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Reconfigurable Simulator Specifications for Future Main Battle Tanks Within the Close Combat Test Bed

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Fort Knox Field Unit
Training Systems Research Division

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

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This research product provides functional specifications for reconfigurable simulators to support research on future main battle tanks in the Close Combat Test Bed (CCTB). A key factor in maximizing the use of networked simulation for research is the flexibility or reconfigurability of the vehicle simulator. Efforts to enhance human performance or to assess alternative embedded training systems, for example, must begin with descriptions of the proposed simulation functionality. The configurations presented are three crew members, side-by-side in the tank hull; two crew members, side-by-side in the tank hull; and two crew members, segregated from one another in the tank hull. These specifications provide examples of the level of systems functionality and design guidelines necessary for the simulator programmers/developers to build a product to support human performance and training research in the CCTB environment.

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Reconfigurable Simulator Specifications for Future Main Battle Tanks Within the Close Combat Test Bed

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FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research in human performance and training. The ARI Field Unit at Fort Knox has been in the forefront of research using networked simulation or soldier-in-the-loop simulation for future ground combat vehicles. A key factor in maximizing the use of such simulation for research is the flexibility or reconfigurability of the vehicle simulator. Efforts to enhance human performance or to assess alternative embedded training systems, for example, must begin with descriptions of the proposed simulation functionality.

This research product provides an example of such a simulation functional description. It was prepared under the Science and Technology task, "Training Requirements for the Future Integrated Battlefield" with funding from the Combat Vehicle Command and Control (CVCC) program sponsored by the Tank Automotive Command (TACOM). ARI's involvement in research on future battlefield conditions is supported by two Memoranda of Understanding. One is between ARI and the United States Army Armor Center and School on Research in Future Battlefield Conditions signed on 12 April 1989. The second is between ARI and the Tank Automotive Command on the Combat Vehicle Command and Control System signed 22 March 1989.

This product presents the specifications of the three different reconfigurable configurations within the Close Combat Test Bed (CCTB) for a future main battle tank. Requirements for systems performance, hardware, and functionality design are presented in detail to allow for the development of the three designs within the CCTB. The results of this effort have been briefed to the Director, Combat Developments, U.S. Army Armor School (USAARMS) and the Chief, Vetronics Laboratory, Tank Automotive Command.

EDGAR M. JOHNSON
Acting Director

RECONFIGURABLE SIMULATOR SPECIFICATIONS FOR FUTURE MAIN BATTLE TANKS WITHIN THE CLOSE COMBAT TEST BED

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RECONFIGURABLE SIMULATOR SPECIFICATIONS FOR FUTURE MAIN BATTLE TANKS WITHIN THE CLOSE COMBAT TEST BED

INTRODUCTION

Purpose

The purpose of this document is to provide detailed specifications for building different configurations in a reconfigurable simulator. The specifications for three configurations are presented herein. These include 3-man, 2-man side-by-side and 2-man segregated designs. These three designs are based on current Close Combat Test Bed (CCTB) simulator hardware and software capabilities, including Combat Vehicle Command and Control (CVCC) system, SINCGARS radio, autoloader and M1 simulator capabilities (see SIMNET M1 Crew Manual, 1988; Chung, Dickens, O'Toole and Chiang, 1988; and Garvey, Radgowski and Heiden, 1988). Several design concepts for 2-man and 3-man configurations are similar to those presented by Steeb et al. (1991). It is intended that these specifications provide a comprehensive understanding of what is required to develop the reconfigurable designs.

The document is divided into five main sections. The first section is the introduction, which provides the overview, background, objectives and scope of the reconfigurable specifications. Section 2, 3 and 4 provide an introduction and specifications for each of the three reconfigurable designs. The fifth and final section provides a summary of the document and a statement of conclusions.

The remainder of this section provides a background discussion of the issues surrounding the reconfigurable simulator design for an armored vehicle with reduced crew size. Specific goals and objectives for designing a reconfigurable simulator are presented. The scope of the design and the reconfigurable simulator subsystems are discussed, along with several assumptions. The section concludes with a discussion of research issues associated with a reconfigurable simulator.

Background

Simulators have long been a relatively inexpensive means of training personnel and testing critical operational issues. One challenge is to develop a simulator that can permit the training and testing of a variety of operational issues. To meet this challenge, a simulator should meet strict fidelity standards but also be easily modified. This concept of modifiable yet high-fidelity simulators is the goal for the reconfigurable simulator. The proposed designs are integrated such that one configuration is a part of the other configurations. For example, the 3-man design includes two crew positions, with necessary hardware, that also make up the 2-man side-by-side and 2-man segregated configurations. These designs also have integrated operating protocols that permit each configuration to operate independently. For example, in the 3-man configuration, over-ride protocols are in place that are the same or easily altered for the two, 2-man designs. We have taken this approach to reduce the costs associated with proposing radically different designs and to ease the transition from one configuration to another.

Numerous efforts have addressed issues and challenges of design, development and application of reconfigurable simulators (see Becker and Curtis, 1989; Hollingsworth and Mikula, 1988; and, Maher, 1988). Much of this work has been instigated by the heavy demand of simulator time for research and training purposes. In an effort to provide lower cost simulators while maintaining a high degree of fidelity, researchers have attempted to optimize simulator design and reconfigurability. Greater reconfigurability is desirable because of the inherent variety of operations that can be simulated for research and/or training. To achieve these higher levels of fidelity and reconfigurability, several technological approaches have been studied.

Advanced "glass" cockpit technology allows rapid reconfiguration of a simulator. Switches and controls can be imbedded into the "glass" or computer display portion of the simulator. Reconfiguring a glass cockpit design is accomplished through software modifications, rather than expensive, cumbersome hardware changes. In a reconfigurable glass cockpit environment, touch screen technology turns a standard display screen into a multi-function display and control device. Other advanced computer interface technologies permit information display as well as control. Control devices such as a mouse, control tablet, light pen, etc, enable operators to interface with controls that are placed on the screen instead of hard-wired controls.

In a reconfigurable simulator, researchers can configure a variety of control functions with interface elements such as switches, gauges, status indicators, menus, digital readouts, maps, and communication support elements (Hollingsworth and Mikula, 1988). By placing interface elements on CRT screens, researchers can configure and reconfigure a simulator for their research needs.

Several control devices are simply not good candidates for "on screen" interface. For example, vehicle control (i.e. steering, acceleration, braking) would not be practical with on screen control. Additionally, it is poor design to require a single operator to interface with several control devices of the same physical modality (Wickens, 1984). An operator should not be required to control the vehicle with controls and displays on one CRT while controlling a map display on another screen. Clearly, not all controls can be placed on the available screens for the above reasons, in addition to the practical concerns of maintaining enough display space.

For training purposes, a simulator should reflect the operational environment. In this case it is the dynamic battlefield with its variety of constantly changing factors. In the research environment the opposite is true, because the researcher seeks to hold certain factors constant. However, the researcher wants the opportunity to make changes to the "environment" to test a variety of issues. A research simulator should be reconfigurable such that the researcher can manipulate the variables of interest. A reconfigurable simulator should permit a relatively rapid modification of variables for purposes of experimental control.

Another issue impacting the design of the reconfigurable simulator is cost, specifically with respect to the current CCTB simulator. While it is possible to approach the reconfigurable design problem from a clean slate, replacing all displays and controls, the proposed design does not. In an effort to keep costs low, hardware systems have bee "recycled" from the current CCTB simulators to the reconfigurable simulators. Although the proposed design does require some new hardware and a significant amount of new software, systems that can be recycled from the CCTB simulator have been incorporated into the new designs.

The method used to develop these specifications comes from the Concept Analysis for Simulation Modification methodology developed for the Army Research Institute's Fort Knox Field Unit by Micro Analysis & Design, Inc. This methodology along with design guidance, assumptions made, knowledge and review of the Close Combat Test Bed, and literature reviews of documents relating to advanced simulator design, control and display design, and future main battle tank efforts lead us to the simulator configurations presented here.

In summary, reconfigurable simulators are flexible tools that permit research into a variety of issues. The proposed designs, for example, will allow several critical human performance issues to be investigated. The primary differences between the three proposed designs are crew size and crew configuration. The investigation of reduced crew size and human performance issues is critical for future generations of armored vehicles. The goals for research within the reconfigurable framework are outlined in the investigation objectives sub-section of this introduction section.

Objectives for Developing a Reconfigurable Simulator Design

Given the discussion above, the following goal and objectives for the specification of a reconfigurable simulator design have been defined:

Goal: To develop a platform for the conduct of research in order to improve or maintain the operational performance and military utility levels of a future main battle tank (MBT) by investigating performance (operator and system) characteristics of multiple vehicle configurations including reduced crew size configurations.

Specification Objectives:

* Provide designers with specified design of simulator.

* Detail advanced design ideas for armored vehicle simulators.

These goals and objectives provide a focus for this document. All design aspects including fidelity requirements, technology applications and the ease of reconfigurability have been influenced by these ideas.

Scope of the Specifications

The current CCTB configuration provides a solid foundation for the development of these specifications. The CCTB configuration is referenced to describe some displays, controls, instruments and systems in the reconfigurable. Functional capabilities of most systems and displays are changed only slightly. For example, in the 3-man configuration, driver station functions do not change even though displays, controls and instrument layout change significantly. Alternatively, changes in the tank commander (TC) and tank systems operator (TSO) stations (previously tank commander and gunner stations) change both physically and functionally. However, the actual configuration of the tank (e.g. engine location, turret characteristics, ammunition storage, etc...) does not impact design and functionality of any crew station.

Although the designs presented in this specification represent specific configurations, these are not the only designs possible. These designs were chosen because they allow for rapid reconfigurability within the simulator and because of specific design guidance. As stated, one of the goals of the reconfigurable simulator is to permit research on multiple vehicle configurations. Steeb et al. (1991) described several 2-man and 3-man MBT designs. The reconfigurable simulator as specified could be used to research each of these proposed designs. By separating crew members, placing crew compartments together, or by removing the driver position, the variety of configurations to study increases. The presented designs themselves also have the capability for being changed or reconfigured into alternative designs. Displays and controls can be altered by changing software drivers and hardware location to increase the variety of possible configurations.

Issues

The following list is a set of design issues and guidelines that was used to develop the specifics of the different configurations. These issues are presented below and are intended to help define each configuration and illustrate the differences and similarities among them.

* Command and control and target acquisition issues are the fundamental issues driving the design of the three reconfigurable simulators.

* All driving functions can be performed from any crew position in the three configurations.

* A new crew member called the TSO performs the duties of the current gunner and/or driver in these proposed designs.

* The TC and TSO have interchangeable functional capabilities.

* The TC and TSO stations are virtually the same physical layout in all three designs (i.e. all functions can be performed from either TC or TSO station except autoloader override and radio control in the 2-man segregated design).

* Forty (40) rounds of ammunition can be stored and fired from each of the three reconfigurable designs.

* All caution and warning signs are displayed as presently configured in the current CCTB simulator.

* Software and hardware from the current simulator will be used as much as possible.

* Reconfigurable designs should be easily reconfigured from one to another. This includes both hardware and software.

Assumptions

Several assumptions have also been made with respect t the three reconfigurable designs. Two lists are presented that detail the assumptions used in this document. The first list presents the overall assumptions that were used in developing the specifications. The second list provides specific subsystems characteristics within the three configurations.

* All systems such as the Commander's Independent Thermal Viewer (CITV), Commander's Control Display (CCD), Gunner's Thermal Sight (GTS), Gunner's Primary Sight

(GPS), main gun, etc., perform as they currently perform in the M1 tank simulator with the exception of one new system and one new control device: the autoloader and the control tablet, respectively. See Appendix A for autoloader specifications and Appendix B for control tablet specifications.

* It is assumed that all hardware, software, and power requirements can be met.

The following list provides specific assumptions for the subsystems of the reconfigurable designs.

Subsystems	Description
Engine Location	A rear engine design is assumed for all three configurations.
Silhouette	The silhouette of all three vehicles does not change from the current simulator. This means that the vehicle is just as easy/difficult to spot by enemy vehicles.
Main Gun	The main gun is remote, located within an unmanned, rotating turret. In the 2-man segregated design, the autoloader separates the two crew members.
Vehicle Dimensions	Related to silhouette, the simulated vehicle size is the same as currently configured in the CCTB. For each crew member, the vision block viewing angle is located at the current CCTB hull position (i.e. current driver position) level.
Weapon Systems	Main gun performance does not change from current CCTB performance. The CDR's weapon station is not included in the three proposed configurations because there is no functional system in the current configuration. The CO-AX machine is not addressed as this capability is not in the current configuration.
Turret Performance	There are no changes in turret performance for the three reconfigurable designs.
Command, Control Communications Systems	Other than the integration of all C3 systems, there are no changes from the present system performance.
Fire Control Systems	Fire control systems or their performance do not change in the three reconfigurable designs.
Target Acquisition	Target acquisition systems do not change beyond the crew position integration of multiple systems within the three proposed designs.

Several documents (Chung, Dickens, O'Toole and Chiang, 1988; Heiden, 1989; Heiden, 1991; Smith, 1990; and TM 11-5820-890-10-1) provide current performance characteristics for the above systems.

Displays and Controls

All three reconfigurable designs have displays and controls in common for the TC and TSO. The specific interface protocols and override issues may differ, but all three configurations have five basic systems. These systems, which include the Commander's Control Display (CCD), Commander's Independent Thermal Viewer (CITV), Gunner's Primary Sight (GPS), Gunner's Thermal Sight (GTS), and Driver's Information Display/Commander's Control Display (DID/CCD), can be displayed on the four main display screens. These display screens include two touch sensitive screens and two non-touch sensitive screens. Only the two non-touch screens can display all five systems while the touch screens can display the CCD, GPS, GTS and DID/CCD. The CITV can not be displayed on the touch screens, because the CITV control switches are associated with the non-touch screens only. Although the touch screens can display any system other than the CITV, the touch screen capable screens are only interactive with the CCD system. A general overview of the three designs is illustrated in Figures 1, 2, and 3.

In a typical mission simulation, crew members will be using several displays for information gathering and systems control. Several displays are for information purposes only and are hard mounted in the simulator (e.g. maintenance monitor panel, engine control panel). This is to insure easy, reliable access to critical information without having crew members step through imbedded menu displays. Several information displays are presented on screen as well, and crew members can interface with most of these displays. The DID/CCD system is the only system that is designed exclusively to provide information and can not be used to control. These commonalities should be considered when reading the details of the specifications that follow.

All TC and TSO stations have a new control device called an 'Unmouse', by MicroTouch. The Unmouse, which is called the control tablet in the reconfigurable simulator, is a touch tablet whose surface points correspond to points on the selected screen. The control tablet is a moveable control device. Crew members should be able to remove the control tablet from the armrest position and attach it to their lap or other convenient position. Velcro straps are recommended to secure the control tablet to the armrest or thigh. Specifications for the control tablet are in Appendix B.

