far stakes should be at least 250m. The minimum distance is 100m. However, the further the distance the better the accuracy that the system will report.
  - Azimuth from near stake to far stake (0.4 mils probable error).
  - Vertical angle from near stake to far stake (0.5 mils probable error).
  - Altitude of the near stake probable error (AN/TPQ-36[10m]) & (AN/TPQ-37 [3m]).

MODULAR AZIMUTH POSITIONING SYSTEM-HYBRID

E-2. The AN/TPQ-36 and AN/TPQ-37 radars are equipped with the MAPS-H. The MAPS-H provides required survey for the radar systems. MAPS-H will be initialized using input from the Precision Lightweight Global Positioning System Receiver (PLGR). Once initialized, the MAPS-H will be continually updated by input from the DAGR, if installed. For initialization, operation, and update information refer to TM 11-6605-308-12&P.

COMMUNICATIONS

E-3. Radar operators use voice and digital communications to communicate with the supported unit. The primary method is digital communications. Radar acquisitions and mission data are transmitted digitally to the fires cell or as directed by the controlling headquarters.

E-4. The use of wire enhances communication responsiveness, security, minimizes the effects of jamming, and minimizes the possibility of threat intercept by radio direction finders.

E-5. The threat situation must be considered when planning and conducting communications. Threat electronic warfare capabilities may dictate changes in normal radar communication procedures.

Communication Networks

E-6. The radar operator establishes communication over staff channels and the command channel when directed by headquarters. However, these channels may be modified by individual units depending on command instruction and standards operations procedures.

DIGITAL COMMUNICATIONS

E-7. Digital communications addresses and authentication codes are prescribed in current cryptographic and authentication manuals. If digital communications are not available, the radar operator uses standard voice procedures to pass target information to the fires cell or as directed by standard operating procedures.

E-8. Radar systems interface digitally with all of the current field artillery digital communication systems. Computer data needed for interface is input during initialization and can be changed by use of function codes or functional displays depending on the version of the system control shelter.

E-9. The digital messages used by WLRs are divided into two groups— receive messages and transmit messages. Messages are displayed according to the priority level of the message. There are three priority levels for messages - 1 (highest), 2, and 3 (lowest). See the digital message format table for a display of which messages are received and transmitted. The radar computer can store net member data (member identifications and unit types) for up to ten receivers.

VOICE COMMUNICATIONS

E-10. When digital communications are not possible, the radar section must report targets by voice. The operator sends a voice call for fire. The radar section initiates a fire-for-effect mission with the supported fire direction center. The call for fire contains six elements. These elements are listed below in the order in which they are used. For a detailed explanation of each element, see ATP 3-09.30:

- Observer identification (or radar call sign).
- Warning order (for example, fire for effect).
- Target location (grid of target).
- Target description (for example, threat artillery).
- Method of engagement.
- Method of fire and control.

Note. Although direction is not one of the six elements of the call for fire, it is transmitted by the radar section as part of the initial call for fire. Radar observer direction is always reported as 6400 mils.

COMMUNICATIONS EQUIPMENT

E-11. Each radar section operates two tactical frequency modulation radio nets as directed by the controlling headquarters. These radios are equipped with speech secure devices for secure voice transmissions. In addition, some sections are equipped with an enhanced position locating system (EPLRS) or the FBCB2. The EPLRS and the FBCB2 provides near real time, jam resistant, secure data distribution and communications, identification, position location, navigation aid, and automatic reporting for operating forces.

ADMINISTRATION

E-12. When the radar section is attached to a unit, the unit of attachment is responsible for providing routine personnel and administrative support. The radar section's parent unit forwards mail, pay, and routine distribution to the unit of attachment's headquarters for delivery to the radar personnel.

CLASS I

E-13. The TAP assigned to a FAB receives field feeding support from the forward support company assigned to the FAB. The TAP assigned to a battalion in a brigade combat team receives field feeding support from the forward support company designated to support the FA battalion.

CLASS III

PETROLEUM, OILS, AND LUBRICANTS

E-14. The TAP assigned to a FAB receives class III support from the forward support company assigned to the FAB. The TAP assigned to a FA battalion in a brigade combat team receives class III support from the forward support company designated to support the FA battalion.

E-15. The consumption rates for AN/TPQ-36 ,AN/TPQ-37, AN/TPQ-50, and the AN/TPQ-53 are:

- AN/TPQ 36
  - Fuel consumption. 1.07 gallons per hour.
  - Fuel capacity. 12.5 gallons.
- AN/TPQ 37
  - Fuel consumption. 5.37 gallons per hour.
  - Fuel capacity. 43 gallons.
- AN/TPQ 50
  - Fuel capacity. 5 gallons
  - Fuel consumption. .42 gallons per hour
- AN/TPQ 53
  - Fuel consumption. 5.37 gallons per hour.
  - Fuel capacity. 43 gallons.

FIELD MAINTENANCE

E-1. Field maintenance is on-system maintenance, repair and return to the user, including maintenance actions performed by operators. It is most often performed by the owning or support unit using tools and test equipment found in the unit. Field maintenance is not limited to simply remove and replace actions. Field maintenance allows for repair of components or end items on or near the system if the maintainers possess the requisite skills, proper tools, proper repair parts, references, and adequate time. Field maintenance is always repair and return to the user and includes maintenance actions performed by operators.

