MID-RANGE TRAINERS: CONCEPT AND DESIGN AS APPLIED TO THE B-52 OAS/CMC PART TASK TRAINER

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ABSTRACT

Mid-range trainers are designed to provide useful training at significantly lower cost and development time than those for full-capability (full-scale) trainers. Mid-range trainers are appropriate for use prior to development of full-scale trainers and as supplements to full-scale trainers. With a mid-range trainer, trainees may, for example, practice operational procedures, become familiar with system control locations and reaction times, and learn to recognize and handle system faults. This paper describes the B-52 OAS/CMC Part Task Trainer, detailing its function as both a conversion trainer to provide the highest level of simulated training while the full-range trainer is being developed, and as a "lead in" trainer before the student moves to the full-range device. Capabilities of the Part Task Trainer are explained. Cost effective aspects of dual use are discussed. Design features to provide lower initial cost and flexibility for future modification and expansion, use of minicomputers, off-the-shelf components, and modular structure are detailed.

INTRODUCTION

Mid-range trainers provide high training value with lower cost and shorter development time then full-range trainers, such as weapons systems trainers. They can be applied effectively in situations requiring: 1) a conversion trainer, to train new or unique procedures, tasks, and functions in the interim during which the weapon system is being built or modified, or when no full-range trainer is available; and 2) an initial lead in trainer, for when the weapon system or full range trainer is in complete operation but training is required for the user to become skilled at lower-level tasks, such as becoming familiar with system controls and locations, practicing operational procedures, and performing system malfunction procedures. As conceived mid-range trainers provide maximum "hands-on" training in a well-ordered training program. In many cases, these mid-range training devices will be the "backbone" of a well ordered, highly developed training program.

TRAINING SITUATIONS

Mid-range Training devices can be effectively developed and applied in two training situations: 1) the fluid training situation, and 2) the static or established training situation.

In a fluid training situation, the training program is being developed and produced while the weapon system is in full scale development. Thus the word fluid is applied because the curriculum and training devices are undergoing change concurrently with changes in the weapon system to meet training requirements and objectives.

In this fluid training situation, the mid-range device will be used as an interim device before development of a full-range trainer such as a Weapon System Trainer. These devices would be designed to train procedures, task and functions of a new system before moving to the weapon system itself. This training concept saves aircraft hours needed for training and effectively trains lower-level training tasks. With these devices, the students or trainees will become familiar with system controls and locations, practice operational procedures and perform system malfunction training. All of this training can be performed in a simulated real-time operational environment. The mid-range trainer would represent the highest level of simulated training. It must be capable of complete lower-level training because the next level would be training in the weapon system itself. The mid-range trainer to be cost effective, must take the load of training lower level objectives away from the weapon system.

Another case for use of interim trainers would be during major weapon system modification. When a weapon system undergoes a major modification, the weapon system is usually modified before the companion full-range simulator is either brought up to date or produced. An interim device will be necessary to train new procedures and new equipment before the weapon system is used. This mid-range trainer would be used in conjunction with a highly developed conversion training program. A simulator attached to this type of training program would be a Part Task Trainer or Cockpit Procedures Trainer, a device specifically designed to train only the changes, modifications and specific tasks and functions related to the operation of the new system.

In the static training situation, the training program has both mid-range and full-range trainers. The weapon system is static in that it has been delivered and all training revolves around an established program and continuous proficiency training situations. An example of the static training situation would be the Combat Crew Training Program. In this situation the mid-range trainer would be used to train at lower levels, preparing the trainee to move to the full-range device. This one fact is important to the well ordered, established training program to provide cost effective use of the full-range device. In the simplest terms, the mid-range trainer provides cost effectiveness by allowing the training manager to use the full-range device for what it was designed for; to train higher level objectives. Mid-range trainers could be specifically designed to fit into a highly developed Combat Crew Training Program. It is conceivable that this type of device would be used as a "lead-in" for training *missions in the full range trainer.* If the trainee is knowledgeable in switch locations system function and operation, the full range trainer sessions can be used for real mission profiles. If problems are encountered in student performance, that student can be given extra training sessions in the mid-range device until proficiency has been attained. The WST training periods now become cost effective and can complement training in the weapon system itself. By moving through the hierachy for training devices, students become better trained and build the confidence that is necessary to perform in the weapon system.

The key to any mid-range trainer is their low cost, high training value and short development time. Use of minicomputers, off-the-shelf components and a modular design is important to reduce the initial cost of mid-range trainers and provide the flexibility necessary for future modifications and expansion of these devices.

As the next sections illustrate, the B-52 Offensive Avionics System (OAS)/Cruise Missile Carrier (CMC) Part Task Trainer (PTT) fills all the necessary requirements of the concept of mid-range trainers as part of a sophisticated training program.

INTRODUCTION TO THE B-52 OAS/CMC PART TASK TRAINER

The U.S. Air Force B-52 Bomber is receiving a major modification in the form of the Offensive Avionics System (OAS). The OAS, which is used by the B-52 radar navigator and navigator to perform navigational and offensive-weapon-delivery tasks, replaces the older ASQ-38 equipment and automates some previously manual functions.

As part of a major weapon system modification, a total aircraft simulator/trainer will be built for the OAS. This full-range trainer is scheduled to be operational in the 1983-1986 time frame, which leaves a gap between scheduled deployment of the OAS and availability of the complete trainer system. Crews using the first B-52 OAS modified aircraft will need a trainer in the interim to fill this gap. The 4235 Strategic Training Squadron (STS), Headquarters Strategic Air Command (SAC), in conjunction with Air Training Command and Technology Service Corporation of Santa Monica, CA, has been tasked to develop and build four B-52 OAS interim trainers to be used by Strategic Air Command in their OAS conversion training program.