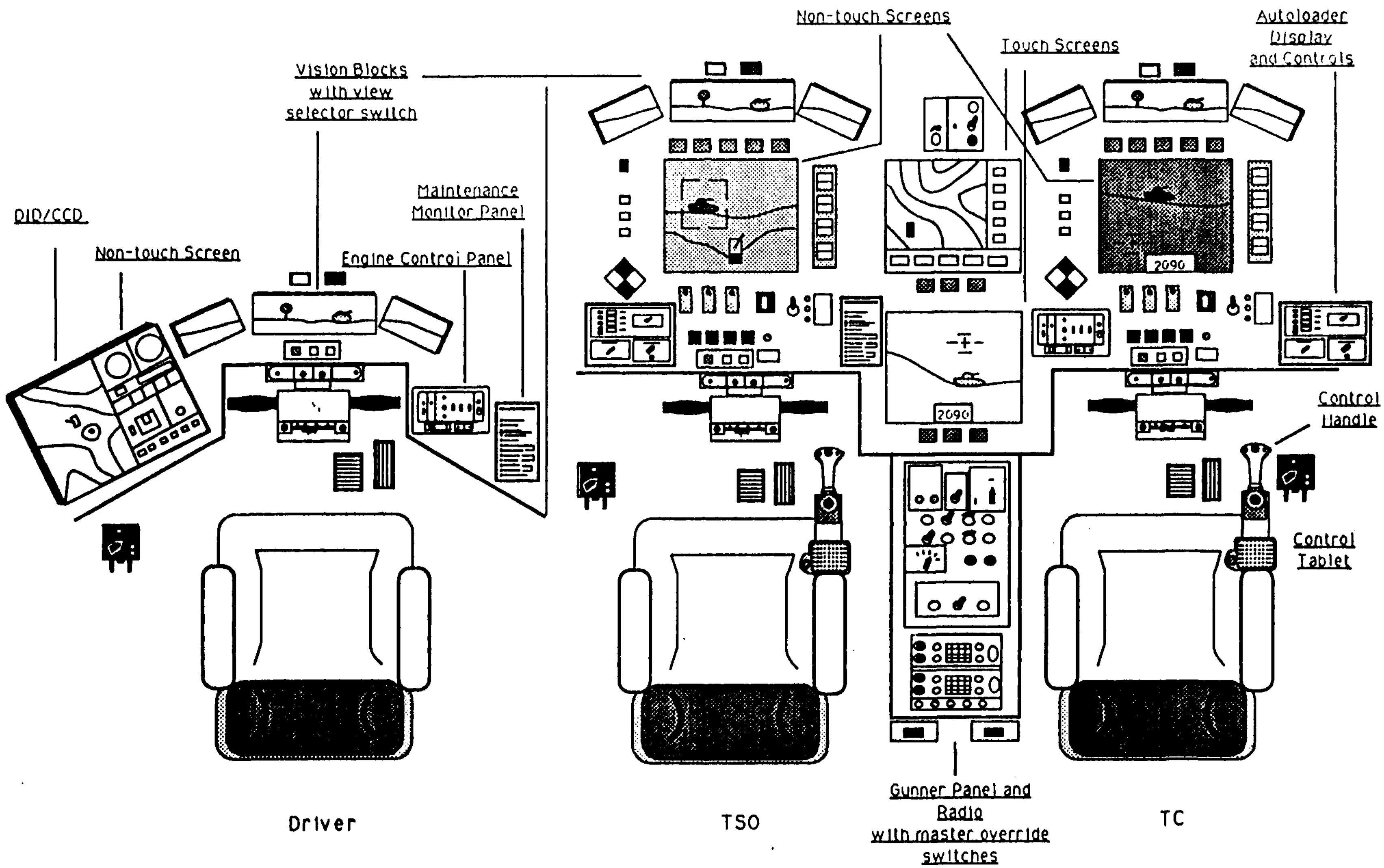

Figure 1. 3-Man configuration with driver, TSO and TC crew stations

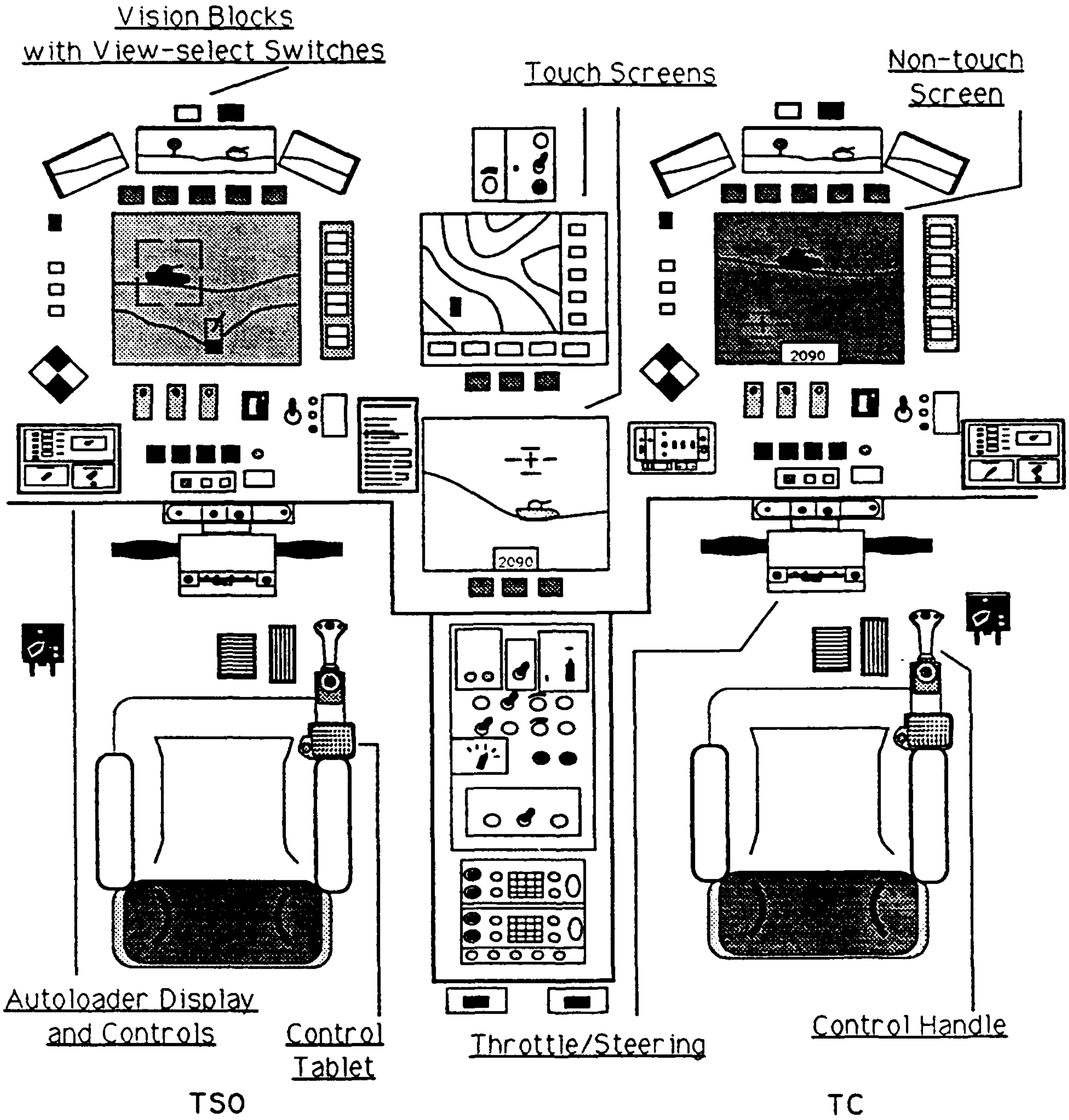

Figure 2. 2-Man side-by-side configuration with TSO and TC crew stations

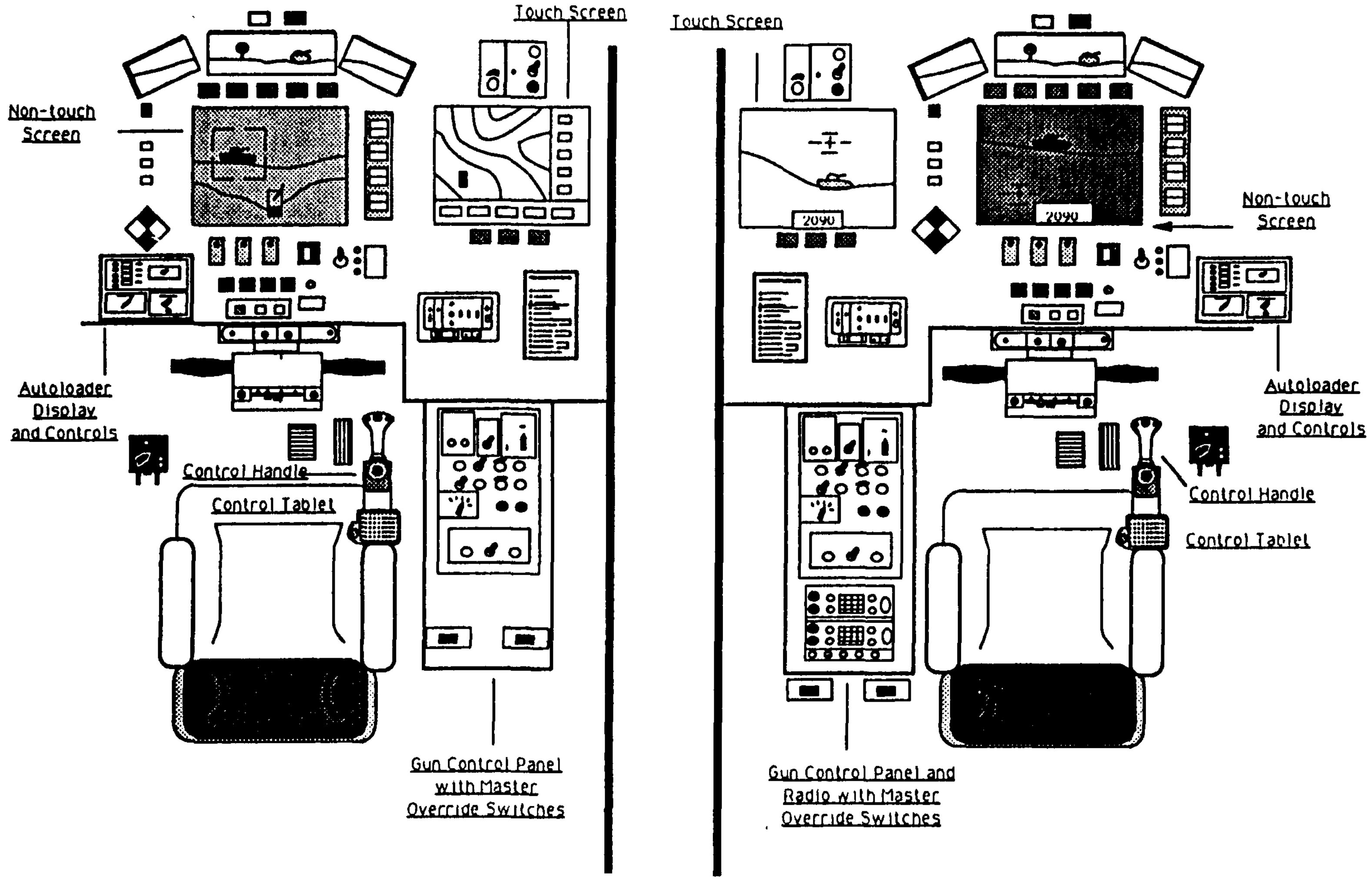

Figure 3. 2-Man segregated configuration with separated TSO and TC crew stations

Override Protocol

Because crew members share instruments, displays and controls in all three reconfigurable designs, a priority protocol must be developed to determine who has control over any given system. Responsibility of all vehicle functions and performance ultimately rests with the TC. Practically, however, the driver, TC and TSO can more effectively operate the vehicle if they properly allocate functional distribution.

In the 3-man reconfigurable simulator, an important override issue involves the driver functions. The driver maintains functional control of the vehicle in most if not all situations. However, the 3-man reconfigurable is designed to permit the TC or TSO to take over driver functions. This permits researchers to play a scenario in which the driver is knocked out of play while the TC and TSO must continue with the mission. The TC can accomplish this by switching driver function allocation with the driver control switch, located above the steering/throttle mechanism in each crew position (see Figure 4). The driver control switch can only be activated when the vehicle is at a complete stop. This switch gives each crew member control over which crew position's driving controls are functional. The responsibility to allocate driving duties exists with the TC; however, if the TC is knocked out of the fight, the switch exists in each position. This switch and the responsibility to allocate driving duties also exists in the TC crew position in the 2-man designs.

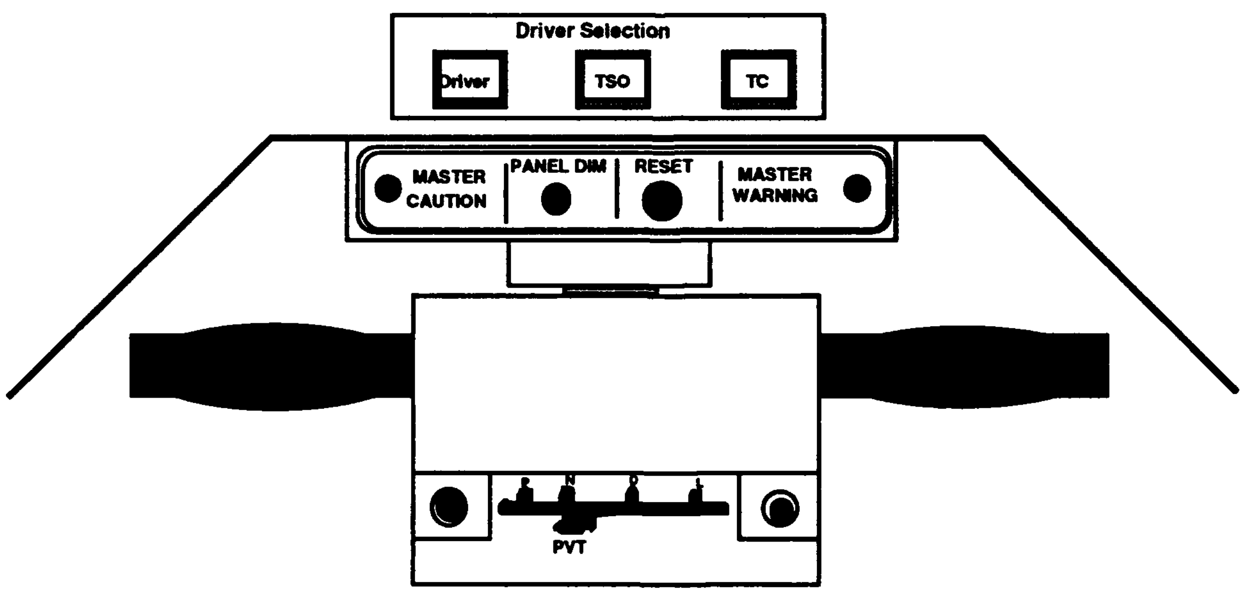

Figure 4. Throttle and steering mechanism with driver control switches.

All other protocol issues involve the TC and TSO positions. In general, any control mechanism that is located between the two crew members can be operated by either one at any time. This operating procedure requires close coordination between crew members. For example, both crew members should not be changing the radio at the same time, nor should one crew member change the radio frequency when in use by the other. Control mechanisms between the crew members include: radio panel, gun control panel, panel lights, fire control mode selection, and driver's engine controls (see Figures 1 and 2). Additionally, a master override control switch is in each of the TC and TSO stations (Figure 5). The master override control switch is a covered, rocker switch located at the end of the gun control panel seen in Figure 5. This switch resets the control of all systems to the TC if he depresses his switch, or the TSO if he depresses his switch. This reset device will essentially prevent the other crew member from controlling any system. The purpose of this switch is to permit either crew member to override control of all systems in the event the other crew member is impaired or knocked out of the fight. For additional details on override protocols, refer to the override sections within each reconfigurable specification.

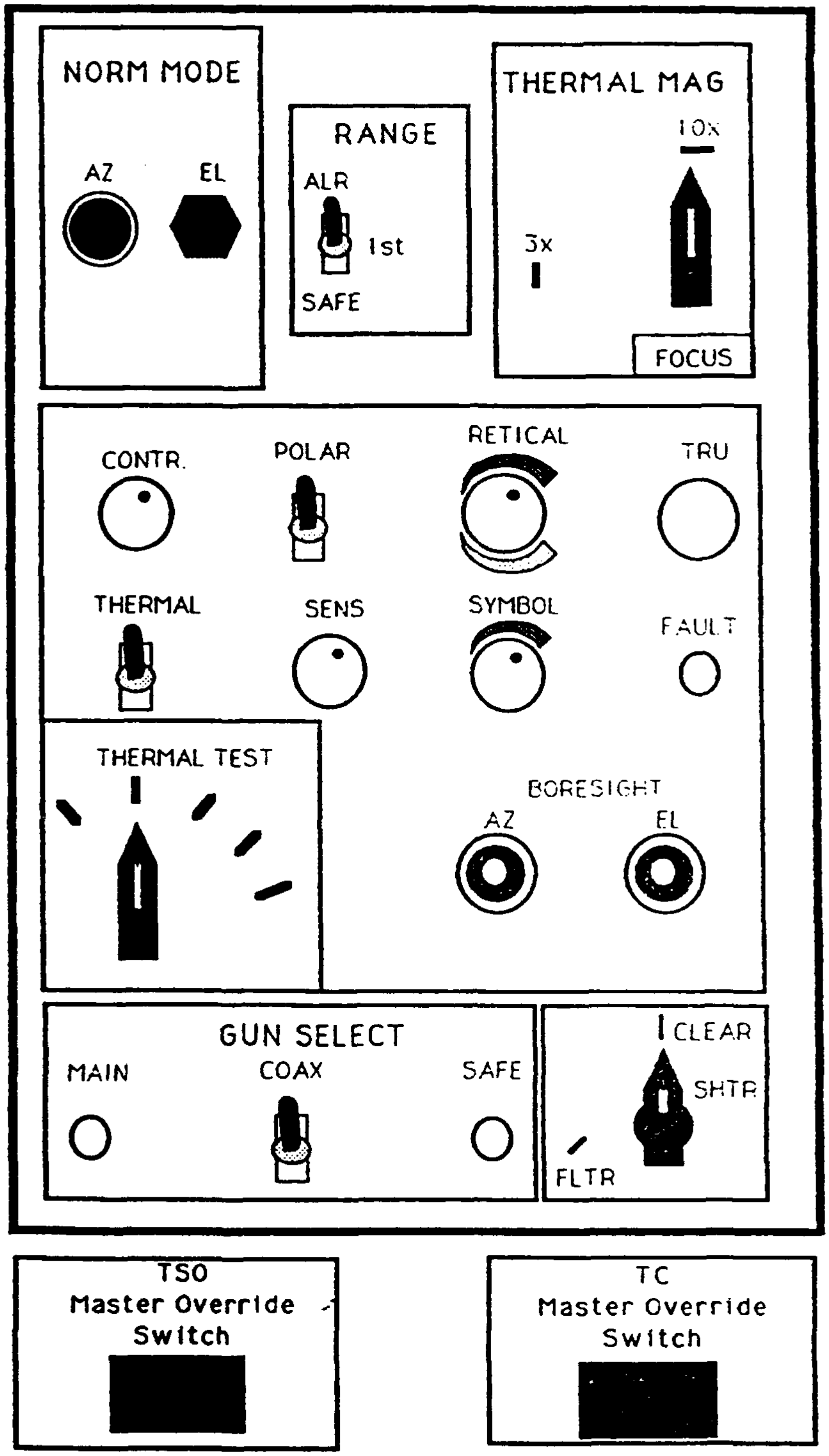

Figure 5. Gun control panel and override control switches

SPECIFICATIONS FOR A 3-MAN CONFIGURATION

Introduction

Purpose

The purpose of this section is to provide detailed specifications for the development of a reconfigurable simulator based on current M1A1/CVCC capabilities within the CCTB. The level of detail of these specifications should be such that the actual crew stations can be built. Previous specifications that detail the current system must be used as references for these specifications (see Chung et. al., 1988; Heiden, 1989; Heiden, 1991; Smith, 1990; and TM 11-5820-890-10-1).

Scope of Specifications

Specifications for reconfigurable development must permit credible training and research. This implies that a certain degree of fidelity is required. However, it is important to adhere to the original SIMNET-D philosophy of making only those modifications necessary to gather the information needed (see Garvey, Radgowski and Heiden, 1988). Therefore, most of the changes from the current CCTB are related to controls, displays, time delays, and sounds associated with each crew position.

Other changes include hardware and software changes. Advanced display and control technologies are implemented to permit easier interface with the weapon system. As presented above, these technologies include a new control tablet technology by MicroTouch called the 'Unmouse' and a modified interface for the shared touch screens displays. Additionally, the layout of displays, controls, and instruments are designed to permit proper interface for each crew member.

Functionally, very few changes are made. The dedicated driver station has no changes in functional requirements. The two other crew positions, TC and TSO, have some changes in functional requirements, including driving functions. Additionally, they share several displays, controls and instruments. This allows the two crew members to share functions as well.

Overview

This section is divided into three major sub-sections. The first sub-section provides an overview of the proposed reconfigurable design, giving the reader the "big picture" of the new configuration. The remaining sub-sections provide detailed specifications for the crew stations to include the dedicated driver station, and a description of the TC/TSO stations.

Overview of Proposed Configuration Design

As illustrated in Figure 1, the 3-man configuration has three side-by-side crew stations. The left-most station is the dedicated driver station with driver hardware, in which only driving functions can be performed. The two remaining stations are adjacent and connected. These crew members have instruments, controls and displays which give them the capability to perform all duties of the current TC, gunner and driver. This design assumes driving will be performed by the dedicated driver; however, driving functions can be performed by any crew member. The rational for this design is to provide a reconfigurable foundation for the two 2-man designs.

This design permits the rapid reconfiguration of the 3-man vehicle into a 2-man side-by-side shared instruments or 2-man segregated configurations. This idea has been the primary influence on our current design. Although some compromises have to be made in order to meet the goal of reconfigurability, this design permits performance of all current operational duties.

Major changes in this design primarily involve three issues: 1) addition of new system controls, 2) display of information and instruments on CRT screens, and 3) the reconfigurability of the simulator. Although these changes impact the look, feel and performance of the simulator, functionally there are few changes. Anything that can be performed in the current tank simulator can be performed in the reconfigurable simulator. With respect to the systems available in the current CCTB simulator, some functional capabilities have been enhanced for the reconfigurable design (e.g. dual control mechanisms for driving), however, there are no additional functions.

Specifications for the Dedicated Driver Station

The dedicated driver station (DDS) includes a new arrangement of displays and instruments (see Figure 6). A 6.5" x 5.5", (9" diagonal) non-touch sensitive screen displays a new system that provides the driver with vehicle information and information about the vehicle surrounding environment. Control devices such as steering column and throttle, transmission lever, brake pedal, parking break switch, and communications equipment do not require hardware or functional changes. A maintenance monitor panel and engine control panel are also placed in the reconfigurable design.

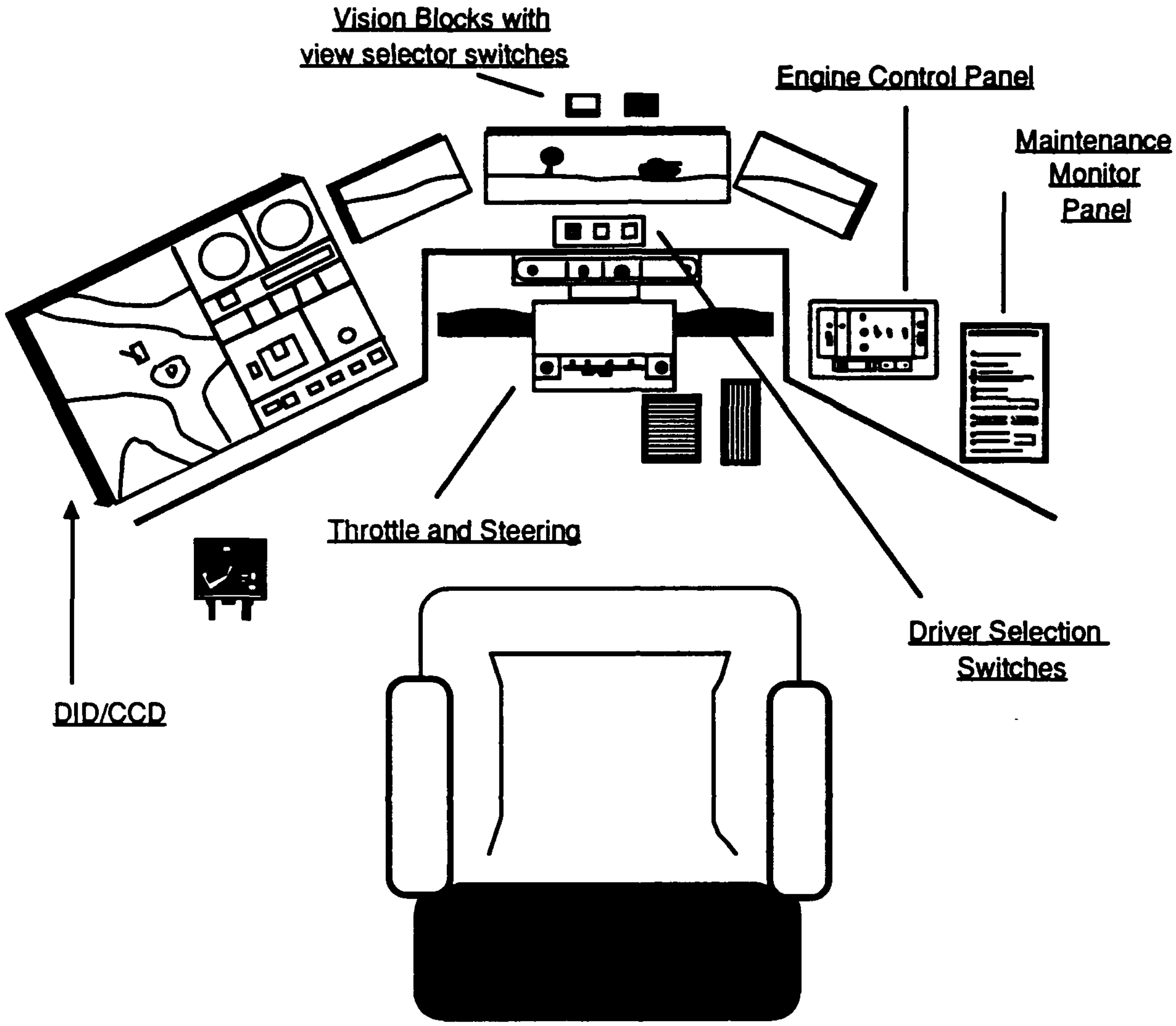

Figure 6. Dedicated driver's station in the 3-man configuration

The driver's compartment is equipped with the following hardware systems:

DID/CCD display
Driver's system controls
Maintenance Monitor panel
Driver's throttle and steering control handle
Transmission lever (located on steering column)
Driver's brake pedals
Driver's seat
Vision blocks
Communications control
Internal light

To perform his driving duties, the driver performs the following major functions:

Steer and control the vehicle (including speed, direction, transmission setting).
Monitor all driver's instruments.
Monitor the CCD for situation awareness while driving.

Hardware Description

The following sections provide general descriptions of displays and controls, and detailed descriptions of each hardware system.

Displays

The dedicated driver station has one display screen and three vision blocks. The driver has a 6.5" x 5.5" (9" diagonal), non-touch screen display. Figure 6 shows the relative location of the screen with respect to other driver station hardware. In the driver's compartment, only the DID/CCD (explained below) can be displayed on this screen. The driver uses this display for information on the surrounding situation because it is not an interactive interface. The display screen should have the same specifications as the non-touch screens in the current CCTB simulator. The display is hard mounted. Figure 7 illustrates the DID/CCD screen.

Controls

The driver has no control mechanism for interface with command and control systems and displays. Driver controls are for vehicle control and engine control only. The driver control devices are:

Driver's throttle and steering control handle.
Transmission lever (located on steering column).
Driver's brake pedals.
Driver's system controls.

These control devices perform functionally the same as the current CCTB.

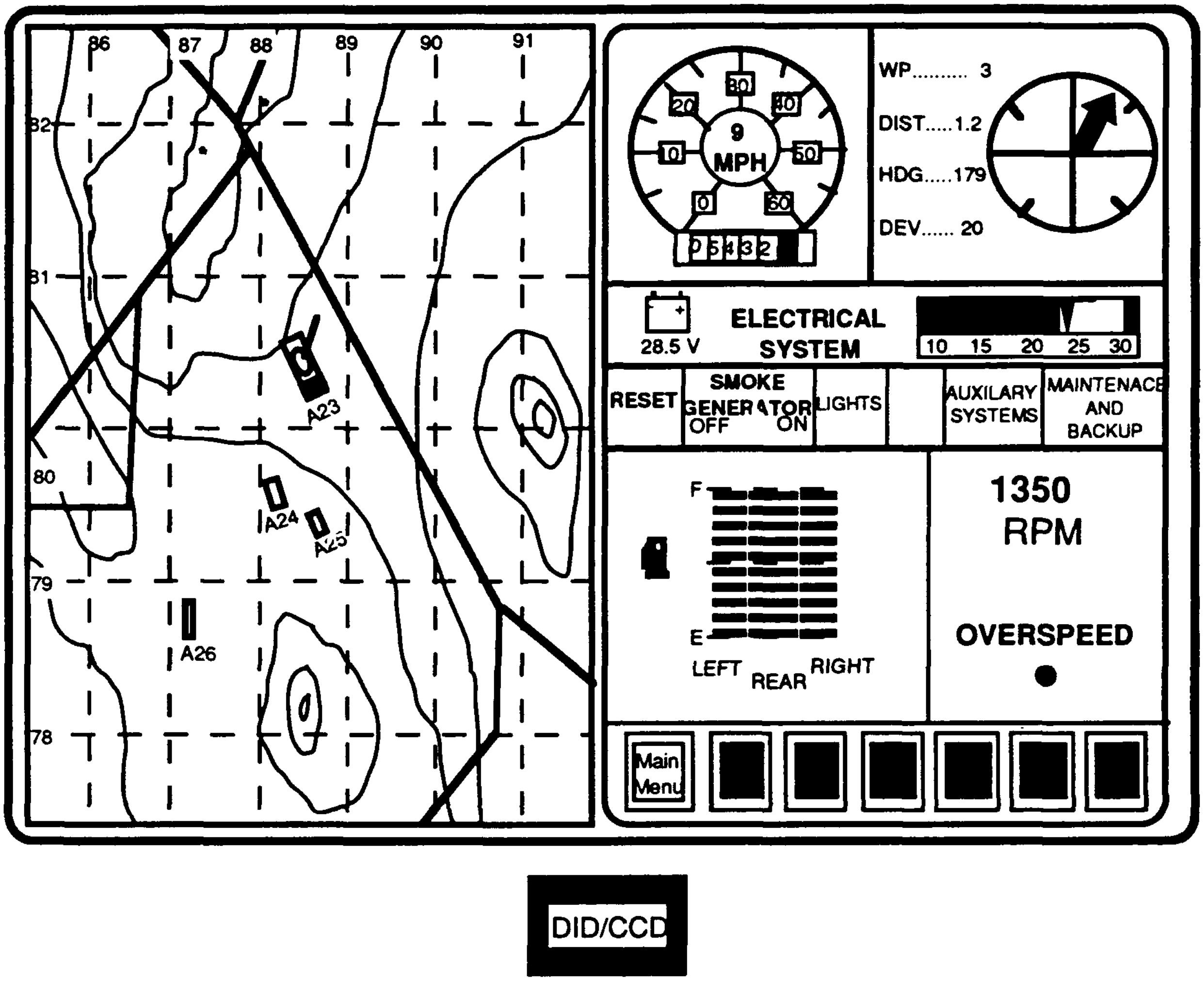

Figure 7. DID/CCD screen

Systems Description

The following systems are modified and discussed in terms of the purpose of the system, the hardware requirements and the functional requirements.