E-2. Within the FAB, field maintenance for items other than radar systems is performed by the assigned forward support company. Field maintenance of radar systems is performed by the TAP (operator maintenance) and by the field maintenance section of the assigned support battalion of the corps. The radar section chief supervises operator maintenance within the TAP.

E-3. Within the FA battalion of the brigade combat team, field maintenance is conducted by the radar sections (operator maintenance) and by the forward support company.

SUSTAINMENT MAINTENANCE

E-4. Sustainment level maintenance is performed by the national-level maintenance providers (including the U.S. Army Materiel Command and installation directorate of logistics maintenance activities).

REPAIR PARTS

E-5. The logistics concept for WLR systems does not place any unusual demands on the supply system. The mandatory parts list governs the supply of radar peculiar items. Each section deploys with its mandatory parts list. The supported unit provides common expendables and the parent unit forwards system-peculiar expendables to the section on an as required basis.

SECURITY

E-6. Because of its small size, the radar personnel cannot provide for its own security in a tactical situation. For this reason, the radar section must fall under the security of an adjacent unit or be augmented with personnel and weapon systems to provide security. The deployed WLR section falls under the responsibility of the supported unit for these functions.

METEOROLOGICAL DATA

E-7. Meteorological (MET) data is crucial to the accuracy of hostile weapon location and friendly fire data. The MET parameters entered during radar initialization affect radar performance by correcting for atmospheric refraction. They are also important in estimating the effect of wind, temperature, and density on the projectile's trajectory. However, the greatest effect on the accuracy of hostile and friendly weapon impact prediction is caused by wind.

E-8. The MET data required for the AN/TPQ-36 and AN/TPQ-37 differ in the MET data elements used by the radar. The AN/TPQ-36 only uses wind speed and direction from the target acquisition MET whereas the AN/TPQ-37 requires relative humidity and temperature from the target acquisition MET along with barometric pressure from the computer MET.

E-9. Current software extrapolates temperature, pressure, and relative humidity back to the radar's altitude assuming the standard atmospheric lapse rate and constant relative humidity. However, the most accurate correction for refraction is obtained from the temperature and relative humidity measured at the surface as near the radar as possible. Therefore, the header and line 00 of the most current target acquisition MET message should be used to obtain temperature and relative humidity. The wind speed and direction should also be taken from the target acquisition MET. The MET line used for wind speed and direction is determined by the altitude of the radar and the altitude of the expected detection area based on screening crest, and the difference between the radar and MET station altitudes. Generally speaking, the line used should provide the wind speed and direction approximately 1000m above the radar altitude. Barometric pressure is also required. This comes from the corresponding computer MET. The line used from the computer MET must correspond to the same altitude as the line used from the target acquisition MET. If you use line 11 of the target acquisition MET (900 - 1000m), you would then use line 3 of the computer MET (1000m).

E-10. It is also necessary to determine the MET station altitude. This can be determined from the header line of either the target acquisition MET or the computer MET. Station height in the header of both MET messages is entered in tens of meters and is equal to altitude.

Appendix F
Tools and Procedures

There are numerous factors that must be considered when employing target acquisition assets within the area of operations. The purpose of this appendix is to provide a collection of formats, procedures, and ideas that have been collected from combat training centers. Most of the forms and procedures can be modified to meet WLR section changing requirements.

EMPLOYMENT CHECKS

F-1. Employment of WLRs are integrated into the commander's intent and guidance and synchronized with the scheme of maneuver. Troop leading procedures and the radar section chief's involvement in the planning process are essential for successful radar employment and responsive counterfire. The radar section chief requires usable tools to facilitate mission preparation and execution. The ability to issue clear warning orders, achieve time lines, conduct pre-combat checks and inspections, and initiate priorities of work are essential to any successful mission.

F-2. Troop leading procedures provide the required guidance to focus the radar section's preparation for and execution of the radar employment plan. Using standard troop leading procedures helps clarify mission requirements, fix responsibilities, and make the best use of available time. Troop leading procedures provide a vehicle for preparing the section for operations.

F-3. The troop leading procedure is the process by which the WLR section chief receives a written or verbal RDO. The process is instinctive and a routine way of thinking for any WLR section chief. It is imperative that the section chief conducts a mission brief with section personnel that is adequate and flexible for combat's preparation. The troop leading procedures listed below are suggestions for effective time management:

- Receive the mission RDO (situation map, operations graphics, execution matrix):
  - Perform mission analysis; assess enemy (intelligence cell and WLR section).
  - Review critical tasks, positioning guidance, planned zones (intelligence cell and WLR section).
  - Prioritize pre-combat checks first, then inspections (WLR section chief).
  - Prepare a timeline (WLR section chief).
  - Conduct risk assessment and management.
- Issue a concise warning order to your section, (WLR section chief):
  - Section mission.
  - Positioning guidance.
  - Threat and counter measures.
  - Pre-combat inspections.
  - Timeline.
- Make a tentative plan, (WLR section chief):
  - METT-TC. Logistics resupply.
  - Survivability measures.
  - Section rehearsals, (site occupations or displacements, defense).
- Initiate movement, (WLR section):
  - Conduct pre-combat checks.
  - Perform rehearsals.