The 4235 Strategic Training Squadron (STS) was tasked to develop the OAS conversion curriculum. Included with this tasking, was the development of a new OAS/Cruise Missile training program and curriculum for the B-52 Combat Crew Training School at Castle AFB, CA. Using the Instructional Systems Development (ISD) approach, the 4235 STS/Special Project Branch developed the training requirements for the OAS and Cruise Missile. With these training requirement in hand, a list of tasks outlined which were essential for training in a ground simulator was developed (see Figure 1). These tasks were determined with both the conversion program *(fluid training situation) and the Combat Crew* Training Program (static training situation) in mind. As requirements and design began to take shape it became readily apparent that an interm mid-range device was absolutely necessary to the Conversion Program and would greatly aid in Combat Crew Training.

The interim trainer will be a Part Task Trainer (PTT), one that addresses some of the tasks, procedures and conditions the crewmembers must handle with the actual weapon system (See Figure 2). Because the air crews receiving training will be highly experienced in the B-52 navigational functions, the focus of the PTT will be on procedures training; specifically, those procedures unique to the new OAS. As an example, the PTT must respond exactly as the OAS would to all commands (button pushes, switch activations, etc.), but only those features used directly in navigational and weapon-targeting procedures need be displayed in radar video.

With only the limited OAS functions included, the PTT would reduce the Conversion Training Program by two flights per crew, saving the Air Force $16,000,000. If applied in the Combat Crew Training Program the device would reduce WST periods necessary to train lower tasks and again savings would amount to approximately $400,000 a year in simulator training time. The above savings alone are significant, but when compared with the cost of the four simulators they become impressive. The entire simulator project was given $1.9 million, which breaks down to $450,000 per device including software and hardware.

Design features of the PTT hardware include mobility, so that the PTT can be moved easily

TASKS FOR THE OAS PART TASK TRAINER

GENERAL NAVIGATION TASKS

Navigation Tasks
(To perform general OAS operation)

- Destination Sequencing/Selection
- Fixpoint Sequencing/Selection
- Direct Steering
- Centerline Recovery Steering

Position Fixing Tasks
(To update aircraft position and course)

- Radar Position Fix
- Terrain Correlation Fix
- Overfly Fix

Calibration Tasks
(To calibrate navigational systems)

- High-Altitude Calibration
- Memory Point Wind Calibration
- Alternate Heading Calibration
- Low-Altitude Calibration

Rendezvous Tasks
(To perform aircraft refueling)

- Point Parallel Rendezvous
- Alternate Air Rendezvous

Special Procedures

- OAS Turn On
- OAS Shutdown

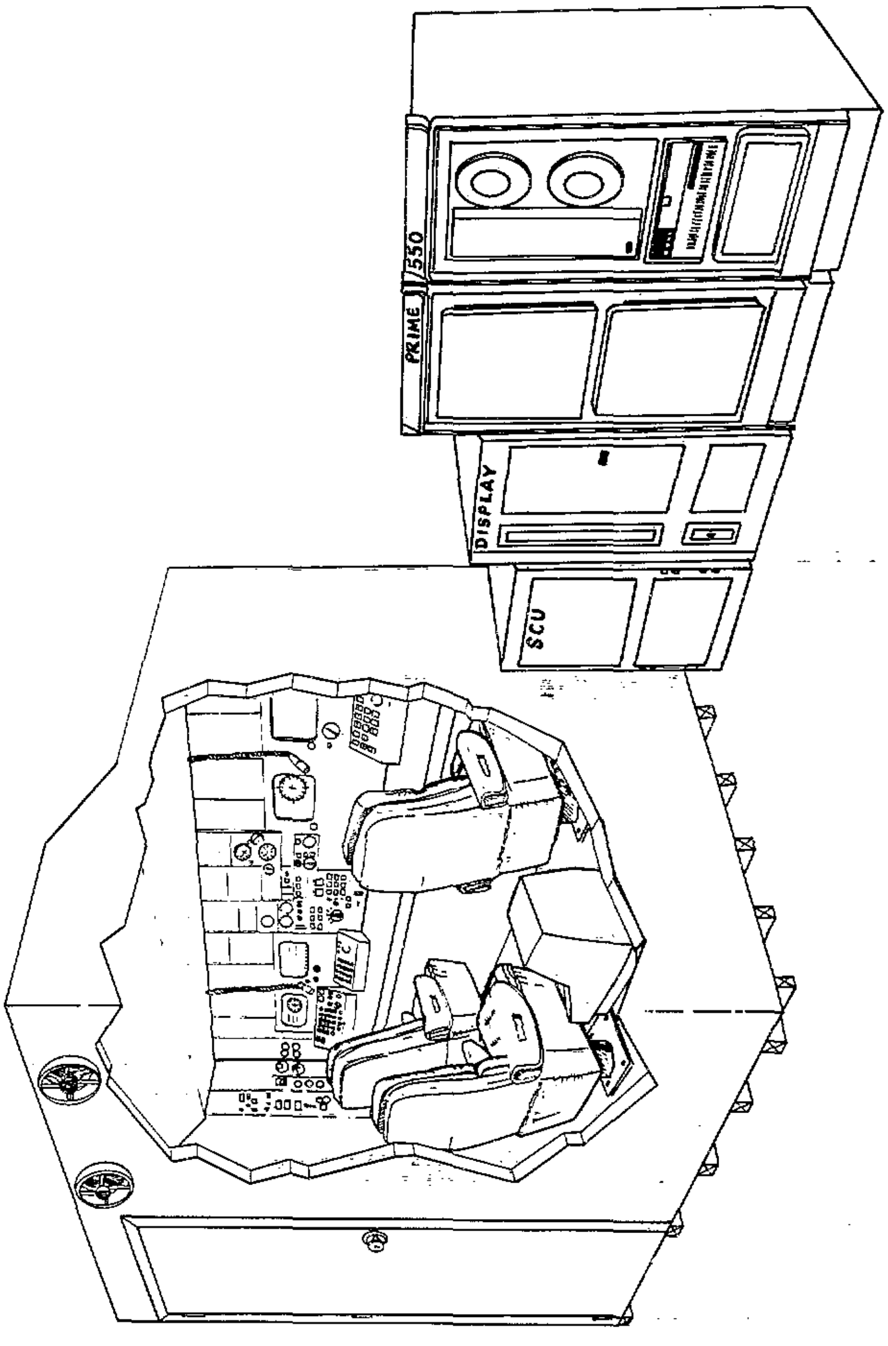
WEAPONS TASKS
(To prepare and launch/release weapons)

