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for the Behavioral and Social Sciences

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Concept Analysis for Simulation Modifications Methodology

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Micro Analysis and Design, Inc.

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13. ABSTRACT *(Maximum 200 words)*

The Close Combat Test Bed (CCTB) was designed to provide an environment for simulation and evaluation of future combat systems. This research report provides a methodology for developing functional specifications for modifications to the CCTB--the Concept Analysis for Simulation Modifications (CASM) methodology. CASM methodology is iterative and detail oriented. It provides guidance for forming teams to develop functional specifications. The methodology is divided into three major sections that discuss the background for the modification, what the modification will consist of, and how the modification will be tested. The CASM methodology provides a structure so that functional specifications are in the proper detail and format and prepared in a timely manner so that modifications can be properly implemented.

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Training Simulation

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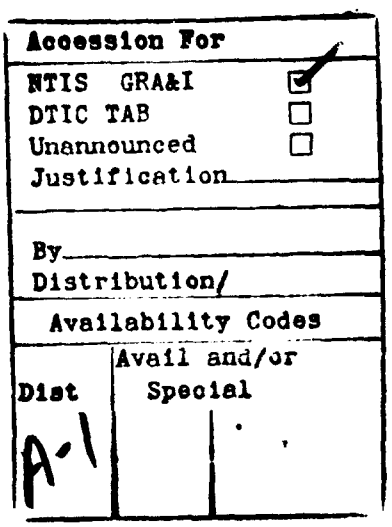
FOREWORD

To ensure that the U.S. Army's future tanks can be used efficiently by soldiers, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) investigates human performance issues related to prototype systems. Simulation of new systems and technologies provides ARI researchers with a medium for addressing human performance issues such as usability, training, workload, and personnel requirements during the earliest stages of weapon system development.

This research report was prepared under the science and technology task entitled "Training Requirements for the Future Integrated Battlefield." ARI's involvement in research on future battlefield conditions supports two Memoranda of Understanding (MOU). One of the MOU between ARI and the U.S. Army Armor Center and School on research in future battlefield conditions was signed on 12 April 1989. The second, between ARI and the Tank Automotive Command on the combat vehicle command and control system, was signed on 22 March 1989.

This report presents a methodology for developing specifications for modifying the Close Combat Test Bed (CCTB), formerly referred to as the Simulation Networking-Developmental Facility, or SIMNET-D. It provides guidance to the users of the CCTB for developing a specification document that communicates the changes they want made to the CCTB hardware developers, software developers, operators, and managers.

This effort has been briefed to the Commanding General of Fort Knox, the Director of the U.S. Army Armor School Directorate of Combat Developments, representatives from the Directorate of Training and Doctrine, representatives from the Direcotrate of Total Armor Readiness, representatives from Project Manager Tank, the U.S. Army Training and Doctrine Command System Manager SIMNET, representatives from the U.S. Army Armaments Research, Development and Engineering Center, and representatives from Project Manager Training Devices.



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CONCEPT ANALYSIS FOR SIMULATION MODIFICATIONS METHODOLOGY

EXECUTIVE SUMMARY

Requirement:

To provide a methodology for developing specifications to modify the Close Combat Test Bed (CCTB).

Procedure:

The methodology developed (Concept Analysis for Simulation Modifications--CASM) is iterative in nature, detail oriented, and accounts for the abilities required to produce a specification. Anyone who wants to modify the CCTB or use it to change or test new ideas within the CCTB can use the CASM. The methodology is aimed at the CCTB engineers, developers, and investigators who will be working with modifications to CCTB. The CASM methodology is broken down into three major sections. The first provides high-level perspective and background information for the modification. The second details the modifications required of CCTB, and the last section provides the investigation plan that will be used to evaluate the modification.

Findings:

Producing specifications is detail oriented and iterative and various skills are required for the specifications to make sense and be feasible. The CASM methodology points this out and when followed ensures that users of the methodology will produce a comprehensive specification.

Utilization of Findings:

The CASM methodology is being delivered to the CCTB to ensure that new specifications will be in the proper detail and format and will be prepared in a timely manner so that the modifications can be properly implemented. These findings were briefed to the Commanding General of Fort Knox, the Director of the U.S. Army Armor School Directorate of Combat Developments, representatives from the Directorate of Training and Doctrine, representatives from the Directorate of Total Armor Readiness,

representatives from Project Manager Tank, the U.S. Army Training and Doctrine Command System Manager SIMNET, representatives from the U.S. Army Armaments Research, Development and Engineering Center, and representatives from Project Manager Training Devices.

CONCEPT ANALYSIS FOR SIMULATION MODIFICATIONS METHODOLOGY

CONTENTS

CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

CONTENTS (Continued)

CONCEPT ANALYSIS FOR SIMULATION MODIFICATIONS METHODOLOGY

INTRODUCTION

This methodology will help you develop specifications for making changes to and conducting evaluations in Close Combat Test Bed (CCTB).[1] This introduction is intended to help familiarize you with the nature of the methodology, with the specifications produced using it, and, to a more limited degree, with CCTB. The Introduction has been divided into the following sections:

- Scope of the Concept Analysis for Simulation Modifications (CASM) Methodology
- The Scope of CCTB
- Audience for the CASM Methodology
- The Nature of the Specifications Developed Using the CASM Methodology
- Audience for the Specification
- Overview of the Specification Content
- Overview of the Specification Process
- Resources for Developing the Specification

If you just want to familiarize yourself with the methodology, you can read only the Introduction and skim the rest of the document. You may also want to look at Appendix A, which provides a sample specification. If you are going to develop a specification or part of a specification, you should read the Introduction, the Preparation Process section, and the sections addressing the parts of the development process you will be participating in.

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[1]The CCTB was formerly referred to as the Simulation Networking-Developmental Facility, or SIMNET-D. For clarity and continuity the term CCTB will be used throughout this document to refer to the facility.

Scope of the Concept Analysis for Simulation Modifications Methodology

The purpose of the Concept Analysis for Simulation Modifications methodology is to provide an approach to developing specifications for changes to CCTB. These changes will normally be made when you want to use CCTB to evaluate new concepts. These concepts may include things such as the addition of a new sensor to a tank, the introduction of an entirely new weapon system such as a forward air defense system, or changes to the command and control workstations in the Tactical Operations Center. These concepts may also be more abstract and include things such as the evaluation of new operational procedures or training methods or comparisons of different combat force structures and tactics. Within the methodology, these concepts are also referred to as systems.

Regardless of the nature of the concept, you can use this methodology to develop specifications that provide the CCTB hardware developers, software developers, and operators with the information they need to understand, implement, and test the changes.

As shown in Figure 1, developing specifications is only one step in using CCTB for evaluating new concepts. As a result, this methodology does not cover all aspects of concept evaluation. Before implementing this methodology, you should make sure that the following steps have occurred:

1. You should understand the charter and operating procedures of the CCTB.

2. A concept and the general goals for evaluating it have been defined. An example might be:

   "To determine the utility of new battlefield data gathering and display technologies for enhancing command and control of tank company operations."

3. An organization or group of organizations has decided to sponsor the evaluation and has secured the resources to do so.

4. Key decision makers within the organization(s) responsible for directing the evaluation effort have been identified and empowered.

5. CCTB has been identified as an appropriate environment for evaluating the concept or key aspects of it.

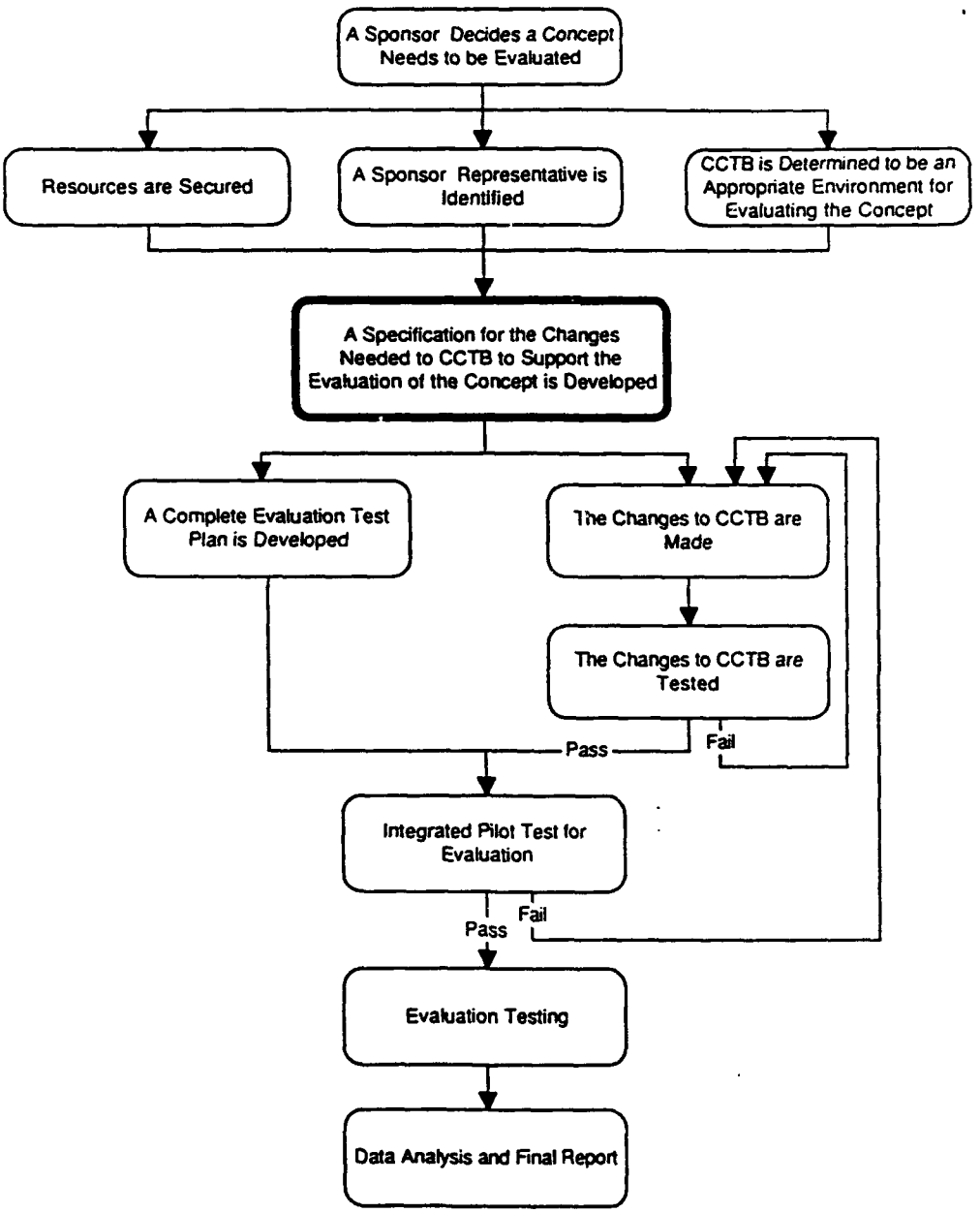

Figure 1. Process for evaluating a concept in CCTB

CASM methodology to develop specifications for modifying CCTB. By following this methodology, you will end up with a detailed description of any modifications to be made, descriptions of the testing to ensure the modifications were made correctly, and an initial plan for performing the overall concept testing.

The Scope of CCTB

CCTB provides a flexible testbed for soldier-in-the-loop evaluations of new concepts within a simulated battlefield environment. It allows the concepts to be evaluated using multiple crews under tactically relevant conditions. It allows these evaluations to be performed at relatively low costs by providing selective fidelity[3] within the simulated environment. In general, CCTB is most useful for evaluating the following:

- The effects of the soldier-in-the-loop on overall system or unit performance (e.g., actual use of alternative or enhanced communications technologies on the battlefield)
- Battlefield interactions within and between crews (e.g., workload sharing), and within and between units (e.g., alternative company tactics to take advantage of new technological capabilities)
- Battlefield interactions between soldiers and crew station technologies (e.g., the use of heads-up displays)

CCTB is not good for evaluating:

- The operational performance characteristics of new technologies (e.g., radio frequency scrambling capabilities, weapon system accuracy)
- Highly skilled, environment or technology-dependent human performance (e.g., gunnery dependant on simulated sight and gun performance, and image quality; target identification dependent on simulated image and display resolution quality)

Considering these advantages and disadvantages will help you decide whether CCTB is appropriate for the concepts you want to evaluate and how you can make the best use of it.

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[3]Selective fidelity - simulating each aspect of the system or environment at the minimum level needed to obtain the desired response from the soldiers participating in the simulation

Audience for the CASM Methodology

The CASM methodology provides guidance to people who have been tasked with integrating and evaluating new concepts within CCTB. This may include people from a wide variety of organizations and backgrounds, including

- Soldier performance researchers
- Combat developments
- Engineering research and development
- Other applied research and development
- Operations, tactics, techniques, and procedures
- System operational test and evaluation
- Training developments
- Directed research or evaluation to meet individual command needs (e.g., Armor School CG, EUCOM)

The CASM methodology accommodates this diversity in uses and users by providing a flexible approach to the development of specifications. As will be described later, the methodology proposes the use of a team approach for developing the specifications. It is this group of people specifically that the methodology is directed to.

The Nature of the Specifications Developed Using the CASM Methodology

In developing specifications using this methodology, you should keep the following in mind:

- You will probably need to develop new designs or at least modify existing designs.
- You should limit the scope of the specification to the scope of CCTB and to the minimum required to meet the goal of the concept being evaluated.
- The coverage of the specification should be comprehensive, but the level of detail may vary as appropriate for each part of the specification.
- The process of developing the specifications is iterative.

The paragraphs that follow discuss these considerations in further detail.

Design

In developing specifications for new concepts to be evaluated within CCTB, you need to develop the concepts into actual design or sets of design alternatives. A key element is a clear definition of the battlefield task which is to be accomplished. For new systems and subsystems, you may need to design soldier-machine interfaces, operating procedures, operational characteristics, and performance parameters. In some cases, the concepts will be fairly well developed and will require only minor modifications for incorporation into CCTB. In other cases, the specification development requires a fair amount of design and analysis. You may need to work out a number of assumptions and generalizations if the concept is not well developed.

Scope

Because the concepts will be implemented in a simulated battlefield environment, you will need to limit the specification in scope to the minimum required to meet the goal of the concept being evaluated. CCTB focuses on the soldier-in-the-loop aspects of the battlefield. These aspects include soldier and crew performance, command and control, and unit performance. CCTB is not intended to be a high fidelity weapon simulator or prototyping system. The specifications you develop must take these limitations of CCTB scope into account.

Coverage and Level of Detail

The use of selective fidelity within CCTB tends to make the specifications broad based and of varying detail. The tank simulators and the battlefield simulation are made up of a number of interrelated systems. The introduction of a new concept is likely to affect several systems and the effects need to be reflected in the specifications. Since selective fidelity is used, the effects and interactions will only be simulated to the degree needed to successfully integrate the concept. As a result, the requirements will be broad based and their level of detail will vary based on their contribution to developing the data required to evaluate the concept.

Iteration

The development of specifications is part of an overall iterative process for evaluating new concepts within CCTB. This process is characterized by a design-develop-test cycle that you repeat as many times as necessary. Figure 2 illustrates this cycle on several levels. For the specification development phase, the cycle includes development of design alternatives, development of a draft specification, and evaluation of the specification for feasibility and completeness. This cycle repeats until an acceptable specification is developed. When developing the specifications, you should keep in mind that:

- feedback and revision are a necessary part of the specification development process
- the specification is only one part of a larger design-develop-test cycle

Audience for the Specification

The output of this methodology is a detailed specification for the changes to be made to CCTB. The primary audience for this specification is the software developers, hardware developers, operators, and managers of CCTB. They will use the specification to make the needed changes to CCTB.

In developing specifications, keep in mind the types of information these people will need. Make your specifications complete and comprehensive. Considerations such as fault conditions, system responses to inadvertent or erroneous soldier actions, and system parameter boundaries should all be addressed in the specification. If they are not, the CCTB developers may be forced to make assumptions about the simulator behavior. These assumptions may not be consistent with your intentions.

In addition, keep in mind that CCTB developers and operators tend to be very capable and creative. If you are considering innovative or technology-stretching ideas, they can help you to explore how to best put them into action. You should solicit their input during the all phases of the specification development.

The specification will also be used by the developers and people performing acceptance testing to ensure that the simulator's performance and appearance meet the specification requirements. As a result, you will need to provide clear

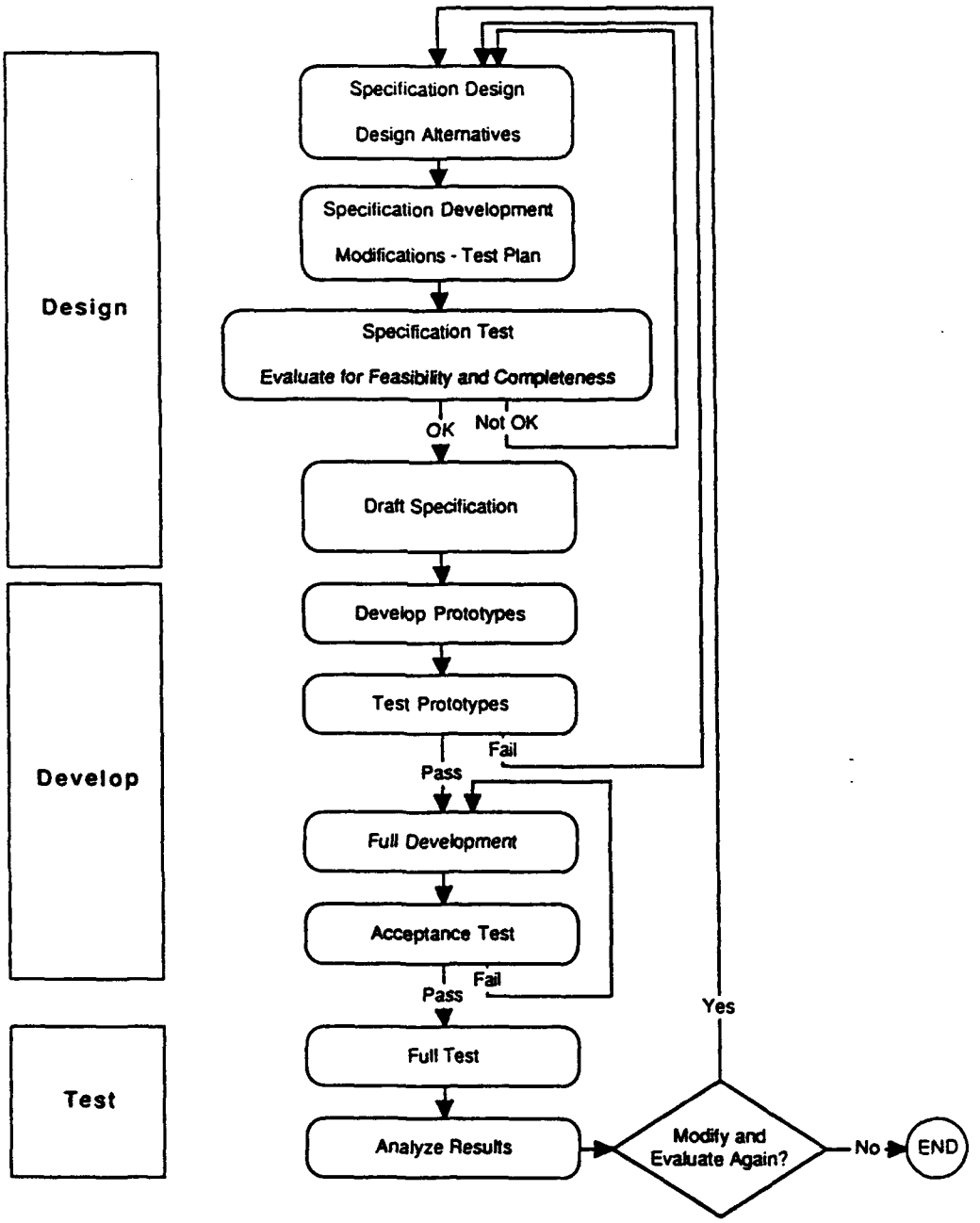

Figure 2. Iterations in the concept evaluation process

performance requirements and standards for making these evaluations as part of the specification.

In some cases there may be users of the specification besides those already mentioned. Weapon system designers, combat developers, training analysts, and other interested parties may use the specification for reference purposes. Organizations involved in these areas who have sponsored the development of the specifications will also be reviewing them. You should be aware of these secondary audiences, and if appropriate, provide additional information within the specification that will be useful to them.

Overview of the Specification Content

The CASM methodology is directed toward producing a specification that contains the following three major sections:

Section 1	Introduction
Section 2	Modifications to CCTB
Section 3	Investigation Plan

In addition to guiding you through the process of developing these sections, the methodology also provides you with guidance for the preparation process and the process of producing the final specification.

The discussion of the preparation process provides you with guidance for:

- establishing the goals and constraints for the effort
- identifying an organizational structure, people, and agencies for supporting the effort
- identifying and gathering information

These activities are critical to the success of the specification development effort.

Section 1 - Introduction

The Introduction provides the users of the specification with an understanding of the concept to be evaluated and the reasons for the changes to CCTB. It provides a general discussion of the concept, the changes, and the evaluation. It also provides a more broad-based discussion of why the evaluation is important in furthering the supporting agency's mission.

Section 2 - Modifications to CCTB

Section 2 provides the detailed descriptions of the changes to be made to CCTB. It includes descriptions of both the physical and functional changes to all of the affected subsystems within CCTB. It also includes a description of the acceptance testing that will be performed to verify that the changes have been made properly.

Section 3 - Investigation Plan

The Investigation Plan describes how the concept will be evaluated within CCTB. The nature of the investigation to be conducted in support of the sponsoring agency goals is outlined in this section. This discussion helps to put the changes into context and provides both the CCTB developers and the specification developers with a better understanding of the changes and the effects of their implementation. Because the investigation plan is not very detailed, it would not be sufficient for actually conducting an evaluation.

Producing the final specification includes the review and approval of the specification by the sponsoring agency and the final production of the document.

Overview of the Specification Process

The breakdown by section described here is useful for organizing the information presented. In actually developing a specification however, there is no strict sequence for performing the activities and many of them will be performed in parallel. You can schedule the performance of these activities in the manner which seems most appropriate to you. One possible approach is illustrated by the flow diagram in Figure 3 and the sample timeline in Figure 4.

Based on the nature of the development effort you may choose to not fully develop some of the sections. Emphasis may be on simply making the modification or on making minor modifications in preparation for a larger testing effort. The CASM methodology has been prepared under the assumption that all sections will be fully developed, but the extent of the development is really left up to you.

The content of the sections and the process for developing that content are different. Given this difference, the discussion of each section is divided by content and process. The content portion describes what goes into the section and its general format. The process portion describes the activities that you should perform to develop the content. The purpose of

this is to provide you with a description of what is to be done and how it can be accomplished.

Resources for Developing the Specification

Several resources have been provided to assist you in developing the specifications. They are outlined below.

- Examples and illustrations have been used throughout this document to help provide clarity.

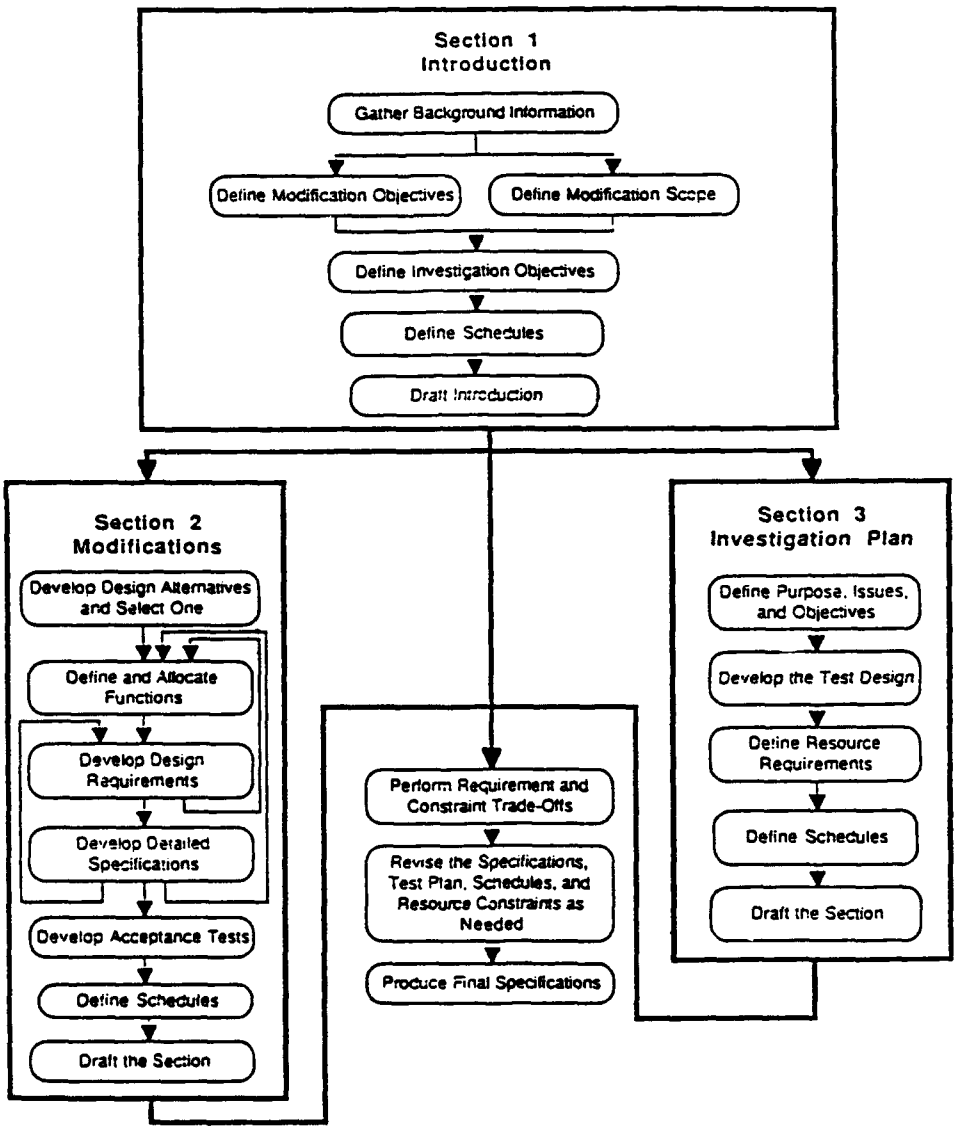

Figure 3. The specification development process

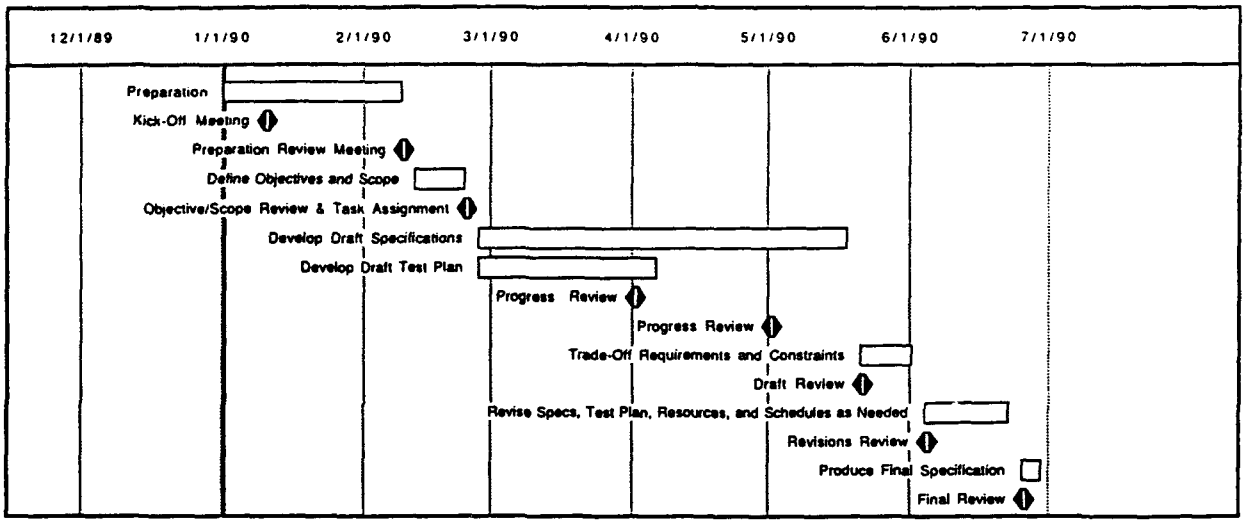

Figure 4. Timeline for the specification development process

- A complete specification for a hypothetical Acoustic Priority and Engagement System has been provided as an appendix for reference. This sample specification has been referenced as appropriate throughout the document.

- References which may be helpful have been cited when appropriate and a reference list is provided at the end of the specification.

- As part of the effort to develop this methodology, a software tool was developed on the Apple Macintosh using Hypercard[4]. This tool helps to guide you through the development process and produce the final specification. The methodology indicates when this tool can be helpful in developing the specification. This software tool and its operating requirements may be obtained from the CCTB Library. The software tool is also available on a workstation at the CCTB facility.

Summary

This section has provided an overview of the CASM methodology and the specifications it guides you in developing. The remainder of this document describes the process for developing a specification as well as a specification's general content and format.

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[4]A registered trademark of Apple Computer, Inc.

THE PREPARATION PROCESS

The purpose of the preparation process is to gather the support and information needed to develop the specification. Preparation activities are conducted after the decision to evaluate a concept in CCTB has been made and before you begin the development of a specification. The preparation process involves the following activities:

- Define the sponsoring agency goals and resource constraints
- Define an organizational structure to support the effort
- Form a specification development team
- Establish contacts at support agencies
- Identify and gather available information

Each of these activities is discussed below. Figure 5 provides a flow chart of the activities and Figure 6 presents a sample timeline.

Define the Sponsoring Agency Goals and Resource Constraints

The definition of the sponsoring agency goals and constraints forms the basis for the rest of the effort. The sponsoring agency is the organization that wants the evaluation in CCTB to be made and is providing the resources for doing it. The sponsoring organization is, in effect, the "client" for the effort. It is possible that there may be more than one sponsoring organization for any given effort. While the goals and resources for each of these organizations should be addressed, it is not within the scope of this methodology to address how to reconcile differences between them. Regardless of the nature of the sponsors, having clearly defined goals and constraints for the effort will help to ensure that the resulting specifications can be implemented.

At this point in the process, the goals for the effort are likely to be fairly broad. For example, a goal at this point might be "To see how useful equipping a tank with an acoustic target acquisition system might be." To the extent possible, you should make these goals specific in order to focus the effort early on. As part of process for developing Section 1, these goals will be more clearly defined and broken into specific objectives. The further this process can be taken while interacting with the sponsor at this stage however, the better.

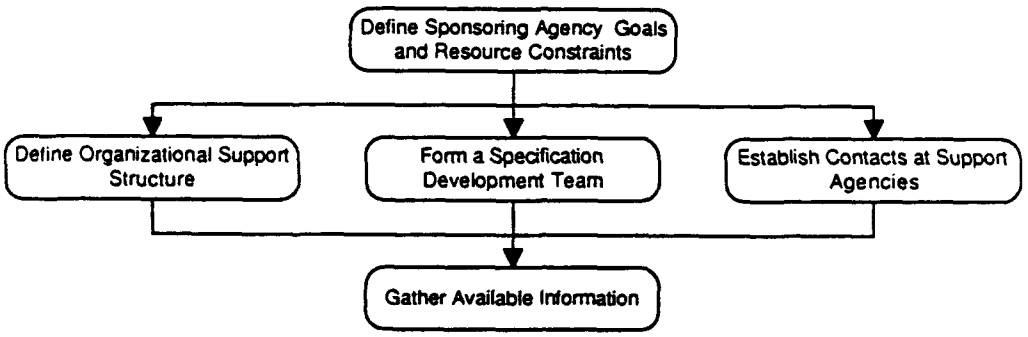

Figure 5. The process flow for the preparation

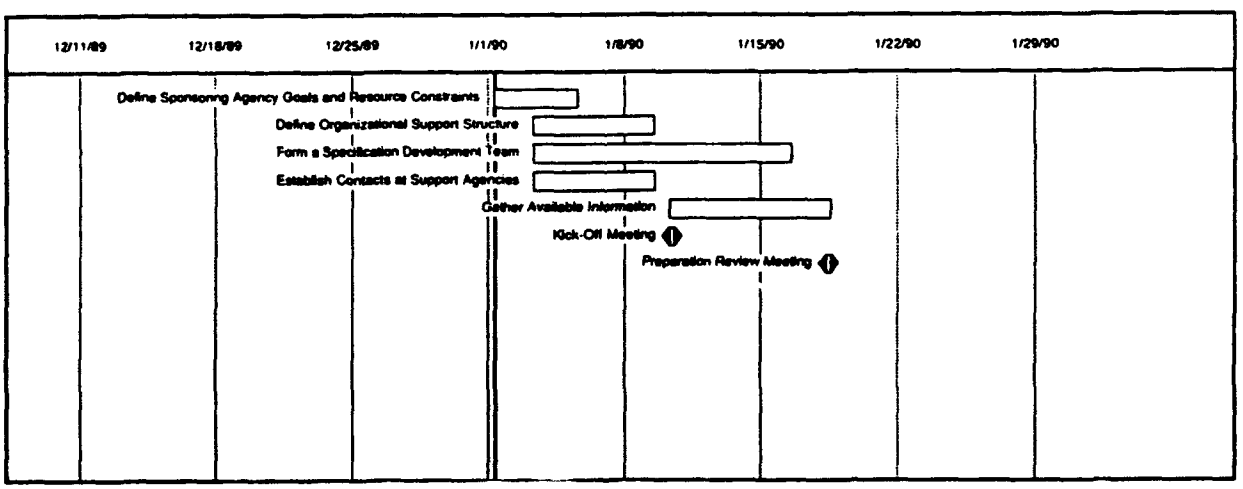

Figure 6. Timeline for the preparation process

Setting specific objectives early on will help to ensure that the specification you develop will meet the sponsoring agency's needs and that you do not waste your efforts on unwanted goals.

You will need to work with the sponsoring agency to establish the constraints on the effort. These include resource and schedule constraints as well as defining the scope for the effort. Obtaining the resource and schedule constraints should be fairly straightforward and include:

- Budgets
- Schedule Milestones
- Equipment and Facilities
- Personnel

Defining the scope may be more difficult. As a minimum, you should consider the scope of CCTB, the goals, and the constraints when defining the scope for the effort. You may need to trade-off these and other relevant considerations until the overall scope is defined.

You do not need to have the goals, constraints, and scope completely defined before performing other activities in the methodology. It will be difficult however, to effectively perform the other activities before this is done.

Define an Organizational Structure to Support the Effort

The organizational structure supporting the effort is primarily concerned with how the sponsoring organization or organizations will assign authority for decision making, set up channels of communications, and provide access to resources. These decisions are really outside of the scope of this methodology, but we felt that they should be addressed because of their criticality to the success of the specification development effort.

There are four key factors which affect the choice of organizational structures to support the effort:

- The size of the effort
- The time available to perform the effort
- The importance of the effort
- The number of sponsors

The size of the effort will dictate the breadth of management and quantity of resources required. Small efforts may require only one person to perform these support functions. Large efforts, on the other hand, could require specially assigned task forces.

The time available to perform the effort generally influences organizational structure only if time is short. Under conditions of short time suspense, a strong leader with considerable authority and a small skilled team are likely to be essential. Longer time scales allow for greater flexibility in structure.

The importance of the effort is closely related to who wants it done. The more clout that person or organization has, the more likely they will be to marshall the resources required to support the effort. Supporting the effort includes providing the most effective organizational structure for the size and scope of the effort.

Finally, the number of sponsors involved and their ability to work together effectively can affect the structure of the supporting organization. The need to serve potentially conflicting goals and properly allocate resources may require more administrative overhead. In some cases, you may need to have an arbitrator to resolve the conflicts in goals. In addition, you may need an independent auditor or "honest broker" to ensure the proper use of resources and the integrity of the delivered product.

As you can see from this brief discussion, establishing an organizational structure to support the effort can become quite complex. A properly functioning support structure is however, essential to a successful effort. Before starting to develop the specifications, you should review the support structure for the effort. The key traits to look for in this structure are:

- Authority

  Who has the authority to make decisions about the project?

  Is this authority well defined?

  Do the people who need it have the authority?

- Communications

  Are there clear communications channels established?

  Do the people participating in the effort know where to go for information and who they should provide information to?

  Are mechanisms in place to ensure that timely information exchange occurs?

- Resources

  Are the resources to perform the effort available?

  Have the sources for obtaining the resources been identified and cooperation secured?

  Are there mechanisms in place for the timely and accurate distribution of resources?

If the structure does not seem adequate to you, you should discuss it with the sponsor or sponsors and try to establish a better structure. While this may or may not be possible, you will at least be aware of where potential problems might lie and make any necessary adjustments in your actions.

Form a Specification Development Team

A variety of skills are required to develop a modification specification for CCTB. These skills range from simulator engineering and military systems engineering to test design and project management. In most cases, one person will not have all the skills required to develop the specification. Given this, you will need to form a team of people with the needed skills.

The number of people and types of skills required will vary depending on the nature of the modification. The "team members" described below are provided for guidance. They are meant to represent roles or capabilities required to develop the specification rather than particular types of individuals. You should base the selection of team members on the needs of the modification effort.

Team Leader

This individual is the coordinator for all of the specification development activities. The primary responsibilities of the Team Leader include the following:

- Directing the efforts of the other team members
- Acting as a liaison between the sponsors and the team
- Ensuring that the project schedules are met and the project resources are used appropriately
- Acting as the initial point of contact between the team and outside supporting agencies, including the CCTB development organization that will implement the specification
- Ensuring the quality and comprehensiveness of the final specification

In order to perform effectively, the Team Leader will need a level of authority consistent with these responsibilities. It is up to the sponsoring agencies to provide this authority. The specific style of management and the implementation of this role will be dependent on the organizational structure and the personality of the Team Leader. There are however, certain traits which are useful for a Team leader. They include:

- Experience in the management of projects similar in size and technical complexity
- Technical expertise in one or more of the other team member areas
- The ability to understand and integrate information from all of the technical areas
- Effective communication skills

While all of these traits are not essential, they are desirable and will help to ensure a successful effort.

The Team Leader may be selected from a number of organizations. The sponsoring organization is probably the most logical source. The sponsor may not have people with the necessary experience or technical expertise. People who have developed specifications previously for other organizations, such as the research and development labs, may also be available. The CCTB staff is another source, as are outside consultants. Regardless of the source, the selection and empowerment of a capable Team Leader will help to ensure that a quality specification will be delivered on time and within the resource constraints.

Sponsor Representative

The Sponsor Representative will represent the sponsoring agency for the effort. He or she is generally a member of the sponsoring agency's staff and is empowered with final decision making authority for the effort. The Sponsor Representative's responsibilities include the following:

- Providing guidance and making judgments about what is and is not central to the effort
- Allocating resources for the effort

By necessity, the Sponsor Representative will work closely with the Team Leader. In many cases, they are likely to be the same person. For efforts with more than one sponsor, you will need to have a Sponsor Representative for each organization.

Military Systems Operations Specialist

This individual will be familiar with the operational aspects of the actual equipment (e.g., tank) to be simulated. This expertise focuses primarily on the tasks performed by the crews and other personnel having roles in the simulation. The Military Systems Operations Specialist's responsibilities include:

- Defining functional requirements for the simulated systems and the crews
- Developing alternative designs for concepts
- Defining crew procedures
- Defining crew and system performance measures for data collection
- Defining evaluation scenarios

Military Systems Operations Specialists may be drawn from a variety of organizations including TRADOC and the other various commands, R&D labs, and consultants. This person will typically be the equivalent of a Captain or Major who has operational or training experience with the system or subsystems included in the evaluation or has the ability to envision possible new systems.

Military Systems Engineering Specialist

This individual will be familiar with the underlying hardware and software in the actual equipment being simulated.