  - Issue movement order and risk assessment.
- Conduct reconnaissance, (WLR section):
  - Select sites to support mission requirements.
  - Perform or coordinate for survey requirements.
  - Make site assessments for survivability and site defense.
- Complete the plan, (WLR section chief):
  - Report site assessments to intelligence cell.
  - Prepare a verbal order for section.
  - Develop route strip maps, preliminary site defense plan.
  - Develop battle-tracking overlays for reconnaissance vehicle and shelter.
- Issue the order (WLR section chief):
  - Focus on movement, positioning, site defense, and survivability measures.
  - Be clear and concise.
  - Require a back brief from the section chief and senior radar operators. This should be a section huddle and each member must understand their role.
- Supervise (WLR section chief):
  - Final pre-combat inspections.
  - Crew drill rehearsals for occupations, site, defense, shelter, and chemical, biological, radiological, and nuclear operations.
  - Execution.

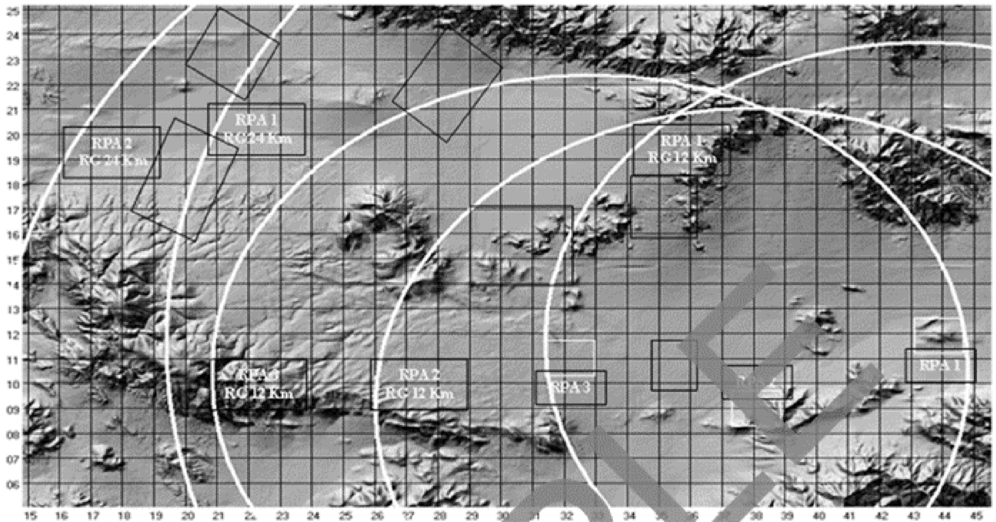
F-4. Troop leading procedures can and should be modified to facilitate planning and execution of each mission. The steps do not have to happen sequentially and may happen simultaneously as METT-TC dictates.

Note. Planning time for a given section should not exceed one-third of the total planning time available. This one-third lasts from receipt of the order from higher headquarters through back briefs from unit immediately following issuance of the operations order.

WLR EXECUTION MATRIX

F-5. The formal RDO is a valuable tool that can be used as is, or modified to reflect the phases or events of an operation. Figure F-1 on page F-3 shows another example of a modified RDO and execution matrix (example includes a terrain graphic).

Note. The WLR execution matrix is a classified document once completed with mission data.



Enemy: Remnants of the 173d MRR(-) opposite 3 BCT to est. an MRB(-) sized security zone to delay & attrit the BCT and gain time & space for follow on forces from the 71st MRR(-) to build a main defensive area.

Mission 3BCT, 52ID, attacks in zone to destroy 25th MIBR & to seize key terrain vic NV 2224 & NV 2319 to protect the flank of the 52ID Main Effort (1BCT).

EFST: Disrupt effective RAG fires against TF 1-12 in its SBF position, TF 2-34 during breaching operations, and TF 1-14 during their assault on OBJ MEADE.

EFAT: Destroy 18 of 36 RAG cannon systems.

Security Assets Inf Sec / A 1-12 TF Survivabilty Assets: None

Q37 Coverage: Fires Bde provides coverage once TF 1-12 LDs

Q36 Mvmt Plan: O/O Follows TF 1-12

PCC/PCI: CASEVAC, React to CBRN attacks **Risk Management** Accidental/Tactical Risk Conducted at section level.

	Phase I 181800L	Phase II TF 1-12 crosses LD	Phase III Obj Meade secured		
RDR Loc.	21601952	17082055	15902233		
AOS	5200	5200	4800		
CUE Schd	IVY	IVY	IVY		
Ready to Cue	181800L	190800L	O/O		
Alt Loc.	500 mtrs	N/C	N/C		
L Sector	-800	N/C	N/C		
R Sector	800	N/C	N/C		
Digital Freq.	FH 109	N/C	N/C		
Voice Freq.	FH 107	N/C	N/C		

Name	Type	Purpose	Trigger	Grids					
Raider 2	CFZ	Protection of TF 1-12 in SBF, Breach & Obj Patton	TF 1-12 Crosses PL PIG	5123,5523, 5519, 5119	OFF	ON	ON		
Dragon 1	CFZ	Protection of TF 1-14 in Obj Meade	TF 1-14 Crosses PL Rat	5816, 6216, 6221, 5721	OFF	ON	ON		
Thunder 1	CFFZ	Facilitate the Destruction of enemy FA systems in the RAG.	181800L	5318, 6215, 6210, 5310	ON	ON	ON		

Figure F-1. Combined RDO and execution matrix

QUICK REFERENCE POSITION SELECTION WORKSHEET

F-6. The following is an example of a quick reference position selection worksheet. This tool may be used with other IPB products in the selection of WLR positions. See figure F-2 for example worksheet.

