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An Interactive Training Device Using a Laser Video Disc

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AN INTERACTIVE TRAINING DEVICE USING A LASER VIDEO DISC

BY

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ABSTRACT

The goal of this paper is to develop an interactive training system. Although the system developed was used to train tank gunners, the system concepts are generic in that they can be applied to many training scenarios.

Applications of computer-based training systems are briefly discussed. The system concepts are defined and hardware and software subsystems are outlined. An architectural overview will precede a detailed discussion of subsystems.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Traditionally, users of large equipment or special-purpose vehicles had to be trained using actual equipment. This could be extremely costly in fuel costs, operating costs, and equipment costs. The first attempt at interactive training was with simulators using real-time computer-generated imagery for visuals. As the CIG (Computer Image Generation) systems became more sophisticated and therefore more costly, a need arose to develop a low-cost alternative for interactive training. Each low-cost system generally can train the user only for a single function whereas the more sophisticated systems can train many individuals in several areas.

This paper deals with an approach to interactive training. A goal of this project was to develop a low-cost alternative to simulators using computer image generation. Chapter 1 will present an overview of training systems along with project goals. Chapter 2 will present a system overview. Chapter 3 discusses hardware subsystems while Chapter 4 presents the software drivers. Finally, Chapter 5 will present project conclusions.

CHAPTER I

BASIC SYSTEM IDEALS AND GOALS

Computer Aided Learning And Education

The education market presents the largest initial opportunity for video disc applications. According to a commonly used statistical data, student´s retention of the material taught is approximately:

- o 10% of what they hear
- o 20% of what they see
- o 30% of what they see and hear
- o 60% of what they see, hear, and do

Laser video disk systems offer the highest degree of interaction of any machine delivering learning material. Interactive, multimedia, self-pacing instruction has long been identified as a powerful learning technology in terms of impact, retention, and speed for teaching most adult/business subjects. It can replace manuals, meetings, seminars, memos, and classrooms which are not the best solution for managerial development.

A training device provides individuals with the opportunity to self-pace and repeat trips through a subject. Furthermore, users gain the key advantage of achieving consistency over time. Courseware material delivered via the laser video disc is not subject to variations in quality and content found in materials delivered live by trainers.

Development Of Project Goals

The goal of this paper is to develop a low cost interactive training device using commercially available hardware. The development of the software necessary to control the system will be outlined.

The system concepts and architecture are generic so that many training enviroments could use the system. The concepts were applied to a part-task trainer to determine if they were feasible. Therefore, some areas, such as user input, will be specific to this application.

CHAPTER II

SYSTEM CONCEPTS

The training device shall instruct an individual to perform a specific action by allowing him or her to perform the actual action in a simulated environment. The simulated environment will provide input to the system as would be found in the real environment, such as input switches and control joysticks, and will provide output to the user in the form of actual sounds and visuals. In this system, the environment cues, both visual and aural, will mostly come from the laser video disc player. However, visual or audio which is dependent on the user's action will be created and mixed into the video or audio coming from the disc player.

The training ability will be limited to pre-defined training scenarios. The computer will be able to anticipate the user's correct response to the given cues. The computer will grade the user's performance and inform the user of the grade.

Any anticipated motion through the database will be pre-recorded on the laser video disc. If the user does not enter the correct motion, the system must correct for this. Even though the images are pre-recorded, a user must perceive motion. This is achieved by allowing the user to view only a small window of the video and then moving the video behind the window.

There will be an alphanumeric display and keypad which will be the main form of communication between the user and the computer. The computer will display a main menu to the user. From this menu, the user can use a keypad to choose between an exercise menu, a calibration menu, a scoring menu, or a trainer reset. From the exercise menu, a user can use the keypad to select an exercise which will consist of a predetermined set of related situations, start an exercise if one has been selected, or return to the main menu. From the scoring menu, the user can return to the main menu, select to see a summary of his scores from each situation of the last exercise, or select to see situation scores from the last exercise in a specific area.

Once an exercise is started, the trainer will progress through a pre-determined set of situations. After each situation, the trainer will display the user's score for that situation before continuing with the next situation.

Each exercise will entail varying levels of difficulty. Each situation within an exercise shall be of similar difficulty. By mastering each exercise, the student will achieve another level of proficiency.

Functional Descriptions

The system can be divided into several functional areas. They are:

1. Main Control Processor
2. Device Simulator
3. Visual Simulator Subsystem
    a. Laser Video Disc Player

b. Graphics Generator

c. Video Shifter

4. Mass Storage Media

5. User Input Devices

6. Aural Cues

Each of the functional areas will be discussed in the following paragraphs.

Main Control Processor

The main control processor will handle all interfaces between the user and the trainer device and all interfaces and communications between the various functional areas of the trainer. The main control processor will control the sequence of events necessary to complete a training exercise. This includes handling communications between the user's inputs and the simulator, controlling the laser video disc player, controlling the real-time graphics generation and sounds for explosions, transferring data from the mass storage media to the aural subsystem and device simulator, generating the menus and responding to the user's reactions to the menus.

Device Simulator

The device simulator is a single-board micro-computer which will simulate the dynamics of the own-vehicle and the the reactions of the vehicle to the user's inputs. It will also simulate the effects of the user inputs on the real-world environment.

The device simulator will do all the real-time floating point operations. For this application, this includes all the ballistic calculations for the ammunition fired and all motions relating to the gun turret dynamics.

Visual Simulator Subsystem

The visual simulator subsystem will be the major contributor to the user's perception of real world environment. The visuals will respond to the motion inputs of the student, and will show the user the results of his actions. For example, it will generate the image of an explosion when the user fires the gun.

The visuals will also provide a reticle, or cross-hair, to show the user where the gun is aiming.

The visual subsystem must combine the prerecorded video signal coming from the laser video disc player with the real-time video signal coming from the graphics generator.

The visual portion of the trainer shall consist of a laser video disc player, a graphics generator, a video mixer, a video shifter, a reticle generator, a video display device, and an optical system.

Mass Storage Media

The mass storage media used in this device was single-sided single-density flexible diskettes. The subsystem will include the diskettes, the disk drive, and the drive controller. The mass storage is used to store database information. This database contains the position coordinates (x, y, z, and velocity) for the own-vehicle and for all targets. This information is recorded for every active video disc frame. The exercise control information and digitized real time sounds are also stored on the flexible diskettes.

User Input Devices

The user input devices are one area which will be user-specific. For the part-task trainer, the user input devices consist of a panel and control joysticks. The panel contains switches which will inform the computer which ammunition and gun the user has selected to set up the exercise. These include ammunition selection, gun selection, sight selection, and fire control mode. The control joysticks will provide the user the capability to move the the gun turret in a horizontal and/or vertical direction. The control joysticks also contain the trigger which will allow the trainee to shoot at targets.