For new or hypothetical systems, this person will have expertise in the general technical and functional aspects of the proposed system. This individual will not necessarily understand all aspects of the military system but will have a good understanding of the affected systems. For example, a modification to CCTB for integrating a new radio would require individuals with expertise in the areas of radio hardware, signal transmission and interference characteristics, and crew station engineering. The Military Systems Engineering Specialist's responsibilities will include:

- Defining functional and fidelity requirements for the simulated systems
- Developing alternative designs for concepts
- Defining system parameters and their characteristics to be included in the simulation
- Defining system hardware characteristics to be included in the simulation
- Developing prototypes and mockups as needed
- Defining system performance measures for data collection
- Defining evaluation scenarios

Military Systems Engineering Specialists may be drawn from a variety of organizations including Army Materiel and the other various commands, R&D labs, and consultants. This person will typically be the equivalent of a Captain or Major who has engineering experience with the system or subsystems included in the evaluation.

Test and Evaluation Specialist

This person will assist in the development of the investigation plan. He or she should be experienced in the conduct of military test and evaluation, particularly as it relates to the CCTB environment. The Test and Evaluation Specialist's responsibilities include:

- Defining system and crew performance measures for data collection
- Defining data collection methods and mechanisms

- Defining evaluation scenarios and basic experimental designs

- Defining the resource requirements and schedules for the evaluations

Test and Evaluation Specialists may be drawn from a variety of organizations including the various commands, R&D labs, and consultants. This person will typically be the equivalent of a Captain or Major who has operations research and systems analysis experience, preferably as it relates to CCTB evaluations.

CCTB Engineering Specialist

This individual must be able to make judgments about what will and will not be possible in CCTB. Furthermore, this individual will represent the target audience (i.e., the implementors of the specification) and provide guidance regarding the type of information and level of detail required for the specification. The CCTB Engineering Specialist's responsibilities include:

- Developing alternative designs for concepts

- Evaluating the feasibility of system parameters and their characteristics, system hardware characteristics, data collection mechanisms, and scenario characteristics to be included in the simulation

- Providing alternatives to aspects of the designs that are determined to be infeasible

- Developing prototypes and mockups as needed

- Providing guidance for the level of detail and formats required for the specifications

The CCTB Engineering Specialists will typically come from the CCTB staff (however this person could also come form outside sources). This role may include several people who are responsible for different aspects of the CCTB hardware and software.

CCTB Manager

This individual will be able to assess the impact of all proposed CCTB modifications on resources required to implement the changes. The CCTB Manager will be responsible for:

- Producing development and testing schedules

- Identifying and scheduling resources for development and testing
- Obtaining CCTB data for the team

The CCTB manager will necessarily come from the CCTB staff.

Training Specialist

This individual will assist the team in defining the training requirements for the evaluation. The Training Specialist will be responsible for:

- Defining functional requirements for the crews
- Defining crew procedures
- Defining crew and system performance measures for data collection
- Defining requirements for training materials, methods, and schedules

The Training Specialists will typically come from the training support organizations such as TRADOC and the branch schools.

Other Subject Matter Experts

People with expertise in the areas of tactics and operations, human factors, or other disciplines should be used as team members when needed.

Again, while these people are referred to as separate individuals, they need not be. For complicated evaluations involving major system changes, the role of the Military Systems Engineering Specialist may be filled using several individuals. For less complex studies, the Military System Operations and Engineering Specialists may be the same person. The Team Leader will typically posses one or more of the capabilities listed.

In forming the team, you should start by selecting a Team Leader and identifying the necessary skills for the team. Then identify people meeting the skill requirements and secure their participation. In doing so, be sure to obtain a commitment from them and their organizations regarding their participation and level of effort. It is not necessary that all of the team members participate in all areas and at all times. You can assign different parts of the specification to different team members for development based on their expertise. The Team

Leader and the individual members will be responsible for coordinating their efforts and sharing information.

Establish Contacts at Support Agencies

In developing a specification you often need to contact various agencies for information and technical support. These agencies can include the various Army commands, service schools, laboratories, and research organizations as well as outside vendors and consultants. Often, the team members will be drawn from one or more of the agencies. You should identify the agencies relevant to the specification development early on and establish a point of contact with them. Doing so will help to provide easier access to information and organization cooperation when it is needed later in the process.

Identify and Gather Available Information

Typically, a wide variety of information is required for developing specifications. Information sources can include:

- System descriptions
- Engineering specifications and drawings
- Operation and training manuals
- Operations, tactics, techniques, and procedures (OTTP) documents
- Scientific reports and articles
- Test and evaluation guidelines
- Previously performed function or task analyses
- CCTB reference documents
- Previous specifications for CCTB
- Computer programs and databases

As part of the specification process, you should identify this information and gather it through the team members and the contacts at the support agencies. Also, you should secure any clearances required for using the information. The reference list at the end of this methodology provides a starting point for identifying the information to be gathered.

Summary of the Preparation Process

During the preparation process the following activities will take place:

- The overall goals for the effort and the constraints on the effort will be defined
- The organizational structure to support the effort will be defined
- A specification development team will be formed
- Contacts will be established at supporting agencies
- Relevant information will be identified and gathered

These activities will provide the basis for performing the remainder of the specification development process.

SECTION 1 - INTRODUCTION

Introduction to Section 1

The content of Section 1 provides readers of the specification with an understanding of the need for the modification, the issues surrounding it, and the goals and objectives in performing it. The process of developing the section helps to provide you with this same understanding. As a result, you will be able to provide the readers with a clear definition of both the direction and scope for the effort.

The remainder of this discussion provides the recommended content for the section and a proposed process for developing the section. Pages A-9 to A-18 in Appendix A provides an example of this section.

Section 1 Content

1.0 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This paragraph should state the purpose of the modification. The following points should be discussed:

- What is being modified - hardware,training, tactics, or organizations. Actual systems should be addressed at this point, rather than any modifications to simulators or the CCTB facility.
- What needs to be evaluated - hardware, training, tactics, or organizations.
- Who is sponsoring the evaluation.
- Why the evaluation is important.

This portion should also include a general outline of what the reader can expect in Section 1 and later on in the Sections 2 and 3.

1.2 BACKGROUND

The general background should be discussed in this paragraph. The intuitive feelings or analytical results which require an evaluation by soldiers, crews, and units should be presented. All of the specific issues which may drive the modification should be brought forward. Each of these issues should be

discussed in further detail in the following subsections.

1.2.1 BACKGROUND ISSUE 1

Pros and cons of the issue for the proposed modification should be discussed openly and objectively. This discussion should be used to provide the reader with an understanding of the relevance or importance of the modification.

1.2.2 BACKGROUND ISSUE 2

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1.2.X SUMMARY OF BACKGROUND ISSUES

1.3 OBJECTIVES FOR THE MODIFICATIONS TO THE REAL SYSTEM

This paragraph should address the overall goal of the modification and the specific objectives of the modification for the real system.

1.4 SCOPE OF THE MODIFICATIONS

The basic assumptions and design concepts associated with the modification to the real system are defined here. These concepts and assumptions will form the basis for the modifications to the simulator.

1.4.1 ASSUMPTIONS

In many cases the concepts on which the modifications are based will be in an early stage of development. As a result it will often be necessary to make assumptions regarding technology, people, or the environment. The assumptions should be stated in this paragraph.

1.4.2 SPECIAL CONSIDERATION 1

These paragraphs should be used for describing major design decisions or issues. This may include things such as basing the design on existing or prototype systems or establishing specific design requirements based on sponsoring agency constraints.

1.4.3 SPECIAL CONSIDERATION 2

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1.4.X SUMMARY OF THE SCOPE

1.5 CCTB INVESTIGATION OBJECTIVES

This paragraph should distill those objectives which can best be evaluated by CCTB from the overall objectives of the modification discussed in Section 1.3. This paragraph should also discuss the value of the results of the CCTB evaluation.

1.6 SCHEDULE FOR IMPLEMENTATION AND EVALUATION

A preliminary schedule for the overall effort should be provided. It should include major milestones for hardware and software development, acceptance testing, investigation test design, and evaluation testing.

Section 1 Process

The purpose of Section 1 is to provide the reader with an understanding of the importance, nature, and objectives of the modification. Performing the steps in developing this section will also help you to understand and clearly state the objectives for the specification. The steps in the process are as follows:

- Assign team responsibilities
- Gather background information
- Define the objectives for the modifications to the real system
- Define the scope of the modifications
- Define the CCTB investigation objectives
- Define the schedule for the effort
- Draft the section

Each of these steps are discussed in the following paragraphs. Figure 7 provides a diagram of the process flow for this step and Figure 8 provides a sample timeline for the effort.

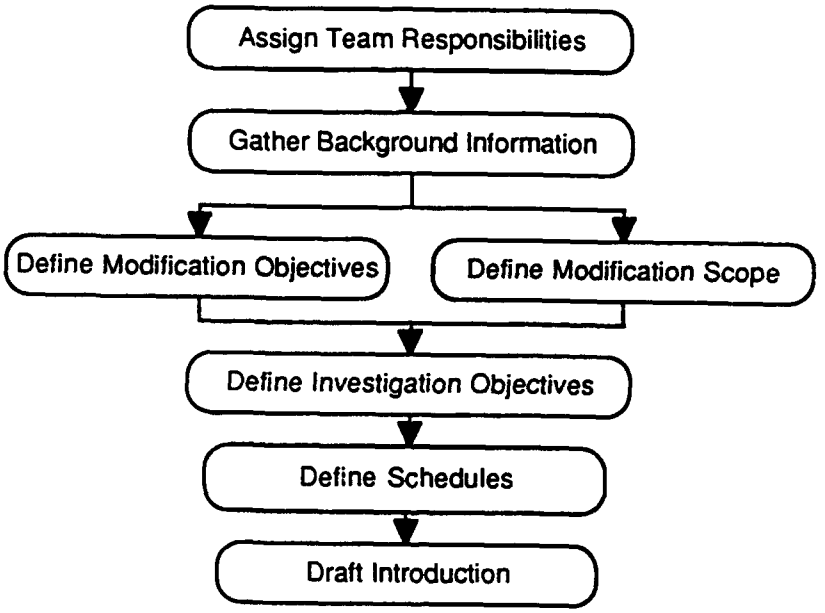

Figure 7. Process flow for the development of Section 1

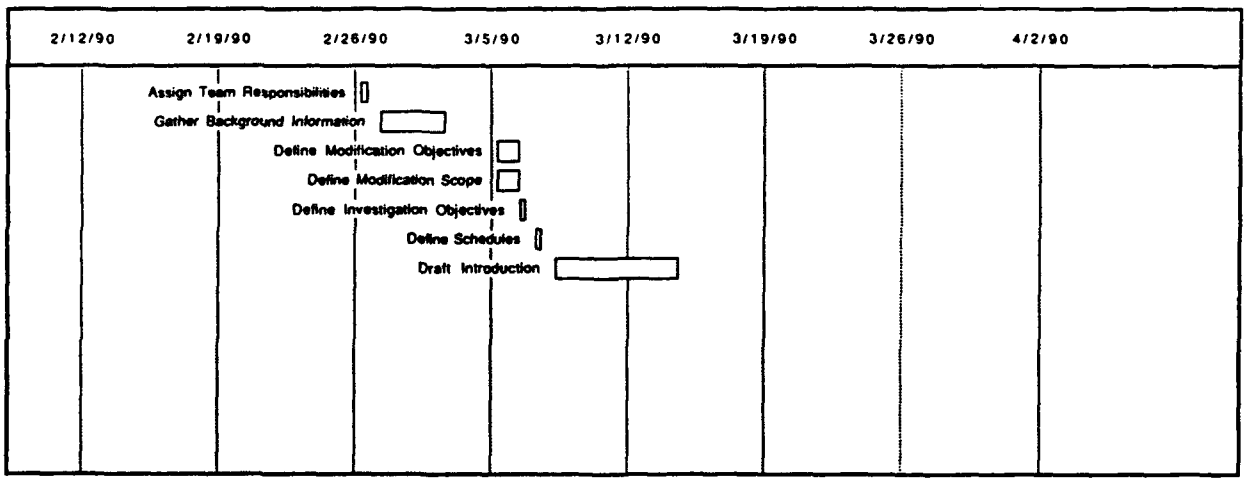

Figure 8. Sample timeline for the development of Section 1

Assign Team Responsibilities

The entire team should be involved in developing this section. This will help to ensure that they all have the same understanding of what modifications are to be made and why. This will also help to provide them with some ownership in the effort early on. The roles of each of the team members are outlined below.

Team Leader The Team Leader will be responsible for directing and coordinating the efforts of the other team members. This includes scheduling meetings, assigning tasks, disseminating information, and ensuring the quality of the specification section. The Team Leader will have final decision making authority unless otherwise directed by the sponsoring agency.

Sponsor Representative The Sponsor Representative will communicate the goals and objectives of the sponsoring agency to the other members of the team. This includes any relevant background information and the rationale for the sponsoring agency goals and objectives. The Sponsor Representative will ensure that the integrity of the goals and objectives are maintained as the specification and investigation objectives are developed. She or he will also participate in the scheduling of the effort and identify the sponsor constraints and requirements for the allocation of resources to the effort.

Military Systems Operations Specialist The Military Systems Operations Specialist will provide expertise regarding the military utility and operational effectiveness for the proposed modification. This will include identifying relevant background information, and defining the objectives, scope, and assumptions for the modification or development in the real world. He or she will also help in tailoring the objectives, scope, and assumptions to the CCTB environment.

Military Systems Engineering Specialist The Military Systems Engineering Specialist will provide expertise regarding the technical aspects of the proposed modification. This will include identifying relevant background information, and defining the objectives, scope, and assumptions for the modification or development in the real world. He or she will also help in tailoring the objectives, scope, and assumptions to the CCTB environment.

Test and Evaluation Specialist The Test and Evaluation Specialist will be responsible for defining the CCTB investigation objectives. She or he will also be assist in defining the scope and objectives for the modification.

CCTB Engineering Specialist The CCTB Engineering Specialist will assist the team in defining the assumptions and scope for the modification and the objectives for the investigation.

CCTB Manager The CCTB Manager will assist the team in defining the scope and schedule for the modification and the objectives and schedule for the investigation.

Training Specialist The Training Specialist will provide input regarding objectives, assumptions, and schedules as they relate to training.

Other Subject Matter Experts The other Subject Matter Experts will provide input regarding objectives, assumptions, and schedules as they relate to their areas of expertise.

Gather Background Information

The purpose in gathering the background information is to provide a basic rationale for making the modification and to assess the technical base related to the modification. Information regarding the basic rationale includes consideration of the goals of the sponsoring agency as well as other issues surrounding the modification. An example of issues which would be appropriate for modifications to the vehicle, or weapon system, or other system include:

- Lethality - improved accuracy, range, and penetration
- Survivability - design considerations, agility, warning systems, and armor protection
- Mobility - both tactical mobility and strategic deployability
- Fightability - modifications which allow the soldier to fight more effectively, such as target acquisition, command & control, position navigation, and automated systems
- Sustainability - maintenance, reliability, fuel consumption, crew workload, etc.
- Means of employment - organization, tactics, techniques, procedures, and doctrine

- Personnel and Training - status of current and future personnel demographics, force structures, and training requirements as they relate to the modification

- Logistical support - ease of or changes in providing fuel, ammunition, and other supply support

Once the relevant issues are defined, the pros and cons of each should be explored in order to obtain a complete understanding of the modification.

The technical base refers to the state-of-the-art with regard to both the technologies included in the modification and simulation technology. This provides the background needed to consider what is feasible in the real world and what is feasible within the CCTB environment. Background material should be sought by reviewing:

- Data/information on the current and proposed systems

- Reports of similar studies, tests, or analyses in the general literature

- Contractor's literature if a specific design is being considered

Sources which may be appropriate for gathering information regarding the rationale and technical base include:

- The sponsoring agency

- Historical combat experience

- Combat Simulations

- Technical libraries

- Defense Technical Information Center

- Combat developers

- Force Development Test and Experimentation (FDTE)

- Concepts Analysis Agency

- Army/DOD Research and Development Centers

- U.S. Army Armament Research, Development and Engineering Center (ARDEC)

- Defense Advanced Research Projects Agency (DARPA)

- Organizations dealing with Manpower, Personnel, and Training (MANPRINT) and Soldier Performance Issues
- Army Research Institute
- Human Engineering Laboratory
- Trainers
- Various TRADOC centers
- Army Training and Evaluation Program (ARTEP)
- Army Material and Systems Analysis Agency
- Ballistics Research Laboratory
- Material developers

In reviewing information from these sources, both objective analyses and subjective insights should be considered in defining the issues. This will provide both the specification development team and the readers of the specification with a more thorough understanding of the concerns surrounding the modification.

The output of this step should be a draft of the background paragraphs for Section 1 including a listing and discussion of the relevant issues. An initial draft of the technical issues should also be developed.

Define the Objectives for the Modifications to the Real System

In this step the overall goal of the modification to the real system and the specific objectives for the modification should be defined. Defining the goals and objectives for the real system first provides a basis for defining the goals and objectives for the simulator. This helps to ensure that the goals and objectives are relevant and meaningful to the larger Army mission.

Using the background information gathered in the previous step, a single goal for the modification should be defined. The goal should be general and provide the overall direction for the effort. For example, the following phrases might be used for defining the goal:

- To improve performance...
- To reduce operational costs...
- To reduce manpower requirements...

The objectives should be more specific and list the expected changes in performance which would result from the modification. These objectives should be measurable through tests or exercises.

In most cases there will be multiple objectives associated with the goal. Examples could be:

- Increase the firing rate
- Increase the target acquisition rate
- Reduce detection signature
- Reduce training requirements

Once the goal and objectives for the modification to the real system have been defined, they should be drafted for incorporation into the section.

Define the Scope of the Modifications

Defining the scope of the modifications involves identifying the major design concepts and assumptions associated with making the modification to the real system. Since this paragraph deals with "scope" instead of "detailed" modifications, the discussion should take a "big picture" approach.

Critical to this paragraph is the documentation of assumptions which carry forward and form the basis of the specification. Areas which may be appropriate for inclusion as assumptions are as follows:

- Any technical performance requirements. Examples may be the update rate of an automated navigation system or the target detection characteristics of an acoustic sensor.
- Assumed configurations or design concepts. These do not necessarily need to be fully developed into working systems or approved of at the time of the specification development. They are simply used as a reference or basis for the specification. Examples may be the configuration and location of crew stations, a particular design prototype, or an existing system component.
- Any training, tactics, or organizational assumptions which may influence the performance of the weapon system or crew.

Major design decisions and assumptions should be written up separately and given as special considerations. The remaining

assumptions should be logically organized and listed. An example of a special consideration and a partial listing of assumptions from the APES specification are provided in Figure 9. When the assumptions have been defined, the paragraph for the section should be drafted.

Example of a Special Consideration

IDENTIFICATION OF FRIEND AND FOE.

The APES will provide the TC with limited identification of friend or foe (IFF) information. Based on the acoustical signature of the detected vehicle, the APES will be able to categorize and identify if the target is a friend or foe. This capability is dependent on the targets distance and the noise level surrounding the vehicle. Because of this degradation, visual and non-visual verification methods will also need to be used for IFF. These may include the use of other technologies such as the TC's Commander's Control Display, or the use of procedures and tactics which minimize the risk of firing on friendly forces.

Example of a Partial Listing of Assumptions

1. The Acoustic Priority and Engagement System (APES) will use an acoustical sensor.

2. The APES will have a limited automatic tracking and automatic gun laying capability. However, it will not provide hands-off final lay for the gunner and TC.

3. The gunner will only have the Gunner's Primary Sight monocular to acquire and lay on targets. Target cues will be available from the APES to the GPS.

4. The TC's station will have an acquisition screen which will display target location returns. To observe images through the Direct View Optics (DVO) or the Tank Thermal Sight (TTS), the TC must use the Gunner's Primary Sight Extension.

Figure 9. Examples of special considerations and assumptions

Define the CCTB Investigation Objectives

In this step the goal and objectives defined for the actual system will be narrowed to those appropriate for evaluation within CCTB. CCTB offers an inexpensive alternative to actual modification of equipment or field validation of changes in organizations, training, and tactics. However, care must be taken to select only those objectives which can be adequately evaluated by a simulator.

CCTB is a "full crew" simulator which can link crews to form units up to company, troop, or battery. The system performs best when providing a look at the soldier-soldier and soldier-machine relationships which occur during battlefield simulations. In other words, CCTB provides a means to view performance with the crew, crews, or unit leaders in the operational decision loop. Given this, the objectives associated with these soldier performance activities are the best candidates for evaluation within the CCTB environment.

The objective, "Improve weapon accuracy," would probably not be a good CCTB Investigation Objective because the accuracy results would be a direct reflection of the accuracy data loaded into the simulator. This objective would best be evaluated by actual test firings.

Careful thought must also be given to the prudent balance between the costs to modify CCTB and the value of the objective which caused the modification. In many cases, objectives can be written to allow the existing CCTB configuration to suffice. In other cases, the objective can be eliminated altogether because the cost would be greater than the benefit.

Given the above background, this paragraph should distill those objectives which can best be evaluated by CCTB from the overall objectives of the modification. Examples of objectives which can be assessed by CCTB may be:

- To access crew acceptance of the modification
- To assess the relative difficulty of training
- To determine if the crew workload is within acceptable limits

This paragraph should also discuss the value of the results of the CCTB evaluation including:

- Who should be able to use the data
- How the data can be used

- The need for any follow-up evaluations

Once the objectives have been tailored down to those appropriate for evaluation within CCTB the paragraph should be drafted.

Define the Schedule for the Effort

Using the sponsoring agencies milestones as a basis, the schedule for the implementation and evaluation of the modification should be developed. The schedule should reflect the major development activities including hardware development, software development, and system tests. It should also reflect the major evaluation efforts including test design and conduct. An example of this schedule from the APES specification is shown in Figure 10.

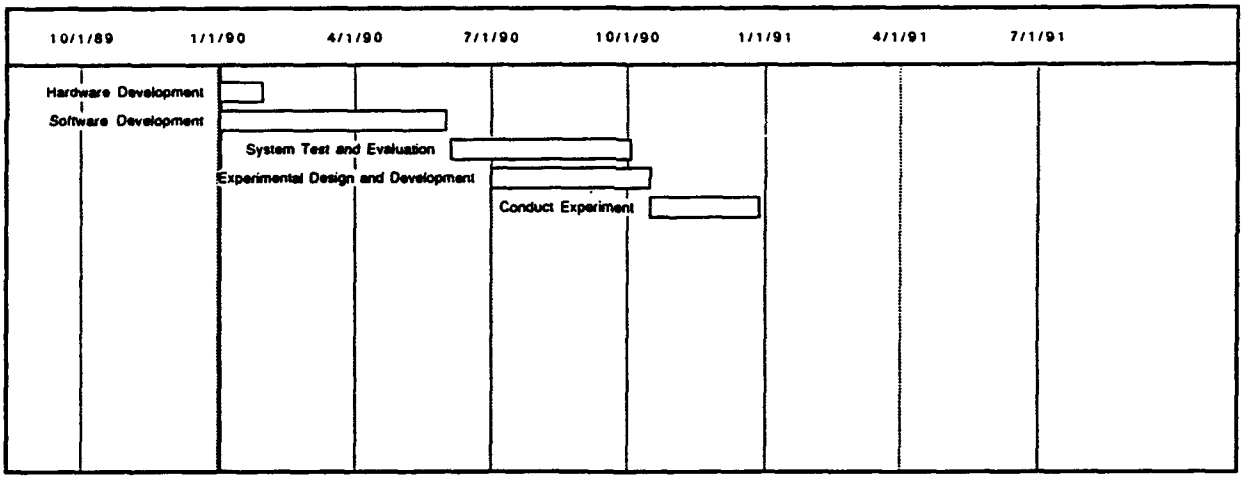

Figure 10. Sample schedule for the modification implementation and evaluation

Draft the Section

The CASM Software Toolkit can be used to draft each of the subsections (word processing tool), create the schedule (project management tool), and integrate and format them into a draft for the section.

SECTION 2 - MODIFICATIONS TO CCTB

Introduction to Section 2

The purpose of this section is to present the detailed specifications for the modifications to CCTB. It begins by providing the reader with the basic purpose of the section and a general description of the modification. It then provides detailed descriptions of the modifications to the vehicle simulators, supporting workstations, and supporting systems within CCTB.

Since CCTB is typically used as a vehicle for studying soldier performance in the simulated battlefield environment, the approach to the modification emphasizes the support of soldier actions. Changes in crew stations, soldier-system, and soldier-soldier interactions provide the main focus of the analysis. System behaviors and operations are also addressed, but only to the extent they are needed to support the rest of the modification.

The remainder of this discussion has been divided into discussions of the proposed content for Section 2 of the requirements document and the recommended process for developing the information for the section. Pages A-19 to A-104 in Appendix A provide an example of this section.

Section 2 Content

2.0 MODIFICATIONS TO CCTB

2.1 INTRODUCTION

The Introduction is used to provide the reader with a basic understanding of the purpose, nature, and content of the section.

2.1.1 PURPOSE

The purpose of the section is to provide detailed specifications for modifications to CCTB. A brief statement describing these modifications should be provided.

2.1.2 SCOPE OF MODIFICATIONS

This subsection is used to remind the reader that the modifications described in this section are being made within the context of the CCTB environment. A brief description of the kinds of

analyses and evaluations that CCTB is and is not useful for should be provided. The idea that "selective fidelity" is used within CCTB should also be provided.

2.1.3 OVERVIEW OF THE SECTION

A brief description of the major subsections should be provided.

2.2 GENERAL SPECIFICATIONS

In this subsection, a general overview of the modifications required in the simulator is provided. Each of the major modifications to the simulator should be discussed. Then, a brief description of the layout and content of the following subsections should be provided.

The subsections describing the specific modifications may be broken down in several ways. We have found breaking them down by crew station and subsystem to be the most useful. Other breakdowns such as by component or crew member should be used if appropriate. The breakdown described here should be used simply as guidance.

The analyses and evaluations conducted within CCTB most often address command and control, communications, and soldier-machine interface issues. Given this, describing the modifications from a crew station perspective helps to ensure that these critical issues are addressed. Modifications almost always include subsystems of the simulated vehicle or of CCTB. Any modifications of these subsystems not completely addressed from the crew station perspective need to be addressed. The crew station and subsystem specifications should be put in an order which is the most logical or useful for making the modifications.

2.3 CREW STATION 1 SPECIFICATION

In general terms, describe all of the modifications required in this crew station. This can include multiple modifications to the crew station that are required. These modifications are discussed in greater detail in the following subsections for the crew station.

2.3.1 SPECIFIC MODIFICATION "A" TO CREW STATION 1

a. Purpose

State the purpose of this specific modification. Discuss how the crew will interact with the

modification, if at all, and what the modification is used for.

b. Hardware Requirements

Describe the hardware changes needed to implement the modification. State the kinds of controls, displays, and other hardware required to make the modification operable. Detail each of the hardware pieces operational characteristics. This includes things such as switches being spring return or detented, and the display characteristics of icons on CRT displays. Also, switches or controls which are not required to be operable and can be represented by decals, should be identified.

c. Functional Requirements

State what operations are performed using each piece of hardware. Other components or subsystems which the hardware interacts with should be identified and described briefly. These interactions do not need to be discussed in depth since this will be done in the Functional Specification for the Crew Station subsection.

2.3.2 SPECIFIC MODIFICATION "B" TO CREW STATION 1

The same format as above is followed for each specific modification to the crew station.

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2.3.X SPECIFIC MODIFICATION "X" TO CREW STATION 1

Depending on the nature of the modifications being made, a combined functional specification may be used for several of the crew station specifications and placed after the crew station discussions. It is particularly useful to do this when there is a great deal of interaction between the crew stations.

2.3.4 FUNCTIONAL SPECIFICATION FOR CREW STATION 1

This section should describe the integrated operation of all of the modifications to the crew station. This should be broken down by each specific operation performed.

1. First functional operation

- Operating procedure

Give an explanation of the actions that the crew must take and the responses provided by the system in order to perform the functional operation.

- Control Settings

List the controls and their settings that are used to perform the functional operation.

- Indication

List all visual display responses, sounds, system actions, or other indications that occur. This includes indication given to the crew as well as personnel outside of the simulator.

- Alternate Conditions and Exceptions

List all fault conditions that could occur if the crew does no follow the Operating Procedure. Also any system or environmental conditions which could result in exceptions to the operating procedures and system responses should be listed.

2. Second Functional Operation

The format for each of the subsequent functional operations is the same as for the first functional operation.

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X. Xth Functional Operation

2.4 CREW STATION 2 MODIFICATION

The format for the rest of the crew stations is the same as for the first crew station.

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2.X CREW STATION X MODIFICATION

The subsystem specifications generally address those modifications which do not directly affect crew operations. This can include operational characteristics of new subsystems, interactions with or changes to other vehicle subsystems, interactions with other manned or semi-automated systems in the simulation, and interactions with the simulated environment.

2.6 SUBSYSTEM 1 SPECIFICATIONS

The general nature of the subsystem modifications should be described. The specific modifications included in the following subsections should be outlined.

2.6.1 SPECIFIC MODIFICATION "A" TO SUBSYSTEM 1

The specific software and hardware modifications needed to represent the operational characteristics for the modification should be described. In most cases, this will be done by defining the performance characteristics for the subsystem. Interaction with other subsystems should be described as well.

2.6.2 SPECIFIC MODIFICATION "B" TO SUBSYSTEM 1

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2.6.X SPECIFIC MODIFICATION "X" TO SUBSYSTEM 1

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2.X SUBSYSTEM X SPECIFICATIONS

There are a group of subsystems associated specifically with CCTB which should be addressed in all specifications. These are:

- System Sounds
- Appearance and Effects
- Damage and Failure
- Semi-Automated Forces
- Combat Support
- Combat Service Support
- Opposing Forces
- Data Collection and Analysis Systems

These subsystems should be discussed for each specification even if only to say that they are not affected. The content of the specification subsections for each of these subsystems is described below.

2.7 SYSTEM SOUNDS

System sounds are the new noises and signals to be simulated as part of the modification. This includes noises associated with system operations, auditory feedback from the system, and system alarms. Changes to existing noises and signals are included as well. Sounds should be identified as being recorded or generated by the simulator. Sources for recorded sounds should be identified. As a minimum, the nature of system generated sounds should be defined.

2.8 APPEARANCE AND EFFECTS

Appearance and effects addresses how the modification will look in the simulated battlefield environment. It is what others see when they look at the modifications. Appearance includes how objects such as tanks look. Effects include things such as weapons bursts and the main gun firing. Verbal descriptions, illustrations, and prototypes should be used as appropriate for specifying the changes to appearance and effects.

2.9 DAMAGE AND FAILURE

Changes in the appearance and performance of the modification due to damage or failure are addressed in this section. Damage can be due to combat or misoperation. Verbal descriptions, illustrations, and prototypes should be used as appropriate for specifying the changes in appearance or performance due to damage.

Failures may be random or caused by misoperation. Failure statistics such as mean time between failure and mean time to repair should be provided for random failures. This should be broken down by system, subsystem, and component as appropriate to the modification. Misoperations which can lead to failures should be identified. Performance and appearance changes for both types of failures should be provided. This includes changes to interrelated subsystems as well as those directly associated with the failure.

2.10 SEMI-AUTOMATED FORCES

Changes in the appearance and performance of the semi-automated forces needed to emulate or accommodate the modification are included in this section. Verbal descriptions, illustrations, and prototypes should be used as appropriate for specifying the changes in appearance or performance of the semi-automated forces.

2.11 COMBAT SUPPORT

Changes in the appearance, performance, and information transfer for the combat support workstation due to the modification are addressed in this section. This includes changes in support from artillery, aviation, air defense, and engineering.

2.12 COMBAT SERVICE SUPPORT

Changes in the appearance, performance, and information transfer for the combat service support workstation due to the modification are addressed in this section. This includes changes in support from maintenance, refueling, rearming, and other suppliers.

2.13 OPPOSING FORCES

Changes in the appearance, performance, and information transfer for the opposing force workstation due to the modification are addressed in this section. This includes both the workstation and the simulated opposing force vehicles.

2.14 DATA COLLECTION AND ANALYSIS SYSTEMS

Changes in the data collection and analysis system associated with the modification are addressed in this section. Changes in instrumentation, data capture, and data storage are included in data collection. The nature of the data and the frequency of its capture should be included in the specification. The need for secondary data such as time stamps to be included with the new data should be specified as well. The specifications for the data analysis should include changes in data reduction, organization, and reporting.

2.15 ACCEPTANCE TESTS

This section describes the testing that will be performed to confirm that the modifications have been made correctly. It will include test descriptions which describe the nature of the test and the acceptance criteria. In most cases, the entire CCTB complex will not be tested as part of acceptance testing. A sampling plan should be developed for performing the acceptance tests and included in the section.

2.16 SCHEDULE FOR THE MODIFICATION

A preliminary schedule for the modification should be provided. It should identify the major milestones for hardware development, software development, and acceptance testing.

2.17 SUMMARY

A brief summary emphasizing the main features of the modification should be provided.

Section 2 Process

The purpose of Section 2 is to develop the detailed specifications for the modifications to CCTB. The process of developing this section is very iterative. Although it is described here as a series of steps, the user will need to perform many of the steps in parallel and revise earlier steps based on information and analyses from later steps. The process for developing Section 2 consists of the following steps:

- Assign team responsibilities
- Develop design alternatives
- Define and allocate the functions to be performed
- Develop the design requirements
  - Develop procedures for the personnel functions
  - Develop requirements for the system functions
  - Define the requirements for soldier-machine interfaces
  - Define the requirements for the support systems
  - Identify alternate conditions and exceptions
- Develop detailed physical and functional specifications
- Develop acceptance testing procedures and criteria
- Define the schedule for the modification
- Draft the section

We emphasize again that this process can be very iterative. You are likely to think of new functional operations, hardware requirements, or fault conditions while working on almost any step in the process. As you come up with new additions, deletions, or changes, you should "war game" them through the existing requirements to ensure that you consider all of the ramifications of the changes.

The following subsections describe the process for performing each of the steps given above. Figure 11 provides a diagram of the process flow for this step and Figure 12 provides a sample timeline for the effort.

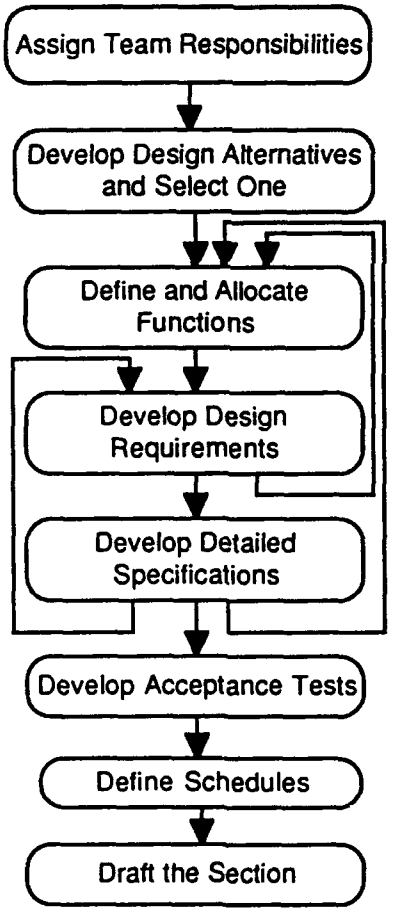

Figure 11. Process flow for the development of Section 2

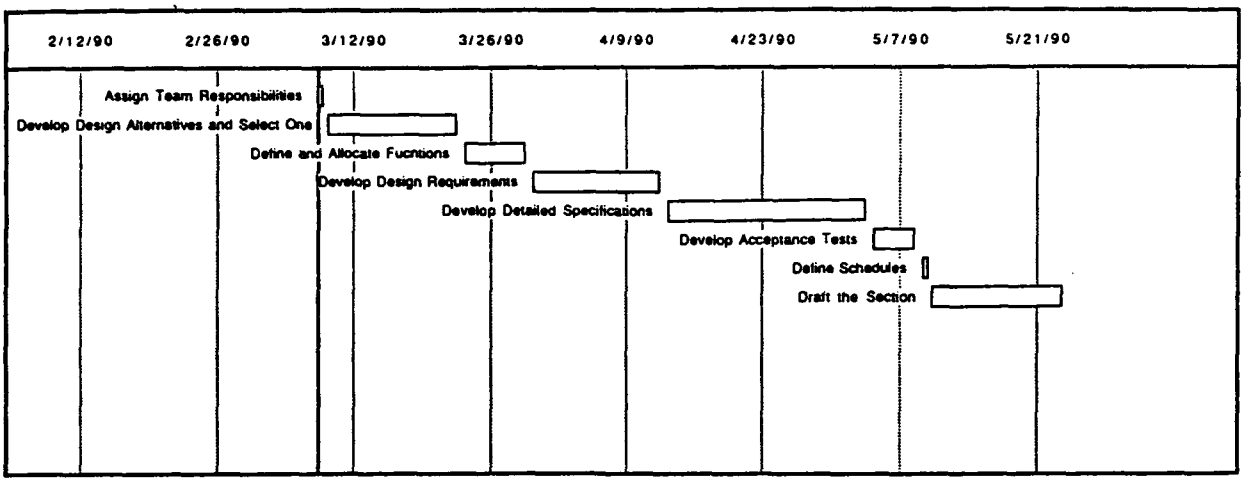

Figure 12. Sample timeline for the development of Section 2

Assign Team Responsibilities

The Military System Operations Specialist or the Military System Engineering Specialist will normally take the lead for the development of this section. The choice of the lead should be based on whether the modification is oriented more toward changes in crew operations or system functions. Regardless of who the lead is, both of these people will be very involved in the effort. The specific roles of each of the team members are outlined below.

Team Leader The Team Leader will be responsible for assisting in the direction and coordination the efforts of the other team members. He or she will support the lead team member for the effort by arranging for people and resources to be made available.

Sponsor Representative The Sponsor Representative will provide guidance regarding the intentions of the sponsoring agency and act as a liaison between the team and the sponsor for providing sponsor clarifications, preferences, and resources.

Military Systems Operations Specialist The Military Systems Operations Specialist will develop alternate crew station designs, define the crew functions, system input-output characteristics, alternate conditions, and system performance and testing requirements.

Military Systems Engineering Specialist The Military Systems Engineering Specialist will develop alternate system designs, system operating characteristics, performance requirements, and acceptance test, and assist in the specification of requirements for support systems.

Test and Evaluation Specialist The Test and Evaluation Specialist will assist in defining the system performance and acceptance testing requirements.

CCTB Engineering Specialist The CCTB Engineering Specialist will assist in developing alternate system and crew station designs, system performance requirements, and acceptance test, and develop the specification of requirements for support systems.

CCTB Manager The CCTB Manager will assist the team in defining the feasibility and schedule for the modification.

Training Specialist The Training Specialist will provide input regarding crew station design and crew procedures as they relate to training.

Other Subject Matter Experts The other Subject Matter Experts will provide inputs as they relate to their areas of expertise.

Develop Design Alternatives

In developing Section 1 for the specification the objectives and scope for the modification were defined. The modifications to the real system were also discussed. In this step, this information will be used to develop design concepts for implementing the modification in CCTB. The flexible nature of CCTB and the use of selective fidelity presents the possibility that more than one design concept could be used to satisfactorily simulate the modification. Developing design alternatives can make trading off requirements and resources easier. Features from separate designs may be combined for the final design.

There are several resources which may be tapped in developing the design alternatives. First, the sponsoring agencies' guidance and objectives may dictate the nature of parts of the design. For example, in the APES specification in Appendix A, we assumed that the sponsor requested that, to the extent possible, the crew station interfaces be the same as those used for the Commanders Independent Thermal Viewer (CITV). This is also an example of using existing designs within CCTB as a resource for obtaining design alternatives. Designs for prototype systems developed by outside vendors, government labs, or other agencies can also be used for design ideas.

Regardless of where the design concepts come from, there will be a need for refining them for incorporation within CCTB. Assumptions regarding system operating characteristics, staffing levels, personnel capabilities, and simulated resource constraints (e.g., ammunition and fuel delivery) will need to be made. What will be simulated at what level of fidelity will have to be determined. Variations in the modifications for experimental purposes will also have to be defined. At this point, the details of the designs do not need to be completely worked out. The issues identified above should be determined however, so that they can be used as guidance for creating more detailed designs in the following steps.

It is recommended that whenever possible, multiple design alternatives be considered during this step in the process. Initially, one should be selected for further development. The others should be used as a source of ideas for parts of the original concept that don't work or as a replacements if the original concept becomes unfeasible. At the completion of this step, one alternative should be selected for further development.

Define and Allocate the Functions to be Performed

In this step, the major functions required to implement the selected design concept are defined. This includes functions which change as a result of the modifications and the development of new functions. In defining the functions the following questions should be answered:

- What changes in existing system and subsystem functions need to be made for the modification? For example, the fire control system may need to be modified to accept input from a new target acquisition system.