Quick Reference Position Selection Worksheet	
METT-TC	
Mission:	Know the critical fire support tasks, the maneuver commanders force protection priorities and understand the scheme of maneuver.
Enemy:	Know the enemy situation, most recent spot reports, template chemical strike locations, field artillery scatterable mines, obstacles, and avenues of approach.
Terrain:	(Weather), Know the terrain so it can be used to your advantage. Use it to mask your movement, provide cover and concealment, screening crests etc. Additionally, know the severely restricted terrain areas, slope and masking problem areas. Remember that heavy rains and high winds degrade operations.
Troops:	Know the concentration of friendly troops in the area of operations, coordinate support for Class VIII, CBRN, and enemy prisoner of war.
Time:	Consider the time available for reconnaissance, coordination, movement, occupation and site preparation.
Civil:	Consider the WLR's impact on local populace and security of section personnel.

Site Assessment Checklist	
Does this position optimize the probability of detection, verification, and location methodology of enemy indirect fires?	
Considering the doctrinal phases and focus of enemy fires, does this position provide the optimum aspect angle?	
Does the position maximize the usage and cover and concealment?	
Can the position be defended?	
Does this position provide good electronic warfare counter measures through the use of screening crest, tunneling, and mask angle)?	
Can the adjacent unit provide security?	
Remarks:.	

Figure F-2. Quick reference position selection worksheet

Note. Monitor the appropriate frequencies to receive intelligence updates. Always prepare a site assessment for each site selected and back brief the fire cell and section. Plan and mark the routes to and from WLR sites, make a strip map, and provide copies to section personnel.

POSITIONING AND MOVEMENT SYNCHRONIZATION CHECKLIST

F-7. The WLR positioning and movement synchronization checklist in figure F-3 on page F-5 can be used in conjunction with the RDO, execution matrix, and the quick reference position selection worksheet to assist in synchronizing the WLR with the fire support plan.

Radar Positioning and Movement Synchronization Checklist	
Required information/location	Known Data
Situation map of enemy indirect weapon systems	
Objective areas, (where the enemy will focus indirect fires)	
Enemy avenues of approach and other known threat data	
Main avenue of approach	
Recon avenue of approach	
Template of chemical strikes, field artillery scatterable mines	
Terrain restrictions: modified combined obstacles overlay	
Movement/positioning terrain limitations, Restricted or severely restricted terrain, slope and screening crest	
Visibility problem areas, intervening crests, optimum aspect angle/range considerations	
Communication considerations, range, retransmission, reporting channels, digital links	
Survivability measures, (adjacent unit coordination, electronic warfare considerations	
Remarks:	

Figure F-3. Radar position and movement synchronization checklist

Note. Known data develops the WLR common picture.

VOICE OPERATOR REGISTRATION PROCEDURE

F-8. The following is an example of how to perform a radar registration using voice communications—

- Key players are battalion (BN), battery (BTRY), fire direction center (FDC), and radar.
- **BN FDC** (BTRY FDC), this is (BN FDC), Performs (type) (radar) registration at grid _______, altitude ______, over.
- **(BTRY) FDC** Perform (type) (radar) registration at grid ________, Altitude _________, out.
- **(BTRY) FDC** (Radar) this is (BTRY FDC), prepare to copy, over.
- **(RADAR)** (BTRY FDC) This is (radar), prepare to copy, out.
- **(BTRY) FDC** (Radar) this is (BTRY FDC), observe (type) (Impact Elevation: mean point of impact, High burst, datum plane) registration, at grid _______, altitude _______, max ord _______, QE________ (specify if m or ft), and HEIGHT OF BURST_______ (if a high burst or datum plane), firing unit grid _______, firing unit altitude ______, report ready to observe, over.

- **(RADAR)** Observe (type) registration at grid _______, altitude _______, max ord ______, QE _________, and height of burst ______ (if necessary), firing unit grid _______, firing unit altitude ________, will report ready to observe, out.
- **(RADAR)** (BTRY FDC) this is (radar), ready to observe, request shot and splash, over.
- **(BTRY) FDC** Request shot and splash, out.
- **(BTRY) FDC** (BTRY), Shot, over.
- **(RADAR)** (BTRY), Shot, out.
- **(BTRY) FDC** (BTRY), Splash, over.
- **(RADAR)** (BTRY), Splash, out.
- **(RADAR)** (BTRY FDC) Did hit grid __________, over.
- **(BTRY) FDC** Did hit grid _________, out.

F-9. At this point, repeat the last six steps until the necessary number of good rounds have been observed by radar. BN FDC will end mission—

- **(BN FDC)** (Radar) and (BTRY FDC), this is (BN FDC), End of mission, over.
- **(RADAR)** End of mission, out.
- **(BTRY) FDC** End of mission, out.

Note. Height of burst for radar registrations is the height of registration point plus height of ground above sea level (The height of the registration point above sea level). Radar will forward did hit information for each to BN and or BTRY FDC via normal mode of communication.