Aural Cues

The aural cues subsystem will generate real-time sound effects. Sounds are digitized and stored on a flexible diskette. During initialization, the sound information is copied from the sound files on the flexible diskette to the aural cues local memory. When it becomes necessary to produce a sound, the aural subsystem will generate the digitized sound.

System Block Diagram

The block diagram of the system appears in Figure 1.

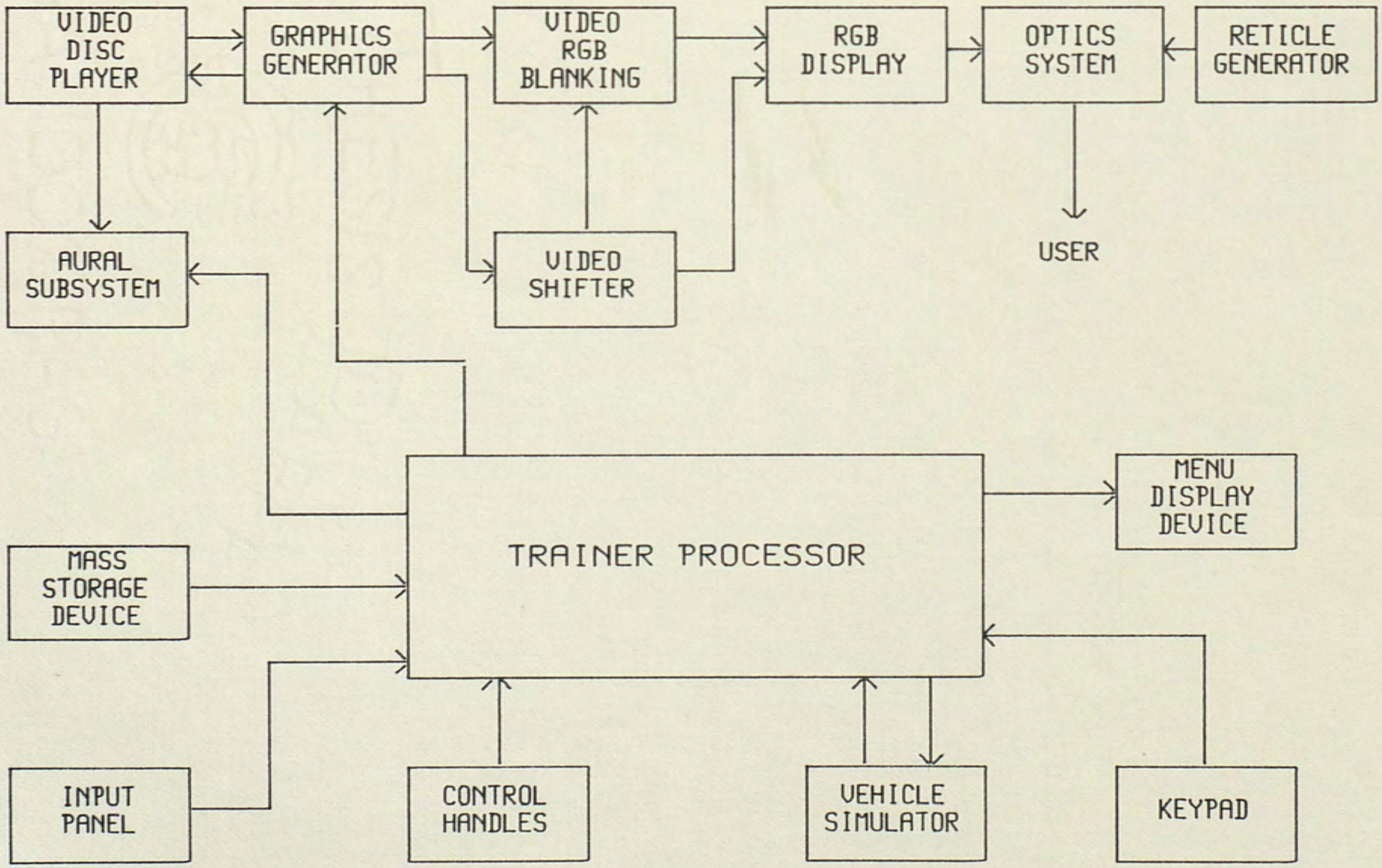

Figure 1 System Block Diagram

CHAPTER III

HARDWARE DESCRIPTION

Architectural Overviews

The part-task training device is a microprocessor-based system. A block diagram of the hardware system is shown in Figure 2. The system consists of a processor subsystem, a flexible diskette controller, a sound board, a graphics generation board, a video shifter/ mixer board, and an input/output expander board.

The main control processor communicates with the remaining boards in the system by way of a standard bus (Intel Multibus or equivalent).

Main Control Computer Subsystem

The main control computer shall be an Intel iSBC 86/30 Single Board Computer. The iSBC 86/30 provides a complete computer system that is designed around a 16-bit 8086-2 microprocessor. The clock rate on the board will be 8 MHz. The iSBC 86/30 provides a maximum of 256k bytes of dynamic dual port RAM (Random Access