- SRAM Alignment
- ALCM Alignment
- SRAM Prearm
- ALCM Targeting
- ALCM Retargeting
- ALCM Prearm
- SRAM Ranging
- SRAM Launching
- ALCM Ranging
- ALCM Launching
- Procedure Irregularity Recovery
- Missile Jettisons
- Launcher Rotation
- Synchronous Bomb Run
- Alternate Bomb Run

MALFUNCTIONS
(To perform alternate/back up procedures when OAS components fail)

- RN Management Panel Fails
- WCP Panel Fails
- Doppler Radar Failure
- OAS Failure

Figure 1



B-52G/H OAS/CMC PART TASK TRAINER

Figure 2

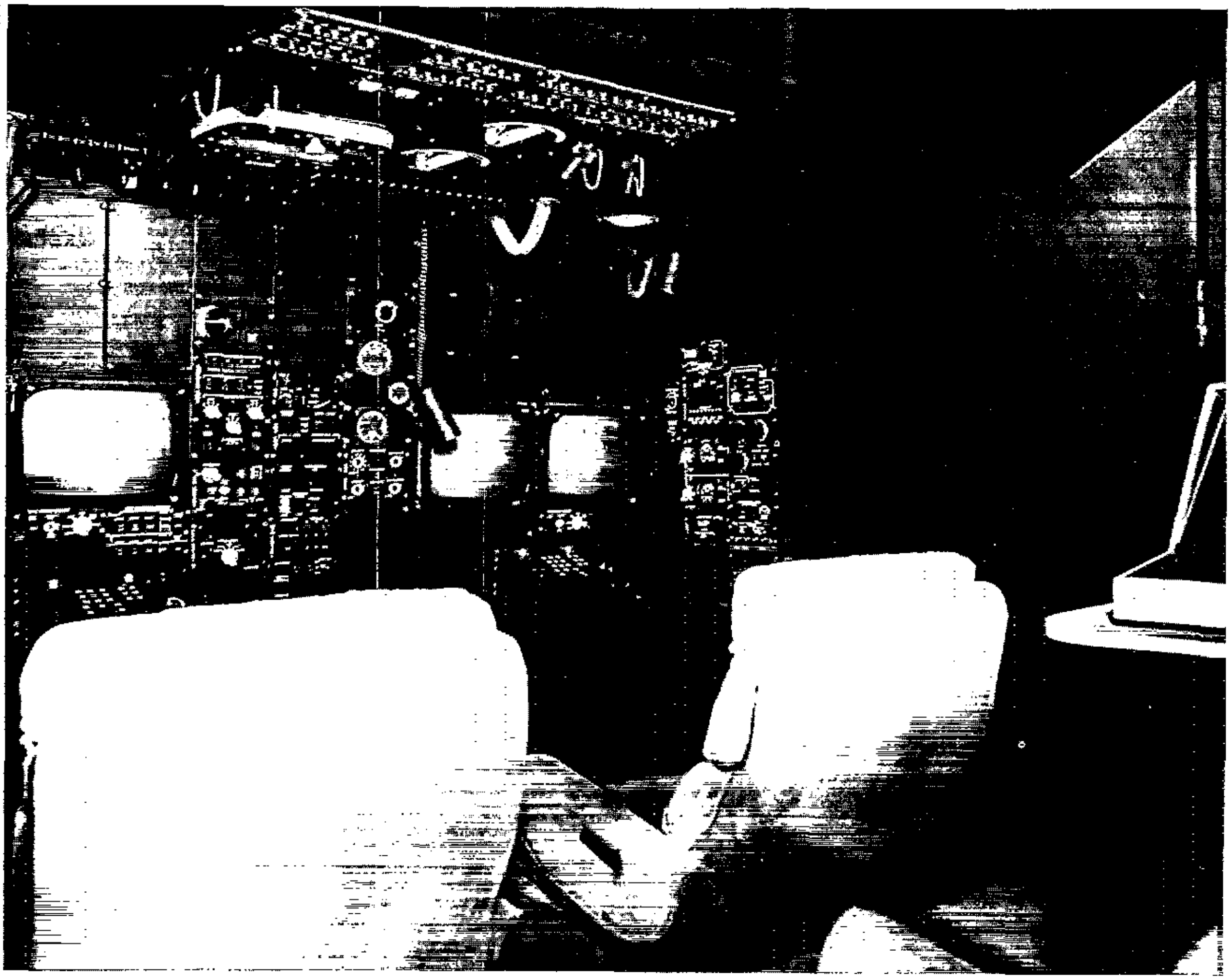
from base to base to meet training schedule; and use of off-the-shelf computer components. To reduced the cost of hardware and make maintenance easy by service contract decreasing PTT down time. As to the software, it must be flexible to handle OAS design changes easily and make future expansion possible.