- What changes in existing crew functions need to be made for the modification? For example, introducing a new target acquisition system may shift the workload burden for positively identifying targets from the TC to the gunner.

- If new systems, subsystems, or crew members are introduced, what functions will they perform? For example, the APES system can perform the target detection, identification, and prioritization, track targets, and lay the gun on the target.

- If existing systems, subsystems, or crew members are removed, which of their functions will need to be reallocated or eliminated? For example, introducing an autoloader and removing the human loader requires that

the human functions beyond simply loading the gun must also be reallocated to crew members or systems.

It should be remembered that systems, subsystems, and crew members include not only those associated with simulated vehicles, but those associated with the entire CCTB complex as well. This includes things such as the Tactical Operations Center (TOC), the Opposing Forces (OPFOR), and data collection and analysis.

Once the functions have been defined, they should be logically grouped. This may be done in several ways and the use of multiple groupings should be considered. For example, one grouping might be by the nature of the function such as "New Functions," "Modified System Functions," "Modified Crew Functions," and "Eliminated Functions." Other groupings could be by subsystem, crew position or station, or tactical operation. You should use your best judgment for determining the number and type of function groups required to support the modification.

Based on the analysis for the function definitions, the personnel available for performing the functions should be identified. This may include vehicle crew members, TOC and OPFOR staff, and CCTB support staff. The primary purpose for identifying these individuals is to make explicit who functions may be allocated to.

As with the identification of personnel, those systems and subsystems incorporated in the design concept and available for function allocation should be identified. The major systems to be considered include the simulated vehicles, the simulated battlefield systems such as the TOC and OPFOR workstations, and the CCTB support systems for data collection and analysis. The specific subsystems affected within these major systems should also be identified. This includes new subsystems, the elimination of existing subsystems, and existing subsystems likely to be modified.

Once the personnel and systems have been identified, the functions should be assigned to them. This is likely to be an iterative process. As the design concepts are developed into requirements, there will be trade-offs made in the assignment of functions to people and systems. These decisions will be based on the actual and assumed performance of the simulated systems, the limitations of simulation technology, personnel capabilities, and schedule and budget constraints. You will need to keep these factors in mind and expect revisions in function assignments.

The output of this step will be listings of functions assigned to systems and people. Figure 13 provides a partial listing of the system and crew functions for the APES.

System Functions	Crew Functions
Detect targets	Confirm targets
Identify targets	Engage targets
Prioritize targets (shared function)	Prioritize targets (shared function)
Track targets	Target damage assessment
Provide data for firing solution	Select targets for transfer to CCD
Lay gun on target	

Figure 13. Partial listing of system and crew functions for the APES

Develop the Design Requirements

The development of the design requirements involves performing several interrelated but separate activities. These activities include the following:

- Develop procedures for the personnel functions
- Develop requirements for the system functions
- Define the requirements for soldier-machine interfaces
- Define the requirements for the support systems
- Identify alternate conditions and exceptions

In performing these activities, detailed requirements for the physical and operational characteristics of the design will be defined. These activities are interrelated so that it will not be possible to perform them completely independently. They are presented separately because the issues to be considered for each area are different.

Develop Procedures for the Personnel Functions

In most cases, the requirements should be developed from the perspective of the people participating in the simulation. This includes the vehicle crew members and the TOC and OPFOR staffs. Defining what these people do and the information they need will

form the basis for the detailed hardware and software requirements. This will help to ensure that the fidelity of the simulation is sufficient to evaluate the modifications.

The procedures developed for this effort do not need to be prepared as formal procedures such as those used in training or operations manuals. They should, however, define what actions the people take, what information they will need or respond to, who they communicate with, and the timing and sequence of these events. Given this, and the fact that the requirements being developed will usually be for a novel design, we recommend that some form of task analysis be performed.

There are several potential resources that may be used as a basis for a task analysis. They include the following:

- Previously performed training task analyses for current or predecessor systems
- Army Field and Soldier manuals
- Subject matter experts and system design engineers
- Army requirements documents (ROCs, RFPs, O&O Plans)

Each of these potential resources should be explored in order to prevent duplication of effort. In most cases a complete formal task analysis will not be required. If it is desired however, details of the exact steps in performing a task analysis can be found in several Army documents including TRADOC Reg 350-7 (1985), LOGC PAM 310-1 (1986), and TRADOC Pamphlet 351-4(T) (1979) among others. As a minimum, we recommend that the following be defined for each new or modified crew/staff function:

- Any events that need to precede or initiate the performance of the function
- The sequence (and timing if needed) of each of the steps in the function
- The control actions taken by the person for each step
- The indications or feedback from the system that the person will look for in each step
- The communications with other people that the person will perform in each step
- Any events that signal the end of the function or that necessarily occur upon the completion of the function

As the requirements for the system and other parts of the specification are more fully developed they should be integrated into the procedures as appropriate. The procedures should also be modified as these other requirements become more mature. Figure 14 provides an illustration in flow chart form of the procedure for manual scanning with the APES.

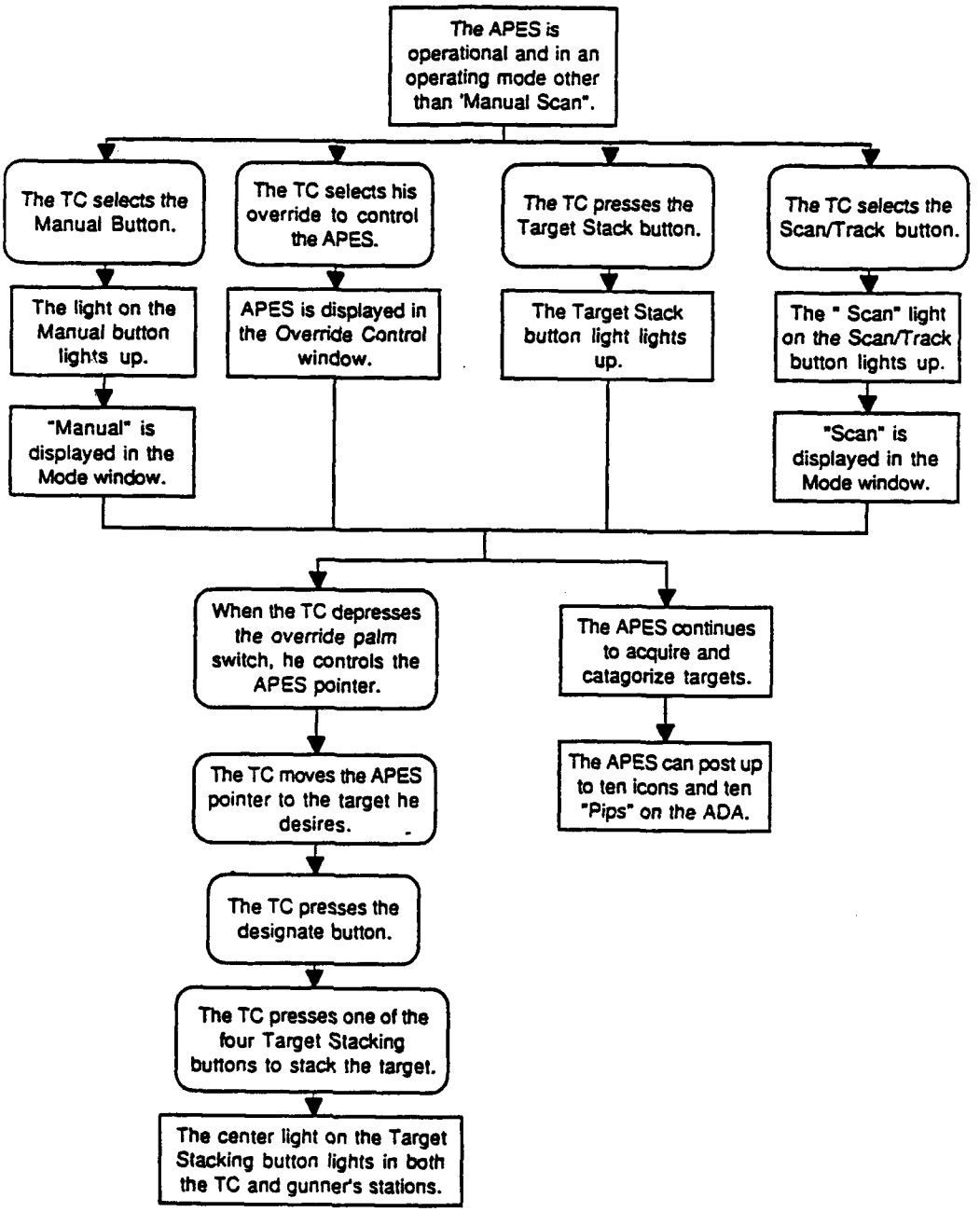

Figure 14. Manual scanning procedure flow chart

Develop Requirements for the System Functions

In this step the requirements for functions assigned to the systems will be defined. In one sense, this will be a mirror image of the procedures development step since the system response to operator actions will be defined. In addition to this, the needed interactions between systems, and between each system and the simulated environment, will be defined. Any system operating characteristics which need to be simulated will also be defined.

The use of selective fidelity means that in many cases, only the basic input-output characteristics for each system function will be required. For example, in simulating an autoloader mechanism for ramming the round, only the time delay, sound, decrement of the inventory, and indication to the crew were needed. It was not necessary to simulate the physical mechanism. Unless there is a great deal of interaction with other systems or the environment, extensive dynamic modeling of the system functions will probably not be necessary. If it is needed, subject matter experts should be used to help define assumptions, the dynamic characteristics of the system, and system interactions.

As a minimum, the following should be defined for each of the system functions:

- Any events which need to precede or initiate the function
- The sequence, timing, and duration of each of the system actions
- The results of the system actions including outputs to operators, other systems, environmental effects, or internal system feedback
- Any events or system interactions which can alter the system actions and the results of those alterations
- Any events which signal the end of the function or which necessarily occur upon the completion of the function

Like the procedures, as the requirements for the other parts of the specification are more fully developed they should be integrated into the system requirements as appropriate. The system requirements should also be modified as these other requirements become more mature. Figures and tables should be used liberally for the presentation of this material. Pages A-20 to A-27 in Appendix A provide an example of system functional specifications for the APES.

Define the Requirements for Soldier-Machine Interfaces

Defining the requirements for the soldier-machine interfaces primarily entails defining hardware requirements. In applying the selective fidelity approach, it should be recognized that the interfaces do not need to replicate those that might actually be used in a fielded system. The use of CRT displays with touch screen, mouse, or joy stick inputs should be considered as alternatives to conventional controls and displays. These devices allow for relatively easy and inexpensive reconfiguration while providing the necessary functional capabilities.

The design concept, the procedures, and the system functional requirements should be used as a basis for determining the soldier-machine interface design. Other designs used in CCTB or developed by vendors, labs, or other agencies should also be explored for identifying interface options. Interface design alternatives should be developed and then evaluated based on their ability to satisfy the procedural and functional requirements. These requirements and interface design concepts should be traded off until a satisfactory design is found.

Once an acceptable interface has been identified, detailed requirements should be developed for it. These requirements should include the following:

General

- The location and layout of the components
- Any coding schemes used for identifying or locating components
- Labeling and other highlighting (e.g., background shading) requirements

Controls

- The type of control and its basic physical and operational characteristics
- The functions or parameters affected by the control
- The operational states for the control such as switch positions
- Interactions with other controls such as interlocks
- Any feedback as a result of control usage by operator

Displays

- The type of display and its basic physical and operational characteristics

- The parameters or events reflected by the display and the relevant ranges, resolution, or states displayed

CRTs or Other Types of Generic Input/Output Devices

- The flexible nature of CRTs and other similar technologies makes it possible for them to be used as displays, controls, or entire control consoles. Given this, all of the requirements cited above should be considered when defining the requirements for these devices.

These requirements should be supported with figures and tables as needed. Pages A-27 to A-40 in Appendix A provide an example of soldier-machine interface requirements for the APES.

Define the Requirements for the Support Systems

The support systems include the semi-automated forces, the combat support, combat service support, opposing force workstations, and the data collection and analysis systems. The system interactions and interdependence within CCTB makes it likely that one or more of these systems will be affected when modifications are made. In some cases, these systems will be the main focus of the modification. The issues to be considered when making modifications to CCTB are discussed below for each of these systems. Pages A-99 to A-100 in Appendix A provide an example of these sections.

Semi-Automated Forces. The semi-automated forces are designed to mimic vehicles with actual crews. As a result, any time the performance or appearance of one of the manned simulators changes, the performance and appearance of the semi-automated forces should change as well. These changes should be identified and included in the specification. Since the semi-automated forces are not manned, assumptions and conventions for the performance of human functions will need to be made. These should be documented in the specification as well.

Combat Support. Combat support includes support from artillery, air defense, aviation, and engineering. It is provided by a person operating the combat support workstation. Modifications should be reviewed to determine if interactions with any of these support functions are affected. Any needed

changes to the workstation, operating procedures, or the nature of the support should be documented in the specification.

Combat Service Support. Combat service support includes maintenance activities and the delivery of fuel, ammunition, and other supplies. It is provided by a person operating the combat service support workstation. Modifications should be reviewed to determine if interactions with any of these support functions are affected. Since these services require direct interaction with the crews of the manned simulators, the need for modifications to the simulators or crew procedures in using these services should be investigated. Any changes needed to the workstation, operating procedures, or the nature of the support should be documented in the specification.

Opposing Forces. The opposing forces can be either semi-automated and controlled by a person operating the opposing forces workstation or manned simulators. Modifications to friendly manned simulators will generally not have an effect on semi-automated opposing forces. Changes to the battlefield environment such as night operations will however. Changes in operations, tactics, techniques, and procedures for either of the forces may have effects as well. The manned simulators can be modified to replicate the characteristics of opposing forces. These issues should be considered for the modifications and any changes to the opposing forces should be documented in the specification.

Data Collection and Analysis. Changes in the data collection and analysis systems will probably have to be made for most modifications. CCTB provides powerful capabilities for gathering and analyzing data. The CCTB document "SIMNET Data Collection and Analysis System" (1989) provides a complete description of the CCTB data collection capabilities along with a listing of the standard data collection parameters available. Modifications to CCTB may result in additional data collection and analysis requirements in the following areas:

- Instrumentation of controls and displays for monitoring crew performance
- Combat performance measures
- Resource usage
- Events to be recorded

- Statistical and other numerical analyses
- Graphs and reports required

Determination of the data collection and analysis requirements should be done in conjunction with the development of the Investigation Plan described in Section 3. This will help to ensure that the data required for performing the investigation can be collected.

Identify Alternate Conditions and Exceptions

This step is concerned with identifying conditions or cases which do not fall within the scope of the normal functions for the design. This typically includes things such as "exceptions to the rule" and operator errors. For example, it is necessary to determine what should happen if a crew member initiates a new function for a system while it is in the middle of performing a different one. Changing environmental conditions or system malfunctions may also cause changes in crew procedures or system operations. It is necessary to tell the system implementors how the simulation should respond in these cases.

The requirements should be examined to determine if there are circumstances which could lead to unpredictable or unwanted simulator behavior. Checking for the possibility of unrealistic behavior such as being able to see through or pass through solid objects, having unlimited resources, having two things occur simultaneously which are physically impossible, and the like should be considered. The simulated environment does not provide the constraints the natural world does without being told to do so. Any special assumptions or restrictions imposed by the conceptual design or the evaluation methodology should also be included here.

The requirements should also be examined to determine what happens if operators perform procedures incorrectly or make other errors. The user needs to attempt to "break" the design by operating it incorrectly. The combinations of available control actions should be examined and system responses for each of them should be defined. This may include feedback to the operator that an error was made.

The exceptional conditions and responses to operator errors should be integrated with the procedures, system requirements, and soldier-machine interface requirements. Any needed modifications to these requirements should be made as well.

Develop Detailed Physical and Functional Specifications

In this step the procedures, system requirements, and interface requirements should be completely integrated. The detailed specifications for the physical and functional characteristics of the design should be developed. This will generally be more a matter of organizing existing information than of generating new information. The exact format and structure is left to the user. The guidance given previously for the content may be used as a basis for this. Figures should be used liberally for the presentation of this material. Pages A-42 to A-99 in Appendix A provide an example of a completed detailed functional specification for the APES.

Develop Acceptance Testing Procedures and Criteria

The acceptance testing is used to confirm that the modifications made to CCTB result in the desired appearance and performance. The acceptance testing consists of test procedures, acceptance criteria, and a sampling plan. The test procedures and criteria can generally be drawn directly from the hardware and functional specifications.

Test procedures should define what actions to take, what data to collect, and what to expect. Test scenarios and test input data should be developed as appropriate. Acceptance criteria may be quantitative or qualitative. Quantitative criteria should specify an acceptable value or range of values. Qualitative criteria should define the appearance or performance characteristics which must be demonstrated.

Since it is not practical to test everything within CCTB, a sampling plan should be developed for the acceptance testing. The plan should provide a series of tests which systematically exercise the system. Tests of individual functions and subsystems as well as integrated tests should be included. As a minimum, all crew or workstation operator functions associated with the modification should be fully tested on one simulator or workstation. Selected functions or subsystems may be tested on other simulators and work stations.

An example of acceptance testing procedures, criteria, and sampling for the APES is provided on pages A-100 to A-103 in Appendix A.

Define the Schedule for the Modification

In order to provide the implementors of the specification with a working time frame, a preliminary schedule for the modification should be developed. The schedule requirements from

the sponsoring agency should be reviewed to determine when the modifications need to be completed. The lead team member and the CCTB manager should review the modification requirements and develop a preliminary schedule. As a minimum, estimates should be made for the timing and duration of the following activities:

- Each major hardware modification
- Each major software modification
- Each major integration activity
- System tests
- Time for modification revisions
- Acceptance testing

Figure 15 provides a sample schedule for the APES system.

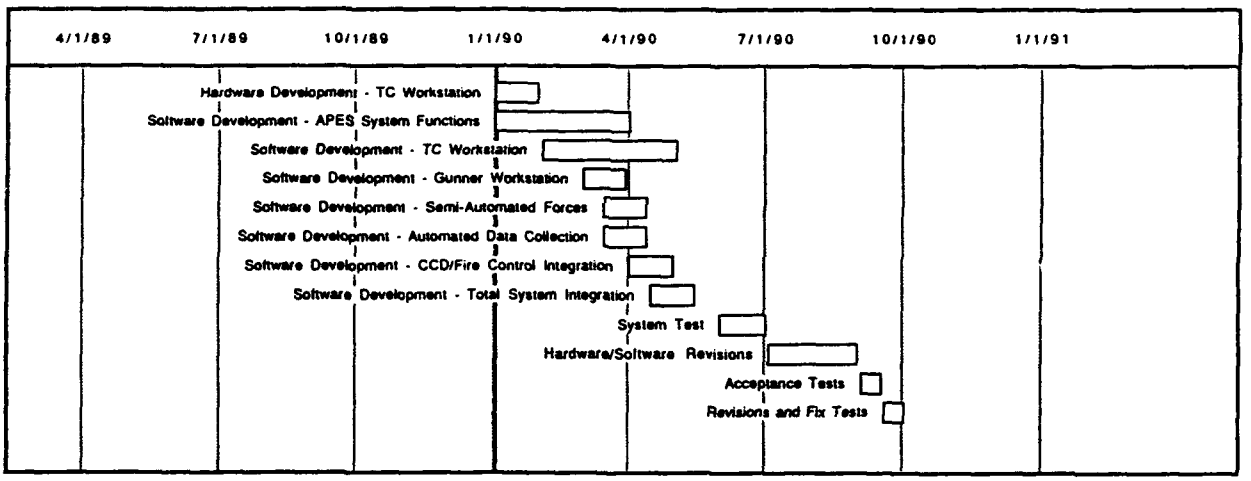

Figure 15. Sample schedule for the modification implementation

Draft the Section

The CASM Software Toolkit can be used to draft each of the subsections (word processing tool), create the tables and figures (word processing tool, drawing tool, flow charting tool), create function, task, subsystem and component lists and relationships (word processing tool, database tool) create the schedule (project management tool), and integrate and format them into a draft for the section.

SECTION 3 - INVESTIGATION PLAN

Introduction to Section 3

Section 3 is the Investigation Plan. It provides the basic information needed to evaluate the proposed system in the CCTB environment. It includes discussions of the data requirements and resource requirements. It is not intended to reflect a fully designed experiment. It is a guide to the CCTB developers and users for the implementation of the proposed modification. While this plan could be used as a basis for investigation, it would require further refinement and detail before actually being used.

This section begins with a discussion of the objectives for the test and the issues surrounding them. The factors and conditions define the experimental variables from which the specific data requirements are derived. Finally, the key resource requirements for the testing are defined. Pages A-105 to A-118 in Appendix A provide an example of this section.

Section 3 Content

3.0 INVESTIGATION PLAN

3.1 PURPOSE OF THE INVESTIGATION

A brief statement of the purpose of the investigation should be provided.

3.2 OVERVIEW OF THE PLAN

The content of the subsections for the plan should be briefly described. A statement indicating that the plan is to be used for guidance and is not a fully developed experiment, should also be made.

3.3 INVESTIGATION PLAN OBJECTIVES AND ISSUES

The objectives for the investigation are developed iteratively and progressively during the development of the modifications and the investigation plan. They are initially presented in Section 1.5 of the specification. They should be restated here for reference. The plan defines the testing, data, and resource requirements needed to meet these objectives.

A discussion of the issues surrounding each of these objectives is provided in the following subsections. These discussions are intended to clarify the intent of

the objectives and identify specific questions to be answered by the testing.

3.3.1 ISSUE 1

This includes a statement of the first issue, the scope of the first issue, and a listing of subissues (questions).

3.3.2 ISSUE 2

.
.
.

3.3.X ISSUE X

3.3.6 SUMMARY

Each of the objectives includes several issues which must be addressed in the testing. In the following sections the methods and measures for answering the questions posed above are presented.

3.4 FACTORS AND CONDITIONS

The factors and conditions reflect the major variables which will be manipulated, held constant, or left uncontrolled for the study. The factors and conditions have been divided into four major groups for discussion and analysis - systematically varied, tactically varied, held constant, and uncontrolled. A table summarizing these factors and conditions for the investigation should be provided here.

3.4.1 SYSTEMATICALLY VARIED FACTORS

Factors are varied systematically for a combination of two reasons:

- To ensure that conditions identified as influencing operational effectiveness are thoroughly examined and their effects identified.
- The factor's probable frequency of occurrence in the combat scenario cannot be accurately determined or obtained naturally in the compressed test time interval.

The factors should be varied systematically within the limits of their respective conditions. The combinations should be selected to:

- best facilitate the comparison of the baseline system with the modified system
- define the performance of the modified system in an operational mode when no comparison exists

3.4.2 TACTICALLY VARIED FACTORS

Factors are tactically varied when their probable frequency of occurrence in combat may be estimated from a description of threat, doctrine, mission profile, or other tactical specifications.

3.4.3 FACTORS HELD CONSTANT

In order to simplify the data, some factors (normally proposed by the combat developer based on experience and studies) will be held constant. These factors are found in a realistic combat environment and represent the most probable status or condition.

3.4.4 UNCONTROLLED FACTORS

Factors over which the tester has no control or which are desired to be left uncontrolled are allowed to occur naturally.

3.5 DATA REQUIREMENTS

This section describes the types of data, basic data collection techniques, data tolerances, and specific data requirements for the investigation. Each of these areas should be described in the following subsections.

3.5.1 TYPES OF DATA AND COLLECTION METHODS

The required data are of two types:

- Objective data referred to as quantitative data (i.e., may be assigned a specific numerical measure)
- Subjective data referred to as qualitative (i.e., opinions, reasons, consensus, and observations)

In measuring system performance, the highly sophisticated instrumentation of the CCTB Automatic Data Collection System (data logger, video cameras, and the audio recorder) may be used to collect much of the needed data. A combination of manual data collection, judgmental observations, and electronic recording

instrumentation may be used to collect the remaining data.

Listings of the specific quantitative and qualitative measures should be provided in this paragraph. The data collection methods should also be identified and described as needed.

3.5.2 TOLERANCES

The precision of the quantitative data collected should be listed here. As a minimum, it should include timed data, count data, and possibly range data.

3.5.3 DENDRITIC STRUCTURE FOR REQUIRED DATA

Since a given point may support or affect more than one objective, a root-like construction (i.e., dendritic structure) may be applied to simplify the process and display information. Tables should be provided which list data requirements in a format designed to facilitate information collection and processing during test execution. These tables should list the reduced quantitative and qualitative data requirements by objective. Sequential numbering of each data point will facilitate the chronological collection of data (subjective and objective).

Unless otherwise stated, all measures should be consistent with those described in the CCTB Automated Data Collection Guidance (1989) document. Any changes in the definition of measures or any new measures should be described.

3.6 RESOURCE REQUIREMENTS

This section should present an overview of the resources required for conducting the test for the investigation. It should include facilities and equipment requirements, personnel requirements, and general support requirements.

3.6.1 FACILITIES AND EQUIPMENT

For this section, the size of the unit in the experiment should be assumed. The following paragraphs should project the equipment and facility needs based on this assumption:

- Manned Simulators. State number of manned simulators, how they are organized, and how adjacent units are simulated and controlled.

- Semi-Automated Forces. State that the opposing forces (OPFOR) and/or friendly forces (BLUFOR) will be maneuvered and simulated by the Semi-Automated OPFOR Staff (if that is indeed the case). State the space and equipment requirements. Indicate who will play adjacent units and what the space and equipment requirements are.

- Battalion Operational Staff Workstation. State the space and equipment requirements.

- Battalion Combat Support Workstation. State the space and equipment requirements.

- Battalion Combat Service Support Workstation. State the space and equipment requirements.

- Data Reduction and Analysis Systems. State the space and equipment requirements.

- Administrative Office Space and Equipment. State the space and equipment requirements.

3.6.2 PERSONNEL

The personnel requirements consist of the people needed to participate in and run the test for the investigation. This includes the following:

- The number and types of soldiers needed to man the simulators.

- The CCTB and command and control staff needed to participate in the investigation.

- CCTB operators and maintainers and data collectors needed to run the investigation.

A table summarizing the personnel requirements should be provided.

3.6.3 GENERAL

If testing or support personnel are brought in from agencies/units outside of Fort Knox, then appropriate housing and welfare facilities would have to be provided. Otherwise, no other support will be required.

3.6.4 INVESTIGATION SCHEDULE

A preliminary schedule for the investigation should be presented. As a minimum, it should include the milestones for test design and development, pilot testing, training, test conduct, and data analysis.

Section 3 Process

The overall purpose of the Investigation Plan is to develop sufficient details of an assessment plan to permit full consideration of the modifications and their potential effects. The plan provides the basic information needed to evaluate the system in the CCTB environment. It includes discussions of fundamental design concepts, data requirements, resource requirements, and investigation schedules.

The Investigation Plan is not intended to be a fully designed experiment, but rather a guide to the CCTB developers and users for the implementation of the modifications. While this concept can be used for a basis for investigation, it would require further refinement and expansion before actually being implemented.

The steps for developing the Investigation Plan are:

- Assign team responsibilities
- Define purpose, issues, and objectives for the investigation
- Develop the test design
- Define the resource requirements for the testing
- Define the testing schedule
- Draft the section

Each of these steps are discussed in the following paragraphs. Figure 16 provides the process flow for the section and Figure 17 provides a sample timeline for developing the section.

Assign Team Responsibilities

The development of the Investigation Plan is an iterative and evolutionary process. It begins with the initiation of the specification process and continues until the completion of the final document. Following the development of Sections 1 and 2, the orientation of the team focuses on how the system could be

tested and evaluated using CCTB. The Test and Evaluation Specialist acts as team leader and is ultimately responsible for the production of the Investigation Plan.

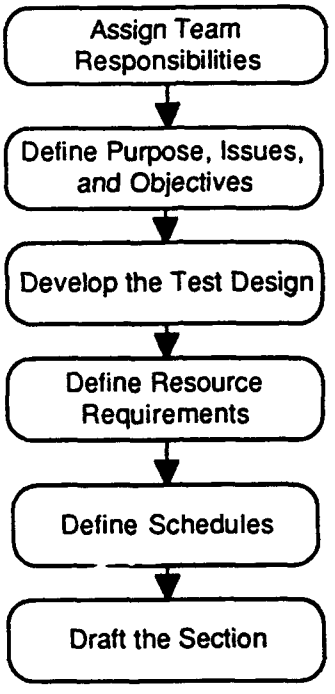

Figure 16. Process flow for the development of Section 3

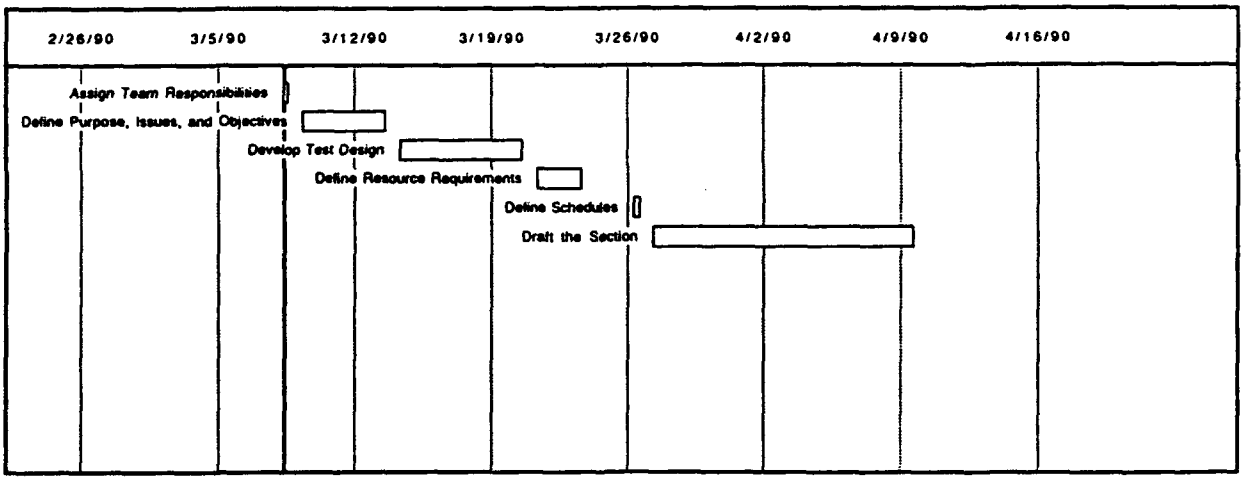

Figure 17. Sample timeline for the development of Section 3

Team Leader. The Team Leader will be responsible for assisting in the direction and coordination the efforts of the other team members. He or she will support the Test and Evaluation Specialist by arranging for people and resources to be made available.

Sponsor Representative. The Sponsor Representative will provide guidance regarding the intentions of the sponsoring agency and act as a liaison between the team and the sponsor for providing sponsor clarifications, preferences, and resources.

Military Systems Operations Specialist. The Military Systems Operations Specialist will assist in defining the test objectives and measurements.

Military Systems Engineering Specialist. The Military Systems Engineering Specialist will assist in defining the test objectives and measurements.

Test and Evaluation Specialist. The Test and Evaluation Specialist will lead the effort and develop the test design, measures, resources requirements, and schedules.

CCTB Engineering Specialist. The CCTB Engineering Specialist will assist in defining the data collection requirements.

CCTB Manager. The CCTB Manager will assist the team in defining the personnel requirements and schedule for the testing.

Training Specialist. The Training Specialist will assist in defining the training requirements and schedules for the testing.

Other Subject Matter Experts. The other Subject Matter Experts will provide inputs as they relate to their areas of expertise.

Define Purpose, Issues, and Objectives for the Investigation

Purpose of the Investigation

The purpose of the investigation will be based on the purpose of the modification developed in Sections 1 and 2. It will normally focus on the assessment of the military utility and operational effectiveness of the proposed modification. An example of a purpose statement might be:

> "Testing based on this plan will provide data and associated analysis on the operational effectiveness and military utility of augmenting the Abrams tank with an Acoustic Priority and Engagement System (APES). It will allow a

comparison of the Abrams with an APES to the Abrams baseline (i.e., Abrams with CITV).

The emphasis should be on evaluating the changes in simulated battlefield performance based on the modification.

Issues

An issue is any aspect of a system's capability that must be questioned before the system's effectiveness and military utility are known. Developing issues is done in three substeps:

- Conversions of functions to issues
- Assessment for applicability in CCTB
- Statement of issues, and review for completeness

Each of these substeps are described below.

Conversion of functions to issues. As part of the development for Section 2, the system will have been analyzed into all its functions. This includes identifying and defining the functions, along with their interrelationships. Initially, the functions are stated in broad categories such as enhancing fightability or reducing workload. Subsequently, these broad category functions are further analyzed into ever increasing levels of detail. A fightability subfunction for an APES for example might be to increase the target acquisition rate for an Abrams tank.

Based on the identified functions, issues are stated. Each function involves at least one issue -- how effectively the system performs that function. Usually, a function relates to more than one issue. The capability of a system to perform a function under various conditions may lead to further issues. A broad issue might be:

"Does the APES enhance fightability of the tank?"

Subissues might be:

"How is target engagement affected?"

"Are tactics changed when the APES is integrated in the tank?"

All of the issues associated with each of the functions should be defined initially.

Assessment for applicability in CCTB. Having developed the issues critical to the full assessment of the proposed system modification, it is necessary to determine if these questions can be answered using CCTB. Each subissue must be considered in the context of the capabilities and limitations of CCTB. For example, in evaluating a target prioritization system, fightability issues such as the changes in procedures can be considered; however, lethality issues such as probability of kill cannot be assessed. Each of the issues should be evaluated for applicability within in CCTB and those that are appropriate should be identified.

Statement of Issues. Issues statements should be developed for each of the applicable issues. Since the issues underlie all further assessment efforts, a careful and precise statement is necessary. Statements are simple enough to preclude ambiguity, but complete enough to cover all a decision-maker needs to know to decide operational effectiveness or military utility. An example of the statement of a broad issue is:

> "How is fightability affected when the APES is integrated into the Abrams tank?"

This issues can contain several more detailed statements of issues such as:

> "How is the command and control of the tank platoon affected by the addition of the APES to the Abrams tank?"
>
> "What will be the significant effects on target engagement efficiency (ability to acquire and engage targets) and effectiveness (ability to win the fight)?"
>
> "What changes in organization, tactics, techniques, or procedures occur as a result of introducing the APES into the tank?"

Once issue statements are developed they should be reviewed for completeness. In reviewing a set of issues, consider:

- Categories of issues common to all systems
- Problems associated with like systems
- Previous issues raised for other systems
- Anticipated issues that could by raised on this system
- Military judgment and expertise

- Design considerations
- Capabilities and limitations of CCTB

Objectives

Objectives for assessing the system modifications in the CCTB environment are simply declarative statements of the broad issues or questions about the military utility or operational effectiveness. They are a means to give focus and linkage of the data requirements (to be discussed later) to the issues. For example, the conversion of an issue into an objective would be:

Issue: "How is fightability affected when the APES is integrated into the Abrams tank?"

Objective: "To assess any changes in the fightability of the tank."

At the completion of this step, statements of the purpose, issues, and objectives should be drafted.

Develop the Test Design

A test design consists of three elements:

- The conditions under which the test is to be conducted (test conditions)
- The data required to address the issues in question (data requirements)
- The plan for analyzing the data (analysis logic)

The overall purpose of this effort is not to develop a full test design plan. The purpose is to develop sufficient details of a assessment plan that will permit full consideration of what the modifications should be and their potential effects on the system to be modified. Consequently, this section will only address pertinent portions of the test conditions and data requirements, while omitting entirely the analysis logic. Each of the elements of the plan defined above are discussed in the following paragraphs.

Test Conditions

As a minimum, the team should consider the test factors and conditions which will affect the implementation of the proposed CCTB modification. Based on the issues, the test concept

designer lists all of the factors that may reasonably be expected to influence the outcome of a test or the performance of the system. These test factors, sometimes referred to as "independent variables," are either controlled or left uncontrolled in the test. The controlled factors may be controlled in three ways:

- Tactically varied
- Systematically varied
- Held constant

In general, tactically varied factors are allowed to occur as a result of tactical operations. This enhances realism and is the preferred method. Limited time and material resources allowed for the conduct of the assessment requires that systematically varying factors be used. This will ensure that all required factors will be examined in sufficient quantity to permit effective analysis. For some factors, prior knowledge or testing indicate a preference. Consequently, the factor is held constant in that state or condition during the conduct of the CCTB trials. Examples of systematically varied factors, tactically varied factors, factors held constant, and uncontrolled factors for the APES are shown in Table 1.

Once all the factors relevant to the tested system are identified, the conditions of each factor required for a realistic assessment of the system are considered. Only those conditions that are expected to have an appreciable effect on the system should be represented. There is a tendency to try to include too many conditions. The greater the number of conditions that are included, the more difficult it will be to conduct CCTB trials.

Emphasis should be placed on selecting the most representative conditions and varying those. The selected conditions for a factor should be the most representative in all senses of the word. They are the conditions that lie between extremes, that are most commonly present in operational circumstances, and that have the most typical effect on the system.

FACTORS	CONDITIONS
Systematically Varied	
System	Abrams with APES, Abrams with CITV
Tactical Mode	Offense, Defense, Movement to Contact
Tactically Varied	
Targets	T72, BMP, Troops
NBC	Scenario Driven
Obscurants	Clear, Smoke
Light	Day, Night
Held Constant	
System modifications	As defined initially
Terrain	Fort Knox
Crews	Same for all trials
OPFOR	Elements of MRR
Uncontrolled	
Learning during trials	As occurs

Table 1: Factors and Conditions

Data Requirements

Data requirements are those data which would be required for an assessment of the CCTB modifications. The team uses the issues as the focal point for developing the data requirements. The resulting data requirements confirm the data which would be available for a full assessment of the system modified on CCTB. Once the requirements are defined, the methods of data collection should be defined. Methods for defining data requirements and data collection methods are provided below.

Data Requirements Development. Required data my be either quantitative (may be assigned a specific numerical measure) or qualitative (opinions, reasons, consensus, and observations). Ultimately, these data requirements will specify the measures which will be used to address the issues. Measures are developed by dividing objectives into subobjectives, and subobjectives into progressively finer subdivisions until measurable entities are derived.

A suggested technique is to construct a dendritic chart showing the progressive breakdown of each subobjective and to number the divisions consecutively for a given data requirement. The breakdown continues until each trace of the structure results in a data requirement. Examples of quantitative and qualitative data requirements for the APES are given in Table 2 and Table 3, respectively.

Data Collection Methods. After the data requirements are determined, the methods of collecting the required data must be identified. First, the team should determine if their data requirements can already be collected within the system. This can be determined by reading the CCTB Data Collection and Analysis (DCA) document. If the required data is not currently collected, within the system, these "non-standard" requirements must be identified so that special extraction software can be written for the automated data recording system.

OBJECTIVE	REDUCED DATA REQUIREMENTS
*1.0 Fightability	*1.1 Number of instances where command and control could not be maintained within the platoon *1.2 Number of instances where effective command and control could not be maintained within the tank crew *1.3 Number of times a TC/gunner selects a switch incorrectly *1.4 Number of times TC has to reissue/revise fire commands *1.5 Percent of rounds fired by tank *1.6 Number of instances in which TC chooses not to use APES *1.7 Number of times APES target selection overridden by TC *1.8 Percent of time in Scan/Auto mode *1.9 Percent of targets engaged *1.10 Percent of times APES target priorities used
*2.0 Workload	*2.1 Average time to acquire targets *2.2 Average time to engage targets *2.3 Average intercom time *2.4 Frequency of intercom use *2.5 Blood pressure of TC over time *2.6 Blood pressure of gunner over time *2.7 Heart rate of TC over time *2.8 Heart rate of gunner over time *2.9 Error rate of target engagement procedures

* Denotes dendritic numbering as distinguished from paragraph numbering.

Table 2: Quantitative Data Requirements

OBJECTIVE	REDUCED DATA REQUIREMENTS
*1.0 Fightability	*1.1 Crewmember observations/ comments on command, control, and communications functions *1.2 Data collector observations/ comments on command, control, and communications functions *1.3 TC/gunner comments on target acquisition *1.4 TC/gunner comments on target engagement effectiveness *1.5 Identify changes in tactics with APES *1.6 Identify changes in procedures with APES *1.7 Comments by crew on combat effectiveness and efficiency *1.8 Comments by observers on changes
*2.0 Workload	*2.1 Crew comments on overall workload *2.2 Data collector comments on overall workload *2.3 Crew observations on target acquisition times *2.4 Crew observations on target engagement times *2.5 Crew observations on ease of use of APES
*3.0 Survivability	*3.1 Crew observations/insights on survivability *3.2 Data collectors opinions on survivability
*4.0 Training	*4.1 Comments of trainers on training program *4.2 Comments of crew on training *4.3 Comments of observers on training *4.4 Identification of training conducted *4.5 Recommendations for needed additional training

* Denotes dendritic numbering as distinguished from paragraph numbering.