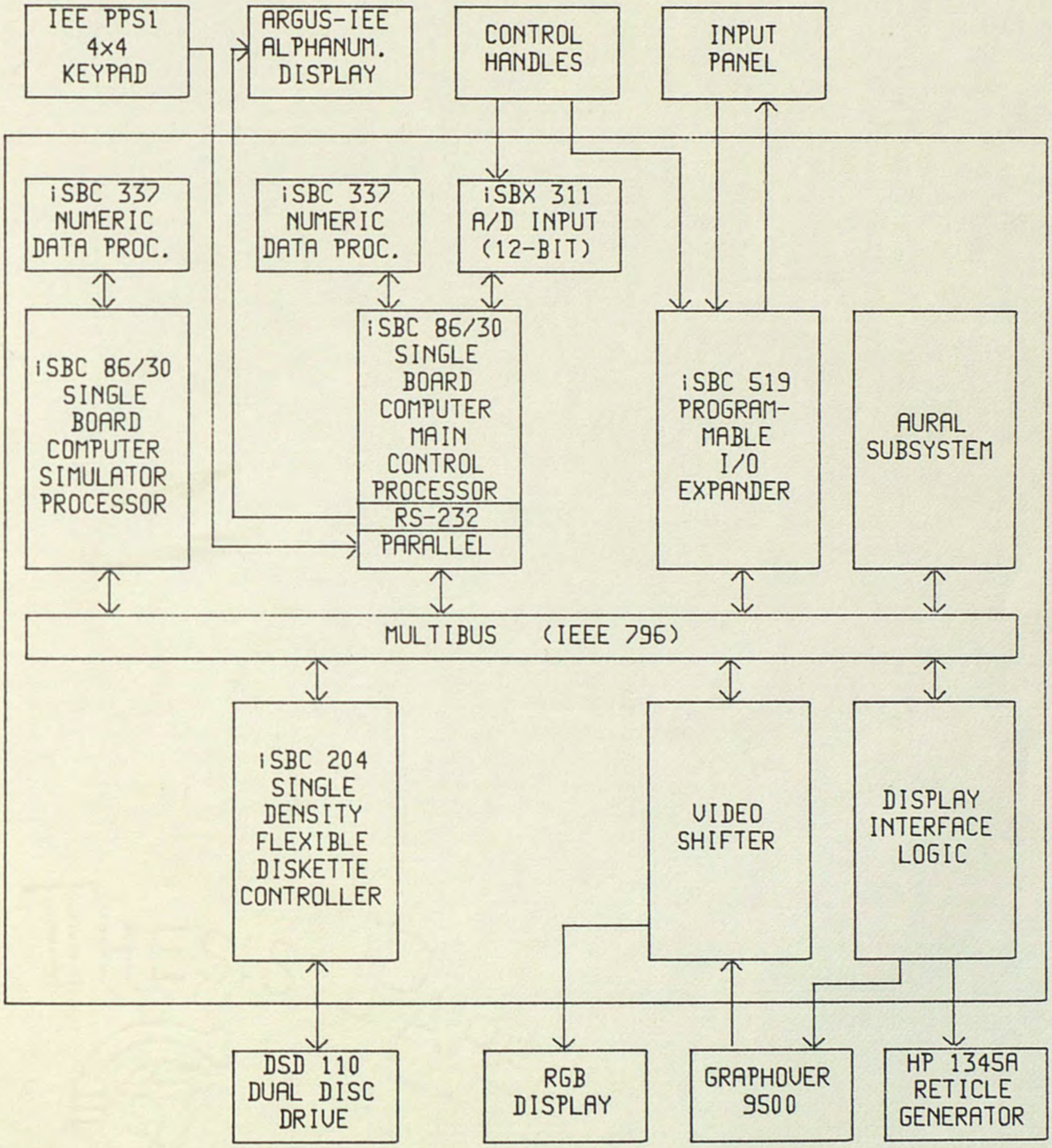

FIGURE 2: Board Level Block Diagram

Memory) and 64k bytes of EPROM (Erasable, Programmable Read Only Memory). The iSBC 86/30 also provides 24 programmable parallel I/O lines via an 8255A Programmable Peripheral Interface (PPI), nine levels of interrupt priority via an 8259A Programmable Interrupt Controller (PIC), one serial I/O port via an 8251A Programmable Communications Interface (PCI), and a baud rate controller via an 8253-5 Programmable Interface Timer (PIT). The 86/30 uses an internal bus for on-board memory and I/O operations and a Multibus interface for all off-board operations. An Intel iSBC 337 Numeric Data Processor shall be added to the board to allow floating point operations.

Simulator Computer Subsystem

The main control computer shall be an Intel iSBC 86/30 Single Board Computer. An Intel iSBC 337 Numeric Data Processor shall be added to the board to allow floating point operations.

Mass Media Subsystem

The mass media subsystem consists of a dual single-density flexible diskette drive and a Intel iSBC 204 Flexible Diskette Controller board. The main controller processor will provide all information for a data transfer when necessary. The interface then performs all required drive positioning and takes control of the bus when needed for data transfer.

The flexible diskette drive is a Data Systems Design Model Number 110/430.

User's Input/Output Interface

The user's I/O interface consists of a user's panel of switches and indicator lights, the trainee's control joysticks, an Intel iSBC 519 Programmable I/O Expansion Board, and an Intel iSBX 331 Analog/Digital Input Board.

The iSBC 519 board provides up to 72 I/O lines via three 8255A PPI's which can be configured by software in various combinations of unidirectional I/O and bi-directional lines. The iSBX 331 board provides eight analog-to-digital channels for analog inputs.

The trainee's panel contains four functional 3-position switches, two 2-position switches, and one 4-position switch. There are 12 indicator lights. These switches and lights require 26 discrete I/O lines. The trainee's control joystick has an additional three discrete input lines for the trigger, palm switch, and range finder. These discrete lines enter the computer subsystem through the iSBC 519 board. The discrete I/O lines are noted in Table 1.

The trainee's control joystick also provides two -5 volt to +5 volt analog signals. These signals are converted to digital signals in the iSBC 339 Analog/ Digital I/O Board.

Graphics Generator Subsystem

The graphics generation subsystem consists of a New Media Graphics GraphOver 9500. The GraphOver 9500 generates and overlays high resolution bit-mapped color graphics or text over the video signal from a National Television Standards Committee (NTSC) color video source. The GraphOver's video circuitry is optimized for use with laser video disc players.

TABLE 1
DISCRETE INPUT/OUTPUT DEFINITION

Discrete I/O	Board	Bit	
Inputs			
Spare	isbc519	0	
Gunner's Power Palm Switch	isbc519	1	
Gunner's Power Laser Switch	isbc519	2	
Gunner's Power Handle Trigger	isbc519	3	
Gun Select Coax	isbc519	4	
Gun Select Main	isbc519	5	
Spare	isbc519	6	
Spare	isbc519	7	
Fire Control Mode Switch Norm	isbc519	0	
Fire Control Mode Switch Emer	isbc519	1	
Ammo Select HEAT	isbc519	2	
Ammo Select HEP	isbc519	3	
Ammo Select BH	isbc519	4	
Ammo Select SABOT	isbc519	5	
Spare	isbc519	6	
Spare	isbc519	7	
Thermal Mag 3X/10X	isbc519	0	1 = 10x
GPS Mag 3X/10X	isbc519	1	1 = 10x
GPS Shutter	isbc519	2	
GPS Filter	isbc519	3	
Thermal Mode On	isbc519	4	
Thermal Mode Off	isbc519	5	
Spare	isbc519	6	
Spare	isbc519	7	

TABLE 1 -- CONTINUED

Discrete I/O	Board	Bit
Outputs		
DS1 Fire Cont Emer	isbc519	0
DS2 Fire Cont Norm	isbc519	1
DS3 Fire Cont Manual	isbc519	2
DS4 TRU Ready	isbc519	3
DS5 TIS Fault	isbc519	4
DS6 Ammo Select SABOT	isbc519	5
DS7 Ammo Select HEP	isbc519	6
DS8 Ammo Select BH	isbc519	7
DS9 Ammo Select HEAT	isbc519	0
DS10 Gun Select MAIN	isbc519	1
DS11 Gun Select TRIG SAFE	isbc519	2
DS12 Gun Select COAX	isbc519	3
Spare	isbc519	4
Spare	isbc519	5
Spare	isbc519	6
Spare	isbc519	7

The GraphOver 9500 communicates with the main control processor across the Multibus through an 8-bit parallel interface. The GraphOver 9500 also provide a 30 Hz signal that is used to interrupt the main control processor and the simulator processor signaling the beginning of a new processing cycle.