OAS PART-TASK TRAINER CAPABILITIES

The physical layout of the PTT (see Figure 3) comprises stations for the two crewmembers (called the radar navigator and the navigator) required to operate the OAS, as well as for an instructor. Included in the PTT is a physical mockup of the OAS identical to the OAS's layout and dimensions of panels, switches, displays, etc. The mockup comprises 16 operations panels, two of which include a keyboard and trackball (one for each crewmember). Four monochromatic display monitors provide up to 33 different display formats, including three with synthetic radar imagery. The instructor's position is equipped with a CRT console for setup and monitoring of the training sessions.

The OAS PTT automatically navigates the B-52 according to a predefined scenario flight plan. The crewmembers are able to monitor, update, and override this automatic navigation system, using the OAS equipment and a variety of OAS navigational procedures supported by the PTT. The PTT also supports OAS procedures to perform in-flight refueling; preparation and delivery of Air Launched Cruise Missiles, Short Range Attack Missiles, and Gravity Weapon Delivery; and backup procedures used when certain OAS failures occur. Takeoffs and landings are not supported by the PTT, but OAS startup and shutdown procedures are functional.

In the PTT, the instructor can select a flight plan from a set of seven canned scenarios or modify any canned scenario to generate a new flight plan. The canned scenarios are representative of actual training missions. Scenarios of up to five hours of flight time can be generated within a region of 2-million square nautical miles, covering the Western and Central United States. Sufficient navigational fixpoints and target areas are included within this region to define at least 100 different realistic



CREWSTATION
Figure 3

scenarios. Actual terrain data are used to generate synthetic radar imagery for display of these navigational fixpoints and target areas. Since radar scope identification is not a primary training requirement the synthetic radar will contain only chosen fix points, target OAP's and radar returns on flight path for navigation orientation.

The instructor also has the capability to inject faults and malfunctions at specific times in the scenario, as well as at any time during the training session. With the ability to steer the aircraft off the flight plan and to accept corrections from the OAS crewmembers for recovery, the instructor acts as the B-52 pilot. He also monitors crewmembers' actions and is able to freeze the training session at any time, to give additional instruction, and then resume the session.

OAS PART TASK TRAINER DESIGN

The PTT has been designed in modules, to facilitate modifications as the OAS itself changes and as additional OAS trainer capabilities are identified. The five modules -- independent subsystems -- of the hardware configuration are depicted in Figure 4 and described below. They illustrate the use of off the shelf equipment.

Mainframe Processing Subsystem

The Mainframe Processing Subsystem (MPS) consists of a minicomputer with disk drive, magnetic tape drive, and system console (See Figure 5). The disk is used for real-time storage and retrieval of radar imagery data; the magnetic tape is used for transfer of software and updates of terrain data.

The MPS is the central processor for the PTT. It is responsible for logical and numerical processing plus control of all other subsystems. The PTT Software runs on the MPS.

The virtual console is a CRT required for the PRIMOS Operating System. The disk drive is required for the operating system, for software and data file storage, and for real-time access to display files for synthetic radar imagery updates. The magnetic tape drive is required for