Table 3: Qualitative Data Requirements

Data Collection. Quantitative and qualitative data may be collected in CCTB automatically or manually. CCTB provides the capability to automatically collect all network and audio data for any exercise through the use of the DataLogger and the Audio Recorder. Manually collected data includes data that can only be captured by a human observer, data that are more easily recorded by a human observer, or data that require on-the-spot interpretation. CCTB has an extensive capability for collecting quantitative data and facilitating the capture of qualitative data. The team should refer to CCTB Data Collection and Analysis System (1989) documentation for an in-depth understanding of its capabilities.

Approach to Test Conduct

Although the details of how the test on CCTB is to be conducted (number of trials, how conditions are to be combined, force ratios, etc.) are not required at this time, the developers must consider the general approach for constructing subtests. This will permit an estimate of the resource requirements and lay the foundation for a more complete test design when the CCTB modification is enacted.

A draft of the test design including test conditions, data requirements, and a test approach should be produced.

Define the Resource Requirements for the Testing

The resources required for the investigation address the facilities and equipment, personnel, and general support requirements. In making these general estimates, the test conditions developed in the previous step should be used as a guide. Substeps for defining requirements for each of the areas listed above are provided below.

Facilities and Equipment

The estimates in this section are based on the assumption of scope of testing. Estimates should include numbers and types of facilities and equipment. The following elements should, as a minimum, be considered when estimating resource requirements:

- Manned simulators
- Semi-automated forces
- Battalion operational staff workstation
- Battalion combat support workstation

- Battalion combat service support workstation
- Data reduction and analysis systems
- Administrative office space and equipment

Listings of resource requirements should be developed for each of these areas.

Personnel

The personnel requirements consist of the people needed to participate in and run the test. Simulator crews, command and control staff, CCTB operators and maintainers, and data collectors will be required, as a minimum, to run the test. An example of what personnel resources requirements might be are shown in Table 4.

General

This is a catch-all category to cover any subjects not covered above. An example of this is housing and welfare for any off-post personnel which may have to be brought in for the test.

Define the Testing Schedule

In order to provide the implementors of the specification with a working time frame, a preliminary schedule for the testing should be developed. The schedule requirements from the sponsoring agency should be reviewed to determine when the testing needs to be completed. The Test and Evaluation specialist and the CCTB manager should then review the testing requirements and develop a preliminary schedule. As a minimum, estimates should be made for the timing and duration of the following activities:

- Test design and development
- Pilot testing
- Training for CCTB operating staff, data collectors, and soldiers participating in the test
- Test conduct including multiple trials
- Data reduction and analysis

CATEGORY	FUNCTION	QUANTITY
TEST	Tank Crews:	
	Platoon Leader	1 four-man crew
	Platoon Sergeant	1 four-man crew
	Tanks 3 and 4	2 four-man crews
	Company Commander	1 four-man crew
	Platoon Leaders	2 four-man crews
TEST SUPPORT	Command Staff	
	Director/BN Cdr	1 person
	S-3	1 person
	S-2	1 person
	Blue Force Coordinator	1 person
	Combat Support	
	Artillery	1 person*
	Engineer	1 person*
	Combat Service Spt	
	S-4	1 person
	Opposing Forces	2 people
ADMINISTRATIVE	SIMNET	
	Coordinator	1 person
	Maintenance	As required
	Data Collectors/ Observers	
	Simulators	7 people
	S-3 Recorder	1 person
	S-2 Recorder	1 person
	S-4/Artillery/ Engr Recorder	1 person

* One person performs these functions.

Table 4: Personnel Requirements

Figure 18 provides a sample schedule for the APES system.

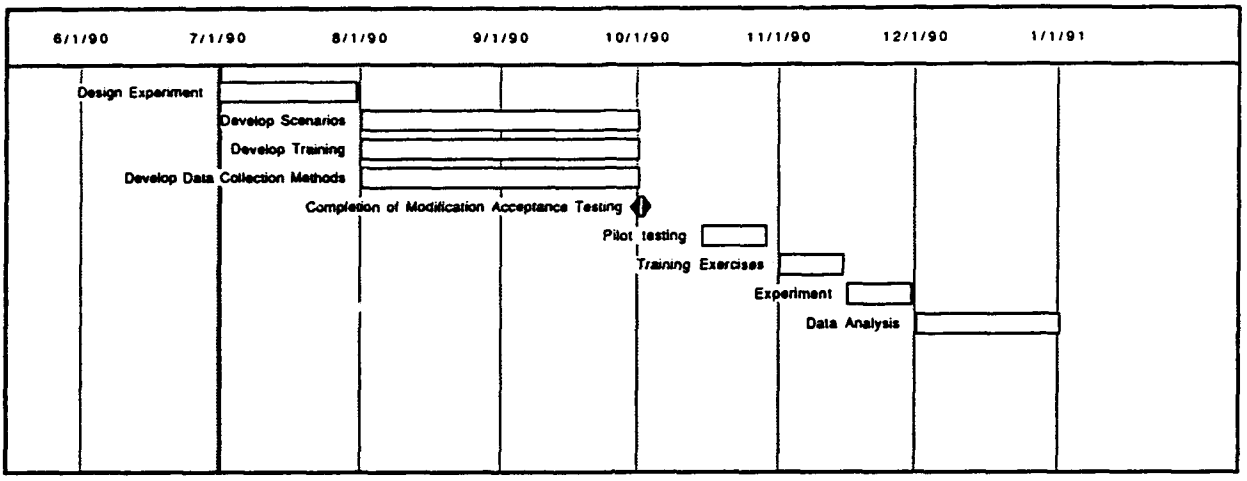

Figure 18. Sample schedule for the modification evaluation

Draft the Section

The CASM Software Toolkit can be used to draft each of the subsections (word processing tool), create the tables (word processing tool), create the schedule (project management tool), and integrate and format them into a draft for the section.

PRODUCE THE FINAL SPECIFICATION

The completed drafts for each of the sections should be forwarded to the sponsoring and implementing agencies for review. If needed, a meeting may be held with these organizations to review the specification. At this meeting the requirements defined by the specifications should be reviewed in light of the sponsoring agencies budget and schedule constraints. Differences between the requirements and constraints should be identified for further examination. When requirements do not exceed the constraints, opportunities for reallocating resources should be explored. When requirements do exceed constraints, the requirements should be examined to determine the primary sources of the demand.

Working with the sponsoring and implementing agencies, the team should explore options for resolving the requirement/ constraint conflicts. This could include changes to the design modifications and testing methods, the use of alternative equipment, materials, or personnel, and changes to budget and schedule constraints. The trade-offs should be made in light of the overall goals for the effort to ensure that they are not compromised. At the end of this trade-off analysis, specific resolutions should be identified for the requirement/constraint conflicts.

The resolutions for the requirement/constraint conflicts involving the modifications and testing should be fully developed and incorporated into the specification. Care should be taken to include the potential "ripple effects" that these changes may have on other modifications and CCTB subsystems. Any changes needed based on these reviews should be made and the specification should be published in final form. The specification can then be delivered to the CCTB developers for implementation.

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SUMMARY

This document has presented methods for developing modification specifications for CCTB. It has described both the content of the specification and the processes for developing the specification. A team of people with the diverse skills needed to develop the specification performs the work for this effort. The specification consists of

- An introduction describing the purpose and need for the specification
- A section providing a detailed description of the modifications to be made
- A section describing a plan for evaluating the changes in the CCTB environment

A specification developed using this methodology should provide the information required for efficient and accurate implementation of the modification to CCTB.

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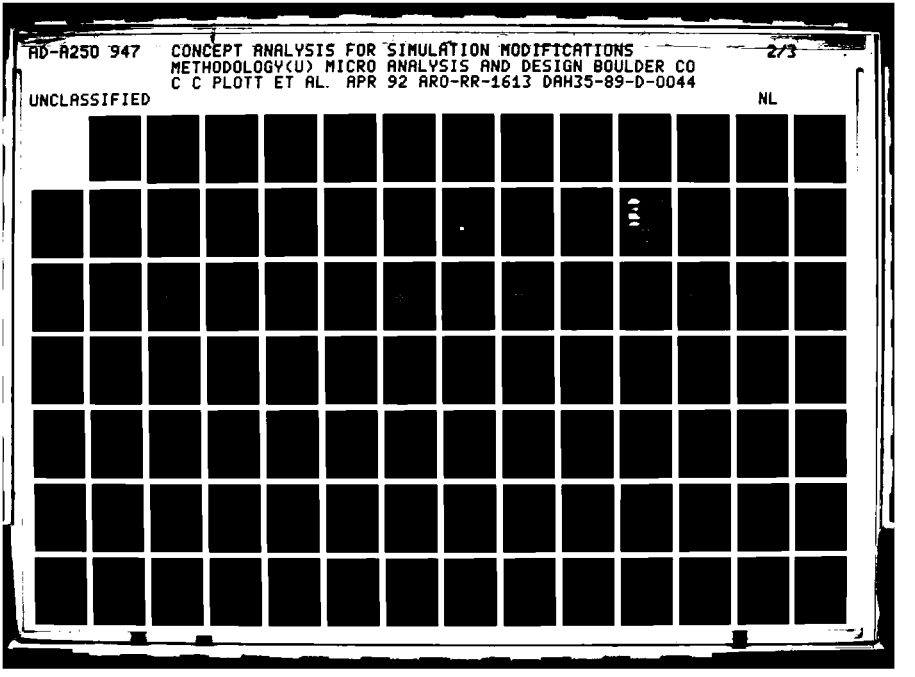
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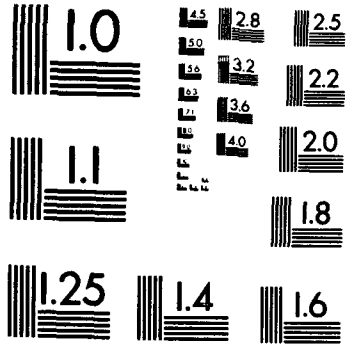

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APPENDIX A

SAMPLE SPECIFICATION

SPECIFICATIONS FOR AN ACOUSTIC PRIORITY AND ENGAGEMENT SYSTEM

ACOUSTIC PRIORITY AND ENGAGEMENT SYSTEM INTEGRATION IN THE SIMNET-D ABRAMS TANK SIMULATOR WITH CVC2

TABLE OF CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

CONTENTS (Continued)

1.0 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT.

The purpose of this document is to provide specifications for integrating the Acoustic Priority and Engagement System (APES) into the Abrams tank simulator in the CCTB facility. The issues surrounding the introduction of an APES screen in a tank and the specific changes to be made to the CCTB facility are both discussed. This has been done to provide the people who will be performing the integration with a comprehensive understanding of what is required.

This document has been divided into three major sections. Section 1 presents the basic rationale for introducing an acoustical target engagement system into the Abrams, the impacts on the tank, and how this translates to the CCTB environment. Section 2 describes the specific modifications which will be made to the CCTB simulator and facility. Section 3 describes the investigation plan for evaluating the changes in simulated battlefield performance of Abrams tanks equipped with an Acoustic Priority and Engagement System. Sections 2 and 3 contain most of the detail for the document and while related, may be used independently.

Section 1 begins by providing a background discussion of the issues surrounding the introduction of a new way to acquire targets in a tank--by a target acquisition system. Specific goals and objectives for integrating the target acquisition system into the tank and tank environment are presented. The scope of the anticipated modifications to the tank and its subsystems are then discussed along with several key assumptions about the proposed modifications. A discussion of how CCTB will be used to investigate the impacts of introducing the APES into the Abrams is then provided. Finally, the overall schedule for the implementation of the specification is presented.

1.2 BACKGROUND.

The rapid advancements in micro-electronics and acoustical engineering during the past ten years have provided many opportunities for tanks to take advantage of this expanding technology. In many cases, the technical capabilities have outstripped our ability to forecast their practical use. Although the Abrams has a superb thermal and optical target acquisition system, finding and engaging targets still remains a key problem and depends primarily on the skills of the gunner and tank commander. Currently, the gunner's view is slaved to a small cone around the main gun. The tank commander (TC) is restricted to that same view and his vision blocks while his hatch is closed, or to binoculars while risking exposure from an open hatch.

Technology offers tankers a better and faster way to acquire targets and a more accurate way to hit them. This document details a target acquisition, prioritization, and engagement system, based at this time only on an acoustical sensor, to help overcome the target acquisition, prioritization, and engagement problem. Other methods of target acquisition, prioritization, and engagement can be incorporated in the future as technology develops.

The discussion which follows addresses some of the issues surrounding the capabilities and limitations of a state-of-the-art APES. This includes target acquisition rate, visibility restrictions, firing accuracy, target selection, identification of friend and foe, signal detectability, and crew workload.

1.2.1 TARGET ACQUISITION RATE.

The Warsaw Pact threat has the capability to mass tanks, armored personnel carriers, and self-propelled artillery in such densities that NATO forces could have to defend against a much larger attacking force. In those critical points of the battlefield, the Abrams tank must acquire targets rapidly, fire accurately, and then acquire the next target. The current system requires the TC to scan the battlefield for possible targets, then proceed with a time consuming method of identifying the target to the gunner. Acquiring targets is one of the most troublesome tasks in the firing sequence. The limiting factor in a tank's kill rate is the rate at which the crew can acquire targets.

The APES has the capability to alert the TC to a possible target, suggest a priority when there are multiple targets, and finally lay the gunner's sight and gun tube so that the target is within the sight's field of view. During actual firing, the APES can either scan for targets, with the TC or APES prioritizing targets, or track targets, designated by the TC or system, to be engaged. Acquisition and engagement rates should increase markedly.

1.2.2 VISIBILITY RESTRICTIONS.

Massive artillery barrages, combined with burning vehicles, produce dust and smoke which is extremely difficult to penetrate with standard optics and thermal sights. Periods of intense rain and snow also cause major visibility problems for the TC and gunner. Even darkness restricts the tanker to his thermal sights. More ominous yet is the development of sophisticated, multi-spectral smoke specifically formulated to defeat thermal imagery and current laser wave bands.

The addition of an APES will alleviate most current visibility handicaps. Tested performance of acoustical passive sensors in these "dirty" conditions has been impressive and should provide a true 24 hour, all weather and conditions capability for target acquisition and prioritization, range determination, and firing.

1.2.3 LAYING THE MAIN GUN.

Currently, one task that places great demand on the TC is laying the main gun on targets for the TC or gunner to engage. This action requires a great deal of skill so that the gunner can quickly identify the target to engage. This action allows for a great deal of error. This error becomes particularly large when the gunner is under stress, is rushed, is firing at a moving target, or is in a moving tank himself. Despite great efforts to stabilize the platform and gunner's sights, properly laying the main gun so that the gunner can secure an accurate sight picture is still a very difficult task and one that is subject to varying degrees of human skill.

The APES will give the TC the capability to lock on to a target, automatically track the target, and lay the main gun so that the target can be identified in the sights. Once laid on the target, the TC or gunner lases to the target so that target range, movement, and center of mass data can be provided to the fire control system. The APES should be particularly valuable at ranges out to 4000 meters.

1.2.4 TARGET SELECTION AND PRIORITIZATION.

In the confusion of a modern, lethal battlefield, where tankers are outnumbered and faced with many decisions, one of the most important decisions is who to shoot next. The decision process is focused on the target which presents the greatest threat to the tank--both in terms of lethality and time. Currently, multiple target situations must be processed and stored in the TC's head while he waits for the firing to proceed, one target at a time.

The APES can scan the selected area for targets, assign a category (Tank, Personnel Carrier (PC), Wheeled, Helicopter, or Unknown), and then recommend a priority of engagement based on the calculated threat to the tank. This capability allows the TC to fight and maneuver his tank without being consumed by the target selection process. The TC can confirm the APES indications, or he can quickly override the selection and move to another presented target.

1.2.5 IDENTIFICATION OF FRIEND AND FOE.

The APES will provide the TC with limited identification of friend or foe (IFF) information. Based on the acoustical signature of the detected vehicle, the APES will be able to categorize and identify if the target is a friend or foe. This capability is dependent on the targets distance and the noise level surrounding the vehicle. Because of this degradation, visual and non-visual verification methods will also need to be used for IFF. These may include the use of other technologies such as the TC's Commander's Control Display, or the use of procedures and tactics which minimize the risk of firing on friendly forces.

1.2.6 SIGNAL DETECTABILITY.

A concern with any electronic device on the battlefield is that the enemy will be able to detect and track the source. Since the APES is a passive system, this problem is eliminated. The APES only receives sound waves and emits no detectable power.

1.2.7 CREW WORKLOAD.

Fighting a tank in combat is a stressful event. Reports from the latest two Israeli tank wars, Yom Kippur and Peace for Galilee, confirm the enormous workload placed upon tank crews to keep their tanks operational, to keep them supplied with ammunition and fuel, and to stay alive. The tank crew, particularly the TC, does not have the luxury of time to devote to a new system, such as an APES, which may be of marginal utility.

Every effort must be made to design the APES to relieve burdens from the TC and gunner. Visual and aural cues must be clear, unambiguous, and require minimal attention. Automatic acquisition, tracking, and gun laying must be accomplished in such a manner that the crew is free for other tasks.

1.2.8 SUMMARY.

As can be seen from this cursory discussion, the decision to add an Acoustic Priority and Engagement System to a tank is complex. The system is expensive and may place an unacceptable burden on the crew, particularly the TC. On the other hand, the potential benefits could be great. If outnumbered in battle, the lives of tankers and the fate of the nation could depend on improved acquisition and greater accuracy. The process described in this document will provide valuable data to decision makers as they search for the best solution.

1.3 OBJECTIVES FOR INTEGRATING AN ACOUSTICAL PRIORITY AND ENGAGEMENT SYSTEM INTO THE ABRAMS.

Given the discussion above, the following goal and objectives have been defined for integrating the APES into the Abrams:

GOAL: To improve the operational performance and military utility of the Abrams tank by adding a prioritization and engagement system.

OBJECTIVES:

1. Increase the fightability of the tank.
2. Maintain a manageable workload for the tank crew.
3. Increase target acquisition rate.
4. Improve target acquisition during periods of night, precipitation, and obscurants.
5. Increase firing and killing rate.
6. Improve accuracy when firing at stationary and moving targets.
7. Improve survivability of the tank.
8. Maintain new training requirements within acceptable limits.
9. Maintain detection signature similar to the current Abrams despite the addition of an emitter.

1.4 SCOPE OF MODIFICATIONS.

Modifications to the Abrams will be oriented on prototype designs developed by Acoustics Engineering International, under contract from the Army Materiel Command. Essentially, this begins with the basic Abrams turret. The APES sensor will fit within the Abrams Universal Receptacle (AUR) on the top, left side of the turret. This housing is also the same receptacle planned for the Commander's Independent Thermal Viewer (CITV) on the future Abrams. Since the same receptacle is used for the APES and CITV, the tank can only be equipped with one or the other, not both. The APES will provide target location returns, whereas the CITV will provide infrared images independent from those of the gunner.

The general assumptions regarding the configuration and operation of the APES are listed below in Section 1.4.1.

1.4.1 ASSUMPTIONS

1. The Acoustic Priority and Engagement System (APES) will use an acoustical sensor.

2. The APES will have a limited automatic tracking and automatic gun laying capability. However, it will not provide hands-off final lay for the gunner and TC.

3. The gunner will only have the Gunner's Primary Sight monocular to acquire and lay on targets. Target cues will be available from the APES to the GPS.

4. The TC's station will have an acquisition screen which will display target location returns. To observe images through the Direct View Optics (DVO) or the Tank Thermal Sight (TTS), the TC must use the Gunner's Primary Sight Extension.

5. The APES scanning sector and targets identified by the APES can be overlaid on the Commander's Control Display (CCD), providing a background map for the APES display.

6. Non-cooperative Identification Friend or Foe (IFF) will not be available for use with this version of APES.

7. Physical space does not permit installation of both an Acoustical Priority and Engagement System (APES) and a Commander's Independent Thermal Viewer (CITV). The Abrams Universal Receptacle (AUR) will only accept one or the other, not both.

8. In order to minimize training requirements, the APES soldier-machine interface will be, to the extent possible, consistent with the CITV soldier-machine interface.

9. The APES is part of a suite of modifications that are integrated together, with the underlying platform being the CVC2 system.

1.4.2. TARGET ACQUISITION SYSTEM DISPLAYS AND CONTROLS.

Due to the current configuration of the CITV within CCTB, considerable modification to the TC station will not be required to integrate an APES display panel into this relatively small space. The TC's Gunner's Primary Sight Extension (GPSE), duplicating the gunner's sight, will remain in place. The APES will occupy the same space and use the same controls and displays as the CITV. However, the CITV controls will have to be reprogrammed. This includes the changes to the TC's control handle and the controls for stacking targets.

1.4.3 GUNNER'S DISPLAY AND CONTROLS.

The display in the Gunner's Primary Sight (GPS) will be modified to add target cuing arrows, range indication, and target sighting icons. The controls for selecting stacked targets used with the CITV will be used for the APES as well.

1.4.4 APES SENSOR.

The APES sensor will be housed within the Abrams Universal Receptacle, similar to the Commander's Independent Thermal Viewer (CITV). The sensor will receive sound waves via a uni-directional microphone and display any targets on a screen. Range, elevation, azimuth, and target movement information, along with the category of target (Wheeled, Tank, PC, Helicopter, or Unknown), will be displayed with sufficient resolution to lay the main gun so that the target can be identified within the tank sights.

1.4.5 FIRE CONTROL INTERFACE.

Major modification is necessary to integrate the sensor inputs from the APES with the display panels and firing solutions. The data transferred from the APES to the fire control system will include target range, center of aural emittence, and velocity vector. This information will be passed through the fire control system to the turret drive system so that targets can be tracked. The system will not have the capability to aim the main gun at the target, only allow the TC or gunner to acquire the target.

1.4.6 SUMMARY.

This subsection has described the basic modifications to the Abrams and the functional requirements for the APES. These modifications were placed in the context of the actual tank in order to provide a comprehensive overview of what will be needed to integrate and operate the APES. These requirements provide the basis for the next subsection which will address how the APES will be evaluated using CCTB.

1.5 CCTB INVESTIGATION OBJECTIVES FOR THE EVALUATION OF THE ACOUSTIC PRIORITY AND ENGAGEMENT SYSTEM (APES).

CCTB offers an inexpensive alternative to the actual modification of Abrams tanks when attempting to determine the value of the Acoustic Priority and Engagement System (APES). The simulator also provides a valuable look at the man-machine relationships which occur between members of the crew, the displays, and the controls. The only modifications necessary are those which cause a crew action, or reaction, and those sounds, indications, and delay times associated with an actual APES.

Much of the modification to the CCTB simulator can be accomplished through the creative use of software and data bases. However, modifications must also be made to the controls and displays for the TC and gunner.

Although other simulators and Abrams tanks could be used to evaluate the value of an APES, CCTB will allow several tank crews to manipulate the controls, exercise new fighting procedures, and interact realistically in a semi-controlled environment. Measures of effectiveness can be produced quickly from recorded data and from subjective data gathered by observers. CCTB can be reconfigured quickly when obvious problems emerge during the system evaluation.

The above discussion helps to illustrate the value of CCTB in evaluating the effectiveness and utility of the APES. It should be recognized, however, that CCTB is not the best vehicle for many other evaluations. This is especially true of evaluations which are dependent on hardware RAM characteristics. Given this, the objectives for the APES within CCTB are as follows:

1. To assess any changes in the fightability of the tank.

2. To determine if the individual crew workload is manageable or if it increases to unacceptable limits.

3. To assess any survivability changes caused by use of the APES.

4. To assess the relative difficulty of training tank crews to operate with the APES.

5. To assess crew acceptance to an APES in general and to the implemented APES displays and controls in particular.

Given these objectives, data gathered from CCTB trials should provide the Combat Developer with a realistic view of how crews will operate with the APES. Much of this data should be valuable in revising the requirements documents in sufficient time to make changes in the actual hardware.

Results from CCTB trials should be valuable in determining whether to proceed with the APES program for new series tanks or to stay with the simpler CITV system. The results may also suggest a follow-on set of trials to consider a mix of CITV and APES within a platoon or company.

Finally, the trials will provide input to the Combat Developer regarding the complexity of the APES displays, controls, and procedures, and whether or not the system should be simplified.

1.6 SCHEDULE FOR IMPLEMENTATION OF THE SPECIFICATION

Figure 1-1 illustrates the schedule for implementing this specification. It includes the hardware and software development for the modification, acceptance testing, and evaluation.

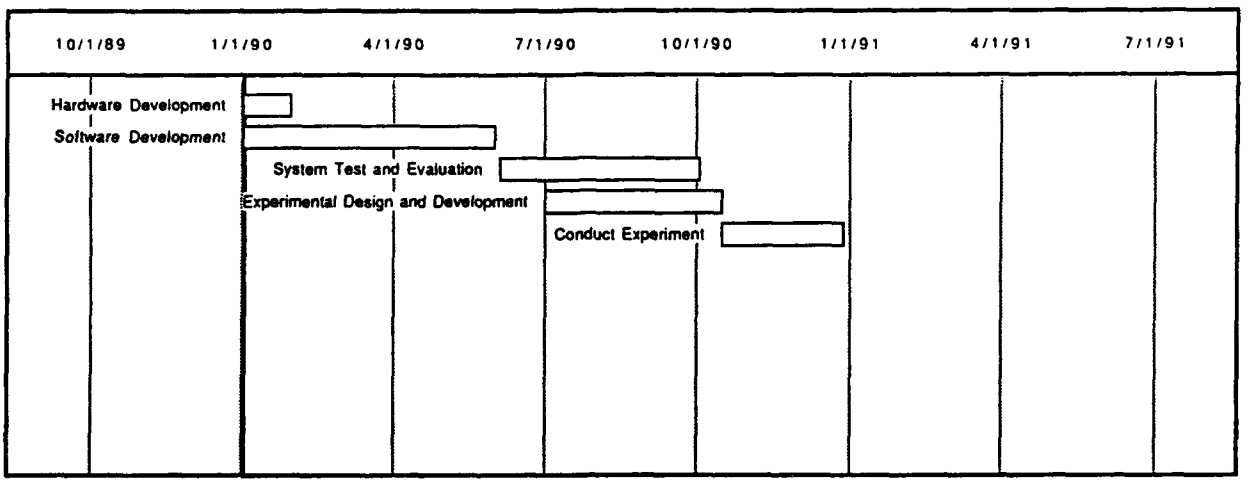


Figure 1-1: Implementation Schedule

2.0 MODIFICATIONS TO CCTB FOR INTEGRATION OF AN ACOUSTIC PRIORITIZATION AND ENGAGEMENT SYSTEM.

2.1 INTRODUCTION.

2.1.1 PURPOSE.

The purpose of this section is to provide detailed specifications for modifications to CCTB systems and subsystems. This will present an acceptable environment for evaluation of the Abrams simulator configured with the Acoustic Priority and Engagement System (APES).

2.1.2 SCOPE OF MODIFICATIONS.

CCTB has proven to be a flexible and useful environment for conducting research on new systems hardware and software concepts. The simulated battlefield environment is a powerful tool for gaining insights into tactical, logistical, command and control, and soldier-machine interface issues early in the requirements phase of the hardware acquisition process. CCTB should provide useful information to decision makers, prior to the commitment of extensive resources, to address the issues of adding a different type of target acquisition device to an Abrams tank.

Modifications to CCTB must sufficiently emulate those modifications expected on a fielded Abrams with an APES. This will permit credible training and research. However, care must be taken to retain the CCTB philosophy of making only those modifications necessary to gather the information needed. Therefore, many of the modifications to CCTB will be related to controls, displays, time delays, and sounds associated with the APES and its operation. A large portion of the modification effort will be devoted to software development and integration into the current acquisition system. In support of this evaluation, there will also be modifications to related CCTB systems for data collection, semi-automated force perfor nce, and tactical and logistical support mechanisms.

2.1.3 OVERVIEW OF THE SECTION.

This section begins with a description of the APES operational characteristics. These characteristics are provided in the beginning so that a working knowledge of the system is provided prior to the implementation of the system. Then modifications required of the simulator are provided. These modifications are primarily the addition of controls, displays, and the accompanying software for the gunner and TC to operate the APES. In these sections, detailed descriptions are provided for the TC as well as the gunner's workstations. Then the functional specification for the integrated system is provided.

The section is organized based on the major operations to be performed with the APES. Modifications to any workstations or friendly/enemy forces are also provided. Lastly, a schedule for the development and acceptance testing for the modifications is presented.

2.2 APES OPERATIONAL CHARACTERISTICS

2.2.1 HORIZON REFERENCE, FIELDS OF VIEW, AND SCAN RATE

The fields of view, horizon reference, and scan rate define what the APES is receiving, or hearing, at any given time. APES has two cones of reception, or for simplicity fields of view (FOV). These cones vary in size from each other, and project out from the sensor. The APES receiver is referenced to the hull for its horizontal reference. The Scan rate is set at a constant velocity. Each of these characteristics are discussed further in the following paragraphs.

The two FOVs (cones of reception) that APES operates under are 5 and 10 degrees. This is the total arc distance of the cone's diameter. The cones get larger as they project from the sensor. Because of the two different FOVs, the APES processes target information differently when it is in the wide FOV (large cone of reception) versus when it is in the narrow FOV (small cone of reception). The differences effect the APES ability to detect, categorize, and identify as friend or foe and are discussed further in Section 2.2.2.

The APES sensor has a 360 degree azimuth field of view. The sensor may be pointed in any direction around the tank. The sensor can either continually rotate through out its 360 degree arc or move between boundaries set by the TC. On the APES display, 0 degrees is always located at the top of the display and is referenced to North. The FOV is stabilized to maintain a line of sight parallel to the original line of sight. This means that the APES is always looking in the same compass direction but translates as the tank moves. Figure 2.2-1 illustrates this.

The elevation FOV has a maximum range of 32 degrees. This range is analogous to that for the gun tube. The FOV may be set to any value within this range. The gun tube horizontal to the hull provides the 0 reference for the FOV. This creates a displayed range of +20 degrees to -12 degrees. For additional reference, -4 degrees, the point at which the gun tube physically crosses the hull's horizontal plane, is indicated on the elevation FOV scale. Figure 2.2-3 illustrates this. The TC can adjust the specified FOV to locate anywhere within this area. The FOV is stabilized to maintain a line of sight parallel to the original line of sight. Figure 2.2-4 illustrates this.

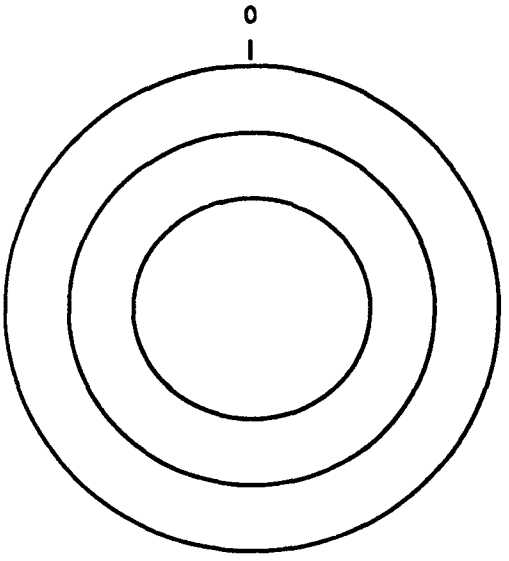


Figure 2.2-1

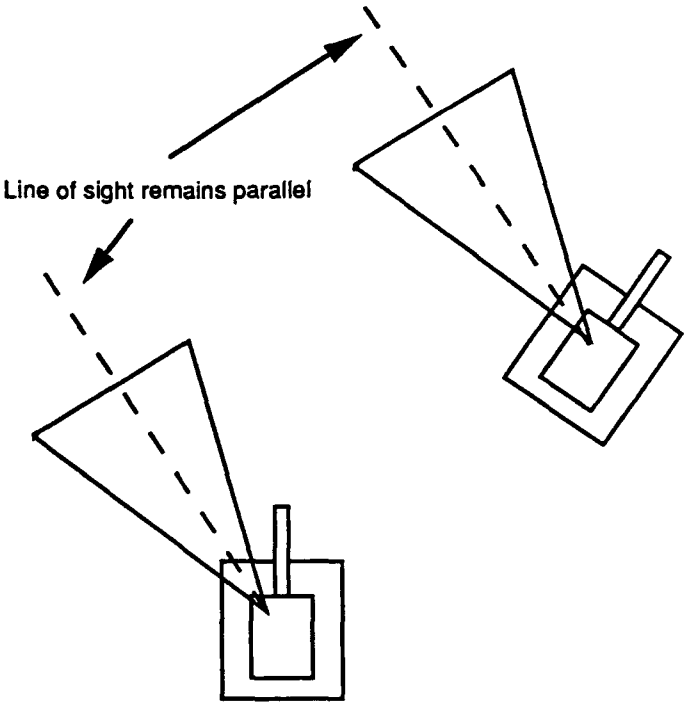


Figure 2.2-2

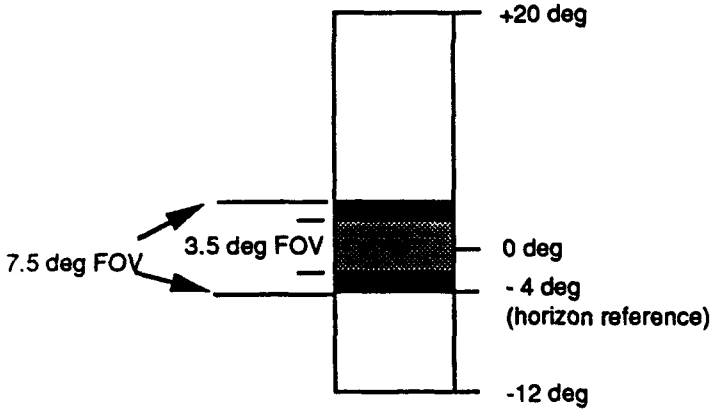


Figure 2.2-3

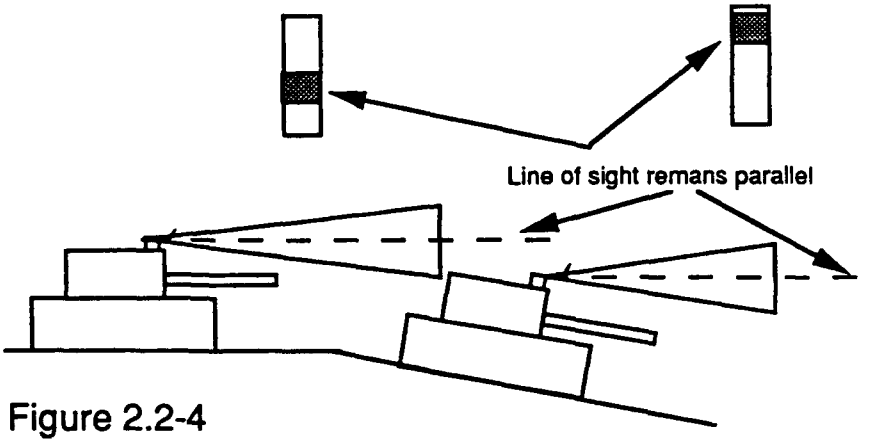


Figure 2.2-4

Scan rate is set at a constant 11.1 degrees a second. The APES scans only within the azimuth FOV boundaries. It scans from one boundary to the other then reverses direction and scans back.

2.2.2 TARGET DETECTION, IDENTIFICATION, TRACKING, AND ENGAGEMENT

Within CCTB, The APES can detect any vehicle which is running, whether stationary or moving. This detection will occur based upon the following probabilities:

	Noise	
	Low	High
Wide FOV	1.0	.50
Narrow FOV	.95	.75

High noise is defined as artillery within 100 meters, tank main gun fire within 20 meters, and another moving vehicle within 20 meters of the sensor. This noise obscures the sensor only in its line of sight, and it creates a blind spot when the sensor is pointing at it. All other forms of noise are considered low noise.

If APES identifies a vehicle, nothing beyond it, based on an arc defined by a circle 4 meters in diameter centered at the midpoint, will be detected. Vehicles within 2 degrees of arc of each other will be detected by APES as one unknown vehicle when it is in the wide band mode. The narrow band is less likely to detect a target under low noise due to the high sensor directionality. Identified targets will be retained during high noise for up to 10 seconds of continuous high noise. After that, the targets will disappear.

The APES can distinguish between tanks, personnel carriers (PC), wheeled vehicles, helicopters, and unknown objects. The probability of identification increases with the number of scans. For the purpose of producing CCTB specifications, the following probabilities, during low battlefield noise, will be used:

	Probability of ID			
Scans	Tank	PC	Wheeled	Helicopter
1	.7	.7	.7	.8
2	.8	.8	.8	.9
3	.9	.9	.9	1
4	1	1	1	1

The APES is capable of accurately tracking all of the identifiable targets regardless of the direction of movement. If the APES is being used to track a specific target, it will continue to track the target even if the FOV is acoustically obscured. However, this will only occur for a period of ten seconds. The APES can provide the fire control system with accurate and timely target range and movement data in both the scan and track modes. This information is accurate enough for the APES to keep the designated target within the FOV of the sight so that either the TC or gunner can engage it. The APES cannot provide accurate enough information so that a firing solution can be generated.

APES also provides a limited IFF capability so that targets can be distinguished. The IFF capability is based on a target being properly identified by type first. The following shows the probably of correctly determining friend or foe status after the target has been detected:

	Noise	
	Low	High
Wide FOV	.95	.25
Low FOV	.95	.90

Once a target has been detected and identified, the icons shown in Figure 2.2-5 will be used to display them on the TC's APES screen. The gunner will be provided with the icons shown in Figure 2.2-6 through his sight.

2.2.3 SIGNAL DETECTION AND INTERFERENCE

Since the APES is a passive system, it cannot be detected by enemy sensors.

Battlefield noise does affect the performance of the APES. Sustained noise, such as artillery barrages or mass bombing will effectively block APES reception during the period of noise. The interference sustained under various conditions is shown in the enemy detection and IFF tables of Section 2.2.2.