VOICE OPERATOR ADJUST FIRE MISSION

F-10. The following is an example for performing a radar adjust fire mission using voice communications:

- **(RADAR)** (BN FDC), this is (radar), hostile weapon (number and type of possible) firing, at grid _______, Altitude _______, Time ________, over.
- **BN FDC** Hostile weapons firing at grid _________, out.
- **BN FDC** (BTRY FDC), this is (BN FDC), conduct adjust fire mission with (radar), at grid _________, altitude _________, over.
- **(BTRY) FDC** Conduct (radar) fire mission, at grid __________, altitude ___________, out.
- **(BTRY) FDC** (Radar), this is (BTRY FDC), authenticate _________, over.
- **(RADAR)** I authenticate __________, out.
- **(BTRY) FDC** (Radar), this is (BTRY FDC), max ord________, QE_________, ALTITUDE _________. Request ready to observe, over.

Note. (BTRY) will also have to provide grid and altitude of firing BTRY (center gun) if radar does not have this information already.

- **(RADAR)** MAX ORD _______, QE _______, ALTITUDE __________ out. (At this point, wait while Radar loads their computer with information.)
- **(RADAR)** (BTRY FDC), this is (radar). Ready to observe, request shot and splash, 1 round, over.
- **(BTRY) FDC** Request shot and splash, 1 round, out. (wait for guns to fire)
- **(BTRY) FDC** (BTRY), shot, over.
- **(RADAR)** (BTRY), shot, out.
- **(BTRY) FDC** (BTRY), splash, over.
- **(RADAR)** (BTRY), splash, out.
- **(RADAR)** (BTRY FDC), did-hit grid is _________, over.

- **(BTRY) FDC** Did-hit grid _______, out. (At this point, BTRY makes corrections.)

Note. Subsequent adjust rounds may be required.

- **(RADAR)** (BTRY FDC), this is (radar), fire for effect, request shot and splash, over.
- **(BTRY) FDC** Fire for effect, request shot and splash, out.

F-11. Radar will follow the mission, like a friendly fire mission, to compile did-hit information at this point:

- **(BTRY) FDC** (BTRY FDC), shot, over.
- **(RADAR)** (BTRY FDC), shot, out.
- **(BTRY) FDC** (BTRY FDC), splash, over.
- **(RADAR)** (BTRY FDC), splash, out.

F-12. Repeat the previous 4 steps until (BTRY) completes rounds and radar logs did-hit information:

- **(BTRY) FDC** (Radar), this is (BTRY FDC), rounds complete, over.
- **(RADAR)** (BTRY FDC), rounds complete, out.
- **(RADAR)** (BTRY FDC), this is (radar). End of mission, over.
- **(BTRY) FDC** (Radar), end of mission, out.

F-13. Radar will then forward did-hit information to BN and or BTRY FDC via normal mode of communications.

Joint Airlift Inspection Record/Checklist

F-14. DD Form 2133, (Joint Airlift Inspection Record/Checklist) is used by the Military Airlift Command for the inspection of equipment to be loaded on military aircraft.

Risk Management Worksheet

F-15. The risk management worksheet provides a starting point to logically track the process of assessing hazards and risks. It is used to document risk management steps taken during the planning, preparation, and execution of training and combat missions and tasks. See ATP 5-19 for additional information on risk management and worksheet.

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Appendix G

Rocket Artillery and Mortar Warn

This appendix describes rocket artillery mortar (RAM) Warn techniques. RAM Warn provides the commander and the supported unit with an early warning capability of imminent rocket artillery or mortar attack to enable the affected personnel the ability to protect themselves from the effects of the attack.

OVERVIEW

G-1. RAM Warn provides Soldiers, staff personnel, and operators with automated warnings and enhanced alerting capabilities. RAM Warn integrates the BCT organic sensors, commercial off-the-shelf warning systems and communication devices, and the forward area air defense (FAAD) workstation in the Air Defense Airspace Management (ADAM) element. The RAM Warn capability is integrated into the ADAM element architectures to provide warning to forces and assets as determined by the commander. Without detection capabilities and mission command, RAM Warn is inoperable. RAM Warn integrates and operates with Army battlefield command systems (ABCS) for battlefield situational understanding. The RAM Warn system is generally designed to be used in fixed and semi fixed sites, however there may be situations in a fluid, maneuver, decisive action event where the RAM Warn system may be employed.

G-2. RAM Warn is a dynamic, modular, and readily-transportable system that provides incoming RAM attack warnings. RAM Warn supports the BCT's force protection mission by performing the following:

- Issuing guidance and orders.
- Delivering audible and visual alerts.
- Maintaining situational understanding.
- Supporting dynamic, joint-forces integration operations.

G-3. RAM Warn sensor links consist of line-of-sight radio transmitters at sensor locations connected through a retransmission site, if necessary, to the ADAM element operating a FAAD computer with counter rocket artillery and mortar Warn services software. RAM Warn communication devices can cover up to 15km distance between the sensors and the ADAM element; or 30km with the use of relay equipment. The transmitter and associated equipment is assigned to each sensor and a retrans section, and each section is responsible for the employment and maintenance of their equipment. Figure G-1 shows RAM Warn architecture.

G-4. . Each section that has the RAM Warn system will have a mesh network consisting of Rajant BreadCrumb® LX4 radios that serves as the backbone of the Warn system. RAM Warn architecture offers two primary capabilities readily to adapt to components that are modularized, standardized, and reconfigurable. The two capabilities provide the following functions:

- Links the RAM Warn Alert Cell Nodes, the FAAD, and sensors (radars) through a uniquely modular, dynamic system.
- Computes the incoming point of impact information and selects the appropriate alert cell node towers within the impact zone to notify.