PART-TASK TRAINER SYSTEM BLOCK DIAGRAM

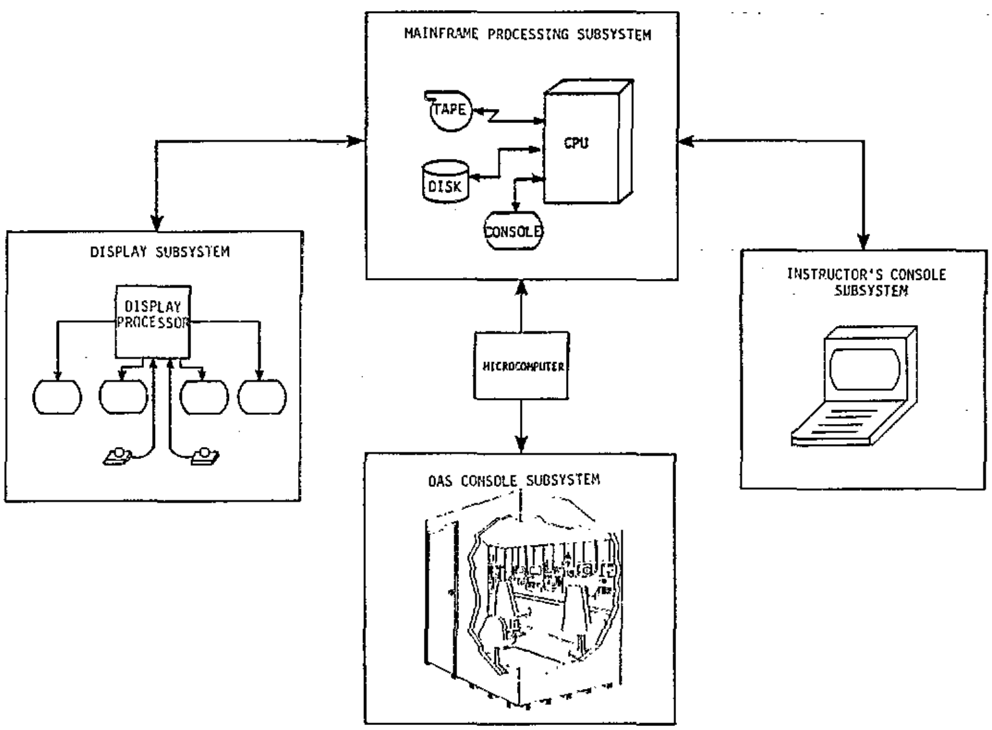


Figure 4

loading terrain files and software updates on the operational systems in the field. All peripherals are standard PRIME equipment.

All peripheral devices on the PRIME 550 CPU (disk drive, magnetic tape drive, and virtual console) have standard interfaces supported by PRIME hardware and software.

The mainframe processing subsystem capabilities are listed below for the PRIME 550 CPU.

PRIME 550 CPU

32 Bit CPU Architecture

128 Registers

512 K Byte Error Correcting Code Main Memory (expandable to 2 M Byte)

1 K Word Cache

Single/Double Precision Floating Point Arithmetic in Firmware

Up to 32 DMA Channels

16 Asynchronous Channels

Up to 63 Simultaneous Users

PERIPHERALS

PRIME Virtual Console (PT-25 CRT Terminal)

PRIME 96 M Byte Cartridge Module Device Disk Drive

PRIME 9-Track, 800 BPI, 45 IPS Tape Drive

The MPS interfaces to the Display Subsystem (DS), Instructor's Console Subsystem (ICS), and Switch Control Unit (SCU). These interfaces are described in the respective subsystem descriptions below.

Display Subsystem

The Display Subsystem (DS) is the primary output device for the navigator and radar navigator positions. The DS includes four monochromatic monitors (called multifunction displays or MFDs) mounted on the panels in the crewstation. The display processor and refresh memory interface with the mainframe processor to generate imagery, graphics and alphanumerics on the MFDs. Two trackballs are also included in the DS and are physically mounted in the