Driver Information Display/CCD Display

Purpose. The DID/CCD display is designed to provide the driver with necessary vehicle performance and systems status information to safely operate the vehicle (see Figure 7). Additionally, the CCD portion of this display is used by the driver to maintain heading, relative location and overall situation awareness.

Hardware requirements. Both the driver information portion and the CCD portion of this display can be on the non-touch screen display, the only display screen in the driver's compartment. Figure 7 shows how the CCD and information displays are positioned on one screen. The non-touch screen that can display the DID/CCD system is located on the driver's left side, just below eye level as illustrated in Figure 6.

Functional requirements. The DID/CCD display conveys information to the driver that is critical for system operations. The DID portion of this display includes a menu interface that permits access to several key sub-menus. Some of the systems that have been placed on this menu-driven display include the auxiliary systems, lights, and smoke generator. Several non-functional controls that are in the current CCTB are accessible, but non-functional on the DID/CCD menu. Because the driver has only this one display and it is non-interactive, a touch screen is not required.

The CCD portion shows current information from the actual CCD which is controlled by the other crew members. It always has the "own-vehicle" icon in the center of the screen, with no interaction capability. Any interface in the CCD display by either of the other two crew members changes the display for the driver. The driver uses this information only for vehicle status (i.e. direction, general situation).

The engine performance displayed on the DID receives the same inputs as the current configuration (i.e. speed, engine status, electrical system information, etc.). The DID portion of the DID/CCD display shows the following information:

Way-point indicator: The Way-point indicator display does not change from the current design except that it is located on the DID screen. Functionality is the same as currently configured in the CCTB.

Fuel level: The fuel level gauge shows the amount of fuel remaining in the three fuel tanks: the left, rear, and right. The fuel level is indicated with levels between empty and full.

Speedometer and odometer indicator: Vehicle speed and mileage are presented in this instrument. Speed is indicated digitally in the center of the speedometer. The speedometer itself indicates speed with an analog presentation of current speed. Mileage is presented at the bottom of the display in a five digit mileage reading with one extra digit for tenths of miles.

Tachometer/RPM numerical readout: RPMs are indicated digitally with an overspeed warning light in the display.

Battery power: A digital readout of battery power is presented along with an analogue readout of battery power. The digital display is presented below a battery icon. The analogue display has color coding to indicate safe and unsafe zones for battery power.

The non-functional, main menu items include:

Reset
Smoke generator (off or on).
Lights.
Auxiliary systems.
Maintenance and backup

Engine Control Panel

Purpose. This control panel permits the driver to start and shut-off the engine and maintain the status of critical engine and vehicle parameters. Additionally, warning lights are associated with this panel to indicate system problems.

Hardware requirements. A panel similar to the one in the current CCTB is required for this design. Figure 8 illustrates the controls, switches and warning lights on this panel.

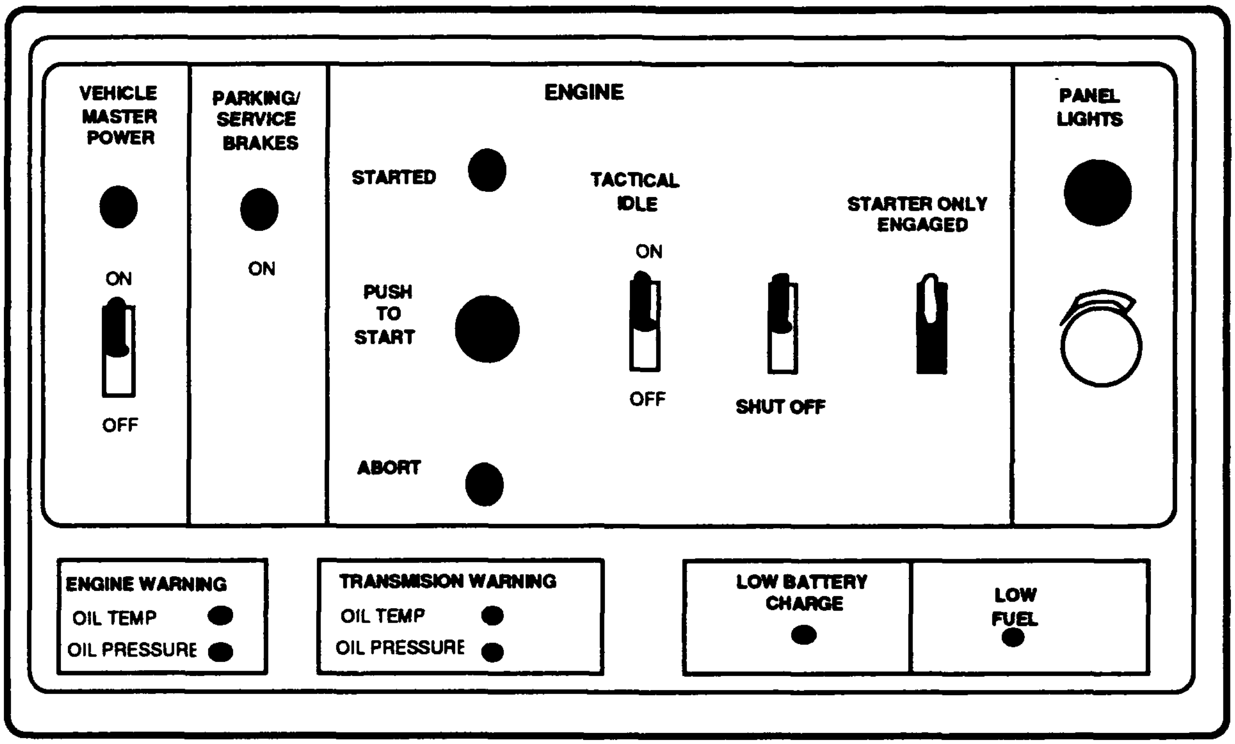

Figure 8. Engine control panel

Functional requirements. Primary controls include engine start/shut-off. Additional controls on this panel include the panel light dimmer switch and the parking break switch. All functional controls on this panel perform as they currently do in the M1 simulator. The warning lights receive inputs in the same manner as they currently do. Four warning displays are associated with this panel. These include engine warning, transmission warning, low fuel warning and low battery warning lights. Non-functional controls are also placed on this panel.

Maintenance Monitor Panel

Purpose. The maintenance monitor panel is a column of warning lights that indicate the status of several system functions (see Figure 9). The information from this panel allows the driver to quickly identify maintenance problems. Some systems are non-functional.

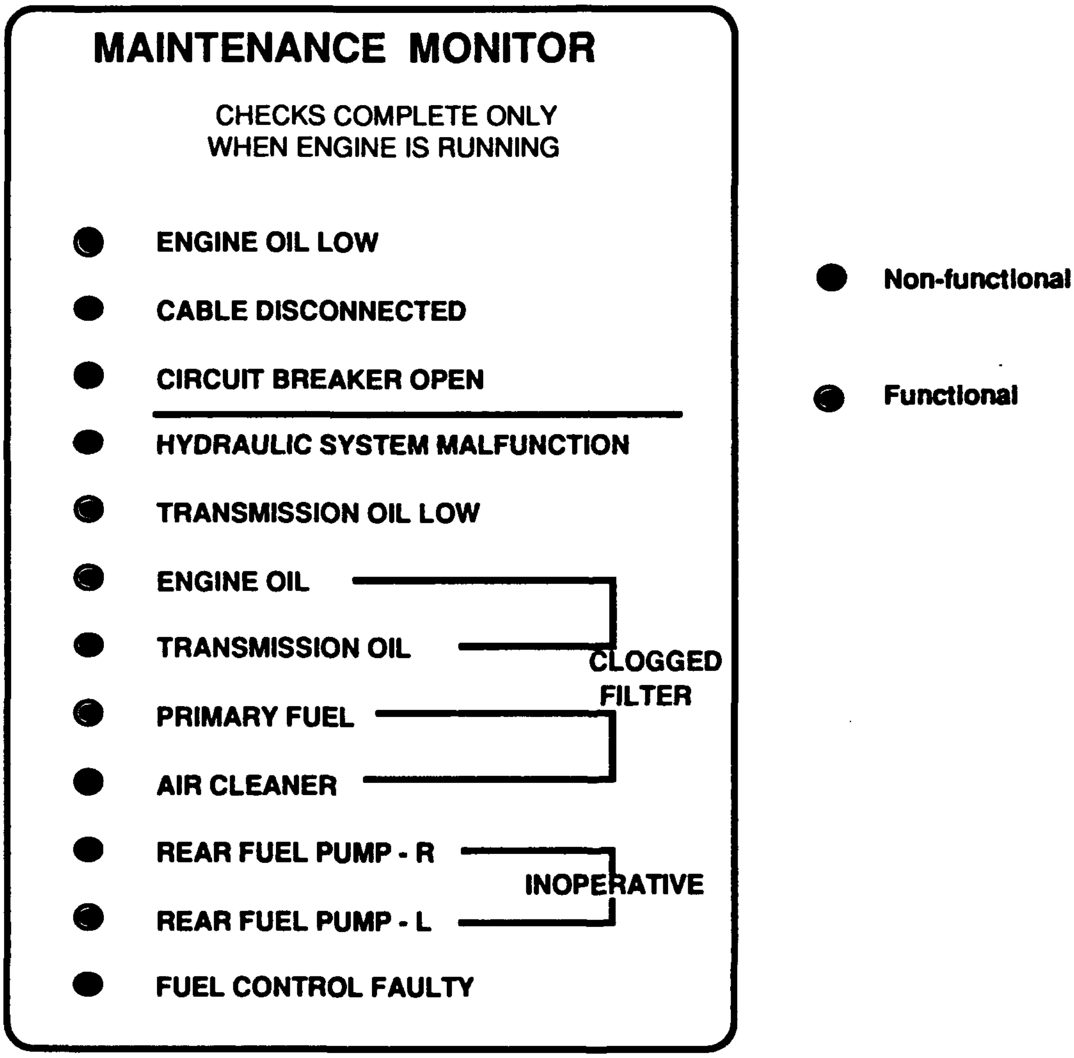

Figure 9. Maintenance monitor panel

Hardware requirements. The maintenance monitor panel has twelve (12) warning lights but only seven (7) are functional. The distinction between functional and non-functional warning lights is indicated in the legend on the right of Figure 9. The labeling of this panel should be similar to the example in Figure 9 which has capitalized, bold print that is readable. This panel is a hard panel display, because it conveys critical information that should not be buried in a system display where the information may not be readily available.

Functional requirements. The seven (7) functioning warning lights must accurately indicate the status of their respective systems. These warning lights receive their inputs in the same manner as they currently do in the M1 simulator. The seven functioning warning lights include:

Engine Oil Low
Transmission Oil Low
Engine Oil (filter clogged)
Transmission Oil (filter clogged)
Primary Fuel (filter clogged)
Rear Fuel Pump - R (inoperative)
Rear Fuel Pump - L (inoperative)

Steering, Throttle, Break and Transmission Controls

Purpose. These controls permit the driver to control the vehicle's speed and direction.

Hardware requirements. The current steering, throttle, break (including parking break pedal) and transmission control mechanism satisfies requirements for the dedicated driver station controls. The only additional hardware requirements are the driver selection switches located above the mechanism. Refer to Figure 4.

Functional requirements. There are no functional changes for these controls in the dedicated driver station of the 3-man configuration. They perform exactly as they currently do. These controls can be rendered non-functional by the TC. He can determine which crew position has driving capability by using the driver selection control switch.

Crew Seat

Purpose. The driver's seat is designed for comfort and compatibility with the driver's controls and displays.

Hardware requirements. The driver's seat is a multi-adjustable automobile-style seat. Standard automobile-style seat adjustment controls are used to make adjustments. The seats are covered with a comfortable, durable seat cover.

Functional requirements. The driver is able to adjust seat position front-to-back, and up-and-down with an adjustable angle seat-back so the controls can be easily reached (see Figure 10).

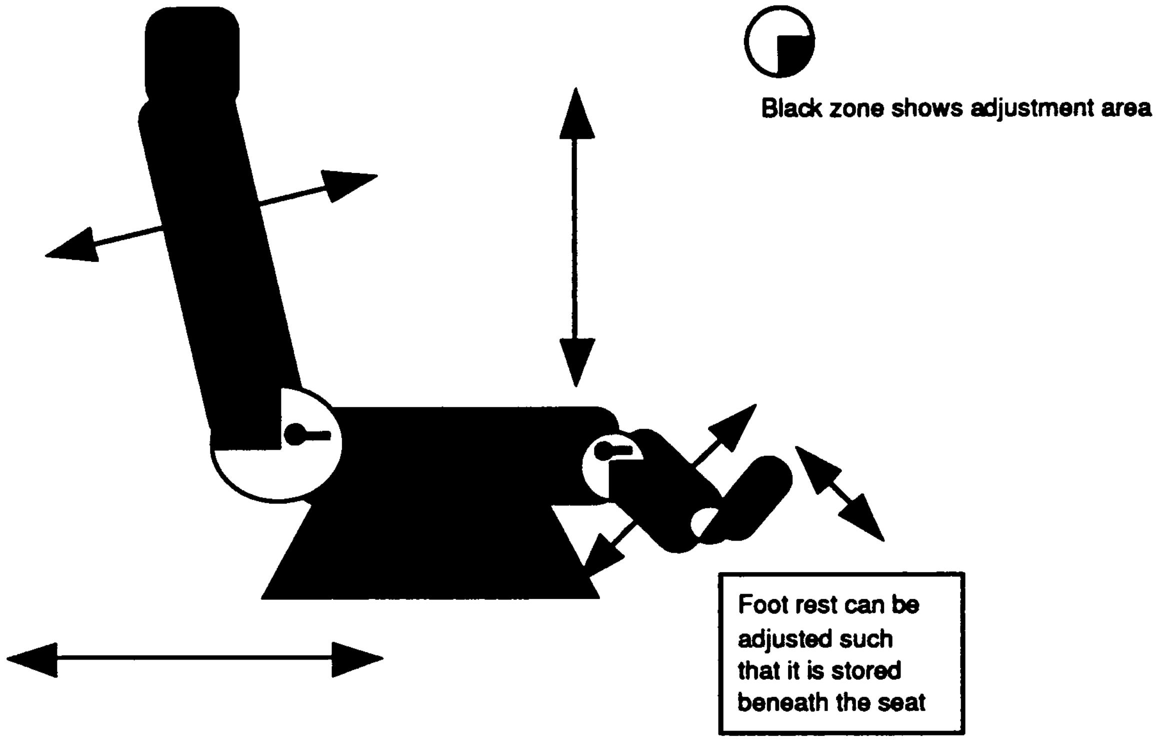

Figure 10. Crew seat and adjustment directions

Display viewing, including vision blocks, is achieved by adjusting seat height and seat-back angle. A leg support and foot rest are included and are also adjustable. These can be adjusted so that they are underneath the main part of the seat.

Vision Blocks

Purpose. Vision blocks permit the driver to see a simulated image of what would normally be viewed outside the vehicle.

Hardware requirements. The hardware in the current CCTB simulator is used in the modified configuration. Additional hardware is not required.

Functional requirements. Vision blocks in the 3-man configuration have the same functional capabilities as the current CCTB driver station vision blocks. The horizontal and vertical visual angles are the same for all three crew members. The horizontal field of view is as currently configured (89 degrees, see SIMNET M1 Crew Manual). However, the horizontal view for the driver is no longer on center as currently configured. The driver position is offset 36 inches to the left of the center of the vehicle. The driver's view reflects this 36 inch displacement.

Rear Sensor Image. A "simulated" sensor (camera) mounted on the rear of the vehicle provides a rear-view image to each crew member. Crew members can select either forward view or rear view. View selection is made by shifting a lever switch located on the center vision block window (see Figure 11). Any crew member can select this view at any time. The primary purpose of the rear view image is for the driving crew member to see what is behind the vehicle when driving backwards. Additionally, any crew member can select the rear-view image to search the rear area of the vehicle. Target acquisition and critical searches are still performed with the GPS, GTS and CITV sensors.

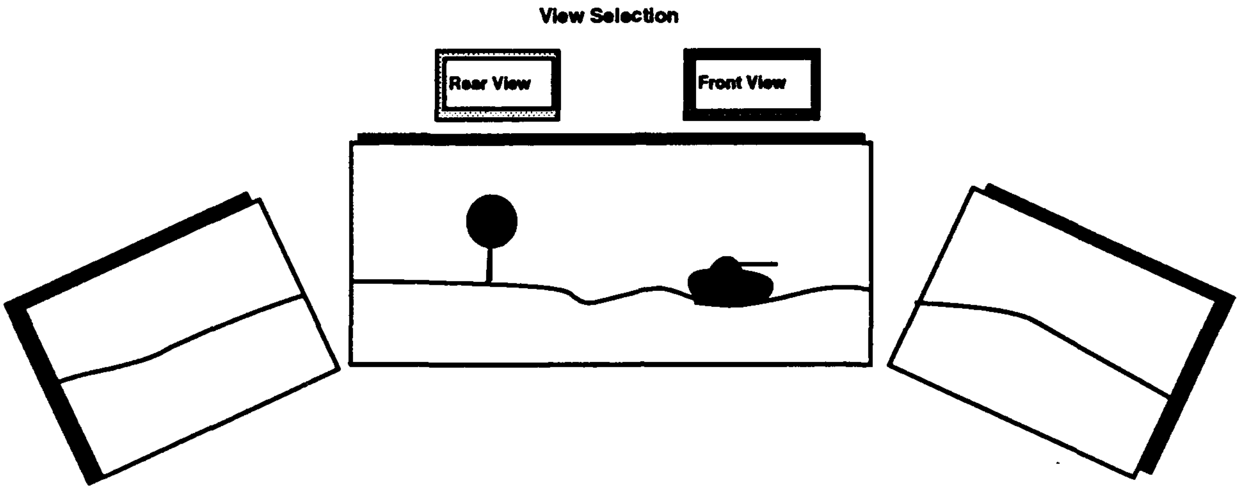

Figure 11. Vision blocks and view selection switches

The viewing angle of the rear sensor is illustrated in Figure 12. The viewing angle is 60 degrees around the focal point of the sensor. The sensor is centered on the rear of the vehicle and is angled slightly down (5 degrees). This permits the crew member to see the ground 7 feet behind the tank (assuming the sensor is mounted 5 feet above the ground). This viewing angle permits crew members to see a wide-angle view of obstructions and/or their own tracks if backing up on their own tracks is required.

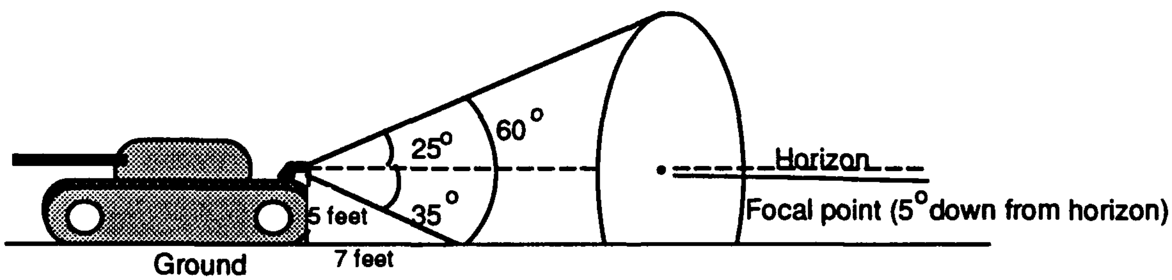

Figure 12. Viewing angles of rear sensor

Communications Control Box

Purpose. The communications control box permits the driver to select a radio or intercom. Volume is also controlled from this box.

Hardware requirements. Communications control box hardware does not change from the current configuration. Current communications lines and control devices can be used in the dedicated driver station.

Functional requirements. No functional changes are required for the communications control box and communications system overall.

Internal Light

Purpose. The internal light is used for the crew member to see inside the simulator when the door is closed and it is dark.

Hardware requirements. The same light system in the current CCTB simulator should be used for the reconfigurable design.

Functional requirements. The internal light functions as it presently does in the CCTB simulator.

Specifications for the Tank Commander/Tank Systems Operator Stations

In the 3-man configuration, the TC shares instruments, displays and controls with the TSO. Both stations are capable of performing all functions required by either position. These include all functions that currently exist in the CVCC-equipped CCTB simulator, including driver functions. Driver control devices, however, can be stowed by the TC and TSO thus giving driving responsibilities solely to the driver. The stations are designed to be symmetrical, with the TSO station mirroring the TC station. Because both stations are the same, specifications for both stations are described in this section.

Changes from the current CCTB configuration are significant. In order to make two shared stations that duplicate systems, controls, displays and functionality, major changes to layout and configuration are required. Additionally, the reconfigurable design attempts to make the environment inside the vehicle more comfortable for crew members. For example, the reconfigurable design provides crew members with a comfortable seat, easy to view systems, and controls and displays within reach of their position.