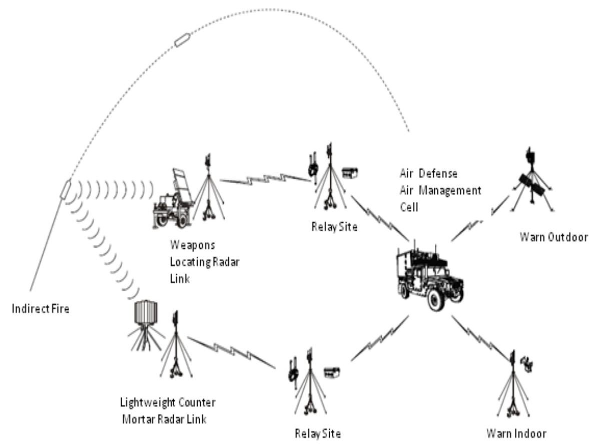

Figure G-1. RAM Warn architecture

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WARNING

Never deploy the system close to overhead wires or lower lines. Failure to comply with these warnings could result in death or serious injury.

CAUTION

Antennas emit high-frequency electromagnetic radiation. Always maintain safe distance from and never stand in front or in the direct path of an operationally configured antenna. Failure to observe this caution can result in minor to moderate injury.

MISSION COMMAND

G-5. The mission command system consists of the FAAD which is located with the ADAM element in the fires cell. The FAAD provides overall mission command for the RAM Warn system by integrating software, sensors and the warning systems. The FAAD interfaces with the Army mission command network by interfacing with the air and missile defense workstation. (AMDWS)

G-6. The fires cell and ADAM personnel share responsibility for the planning, coordinating and synchronizing of RAM Warn operations for the BCT. The FA battalion has responsibility for the emplacement of sensors and relays.

G-7. The fires cell plans, coordinates, and synchronizes sensor coverage with the ADAM element and FA battalion. The fires cell must advise the commander and ensure the primary mission of the WLRs is to the counterfire fight.

G-8. The ADAM element plans and coordinates the emplacement of the warning systems and develops and executes the RAM Warn architecture. The ADAM element coordinates with the fires cell for WLR cover to support the RAM Warn task. The ADAM element emplaces the indoor and outdoor RAM Warn antenna masts and radios at the area which the commander wishes to have warning capability for enemy indirect fire.

G-9. The FA battalion coordinates its WLR coverage with the BDE fires cell, and executes the BCT sensor coverage plan. The FA battalion also plans, coordinates, and employs retrans teams and emplaces sensor and retransmission RAM Warn masts and radios as required. The retrans teams belong to the FA BN and the primary purpose is to retransmit FM communications from the firing batteries to the BN FSE, coordination must be made and the commander advised if RAM Warn retransmission will interfere or affect retransmission of the BN's fires communication.

G-10. To initiate an automatic warn it takes two or more sensors acquiring the same round. Due to the unique limitations of each radar and location requirements for each radar system listed previously, careful planning must be done to place radars in a position for redundant coverage of the proposed defended area. In certain instances it may not be possible to have all radars in a position to perform counter fire and RAM Warn simultaneously. Counterfire, Targeting, and Intelligence Officers in concert with S3's and key planners must perform detailed analysis of the enemy weapons systems, high pay off targets and tactics to ensure that sensor coverage for the counterfire mission is not degraded or inform the commander of the coverage issues if a RAM Warn mission is directed.

SITE SELECTION

G-11. Site selection is a general site survey to determine the location of the outdoor antenna and a site path profile to determine the RF signal path profile.

G-12. The RF signal path profile must be performed before installing the equipment and determines the best location of the antenna, based off the height and obstacles in front of the antenna. Once conducted, provide a copy of the data to the installation team.

G-13. When conducting a general site survey in an urban environment, consider placing the antenna(s) on top of area buildings and structures for better line of sight to the receiving wireless systems.

G-14. In a non-urban environment, identify terrain features that provide a clear line of sight between the antennas, such as hilltops or areas with few or short trees. To maximize performance, personnel should always try to mount the antenna in a location where a direct line of sight exists. If the obstruction is not exceptionally high, aim both antennas near the top of the obstruction.

G-15. The wireless system also supports installation in non-line of sight conditions. Position the antenna as high as possible and obtain a satisfactory multipath RF signal by directing each antenna towards a structure in sight of both communicating wireless systems.

G-16. The placement of antennas is important to minimize interference during transmission. If using a mast, select a location with level ground. Once the mast is erected, ensure the mast is level.

WARNING

Maintain a minimum distance equal to twice the height of the antenna between power lines and antennas.

G-17. RAM Warn tower positions are critical and should allow for overlapping audio and wireless network transmission. Place outdoor alarms no greater than 1000m apart to ensure proper coverage. The maximum audio radius for the outdoor alarms is 500m. The maximum audio radius for the outdoor alarms is 500 m.

The maximum distance recommended between for the audio warning towers is 3-5 kilometers. When doing an outdoor site survey for the RAM Warn outdoor alert cell nodes, allow at least 30 ft from the center mast to any pedestrian pathway and roadways to allow for the guy line installation. Personnel should always choose a location free of overhead obstructions and ensure the site is free of items causing electrical or RF interference. The area should be as flat as possible and free from debris. If there are rocks and gravel present, attempt to clear the area so the stakes are embedded in solid soil. Figure G-2 and figure G-3 on page G-5 show the different parts of the outdoor mast assembly for the alert cell node and the recommended coverage area.