MAINFRAME PROCESSING SUBSYSTEM BLOCK DIAGRAM

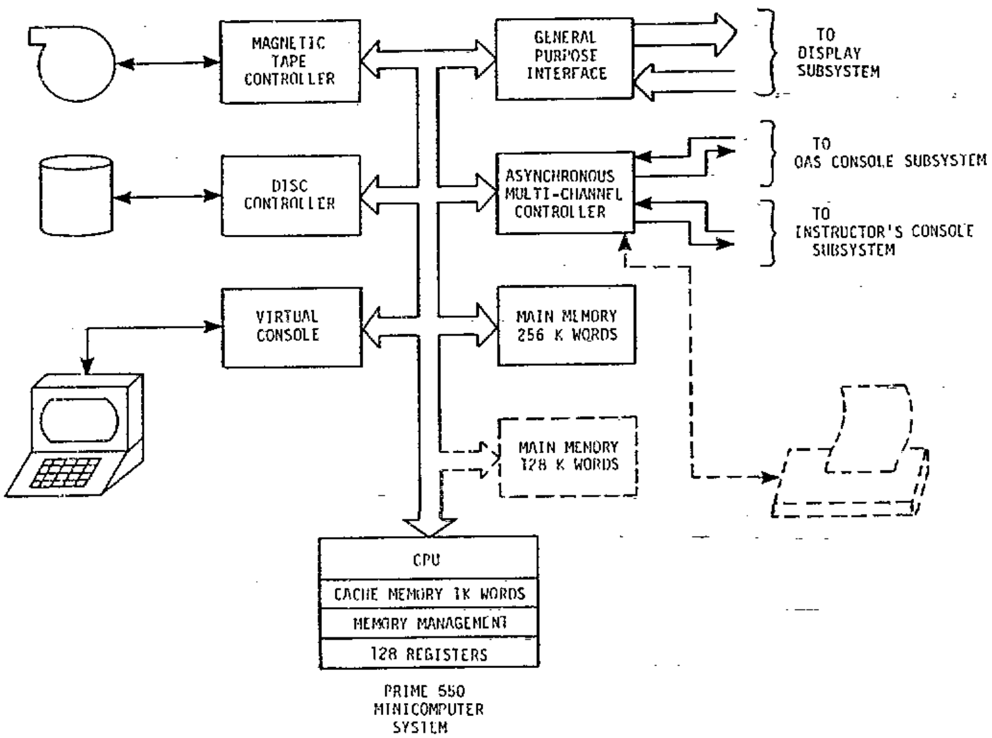


Figure 5

DISPLAY SUBSYSTEM BLOCK DIAGRAM

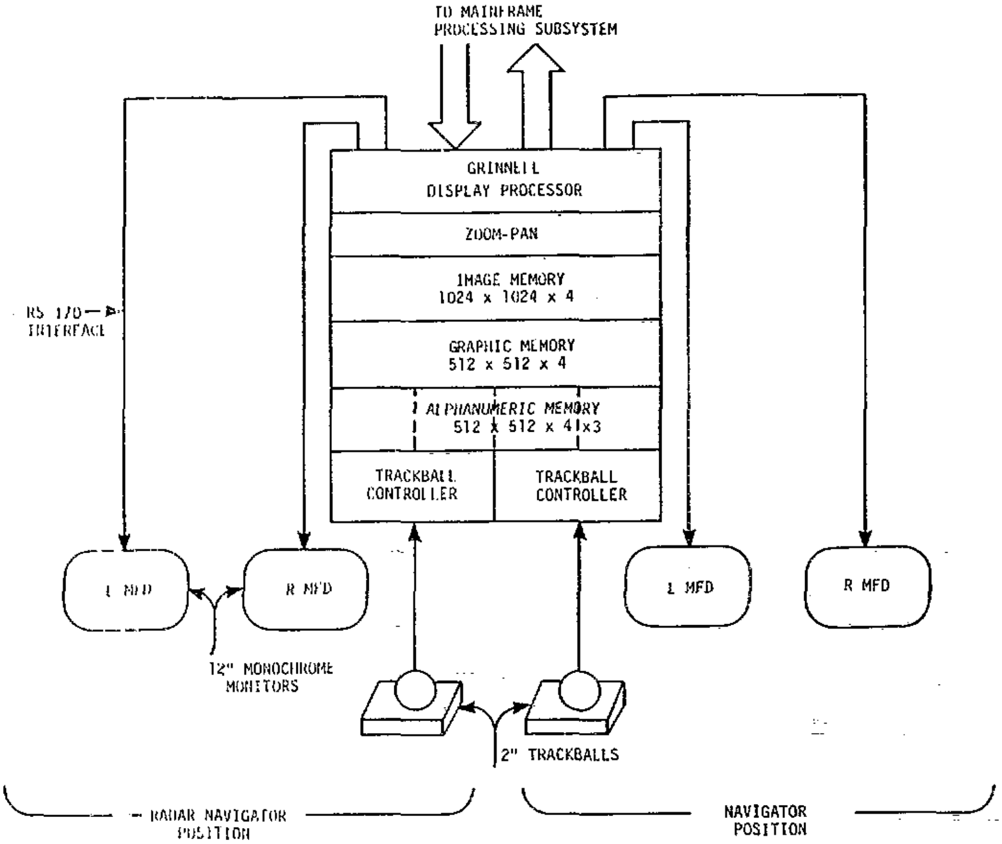


Figure 6

crewstation to allow the crewmembers to position crosshairs on the MFDs (See Figure 6).

Each crewmember has control of two MFDs and one trackball. Thirty-three different display formats may be selected for presentation on any one or combination of MFDs. Most display formats contain only alphanumeric data, but some contain alphanumeric data overlaid on radar video imagery, which at any one time may include crosshairs, ground track vector, and navigational markers (aircraft heading vector, range rings, bezel rings).

The display processor, refresh memory, and trackballs are a special-purpose system provided by Grinnell Systems Corporation for this application. The monitors are model NDC-12 provided by TSD Display Products, Inc.

The DS interfaces with the mainframe processor via two high-speed, unidirectinal 16-bit parallel interfaces with direct-memory-access (DMA) transfer capability. To accomplish 16-bit parallel data transfers, the General Purpose Interface Board provided with the PRIME computer was modified by Grinnell to interface with the display controller.

The following is a list of the Display Subsystem Capabilities:

IMAGE

One Image Shared By Up To Four Monitors

4 Bits (16 Levels) Gray Scale Image

4 Bits For Four Overlays (also shared by monitors)

1024 x 1024 Resolution (512 x 512 displayable at any one time)