These stations are equipped with the following hardware systems (systems that are shared are described appropriately, see Figure 1):

Non-touch screen displays (1 each position)
Touch screen displays (2 displays, shared)
Gunner's control panel (shared)
Communications panel (shared)
Control tablet (1 each position)
Control handle device (1 each position)
Vision blocks (set of three for each position)
Vehicle control panel (shared)
Ammo transfer panel (shared)

Driving Hardware :

Stowable throttle and steering control handle (1 each position)
Transmission lever (1 each position)
Driver's brake pedals (1 each position)
Driver's system controls (1 each position)

The TC and TSO may perform the following major functions:

Vehicle command and control
Main gun operations (firing)
Target search and acquisition
Reporting
Steer and control the vehicle (including speed, direction, transmission setting)
Monitor driver's instruments

Hardware Description

The following sections describe the hardware inside the simulator. These sections provide general descriptions of displays, controls and the override protocol for the two crew members. The section that follows provides detailed descriptions of each hardware system including a discussion of the purpose of the system, the hardware platforms they require, and the system's functional requirements.

Displays

The TC/TSO crew compartment has four display screens, two touch screens and two non-touch screens, and a set of vision blocks for each crew member. As stated previously, these screens are "recycled" from the current CCTB simulator in an effort to maintain low costs. Each crew member has a 6" x 6", non-touch sensitive display screen. They share two 6.5" x 5.5", touch-screen displays. Figure 1 shows the relative location of each screen. All five systems (i.e. CITV, CCD, GPS, GTS, and DID/CCD) can be displayed on the non-touch screens. The CITV system can only be displayed on the non-touch screens. This is because the CITV control switches exist only around the non-touch screens. The CCD, GPS, GTS, and DID/CCD systems can be displayed on both touch and non-touch screens. The touch screen interface, however, exists only for the CCD system. A set of selector buttons is located adjacent to each screen for selection of a system for display on that screen.

The touch screen display screens should have the same specifications as the touch screens in the current CCTB simulator. Each screen is accompanied by hard-wired control switches that are used to select systems for display and adjust-selected displays. Figures 13 and 14 illustrate the control switches that must be hard-wired and their location.

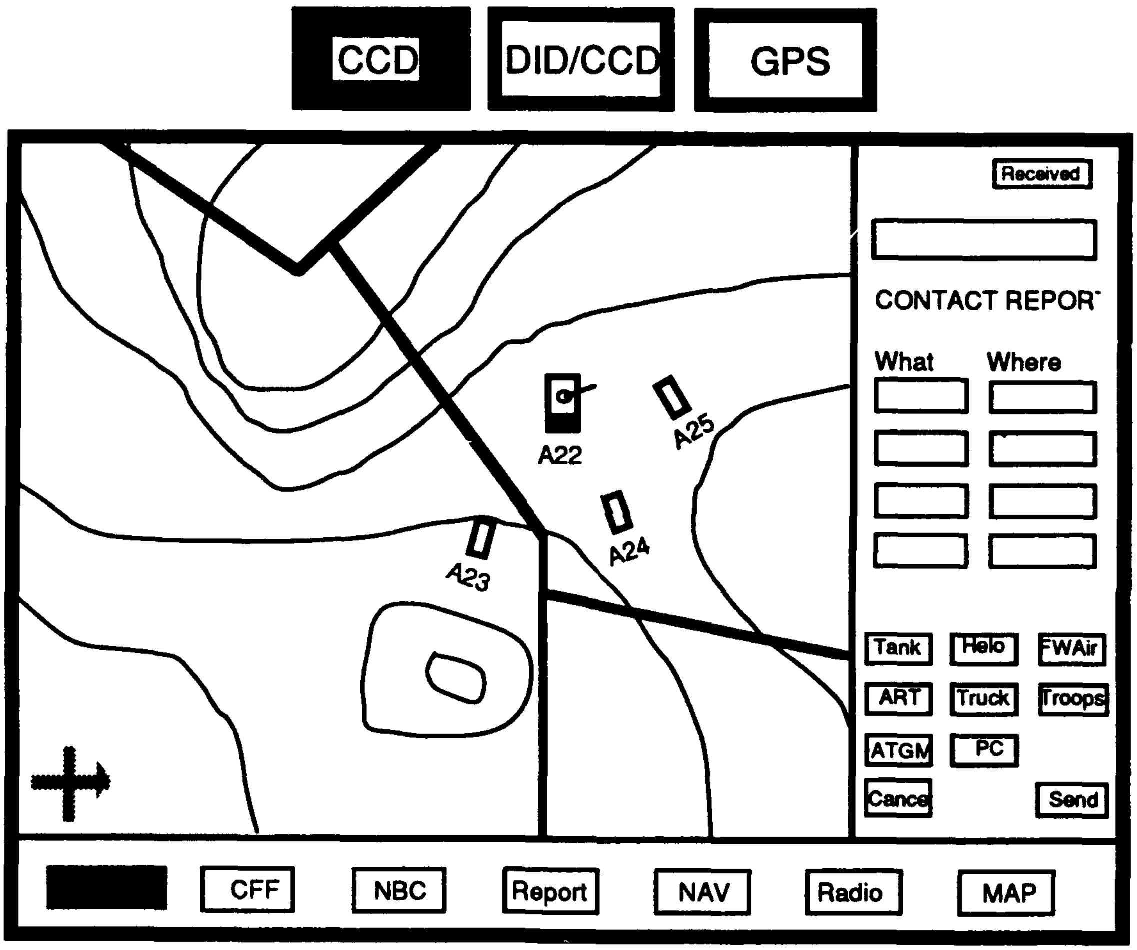

Figure 13. CCD display screen and touch screen control switches

Touch screen control switches include:

GPS selection
CCD selection
DID/CCD selection

The non-touch screens also have the same specifications as the non-touch screens in the current CCTB simulator. These have fixed positions as seen in Figure 14. Control devices for switching displays and adjusting screens are also be required.

CITV controls such as target stack switches border the non-touch screen as seen in Figure 14.

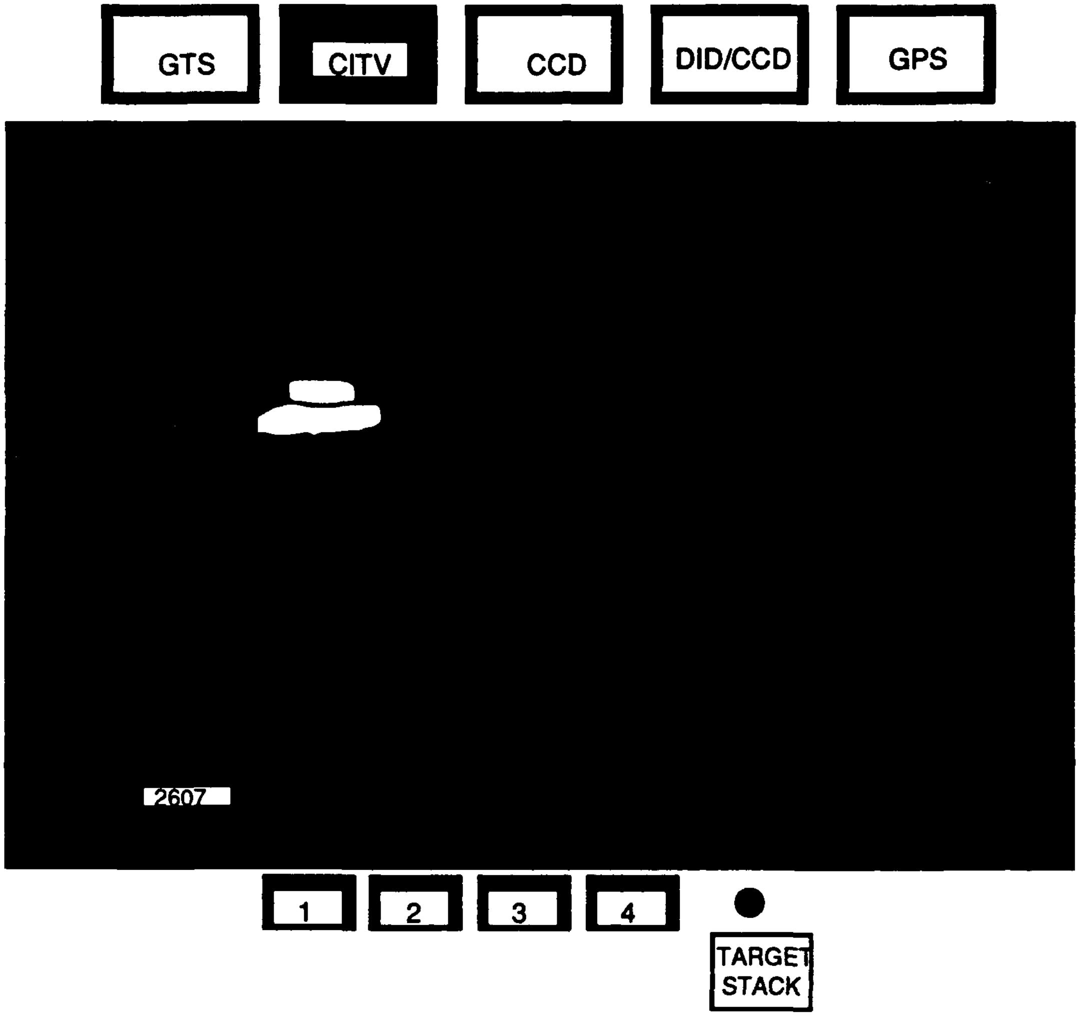

Figure 14. CITV display screen and controls and non-touch screen control switches

Non-touch screen selection switches include

CCD selection
DID/CCD selection
GTS selection
CITV selection (do not with touch screens)
CITV control switches (do not with touch screens)

Each crew member has a unique cursor that appears on any display that has been selected by the TC/TSO. The cursor is a cross-hairs pattern (see Figure 15) with an arrow pointing in the direction of the crew position as seen in Figures 13 and 14 in the lower left corner. Each cursor can be either green (go, active) or flashing red (stop, inactive), depending on the active status of the system that is selected. (See Smith and Thomas, 1964 for a background on color selection for information displays.) When a crew member has a green cursor, it means his system is "active," which indicates that it is under his control. A red, flashing cursor means "inactive," indicating the system cannot be accessed because it is controlled by the other crew member. The override protocol for priority control is described in further detail below.

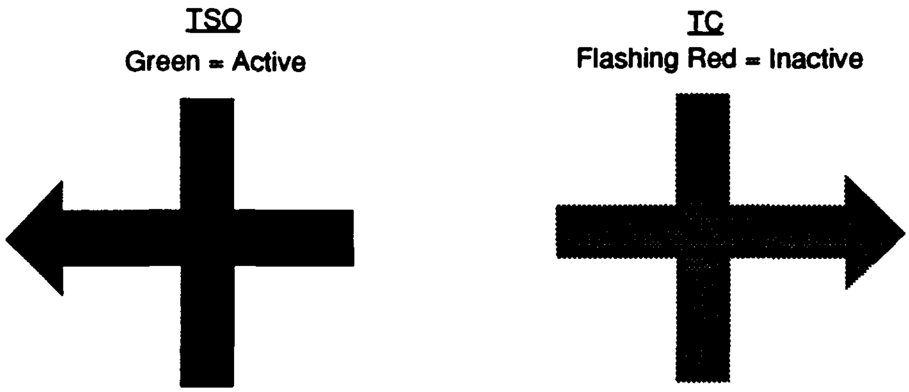

Figure 15. Arrow cursor indicating system status and crew position control

Controls

Crew members can interface with systems in several ways. The Commander's Override Handle interface that presently exists is used in the reconfigurable simulator (see Figure 16). The control handle controls cursor movement, main gun movement, and CITV sensor movement. The control handle has the same control mechanisms as the current CCTB control handle. This includes normal control handle movement and thumb-switch control.

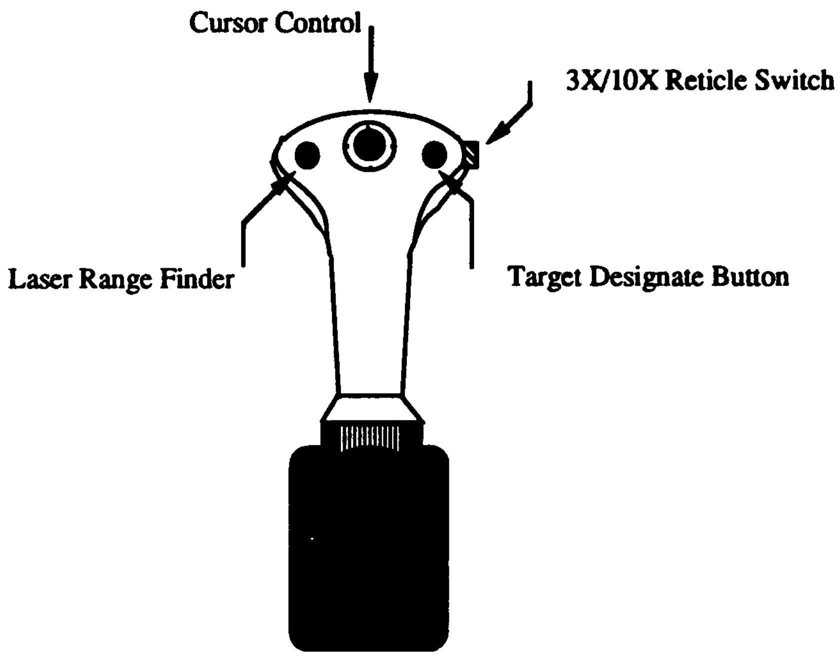

Figure 16. Commander's override handle

A new control tablet interface capability permits crew members to touch a pad that corresponds to any selected screen and move a cursor and/or push a button to interface with the screen (see Figure 17). Appendix B provides detailed specifications of the control tablet. By pressing the control tablet button, a crew member can move his cursor from one display to another in a counter-clockwise fashion. Under normal conditions, a green cursor appears on the selected screen indicating an active screen. It is important to point out that the cursor does not necessarily move on each display. The cursor can only be moved on system displays that permit interface, such as the CCD. However, the cursor is used to indicate activity/inactivity on every system display.

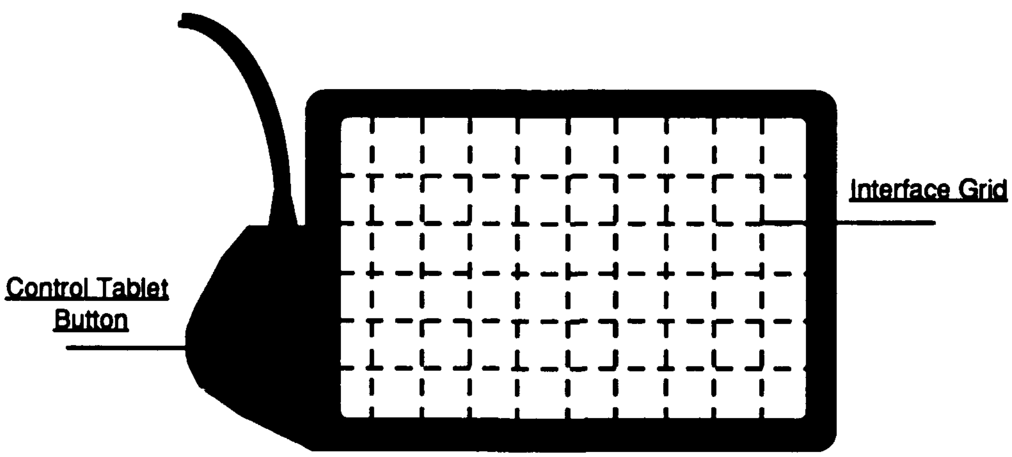

Figure 17. Control tablet

The control tablet is a moveable control device. For example, crew members should be able to remove the control tablet from the arm rest position and attach it to their lap or other convenient position. Velcro straps are recommended to secure the control tablet to the armrest or thigh.

If a selected display screen is showing a system that is currently in use by the other crew member, a flashing red cursor appears instead of a solid green cursor, indicating that the system is currently unavailable. The crew member with the flashing red (inactive) cursor can only interface with that system if one of two things occur: (1) if the other crew member moves his cursor from that system (with his control tablet), or (2) the other crew member selects another system for his active display (with the system selection buttons). In either case, a flashing red cursor on system display that is actively used by the other crew member automatically turns green (active) when the other crew member takes one of the above two actions. If a crew member moves from screen to screen with his control tablet, and he selects one of the shared screens that is actively used by the other crew member, the cursor skips this display screen and moves to the next available screen.

Crew members can select a system to be displayed on a screen by depressing the system select button of their choice located next to each screen (see Figures 13 and 14). This design permits the crew member to select or change systems by simply pressing one button. Once a system has been selected for display on a screen, the system displays that system but it is not necessarily active. As described above, the only way to activate this system is to move the cursor to it with the control tablet. If a crew member had his cursor on a screen and then selected a different system for that screen then the system would become active (assuming the system is not in use by the other crew member).

A hierarchy of controls exists. The three existing control mechanisms, listed in order of precedence, are: control tablet, control handle, and touch screen. This means that control tablet inputs will take precedence over any control handle movement and/or touch screen input. This hierarchy is primarily to establish an order of control.

The concepts associated with control of the four main screens and the five systems that they can display are complex. These concepts are discussed in more detail after the following description of systems.

Override Protocols

Because the TC and TSO share instruments, displays and controls, a priority protocol must be developed to determine who has control over any given system. As described previously, responsibility of all vehicle functions and performance ultimately rests with the TC. Practically, however, both the TC and TSO can more effectively operate the vehicle if they properly allocate functional distribution.

Because the TC and TSO share system displays and both crew members can have the same system displayed on different screens, a priority method for operation must be employed. This prevents both crew members from attempting to control the same system at the same time. For example, it would be futile for the TC to lay the main gun with the GPS in one direction while the TSO attempts to lay it in the other direction. Therefore, the first crew member to select a system and move his cursor to it gains control of that system. Or, if a crew member selects a currently inactive system on the screen with his cursor already on it, the system comes up active. He can forfeit control of the system by moving his cursor off that system screen or by selecting another system for that screen. His control handle and control tablet only work on an active system screen (i.e. his cursor must be on the screen and "active" in order for his controls to work).

For example, if the TC selects the CITV on his non-touch screen and moves his cursor to it by pressing the control tablet button, he gains control of the CITV system (unless, of course, the TSO had already had the CITV selected and active with his own cursor. The TC knows he has system control if his cursor is green, indicating an "active" system. If the TC is finished with the CITV but does not move his cursor or select another system for that screen, he still controls that system. If the TSO attempts to use the CITV by selecting it and moving his cursor to it, he should notice that his cursor is red and flashing, indicating an inactive system. He must coordinate with the TC to deactivate the TC control of that system. The TC then has to move his cursor off that screen with his control tablet button and/or select another system for display on that screen.

Two exceptions to this protocol exist. One exception is the master override control switch described previously. A second exception is related to the shared touch screen display. Both crew members can interface and therefore control the CCD system if it is active on either of the two touch screens, located between the TC and TSO. If the CCD is active for the TC (i.e. the TC's cursor arrow facing his position is green) on a touch screen, the TSO can interface with that display, but only through the touch-screen interface. There is an advantage to this in that if the TC is too busy to change system selection/activation, the TSO can still use the CCD system, even though it is active for the TC. The TSO should not automatically assume he can use the system, however, since he should see the TC's green cursor indicating the system is in use by the TC.

Systems Description

The following systems are used in the reconfigurable simulator. They are described in terms of their purpose, hardware requirements and functional requirements. Hardware requirements are described in terms of the above hardware description. Display screens on which each system can be displayed and the interface devices for each system are referenced but not described further.

CCD Display

Purpose. The CCD provides automated command and control capabilities to the TC/TSO. The CCD also provides a means of communications with its message generation, relay and reception capabilities. The CCD is an interactive situation display. It shows a map of the surrounding area and orientation of the vehicle.

Hardware requirements. The CCD is displayed on either touch or non-touch screens. It is controlled by touch interface (touch screen only), by control handle thumb-switch control, or by control tablet. The control handle thumb-switch control should perform as specified in current CCTB simulator. Control tablet hardware is specified in detail in Appendix B.

Functional requirements. Functionally, the CCD display remains unchanged from its current configuration. Other than the additional control features, no additional functions are required.

Vision Blocks

Purpose. Vision blocks permit crew members to see a simulated image of what would normally be viewed outside the vehicle.

Hardware requirements. The hardware in the current CCTB simulator is in the modified configuration. Additional hardware is not required.

Functional requirements. Vision blocks in the 3-man configuration have the same functional capabilities as the current CCTB driver station vision blocks. The horizontal and vertical visual angles are the same for all three crew members. The horizontal field of view is as currently configured (89 degrees, see SIMNET M1 Crew Manual). The horizontal view for the TSO is on center, as configured for the driver in the current CCTB. The horizontal view for the TC position is centered 36 inches to the right of the center of the vehicle. The TC's view reflects this 36-inch displacement.

Rear Sensor Image. See the discussion of the rear sensor image in the driver's systems description.

Gunner Primary Sight

Purpose. The GPS is used by either crew member performing gunner duties. This sight provides an optical image display of the area where the sight is aimed. The GPS is used to aim the main gun, search for targets, and determine range to target. A reticle is displayed over the image of this sight to permit aiming accuracy.

Hardware requirements. The current CCTB configuration depicts the GPS as an optical sight. The GPS in the reconfigurable simulator takes the same image that was projected in the optical sight and projects it onto a display screen. The GPS, depicted in Figure 18, can be displayed on all screens. Cursor movement and aiming the main gun in the GPS display is controlled by the control handle.