2.2.4 SYSTEM UPDATES

The APES updates/samples the following systems at the following rates:

System	Rate
Controls/Displays	10 hz
Turret Drive Controls	120 hz (tracking)

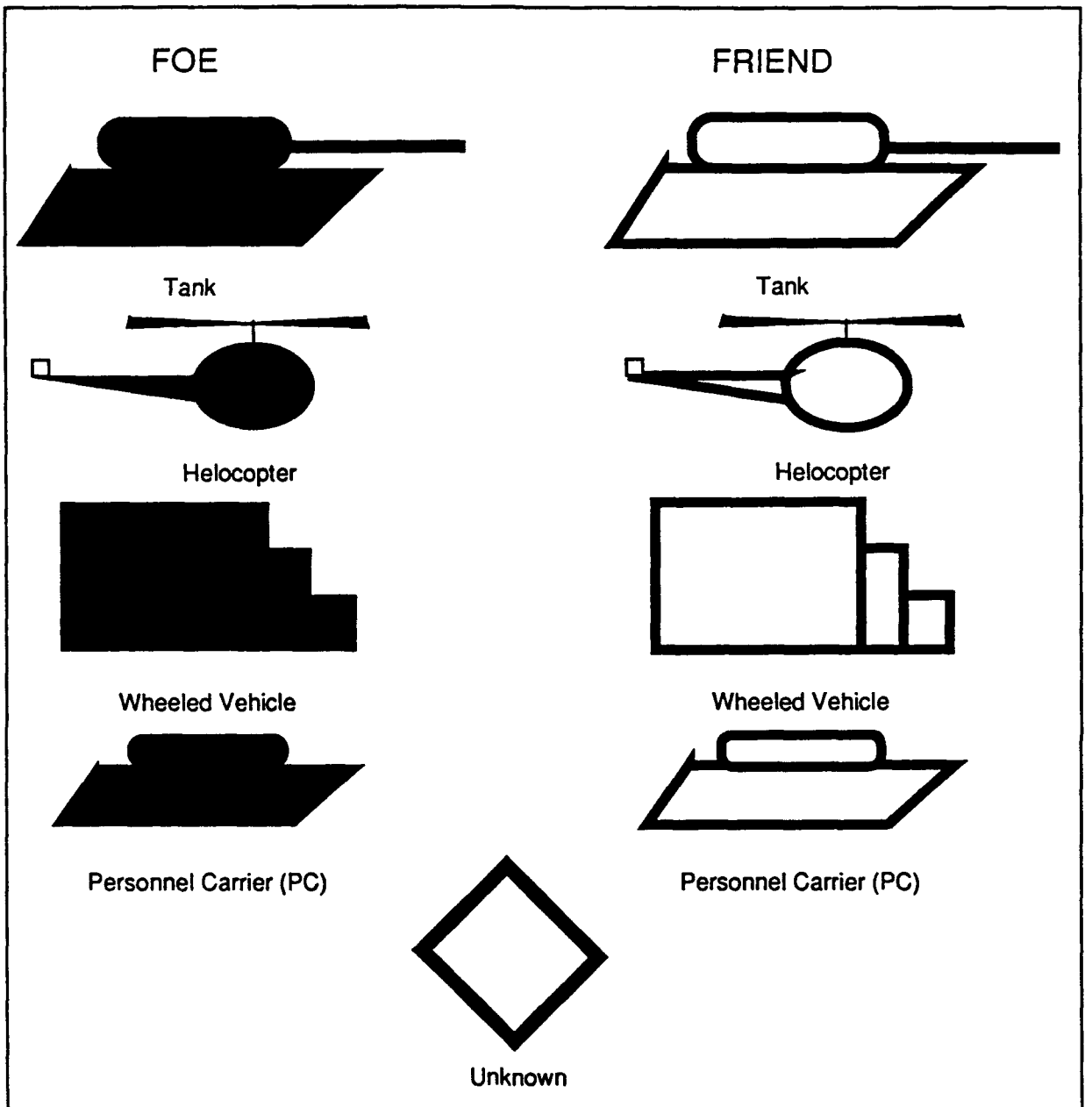


Figure 2.2-5 Icons for TC's display

Next target direction

Figure 2.2-6 Icons for gunner's sight

2.2.5 PRIORITIZATION LOGIC

The factors to be included in the prioritization logic are target range, direction of movement, speed, and type. A summation of the ratings for the speed-type, range-type, and bearing ratings given in Tables 2-1, 2-2, and Figure 2.2-6 will be used to prioritize the targets. If two or more targets receive the same score, they will be prioritized on their sequence of detection with first-detected having a higher priority.

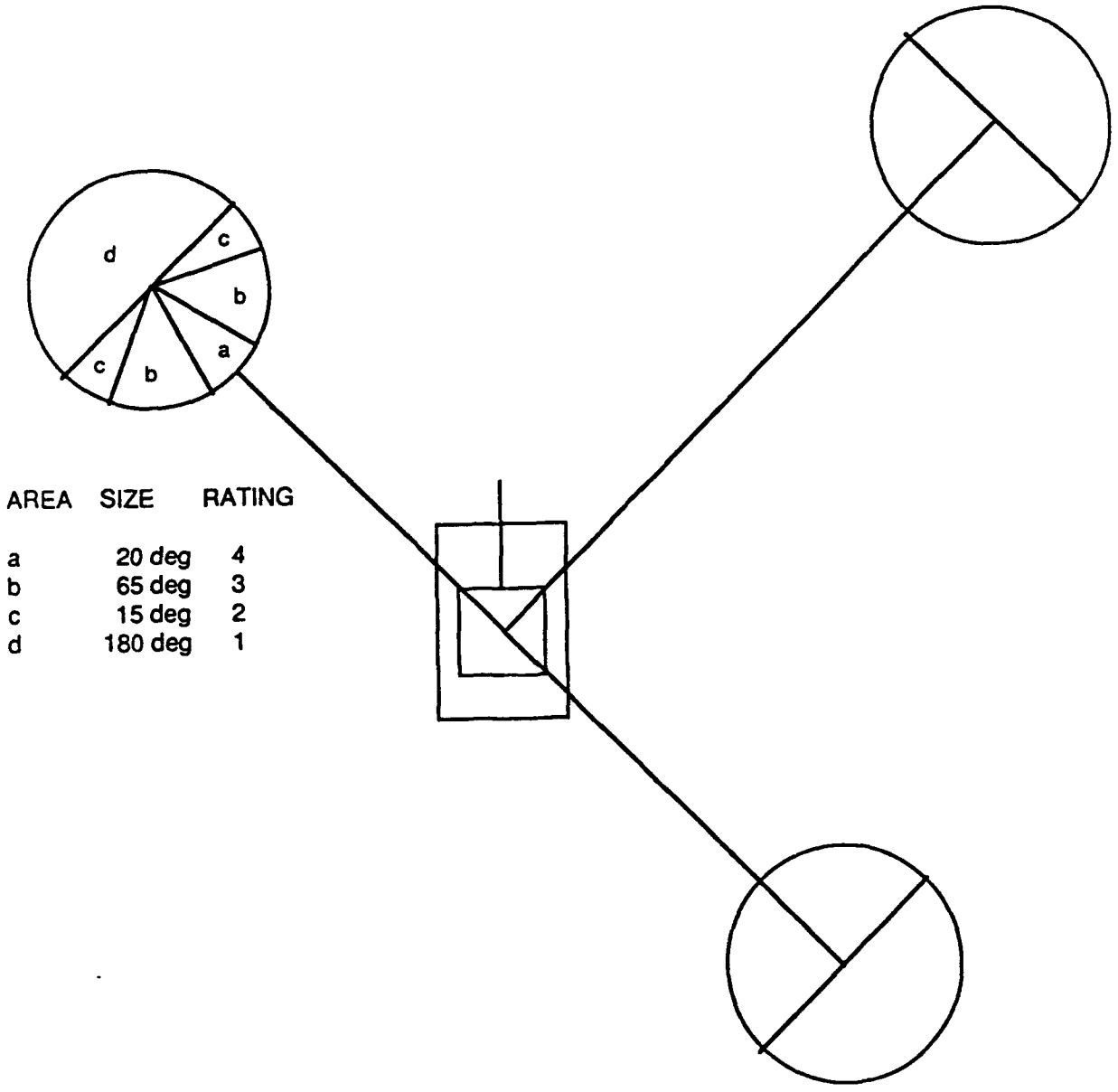
Figure 2.2-7 shows the ratings for the bearing of targets within view of the APES. The dark centerline is perpendicular to a ray extending from the tank to the target. The target's direction of movement from this centerline is used as the basis for the rating.

Type	Helo	Tank	PC	Wheeled	Unknown
Speed (m/hr)					
0-10	7	6	7	2	1
10-30	6.5	6.5	1	1	1
30-60	5	7	0	0	1
60>	5	0	0	0	1

Table 2-1: Speed Type Matrix

Type	Helo	Tank	PC	Wheeled	Unknown
Range (m)					
0-100	3	5.5	8.5	4	2
100-500	4	7	7	3	2
500-2000	6	9	5	2	2
2000-3000	8.5	7.5	4	2	2
3000-6000	8	4	3	2	2

Table 2-2: Range Type Matrix



AREA	SIZE	RATING
a	20 deg	4
b	65 deg	3
c	15 deg	2
d	180 deg	1

Figure 2.2-7 Target Bearing Ratings

2.3 SPECIFICATIONS FOR THE ABRAMS SIMULATOR WITH APES.

Modifying the Abrams simulator to incorporate an APES will require the TC's current CITV display and controls to be modified. The TC's override must be modified so that the TC can control both the main gun and the APES. The visual display in the GPS will also require modification for both the optical and thermal channels. These modifications will primarily involve the functions associated with acquiring targets, selecting targets, and laying the cross-hairs on the target.

Replacing the current CITV with an APES will allow the tank to acquire and engage any target within line of site of the APES. The TC will be the principal operator of the APES, and the gunner will verify the acquired target and operate the fire control system.

The APES screen and controls (Figure 2.3-1) for the TC will replace the CITV screen and controls. The TC will also have the Commander's Control Display (CCD). These two systems must be integrated so that information acquired by the APES can be passed to the CCD. This integration will be discussed in more detail in Section 2.6.

The following sections describe, in detail, the modifications to be made to the simulator. First the TC's station will be discussed. The hardware requirements will be identified, including the physical and basic functional requirements. This same format will be followed for the gunner's station. Then, the overall functional specification will be discussed. This will specify how the hardware and tank crew interact, and the operations that have to be simulated.

2.4 TANK COMMANDER STATION SPECIFICATION.

The TC's station will be changed to replace the CITV display with the APES display, the TC's override will be modified, and the functions of the current buttons and switches for the CITV will be changed. Also, the GPSE will have to be modified so that the TC can engage targets acquired by the APES with the GPSE. These modifications are described in detail below. Their operation and interactions will be discussed in the Functional Specification Section.

2.4.1 APES DISPLAY.

a. Purpose

The APES Display projects potential targets on a screen for the TC. The display helps the TC to detect, categorize, prioritize, and designate targets.

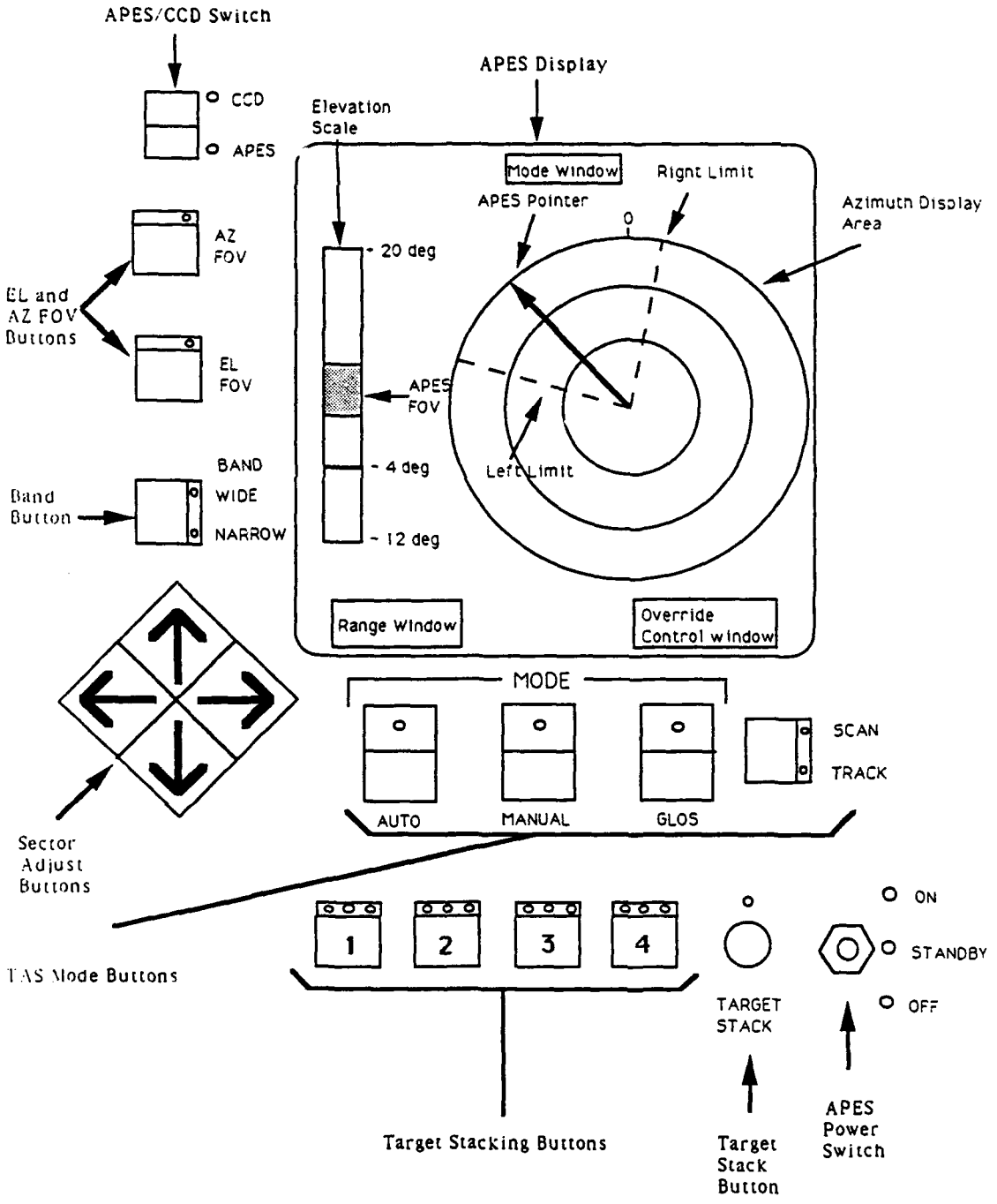

APES/CCD Switch
CCD
APES
APES Display
Elevation Scale
Mode Window
Right Limit
APES Pointer
0
Azimuth Display Area
AZ FOV
EL and AZ FOV Buttons
EL FOV
20 deg
APES FOV
4 deg
12 deg
Left Limit
BAND
Band Button
WIDE
NARROW
Range Window
Override Control window
MODE
SCAN
TRACK
AUTO
MANUAL
GLOS
Sector Adjust Buttons
TAS Mode Buttons
1
2
3
4
ON
STANDBY
OFF
TARGET STACK
APES Power Switch
Target Stacking Buttons
Target Stack Button

Figure 2.3-1

b. Hardware Requirements

The APES screen is the same 6 inch by 6 inch color display that is currently in the simulator. All of the buttons and switches around the CITV display will remain, except the functions for almost all of them will have to be modified.

c. Functional Requirements

The current display will change to display information from the APES (see Figure 2.4-1). On the left of the screen is a vertical Elevation Scale. On the scale is a shaded area which represents the field of view (FOV) that the APES is scanning. This shaded area can change in size to represent the two fields of view (FOV) that the APES can use to scan - 5 and 10 degrees. These EL FOVs can be moved up and down the Elevation Scale to scan the area desired by the TC. Inside the Elevation Scale is a bar showing the elevation of the selected target within the APES's EL FOV, and a bar providing horizontal reference with respect to the attitude of the tank hull. This horizontal reference is always at -4 degrees. On the left side of the elevation scale is a round icon that moves up and down the scale. This is the GPS icon. This icon represents the location of the main gun sight (GPS/GPSE) on the elevation scale.

To the right of the elevation scale is the Azimuth Display Area (ADA). This area displays the radial sector scanned by the APES. The area scanned by the APES is viewed from the top down. This area consists of three concentric circles with an icon in the center representing the vehicle with the APES (own vehicle icon).

The ADA is always oriented so that the top is at grid north. The concentric circles within the ADA are for aiding in range determination.

The own vehicle icon provides hull, gun tube, sector of scan, and the current sensor orientation just as it does on the CITV. The line that shows the APES orientation on the Azimuth Display Area is called the APES pointer. The APES pointer extends to the last range circle to show the area that the APES is scanning. When the AZ FOV is set and the APES is scanning, the AZ FOV limits are displayed on the ADA. As the APES sensor sweeps back and forth the APES pointer reflects this movement on the display.

A window in the upper left corner of the display indicates the active APES mode. The modes that are displayed are: STANDBY, GLOS, AUTO TRACK, AUTO SCAN, MANUAL SCAN, and MANUAL TRACK. These modes are explained in the overall functional specification section.

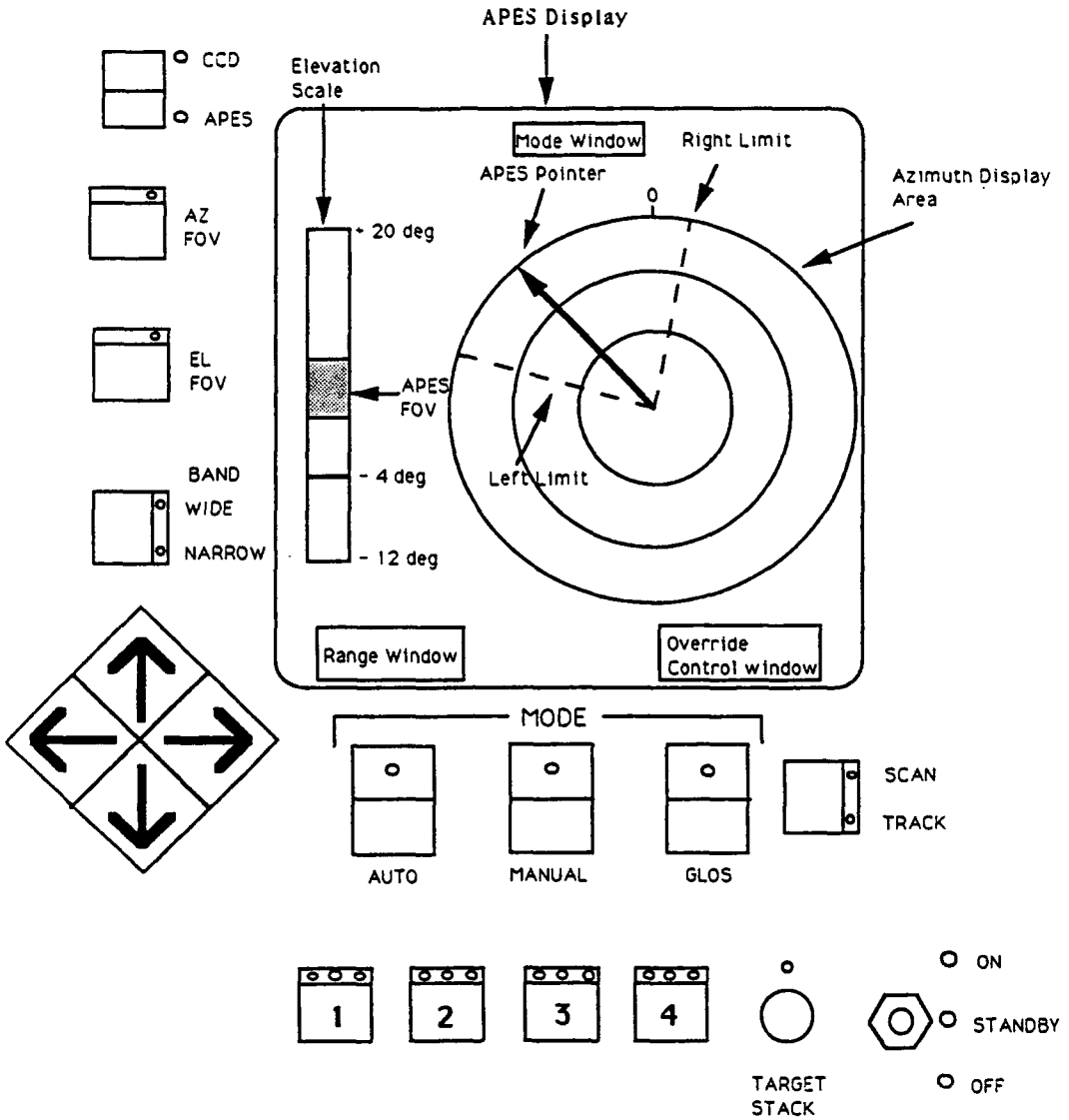

APES Display
CCD
APES
Elevation Scale
Mode Window
Right Limit
APES Pointer
0
Azimuth Display Area
AZ FOV
+ 20 deg
EL FOV
APES FOV
- 4 deg
BAND
WIDE
NARROW
- 12 deg
Left Limit
Range Window
Override Control window
MODE
SCAN
TRACK
AUTO
MANUAL
GLOS
1
2
3
4
ON
STANDBY
OFF
TARGET STACK

Figure 2.4-1

At the bottom left corner of the display is the RANGE window. This window will display the range to the target that is currently being scanned or tracked.

At the lower right hand corner of the display will be an OVERRIDE CONTROL window. This window displays the system that the override is currently controlling. The TC's override can control either the APES or the main gun. If the APES is being controlled, then APES is displayed in the window. If the main gun is being controlled, then MAIN GUN is displayed in the window.

The APES is capable of acquiring, prioritizing, categorizing, and tracking targets. Ten discrete targets can be displayed using icons for the following categories: Tanks, PCs, Wheeled, Helicopter, or Unknown. Figure 2.2-5 shows the APES display icons. Beyond the ten icons, up to 10 additional APES "PIPs" can be displayed. In addition, each of the APES icons will display the recommended priority for engagement from one through ten. The highest priority target will blink.

2.4.2 TC's OVERRIDE

a. Purpose

The TC's override is used to control both the APES pointer (see Section 2.4.1.b) and the main gun. For both systems, it can change both the azimuth and elevation of the system's orientation.

b. Hardware Requirements

The TC's override will not require any physical modification. The buttons and switches will all work as they currently do except the Laser Range Finder (LRF) button, the 3X/10X Reticle Switch, and the trigger on the override.

c. Functional Requirements

The LRF button will be modified so that it is disabled in the Auto Scan and Manual Scan modes. In the GLOS, Auto Track, and Manual Track modes, the LRF button will work in conjunction with the gunner's LRF. When the LRF button is pushed in either of these three modes, the LRF provides the range and lead data that is required for the correct ballistic solution. The button is still called the LRF switch. It will operate exactly as the gunner's does with the range appearing in the GPSE when a target is lased.

The 3X/10X Reticle function switch must be modified to toggle control between the APES and the main gun. The switch will become the APES/MAIN GUN switch. On the APES display, the

OVERRIDE CONTROL window (see section 2.4.1.b) will display which system the override is currently controlling. When APES is displayed in the window, the override controls the APES pointer on the APES screen. When MAIN GUN is displayed, the override controls the main gun. Pressing the APES/MAIN GUN switch toggles the override's control between the two systems. When the turret is first powered up, the TC's override controls the main gun.

The trigger on the TC's override will have to be modified so that when the override is controlling the APES, the trigger is disabled. When the trigger is controlling the main gun, then the trigger is functional. Disabling the trigger in the APES mode is required so that the TC does not in advertently fire the main gun while he is trying to control the APES.

2.4.3 APES CONTROLS.

a. Purpose.

The APES Controls select the following functions:

- Operation of the APES sensor
- Sector and range selection
- Target prioritization and passing

b. Hardware Requirements.

All of the current switches and buttons from the CITV are retained for the APES (Figure 2.3-1). No new switches or buttons are required. The functions of the CITV controls will have to be modified so that they can control the APES. These controls are the APES/CCD switch, AZ FOV button, EL FOV button, BAND button, Sector Adjust buttons, GLOS button, Auto button, Manual button, Scan/Track button, and APES Power switch. The Target Stack button and the Target Stacking buttons will function as they currently do in the CITV.

The only button whose physical functioning needs to change is the FOV Mode Button. This button must act as a toggle. One of the lights on the button must always be lit, and when the button is pressed, the lit light goes out and the other light must light.

c. Functional Requirements.

<u>APES/CCD Switch</u>

The APES/CCD Switch (See Figure 2.4-2) is used to send information gathered by the APES to the CCD if desired. In the

APES position, the APES light is lit and no information is passed between the APES and CCD. If the switch is in the CCD position, the CCD light is lit. In this mode, the AZ FOV from the Azimuth Display Area and any target information collected by the APES is displayed redundantly on the CCD. As the APES determines range, azimuth, and the category of any target it acquires, this information is sent to the CCD. Using the CCD's POSNAV information based on the tank's location, the range to the target, and direction to the target, the CCD computes the location of the target on the map. Then, a target type icon is displayed on the CCD map at the location that the APES picked it up. The icon is red in color and flashes for 5 seconds and then is solid.

AZ FOV Button

The AZ FOV button (see Figure 2.4-2) is used to set the azimuth sector of scan for the APES. When the AZ FOV button is selected the AZ FOV light on the button lights. STANDBY or the current operational mode, depending on what mode the APES is operating, is highlighted with inverse video in the APES's Mode window. The APES sensor goes into the Standby mode. At this time, the TC can set his left and right sector limits. Using the commanders override, the TC moves the APES pointer to the desired azimuth and pushes either the left or right arrow on the Sector Adjust buttons cluster. This sets his left or right limit respectively.

EL FOV Button

The EL FOV button (see Figure 2.4-2) is used to set the elevation sector of scan for the APES. When the EL FOV button is selected, the light on the button lights up. STANDBY or the current operational mode, depending on what mode the APES is operating, is highlighted with reverse video in the APES's Mode window. The APES sensor is in the Standby mode. If the TC selects the "Up" arrow from the Sector Adjust buttons cluster, the EL FOV area moves up the elevation scale. If the "Down" arrow is selected, then the EL FOV area moves down the elevation scale.

Sector Adjust Buttons

The Sector Adjust buttons (see Figure 2.4-2) work as stated above. They are only used to set the AZ FOV and the EL FOV.

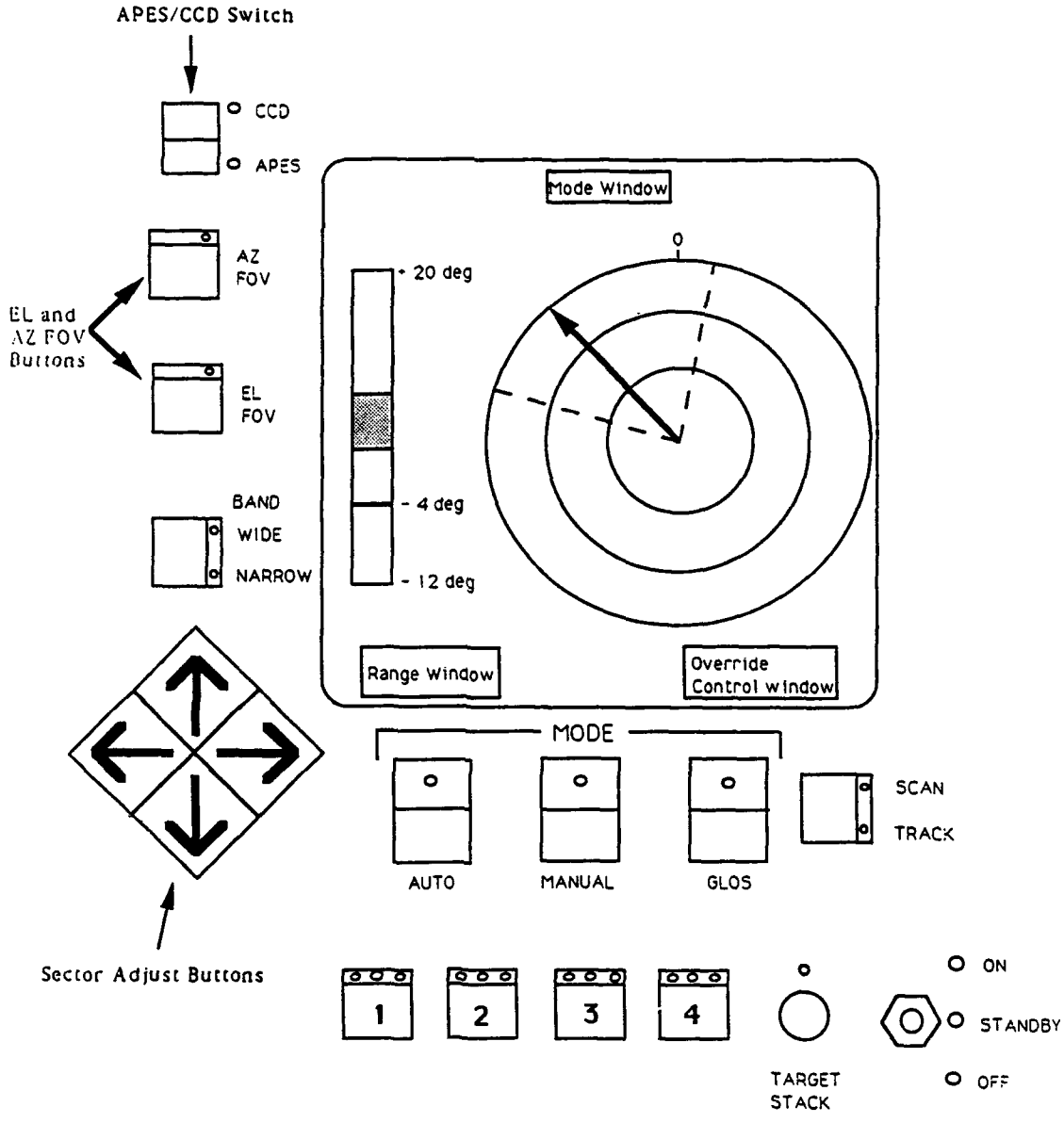

APES/CCD Switch
CCD
APES
AZ
FOV
EL and
AZ FOV
Buttons
EL
FOV
BAND
WIDE
NARROW
Mode Window
0
20 deg
4 deg
12 deg
Range Window
Override
Control window
MODE
AUTO
MANUAL
GLOS
SCAN
TRACK
Sector Adjust Buttons
1
2
3
4
TARGET
STACK
ON
STANDBY
OFF

Figure 2.4-2

Band Button

The Band button (see Figure 2.4-3) is used to change the cone of reception that APES uses to detect targets. When the Wide FOV light is lit, the APES is in the wide FOV mode. At this time, the APES listens along a ten degree arc cone that extends out from the APES sensor out to it's 4000 meter range. When the Narrow FOV light is lit, the APES is in the narrow FOV mode. At this time, the APES listens along a five degree arc cone that extends out from the APES sensor out to it's 4000 meter range. The Wide FOV mode is best used to acquire targets, and the Narrow FOV mode is best used to track acquired targets. When the FOV is changed from one mode to the other, target positions remain on the APES display as already categorized. The APES is capable of acquiring, categorizing, and laying the gun on the target, with varying degrees of accuracy in either of the two modes.

Modes of Operation

Four buttons (see Figure 2.4-3) are used to put the APES into it's different modes. These controls are: the Auto button, the Manual button, the GLOS button, and the Scan/Track button. The Auto and Manual button are used in conjunction with the Scan/Track button to place the APES into a mode of operation. The GLOS button is not dependent on the Scan/Track button position.

GLOS Button

When the GLOS (gun line of sight) switch is selected, the light on the switch lights. "GLOS" is displayed in the Mode window, and the APES goes into the GLOS mode. When in the GLOS mode, the APES becomes slaved to the main gun. Wherever the main gun points, the APES follows. On the Azimuth Display Area, the APES pointer is superimposed upon the main gun of the own vehicle icon, reaching from the center of the ADA to the outer range circle or target. The EL FOV centers the GPS Icon on the Elevation scale. Pressing the GLOS button again causes nothing to happen.

Scan/Track Button

The Scan/Track button is used with the Auto and Manual buttons. As with the CITV, this button acts as a toggle with one of the lights always being lit when the system is in operation. When the Scan light is lit, the APES acts independently of the gunner's optics and the main gun. The scan modes allow the APES to acquire, prioritize, and categorize targets but not to lay the main gun on targets. It only looks for targets. If the Track light is lit, then the APES can lay the main gun so that either the TC or gunner can acquire and engage it.

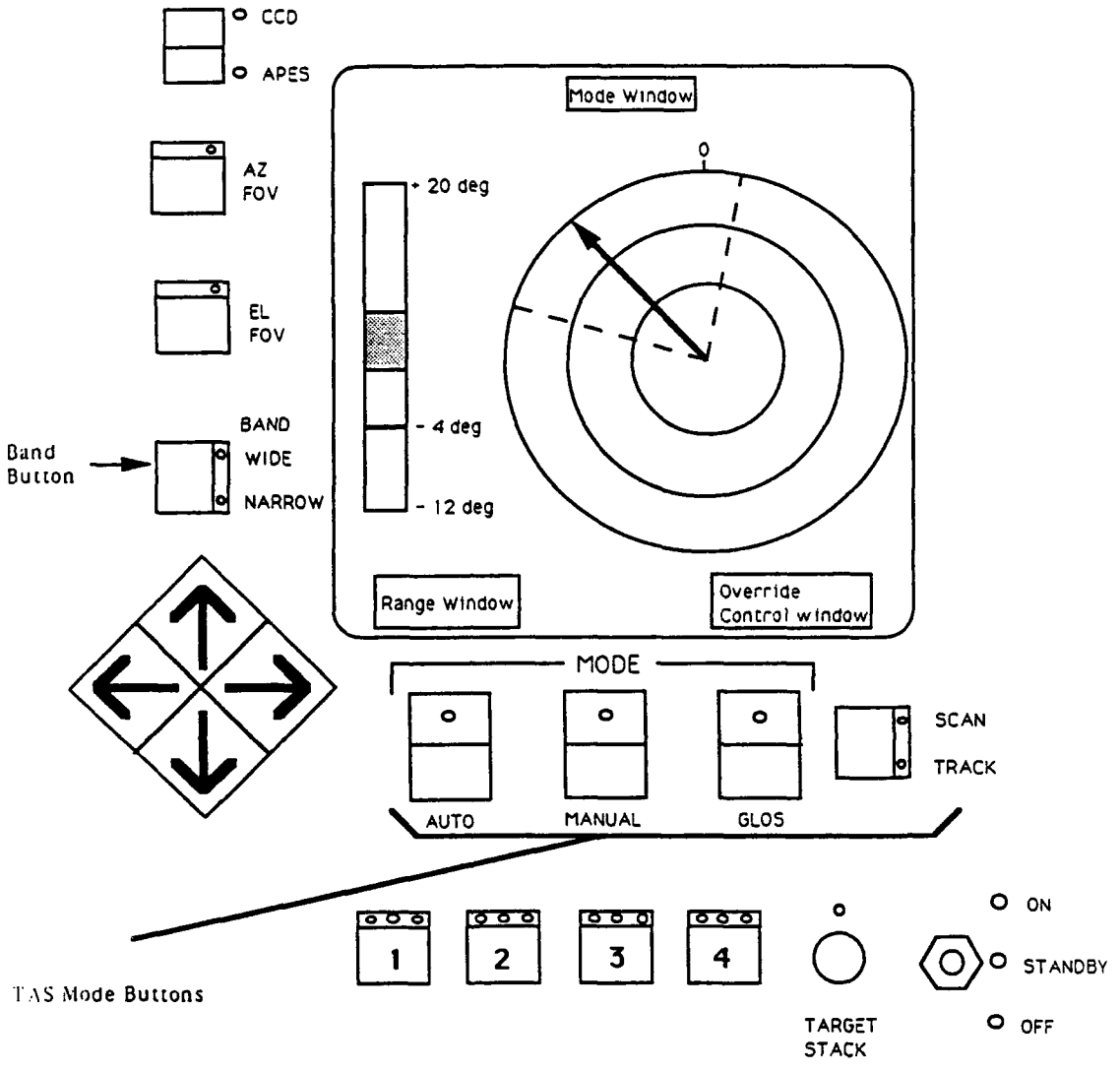

CCD
APES
AZ
FOV
EL
FOV
BAND
WIDE
NARROW
Band
Button
Mode Window
0
+ 20 deg
- 4 deg
- 12 deg
Range Window
Override
Control window
MODE
AUTO
MANUAL
GLOS
SCAN
TRACK
1
2
3
4
TARGET
STACK
ON
STANDBY
OFF
TAS Mode Buttons

Figure 2.4-3

Auto Button

The Auto switch, as stated, is used in conjunction with the Scan/Track button. When the Auto switch is pressed, the light on the switch lights. "Auto" and the position of the Scan/Track button are displayed in the Mode window.

Auto Scan Mode - If "scan" is lit, then "Auto Scan" is displayed and the APES goes into the Auto Scan mode. The Auto Scan mode allows the APES to automatically acquire, categorize, and prioritize targets. In the Azimuth Display Area, the APES pointer continually sweeps between the left and right limits. The gunner or TC must lase the target in order to get a correct ballistic solution. The range to the target is displayed in the Range windows of the APES display and GPS/GPSE.

Auto Track Mode - If "track" is lit, "Auto Track" is displayed in the Mode window and the APES goes into the Auto Track mode. When in the Auto Track mode, the APES changes its field of scan to only the selected target. This mode also causes the APES to lay the main gun on to the target being tracked. If the gunner wants to engage the target, he must fire the main gun. He must also index the correct ammunition. When the TC or gunner presses the lase button, then the targeting data acquired by the LRF is sent to the ballistic computer. The LRF provides range, velocity, and direction data to the ballistic computer to determine the correct ballistic solution to engage the target. When locked on to the target, the range to the target is displayed in the Range window of the APES screen. After the target is engaged, the APES must make a complete sweep of the sector to update its target location and priority information. It then lays the main gun on the next target. The ADA shows the APES pointer sweeping back and forth between engagements and pointed at the target when engaging that target.

Manual Button

Manual Scan Mode - When the Manual switch is selected, the light on the button lights up. "Manual" and the position the Scan/Track button is in is displayed in the Mode window. If "Scan" is lit, then "Manual Scan" is displayed in the Mode window and the APES goes into the Manual Scan mode. This mode allows the APES to automatically acquire and categorize targets, but does not prioritize the targets. If this mode is entered from an Auto mode, then any prioritized targets remain on the screen with their pre-assigned priority. This mode gives the TC control of the APES pointer on the screen to point at and prioritize targets with the four target stack buttons. The gunner or TC must lase the target in order to get a correct ballistic solution. The range to the target is displayed in the Range windows of the APES display and the GPS/GPSE.

Manual Track Mode - If "Track" is lit, then "Manual Track" is displayed in the Mode window and the APES goes into the Manual Track mode. In this mode, the APES automatically acquires and identifies targets on the ADA. At this point, the TC must designate a target and the APES will move the main gun to that location and track the designated target. The gunner must fire the main gun if he wants the target engaged. He must also index the correct ammunition. When the TC or gunner presses the lase button, then the targeting data acquired by the LRF is sent to the ballistic computer. The LRF provides range, velocity, and direction data to the ballistic computer to determine the correct ballistic solution to engage the target. When locked on to the target, the range to the target is displayed in the Range window of the APES screen. After the target is engaged, the APES must make a complete sweep of the sector to update target locations.

Target Stack Buttons

The Target Stack buttons (see Figure 2.4-4) are used by the TC to prioritize targets as he desires. They function as they currently do with the CITV. There are four rectangular buttons used to prioritize targets within the target stack and one round button that allows targets to be sent to the gunner.

The four rectangular buttons are the Target Stacking buttons. On the Target Stacking buttons, the center light lights up when a target is stacked. The left and right lights light up depending on if the target is left or right of the main gun. When the TC designates a target to a specific priority in the stack, he overrides any previous target in that priority location. The target in that location, along with any other targets of a lower priority, is rippled back to the next lower priority location.

The round button is the Target Stack button. When the Target Stack button is pressed and the LED above it is lit, the target stack is sent to the gunner so that he can use it to engage targets. If the button is pressed again, then the LED goes out and no additional targets are sent to the gunners target stack. The gunner's target stack remains filled with any targets sent to it prior to deselecting the target stack option. As long as the Target Stack is active, when the APES mode is changed between the automatic mode and manual mode, the target stack remains filled.