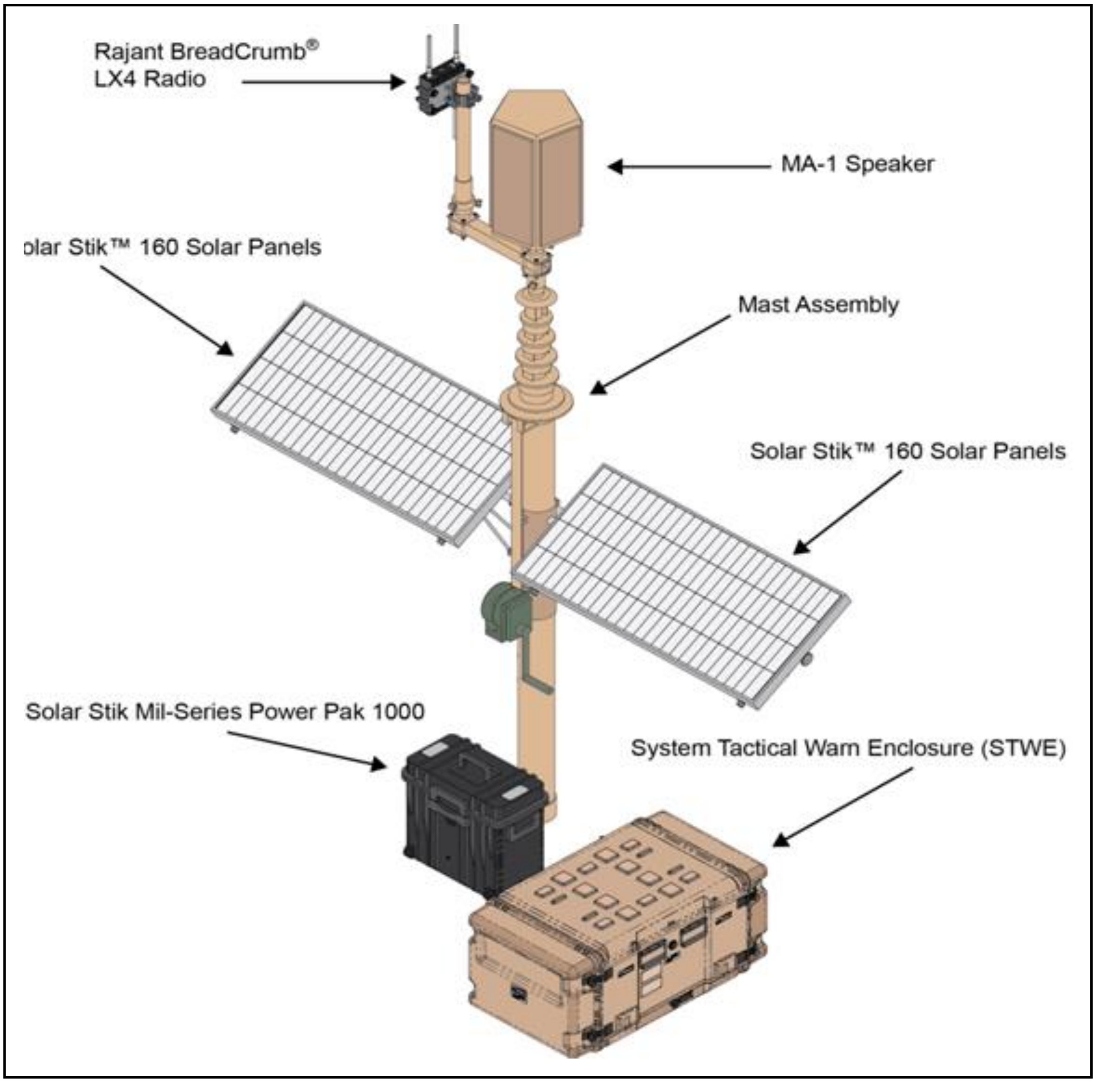

Figure G-2. Outdoor mast assembly

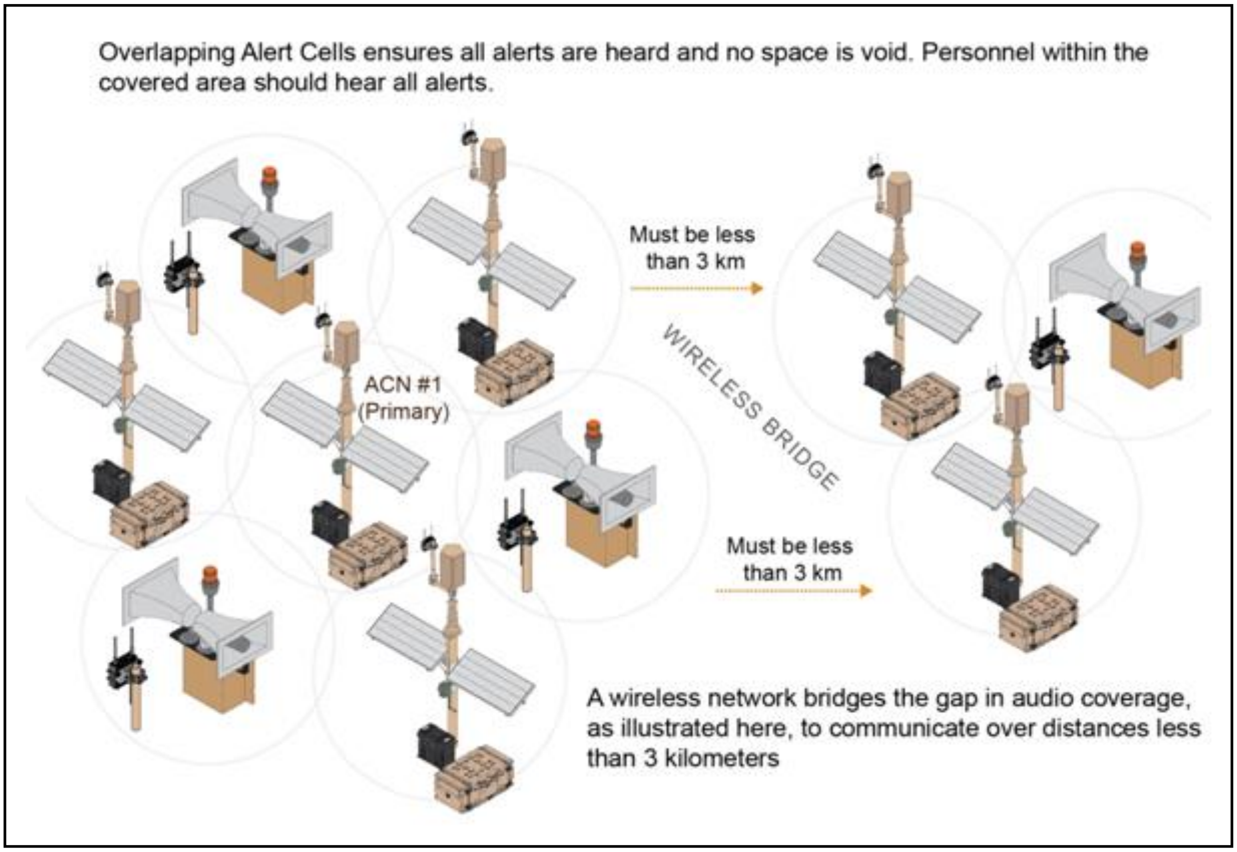

Figure G-3. Recommended coverage area

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Glossary

SECTION I – ACRONYMS AND ABBREVIATIONS

ADAM	air defense airspace management
AFATDS	Advanced Field Artillery Tactical Data System
ATG	antenna transceiver group
ATIZ	artillery target intelligence zones
ATP	Army techniques publication
BCT	brigade combat team
BN	battalion
BTRY	battery
CFFZ	call for fire zone
CFZ	critical friendly zone
CZ	censor zone
DA	Department of the Army
DIVARTY	division artillery
DTED	digital terrain elevation data
EW	electronic warfare
FA	field artillery
FAAD	forward area air defense
FAB	field artillery brigade
FDC	fire direction center
FEM	field exercise mode
FLOT	forward line of own troops
FM	field manual
FS	fire support
FSCOORD	fire support coordinator
FSO	fire support officer
ft	feet
IPB	intelligence preparation of the battlefield
JP	joint publication
km	kilometer
LCMR	lightweight counter mortar radar
m	meters
MAPS-H	modular azimuth positioning system - hybrid
max ord	maximum ordinate
MDMP	military decisionmaking process
MEG	mission essential group
MET	meteorological
METT-TC	mission, enemy, terrain and weather, troops and support available, time available, civil considerations
MHz	megahertz
mm	millimeter
mph	miles per hour
NCO	noncommisioned officer

OCG	operations control group
OCS	operations control shelter
PDG	power distribution group
QE	quadrant elevation
RAM	rocket artillery mortar
RDO	radar deployment order
RPAS	radar position analysis system
TAP	target acquisition platoon
TLE	target location error
UAS	unmanned aircraft systems
U.S.	United States
WLR	weapon locating radars

SECTION II – TERMS