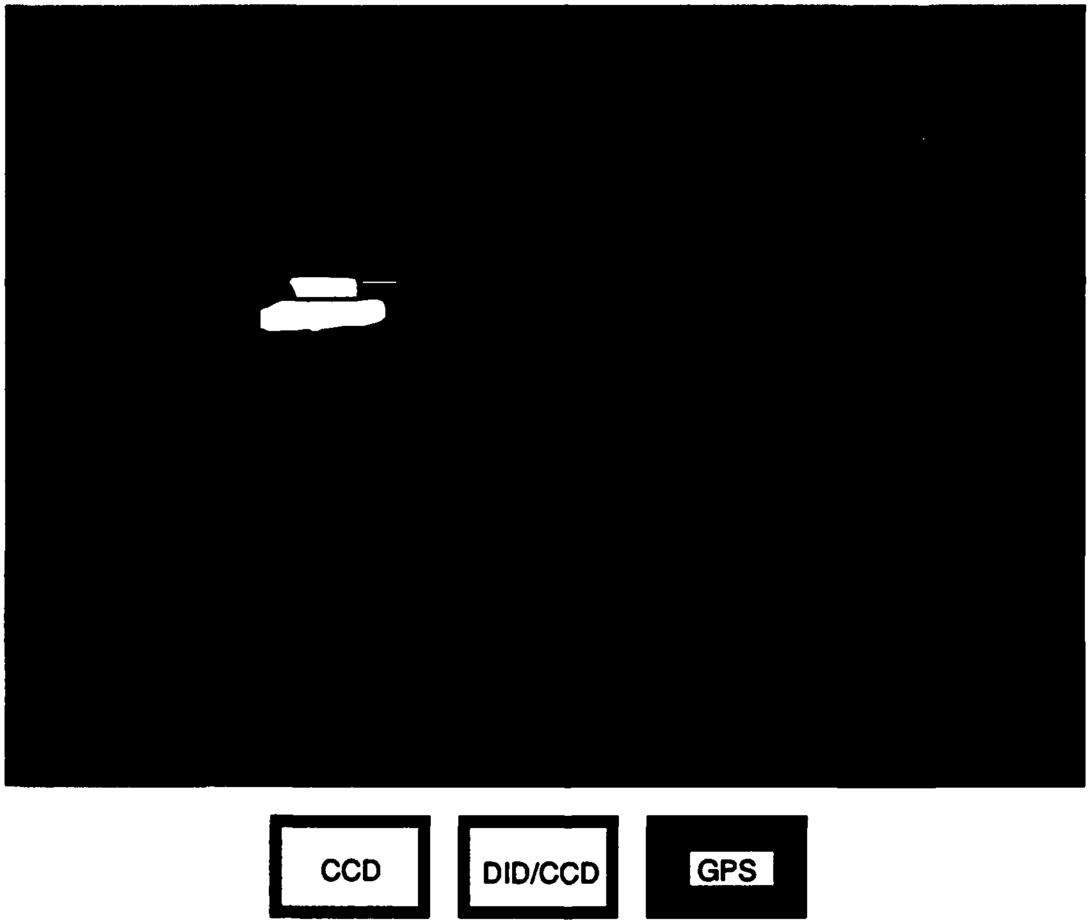

Figure 18. GPS display screen with selection switches

Functional requirements. There are no functional changes for the GPS system and display. As currently configured, control handle movement is coordinated with main gun movement.

Gun Control Panel

Purpose. The gun control panel is a suite of control devices that are used to perform gunner functions. Figure 5 illustrates this panel. These controls are required to set parameters associated with the main gun.

Hardware requirements. The gun control panel has control devices that exist in the current CCTB; however, the layout of these controls changes in the new configuration. The panel has all gunner controls, with the exception of autoloader controls, in one location between the two crew members. Hardware from the current simulator can be used to create the panel for the modified configuration. Additional hardware may be required to create a panel that holds all controls. These controls can be seen in Figure 5.

Functional requirements. Gunner controls that are currently functional remain functional in the modified configuration. Those controls that are not functional (for example, Normal Mode Drift, Boresight AZ/EL, Thermal Test) remain non-functional but are displayed. The following functions are required for the modified gun control panel:

Range switch (Arm last, Arm 1st, SAFE)
Thermal Magnification switch (3x, 10x)
Polarity (White Hot, Black Hot)
Reticle
Thermal Mode (On, Off, Standby)
Gun Select (CO-AX, Main gun)

CITV

Purpose. The CITV is a thermal view of the environment used primarily for target search and acquisition. It can be used to slew the main gun to a target. The purpose of the CITV is not altered for this configuration. See Figure 14 for an illustration of the CITV screen.

Hardware requirements. The CITV can only be displayed on a non-touch screen. Cursor movement and aiming the CITV sensor head in the CITV display is controlled by the control handle device.

Functional requirements. The CITV and its associated control devices maintain the functionality of the current, CVCC equipped simulator. Although controls and displays change location within the simulator, the CITV is able to perform all present functions and no additional functions are added. Control handle movement is coordinated with reticle/cursor movement such that left pressure rotates the CITV sensor left or counter-clockwise, right pressure rotates right or clockwise, and backward pressure raises the CITV sensor while forward pressure lowers it. The control handle is motion sensitive so greater movement translates to faster movement.

Gunner Thermal Sight (GTS)

Purpose. The GTS is an optical display of a thermal image used by either crew member in performing gunner duties. It is used to search for targets, determine range to target, and aim the main gun. A reticle image is displayed over the image of this sight to permit aiming accuracy.

Hardware requirements. The GTS can be displayed on either touch sensitive or non-touch screen displays (see Figure 19). Cursor movement and aiming the GTS sensor on the GTS display is controlled by the control handle.

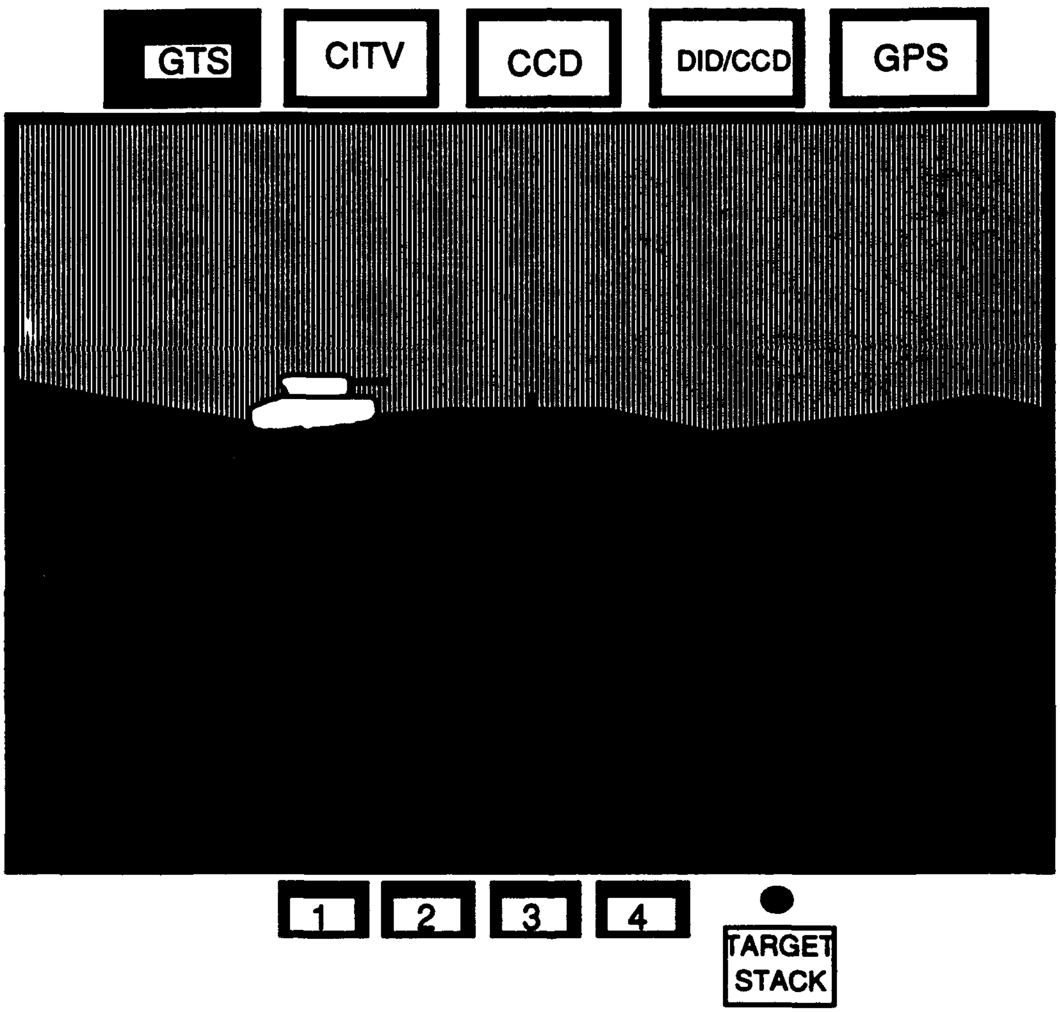

Figure 19. GTS display screen and selection switches

Functional requirements. The GTS and its associated control devices maintain the functionality of the current simulator. Although controls and displays change location within the simulator, the GTS is able to perform all present functions and no additional functions are added.

Main Gun, Turret Controls

Purpose. Control of the main gun and turret is important for target search, acquisition and engagement. The turret rotates clockwise and counter-clockwise with the main gun attached. The main gun can be raised and lowered as well. Either crew member can control the main gun and turret.

Hardware requirements. The turret and main gun can be controlled through aiming of the GPS, GTS and CITV systems. The control handle is the primary means of controlling of the main gun, as it is presently configured. The control tablet also permits main gun and turret control as described above in the GPS and GTS sections.

Functional requirements. The rate of rotation and vertical movement of the main gun does not change from the current configuration. Functionally, the main gun and turret control does not change from its present configuration. Control handle movement is coordinated with cursor movement such that left pressure rotates the main gun left or counter-clockwise, right pressure rotates right or clockwise, and back pressure raises the main gun while forward pressure lowers it. The control handle is motion sensitive so greater movement translates to faster movement.

Radio Controls

Purpose. The radio controls within the TC and TSO station permit either crew member to change radio frequencies, internal mode, volume and any necessary communications control changes on the SINCGARS radio.

Hardware requirements. Communications hardware does not change from the current configuration. Current communications lines and control devices can be used in the modified configuration. The communications panel is located between the two crew members as seen in Figure 1.

Functional requirements. No functional changes are required for the communications panel and communications system overall. (see TM 11-5820-890-10-1, 1986).

Communications Control Box

Purpose. The communications control box lets each crew member select radios, intercom setting and volume from a separate control box.

Hardware requirements. The same hardware as used in the current CCTB is used for the two communications control boxes, one for each crew member.

Functional requirements. There are no functional changes between the controls in the CCTB and the reconfigurable.

Autoloader Control Panel

The Autoloader is the only new system in the 3-man configuration. It is very complex, therefore details of the autoloader are presented in Appendix A. Figure 20 illustrates the autoloader control panel.

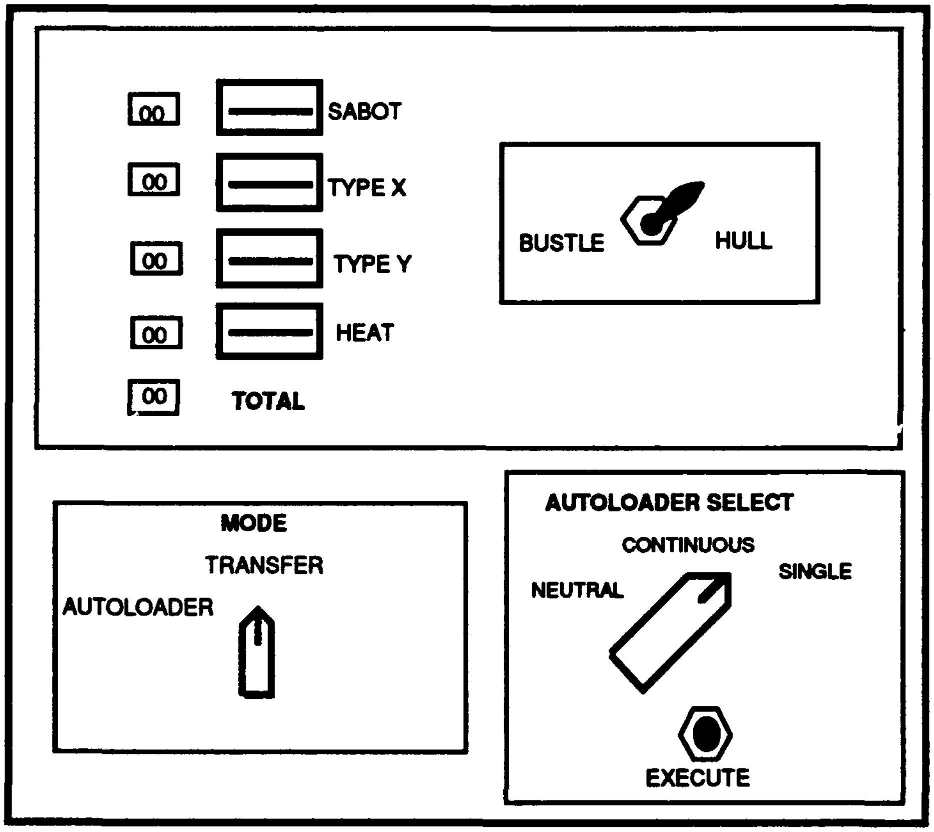

Figure 20. Autoloader control panel

TC/TSO Driving systems

Although the 3-man reconfigurable design does not require the TC or TSO to drive, the reconfigurable design takes advantage of 100% functional redundancy in driver controls for all three crew members. It is assumed that with this configuration, the dedicated driver performs the majority of driving functions. However, if one was interested in determining the effects of a 3-man crew with driving duties distributed among all crew members, clearly one could simulate that environment.

Reconfiguring this simulator design into a 2-man design (shared instruments or segregated) could be done rapidly. This is one reason for including driving capabilities to the TC and TSO stations.

The following systems associated with driving functions have the same purpose, hardware requirements, and functional requirements as described in the driving systems description for the driver crew position in the 3-man configuration. The only exception is the requirement that the steering and throttle device is stowable. Refer to the 3-man driver specification section for details about the following systems:

Driver Information Display/CCD Display

Including the following instruments and displays:

CCD map view with own-vehicle centered

Way-point indicator

Fuel level

Speedometer and odometer indicator

Tachometer/RPM numerical readout

Battery power

Engine Control Panel

Maintenance Monitor Panel

Steering, Throttle, Break and Transmission Controls (stowable)

Crew's Seat

General Anthropometric Design

The systems, controls, and displays within the reconfigurable simulator should be arranged such that the human operators can easily interface with them. Crew members sit on automobile-style seats that are adjustable in three directions: sitting height, seat back angle and front-back distance. Figure 10 illustrates the multi-adjustable seat. Sitting in this seat, crew members should be able to easily reach all control devices and see all displays.

Figure 21 shows the approximate, recommended viewing angles and distances for the 50th percentile male operator. Measurements are based on 10-degree seat-back angle, minimum seat height (10") and zero forward seat adjustment (Van Cott and Kinkade, 1972).

Adjustments can be made to this seat such that the 5th to 95th percentile male operator can place himself into a comfortable position with control of all systems. Figure 22 shows approximate viewing distances and reach distances for the 50th percentile male operator. Again, these data are based on 10-degree seat back angle, minimum seat height (10") and zero forward seat adjustment.

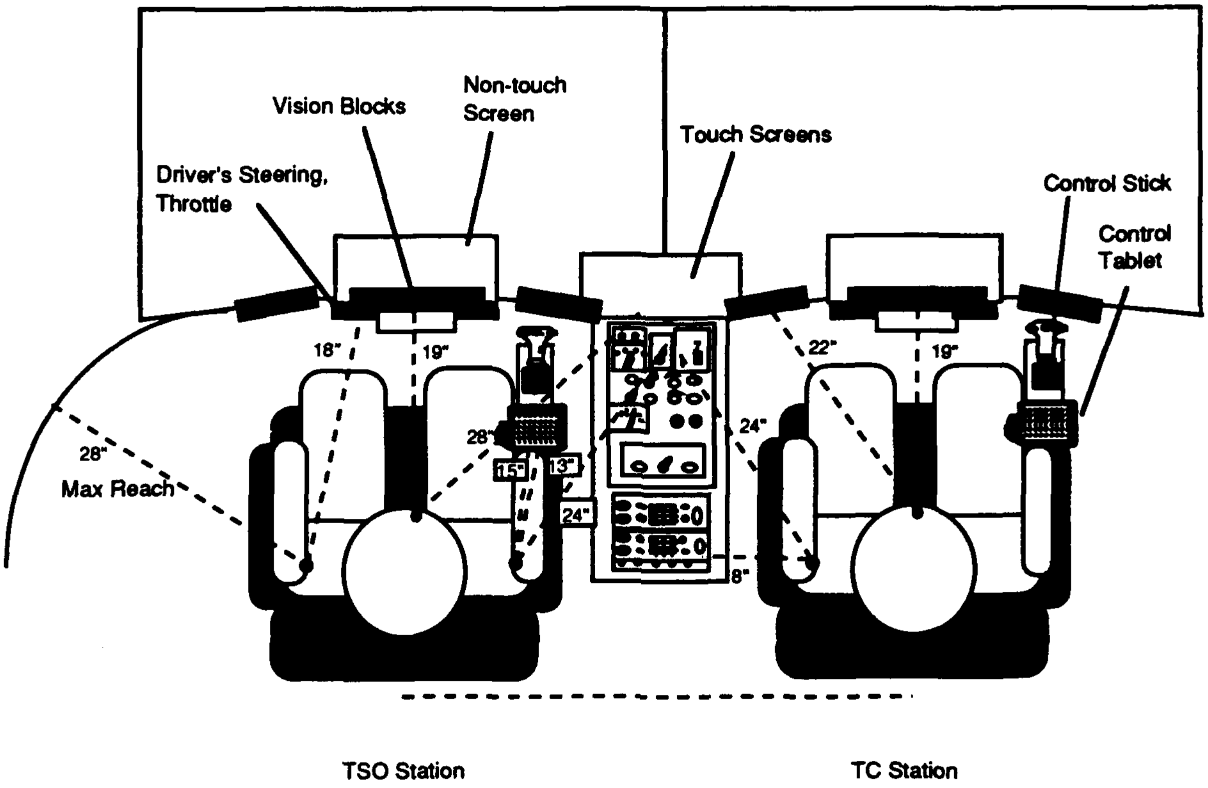

Figure 21. Approximate viewing angles and distances for 50th percentile male crew member

All controls need to be placed within easy reach. The control tablet and control handle are located on the right armrest. The control tablet, however, is a moveable control device. Crew members should be able to remove the control tablet from the armrest position and attach it to their lap or other convenient position. Velcro straps are recommended to secure the control tablet to the armrest or thigh. The touch screens should also be within easy reach.

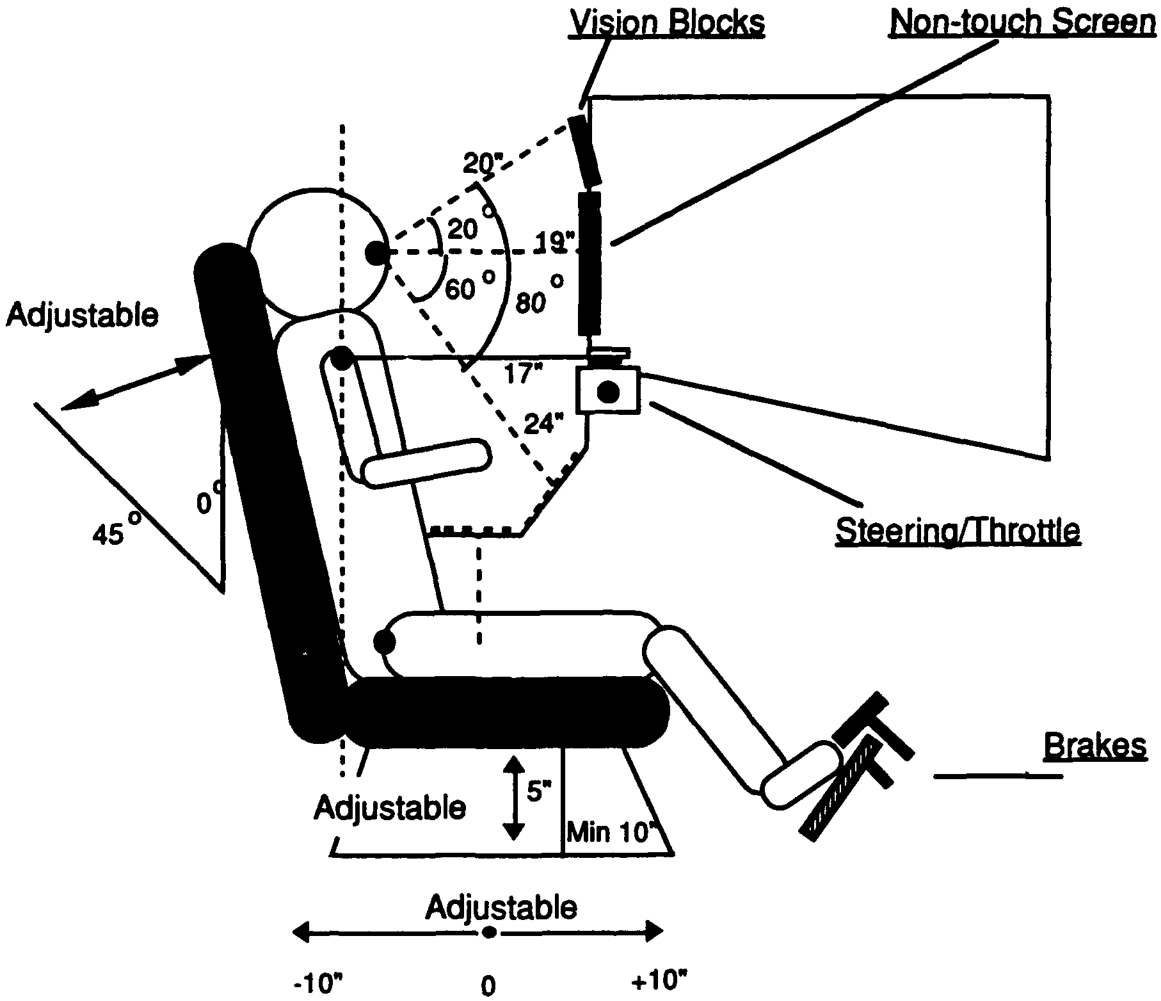

Figure 22. Approximate viewing distances and reach distances for the 50th percentile male

SPECIFICATIONS FOR A 2-MAN, SIDE-BY-SIDE CONFIGURATION

Introduction

Purpose

The purpose of this section is to provide detailed specifications for development of a 2-man reconfigurable simulator based on the current CCTB. Much of the detail of the 3-man specification applies directly to this design also. Differences are highlighted below.

Scope of Specifications

The scope of the 3-man specification applies directly to the 2-man side-by-side design.

Overview

This section is divided into three major sub-sections. The first sub-section provides an overview of the proposed reconfigurable design. The other two sub-sections provide detailed specifications for the TC and TSO crew stations. Because both stations are essentially the same in terms of systems, controls, displays, and functionality, only one position is described.

As illustrated in Figure 2, the 2-man configuration has two side-by-side crew stations. The TSO occupies the left position while the TC occupies the right position. Both crew positions have instruments, controls and displays which give them the capability to perform all duties of the current TC, gunner and driver. This design assumes driving is performed by either crew member; however, an operations policy should be developed to determine functional responsibility and priority.