Reticle Generator Subsystem

The reticle generator is separate from the graphics generator because the resolution of a cathode ray tube (CRT) display device is not sufficient. The device used to generate the reticle is a Hewlett-Packard 1345A Digital Display Module. It produces vector graphics on its display screen in response to digital commands from the main control processor. It is a high resolution, 2048 x 2048 addressable points, random refresh device.

Video Shifter Subsystem

The Video Shifter Module is a single board design which provides the capability of moving a NTSC composite video signal horizontally or vertically on a screen. The Video Shifter Module also blanks the video so that the display intensity remains stable as the video moves across the display screen.

Laser Disc Player

The laser video disc player used is the Sony LDP-1000A. It is a versatile industrial grade disc player. It interfaces to the GraphOver 9500 through a RS-232C serial port.

Alphanumeric Display And Keypad

The alphanumeric display used was an ARGUS-IEE 8-line by 40-character dot matrix gas discharge Alphanumeric Display Module. The display module utilizes a DC excited plasma message panel to display characters in a 5 by 7 dot matrix format. The unit consists of the display panel with full electronics to provide all drive, control, and refresh functions. It is interfaced to a universal serial data converter module made by IEE so that the main control processor can interface the device through an RS-232C serial interface.

CHAPTER IV

SOFTWARE DESCRIPTION

The software for the trainer is divided into the following functional areas: operational software, test and diagnostics software, and support software. The operational software includes an executive, which provides the overall processor control and synchronization to the video, and the man/machine interface. The input/output routines located in the main control processor provides for the loading of the database, the graphics and audio interface, the control of the laser recorder, and the trainee's display and keypad interface. The real-time simulation software simulates the turret and gun dynamics, the ballistic computer simulation, the hit/miss calculations, the trajectory calculations, round, tracer and explosion management, and real time scoring processing.

The test and diagnostic software shall include the manufacturer's diagnostics for determining faults to a board level for the boards they supplied. In addition, calibration software shall be provided to align the trainee's joysticks, the reticle, and the graphics overlays to the video.

The support software shall provide the means of converting the database generated on a VAX or similar microcomputer or main-frame computer to a format compatible to the trainer processor. The following makes up the database for trainer system.

1. Exercise Control File

2. Own-vehicle Data File

3. Target Data File

This paper will address only the operational software located in the main control processor in detail. A detailed functional breakdown for the trainer software is shown in Table 2. The software will be described in the following paragraphs.

TABLE 2
TRAINER FUNCTIONAL SOFTWARE BREAKDOWN

- Operational Software
  - Interrupt Routines
    - Video/Frame Sync
    - Laser Recorder(Serial Comm. TX Ready)
    - Sound System
    - Student Keypad
  - I/O Drivers
    - Exercise Data Storage
    - Trainee's Display
    - Trainee's Keypad
    - Trainee's Handle
    - Video Shifter
    - Sound Generator
    - Graphics Board
    - Laser Recorder
    - Reticle Controller
  - M60/A1 Trainer Executive
    - Hardware and Software Initialization
    - Man/Machine Interface
    - Exercise Control
    - Exercise Selection
    - Data Base Interface
    - Scoring
    - Real Time Executive
      - Simulation
        - Turret Dynamics
        - Ballistic Computer
        - Hit/Miss Calculations
        - Trajectory Calculation
        - Round Management
        - Tracer and Explosion Management
        - Real Time Scoring
      - Graphics Processing
      - Sound System Processing
      - Crew Station Processing
- Test and Maintance
  - Diagonistics
  - Calibration
- Support Software
  - Data Base Generation
  - Data Base Conversion

Interrupt Routines

The main control processor receives four interrupts from various subsystems. The interrupt service routines are described below.

Video/Frame Sync

This interrupt is generated by the video hardware 30 times a second. It signals the start of a new processing cycle. Upon receipt of the interrupt, the processor exchanges information with the simulator processor through a dual-ported RAM. This exchange occurs only once a frame to prevent both processors from trying to access the memory at the same time. The keypad service routine is called from this routine every third processing frame. The panel and control joystick routines are serviced every frame. While an exercise is active, video frames are counted to determine when to end an exercise. When a terminal count is reached for the number of frames in an exercise, this routine sets the situation complete flag.

Trainee´s Display

This signal is generated by the Programmable Communications Interface (PCI) chip when it is ready to transmit the next byte to the trainee´s display through the serial port. If there is any data in the display buffer, it will send the next byte of data.

Sound System

This interrupt is generated from the timer located on the processor board. It signals that the last sound cycle has been completed. The code checks to see if another cycle is necessary and will start the next cycle. If another cycle is not necessary, the software will disable the interrupt.

Graphics

This interrupt is generated by the graphics subsystem to signal that it has accepted the last command set to it and is ready for another command. If there is any data in the graphics buffer, the software will send another command.

Input/Output Drivers

Exercise Data Storage

The data storage for each exercise is stored in a file on a flexible diskette. There are three types of files stored. They are:

1. Exercise Control File -- This file contains information relating to the sequence of events will occur during a given exercise. It is loaded off of a flexible diskette and into local memory when an exercise is selected. Table 3 shows the commands that are allowable in the control file and the functions that they perform.

2. Own-vehicle Data File -- This file contains the location data for the own-vehicle. It lists the x, y, and z coordinates as well as the velocity of the own-vehicle and the yaw and roll which is recorded into the video for every frame of active video. It is loaded from the flexible diskette at the beginning of each situation.

TABLE 3
EXERCISE CONTROL FILE COMMANDS

* Note: All commands are bytes, all data is in bytes

CODE	GRAPHOVER CONTROL COMMANDS	FUNCTION(S) PERFORMED
****	******************	************************
01	VIDEO_OFF	TURN OFF GRAPHOVER VIDEO
02	VIDEO_ON	TURN ON GRAPHOVER VIDEO
03	GRAPHOVER_CLEAR	CLEAR ALL GRAPHOVER OVERLAYS
04	SELECT_VIDEO_A	GRAPHOVER SELECT VIDEO INPUT "A"
05	SELECT_VIDEO_B	GRAPHOVER SELECT VIDEO INPUT "B"