counterfire

Fire intended to destroy or neutralize enemy weapons. (JP 3-09)

target acquisition

The detection, identification, and location of a target in sufficient detail to permit the effective employment of weapons. Also called TA. (JP 3-60)

critical friendly zone

An area, usually a friendly unit or location, which the maneuver commander designates as critical to the protection of an asset whose loss would seriously jeopardize the mission. (FM 3-09)

References

All URLs accessed on 18 June 2015.

REQUIRED PUBLICATIONS

These documents must be available to the intended users of this publication.

ADRP 1-02, *Terms and Military Symbols*, 2 February 2015.

JP 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 8 November 2010.

RELATED PUBLICATIONS

These documents contain relevant supplemental information.

JOINT PUBLICATIONS

Most joint publications are available online: http://www.dtic.mil/doctrine/new_pubs/jointpub.htm.

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JP 3-60, *Joint Targeting, 31 January 2013.*

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Most Army doctrinal publications are available online: https://armypubs.us.army.mil/doctrine/Active_FM.html.

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PRESCRIBED FORMS

DA Form 5310, *Radar Friendly Fire Log*.

DA Form 5957, *Radar Deployment Order*.

Unless otherwise indicated, DA forms are available on the Army Publishing Directorate (APD) web site (www.apd.army.mil); DD forms are available on the Office of the Secretary of Defense (OSD) web site (www.dtic.mil/whs/directives/infomgt/forms/formsprogram.htm).

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ATP 3-09.12
24 July 2015

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