Figure 10 shows the seat for both crew members. This is the same seat detailed in the 3-man specification.

The 2-man, side-by-side vehicle is designed to be easily reconfigured into alternative, 2-man segregated or 3-man configurations. The degree of reconfigurability has been a primary influence on our current design. Although some compromises have to be made in order to meet the goal of reconfigurability, this design permits performance of all current CCTB functions.

Specifications for the Tank Commander/Tank Systems Operator Stations

The 2-man side-by-side specifications are very similar to the specifications for the TC and TSO compartment in the 3-man design. The main difference is that the 2-man side-by-side configuration does not have a dedicated driver's station. The TC/TSO specifications for the 3-man configuration are referenced throughout this section of the specification.

In the 2-man configuration, the TC shares instruments, displays, and controls with the TSO. Both stations are capable of performing all functions required by either position. These include all functions that currently exist in the CVCC equipped CCTB simulator, including driver functions. Driver control devices, however, can be stowed by the TC and TSO, thus giving driving responsibilities solely to a single crew member. The stations are designed to be symmetrical, with the TSO station mirroring the TC station. Because both stations are the same, specifications for both stations are described in this section.

Hardware systems for the 2-man side-by-side design do not change from the 3-man specifications for TC and TSO crew stations. The TC/TSO station has the same systems, displays, and controls (including driving systems) as listed in the 3-man specification (see Figures 1 and 2). Additionally, the major functions of the TC and TSO are the same as specified in the 3-man specification.

Hardware Description

The following sections describe the hardware inside the simulator. Because the 2-man side-by-side design is essentially the same as the 3-man configuration, most hardware systems descriptions refer to the 3-man descriptions. Additionally, the override protocols are very similar to the 3-man design. The few differences between the 2-man side-by-side and 3-man designs are detailed; otherwise, the TC/TSO specifications in the 3-man design should be referenced.

Displays

For a general description, see the displays sub-section for the TC/TSO specifications in the 3-man design.

Controls

For a general description, see the controls sub-section for the TC/TSO specifications in the 3-man design.

Override Protocols

Because the TC and TSO share instruments, displays, and controls, a priority protocol must be developed to determine who has control over any given system. As in the 3-man design, responsibility of all vehicle functions and performance ultimately rests with the TC. Practically, however, both the TC and TSO can more effectively operate the vehicle if they properly allocate functional distribution. The override protocol description for the TC/TSO in the 3-man design is essentially the same for the 2-

man side-by-side design. The one difference is that the driver control switch has only two settings, TC or TSO. The driver control override functions the same way but for only 2 crew members. See the override protocol section for the TC and TSO in the 3-man design for specifications.

Systems Description

The following systems are used in the 2-man side-by-side reconfigurable simulator and do not change from the system descriptions for the TC and TSO in the 3-man design. See that section for details about the purpose, hardware and functional descriptions.

CCD Display

Gunner Primary Sight

Gun Control Panel

CITV

Gunner Thermal Sight

Main Gun, Turret Controls

Radio Controls

Communications Control Box

Autoloader Control Panel

TC/TSO Driving Systems

The requirement to make this design reconfigurable has resulted in driver controls for the two crew members. Driving responsibilities must be determined by an operational protocol that can be determined through simulator exercises. For example, it may be practical for the TSO to drive in non-engagement situations while the TC should be driving when engaging targets. This protocol is to be determined. Because of this design, reconfiguring this simulator into a 2-man segregated or 3-man design could be done rapidly. The following driving systems are detailed in the 3-man TC/TSO systems description section.

Driver Information Display/CCD Display

Engine Control Panel

Maintenance Monitor Panel

Steering, Throttle, Break and Transmission Controls (stowable)

Crew's Seat

The following systems descriptions are different from the 3-man reconfigurable design specifications and therefore are detailed below.

Vision Blocks

Purpose. Vision blocks permit crew members to see a simulated image of what would normally be viewed outside the vehicle.

Hardware requirements. The hardware in the current CCTB simulator is used in the modified configuration. Additional hardware is not required.

Functional requirements. Vision blocks in the 2-man side-by-side configuration have the same functional capabilities as the current CCTB driver station vision blocks. The horizontal and vertical visual angles are the same for both TSO and TC. The horizontal field of view is as currently configured (89 degrees, see SIMNET M1 Crew Manual). The horizontal view for the TSO is centered 18 inches to the left of vehicle center, while the horizontal view for the TC position is centered 18 inches to the right of the vehicle center. The TSO and TC views reflect their respective 18-inch displacements.

Rear Sensor Image. See the discussion of the rear sensor image in the driver's systems description in the 3-man configuration.

Autoloader Control Panel

The Autoloader is the only new system in the 2-man side-by-side configuration. It is very complex, therefore details of the autoloader are presented in Appendix A. Figure 20 illustrates the autoloader control panel.

General Anthropometric Design

The general anthropometric design for the TC and TSO in the 2-man side-by-side configuration is the same for the TC and TSO in the 3-man reconfigurable. See the General Anthropometric Design section in the 3-man reconfigurable specification.

SPECIFICATIONS FOR A 2-MAN, SEGREGATED CONFIGURATION

Introduction

Purpose

The purpose of this section is to provide detailed specifications for development of a 2-man segregated, reconfigurable simulator based on the current CCTB. While much of the detail of the 3-man specification applies directly to this design, this design is more unique than the 2-man side-by-side configuration. The major change for this configuration is that the crew members are segregated, and do not share instruments, displays, or controls. Each crew member has his own set of displays and controls to perform the required duties. Unique attributes for this configuration are specified below.

Scope of Specifications

The scope of the 3-man specification applies directly to the 2-man segregated design.

Overview

This section is divided into three major sub-sections. The first sub-section provides an overview of the proposed reconfigurable design. The other two sub-sections provide detailed specifications for the TC and TSO crew stations. Because both stations are essentially the same in terms of systems, controls, displays, and functionality, only one position is described.

Overview of Proposed Configuration Design

As illustrated in Figure 3, the 2-man configuration has two segregated crew stations with the TSO in one and the TC in the other. A crew segregated design is significant for several reasons. It is assumed that the crew is segregated because the physical design of the vehicle requires separation. The main gun or the autoloader, if placed between the crew members, would most definitely separate the two. Segregation can enhance survivability as well.

Both crew positions have instruments, controls, and displays which give them the capability to perform all duties of the current TC, gunner and driver. This design assumes driving can be performed by either crew member; however, an operations policy should be developed to determine functional responsibility and priority. Override protocol for driving duties is described below.

Figure 10 shows the seat for both crew members. This is the same seat detailed in the 3-man specification. Refer to the 3-man

TC/TSO specifications for a detailed overview of the proposed configuration design.

Specifications for the Tank Commander/Tank Systems Operator Stations

The 2-man segregated specifications are very similar to the specifications for the TC and TSO compartment in the 3-man design. The TC/TSO specifications for the 3-man configuration are referenced throughout this specification.

In the 2-man segregated configuration, the TC station is configured with the same hardware as the TSO station. Each station is symmetrical to the other. Both stations are capable of performing all functions required by either position. These include all functions that currently exist in the CVCC equipped CCTB simulator, including driver functions. Driver control devices, however, can be stowed by either the TC and/or TSO; thus, driving responsibilities are given solely to the crew member who is driving. Because both stations are the same, specifications for both stations are described in one section.

Hardware systems for the 2-man segregated design do not change from the previously described 3-man specifications for TC and TSO crew stations. The TC and the TSO stations have the same hardware systems (including driving hardware) as those listed in the 3-man specification (see Figures 1 and 3). Additionally, the major functions performed by the TC and TSO do not change from those listed in the 3-man specification.

Hardware Description

The following sections describe the hardware inside the simulator. Because the 2-man segregated design is essentially the same as the 3-man configuration, most hardware systems descriptions refer to the 3-man descriptions. Additionally, the override protocols are very similar to the 3-man design. The few differences between the 2-man segregated and 3-man designs are detailed, otherwise; the TC/TSO specifications in the 3-man design should be referenced.

Displays

Both the TC and TSO have the two display screens each, one touch sensitive and the other non-touch sensitive. In the segregated design the displays are located in the same horizontal plane, as seen in Figure 3. For a general description of each, see the displays sub-section for the TC/TSO specifications in the 3-man design.

Controls

The TC and TSO have the same control devices as described in the 3-man reconfigurable specification. However, the functionality of these controls has changed with respect to override protocols. These protocols are addressed in the next section. For a general description of the control devices, see the controls sub-section for the TC/TSO specifications in the 3-man design.

Override Protocols

Because the TC and TSO have some of the same instruments, displays, and controls in segregated compartments, a priority protocol must be developed to determine who has control over any given system. As in all reconfigurable designs, responsibility of all vehicle functions and performance ultimately rests with the TC. Practically, however, both the TC and TSO can more effectively operate the vehicle if they properly allocate functional distribution.

In general, any control mechanism that exists in both stations can be operated by either one at any time. This operating procedure requires close coordination between crew members. For example, both crew members should not be operating the autoloader at the same time, nor should one crew member operate driving controls when in use by the other. Both crew members have the following control mechanisms: gun control panel, panel lights, fire control mode selection, and driver's engine controls (see Figures 3, 5, and 8). Note that the TSO station does not have a radio. The TC has the only radio in the segregated configuration.

The override protocols dealing with the interaction of screen and relinquishing control of systems is the same as described in the 3-man configuration design. The major exceptions follow. In the two previous configurations, the TC and TSO shared touch screens, which meant sharing a CCD interface. Regardless of who had the "active" control of the CCD on the touch screen, either of the two crew members could interface with the CCD. In this case, however, the two crew members are segregated and therefore only one crew member can have "active" control of the CCD system. In other words, the touch screen interface is rendered inoperative unless the crew member has an active, green cursor in the CCD.

Systems Description

The following systems are used in the 2-man segregated reconfigurable simulator and do not change from the system descriptions for the TC and TSO in the 3-man design. See that section for details about the purpose, hardware and functional descriptions.

CCD Display

Gunner Primary Sight

Gun Control Panel

CITV

Gunner Thermal Sight

Main Gun, Turret Controls

Radio Controls

Communications Control Box

TC/TSO Driving systems

The requirement to make this design reconfigurable has resulted in driver controls for the two crew members. Driving responsibilities must be determined by an operational protocol that can be determined through simulator exercises. For example, it may be practical for the TSO to drive in non-engagement situations while the TC should drive when engaging targets. This protocol is to be determined. Because of this design, reconfiguring this simulator into a 2-man side-by-side with shared instruments or 3-man design could be done rapidly. The following driving systems are detailed in the 3-man TC/TSO systems description section.

Driver Information Display/CCD Display

Engine Control Panel

Maintenance Monitor Panel

Steering, Throttle, Break and Transmission Controls (stowable)

Crew's Seat

The following systems descriptions are different in the 3-man reconfigurable design specifications and therefore are detailed below.

Vision Blocks

Purpose. Vision blocks permit crew members to see a simulated image of what would normally be viewed outside the vehicle.

Hardware requirements. The hardware in the current configuration is used in the modified configuration. Additional hardware is not required.

Functional requirements. Vision blocks in the 2-man segregated configuration have the same functional capabilities as the current CCTB driver station vision blocks. The horizontal and vertical visual angles are the same for both TSO and TC. The horizontal field of view is as currently configured (89 degrees, see SIMNET M1 Crew Manual). The horizontal view for the TSO is centered 36 inches to the left of vehicle center, while the horizontal view for the TC position is centered 36 inches to the right of the vehicle center. The TSO and TC views reflect this displacement. The displacement of the crew is necessary to fit the autoloader between them. This is also why the crew is segregated.

Rear Sensor Image. See the discussion of the rear sensor image in the driver's systems description in the 3-man configuration.

Autoloader Control Panel

The Autoloader is the only new system in the 2-man segregated configuration. It is very complex, therefore details of the autoloader are presented in Appendix A. Figure 20 illustrates the autoloader control panel.

General Anthropometric Design

The general anthropometric design for the TC and TSO in the 2-man segregated configuration is the same for the TC and TSO in the 3-man reconfigurable. See the General Anthropometric Design section in the 3-man reconfigurable specification.

SUMMARY AND CONCLUSIONS

This document provides detailed specifications for three reconfigurable tank simulator designs. A 3-man, 2-man side-by-side and 2-man segregated design are presented with sufficient detail to begin the development process. These three designs are relatively easy to reconfigure from one to another and they provide researchers with a solid platform with which to investigate numerous issues. Some possible areas of investigation include training requirements for these new systems, employment considerations for this new technology, crew workload analysis, systems performance analysis, continuous operations research, and reduced crew configuration research.

This specification is not the final document in the development process. Additional decisions must be made and detail is required in order to finalize these designs. For example, materials have not been specified for these simulators. Also, the anthropometric data provided is merely an example of anthropometric guidelines. A mock-up should be built prior to actual simulator development.

The most valuable part of this document is the concept of reconfigurable simulators and how that concept relates to the proposed designs. The 3-man simulator can easily be reconfigured to the 2-man side-by-side or the 2-man segregated simulator. These reconfigurable simulators have been designed to optimize reconfigurability without compromising simulator fidelity. Additionally, concepts of future armored vehicles are incorporated into these designs. Each simulator represents a unique research and/or training platform that has flexibility and fidelity to meet all simulator needs.

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APPENDIX A

MODIFICATIONS TO THE CCTB FOR INTEGRATION OF AN AUTOLOADER INTO THE RECONFIGURABLE SIMULATOR SPECIFICATIONS

Introduction

Purpose

The purpose of this appendix is to provide detailed specifications for modifications to CCTB systems and subsystems. This will present an acceptable environment for the development of an autoloader for the three reconfigurable simulator specifications.

Overview of the Section

The autoloader specification provided applies to all of the reconfigurable configurations. The section begins with a general description of the modifications to be made to the current CCTB. These modifications are primarily the addition of new control panels and accompanying software for the Tank Systems Operator (TSO) and Tank Commander (TC) to operate the autoloader. A detailed description is provided for the TC. It is organized based on the major operations to be performed with the autoloader. The same is then done for the TSO workstation. The section concludes with the modifications to other CCTB systems required to facilitate the autoloader.

Specifications for the Reconfigurable Simulator with Autoloader

Modifying the reconfigurable simulator to incorporate an autoloader will require that current CCTB fire control panels be altered. There will be modifications in the TC and TSO stations. The modifications will primarily impact the functions associated with ammunition handling.

The specifications that follow are for an autoloader that holds 40 rounds of ammunition. The performance characteristics presented come from a discussion of autoloader performance characteristics for autoloaders developed at Benet Laboratory. These times were then approved by the U.S. Army Armaments Research, Development, and Experimentation Center (ARDEC).

The autoloader control panels will allow both the TC and TSO to manipulate the autoloader. The physical configurations of the panels will be somewhat different (See Figures 1, 2, and 3 in the main document for the location of the autoloader controls in each of the three reconfigurable specifications.), but the functions will be very much the same within the three specifications. The TC will have an additional function not available to the TSO. The TC will have the capability to override the TSO autoloader controls. This will ensure that the Tank Commander is in control of the fire control system.

The following sections describe in detail the modifications that will have to be incorporated. First, TC autoloader controls will be discussed. The hardware requirements will be identified including the physical and basic functional requirements. 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. This format will then be followed for the TSO workstation.

The sections following the manned simulator modifications will be similarly organized. If there are modifications for a particular system, then they will be indicated as such.

Reconfigurable Simulator Autoloader Specification

The reconfigurable simulator cockpits will include the addition of the panels in Figures A-1, A-2, and A-3. These new panels are called the Ammunition Select Panel, the Autoloader Select Panel, and the Mode Select Panel. Each of these panels is discussed in detail below. In the Functional Specification Section, the operation and interactions of the three panels will be discussed.

Mode Select Panel

Purpose

The Mode Select Panel places the autoloader into two (2) different modes: AUTOLOADER and TRANSFER.

Hardware Requirements

The Mode Select Panel (Figure A-1) consists of a two (2) position selector. The two position selector is called the Mode Selector and has the following positions: AUTOLOADER and TRANSFER. The switch must lockout for both positions. To move the selector into or out of a position, the selector will need to be pushed in. This will prevent inadvertent actuation of the switch. The switch position labels must light up when the selector is moved to that position. This will allow the crew members to see what position is selected under low light conditions.

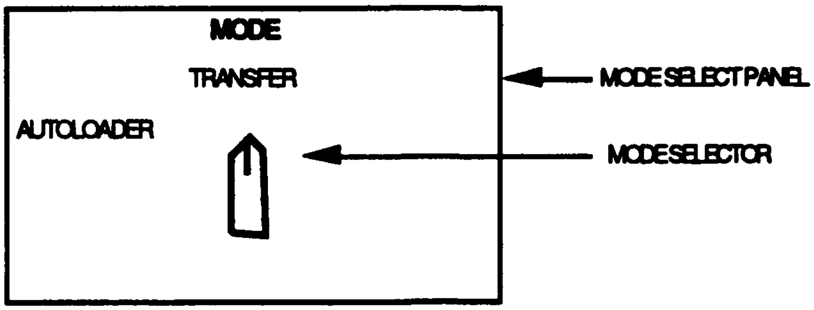

Figure A-1. Mode Select Panel

Functional Requirements

The Mode Selector determines the mode in which the autoloader operates. The two modes are AUTOLOADER and TRANSFER. The Mode Selector will usually be in the AUTOLOADER position. This will allow normal ammunition handling by the autoloader. Depending on the position of the Autoloader Selector, the autoloader will continuously load rounds after firing or load rounds upon demand. The TRANSFER mode deploys the Ammunition Transfer Mechanism and allows rounds to be transferred from the hull to the bustle.

Autoloader Select Panel

Purpose

The Autoloader Select Panel determines how the autoloader operates.

Hardware Requirements

The Autoloader Select Panel (Figure A-2) consists of a three (3) position selector, a push button, and a light. The three position selector is called the Autoloader Selector. For the TC station, the positions are TSO CONTROL, CONTINUOUS, and SINGLE. The appropriate position label must light up when the Autoloader Selector is moved to that position. This allows the crew to see the selected position under low light conditions. The Autoloader Selector must be capable of locking out in each of the positions to prevent inadvertent actuation. The selector should operate by pushing in and turning the selector to move in and out of the positions.

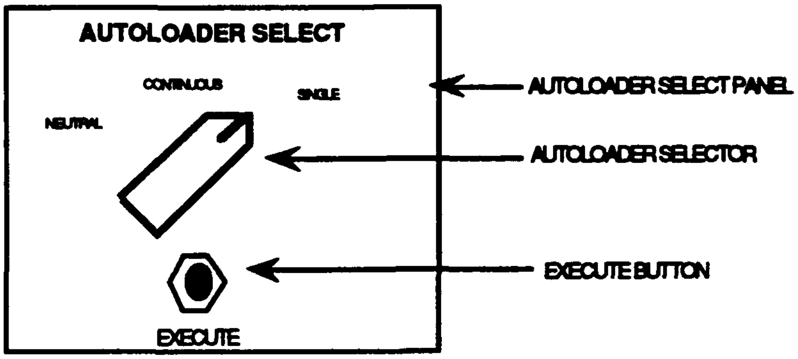

Figure A-2. Autoloader Select Panel

The push button is the Execute Button which causes the selected actions to occur. It is a spring return push button which is illuminated when the Turret Power is on.

The light next to the Execute Button is the Autoloader Safe light. It must be red in color when lit.

<u>Functional Requirements</u>

The Autoloader Select Panel determines how the autoloader will operate.

The TSO CONTROL position serves two functions. 1) It acts as a safety switch by disabling the autoloader mechanism, and 2) it allows the TC to give control of the autoloader to the TSO. The TSO's switch must be in NEUTRAL and TC's in TSO CONTROL, or the turret power must be off for the autoloader to be in a safety condition. Placing the switch in TSO CONTROL or NEUTRAL during any operation being controlled by the workstation (i.e., TC or TSO station) will stop the operation.

When the TC Autoloader Selector is in the TSO CONTROL position, the TSO Mode Select Panel, Autoloader Select Panel, and Ammunition Select Panel are operational. If the TC Autoloader Selector is not in the TSO CONTROL position, his control selections override the TSO's.

All other positions are dependent on the positioning of the Mode and Ammunition Select Panels and will be discussed in the Functional Specification Section.

The purpose of the Execute Button is to provide an enabling signal to the autoloader. Pressing the button initiates the designated autoloader operation. The button works in conjunction with all positions of the Autoloader Selector except TSO CONTROL. The Execute Button will have to be pushed only once when the Autoloader Selector is put in the CONTINUOUS position. After the initial time, the Execute Button will not have to be pushed as the autoloader receives its enabling signal automatically in this condition. All other operations require that the Execute button be pushed for initiation.

The purpose of the Autoloader Safe light, is to inform the TC and TSO of when the autoloader is in a safe, non-operable condition. The Autoloader Safe light will light up when the TC Autoloader Selector Switch is in the TSO CONTROL position and the TSO's is in the NEUTRAL position.

Ammunition Select Panel

Purpose

The Ammunition Select Panel is used to select the ammunition the type.

Hardware Requirements

The Ammunition Select Panel (Figure A-3) consists of four (4) lighted push buttons, five (5) LED readouts, and a two (2) position toggle switch. The push buttons are called the Ammunition Select Buttons. They are labeled: SABOT, TYPE X, TYPE Y, and HEAT. For the current modification, only the HEAT and SABOT buttons must work.

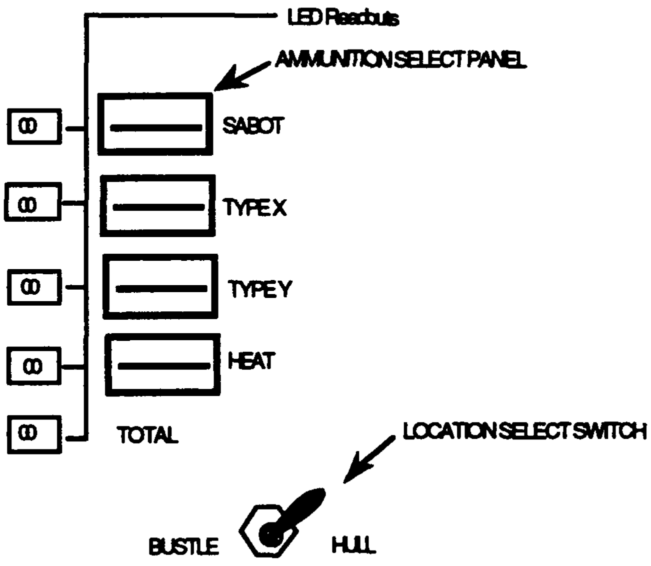

Figure A-3. Ammunition Select Panel

The buttons must have the capability to light up their top and bottom halves independently. When the desired ammunition is selected by depressing the button, the bottom half of the button will light up indicating that the ammunition has been selected. When the round is loaded, the top half of the button will light. If the round is subsequently unloaded, the top half will go dark.