CODE	VIDEO DISK CONTROL COMMANDS	FUNCTION(S) PERFORMED
****	******************	************************
06	SEEK_FRAME (FRAME NUMBER)	VIDEO DISK SEEK FRAME
07	WAIT_FOR_SEEK_DONE	WAIT TILL VIDEO DISK SEEK IS COMPLETE
08	WAIT_FOR_FRAME (FRAME NUMBER)	WAIT FOR VIDEO DISK TO GET TO SPECIFIED FRAME
09	DISK_PLAY_FORWARD	VIDEO DISK PLAY FORWARD IN NORMAL SPEED
10	DISK_STOP	VIDEO DISK HALT
11	FRAME_NUMBER_ENABLE	ENABLE VIDEO DISK FRAME NUMBER DISPLAY
12	FRAME_NUMBER_DISABLE	DISABLE VIDEO DISK FRAME NUMBER DISPLAY
13	AUDIO_RIGHT_ENABLE	ENABLE VIDEO DISK RIGHT AUDIO CHANNEL
14	AUDIO_RIGHT_DISABLE	DISABLE VIDEO DISK RIGHT AUDIO CHANNEL
15	AUDIO_LEFT_ENABLE	ENABLE VIDEO DISK LEFT AUDIO CHANNEL
16	AUDIO_LEFT_DISABLE	DISABLE VIDEO DISK LEFT AUDIO CHANNEL

TABLE 3 -- CONTINUED

CODE	HIGH RES CONTROL COMMANDS	FUNCTION(S) PERFORMED
****	********************	*************************
17	HI_RES_CLEAR	CLEAR SCREEN ON HIGH RES DISPLAY
18	HI_RES_ON_10X	GENERATE RETICLE AND LRF DISPLAY

CODE	SYSTEM CONTROL COMMANDS	FUNCTION(S) PERFORMED
****	********************	*************************
19	INIT_SYSTEM	INITIALIZE FOR NEW SITUATION
20	INIT_SCORE	INITIALIZE SCORE FOR NEW EXERCISE
21	END_OF_EXERCISE	EXERCISE COMPLETE
22	PREAMBLE_FRAME_COUNT (FRAMES)	NUMBER OF FRAMES FOR SITUATION PREAMBLE
23	ACTIVE_FRAME_COUNT (FRAMES)	NUMBER OF FRAMES GUNNER IS ACTIVE (STARTS IMMEDIATELY FOLLOWING PREAMBLE)
24	TARGET_1	DATA FOR TARGET #1
	(TYPE)	TARGET TYPE (SEE KEY)
	(ACTIVE_FRAME)	FRAME WHEN TARGET #1 IS ACTIVE
	(INACTIVE_FRAME)	FRAME WHEN TARGET #1 IS INACTIVE
25	TARGET_2	DATA FOR TARGET #2
	(TYPE)	TARGET TYPE (SEE KEY)
	(ACTIVE_FRAME)	FRAME WHEN TARGET #2 IS ACTIVE
	(INACTIVE_FRAME)	FRAME WHEN TARGET #2 IS INACTIVE
26	AMMO_TYPE (TYPE)	AMMO TYPE (SEE KEY)
27	SIGHT_MODE (MODE)	GPS OR TIS SIGHT MODE (SEE KEY)
28	R/T_MODE (MODE)	SET R/T MODE (SEE KEY)
29	R/T_ACTIVE	START SITUATION REAT TIME FRAME PROCESSING
30	DELAY (TIME)	WAIT FOR "TIME" SECONDS

TABLE 3 -- CONTINUED

CODE	SYSTEM CONTROL COMMANDS	FUNCTION(S) PERFORMED
****	*******************	************************
31	COMPUTE_SITUATION_ SCORE	COMPUTE SCORE FOR THIS SITUATION
32	DISPLAY_SITUATION_ SCORE	DISPLAY SCORE FOR THIS SITUATION
33	COMPUTE_EXERCISE_ SCORE	COMPUTE SCORE FOR THIS EXERCISE
34	DISPLAY_EXERCISE_ SCORE	DISPLAY SCORE FOR THIS EXERCISE
35	CLEAR_SCORE	CLEAR ALL DISPLAYS SHOWING SCORE
36	END_OF_DATA	SIGNIFY END OF DATA FILE

TABLE 3.B
KEY TO ARGUMENTS
FOR CONTROL FILE

A. SEEK_FRAME (FRAME NUMBER)	WORD, RANGE = 1, 53,999 (FRAMES)
B. WAIT_FOR_FRAME (FRAME_NUMBER)	WORD, RANGE = 1, 53,999 (FRAMES)
C. PREAMBLE_FRAME_COUNT (FRAMES)	WORD, RANGE = 0, 54,000 (FRAMES)
D. ACTIVE_FRAME_COUNT	WORD, RANGE = 0, 54,000 (FRAMES)
E. INIT_SYSTEM (DATA FILE NUMBER KEY)	WORD, RANGE = 0, 127 number of data file for this situation

TABLE 3.B -- CONTINUED

F. TARGET_1(2) (TYPE)	WORD, RANGE = 1, 6 1 - T62 TANK 2 - BTR-60 PERSONNEL CARRIER 3 - ZSU-23 ANTI-AIRCRAFT TANK 4 - TRUCK WITH ROCKET LAUNCHER 5 - M-60 TANK 6 - DUCE-N-HALF TRUCK
(ACTIVE_FRAME)	WORD, RANGE = 1, 53,999 (FRAMES)
(INACTIVE_FRME)	WORD, RANGE = 1, 53,999 (FRAMES)
G. AMMO_TYPE (TYPE)	WORD, RANGE = 1, 4 1 - HEAT 2 - HEP 3 - APDS 4 - CO-AX
H. SIGHT_MODE (MODE)	WORD, RANGE = 1, 2 1 - GPS 2 - TIS
I. R/T_MODE (MODE)	WORD, RANGE = 1,3 1 - RETICLE LAY MODE 2 - TRACKING ONLY MODE 3 - FIRING MODE
J. DELAY (TIME)	WORD, RANGE = 1, 2**16-1 (FRAMES)

3. Target Data File -- This file contains the location data for each target, friendly or enemy, which is in the video for the situation. The data contains the x, y, and z coordinates of the target as well as its velocity and range. There is also a byte which will be set if the target is obscured behind cover. It is loaded from the flexible diskette at the beginning of each situation.

Table 4 shows the make-up of the own-vehicle and target data files.

Trainee's Display

This module contains all the primitive and global routines necessary to output to the ARGUS-IEE Plasma Display. The display is capable of displaying a main menu, an exercise menu, a calibration menu, a scoring menu, and four scoring pages. The layout of the pages are shown in Figure 3.