APES Power Switch

The APES power switch (see Figure 2.4-4) works in conjunction with the turret power switch. The turret power switch must be on before the APES can be powered up. The APES can be powered up either by going directly to ON or by going to standby first. In either case, it takes five minutes for the

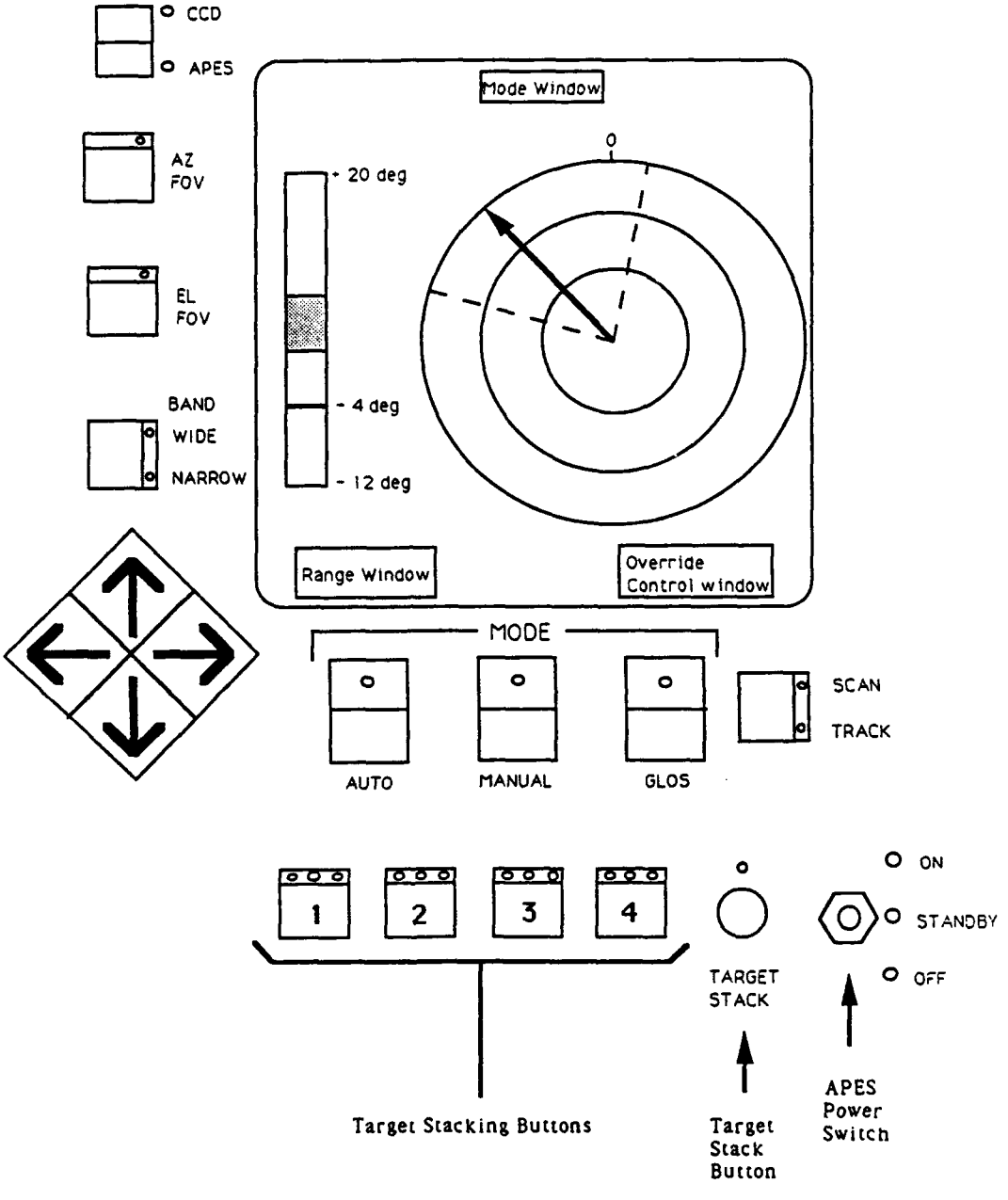

CCD
APES
AZ
FOV
EL
FOV
BAND
WIDE
NARROW
Mode Window
0
+ 20 deg
- 4 deg
- 12 deg
Range Window
Override
Control window
MODE
AUTO
MANUAL
GLOS
SCAN
TRACK
1
2
3
4
Target Stacking Buttons
TARGET
STACK
Target
Stack
Button
ON
STANDBY
OFF
APES
Power
Switch

Figure 2.4-4

system to fully power up to be operational. *If ON is selected,* then the default mode that the APES mode switches are in is displayed in the Mode window. If the APES Power switch is in the STANDBY position, then "STANDBY" is displayed in the Mode window. In the Standby mode, the APES is ready for operation, but not actually receiving. When the APES Power switch is put into the STANDBY position, this overrides any operation currently going on with the APES.

2.4.4 Gunner's Primary Site Extension (GPSE)

a. Purpose

The purpose of the GPSE is to allow the TC to look where the gunner is aiming the main gun, to be able to verify that the gunner is engaging the correct target, and for the TC to be able to engage targets using the gunner's primary and thermal sights.

b. Hardware Requirements

The GPSE will remain in it's current position in the TC's station with the CITV. The GPSE will function as it currently does, except it will incorporate data provided by the APES.

c. Functional Requirements

The functional requirements for the GPSE are the same for the GPS. See section 2.5.1.

2.5 GUNNER STATION SPECIFICATION

The gunner's station will be changed to integrate the APES with the gunner's fire controls. The change that will take place in the gunner's station is modifying the GPS so that the gunner can engage targets acquired by the APES with the GPS. This modification is described below. The operation and interactions will be discussed in the Functional Specification Section.

2.5.1 GPS (Gunner's Primary Sight)

a. Purpose

The purpose of the GPS is to allow the gunner to aim the main gun. The modifications to the GPS will allow the gunner to engage targets with the GPS. These modifications are limited to projecting additional icons and information into the GPS so that the gunner can accomplish this. The gunner is able to use either the primary or thermal sights to engage the targets, or he can use the projected icons to engage the targets.

b. Hardware Requirements

The GPS will require no physical modifications to its exterior. The only modifications will be the addition of the projected icons within the GPS.

c. Functional Requirements

Within the sight, information will be presented to the gunner. To the right of the range window, a single letter will designate the type of target the APES has detected and laid the main gun on. This is the Target type designator. The letter designators are: T - tank, P - PC, H - helicopter, W - wheeled vehicle, and U - unknown. The Target Type Designator blinks when the APES is laying the main gun on to the target (e.g., Manual and Auto Track modes). This blinking informs the viewer that the APES is operating the fire control system. This occurs when the gunner or TC has his palm switch depressed and the elevation and traverse handles are in the neutral position. When the elevation and traverse handles are moved, the TC or gunner can elevate and traverse the main gun. The triggers on the elevation and traverse control are still active and will fire the main gun when the palm switches are depressed and the triggers pulled.

Also, within the GPS, a solid triangle will be displayed on the outer edge of the sight. This is the Next Target Direction Icon. This will point in the direction that the gun tube will move or needs to move in order to lay upon the next target. This icon will only appear when the target stack is active and there are targets in the stack.

2.6 FUNCTIONAL SPECIFICATION

This section describes the integrated operation of the TC and Gunner station modifications discussed above. The section is organized around the following APES operations:

1. Placing the APES into Operation

2. Placing the APES into the Standby Mode

3. Turning the APES Off

4. Selecting APES Azimuth Sector of Scan

5. Selecting APES Elevation Sector of Scan

6. Selecting APES Range

7. Activating the Target Stack

8. Engaging Targets

9. Automatic Scanning

10. Manual Scanning

11. Automatic Tracking of a Target

12. Manual Tracking of a Target

13. Slaving APES to the Main Gun

14. Sending Targets to the CCD

Each of these operations are described in detail in the following subsections. The descriptions include a process flow chart which illustrates the sequence actions taken by the crew and actions performed by the system. Also included in subsections are the control settings, indications to the crew, and any alternate conditions and exceptions for each operation.

1. Placing the APES into Operation

- Operating Procedure

In order for the APES to operate, it must be powered up. This is accomplished by setting the Master Battery switch to ON, the Turret Power switch to ON, and the APES Power switch to ON or STANDBY. The flow process is shown in Figures 2.2-1a and 2.6-1b.

- Control Settings

Master Battery	-ON
Turret Power	-ON
APES Power	-ON or STANDBY
Override Control	-NA
APES Mode Switches	-NA
SCAN/TRACK button	-NA
BAND Button	-NA
TARGET STACK button	-NA
TARGET STACKING buttons	-NA
Sector FOV buttons	-NA
APES/CCD Switch	-Any

- Indication

<u>APES Display, Controls, and System Functioning</u>

<u>APES Power Switch</u>

- When the APES power switch is switched to the "On" or "Standby" position, all panel lights will light for five (5) seconds and then go out.

- Depending on what position the APES Power switch is in, within five (5) minutes, the APES goes into one of the following modes:

- If the APES power switch is in the "Standby" position, the following happens:

  - The APES goes into the Standby mode after five (5) minutes.

  - The APES is not receiving.

  - "Standby" is displayed in the Mode window.

- If the APES power switch is in the ON position, the following happens:

  - The APES goes into the Auto Scan mode after five (5) minutes.

  - The APES is receiving.

  - "Auto Scan" is displayed in the Mode window.

- The following occurs regardless of which position the APES Power switch is in:

  - The Elevation Scale and Azimuth Display Area are displayed on the APES screen.

  - The FOV is automatically set to Wide.

  - No range appears in the Range window.

  - "Main Gun" is displayed in the Override Control window.

  - The light on the Auto switch is lit.

  - The "Scan" position light on the Scan/Track button is lit.

- When a mode is displayed in the Mode window, it indicates the APES is ready for operation.

<u>GPS/GPSE Controls and Display</u>

- No information or icons are displayed in the GPS/GPSE while the APES is warming up.

<u>TC Fire Controls</u>

- The TC's override controls the main gun while the APES is warming up.

Gunner Fire Controls

• The gunner's fire controls are not affected by the APES during warm up.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- If the APES power switch is turned from either the ON to the STANDBY position, or vice versa, the APES powers up into the mode that the switch is in five (5) minutes after the switch was moved out of the OFF position.

- If the APES power switch is turned to the OFF position prior to the five minute warm up, when it is turned back to either the ON or STANDBY position, another five minutes must pass prior to the system being operational.

- The APES Power switch is the only control which affects how the system powers up.

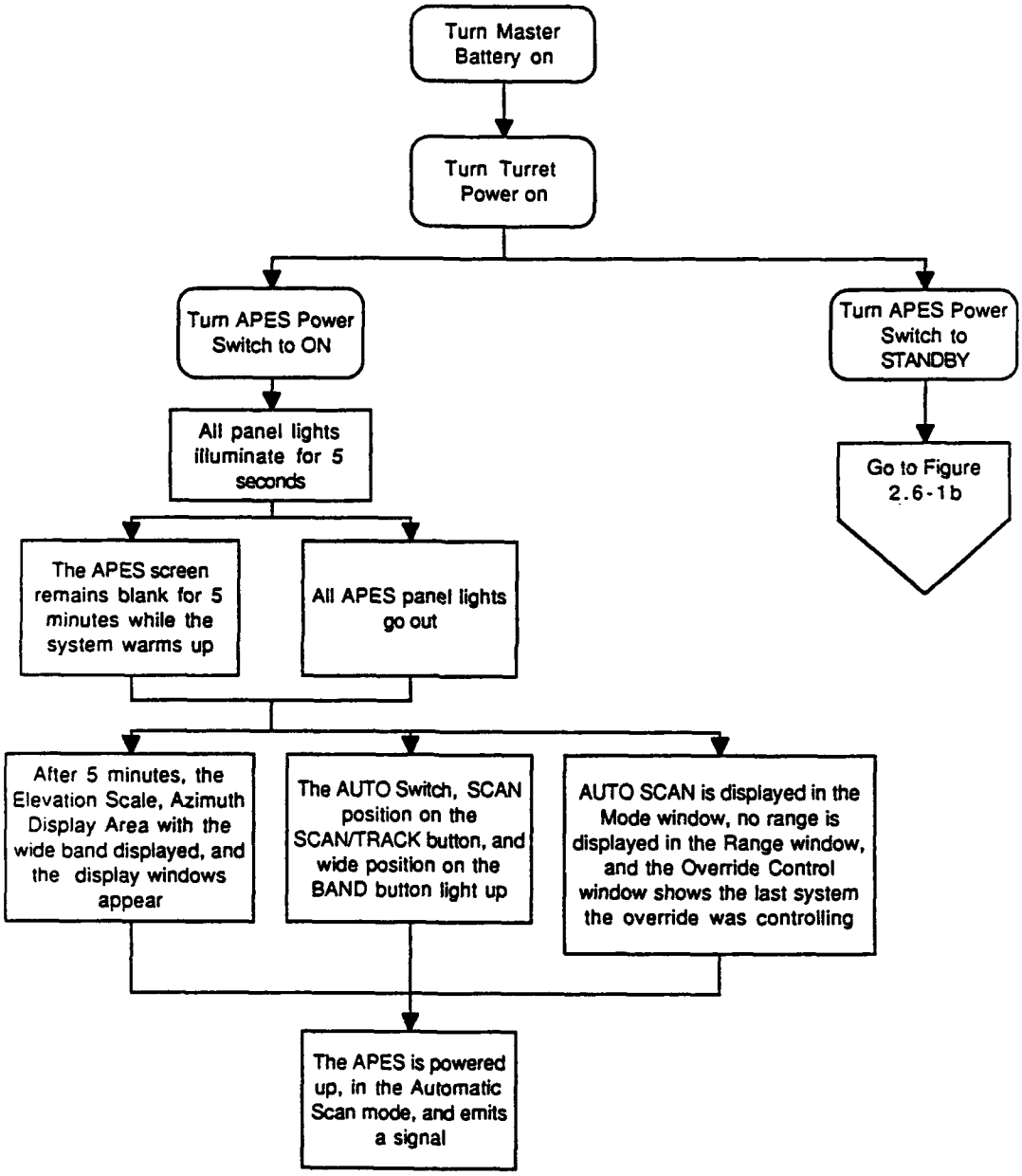


Figure 2.6-1a: Placing the APES into Operation

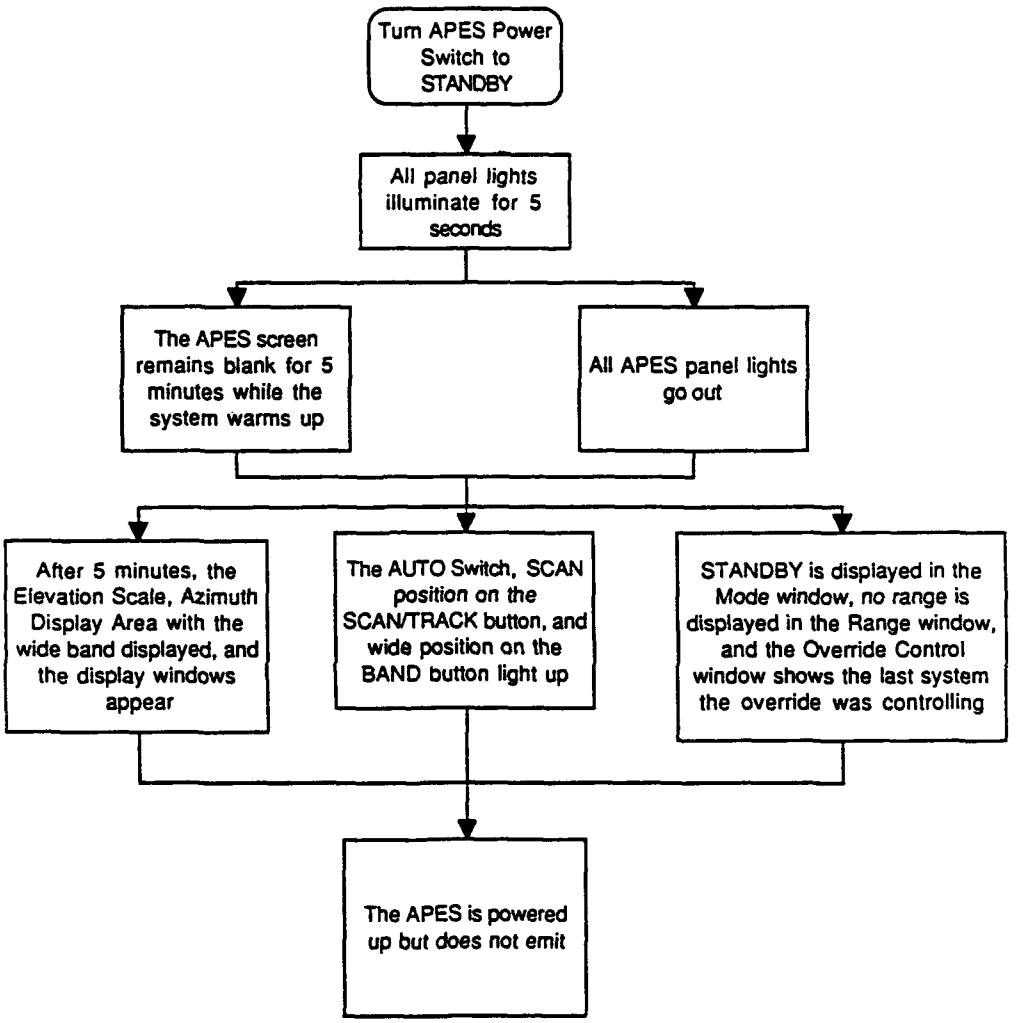


Figure 2.6-1b: Placing the APES into Operation (cont.)

2. Placing the APES into the STANDBY mode

- Operating Procedure

The STANDBY mode is for placing the APES into a non-operable status, yet being able for it to go into operation at a moment's notice. The flow process is shown in Figure 2.6-2.

- Control Settings

APES Power Switch	-STANDBY
Override Control	-Any
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-Any
APES/CCD Switch	-Any

-Indication

APES Display, Controls, and System Functioning

- When the APES Power switch is switched to the "Standby" position, the APES goes into the Standby mode.
- "Standby" is displayed in the Mode window.
- All button lights that were lit prior to switching to the Standby mode remain lit.
- The APES does not receive.
- The Elevation Scale and Azimuth Display Area remain displayed.
- Both the EL FOV and AZ FOV remain on the screen.
- The Override Control Window displays "Main Gun" and the Range Window displays no range.

GPS/GPSE Controls and Display

- No information or icons will be displayed in the GPS/GPSE.

TC Fire Controls

- The TC's override controls the main gun when the APES is in the Standby mode.

Gunner Fire Controls

- The gunner's fire controls perform normally.

-Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- Placing the APES Power switch in the "Standby" position overrides all other modes unless the APES Power switch is put into another position.

- When the APES Power switch is moved from the Standby to the On position, the APES goes into the mode that is indicated by the Mode switch settings immediately.

AZ and EL FOV Buttons

- The only operations that can occur while the APES is in the Standby mode is the setting of the azimuth and elevation sector of scan (see numbers 4 and 5 below).

TC and Gunner Fire Controls

- The gunner or TC will still have the ability to acquire and engage targets using the gunner's primary or thermal sight.

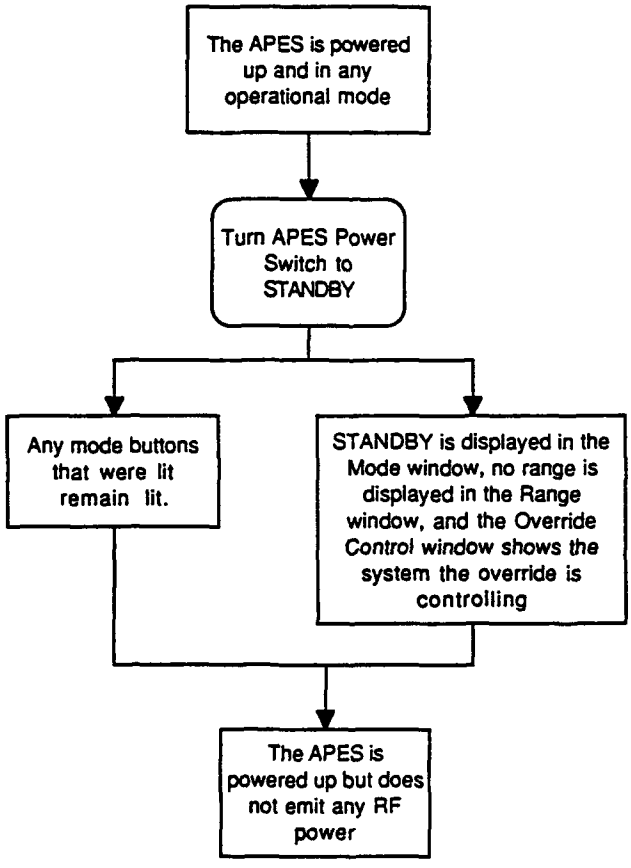


Figure 2.6-2: Placing the APES in the STANDBY Mode

3. Turning the APES Off

- Operating Procedure

The APES can be turned off by either turning the APES Power Switch, the Turret Power Switch, or the Master Battery Switch to the OFF position. The flow process is shown in Figure 2.6-3.

- Control Settings

APES Power Switch	-OFF
Override Control	-Any
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-Any
APES/CCD Switch	-Any

- Indication

APES Display, Controls, and System Functioning

- When the APES is shut off, the system is completely powered down.
- The APES display screen goes blank.
- The APES does not receive.

GPS/GPSE Controls and Display

- No information or icons can be projected in the GPS/GPSE.

TC Fire Controls

- The TC's override will no longer be able to control the APES. The override will control the main gun.

Gunner Fire Controls

- The gunner's fire controls will perform normally.

- Alternate Conditions and Exceptions

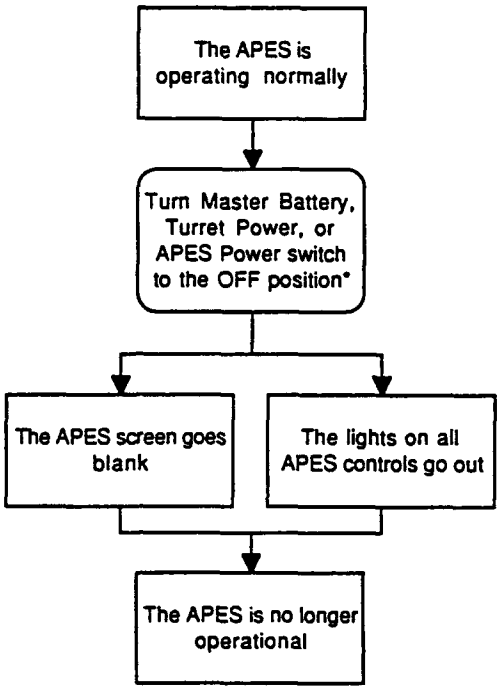
APES Display, Controls, and System Functioning

- Selecting any APES control will cause no action or function to occur.

- If the Turret Power Switch or the Master Battery Switch are used to turn the APES off, then, as long as no other power switches are turned off afterward, when that switch is turned on the APES will power up normally.

TC and Gunner Fire Controls

- The gunner or TC will still have the ability to acquire and engage targets using the gunner's primary or thermal sight.



If a switch other than the APES power switch is used to turn off the APES, then when that switch is turned on, it is as if the APES were being turned on.

Figure 2.6-3: Turning the APES OFF

4. Selecting APES Azimuth Sector of Scan

-Operating Procedure

The TC sets the azimuth sector of scan to focus the APES on the sector that he wants the APES to operate in. This sector is the AZ FOV for the APES. The TC sets this sector by selecting the AZ FOV button when the APES is turn on. The flow process is shown in Figures 2.6-4a and 2.6-4b.

- Control Settings

APES Power Switch	-ON
Override Control	-APES
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-AZ FOV
APES/CCD Switch	-Any

- Indication

APES Display, Controls, and System Functioning

AZ FOV Button

- When pressed the AZ FOV button lights.

- The AZ FOV lignt goes out when the AZ FOV button is pressed again.

System Functions

- The APES goes into the Standby mode.

- After the AZ FOV light goes out, the azimuth sector of scan is now set. The APES begins scanning the new sector in the mode that is displayed in the Mode window.

APES Display

- The mode that the APES was in, prior to selecting the AZ FOV button, is displayed in the Mode window in reverse video.

- All buttons that were lit prior to pressing the AZ FOV remain lit.

- No range will be displayed in the Range Window.

- The APES pointer quits moving and is positioned in the center of the AZ FOV.

- If the Override is controlling the main gun whenever the AZ FOV is selected (lit), then the words "MAIN GUN" will flash in the Override Control window. The TC must change the override control mode to "APES" to set the AZ FOV.

- The pointer rotates clockwise when the override is pushed to the right, and it rotates counter clockwise when the override is pulled to the left.

Sector Adjust Buttons

- When the "Left" arrow is pressed, the left limit is set to the location of the APES pointer. When the "Right" arrow is pressed, the right limit is set to the location of the APES pointer.

GPS/GPSE Controls and Display

- No information or icons will be projected into the GPS/GPSE when the AZ FOV is being set.

TC Fire Controls

- The APES pointer moves when the TC's override is controlling the APES. The palm switch must be held in to move the APES.

Gunner Fire Controls

- The gunner's fire controls perform normally.

- **Alternate Conditions and Exceptions**

APES Display, Controls, and System Functioning

APES Power Switch

- Selecting any control besides the APES Power switch, Override Control button, or moving the TC's override causes no action to occur. Selecting a different position with the APES Power switch causes the APES to go into either Standby or Off.

Mode Switches

- If a Mode switch is selected, the new mode is displayed, in reverse video, in the Mode window. However, the APES sensor stays in the Standby mode.

TC and Gunner Fire Controls

- Selecting the Override Control switch causes the override to control either the main gun or APES pointer.

- If the TC's override is controlling the APES, and it is pushed forward or pulled back, no action occurs.

- If the TC releases the palm switch prior to pressing the left or right arrow, then neither of the limits will move.

- If the override is controlling the main gun, then "Main Gun" flashes in the override control window, and when the override is moved, with the palm switch depressed, then the main gun moves.

- The gunner or TC will still have the ability to acquire and engage targets using the gunner's primary or thermal sight.

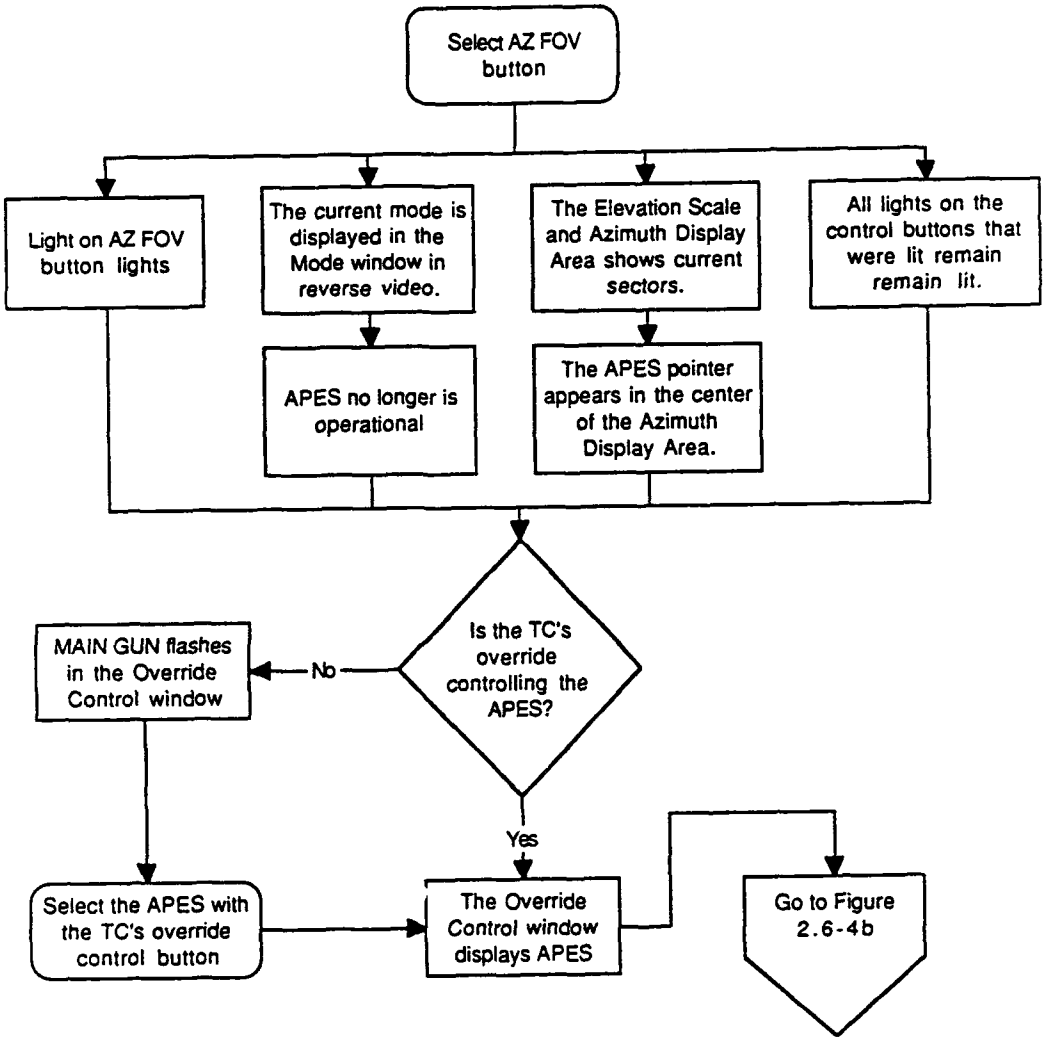


Figure 2.6-4a: Selecting APES Azimuth Sector of Scan

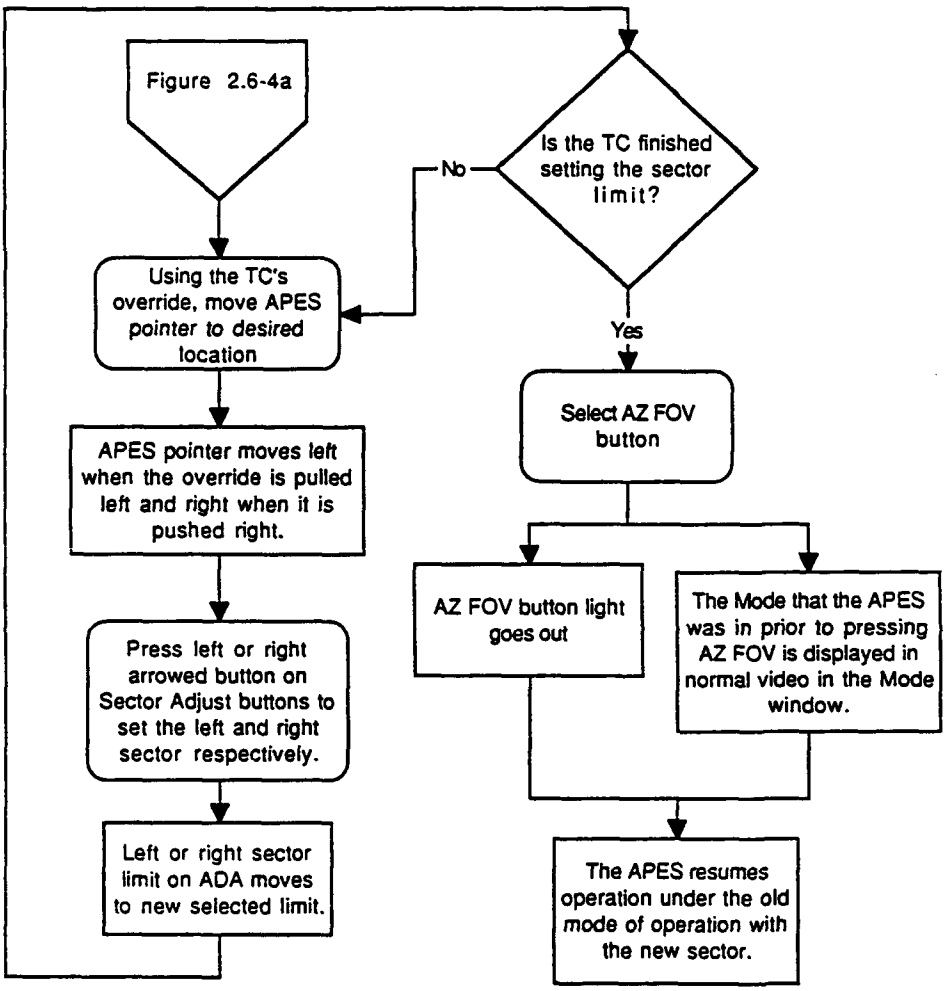


Figure 2.6-4b: Selecting APES Azimuth Sector of Scan (cont.)

5. Selecting APES Elevation Sector of Scan

-Operating Procedure

The TC sets the elevation sector of scan to focus the APES on the sector that he want the APES to operate in. This sector is the EL FOV for the APES. The TC sets this sector by selecting the EL FOV button when the APES is turn on. The flow process is shown in Figures 2.6-5a and 2.6-5b.

- Control Settings

APES Power Switch	-ON
Override Control	-APES
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-EL FOV
APES/CCD Switch	-Any

- Indication

APES Display, Controls, and System Functioning

EL FOV Button

- When pressed, the EL FOV button lights.

- The EL FOV light goes out when the EL FOV button is pressed again. The elevation sector of scan is now set.

System Functions

- When the EL FOV light is lit, the APES goes into the Standby mode.

- After the EL FOV light goes out, the APES begins scanning the new sector in the mode that is displayed in the Mode window.

APES Display

- The mode that the APES was in, prior to selecting the EL FOV button, is displayed in the Mode window in reverse video.

- The EL FOV Area moves up the Elevation Scale when the "UP" arrow of the sector adjust buttons is pressed and down when the "DOWN" arrow of the sector adjust buttons is pressed.

- All buttons that were highlighted prior to pressing the EL FOV remain lit.

- If the Override is controlling the main gun whenever the EL FOV is selected (lit), then the words "MAIN GUN" will flash in the Override Control window.

- While setting the EL FOV, no range will be displayed in the Range Window.

Sector Adjust Buttons

- When the "Up" arrow is pressed, the EL FOV area on the Elevation Scale moves up. When the "Down" arrow is pressed, the EL FOV area on the Elevation Scale moves down.

GPS/GPSE Controls and Display

- No information or icons will be projected into the GPS/GPSE.

TC Fire Controls

- Moving the TC's override causes no action on the APES display to occur.

Gunner Fire Controls

- The gunner's fire controls perform normally.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- Selecting any control besides the APES Power switch, Override Control button, or moving the TC's override causes no action to occur. Selecting a different position with the APES Power switch causes the APES to go into either Standby or Off.

Mode Switches

- If a Mode switch is selected, the new mode is displayed, in reverse video, in the Mode window. However, the APES sensor stays in the Standby mode.

TC and Gunner Fire Controls

- Selecting the Override Control switch causes the override to control either the main gun or APES pointer.

- When controlling the APES, if the TC's override is pushed to the right or pulled to the left, no action occurs.

- If the override is controlling the main gun, then "Main Gun" flashes in the override control window, and when the override is moved, with the palm switch depressed, then the main gun moves.

- The gunner or TC will still have the ability to acquire and engage targets using the gunner's primary or thermal sight.

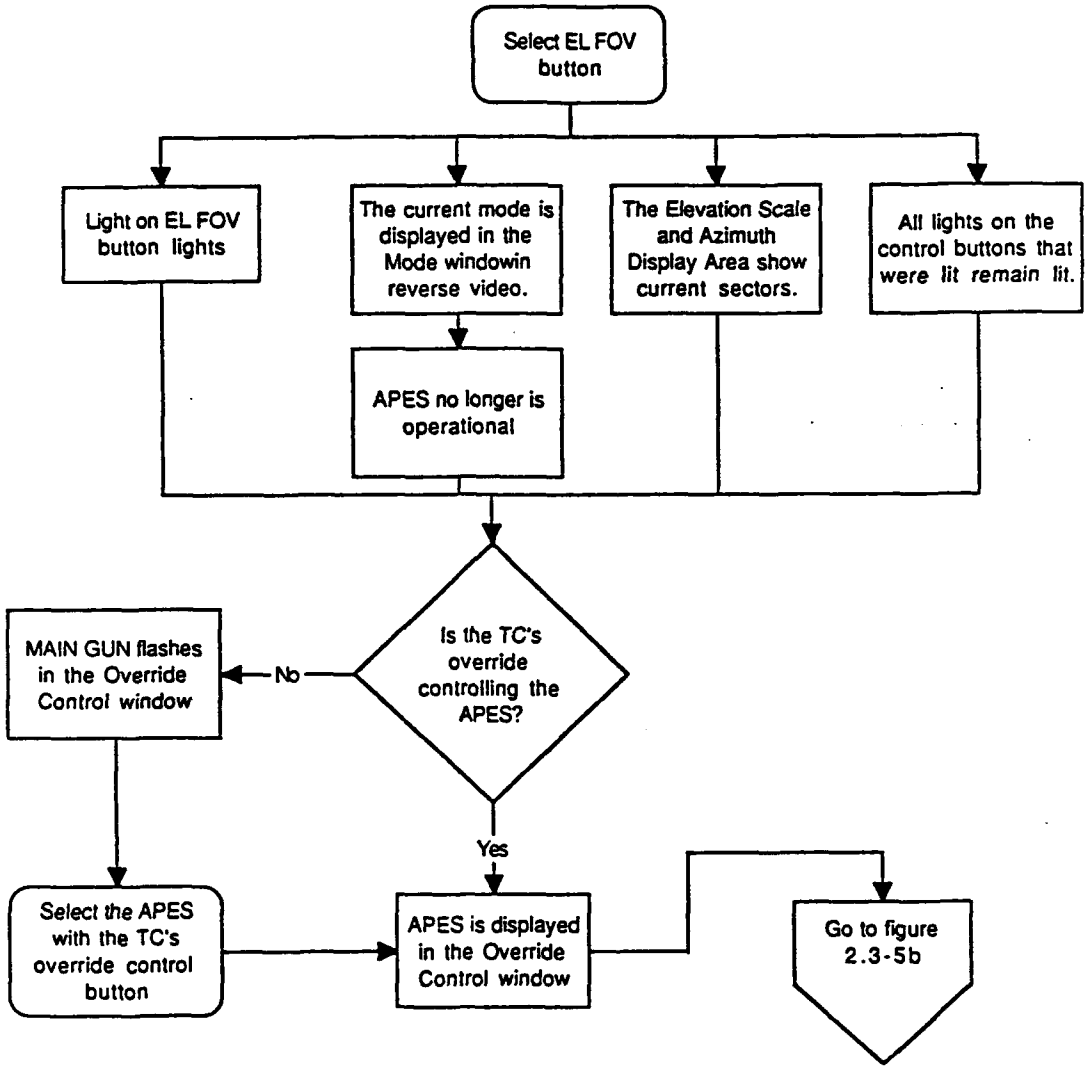


Figure 2.6-5a: Selecting APES Elevation Sector of Scan

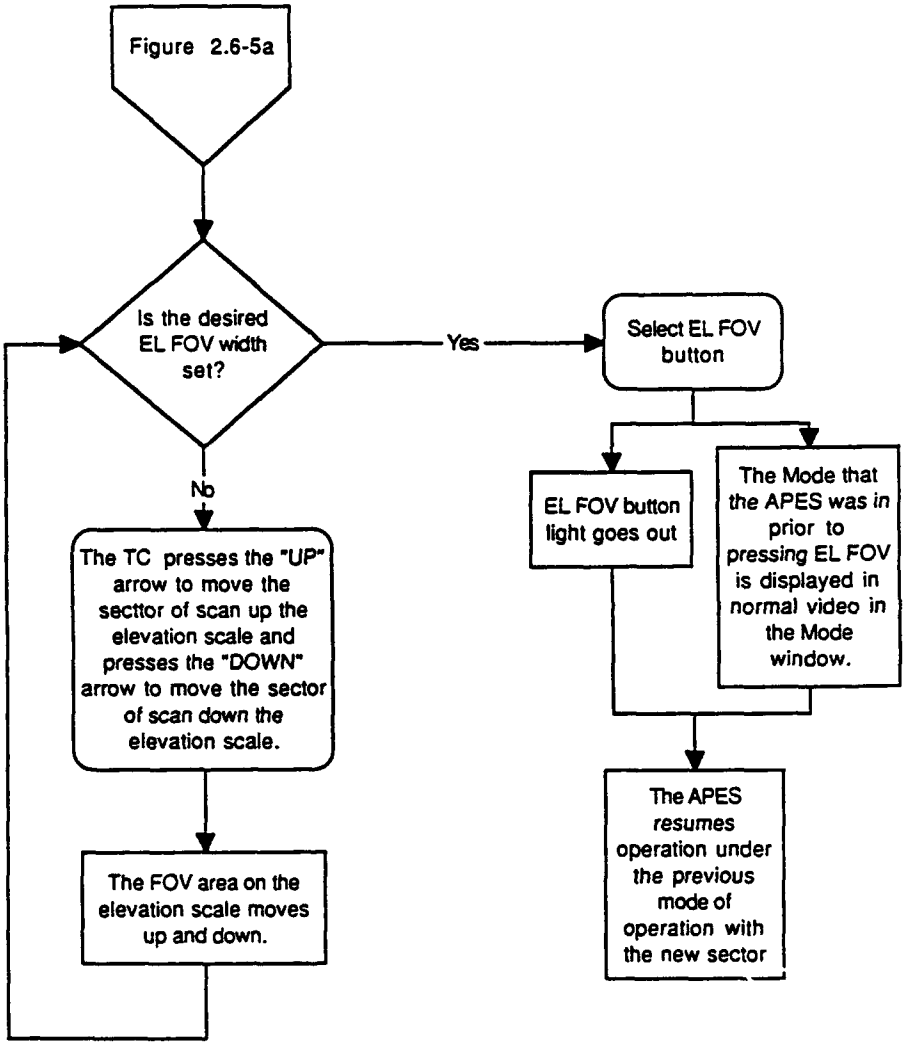


Figure 2.6-5b: Selecting APES Elevation Sector of Scan (cont.)