These two part buttons provide indication to the crew regarding which rounds are loaded and selected.

After loading the round, a different ammunition type may be selected. This will cause the bottom half of the button for first type to go dark leaving the upper "loaded" half lit. The bottom half of the button for the new type will light. Only one type of ammunition may be selected at a time. Figure A-4 illustrates these various conditions.

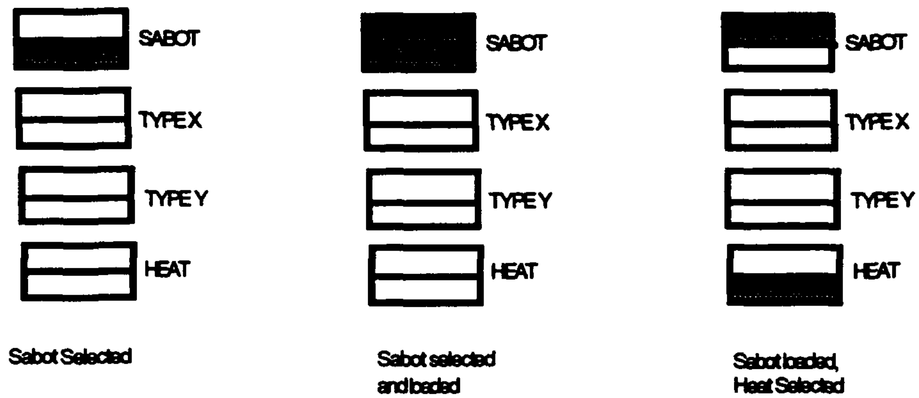

Figure A-4. Select and Load Indications for the Autoloader

Four of the five LED numerical readouts indicate the number of rounds for each of the four ammunition types. The fifth LED is for the total number of rounds on board respectively. The LEDs must display two digits and increment and decrement by one.

The two position switch is called the Location Select Switch and it has the following positions: BUSTLE or HULL. The switch position labels will illuminate when selected.

<u>Functional Requirements</u>

Selecting a round will cause the turret bustle to rotate the chosen type of round to the Loading Port. The bustle will have to rotate any time that a new type of round is selected, or after a round is rammed into the gun tube.

The Location Select Switch acts as an inventory switch in all modes. It causes the LED readouts on the Ammunition Select Panel to indicate the quantity of ammunition, by type, stored in the bustle or hull.

The LEDs display the number of rounds on hand in either the bustle or the hull depending on the position of the Location Select switch. As rounds are transferred or fired, the LEDs must increment or decrement appropriately.

Functional Specification

This section describes the integrated operation of the three TC station panels discussed above. The section is organized around the following autoloader operations:

Placing the autoloader into operation.
Putting the autoloader into Neutral.
Giving the TSO control of the autoloader.
Single round loading and firing the main gun.
Continuously loading and firing the main gun.
Transferring rounds from the hull to the bustle.

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 along with system performance times. Also included in subsections are the control settings, indications to the crew, and any alternate conditions and exceptions for each operation.

A summary of switch combinations for the operations are presented in Table 2-1. These are the only working combinations for the autoloader. If a different combination is attempted, no action will occur and an auditory warning will sound to the crew.

Table A-1

Summary of Control Actions by Procedure

	SWITCH POSITIONS BY SWITCH				
PROCEDURE	MODE	AUTOLOAD	AMMO	LOCATION	EXECUTE
Place into operation	any	any	any	any	no
Put in Safe	any	TC-TSO CNTRL TSO-NEUTRAL	any	any	no
Give TSO control	any	TC-TSO CNTRL TSO-any	any	any	no
Single round load & fire	AUTOLOAD	SINGLE	any	any	yes
Continuous load & fire	AUTOLOAD	CONTINUOUS	any	any	yes
Transfer hull to bustle	TRANSFER	SINGLE	type	any	yes

Placing the Autoloader Into Operation

Operating procedure.

In order for the autoloader to operate, it must be powered up. The autoloader is powered up when the Turret Power Switch is in the ON position. The autoloader will power up under any switch combination as long as the Turret Power Switch and the Master Battery on the TC control panel are on. The process flow for this operation is shown in Figure A-5.

Control settings.

Mode Selector	-Any
Autoloader Selector	-Any
Ammunition Selector	-Any
Location Select Switch	-Any
Execute Button	-NA

Indication.

o When the Turret Power Switch is turned on, all control panel lights will light and the LEDs will display "88" for five (5) seconds.

o After that, the positions that the selectors are in will light up.

o The LED readouts will show the number of rounds at the location indicated by the Location Selector Switch.

o The other control switches will illuminate the label for the current position of the switch.

Alternate conditions and exceptions.

None

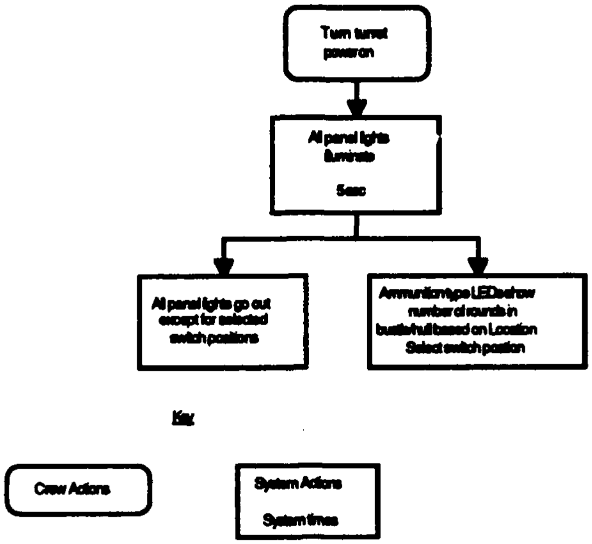

Figure A-5 Placing the Autoloader into Operation

Putting the Autoloader into Safe

Operating procedures.

Placing the TC Autoloader Select switch in TSO CONTROL and the TSO's in NEUTRAL will put the autoloader system in a safe condition. In addition, if the TC is in control and performing an operation, placing the switch in TSO CONTROL will stop the operation. The process flow for the operation is shown in Figure A-6.

Control action.

Mode Selector	-Any
Autoloader Selector	-TC - TSO CONTROL TSO - NEUTRAL
Ammunition Selector	-Any
Location Select Switch	-Any
Execute Button	-NA

Indication.

o The TSO CONTROL and NEUTRAL positions of the TC and TSO Autoloader Selectors, respectively, will be lit.

o The Autoloader Safe lights in both the TC and TSO stations will light.

o Any Ammunition Selection Buttons will be lit according to the status of the main gun.

o The LED readouts will show the number of rounds at the location indicated by the Location Select Switch.

o The other control switches will illuminate the label for the current position of the switch.

Alternate conditions and exceptions.

- Pressing the Execute Button will cause no action.

- Toggling the Location Select Switch will provide an inventory readout of the rounds in the hull and bustle.

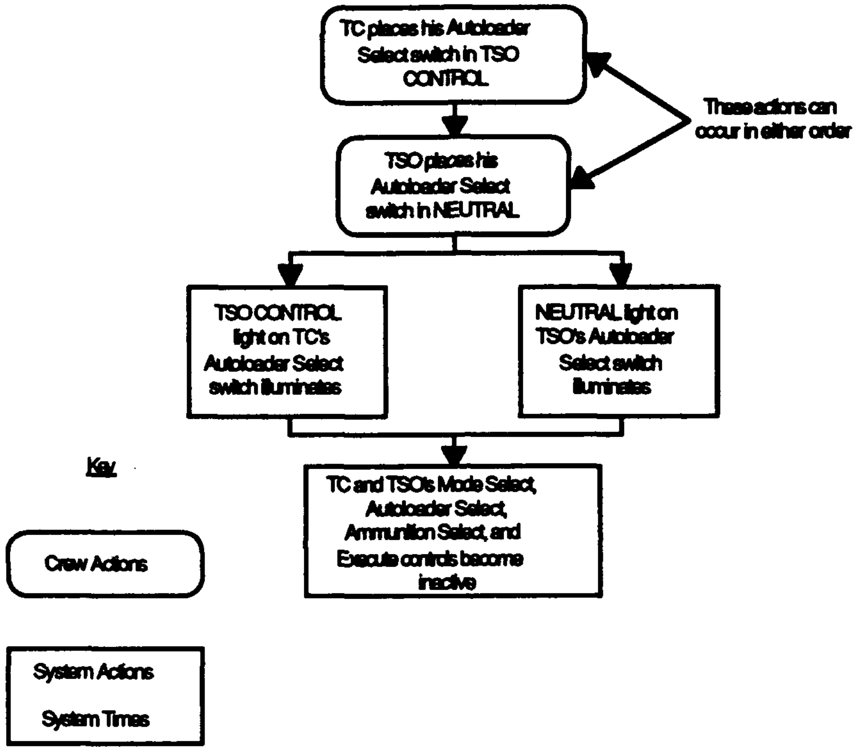

Figure A-6 Putting the Autoloader into Safe

Giving the TSO Control of the Autoloader

Operating procedures.

Placing the TC Autoloader Selector in the TSO CONTROL position will make the TSO station operational and disable the TC station. The process flow for the operation is shown in Figure A-7.

Control settings.

Mode Selector	-Any
Autoloader Selector	-TC - TSO CONTROL
Ammunition Selector	-Any
Location Select Switch	-Any
Execute Button	-NA

Indication.

o The TSO CONTROL position of the TC Autoloader Selector is lit.

o The TC Ammunition Select panel will only display the ammunition inventory with the toggling of the location select switch.

o The remaining TC indicators will go dark.

o The TSO control panel lights will illuminate consistent with the current positions of the selectors and switches.

Alternate conditions and exceptions.

- The TC pressing the Execute Button will cause no action.

- Toggling the Location Select Switch will provide an inventory readout of the rounds in the hull and bustle.

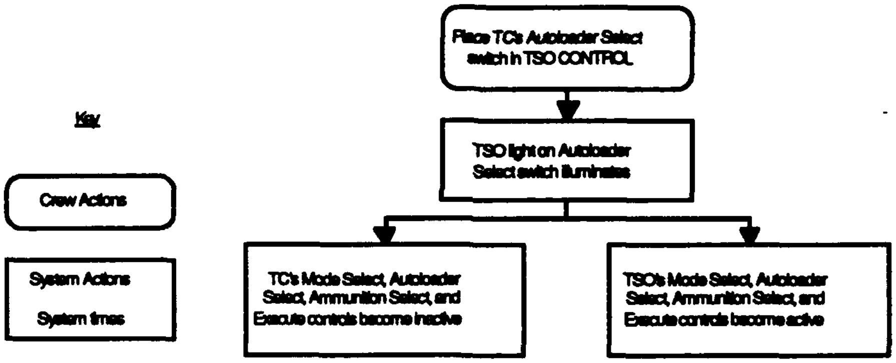

Figure A-7 Giving the TSO Control of the Autoloader

Single Round Loading and Firing the Main Gun

Operating procedures.

This operation allows the TC to select ammunition and fire the gun one round at a time. The autoloader will not load the next round until the TC activates it. The process flow for this operation is shown in Figures A-8 and A-9.

Control settings.

Mode Selector	-AUTOLOADER
Autoloader Selector	-SINGLE
Ammunition Selector	-Any
Location Select Switch	-Any
Execute Button	-PUSHED

Indication.

o The AUTOLOADER position of the Mode Selector is lit.

o The SINGLE position of the Autoloader Selector is lit.

o The Ammunition Select Button of the selected ammunition is lit.

o The LED readouts will show the number of rounds at the location indicated by the Location Selector Switch. The LED readouts of the selected ammunition will decrement as each round is fired.

o The Location Select Switch will be lit with either HULL or BUSTLE depending on the position of the switch.

Alternate conditions and exceptions.

- The selected round will already be at the ram position when selected.

- The Execute Button must be pushed each time for the selected ammunition to be loaded.

- Toggling the Location Selector Switch will only cause the ammunition readouts on the Ammunition Control to reflect the current inventory of rounds in the hull or bustle.

- When only one round of the selected type is remaining in the bustle, an auditory warning will be given to the crew.

- If the TC or TSO desire to load the last round, the execute button must be pushed again.

- When the last round is loaded, the last round warning must continue until another type of round is selected.

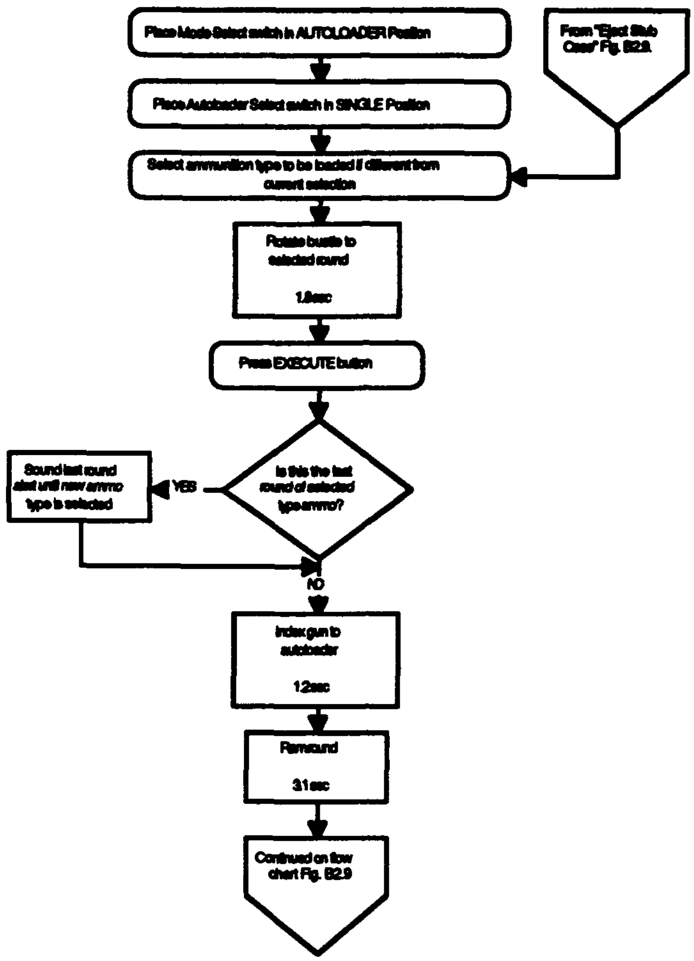

Figure A-8 Single Round Loading and Firing the Main Gun

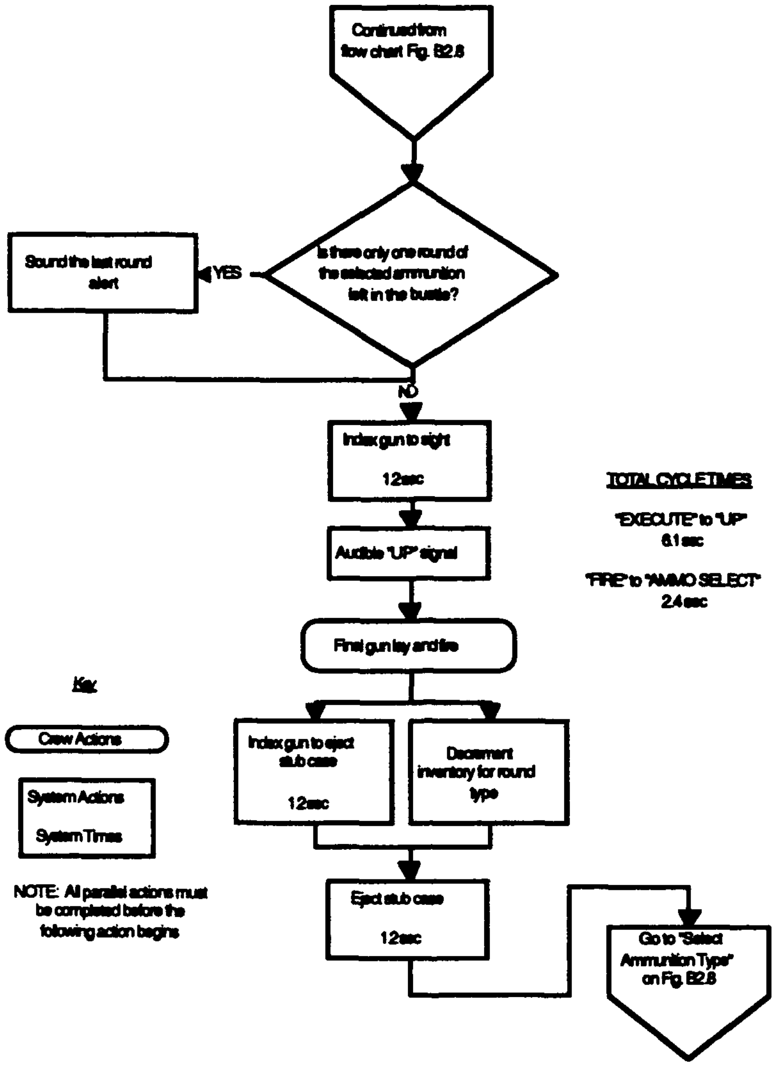

Figure A-9 Single Round Loading and Firing the Main Gun (cont.)

Continuously Loading and Firing the Main Gun

Operating procedures.

This operation allows the TC to continuously fire the main gun by having the autoloader automatically load the selected round immediately after the gun is fired. The process flow for this operation is shown in Figures A-10 and A-11.

Control action.

Mode Selector	-AUTOLOADER
Autoloader Selector	-CONTINUOUS
Ammunition Selector	-Any
Location Select Switch	-Any
Execute Button	-PUSHED to initiate only

Indication.

o The AUTOLOADER position of the Mode Selector will be lit.

o The CONTINUOUS position of the Autoloader Selector will be lit.

o The Ammunition Button of the selected ammunition will be lit.

o The LED readouts will show the number of rounds at the location indicated by the Location Selector Switch. The LED readouts of the selected ammunition will decrement as each round is fired.

o The Location Select Switch will be lit with either HULL or BUSTLE depending on the position of the switch.

Alternate conditions and exceptions.

- The Execute Button must be pushed the first time to load the round.

- Pressing the Execute button after the initial time will cause no action to occur.

- Toggling the Location Selector Switch will only cause the ammunition readouts on the Ammunition Control to reflect the current inventory of rounds in the hull or bustle.

- When only one round of the selected type is remaining in the bustle, an auditory warning will be given to the crew.

- If the TC or TSO desire to load the last round, the execute button must be pushed again.

- When the last round is loaded, the last round warning must continue until another type of round is selected. When the next type of round is selected, it will automatically load and the crew can continue to fire.

- If a new round type is selected, it will be loaded after the current round is fired.