TABLE 4
EXERCISE DATA FILE

Own Vehicle Data (Required for each frame)

1.	vtd_ov_x	Real
2.	vtd_ov_y	Real
3.	vtd_ov_z	Real
4.	vtd_ov_vel	Real
5.	vtd_video_yaw	Real
6.	vtd_video_pitch	Real

Note: A) Own vehicle yaw rate = 0
B) vtd_ov_yaw = vtd_video_yaw for first data frame

Target Data (Required for each frame)

1.	vtd_tgt1_x(k)	Real
2.	vtd_tgt1_y(k)	Real
3.	vtd_tgt1_z(k)	Real
4.	vtd_tgt1_rng(k)	Real
5.	vtd_tgt1_vel(k)	Real
6.	tgt_obscured1(k)	Byte
7.	vtd_tgt2_x(k)	Real
8.	vtd_tgt2_y(k)	Real
9.	vtd_tgt2_z(k)	Real
10.	vtd_tgt2_rng(k)	Real
11.	vtd_tgt2_vel(k)	Real
12.	tgt_obscured2(k)	Byte

MAIN MENU:

```
 ----------------------------------------
0|              MAIN MENU               |
1|       1 EXERCISE MENU                |
2|       2 SCORE MENU                   |
3|       3 CALIBRATION MENU             |
4|       4 RESET                        |
5|                                      |
6|                                      |
7|>                                     |
 ----------------------------------------
```

EXERCISE MENU:

```
 ----------------------------------------
0|             EXERCISE MENU            |
1|      1 OWNVEHICLE FIXED  - TARGET FIXED  |
2|      2 OWNVEHICLE FIXED  - TARGET MOVING |
3|      3 OWNVEHICLE MOVING - TARGET FIXED  |
4|      4 OWNVEHICLE MOVING - TARGET MOVING |
5|    ENT START EXERCISE                |
6|    CLR RETURN TO MAIN MENU           |
7|>                                     |
 ----------------------------------------
```

SCORE MENU:

```
 ----------------------------------------
0|               SCORE MENU             |
1|                                      |
2|      1 SUMMARY PAGE                  |
3|      2 RETICLE AIM EVALUATION PAGE (RA) |
4|      3 TARGET ACQUISTION EVAL PAGE (TA) |
5|      4 SYSTEM MANAGEMENT EVAL PAGE (SM) |
6|    CLR RETURN TO MAIN MENU           |
7|>                                     |
 ----------------------------------------
```

FIGURE 3
MENU FORMATS

SCORE SUMMARY:

```
 ------------------------------------------------
0|                SCORE SUMMARY                  |
1|EX NO xxx   SITS x   TGTS xx   KILLS xx        |
2| AVG FIRE TM xx.x  AVG KILL TM xx.x            |
3| TOT RNDS xxx                                  |
4|       AVG SCORE  TOT ERRORS                   |
5|    TA    x          x x-x-x-x                 |
6|    RA    x          x x-x-x-x                 |
7|    SM    x          x x-x-x-x                 |
 ------------------------------------------------
```

RETICLE AIM EVALUATION SUMMARY:

```
 ------------------------------------------------
0| RA PAGE --Any key returns to Score Menu|
1|  TGT AMO FIRE KILL RNDS  AZ    EL   SCR|
2|1 xxx  xx xx.x xx.x xxx  xxx.x xxx.x  x |
3|2 xxx  xx xx.x xx.x xxx  xxx.x xxx.x  x |
4|3 xxx  xx xx.x xx.x xxx  xxx.x xxx.x  x |
5|4 xxx  xx xx.x xx.x xxx  xxx.x xxx.x  x |
6|5 xxx  xx xx.x xx.x xxx  xxx.x xxx.x  x |
7|AVG       xx.x xx.x                   x |
 ------------------------------------------------
```

TARGET ACQUISITION EVALUATION SUMMARY:

```
 ------------------------------------------------
0| TA PAGE --Any key returns to Score Menu|
1|          TGT   ERRORS       SCORE      |
2|        1 xxx  xx x-x-x        x        |
3|        2 xxx  xx x-x-x        x        |
4|        3 xxx  xx x-x-x        x        |
5|        4 xxx  xx x-x-x        x        |
6|        5 xxx  xx x-x-x        x        |
7|          TOT  xx          AVG x        |
 ------------------------------------------------
```

FIGURE 3 -- CONTINUED

SYSTEM MANAGEMENT EVALUATION PAGE

```
 ------------------------------------------
0| SM PAGE --Any key returns to Score Menu|
1|           TGT   ERRORS      SCORE       |
2|         1 xxx  xx x-x-x-x     x         |
3|         2 xxx  xx x-x-x-x     x         |
4|         3 xxx  xx x-x-x-x     x         |
5|         4 xxx  xx x-x-x-x     x         |
6|         5 xxx  xx x-x-x-x     x         |
7|           TOT  xx          AVG x        |
 ------------------------------------------
```

CALIBRATION MENU

```
 ------------------------------------------
0|            CALIBRATION MENU             |
1|                                         |
2|      1 HP CALIBRATION                   |
3|      2 GRAPHOVER CALIBRATION            |
4|      3 VIDEO SHIFTER CALIBRATION        |
5|      4 GUNNER HANDLE CALIBRATION        |
6|    CLR RETURN TO MAIN MENU              |
7|                                         |
 ------------------------------------------
```

GENERAL CALIBRATION PAGE

```
 ------------------------------------------
0|               CALIBRATION               |
1|                                         |
2|       DIRECTION           BUTTON        |
3|          UP                  2          |
4|    LEFT      RIGHT        4     6       |
5|         DOWN                 8          |
6|                                         |
7|   CLR RETURN TO CALIBRATION MENU        |
 ------------------------------------------
```

FIGURE 3 -- CONTINUED

Trainee's Keypad

This module reads the keypad through two 8-bit ports to determine if the user has selected an action from the trainee's display. It must debounce the keypad through software. It will be called every third processing frame, or every tenth of a second.

Trainee's Joystick

This module must read the analog-to-digital converter to determine the horizontal and azimuth turret angle inputs the user is entering. These values are filtered to delete noise and are then scaled and sent to the simulator for processing. The joysticks are also read for trigger inputs and laser ranger finder inputs. This routine is called once every frame or 30 times a second.

Video Shifter

The elevation and azimuth angle of the turret is received from the simulator. This module will scale the angles, and convert them into the necessary delay time to shift the video. A horizontal and vertical shift count is outputted to the video shifter board through two 16-bit output ports every 1/30th of a second.

Sound Generator

The sound subsystem is set up to produce six real-time sounds. They are:

1. null sound (silence)

2. firing (main gun)

3. reload (main gun)

4. load (main gun)

5. 1 kHz test sound

6. coax (machine gun)

This module will contain the procedures necessary to develop the proper commands to the sound subsystem interface, send the commands, auto-sequence through several commands, and set volume and sound flags.

The software and hardware can be set up to either play a sound continuously until a null sound command is received, or it can be set up to play a defined length and turn itself off.

The call to the procedure has two arguments passed with it. One will be the sound number and the other will be a volume level.

The main control processor software communicates to the hardware through six 16-bit ports.