ALPHANUMERICS

Independent Alphanumerics On Each Monitor

May Overlay Portions Of Image Data

Dual Intensity

Reverse Video

Underline

Blink

7 x 9 pixel characters in 8 x 12 matrix

OAS CONSOLE SUBSYSTEM CONFIGURATION

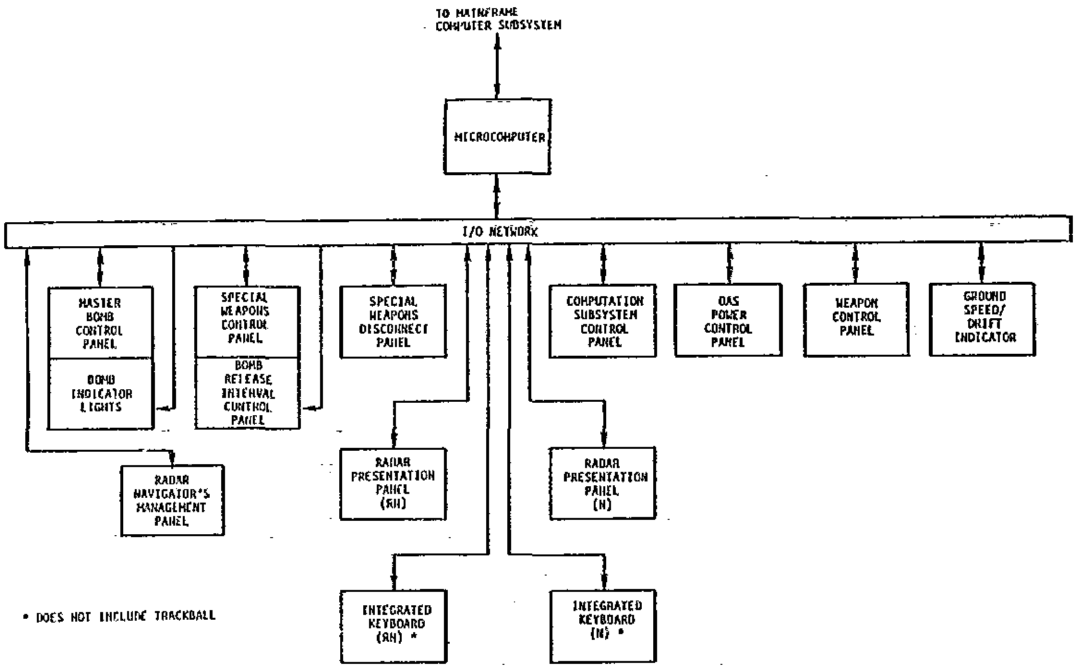


Figure 7

128 alphanumeric characters, special symbols

MONITORS

4 Monochromatic (P39 Phosphor) Monitors

6" x 9" Viewing Area (or 12" diagonal)

OAS Crewstation Subsystem

The OAS Crewstation Subsystem (see Figure 7) contains operational mockups of those OAS and weapon panels required for the specified procedures training in the PTT. This subsystem consists of the 16 panels used by the crewmembers. The panels are equipped with switches, buttons, lamps, and two keyboards. The four MFDs and two trackballs are physically located with the panels in the crewstation but are logically part of the Display Subsystem.

Switch Control Unit

The Switch Control Unit (SCU) provides an interface between the mainframe processor and the switches and lamps in the panels in the crewstation. The SCU is responsible for: 1) *sensing switch activations on the panels and* reporting them to the MPS, and 2) generating appropriate signals to light/extinguish lamps on the panels by request of the MPS.

The SCU block diagram is shown in Figure 7. The SCU is a CROMEMCO Z2 microcomputer with appropriate software.

The interface box (see Figure 8), which is mated with the Cromenco Z2 microcomputer to form the Switch Control Unit, is being produced at the 3300 Technical Training Wing/Technical Training Division, Keesler AFB, MS.

Instructor Console Subsystem

The Instructor's Console Subsystem (ICS) serves as a system monitor and control interface for the instructor. It provides for interchange of textual data with the Part Task Trainer control programs executing in the MPS. The following data are displayed at the Instructor's Console on an alphanumeric CRT display:

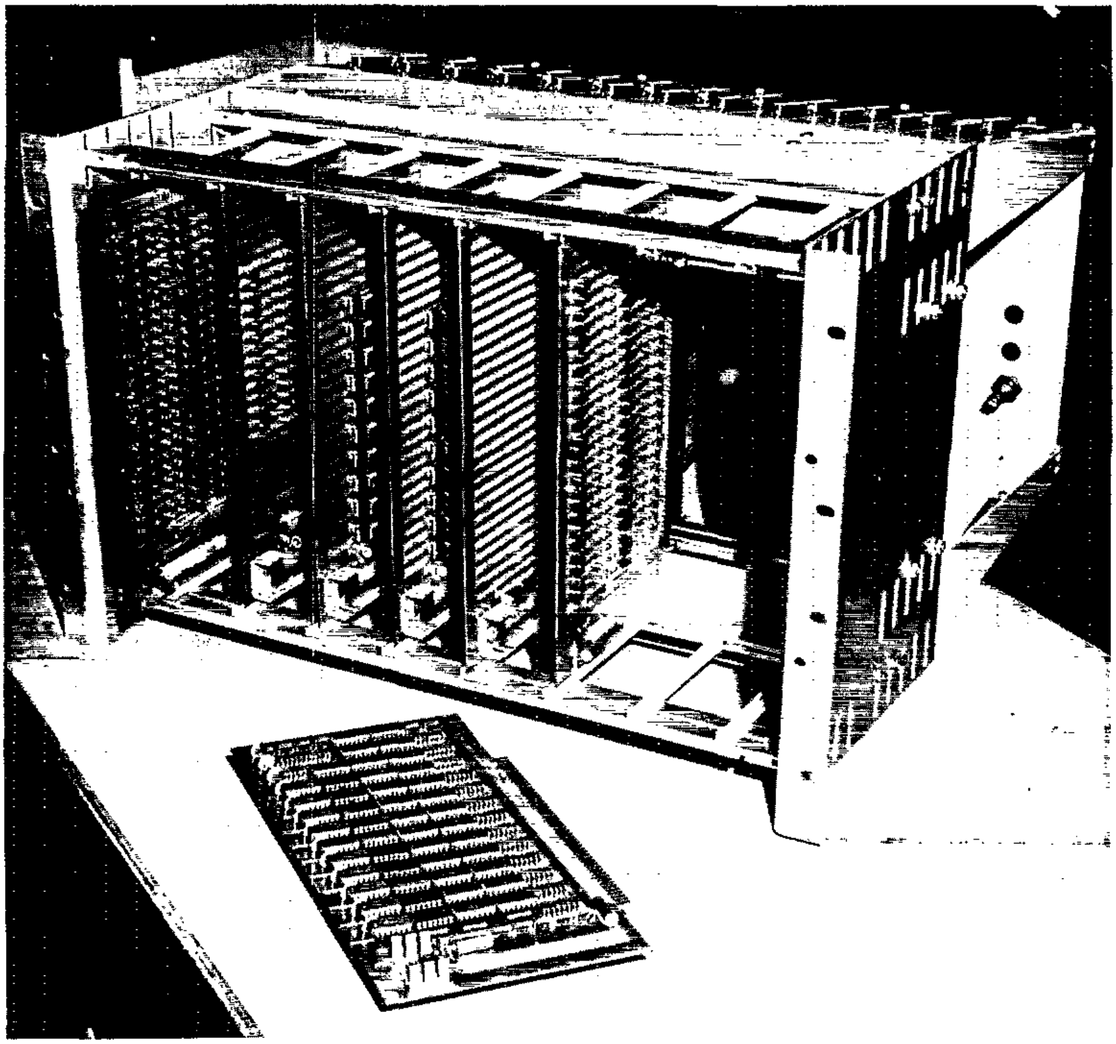
Flight Parameters

Mission Data

Status of OAS-Emulated Subsystems

Operational Faults

Alphanumeric data and control codes are input through a keyboard. Functions which can be exercised are:



INTERFACE BOX
Figure 8

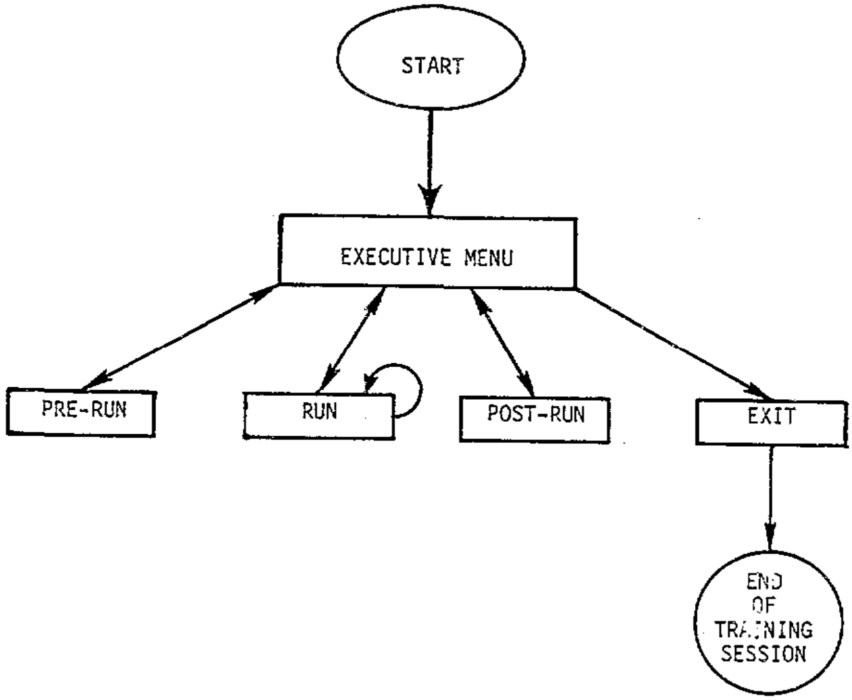


Figure 9

Trainer Session Control

Alteration of Flight Parameters

Alteration of Mission Data

Modification of OAS-Emulated Subsystems Status

Fault Seeding

Recovery from Operational Faults.

The ICS is a SOROC IQ 140 CRT terminal.

The instructor can interact with the PTT in three operational modes: Pre-Run, Run, and Post-Run. The interface has been designed to facilitate moving back and forth among any of the three modes (see Figure 9).

The Pre-Run mode occurs prior to the training (simulation) session and allows the instructor to select and edit a scenario for training, and complete setup and initialization procedures. The Run mode is the actual training period or simulation, during which the instructor monitors the crewmembers actions and injects changes into the session. The Post-Run mode occurs after the training session, in which the instructor can initiate a limited review and analysis.

All sessions must go through some minimum initialization via the Pre-Run mode of the user interface. After the appropriate initialization, the instructor will enter the Run mode, via commands available to him, to begin the training session. He will be provided with commands that allow him to abort the session and return to the Pre-Run mode, or interrupt for a time period and then resume within the Run mode itself. Once the run is complete, the instructor may enter the Post-Run mode, in which he may conduct limited review and analysis, or he may return to the Pre-Run mode to initiate another training session.

The software has a modular design, which will aid in making future changes. Software development is performed on the mainframe procesor in a high-level language. The PTT software package with the exception of the Switch Control Unit software is being designed and produced by Technology Service Corporation of Santa Monica, CA. The Switch Control Unit software is being developed by the 3300 Technical Training Wing/Technical Training Division at Keesler Air Force Base, MS. The entire software package outlined in the above paragraphs will be an 18 month effort. Funding for the B-52 OAS/CMC PTT was received on 27 April 80 and first production unit will be delivered to Strategic Air Command on 15 Oct 81.

SUMMARY

A full-capability trainer cannot be delivered prior to OAS deployment, yet procedures training is essential for the OAS conversion training and operational use of the new system. The B-52 Offensive Avionics System Part Task Trainer is a powerful training system provided at a low cost and in a short-term schedule.

Undoubtedly there are other military systems whose training requirements can also be met by a mid-range trainer. Such systems are likely to require software control of switch panels, real-time instructor interaction, multiple displays, and graphics displays--requirements *which are being satisfied by the PTT.* The modularity and flexibility being designed into the hardware and software of the PTT will minimize the efforts required to adapt this design to other applications.

REFERENCE

1. Offensive Avionics System Part Task Trainer, Software Performance Specification, TSC-PD-A248-6, December 8, 1980, Revised 1 March 1981.

2. Offensive Avionics System Part Task Trainer Specification Document, TSC-PD-A248-3, August 15, 1980, Revised October 6, 1980.

3. Instructor's Manual, TSC-PD-A248-3, October 7, 1980.

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