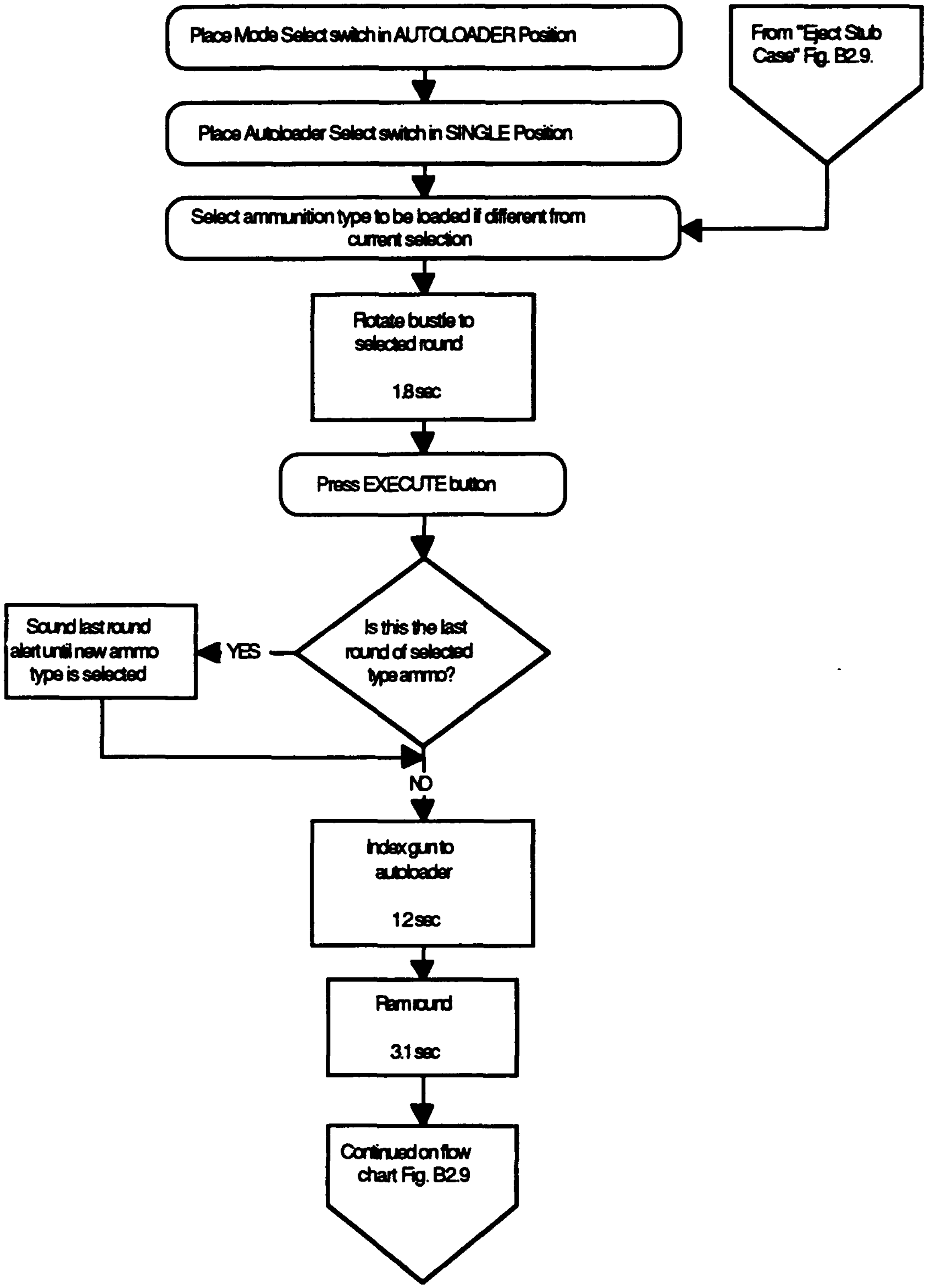

Figure A-10 Continuously Loading and Firing the Main Gun

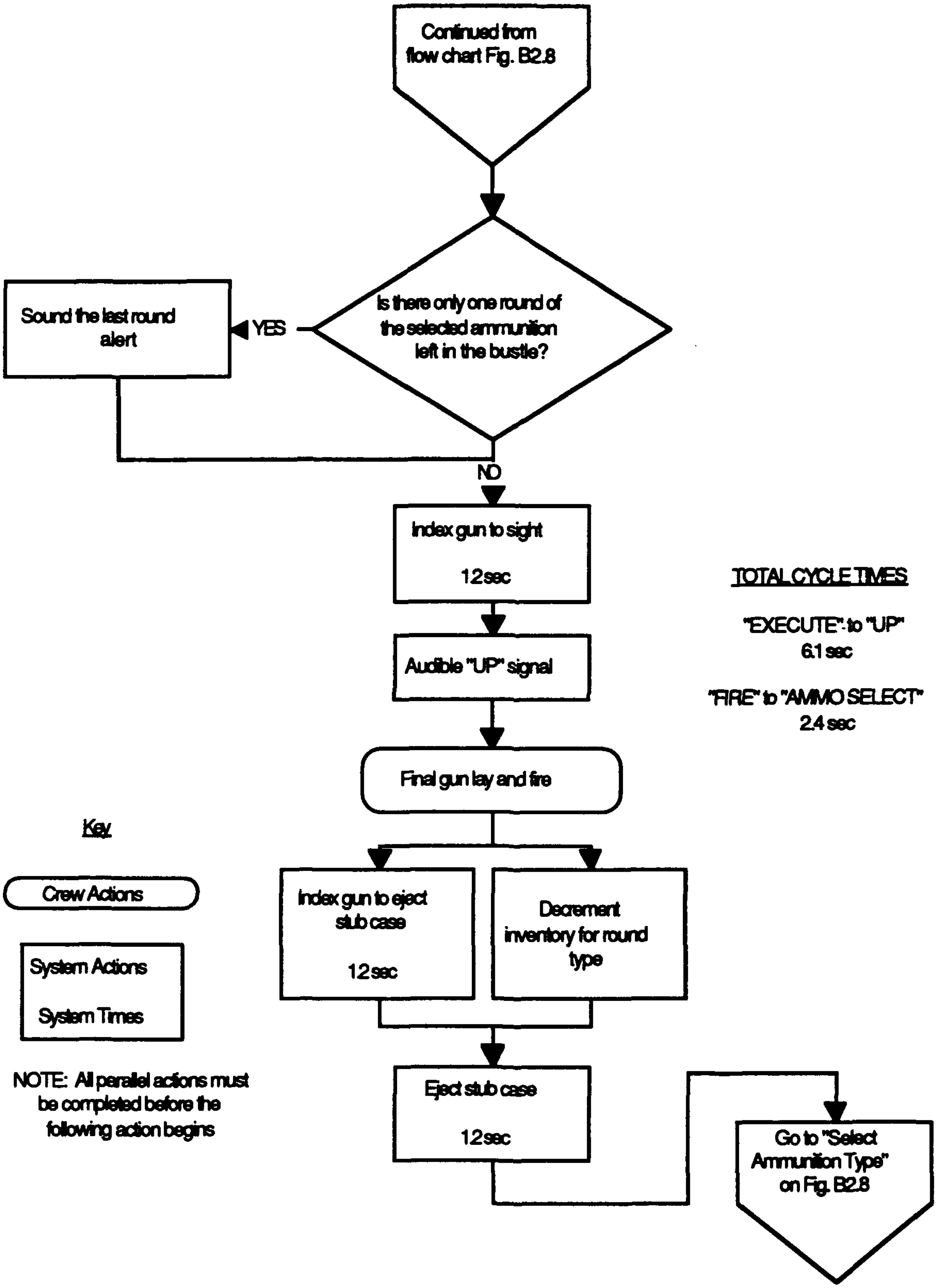

Figure A-11 Continuously Loading and Firing the Main Gun (cont.)

Transferring Rounds from the Hull to the Bustle

Operating procedures.

This operation allows the TC to transfer rounds from the hull to the bustle in order to maintain a ready-to-fight condition. Once in the bustle, rounds cannot be transferred back to the hull. The process flow for this operation is shown in Figures A-12 and A-13.

Control settings.

Mode Selector	-TRANSFER
Autoloader Selector	-SINGLE
Ammunition Selector	-Type ammunition to be transferred
Location Select Switch	-Any
Execute Button	-PUSHED

Indication.

- The TRANSFER position of the Mode Selector is lit.

- The SINGLE position of the Autoloader Selector is lit.

- The Ammunition Select Button of the selected ammunition is lit.

- The LED readouts will show the number of rounds at the location indicated by the Location Selector Switch. The Hull LED readouts will decrement while the Bustle readouts will increment as rounds are transferred.

- The Location Select Switch will be lit with either HULL or BUSTLE depending on the position of the switch.

Alternate conditions and exceptions.

\- The process is repeated as long as there are rounds of the type selected in the hull, there are two or more empty round canisters in the bustle, and the Execute Button is pushed. The auditory signal for non-functional control actions will sound when any of these conditions are reached. At least one canister in the bustle will remain empty at all times.

\- Toggling the Location Selector Switch will only cause the ammunition readouts on the Ammunition Control to reflect the current inventory of rounds in the hull or bustle.

\- Placing the Autoloader Selector in the CONTINUOUS, UNLOAD, or MISFIRE position causes no action to occur.

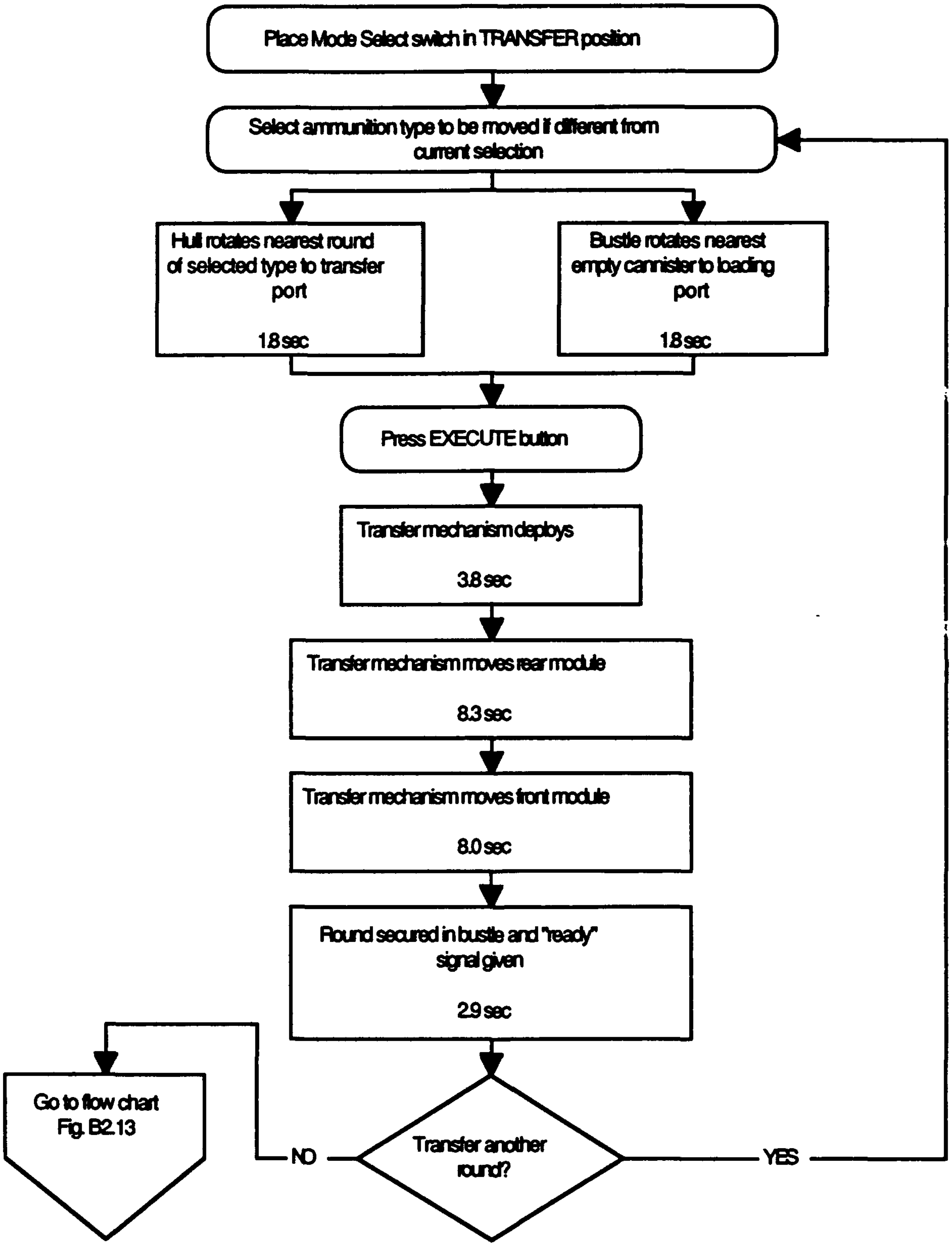

Figure A-12 Transferring Rounds from the Hull to the Bustle

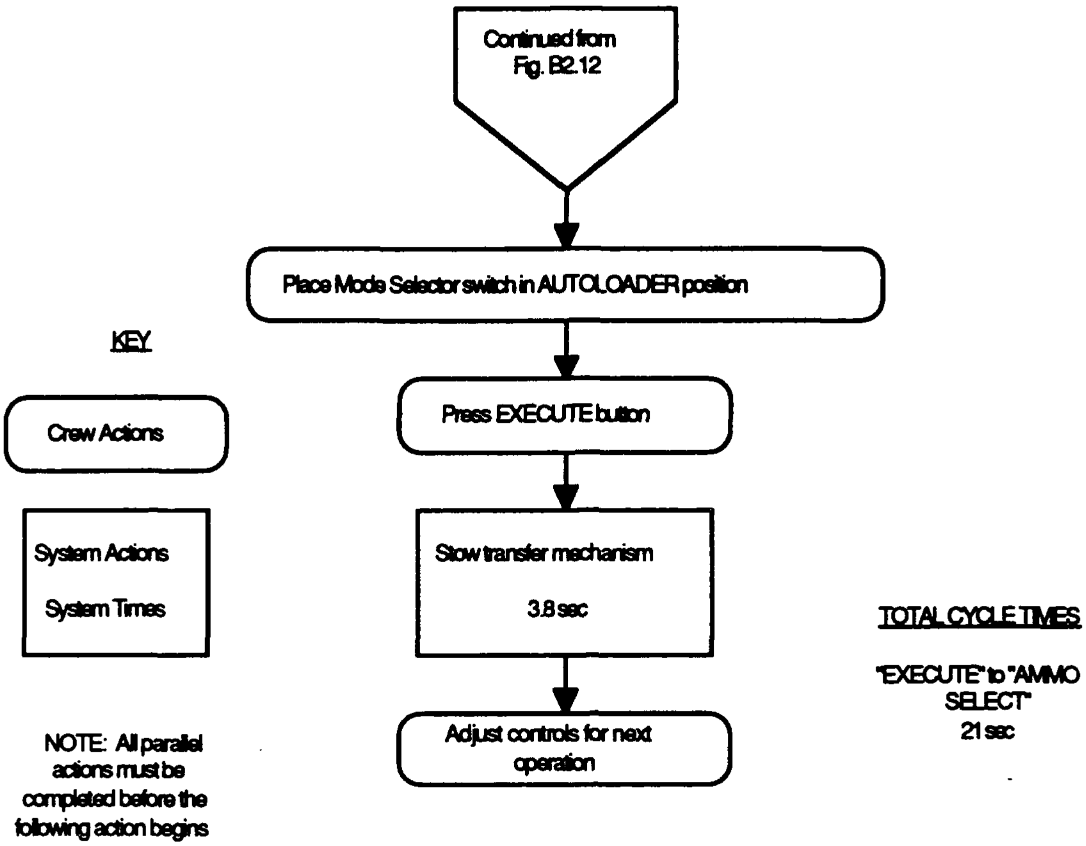

Figure A-13 Transferring Rounds from the Hull to the Bustle (cont.)

TSO Station Specification

The TSO station will change to include the addition of the panels in Figures 2.1, 3.1, 4.1, and 4.2 of the reconfigurable specification. The changes include the addition of the Autoloader Select Panel, Ammunition Select Panel, and the Mode Select Panel.

Mode Select Panel

Purpose

See Tank Commander's Mode Select Panel.

Hardware Requirements

The TSO Mode Select Panel is the same as the TC panel. The Mode Selector has the AUTOLOADER and TRANSFER modes. This selector must also have a lockout feature similar to the TC's.

Functional Requirements

These are the same as the TC's.

Autoloader Select Panel

Purpose

See TC Autoloader Select Panel.

Hardware Requirements

The TSO Autoloader Select Panel is identical to the TC's except that the TSO CONTROL position is the NEUTRAL position on the TSO panel.

Functional Requirements

The functional requirements are the same as the TC's.

Ammunition Select Panel

Purpose

See TC Ammunition Select Panel.

Hardware Requirements

The TSO Ammunition Selector is identical to the TC's.

Functional Requirements

The functional requirements are the same as the TC's.

Functional Specification

The functional specifications for the integration of the TSO panels are the same as the TC panels. As stated earlier, the TSO panels are active when the TC Autoloader Selector is in the TSO CONTROL position. If it is not in this position, then the TSO panels will not work.

Although only the TC or TSO control panels may be active, the TC and TSO must know what the status of the main gun is at all times. When the TC is in control, the TSO controls and displays should be in the following conditions:

- The indicators for the Ammunition Select panel must be active. All other indicators should be dark. The only exception would be the NEUTRAL indicator if the switch is in that position.

- The only operational control actions will be movement of the Location Select switch and placing the Autoloader Select switch in NEUTRAL.

The same conditions go into effect for the TC station when the TC Autoloader Select switch is placed in TSO CONTROL.

Integration

As stated in the introduction, the autoloader is part of a suite of modifications to be incorporated into the simulator. The autoloader is not an independent system within the simulator, but rather a subsystem of a set of systems. Therefore, the autoloader must integrate with or pass information to different systems within the simulator. The systems that it integrates with are the CVCC system (CCD) and the fire control system. Currently, there is no integration required between the autoloader and the CITV.

CVCC

The autoloader must be integrated with the CVCC system through the Ammunition Select Panel. The sensors that determine the number of rounds, by type, and display this information using the LED readouts must also be tied into the CCD. The bustle and hull sensors must send their round inventory data to the CCD whenever the TC calls up the Log Report. The CCD must aggregate the data by ammunition type. Then, using its built-in status computing algorithms, the CCD automatically fills in the main gun ammunition status with its Green, Amber, Red, or Black designators.

Fire Control System

The autoloader must also be integrated with the fire control system's ballistic computer through the Ammunition Select Panel. When an ammunition type is selected (only HEAT and SABOT are currently required to be operational), the type selected is indexed into the ballistic computer. The ballistic computer then computes the correct firing solution to the target.

The autoloader must also integrate with the firing circuitry of the Fire Control System. Whenever the Transfer Mechanism is deployed, the gun is indexed to eject or load a shell, or the autoloader is ramming a round, the firing circuitry must be disabled so that the main gun cannot fire.

Auditory Signals

There are three (3) auditory signals associated with the autoloader. They are for informing the crew of an erroneous switch combination, the loader's "up", and the last round alert. Auditory signals will come over the TC and TSO intercom headphone.

The erroneous switch combination signal is sounded when the crew attempts to initiate a switch combination that performs no action. The sound be must loud and distinctive enough to get the crew's attention and cause them to check their switch positions.

The loader's "up" is sounded after a round is loaded and indicates that the gun is ready to fire. The sound should be loud enough to be heard and distinct. It notifies the crew that the autoloader has loaded a round, the gun is in a "fire" condition, and the gun has returned to the sight.

The last round alert is for informing the crew that there is only one round of the type currently selected in the bustle. The sound should be an oscillating signal lasting 3 seconds. The alert will sound continuously after the last round is loaded until a new ammunition type is selected. The alert will also sound continuously when an ammunition type with no rounds in the bustle is selected.

System Sounds

Table A-2 presents the system actions which require accompanying sounds. Most of these sounds may be obtained from the prototype system developed at the Binet labs.

Table A-2

System Actions Requiring Sounds

Index gun to eject stub case
Eject stub case
Index gun to autoloader
Index gun to sight

Ram round

Rotate bustle - 1 to 8 rounds
Rotate bustle between rearm and load ports

Rotate hull front module carriage - 1 to 11 rounds
Rotate hull rear module carriage - 1 to 11 rounds

Deploy transfer mechanism
Stow transfer mechanism

Transfer front module from hull to bustle
Transfer rear module from hull to bustle

Stow and connect front and rear modules in bustle after transfer

Appearance

The outward appearance of the tank will not change within the CCTB environment as a result of the autoloader. The only change to the appearance will be to show the indexing of the gun for loading.

Damage and Failure

There will be no changes to the combat damage calculations. At this time, failure rates for the autoloader will not be played in the simulation. It will be assumed to be completely reliable.

Semi-Automated Forces Modifications

The only modifications to the semi-automated forces will be in their engagement rates and reload times. The following table describes those rates:

Action	Time
Engage Targets	10 Rounds per Minute Maximum
Upload Tanks	4 Rounds per Minute Maximum
Transfer Ammunition	4 Rounds per Minute Maximum

The Semi-automated tanks will have to transfer ammunition at least after firing their bustle ammunition (17 rounds), or after firing all of one type of ammunition when the bustle is expended.

The semi-automated forces must be at a halt whenever they want to transfer ammunition or upload additional ammunition. The semi-automated tanks can also hold only 39 rounds.

Combat Support Workstations

No modifications required.

Combat Service Support Workstations

No modifications required.

Opposing Force Workstations

No modifications required.

Data Collection and Analysis Systems

The simulator will need to be instrumented to record the autoloader switch positions each time the Execute Button is pressed. As a minimum, a time stamp should also be recorded along with the switch positions. Data should be reduced to present time lines and frequency counts for each of the switch position combinations.

Acceptance Test Criteria

The functions of loading and transferring will be tested prior to product acceptance. These will be performed on all modified simulators. 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 analysis systems will be evaluated using dummy data.

Summary

This section has provided detailed specifications for integrating an autoloader into the reconfigurable simulators. It has included modifications to crew stations, functional characteristics and performance parameters, modifications to related CCTB systems, and acceptance criteria.

APPENDIX B

"UNMOUSE" OR CONTROL TABLET

The UnMouse is a compact, touch-sensitive tablet used for cursor control, graphic input, and function key selection. It works by just touching the 3 inch by 4.5 inch glass tablet with a finger or conductive stylus. It is an absolute pointing device, meaning that its touch points map directly to corresponding points on the display. While the resolution is 1,000 by 1,000 touch points, the unit averages out the entire area of contact to a single point giving pixel-by-pixel control with a finger.

The touch tablet employs analog capacitive touch-sensing technology to detect a finger's touch and functions much like a MicroTouch touch screen. Beneath the sensor is an analog microswitch which emulates the mouse button. By pressing harder anywhere on the glass, this switch is activated once a pre-set force threshold is reached. The microswitch may also be activated by pressing on the top of the UnMouse frame allowing easy clicking if the cursor location doesn't have to change. Dragging is performed by clicking and sliding.

A second button is located to the left of the tablet. Pressing this button switches the unit to function key mode for a set time allowing a function to be selected form templates placed under the glass. Up to five templates may be stored in the template holder.

Drawing is done using the UnMouse's stylus or any mechanical pencil that has a conductive metal shaft. Tracing may be done by inserting an image into the template holder and drawing over it.

Custom OEM versions of the UnMouse are available for integration into keyboards and portable computers. Custom features include different size sensors, software adapted to a specific graphical interface, and specific controller interfaces.

UnMouse Specifications

<u>General</u>

Main Components	Glass tablet, controller box, power supply
Peripheral Components	Stylus, templates, driver software
Sensing Technology	Analog Capacitive Sensing
Touch Screen Resolution	1,000 touch points per axis within calibrated zone. (approximately 330 ppi along Y axis, 250 ppi along X axis)

Conversion Speed	60 touch points per second
Interface	Communicates over Apple Desktop Bus(ADB), (PC version available in third quarter '89. Custom versions also available.)

Physical Description

Tablet dimensions	Active area 3 x 4.5 inches with 0.5 inch border. Height .56 inches.
Sensor Construction	1/8 inch glass with transparent resistive coating on surface.
Controller Box Dimensions	6.63 x 6.13 inches; 1.25 inch clearance height. (more compact, low power, ASIC controller available in fourth quarter '89.)
Cable length	3 feet from sensor to controller; 2.66 feet from controller to ADB connector.
Stylus	Pencil sized; plastic construction.

Macintosh Driver

Macintosh Driver	Automatically installs from distributed boot-up disk. Compatible with all Mac software.
Control Panel	Allows for calibration and setting of activation force for microswitch.
Function Keypad	Activated for 1.5 seconds after pressing red button.
Templates	Preprinted templates available for Word, Excel, Word Perfect, MacPaint and MacDraw. Blank templates included with template creation software.
Dragging	Done by clicking and sliding. Once driver has detected a lateral movement, user may let up on analog microswitch, and dragging will still occur as long as contact with glass is maintained. Feature permits dragging with minimal pressure.
Calibration	Routine accessed from control panel. Calibration is done by touching two corners of the screen. EEPROM on

controller automatically stores calibration values.

Operations

Mouse Button Emulation	Analog microswitch activated by pressing on glass.
Microswitch	Maximum activation pressure variation 2x across sensor. Microswitch also activated by pressing on top of UnMouse bezel.
Drawing	Done with supplied UnMouse stylus or mechanical pencil with conductive sheath.
Tracing	Place image in template holder. Use stylus to trace over lines.
Cleaning	Water, isopropyl alcohol, Windex or any glass cleaners may be used.

Reliability/Environmental

MTBF	Greater than 80,000 hours (per MIL-Handbook-217D).
Surface Durability	Cannot be scratched by stylus with Mohs rating of less than 7 (hardness of glass).
Touch life	Greater than 7 million touches in any one location.
Contaminants	Sensing not effected by grease, dirt buildup, or moisture.
Operating Temperature Range	Controller board: 0 to 55 degrees C. Tablet: -15 to 70 degrees C.