Graphics Board

The GraphOver 9500 is an intelligent graphics generator with a large number of built-in commands. The software develops the commands necessary to control the GraphOver 9500. It enters the commands into a software buffer. When the GraphOver accepts a command, it will signal the processor through an interrupt and the processor software will send out the next byte in the buffer. The software will disable the interrupt when there is no data in the buffer. The software communicates with the GraphOver through an 8-bit port.

Laser Recorder

The laser recorder is controlled by the GraphOver 9500. This software module develops the commands necessary for the GraphOver to control the device and enters the commands into the graphics buffer.

Reticle Controller

This module will receive the correct position of the reticle from the simulator. It will then transform this information into screen coordinates and develop the commands necessary for the HP 1345A Digital Display Module to display the reticle. The HP 1345A contains internal refresh circuitry with a 4096-word refresh memory buffer. Therefore, the software does not need to be concerned with refresh. The software communicates to the device through a 16-bit port.

Flexible Diskette

This module will handle all control necessary to interact with the iSBC 204 Flexible Diskette Controller. The software is a read-only routine. It will display on the trainee's display an error message received from the controller. Possible errors are:

1. Disk Read Error

2. Drive Not Ready

3. File Not Found

4. Bad Filename

This procedure uses ISIS operating system calls to read the diskette directories.

Trainer Executive

The trainer executive provides all control and sequencing necessary to initialize and run the system. It relinquishes control only to the interrupt routines. There are several layers to the executive. The main level has control when the trainer is turned on, waiting for a user input. The executive displays the main menu and simply waits for a user input from the keypad. When an input is detected, the executive determines whether it is a valid input or not. If it is not valid, the executive informs the user and waits for a valid input. If a valid input is detected, it passes control to a lower level -- either the exercise executive, the scoring executive, or the calibration executive, depending on the input. Both the scoring and calibration menus can display their respective menus, and allow only for selected functions to occur. Control can only be returned to the main executive. The exercise executive displays the exercise menu and waits for an exercise to be selected. When the exercise is selected, it loads the exercise command file from a flexible diskette to a software buffer and waits for a start command or a return to main menu command to be given. Upon receipt of a start command the control is passed to exercise control, which is described below. Exercise control will return control back to the main executive level.

Hardware And Software Initialization

Upon power-up, the system must initialize certain hardware functions and software variables before entering the main executive level. The initialization functions are described in the following paragraphs.

Sound Subsystem Initialization - Upon power-up, the board is in an unknown state causing it to make undesirable noises. The board will first be put in a known state. The code will then retrieve the sound information from the flexible diskettes and load them into the the aural sound subsystem local memory.

Local Memory Initialization - All memory located on the processor board will be set to zero.

Dual-ported Memory Initialization - All memory located off-board, but addressable through the Multibus will be set to zero.

Interrupt Vector Initialization - All unused interrupt vectors will be initialized with a vector that points to a location containing an interrupt return command. All interrupts that are used will be loaded the the correct vector to the desired interrupt service routine.

On-board Hardware Initialization - The real math co-processor will be initialized and the Programmable Interrupt Controller (PIC) will be initialized.

Video Shifter - The video shifter will be initialized so that the picture is centered on the screen.

Initialize Alphanumeric Display - The Programmable Communications Interface will be initialized to a 1200 baud serial interface with one stop bit and no parity. The Programmable Interface Timer will be initialized to provide the baud rate clock.

Keypad Initialization - The Programmable Peripheral Controller on the processor board will be initialized to have two 8-bit input ports to accept keypad inputs.

GraphOver Initialization - The Programmable Peripheral Controller on the special purpose interface board will be initialized to have an 8-bit input port and an 8-bit output port to allow bi-directional communication with the GraphOver. The GraphOver is then reset through a software command, and its color lookup tables are loaded with the desired color values, its hardware fill circuitry and color planes are initialized.

Panel Initialization - The Programmable Peripheral Controllers on the iSBC 519 board will be initialized to interface with the panel. Software variables used in the panel procedures are initialized.

Reticle Generator Initialization - The hardware interface circuitry will be initialized to allow bi-directional communication between the processor and reticle generator. The refresh memory resident in the reticle generator must be initialized.

Control Variables Initialization - Software variables which are non-zero will be initialized to the required value.

Man/Machine Interface

The part-task trainer is a menu driven system. After the system initialization has been the completed, the main system menu shall be displayed on the trainee's display. The gunner shall be able to select one of the following system functions from the trainee's keypad:

1. Exercise Menu

2. Score Menu

3. Calibration and Diagnostics Menu

The exercise menu shall provide two modes of operation. The first shall allow the trainee to select his own exercises from the current list of exercises while the second mode shall start with the simplest exercise and the trainer shall choose each proceeding exercise based on the trainee's proficiency demonstrated on the current exercise.

The scoring menu shall display upon the trainee's request the total score for the exercise just completed. In addition to the summary score, a score for each situation completed shall be displayed in the trainee's sight.

The calibration and diagnostics menu is provided for service technicians to calibrate and troubleshoot the system. From this menu, an adjustment for the reticle position, video shifter, graphics overlays, or trainee's joystick zero position shall be provided.

Trainee's Panel And Joysticks - The function of the trainee's panel and joysticks shall replicate those of the tank's.

Aural System - During an exercise the aural system shall provide the tank commanders oral prompts to the trainee. The aural system shall inform the trainee when control of the turret and weapon shall be turned over to him, the target selected by the tank commander and type of ammo required. In addition, while the trainee is firing, the aural system shall provide the sound of the guns firing.

Exercise Control

The exercise control procedure is set up to be a "do case" structure. The exercise commands are taken from a buffer which was created from the information was loaded from the flexible diskette files. The command selector proceeds through the buffer using the command as a index into the do case structure. Each case provides the function desired. These commands were listed in Table 3. The control of the system remains here until an end of exercise or invalid command is received.

Database Interface

The database information must contain own-vehicle and target information for every frame. However, due to memory size limitations, only every other point could be stored. Hence, the data must be interpolated to create the missing data points.

The database files are copied from files on the flexible diskettes into local processor memory. They are then transferred to the simulation processor where interpolation takes place. The transfer of files and interpolation takes place at the beginning of each training situation.

Scoring

Scoring can be broken into three areas:

1. Real-time scoring

2. Situation scoring

3. Exercise scoring

Real-time scoring is accomplished in the simulation processor. It keeps tracks of the variable which must be given to the non-real time situation and exercise scoring routines.

Situation scoring is distinguished from exercise scoring in that an exercise consists of up to five situations. Situation score is the score for each individual situation, and exercise score is the summary of the situation scores which occurred in the last exercise.