6. Selecting APES Band (Cone of Reception)

- Operating Procedure

The TC presses the Band button to change the scale on the APES display. The flow process is shown in Figure 2.6-6.

- Control Settings

APES Power Switch	-ON
Override Control	-Any
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-The BAND button is pressed to select the other band mode.
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-Any
APES/CCD Switch	-Any

-Indication

APES Display, Controls, and System Functioning

- When in an operating mode, one of the two (wide or narrow) band modes is operational (initially the wide band mode is operational when the APES is powered up).

- When the band button is pressed, the current lit band light will go out. The alternate light will light up.

- The APES pointer will expand or contract depending on the selected band mode.

- All displayed targets that are within the operational range (4000 meters) of the APES remain on the APES display. The detection probabilities in Section 2.2.2 apply only to new targets that the APES detects in the new band mode.

- Within one tenth of a second, the APES pointer will rescale and show the targets in the correct location when the new band mode is selected.

- The APES will continue in its current operational mode scanning at the new band.

- Selecting Target Stack buttons will still lay the main gun on the stacked target if the APES is in a Scan mode. The APES will also cause the main gun to track a target when it is in a Track mode.

GPS/GPSE Controls and Display

- The target designation and next target location icons that are displayed in the GPS/GPSE are projected regardless of which band the APES is operating under.

TC Fire Controls

- The TC's control functioning is dependent on the selected APES mode.

Gunner Fire Controls

- The gunner's control functioning is dependent on the selected APES mode.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

- If another control, besides the APES Power Switch, is selected prior to the finishing of rescaling, the APES will perform that operation after the APES pointer is finished rescaling.

APES Power Switch

- If the APES Power Switch is switched to the Standby mode, then the APES Pointer rescales, but no targets are displayed.

TC and Gunner Fire Controls

- The gunner or TC will have the ability to acquire and engage targets using the gunner's primary or thermal sight during this process.

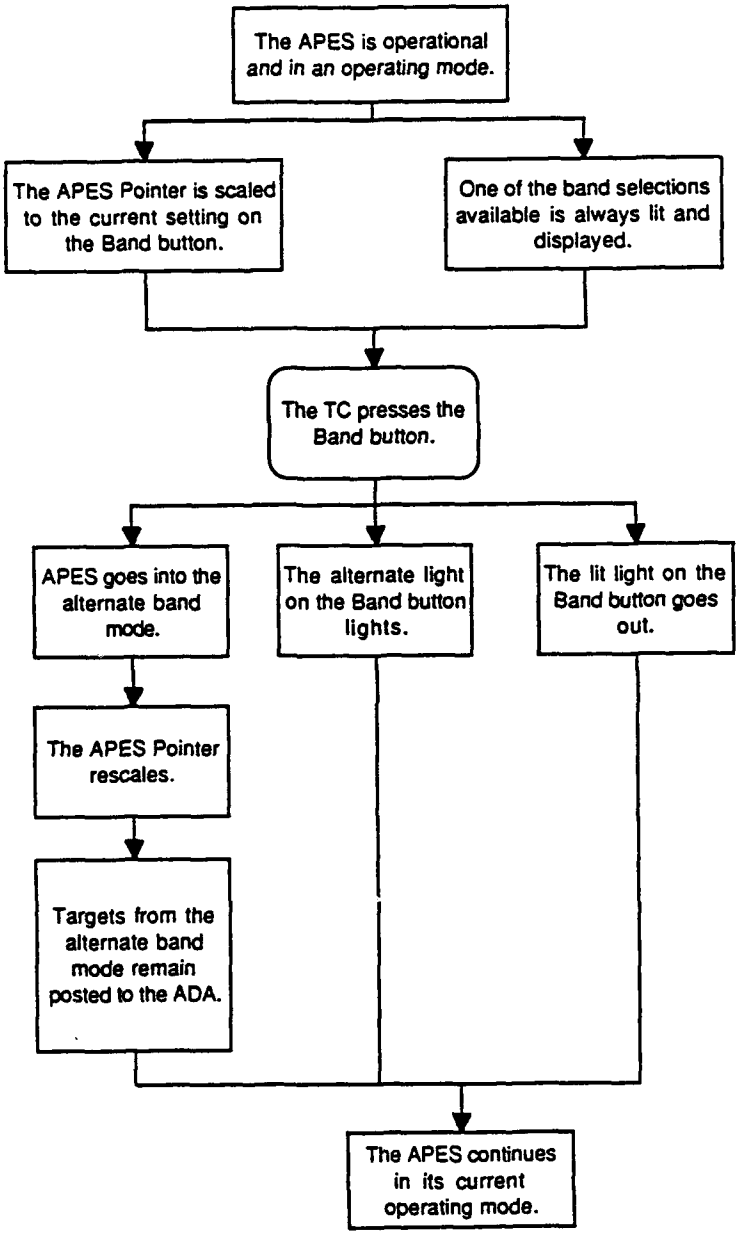


Figure 2.6-6: Selecting APES Band Mode

7. Activating the Target Stack

- Operating Procedure

In order for the APES system to pass targets to the target stack, the Target Stack button must be pressed to activate the target stacking feature. When the Target Stack button light is lit, the target stack is activated. Like the CITV, if the TC has activated the target stack, then the gunner must activate the target stack at his location in order for the stack to be active at the gunner's station. There are two ways in which targets can be stacked, either automatically (see 9 below) or manually (see 11 below). See Figure 2.6-7 for the flow process.

- Control Settings

APES Power Switch	-ON
Override Control	-Any
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Selected
TARGET STACKING buttons	-Any
Sector FOV buttons	-OFF
APES/CCD Switch	-Any

- Indication

<u>APES Display, Controls, and System Functioning</u>

<u>Target Stack Button</u>

- Selecting the Target Stack buttons at both the TC and gunner stations causes the target stack to become active. Lights on both the TC and Gunner's Target Stack Buttons will light when the respective button is pressed. If the lights are not lit, then the target stack is not active.

- When the target stack is active, targets that are stacked, either manually or automatically, are sent to the gunner's station.

- If the TC and gunner have activated the target stack and there are targets in the stack, then the associated Target Stacking buttons, at both the TC and gunner's station, have their center light lit.

<u>GPS/GPSE Controls and Display</u>

- If there are multiple targets in the stack, the Next Target Direction Icon is displayed in the GPS/GPSE.

• The Target Type designator displays the associated letter in the GPS/GPSE for the stacked target.

• Depending on the mode of operation, the Target Type Designator will blink informing the viewer that the APES and fire control system will be moving the turret.

TC Fire Controls

• The TC's control functioning is dependent on the selected APES mode.

Gunner Fire Controls

• The gunner's control functioning is dependent on the selected APES mode.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- If the APES Power switch is moved to either the STANDBY or OFF position, the APES goes into that mode (see 2 and 3 above).

AZ or EL FOV Buttons

- Selecting FOV buttons causes the APES to go into one of the Set Sector Modes (see 4 and 5 above).

BAND Button

- Selecting the Band button causes the APES Pointer to rescale between the wide and narrow bands (see 6 above).

APES Mode Buttons

- Selecting different mode buttons causes the APES to change modes (see 7 above and 9, 10, 11, and 12 below).

Scan/Track Button

- Pressing the Scan/Track button mode causes the lights, on the button, to toggle between the SCAN and TRACK positions. It does effect how the APES currently operates because it can change the mode from a scan to a track mode.

GPS/GPSE Controls and Display

- The gunner can turn on or off the target stack as he currently can with the CITV.

- The gunner can pick any of the four target stacking buttons to observe a designated target.

TC and Gunner Fire Controls

- The TC can use the target stack to engage targets from his position. The TC's override must be controlling the main gun while the APES is in the Auto Scan mode.

- As with the CITV, when the gunner or TC, whomever is controlling the turret and engaging targets from the target stack, release their palm switches, the target is removed from the target stack.

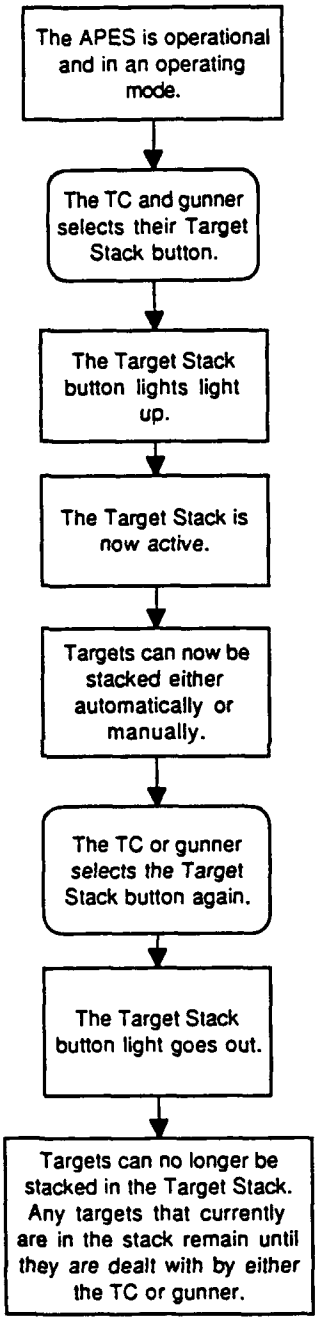


Figure 2.6-7: Activating the Target Stack

8. Engaging Targets

- Operating Procedures

The CCTB M1A1 tank simulator, equipped with an APES can allow both the TC or gunner to engage targets with equal ease and accuracy. The fire control system with the APES can engage targets in the following modes: AUTOMATIC SCANNING, AUTOMATIC TRACKING, MANUAL SCANNING, and MANUAL TRACKING. The TC and gunner need not turn any APES controls to engage targets, they must only perform the normal fire control procedures.

- Control Settings

APES Power Switch	-ON
Override Control	-Any
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-OFF
APES/CCD Switch	-Any

- Indication

<u>APES Display, Controls, and System Functioning</u>

- The normal indications for the operational modes are active.

<u>GPS/GPSE Controls and Display</u>

- Any targets that are acquired and identified by the APES will be displayed in the GPSE with the Target Type Designator and Next Target Direction icon

<u>TC and Gunner Fire Controls</u>

- The TC can control the turret and fire control system whenever his override is controlling the main gun.

- When the override is controlling the main gun, all functions that the TC can perform with the override are active.

- When the TC lases a target, he is lasing with the same LRF that the gunner is using.

- The TC can still verify targets and engage them with the GPSE.

- Either the TC or the gunner must operate the autoloader to ensure that the correct ammunition is loaded for the target to be engaged.

- To engage a target, the gunner or TC places the reticle within the sight on the target.

- The palm switches must be depressed in order for the triggers to work.

- The TC or gunner need to lase to the target in any mode.

- Alternate Conditions and Exceptions

TC Fire Controls

- The TC cannot engage targets if his override is not controlling the main gun.

9. Automatic Scanning

The TC can go into the Auto Scan mode by selecting the Auto switch and selecting SCAN with the Scan/Track button. This mode causes the APES to automatically scan the set sector. The APES will acquire targets within the line of sight of the APES within the sector, categorize the targets acquired, and prioritize the target. This is the automatic "hunter" mode of the system. The gunner will still have to lay the main gun and engage targets. The flow process is shown in Figure 2.6-9.

- Control Settings

APES Power Switch	-ON
Override Control	-Any
APES Mode Switches	-AUTO
SCAN/TRACK button	-SCAN
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-OFF
APES/CCD Switch	-Any

-Indication

APES Display, Controls, and System Functioning

Auto Button

- When the Auto button is pressed, the light on the button goes on.

Scan/Track Button

- The Scan/Track button has the SCAN position lit.

APES Display

- AUTO SCAN is displayed in the Mode window.

- The system that the TC's override is currently controlling is displayed in the Override control window.

- The APES pointer moves back and forth across the selected sector on the Azimuth Display Area following the movement of the APES sensor.

- Any targets that are within the line of sight, range, and the scan sector that the APES is currently set to are acquired based on the probabilities in Section 2.2.2.

- Based on the probabilities in Section 2.2.2, the targets are categorized correctly. The vehicle type icons in Figure 2.2-5 are displayed on the Azimuth Display Area in the location that they are identified in relation to the Own Vehicle Icon.

- Based on the prioritization logic in Section 2.2.5, the targets are prioritized. The first ten highest priority targets will have a priority number posted below its icon on the Azimuth Display Area.

- The range to the highest priority target is displayed in the Range windows.

Target Stack and Target Stacking Buttons

- If the target stack has been activated , then the target stack is automatically filled by the APES. The gunner's Target Stacking buttons will light up when a target has filled the designated position in the stack (e.g., the first four priority target positions).

- The gunner or TC can engage targets using the target stack. The TC or gunner can select any of the four target stacking buttons to chose a target.

GPS/GPSE Controls and Display

- The Target Type Designator and Next Target Direction Icon are projected in the GPS/GPSE.

- When a Target Stacking button is pushed, then the main gun and sights are slewed to that target for the TC or gunner to engage.

- The Target Type Designator does not blink. The TC or gunner have control of the turret.

- If there are multiple targets in the target stack, the Next Target Direction Icon is displayed in the GPS and GPSE.

TC and Gunner Fire Controls

- The TC and gunner's fire controls operate the turret and fire control system. The TC can engage targets when his override is controlling the main gun.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- If the APES Power switch is moved to either the STANDBY or OFF position, the APES goes into that mode (see 2 and 3 above).

AZ and FOV Buttons

- Selecting a FOV button causes the APES to go into one of the Set Sector modes (see 4 and 5 above).

BAND Button

- Selecting the BAND button causes the APES Pointer to rescale between the wide and narrow modes (see 6 above).

Mode Buttons

- Selecting different mode buttons causes the APES to change modes (see 7 above and 10, 11, and 12 below).

Scan/Track Button

- Pressing the Scan/Track button mode causes the lights, on the button, to toggle between the SCAN and TRACK positions. It does effect how the APES currently operates because it can change the mode from a scan to a track mode.

APES/CCD Switch

- Selecting the CCD position of the APES/CCD switch causes any targets identified to appear on the CCD display. Based on the own vehicle's current location, and the azimuth and direction of the target, the CCD plots the target in the correct location on the screen.

- Selecting the APES position of the APES/CCD switch causes no targets to appear on the CCD display.

System Functioning

- If the TC's override is controlling the APES, then when the palm switch is depressed and the override moved, the APES will act as if it is in the Manual Scan mode (see 11 below).

TC Fire Controls

- If the TC's override is controlling the main gun, then when the palm switch is depressed and the override moved, the turret and main gun will move. The Own Vehicle Icon will be updated instantly.

- With the APES in AUTO SCAN and the TC's override controlling the main gun, if the TC presses a target stacking button in this mode, he can engage targets from the target stack. He must have his palm switch depressed and the turret will slew to the selected target in the stack. He can select either of the four buttons to bring up the desired target. If he releases the palm switch, the target is removed from the target stack and the TC must go into the Manual Scan mode (see number 11 below) and restack the target.

- As with the CITV, when the gunner or TC, whomever is controlling the turret and engaging targets from the target stack, release their palm switches, the target is removed from the target stack.

Gunner Fire Controls

- The gunner can turn on or off the target stack as he currently can with the CITV.

- The gunner can pick any of the four target stacking buttons to observe a designated target.

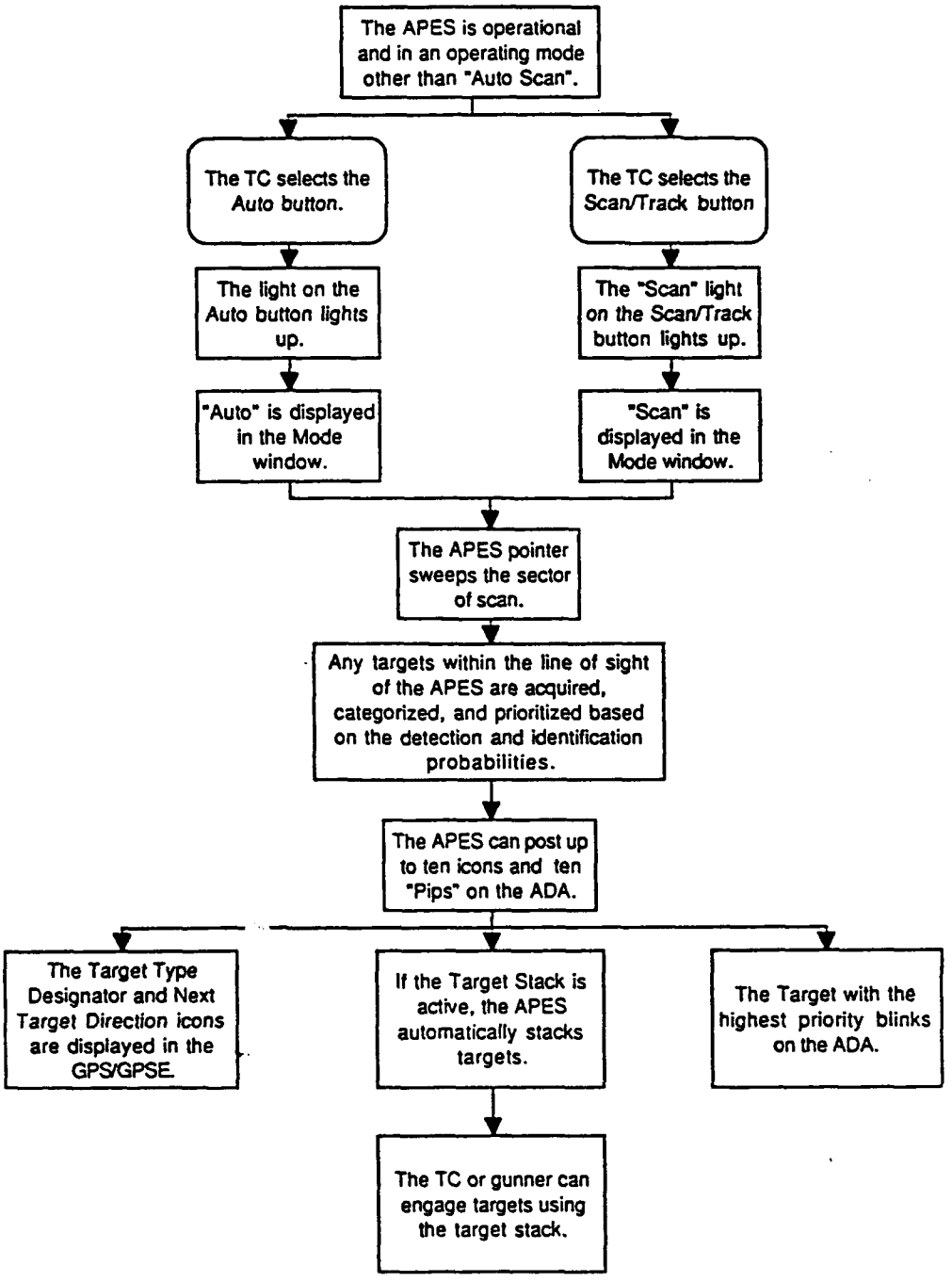


Figure 2.2-9: Automatic Scanning

10. Manual Scanning

- Operating Procedure

The Manual Scanning mode allows the TC to manually prioritize targets for the gunner. The TC places the APES in the Manual Scan mode by selecting the Manual switch, pressing the Scan/Track button so that SCAN is lit, the Target Stack button is lit, and the TC's override is controlling the APES. The flow process is shown in Figure 2.6-10.

- Control Settings

APES Power Switch	-ON
Override Control	-APES
APES Mode Switches	-MANUAL
SCAN/TRACK button	-SCAN
BAND Button	-Any
TARGET STACK button	-Selected
TARGET STACKING buttons	-Select successively or as priority dictates
Sector FOV buttons	-OFF
APES/CCD Switch	-Any

- Indication

APES Display, Controls, and System Functioning

Manual Button

- When the Manual button is pressed, the light on the button goes on.

Scan/Track Button

- The Scan/Track button has the SCAN position lit.

APES Display

- The Override Control window displays APES.
- MANUAL SCAN is displayed in the Mode window.
- The Target Stack button light is lit.
- The range to the target in the first stack position is displayed in the Range windows.
- As long as the TC does not have the palm switch on the override depressed, the APES pointer moves across the designated sector. When the palm switch is depressed, the TC gains control of the APES pointer.

- With the palm switch depressed, when the override is moved, the APES pointer moves in the following directions:

Override	APES pointer
pushed to the right	rotates clockwise on the ADA
pulled to the left	rotates counter clockwise on the ADA

System Functioning

- The APES automatically acquires and identifies targets. This information is displayed on the Azimuth Display Area using the icons in Figure 2.3-1.

Target Stack and Target Stacking Buttons and Procedures

- When the pointer is on the desired target, the TC designates the target using the Designate button on the TC's override.

- The TC then selects the desired Target Stacking button.

- The center light on the selected Target Stacking button lights up.

- On the Azimuth Display Area, the priority number from the selected target stack number is displayed below the icon.

- If the TC and gunner's Target Stack button is lit, then the Target Stack is active and any stacked targets are sent to the gunner.

- The TC must fill the target stack. The TC's override must control the APES when he is designating targets for the target stack. The gunner's Target Stacking buttons will light up when a target has filled the designated position in the stack (e.g., the first four priority target positions).

GPS/GPSE Controls and Display

- The Target Type Designator and Next Target Direction icon are displayed in the GPS and GPSE for the gunner and TC to use to engage targets.

- When a Target Stacking button is pushed, then the gun is slewed so that the target is displayed in the GPS/GPSE.

- The target in the first stack position is always the primary target.

- The Target Type Designator is not blinking. The TC or gunner has control of the turret.

• If there are multiple targets in the target stack, the Next Target Direction Icon is displayed in the GPS and GPSE.

• The Target Type Designator will display the type of target that it is tracking.

TC Fire Controls

• The TC's override must be controlling the APES for him to designate targets, and it must control the main gun to engage targets.

Gunner Fire Controls

• The TC or gunner can engage targets using the target stack. The gunner can select any of the four target stacking buttons to chose a target. The TC must change his override control to MAIN GUN in order to engage targets from the target stack.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- If the APES Power switch is moved to either the STANDBY or OFF position, the APES goes into that mode (see 2 and 3 above).

AZ and EL FOV Buttons

- Selecting a FOV button causes the APES to go into one of the Sector modes (see 4 and 5 above).

BAND Button

- Selecting the BAND button causes the APES Pointer to rescale between the wide and narrow modes (see 6 above).

Mode Buttons

- Selecting a different mode button or the Scan/Track button causes the APES to change modes (see 7, 9, 10 above or 12 below).

APES/CCD Switch

- Selecting the CCD position of the APES/CCD switch causes any targets identified to appear on the CCD display. Based on the own vehicle's current location, and the azimuth and direction of the target, the CCD plots the target in the correct location on the screen.

- Selecting the APES position of the APES/CCD switch causes no targets to appear on the CCD display.

System Functioning

- If the override is controlling the main gun, then the APES will continue to acquire and identify targets, but none will be designated to go into the target stack.

- If the TC does not have his palm switches depressed, the APES will continually scan the sector.

Target Stack and Target Stacking Buttons

- If the Target Stack buttons are not selected, then the targets designated by the TC are not sent to the gunner's station. The TC will still be able to stack targets, but the Target Stack will not be active.

- If the TC selects a target stack location that is already filled, then the target that was in that location and all targets of a lower priority are moved down in priority one position (e.g., If the first position is filled and the designated target is put in the first position, then the target that was in the first position now goes to the second position. All targets of a lower priority are moved down in priority.).

TC and Gunner Fire Controls

- If the TC presses the Designate buttons while he is controlling the main gun, nothing happens.

- As with the CITV, when the gunner or TC, whomever is controlling the turret and engaging targets from the target stack, release their palm switches, the target is removed from the target stack.

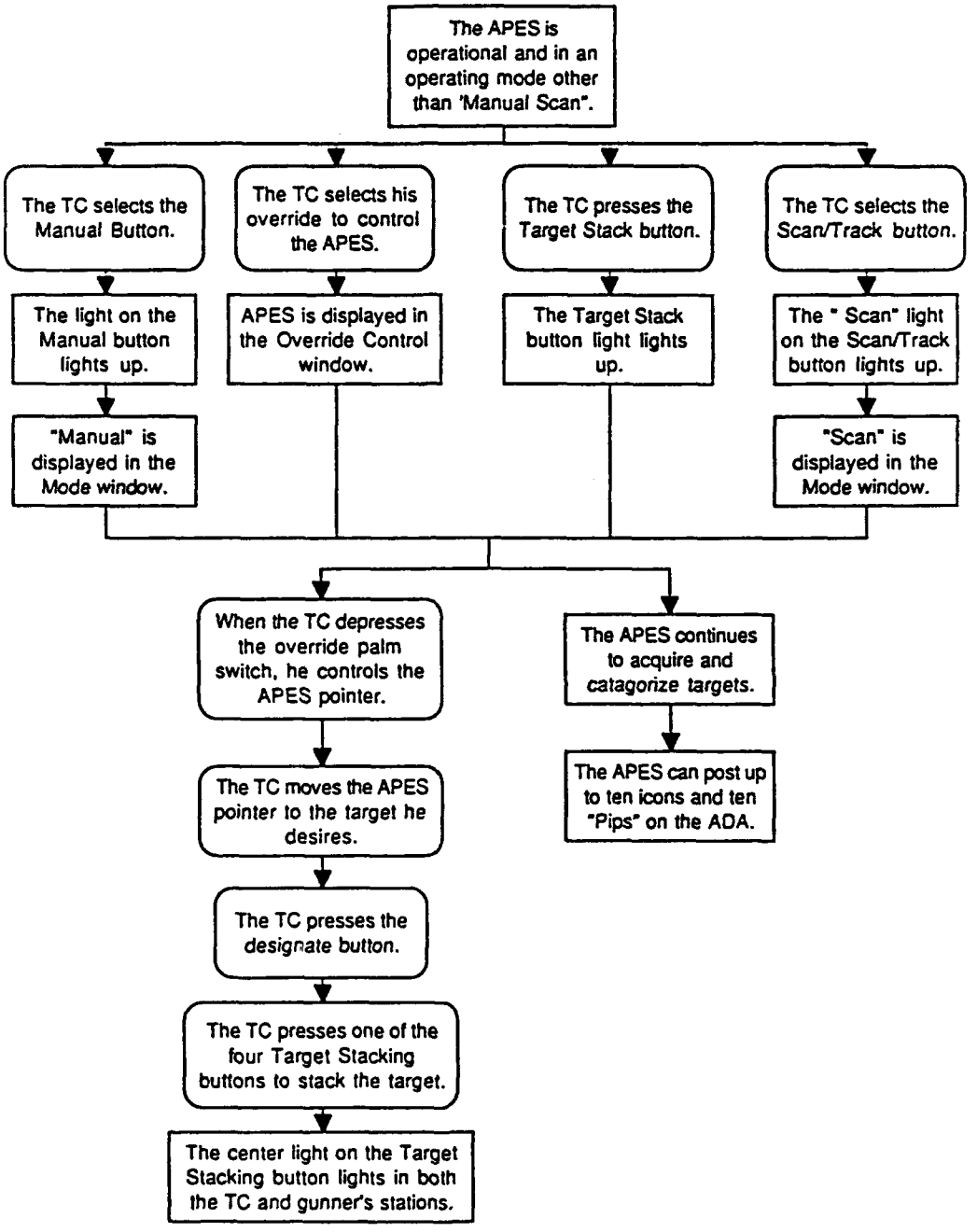


Figure 2.6-10: Manual Scanning

11. Automatic Tracking of the Target

- Operating Procedure

The TC places the APES in the Automatic Tracking mode by selecting the Auto button, and selecting the TRACK position on the SCAN/Track button. This is the automatic "Hunter - Killer" mode of operation of the APES. In this mode, the APES will acquire, categorize, prioritize, and lay the main gun on the highest priority target. The TC or the gunner will have to verify the target and pull the trigger to engage the target. The flow process is shown in Figure 2.6-11.

- Control Settings

APES Power Switch	-ON
Override Control	-MAIN GUN with the palm switch on the override depressed or the gunner must depress the palm switches on his control handles
APES Mode Switches	-AUTO
SCAN/TRACK button	-TRACK
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-OFF
APES/CCD Switch	-Any

- Indications

APES Display, Controls, and System Functioning

Auto Button

- The light on the Auto button is lit.

Scan/Track Button

- The Scan/Track button has the TRACK position lit.

APES Display

- AUTO TRACK is displayed in the Mode window.

- The system that the TC's override is currently controlling is displayed in the Override Control window.

- Initially, the APES pointer moves back and forth across the selected sector on the Azimuth Display Area.

- The icon for the target with the highest priority blinks at a rate of one time per second.

- The Range window will display the range to the highest priority target in the range windows.

- When the APES is tracking a target, the APES pointer follows the target with the highest priority. All other target icons are displayed on the Azimuth Display Area but their locations are not updated.

System Functioning

- All targets in line of sight, range, and scan sector that the APES is currently set to are acquired based on the probabilities in Section 2.2.2.

- Based on the probabilities in Section 2.2.2, the target is categorized correctly. The vehicle type icons in Figure 2.2-5 are displayed on the Azimuth Display Area in the location that they are identified in relation to the Own Vehicle Icon.

- Based on the prioritization logic in Section 2.2.5, the targets identified are prioritized. The first ten highest priority targets will have a priority number posted below its icon on the Azimuth Display Area.

- The APES will only cause the turret and main gun to move if either the gunner has his palm switches depressed or the TC has his override palm switch depressed while the override is controlling the main gun, and the controls are in the neutral position.

- The APES causes the turret and gun tube to slew so that the target is laid within the GPS/GPSE FOV.

- The TC or gunner must perform the final lay on the target using their turret controls. When the controls are moved out of the neutral position, then the TC or gunner controls the turret to lay the sights on the target.

- The APES tracks the target with the highest priority so that it remains in the FOV of the sights until either the gunner or TC and releases his palm switch. The target that was being tracked then loses its priority and the APES will not reassign it a priority. There are two ways in which it can be reassigned a priority. The first way it can be reassigned a priority, is if the TC manually assigns it (see 11 and 12 below). The second is if the target leaves and returns to line of sight of the APES.

- After a target is engaged, the crew member who engaged the target will release his palm switches to clear that target out of the APES. The APES will make a complete pass over the sector of scan. This will update locations of targets, acquire any new targets that entered the scanned sector, identify targets

based on Section 2.2.2, prioritize targets based on the prioritization logic in Section 2.2.5, and designate the highest priority target.

GPS/GPSE Controls and Display

- The Target Type Designator and Next Target Direction icon are displayed in the GPS and GPSE for the gunner and TC to use to engage targets.

- The Target Type Designator will display the type of target that it is tracking.

- The Target Type Designator will blink at a rate of 2 Hz. To indicate to the viewer that the APES is controlling the turret.

TC and Gunner Fire Controls

- When the TC or gunner presses the lase button, target range, velocity, and heading data are determined by the LRF and this data is fed into the ballistic computer.

- Either the TC or gunner's palm switches on their turret fire controls must be depressed. The TC's override must be controlling the main gun in order for him to engage targets in the Auto Track mode.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- If the APES Power switch is moved to either the STANDBY or OFF position, the APES goes into that mode (see 2 and 3 above).

AZ and EL FOV Buttons

- Selecting a FOV button causes the APES to go into one of the Sect Sector modes (see 4 and 5 above).

BAND Button

- Selecting the BAND button causes the APES Pointer to rescale between the wide and narrow modes (see 6 above).

Scan/Track Button

- Selecting a different mode button or the Scan/Track button causes the APES to change modes (see 7 and 9 above and 11 and 12 below).

APES/CCD Switch

- Selecting the CCD position of the APES/CCD switch causes any targets identified to appear on the CCD display. Based on the own vehicle's current location, and the azimuth and direction of the target, the CCD plots the target in the correct location on the screen.

- Selecting the APES position of the APES/CCD switch causes no targets to appear on the CCD display.

System Functioning

- If neither the gunner nor TC's palm switches are depressed, the APES will perform like the Auto Track mode.

- If the TC's override is controlling the APES, then when the override's palm switch is depressed, the APES will act as if it is in the Manual Track mode (see 11 below).

TC and Gunner Fire Controls

- As with the CITV, when the gunner or TC, whomever is controlling the turret and engaging targets from the target stack, release their palm switches, the target is removed from the target stack.

- If the gunner or TC picks any of the four target stacking buttons, the APES will track the target in that position.

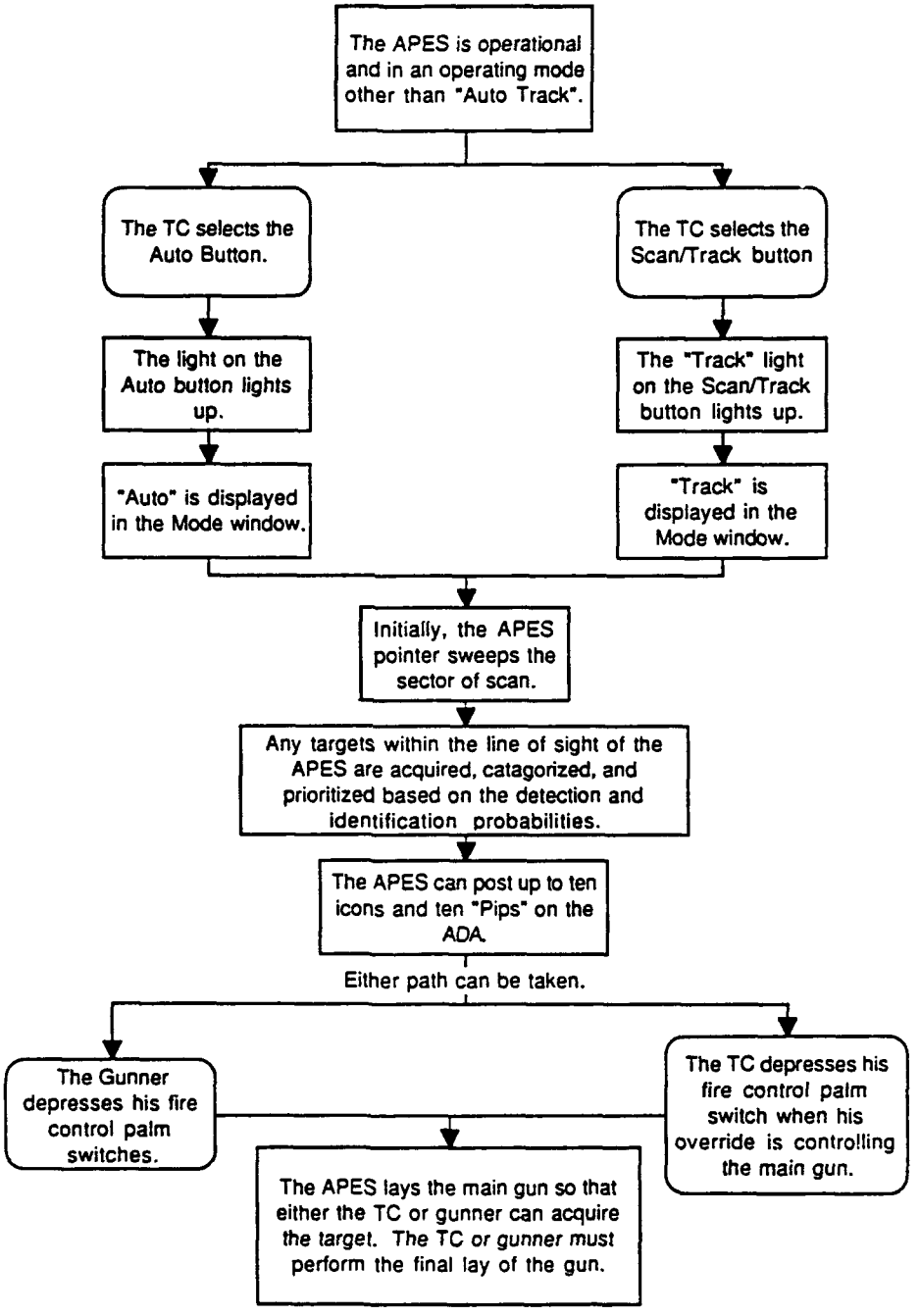


Figure 2.6-11: Automatic Tracking of a Target

12. Manual Tracking of a Target

- Operating Procedure

The TC places the APES and fire control system into the Manual Tracking mode by selecting the Manual button, pressing the Scan/Track button so that TRACK is lit, and the TC's override is controlling the main gun if he is going to be engaging the targets. The flow process is shown in figure 2.6-12.

- Control Settings

APES Power Switch	-ON
Override Control	-APES with the palm switches on either the TC or gunner controls depressed
APES Mode Switches	-MANUAL
SCAN/TRACK button	-TRACK
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-OFF
APES/CCD Switch	-Any

- Indication

APES Display, Controls, and System Functioning

Manual Button

- When the Manual button is selected, the light on the button lights up.

Scan/Track Button

- The Scan/Track button has the Track position lit.

APES Display

- MANUAL TRACK is displayed in the Mode window.

- As long as the TC does not have the palm switch on the override depressed, the APES pointer moves across the designated sector.

- After a target has been designated, the range to the tracked target will be displayed in the Range windows.

- When the APES is tracking a target, the APES pointer follows the designated target. All other target icons are displayed on the Azimuth Display Area but their locations are not updated.

System Functioning

- As long as the palm switches are not depressed, the APES automatically acquires and categorizes targets. This information is displayed on the Azimuth Display Area using the icons in Figure 2.2-5.

- When the palm switch is depressed, the TC gains control of the APES pointer.

- With the palm switch depressed, when the override is moved, the APES pointer moves in the following directions:

Override	APES pointer
pushed to the right	rotates clockwise on the ADA
pulled to the left	rotates counter clockwise on the ADA

- When the pointer is on the desired target, the TC designates the target using the Designate button on the TC's override.

- When a target has been designated, the APES will track the designated target.

- The APES will cause the turret and main gun to move if either the gunner has his palm switches depressed or the TC has his override palm switch depressed while the override is controlling the main gun.

- The APES causes the turret and gun tube to slew so that the target is within the FOV of the GPS/GPSE.

- The APES tracks the designated target until either the gunner or TC and releases his palm switch. The target that was being tracked then loses its priority and the TC must reassign it a priority.

- After a target is engaged, the crew member who engaged the target will release his palm switches to clear that target out of the APES. At this point, the TC can either designate another target to track, or he can have his APES display updated.

GPS/GPSE Controls and Display

- The Target Type Designator will display the type of target that it is tracking.

- The Target Type Designator will blink at a rate of 2 Hz.

TC and Gunner Fire Controls

- When the TC or gunner presses the lase button, target range, velocity, and heading data are determined by the LRF and this data is fed into the ballistic computer.

- The TC's override must control the APES in order for targets to be designated for tracking.

- Either the TC or gunner's palm switches on their turret fire controls must be depressed and in the neutral position. When the controls are moved out of the neutral position, the TC or gunner can perform their final lay. The TC's override must be controlling the main gun in order for him to engage targets in the Manual Track mode.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- If the APES Power switch is moved to either the STANDBY or OFF position, the APES goes into that mode (see 2 and 3 above).

AZ and EL FOV Buttons

- Selecting a FOV button causes the APES to go into one of the Set Sector modes (see 4 and 5 above).

BAND Button

-Selecting the BAND button causes the APES Pointer to rescale between the wide and narrow modes (see 6 above).

Mode Buttons

-Selecting a different mode button or the Scan/Track button causes the APES to change modes (see 7, 9, 10, and 11 above).

APES/CCD Switch

- Selecting the CCD position of the APES/CCD switch causes any targets identified to appear on the CCD display. Based on the own vehicle's location, and the azimuth and direction of the target, the CCD plots the target in the correct location on the screen.

- Selecting the APES position of the APES/CCD switch causes no targets to appear on the CCD display.

System Functioning

- If the APES is controlling the main gun, then the APES sweeps back and forth the scan sector and acquires and identifies targets. The system will not automatically or manually track targets. Also, the TC cannot designate targets for stacking or tracking because he does not have control of the APES pointer.

- As with the CITV, when the gunner or TC, whomever is controlling the turret and engaging targets from the target stack, release their palm switches, the target is removed from the target stack.

Target Stack and Target Stacking Buttons and Procedures

- Selecting the Target Stack or Target Stacking buttons causes no change in the operation of the system. Targets cannot be stacked in this mode.

TC and Gunner Fire Controls

- If no target is designated to be tracked by the APES, then if the gunner has his palm switches depressed, he can slew the turret to any location that he desires.