Situation Scoring - This module evaluates the scoring data at the end of each situation, in non-real time. The time of first fire and the time of target kill are scored and the reticle aim state is updated, and graded down if more than 100 rounds have been fired at the target. The number of laser errors and time of flight errors are scored in the system management state. The number of identification errors, acquisition errors, and firings at friendly targets are calculated and scored in the Target Acquisition Evaluation score. The masks of Target Acquisition Evaluation and System Management Evaluation errors are updated.

Exercise Scoring - This module updates the scores and calculates the average scores at the end of the exercise in non-real time. The total number of System Management Evaluation and Target Acquisition Evaluation errors in the exercise are computed, and an overall mask for System Management Evaluation errors and for Target Acquisition Evaluation errors are computed. The masks are used to indicate to the user which errors were committed. The total numbers of rounds fired, and hits scored are calculated. The average times of first fire, target hit, and target kill are computed.

Real-time Processing

Simulation Processor Interface - The interface consists of a control buffer and two ping-pong buffers; one for information going from the main processor to the simulator, and one for information going from the simulator to the main processor.

The control buffer contains variables that are generally constant throughout a situation. The exception is the frame flag. This flag tells both processors which of the ping-pong buffer to use. By not allowing the processor to access the same buffer an any given frame, neither processor will lose time due to trying to access the buffer at the same time. The layout of the control buffer appears in Table 5.

The two ping-pong buffers contain information that is generated every frame. The main processor must pass the simulator user inputs, and the simulator must give the main processor certain control parameters such as video offsets, reticle position, tracer position, and explosion positions. Tables 6 and 7 contain the layout of the ping-pong buffers.

TABLE 5
MAIN PROCESSOR INPUT CONTROL AND
DATA BUFFER LAYOUT

Variable Name	Variable Description
frame	Buffer to be used by simulator
Start_Simulation	Start of Simulation Flag
Simulator_Ready	Simulator Ready Flag
Situation_Complete	Situation Completed Flag
Target_type(2)	Target type required
Active_Frame_tgt(2)	Frames target is active
Inactive_Frame_tgt(2)	Frames target is inactive
ammo_type_required(2)	Ammo type required
RT_active_frame_count	Length of situation
Sight_required	Sight required for situation
No_targets	No. of targets in situation
Type_of_exercise	Fire control mode
IO_Ready	IO processor Ready Flag
Enable_interpolation	Allows simulator to interpolate
vtd_tot_tgts	Running count of of targets
exe_situation	Current situation number
vtd_ex_end	End of exercise flag

TABLE 6
SIMULATOR TO MAIN PROCESSOR INTERFACE
BUFFER LAYOUT

Variable Name	Variable Description
wpe_trcr_hor_1	First Tracer Horizontal Angle
wpe_trcr_el_1	First Tracer Elevation Angle
wpe_trcr_hor_2	Second Tracer Horizontal Angle
wpe_trcr_el_2	Second Tracer Elevation Angle
wpe_trcr_hor_3	Third Tracer Horizontal Angle
wpe_trcr_el_3	Third Tracer Elevation Angle
wpe_trcr_hor_4	Fourth Tracer Horizontal Angle
wpe_trcr_el_4	Fourth Tracer Elevation Angle
wpe_trcr_hor_5	Fifth Tracer Horizontal Angle
wpe_trcr_el_5	Fifth Tracer Elevation Angle
wpe_expl_enable	Explosion Enable Flag
wpe_expl_typ	Explosion Type
wpe_tracer_1	First Tracer Flag
wpe_tracer_2	Second Tracer Flag
wpe_tracer_3	Third Tracer Flag
wpe_tracer_4	Fourth Tracer Flag
wpe_tracer_5	Fifth Tracer Flag
wpf_fire	Main Gun Fired

TABLE 6 -- CONTINUED

Variable Name	Variable Description
pjc_expl_el	Explosion Elevation Angle
pjc_expl_hor	Explosion Horizontal Angle
rfs_disp_rng	Laser Range to Display
rfs_line	Reticle Vertical Position
rfs_elem	Reticle Horizontal Position
rfs_fail_sym	LRF Failure Symbol Enable
rfs_mult_rtn	Multiple Returns Symbol Enable
rfs_mg_ready	Main Gun Ready Symbol Enable
rfs_not_on_safe	LRF Not On Safe Flag
blc_rng_mode	BLC is in auto,manual or failed
tur_az_angl_vs	Video shifter turret azimuth angle in radians
el_los_vs	Video shifter line-of-sight elevation angle in radians
pjc_expl_rng	Range from ov to explosion
tur_az_angl	LOS elevation angle in radians
el_los	Range from ov to explosion

TABLE 7
MAIN PROCESSOR TO SIMULATOR
INTERFACE BUFFER LAYOUT

Variable Name	Variable Description
csu_phd_trav	Power Handle Traverse Angle
csu_phd_el	Power Handle Elevation Angle
csu_sight_inuse	Sight In Use
csu_fir_ind	Firing Indicator Word
csu_amo_sel_ind	Ammo Selected Indicator
csu_fcm	Fire Control Mode
csu_sw_ind	Switch Indicator
csu_lrf_on_mom	Laser Rangefinder On Momentary
csu_tis_enbl	TIS Enabled Flag
csu_tur_stbln	Turret Stabilization State

Graphics Processing - When an explosion is active, the simulator will send the real world coordinates of the explosion. The main processor will convert these coordinates to screen coordinates to position the explosion. On the first frame, that the explosion is active, the software will draw the explosion. The explosion is drawn twice, once in two of the four available planes using one lookup table for colors, and again in the other two available planes using a different color lookup table. An explosion timer is then set to two seconds. Once every processing frame, the software will activate two of the four planes, its associated lookup table, and enable the hardware fill capabilities for those planes. The next frame the other two planes are enabled along with the lookup table and hardware fill. In this manner, an explosion can rapidly change colors without a tremendous amount of input/ output. When the explosion timer counts down to zero, the explosion is erased from the screen.

CHAPTER V

CONCLUSIONS

The goal of this research project was to develop an interactive training device using a laser video disc player. A system was built and is currently being utilized by General Electric's Simulation and System Control Department in Daytona Beach, Florida.

The ideas presented in this paper adapted quite well to a training environment. However, as the system was developed as a prototype device, several areas could be changed to create a more desirable system.

One idea is to eliminate large items such as the GraphOver 9500. After building the system, it appears that this device is somewhat of an overkill. There currently exist several simple devices that could be used instead, or perhaps a design using available LSI graphics controller chips such as the NEC 7220 controller could be used.

The reticle generator also was an overkill. An idea that occurred during development was to use a side-lighted slide with a reticle etched into the slide directly in the optical path. This would allow the user to see the reticle, but would not require computer control.

Another interesting area of improvement would be mass media storage. Since the system contains a laser disc, digital information could be stored directly on the disc eliminating the need for flexible diskettes. This method would require a decoding board, but there are several manufacturers currently engaged in this state of the art technology.

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