- If neither the TC or Gunner have their palm switches depressed, the APES will operate as if in the Auto Scan mode.

- If the gunner picks any of the four target stacking buttons, the APES will track the target in that position.

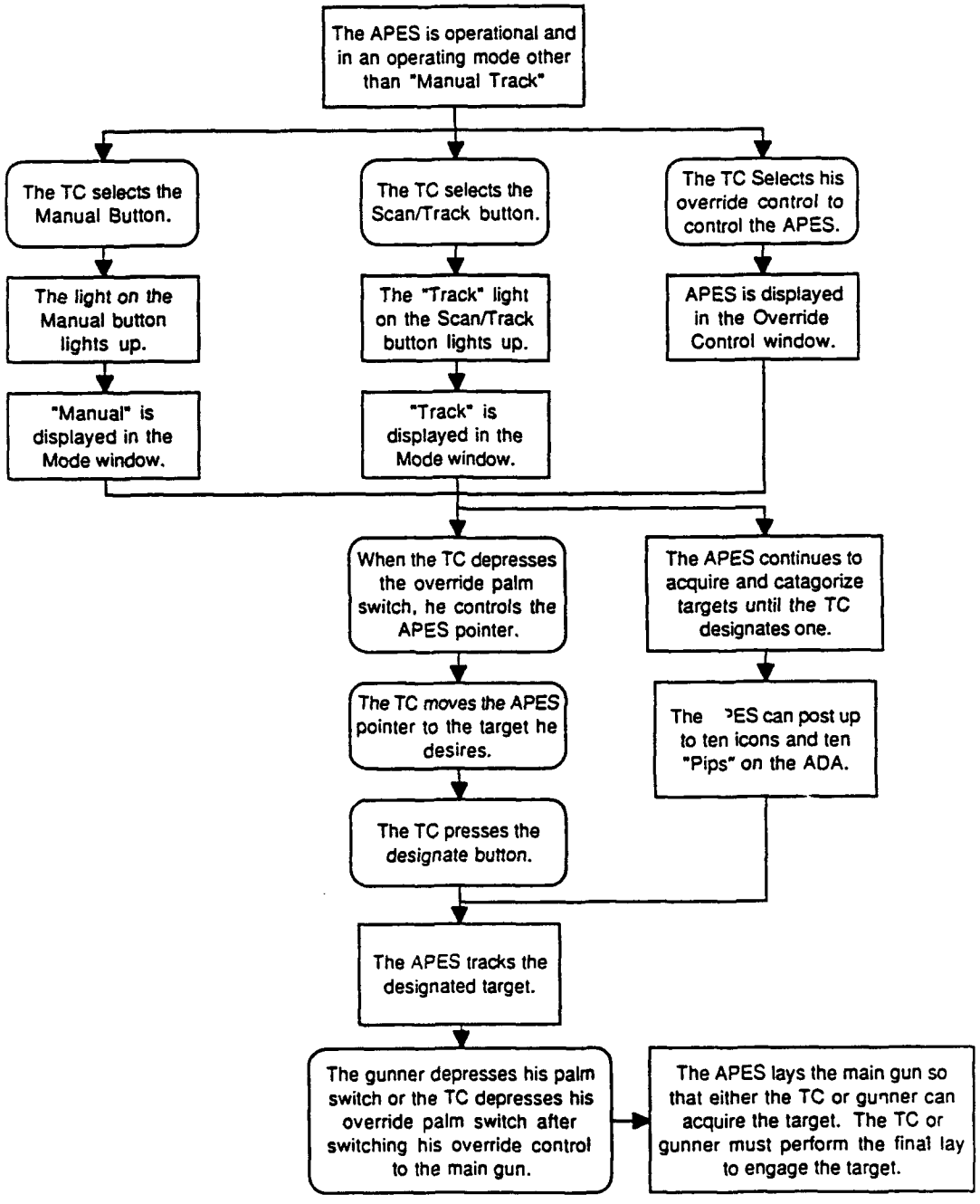


Figure 2.6-12: Manual Tracking of a Target

13. Slaving the APES to the Main Gun

- Operating Procedure

The APES is slaved to the main gun by pressing the GLOS (Gun Line Of Sight) button. In this mode, the APES will scan around the orientation of the main gun. The flow process is shown in Figure 2.6-13.

- Control Settings

APES Power Switch	-ON
Override Control	-Any
APES Mode Switches	-GLOS selected
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-OFF
APES/CCD Switch	-Any

- Indication

APES Display, Controls, and System Functioning

GLOS Switch

- The GLOS button lights when selected.

Mode Switch

- Any other Mode switch unlights.

- When an alternate mode of operation is selected, the APES moves back to its old EL and AZ FOV settings and operates in the mode selected.

APES Display

- The APES pointer rotates so that it is superimposed on the gun tube of the own vehicle icon.

- The APES elevates or depresses its orientation so that the GPS Icon is in the center of the APES operating band.

- The APES pointer stays superimposed on the main gun.

- A range is displayed to the target nearest the center of the area of scan.

- If the main gun is moved, the GLOS sector scan moves so that it is always centered on the main gun.

System Functioning

- The APES continues to scan in its selected band.
- GLOS is displayed in the Mode window.
- Any targets within the new sector of scan are displayed.

GPS/GPSE Controls and Display

- The Target Type Designator is displayed in the GPS and GPSE.
- Any targets within the FOV of the APES and sight are displayed in the GPS and GPSE.
- The target type of the target nearest the center of the reticle will be displayed in the Target Type Designator.
- The Target Type Designator will not blink.
- No Next Target Direction Icon will be displayed.

TC and Gunner Fire Controls

- The gunner's controls perform normally.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

- Selecting a FOV buttons causes the APES to go into one of the Set Sector Modes (see 4 and 5 above).

- Switching the APES Power Switch to either STANDBY or OFF causes the APES to go into that mode (see 2 and 3 above).

- Selecting the BAND button causes the APES Pointer to rescale between the wide and narrow modes (see 6 above).

- Selecting either the Manual or Auto button causes the APES to change modes (see 9, 10, 11, and 12 below).

- Pressing the Scan/Track button while in the GLOS mode causes the lights, on the button, to toggle between the SCAN and TRACK positions. It does no effect how the APES currently operates.

- Selecting the Target Stack buttons toggles the target stacking on and off (see 8 below).

- If the TC's override is controlling the APES, when the palm switch is depressed and the handle moved, the APES will move as the TC wants it to. When the palm switch is released, the APES moves back to GLOS.

TC Fire Controls

- If the TC's override is controlling the main gun, when the palm switch is depressed, the turret moves and the APES follows the main gun.

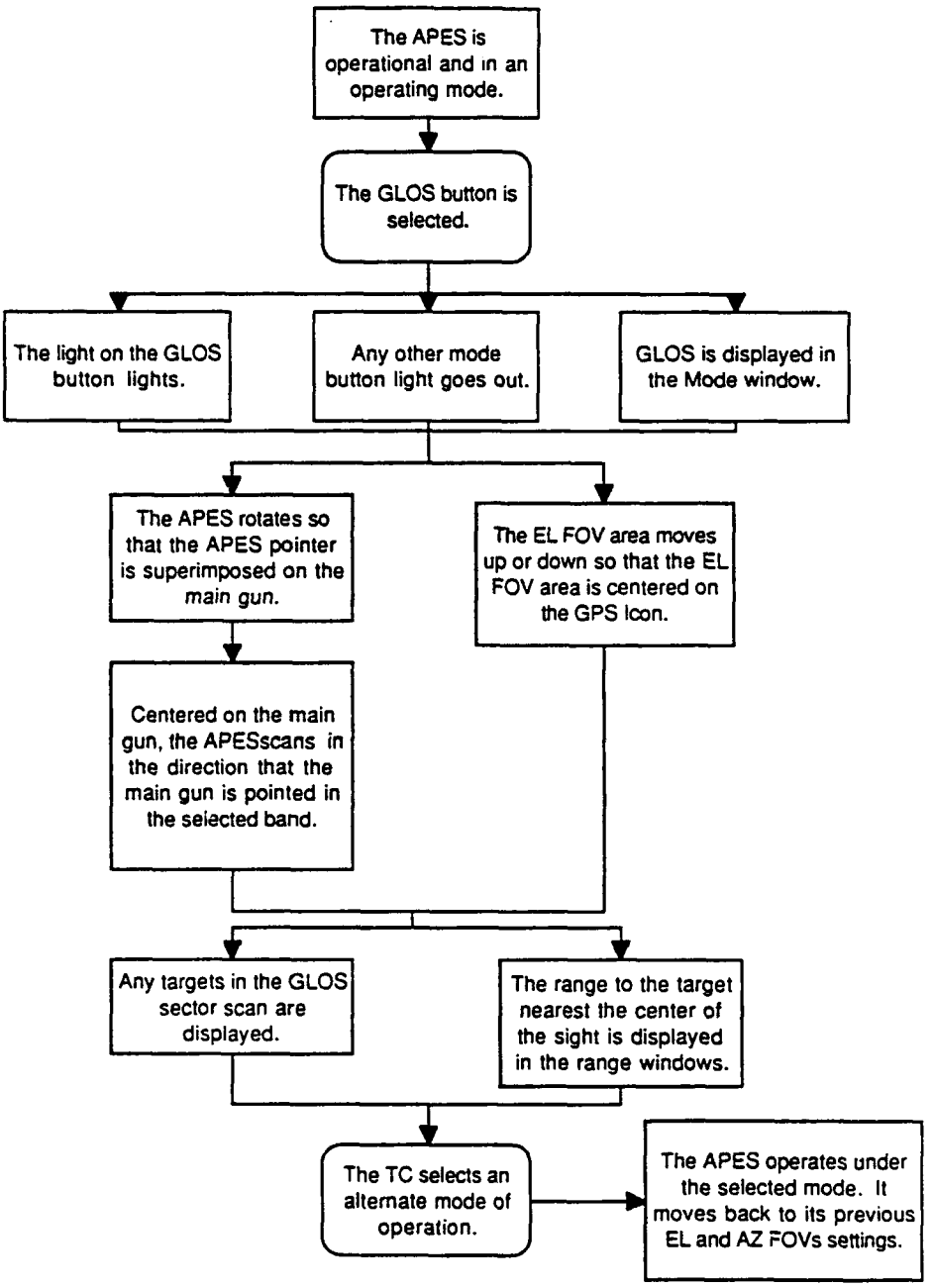


Figure 2.6-13: Slaving the APES to the Main Gun

14. Sending Targets to the CCD

- Operating Procedure

The TC can send information from the APES to the CCD for posting by moving the APES/CCD switch to the CCD position. Based on the own vehicle's current location, and the azimuth and direction of the target for any targets that are acquired or identified by the APES, the CCD plots in the correct location on the CCD screen with the icon type of the target. The flow process is shown in figure 2.6-14.

- Control Settings

APES Power Switch	-ON
Override Control	-Any
APES Mode Switches	-Any
SCAN/TRACK button	-Any
BAND Button	-Any
TARGET STACK button	-Any
TARGET STACKING buttons	-Any
Sector FOV buttons	-Any
APES/CCD Switch	-CCD

- Indication

APES Display, Controls, and System Functioning

APES/CCD Switch

- When the APES/CCD switch is moved to the CCD position, the CCD position light lights up.

Mode Buttons

- All button lights for the current mode of operation remain lit.

APES Display

- The system that the TC's override is currently controlling is displayed in the Override Control window.

System Functioning

- The APES performs the operation for the current selected mode.

- All targets that are acquired and identified are displayed on the CCD. Based on the own vehicle's location, and the range and direction to the target, the CCD figures out the location to post the icon type for the target on the CCD screen.

GPS/GPSE Controls and Display

- There is no indication to the gunner that the APES is sending information to the CCD.

TC and Gunner Fire Controls

- The TC and gunner's fire controls perform according to the mode of operation that the APES controls are in.

- Alternate Conditions and Exceptions

APES Display, Controls, and System Functioning

APES Power Switch

- If the APES Power switch is moved to either the STANDBY or OFF position, the APES goes into that mode (see 2 and 3 above).

AZ and EL FOV Buttons

- Selecting a FOV button causes no additional data to be sent to the CCD. Any targets sent to the CCD will remain posted on the CCD screen.

System Functionality

- Selecting an alternate mode of operation places the APES in that mode, all target information that the APES gathers is sent to the CCD for posting.

CCD Functionality

- Once a target is sent to the CCD, it is treated as a posted icon within the system.

- If the TC wants to send a spot report on the target, or a call for fire, the TC selects that report and he selects the target icon to input the type of enemy and location into the report.

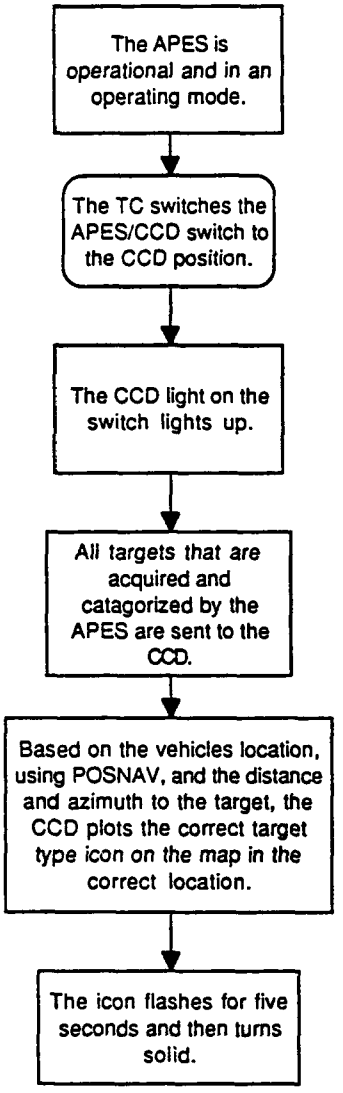


Figure 2.6-14: Sending Targets to the CCD.

2.7 INTEGRATION

As stated in the introduction, the APES is part of a suite of modifications to be incorporated into the simulator. The APES is not an independent system within the simulator, but rather a subsystem of a set of systems. Therefore, the APES must integrate with or pass information to different systems within the simulator. The systems that it integrates with are the CVC2 system (CCD) and the fire control system. Currently, there is no integration required between the autoloader and the APES.

CVC2

As stated in the functional specification, Section 2.6, the APES can pass information to the CCD. When the APES/CCD switch is in the CCD position, any targets that the APES detects can be displayed on the CCD. The APES will determine target range, azimuth to the target, direction of travel, speed, and target type. This information will be sent to the CVC2 system, where the data will be processed so that the target can be displayed on the CCD itself. Using the POSNAV data that the CVC2 system gathers, the CVC2 system will use the data from the APES to determine the target's location in UTM grid. Then the target type data will be used to determine what type of target icon will be posted on the CCD. Then the correct icon will be displayed on the CCD.

FIRE CONTROL SYSTEM

The APES must also integrate with the gun/turret drive system in the simulator. When the APES is in a tracking mode and tracking a target, the range, azimuth, direction of travel, and speed data for the target are taken 120 times per second. This information is fed to the gun/turret drive. Based on the targets movement, the gun/turret drive will track the target so that it remains within the sight's field of view. The targets movement will be updated on the CCD 10 times per second.

2.8 AUDITORY SIGNALS AND SYSTEM SOUNDS

No auditory signals or system sound will be required for the Acoustic Priority and Engagement System.

2.9 APPEARANCE

No appearance changes will be required for the Acoustic and Engagement System.

2.10 DAMAGES AND FAILURES

Failures of the APES will not be modeled. It will be assumed to be 100% reliable for the purposes of evaluation in CCTB. Combat damage caused by an overhead artillery burst or anything greater will result in total loss of the APES.

2.11 SEMI-AUTOMATED FORCE MODIFICATIONS

Semi-automated forces equipped with a APES will have the enhanced target detection and acquisition capabilities provided by the APES. They will use the same prioritization and IFF scheme included in the APES.

2.12 COMBAT SUPPORT, SERVICE SUPPORT, AND OPPOSING FORCE WORKSTATIONS

No changes to the Combat Support, Service Support, or Opposing Force workstations will be required.

2.13 DATA COLLECTION AND ANALYSIS SYSTEMS

The data collection system will need to be modified to collect APES target data and crew inputs. The APES target data collected directly will simply be the APES detection, loss of detection, and identification times for each target. From this and the current data collection done for each simulator, measures for the following can be computed or determined for each target:

Detect to loss of detect time
Identification to loss of detect time
Detection to identification time
Detection to engagement time
Identification to engagement time
Number of identified targets engaged
Number of detected non-targets engaged

The crew inputs include the TC and gunner operation of any of the controls associated with the APES or the target stacking and passing system. Control actuation times and frequencies should be recorded. In addition, the number of targets that cannot be identified by the TC/gunner through their sights should be recorded. This will be recorded by the number of enemy tanks acquired in the sights but not fired on, and the number of friendly tanks fired upon.

2.14 ACCEPTANCE TESTING

All of the APES functions described in subsection 2.3 through 2.6 will be tested prior to product acceptance using a series of test scenarios. These tests will be performed on the initial simulator modified. Each additional simulator will be

tested for target detection, identification, designation, and manual stacking and passing. The other operations will be tested on a random basis. Any failure of a simulator to perform a desired function will be grounds for non-acceptance. Semi-automated force performance will be evaluated during crew training. Data collection changes will be completely tested on one simulator and randomly sampled on the others. The test scenarios, procedures, and descriptions are provided in the following subsections.

2.14.1 SCENARIO PARAMETERS

The basic test scenarios will be the presentation of a set of targets for detection by the APES. These target sets will be defined by randomly varying the following parameters.

- 1 to 30 targets will be displayed.
- Both simultaneous and successive presentation of targets will occur.
- The following target types will be displayed: Tanks, PCs, Helicopters, Wheeled Vehicles, and other targets which are identified as unknown targets.
- Target characteristics (range, velocity, and direction) will be based on the prioritization parameters from Section 2.2.5.
- Targets will be placed in realistic locations on the terrain.

2.14.2 TEST PROCEDURES

The following are the steps that will be followed to set up and run the acceptance testing.

1. Targets for the scenarios to be run will be defined.
2. The acceptable limits of performance will be defined, based on the operational mode and the specification requirements.
3. The scenario will be loaded into the simulator and the test executed with pauses as needed.
4. Results of each scenario will be documented.
5. A maximum of 3 trails for any given test scenario will be run to allow the system to perform as the specification requires.

2.14.3 TESTING

Prior to testing the operational modes of the APES, the various setup operations (e.g., setting EL and AZ FOVs, powering up the system, changing the range modes, manipulation of the APES pointer and the main gun, and passing targets to the CCD) will be performed to determine if they meet the specification requirement. The following are the specific tests that will be run on the various operational modes of the APES.

1. Auto Scan Mode

- 10 scenarios in flat , unobscured terrain.

- 10 scenarios in hilly and obscuring terrain.

Criteria: All targets must be detected, categorized, and prioritized within the limits established by the specification requirement.

2. Manual Scan Mode

- 1 scenario in flat, unobscured terrain.

- 2 scenarios in hilly and obscuring terrain.

Criteria: All targets must be detected and categorized within the limits established by the specification requirement. The target stacking feature will be exercised in this mode.

3. Auto Track Mode

- 1 scenario in flat, unobscured terrain.

- 2 scenarios in hilly and obscuring terrain.

Criteria: All targets must be detected, categorized, and prioritized within the limits established by the specification requirement. Also, the system must track the target as determined by the specification requirement to allow successful engagement of the target.

4. Manual Track Mode

- 1 scenario in flat, unobscured terrain.

- 2 scenarios in hilly and obscuring terrain.

Criteria: All targets must be detected, categorized, and prioritized within the limits established by the specification requirement. Also, the system must track the target as determined by the specification requirement to allow successful engagement of the target.

5. GLOS Mode

- 1 scenario in flat, unobscured terrain.

- 2 scenarios in hilly and obscuring terrain.

Criteria: The APES sensor performs as established by the specification requirement.

2.15 DEVELOPMENT SCHEDULE

Figure 2.15-1 provides the development schedule for implementing the modifications. It includes the development of the hardware and software for the modification as well as the acceptance testing.

2.16 SUMMARY

This section has provided detailed specifications for integrating an acoustic prioritization and engagement system into the Abrams simulator in CCTB. It has included modifications to crew stations, functional characteristics and performance parameters, modifications to related CCTB systems, acceptance criteria, and a development schedule.

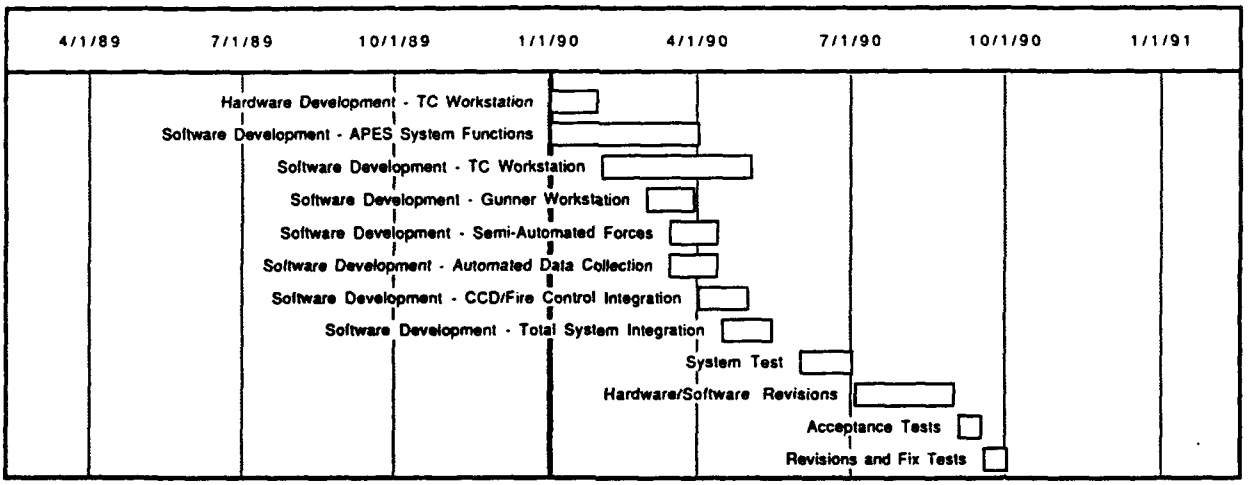


Figure 2.15-1: Modification Schedule

3.0 INVESTIGATION PLAN.

3.1 PURPOSE OF THE INVESTIGATION.

Testing based on this plan will provide data and associated analysis on the operational effectiveness and military utility of augmenting the Abrams tank with the Acoustic Priority and Engagement System (APES). It will allow a comparison of the Abrams with APES to the Abrams baseline (Abrams with CITV).

3.2 OVERVIEW OF THE PLAN.

This plan provides the basic information needed to evaluate the APES in the CCTB environment. It includes discussions of data and resource requirements. It is not intended to reflect a fully designed experiment, but a guide to the CCTB developers and users for the implementation of the APES. While this plan could be used as a basis for investigation, it would require further refinement and detail before actually being used.

This section begins with a discussion of the objectives for the test and the issues surrounding them. The factors and conditions define the experimental variables from which the specific data requirements are derived. Finally, the key resource requirements and schedule for the testing are defined.

3.3 INVESTIGATION OBJECTIVES AND ISSUES.

The investigation objectives were originally developed and presented in Section 1.5. They are restated below for reference:

1. To assess any changes in the fightability of the tank.

2. To determine if the individual and crew workload is manageable or if it increases to unacceptable limits.

3. To assess any survivability changes caused by the use of the APES.

4. To assess the relative difficulty of training tank crews to operate with the APES.

5. To assess crew acceptance to the APES in general and to the implemented APES displays and controls in particular.

The investigation plan defines the testing, data, and resource requirements needed to meet these objectives. A discussion of the issues surrounding each of these objectives is provided in the following subsections. These discussions are intended to clarify the intent of the objectives and identify specific questions to be answered by the testing.

3.3.1 HOW IS THE FIGHTABILITY OF THE TANK AFFECTED WHEN AN ACOUSTIC PRIORITY AND ENGAGEMENT SYSTEM IS INCORPORATED IN THE ABRAMS TANK?

This objective addresses the effects of APES design feature changes on an Abrams crew's ability to acquire, engage, and defeat an enemy force more efficiently and effectively in simulated combat. This includes additional duties for crew members, changes in organizations, tactics, techniques and procedures (OTTP), changes in system hardware and software, and sounds and timing changes necessitated by system modifications. The questions to be answered in the testing include:

- How will command, control, and communications of the Abrams tank be affected by the addition of the APES?
- What will be the significant effects on target engagement efficiency (ability to acquire and engage targets) and effectiveness (ability to win the fight)?
- Will the battle outcomes be significantly affected?
- What changes in OTTP occur as a result of introducing the APES into the tank?
- What changes in OTTP could be made to take greatest advantage of the tank with APES?

3.3.2 HOW DOES THE WORKLOAD OF THE CREW MEMBERS CHANGE WHEN THE ACOUSTIC PRIORITY AND ENGAGEMENT SYSTEM IS INCORPORATED IN THE ABRAMS TANK?

This objective addresses the identification of changes in workload and the effects those changes have on the crew's ability to perform their functions with APES. It includes the changes in performance times and error rates as well as the crew members subjective experience of workload. The questions to be answered in the testing include:

- What are the effects on target acquisition, target engagement, and communication times?
- What are the effects on target acquisition, target engagement, and communication error rates?
- What are the effects of target acquisition, target engagement, and communications while using APES on the crew's perception of workload?

3.3.3 HOW DOES APES AFFECT THE SURVIVABILITY OF THE ABRAMS IN SIMULATED BATTLE?

Although survivability encompasses a wide variety of factors which result in the reduction of crew casualties and battle damage, this objective addresses the relative length of time that a tank with APES is able to continue the fight in battle as compared to a baseline tank. The questions to be answered in the testing include:

- Will a tank in simulated battle survive longer when using the APES?

3.3.4 WHAT IS THE EFFECT ON TRAINING REQUIREMENTS WHEN THE APES IS INCORPORATED IN THE ABRAMS TANK?

This objective addresses the identification of changes in training requirements needed when the APES is introduced. The questions to be answered in the testing include:

- What transition training is needed to train an Abrams simulator trained crew to a proficient level on an Abrams simulator with APES?

- What is the expected difference in training a tank crew on an Abrams simulator with APES from training on an actual Abrams tank configured with the APES?

3.3.5 WHAT IS THE CREW'S RESPONSE TO APES IN GENERAL AND TO THE IMPLEMENTED APES DISPLAYS AND CONTROLS IN PARTICULAR?

This objective addresses the tank crew's subjective response to both the introduction of the APES into the Abrams and the man-machine interfaces associated with the implemented APES. The issues include the perceived effects of the utility of the APES and its ease of use. The questions to be answered in the testing include:

- What are the crew's perceptions of the effects of APES on efficiency and effectiveness of target acquisition and engagement?

- What features of the man-machine interface were most difficult to use or understand? Which were easiest?

- 3.3.6 SUMMARY.

As can be seen in the discussions above, each of the objectives includes several issues which must be addressed in the testing. In the following sections the methods and measures for answering the questions posed above are presented.

3.4 FACTORS AND CONDITIONS.

The factors and conditions reflect the major variables which will be manipulated, held constant, or left uncontrolled for the study. The factors and conditions have been divided into four major groups for discussion and analysis - systematically varied, tactically varied, held constant, and uncontrolled. Table 3-1 summarizes these factors and conditions while the following subsections further describe them.

3.4.1 SYSTEMATICALLY VARIED FACTORS.

Factors are varied systematically for a combination of two reasons:

a. To ensure that conditions identified as influencing operational effectiveness are thoroughly examined and their effects identified.

b. The factor's probable frequency of occurrence in the combat scenario cannot be accurately determined or obtained naturally in the compressed test time interval.

The factors in Table 3-1 will be varied systematically within the limits of their respective conditions. The combinations have been selected to (1) best facilitate the comparison of the Abrams tank with APES versus the Abrams tank with CITV, and (2) define the performance of the tank with APES in an operational mode when no comparison exists.

3.4.2 TACTICALLY VARIED FACTORS.

Factors are tactically varied when their probable frequency of occurrence in combat may be estimated from a description of threat, doctrine, mission profile, or other tactical specifications. Table 3-1 shows the tactically varied factors and conditions.

3.4.3 FACTORS HELD CONSTANT.

In order to simplify the data, some factors (normally proposed by the combat developer based on experience and studies) will be held constant. These factors are found in a realistic combat environment and represent the most probable status or condition. Table 3-1 lists the factors held constant.

3.4.4 UNCONTROLLED FACTORS.

Factors over which the tester has no control or which are desired to be left uncontrolled are allowed to occur randomly. These factors are shown in Table 3-1.

FACTORS	CONDITIONS
Systematically Varied	
System	Abrams w/APES, Abrams w/CITV
Tactical Mode	Offense, Defense, Movement to Contact
Tactically Varied	
Targets	T72, BMP, Troops
NBC	Scenario Driven
Obscurants	Clear, Smoke
Light	Day, Night
Held Constant	
System modifications	As defined initially
Terrain	Fort Knox
Crews	Same for all trials
OPFOR	Elements of MRR
Uncontrolled	
Learning during trials	As occurs

Table 3-1: Factors and Conditions

3.5 DATA REQUIREMENTS.

This section describes the types of data, basic data collection techniques, data tolerances, and specific data requirements for the investigation. Each of these areas are described in the following subsections.

3.5.1 TYPES OF DATA AND COLLECTION METHODS.

The required data are of two types: 1) Objective data referred to as quantitative data (i.e., may be assigned a specific numerical measure), and 2) Subjective data referred to as qualitative (i.e., opinions, reasons, consensus, and observations).

In measuring system performance, the highly sophisticated instrumentation of the CCTB Automatic Data Collection System (data logger, video cameras, and the audio recorder) will be used to collect much of the needed data. A combination of manual data collection, judgmental observations, and electronic recording instrumentation will be used to collect the remaining data.

3.5.2 TOLERANCES.

Unless noted elsewhere, the precision of the quantitative data collected should be as listed below:

a. Timed data: + or - 1 second (manual),
+ or - .1 second (CCTB).

b. Count data: + or - 1 event.

c. Range data: To nearest meter.

3.5.3. DENDRITIC STRUCTURE FOR REQUIRED DATA.

Since a given point may support or affect more than one objective, a root-like construction (i.e., dendritic structure) is applied. Tables 3-2 and 3-3 list data requirements in a format designed to facilitate information collection and processing during test execution. Table 3-2 lists the reduced quantitative data requirements by objective, while Table 3-3 lists the reduced qualitative data requirements by objective. Sequential numbering of each data point facilitates the chronological collection of data (subjective and objective). Unless otherwise stated, all measures are consistent with those described in BBN's CCTB Automated Data Collection Guidance document.

OBJECTIVE	REDUCED DATA REQUIREMENTS
*1.0 Fightability	1.1 Number of instances where effective command and control could not be maintained within the platoon
	1.2 Number of instances where effective command and control could not be maintained within the tank crew
	1.3 Number of times a TC/gunner selects a switch incorrectly
	1.4 Number of times the TC has to reissue/revise fire commands
	1.5 Percent of rounds fired by tank
	1.6 Number of times TAS target selection overridden by TC
	1.7 Percent of time in Scan/Auto mode
	1.8 Number of instances in which TC chooses not to use APES
	1.9 Total losses/survivors
	1.10 Total shots/hits/kills
	1.11 Average time to engage
	1.12 Average shot/hit/kill range
	1.13 Average range of hit against
	1.14 Average loss range
	1.15 Number of engagements
	1.16 Loss and survivor ratios
	1.17 Hit and kill rates
	1.18 Rounds per kill
	1.19 Specific exchange ratio
	1.20 Force exchange ratio
	1.21 Surviving force ratio differential
	1.22 Range distributions of shots, hits, and kills
	1.23 Kills over time
	1.24 Cumulative kills over time
	1.25 Losses over time
	1.26 Cumulative losses over time
	1.27 Strength over time
	1.28 Detect to loss of detect time
	1.29 ID to loss of detect time
	1.30 Detection to ID time

* The following numbering denotes dendritic numbering as distinguished from paragraph numbering.

Table 3-2: Quantitative Data Requirements

OBJECTIVE		REDUCED DATA REQUIREMENTS	
		1.31	Detection to engagement time
		1.32	ID to engagement time
		1.33	Percent of targets engaged
		1.34	Number of ID targets engaged
		1.35	Number of detected non-targets engaged
		1.36	Percent of times APES target priorities used
2.0	Workload	2.1	Average time to acquire targets
		2.2	Average time to engage targets
		2.3	Average intercom time
		2.4	Frequency of intercom use
		2.5	Blood pressure of TC over time
		2.6	Blood pressure of gunner over time
		2.7	Heart rate of TC over time
		2.8	Heart rate of gunner over time
		2.9	Error rate of target engamement procedures
3.0	Survivability	3.1	Average time to recognition by threat
		3.2	Average survival time in battle
4.0	Training	4.1	Time to train in CCTB by position
		4.2	Time to retrain to Abrams with CITV
		4.3	Time to retrain to Abrams with APES
		4.4	Average time to engage over time
5.0	Acceptance	5.1	Individual APES operations frequencies by operation and crew member

Table 3-2: Quantitative Data Requirements (continued)

OBJECTIVE	REDUCED DATA REQUIREMENTS
1.0 Fightability	1.1 Crewmember observations/ comments on command, control, and communications functions
	1.2 Data collector observations/ comments on command, control, and communications functions
	1.3 Tank commander comments on target acquisition
	1.4 Gunner comments on target acquisition
	1.5 Tank commander comments on target engagement effectiveness
	1.6 Gunner comments on target engagement effectiveness
	1.7 Identify changes in tactics with APES
	1.8 Identify changes in procedures with APES
	1.9 Comments by crew on combat effectiveness and efficiency
	1.10 Comments by observers on changes
2.0 Workload	2.1 Crew comments on overall workload
	2.2 Data collector comments on overall workload
	2.3 Crew observations on target acquisition times
	2.4 Crew observations on target engagement times
	2.5 Crew observations on ease of use of APES
	2.6 Crew observations on placement of displays and controls

* The following numbering denotes dendritic numbering as distinguished from paragraph numbering.

Table 3-3: Qualitative Data Requirements

OBJECTIVE		REDUCED DATA REQUIREMENTS	
3.0	Survivability	3.1	Crew observations/insights on survivability
		3.2	Data collectors opinions on survivability
4.0	Training	4.1	Comments of trainers on training program
		4.2	Comments of crew on training
		4.3	Comments of observers on training
		4.4	Identification of training conducted
		4.5	Recommendations for needed additional training
5.0	Acceptance	5.1	Comments of crew on utility of APES
		5.2	Commnets of crew on interface features difficult to use or understand
		5.3	Comments of crew on desireable interface features

Table 3-3: Qualitative Data Requirements

3.6 RESOURCE REQUIREMENTS.

This section presents an overview of the resources required for conducting the test for the investigation. It includes facilities and equipment requirements, personnel requirements, and general support requirements.

3.6.1 FACILITIES AND EQUIPMENT.

For this section it is assumed that a company-size experiment will be run. The following paragraphs project the equipment and facility needs based on this assumption.

a. Manned Simulators. Seven manned tank simulators are required. One full four tank platoon, the company commander's tank, and the two adjacent platoon leader's tanks. (Tanks within these two platoons will be maneuvered and simulated by the Blue Semi-Automated Force Coordinator.)

b. Semi-Automated Forces.

Opposing forces (OPFOR) will be maneuvered and simulated by the Semi-Automated OPFOR Staff. A separate room is required to separate this staff from the Blue staff. Two situation display screens are required to maneuver the OPFOR and provide fire support for the OPFOR.

Only one platoon will be fully manned in the Blue company. The two adjacent platoon leaders' tanks will be manned, but tanks within those platoons will be unmanned and controlled by the Blue Semi-Automated Force Coordinator. This coordinator will respond to radio messages and will maneuver and fight the six semi-automated tanks in accordance with instructions from the platoon leaders. The Blue Semi-Automated Force Coordinator requires a display screen and two radios to respond to his two platoon leaders.

c. Battalion Operational Staff Workstation. Two situation display screens and two radios are required for the S3 and S2 working together. This workstation and the Combat Support and Combat Service Support Workstations (below) can be located in one room.

d. Battalion Combat Support Workstation. A display screen and radio are required to respond to fire support requests. An additional radio may be required if Engineer support is provided to the company commander.

e. Battalion Combat Service Support Workstation. One display screen and radio are necessary for the S4/S1 to respond to logistics reports and requests.

f. Data Reduction and Analysis Systems. A "plan view" display is necessary to depict and replay, if required, the maneuver of both forces. This display, along with necessary analytical systems and word processors, require a separate room or partitioned room.

g. Administrative Office Space and Equipment. A separate office with telephone is desired for the Test Director. No additional space or equipment are required.

3.6.2 PERSONNEL.

The personnel requirements consist of the people needed to participate in and run the test for the investigation. Tank crews and command and control staff will be needed to participate in the investigation. CCTB operators and maintainers and data collectors will be needed to run the investigation. Table 3-4 summarizes the personnel requirements.

3.6.3 GENERAL.

There are no requirements for housing and welfare other than those currently existing at Fort Knox. If testing or support personnel are brought in from agencies/units outside of Fort Knox, then appropriate housing and welfare facilities would have to be provided. Otherwise, no other support will be required.

3.7 SCHEDULE

Figure 3-1 provides the preliminary schedule for the evaluation. It includes the development of the experiment, data collection methods, and training, as well as the pilot tests, and actual evaluation.

CATEGORY	FUNCTION	QUANTITY
TEST	Tank Crews:	
	Platoon Leader	1 four-man crew
	Platoon Sergeant	1 four-man crew
	Tanks 3 and 4	2 four-man crews
	Company Commander	1 four-man crew
	Platoon Leaders	2 four-man crews
TEST SUPPORT	Command Staff	
	Director/BN Cdr	1 person
	S-3	1 person
	S-2	1 person
	Blue Force Coordinator	1 person
	Combat Support	
	Artillery	1 person*
	Engineer	1 person*
	Combat Service Spt	
	S-4	1 person
	Opposing Forces	2 people
ADMINISTRATIVE	CCTB	
	Coordinator	1 person
	Maintenance	As required
	Data Collectors/ Observors	
	Simulators	7 people
	S-3 Recorder	1 person
	S-2 Recorder	1 person
	S-4/Artillery/ Engr Recorder	1 person

* One person performs both of these functions.

Table 3-4: Personnel

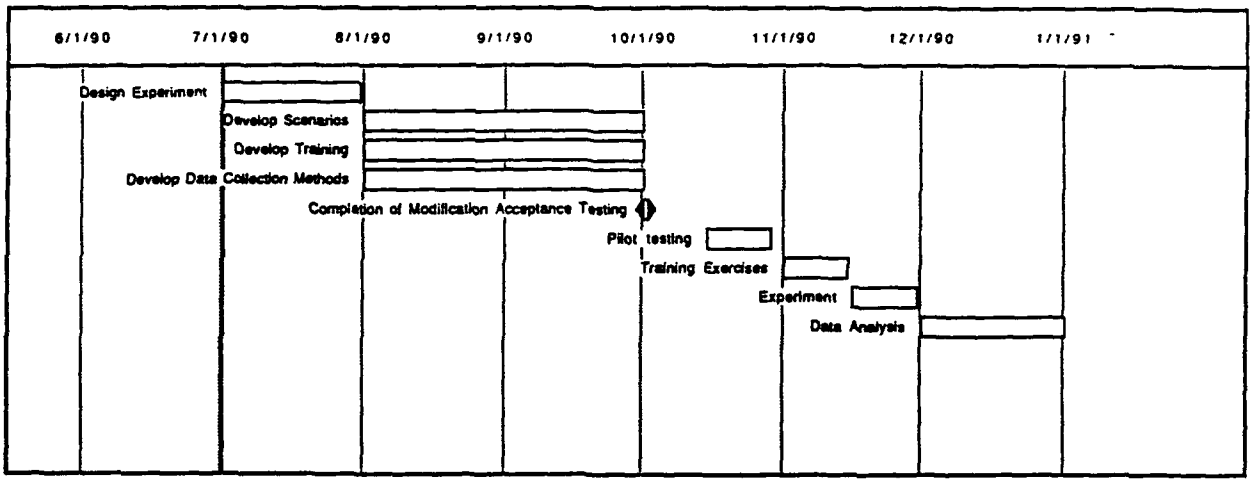


Figure 3-1: Evaluation Schedule