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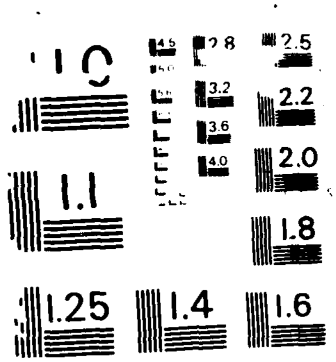

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AIR FORCE HUMAN RESOURCES LABORATORY

INSTRUCTOR/OPERATOR STATION (IOS) DESIGN GUIDE

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A design guide for instructor/operator stations of an aircrew training device was prepared. The guide was developed based on surveys of representative Air Force operational aircrew weapon system trainers and an analysis of instructor functions in the employment of weapon system trainers in aircrew training programs. The guide outlines the different types of instructor/operator stations which can be implemented and the design characteristics which should be incorporated. Recommended control and display/indicator panels and abbreviations were identified. A summary of lessons learned, in terms of displays, controls, location and manning, is included.

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SUMMARY

The interface between the instructor and the simulation system of an aircrew training device (ATD) is critical in establishing the effectiveness of the device. While technology has provided a broad range of interface options, the implementation has not always proven to be user-acceptable, user-friendly, or training effective. As a result, the Air Force Human Resources Laboratory at Williams AFB, as part of a long-range training research and development program, undertook the development of a design guide for the instructor/operator stations of ATDs.

A two-phase effort was completed. Phase I involved a survey of representative operational weapon system trainers to collect data on existing problems and recommendations. Phase II was concerned with the development of a design guide and a prototype instructor/operator station specification.

This report is the design guide and sample specification which were developed based on the results of the survey, the analysis of design data, and an analysis of the instructor role and functions in the use of aircrew training devices in aircrew training. The guide includes IOS design characteristics, a list of functions which should be performed to accomplish training, a design guide for control and indicator panels, a list of standard abbreviations for use in data displays and panels, summaries of lessons learned from the surveys in terms of displays and controls, and a sample IOS specification.

PREFACE

A two-phase effort was undertaken to develop a design guide for instructor operator stations. The first phase involved a survey of representative aircrew training devices (ATD) and was conducted with the cooperation and assistance of many AF training personnel. Their inputs in terms of problems encountered and recommendations were invaluable. The author wishes to express his appreciation for their assistance and patience during the surveys.

This research and development supports the Training Technology goal as outlined in the Air Force Human Resources Laboratory (AFHRL) Research and Technology Plan. The general objective of this goal is to identify and demonstrate cost-effective strategies and new training systems to develop and maintain combat effectiveness. The work was performed by ICON, Inc., as a subcontractor to the University of Dayton Research Institute (Contract No. F33615-84-C-0066) for the AFHRL Operations Training Division (AFHRL/OT) under Work Unit 1123-03-79, with Dr. Gary S. Thomas as technical monitor.

Dr. Gary Thomas of AFHRL/OT provided technical direction for the project. Mr. Craig McLean at the Simulator Systems Program Office assisted in coordinating the survey and providing valuable inputs and insight into the ATD development process.

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INSTRUCTOR/OPERATOR STATION DESIGN GUIDE

1.0 INTRODUCTION

The instructor/operator station (IOS) provides the interface between the simulator instructor and the aircrew training device (ATD). The characteristics of the interface directly affect the effectiveness of training and hence, of the training device itself.

1.1 Background

The United States Air Force undertook a series of research and development (R&D) efforts in the mid-1980s to assess training device effectiveness. These efforts looked not only at ATD utilization in training programs, but also at the utilization of training and instructional features, and at user and instructor acceptance of the devices. The results in general revealed that not all trainers were being utilized as expected, that user acceptance was not always high, and that many trainer capabilities were not being utilized. The studies indicated a wide variety of causal factors, ranging from a lack of user training to changes in training objectives and weapon system modifications which were not incorporated in the trainer. In addition, advances in technology were clearly impacting trainer IOS design, especially in control, display, and software capabilities.

As a result, the Aeronautical Systems Division, through the Air Force Human Resources Laboratory (AFHRL) at Williams AFB, Arizona, undertook the development of an IOS design guide.

1.2 Approach

The effort began with a survey of the IOSs of selected Military Airlift Command (MAC) and Strategic Air Command (SAC) weapon system trainers at Altus AFB, Little Rock AFB, and Castle AFB. In addition, a visit was made to McConnell AFB to review the KC-135R trainer. The objective was to collect data on IOS utilization including problems in operation and training. A design guide was to be developed to fill the gap in existing IOS design data and methods such as human factors engineering, systems analysis, and instructional development. The final task was to develop an IOS specification to be incorporated into a typical trainer procurement specification utilizing the design guide material.

1.3 Purpose

The purpose of the guide is to provide the trainer system procurement staff with sufficient data and formats to specify an effective IOS(s) for future ATDs. The guide, when used with existing system acquisition guides, human factors engineering guides, and instructional development efforts, should result in the design and development of an IOS that is responsive to training requirements and to user needs and characteristics. At the same time, it should prevent the recurrence of past design deficiencies.

2.0 SCOPE

This guide applies to the procurement of all ATDs suporting aircrew training from undergraduate pilot training through initial qualification, upgrade, and special qualifications training.

3.0 APPLICABLE DOCUMENTS

3.1 Specifications

MIL-M-18012	Markings for Aircrew Station Displays, Design and Configuration of
MIL-T-23991	Training Devices, Military, General Specification for
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Specification for
MIL-C-29025	Communication Systems for Training Devices, General Specification for
MIL-C-29053	Training Requirements for Aviation Weapon Systems
MIL-S-38039	Systems, Illuminated, Warning, Caution, and Advisor, General Specification for
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-C-81774	Control Panel, Aircraft, General Requirements for
MIL-T-82335	Trainer, Fixed Wing, Flight: General Specification for

3.2 Standards

MIL-STD 1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD 411	Aircrew Station Signals
MIL-STD 783	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD 203	Aircrew Station Controls and Displays for Fixed Wing Aircraft
MIL-STD 250	Aircrew Station Control and Displays for Rotary Wing Aircraft
MIL-STD 1333	Aircrew Station Geometry for Military Aircraft
MIL-STD 721	Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety
FED-STD 595	Colors

3.3 Air Force Publications

AF Regulation 50-8 Policy and Guidance for Instructional System Development (ISD)

AF Regulation 50-11 Management of Training Systems

AF Regulation 57-1 Statement of Operational Need (SON)

AF Regulation 60-12 Planning and Scheduling Aircrews and Equipment

AF Regulation 800-2 Acquisition Program Management

AF Regulation 51-series - Aircrew Training

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4.0 DEFINITIONS

The following terms are used throughout the guide.

Simulator Training System - an integrated group of subsystems consisting of hardware, software, and personnel designed to conduct training of the aircrew(s) of an operational system via simulation. A variety of subsystems may be required to meet the specified training objectives including simulations of motion, vehicle dynamics, weapon system characteristics and capabilities, geophysical environment, electromagnetic environment, warfare environment, and any other aspect of the task required for crewmember(s) training. A typical simulator-based training system will consist of the following subsystems:

1. Trainee station or mockup,

2. Computer system with software operating system,

3. Instructor/Operator interface,

4. Simulation software, and

5. Training software.

In addition, the following subsystems may be present:

6. Visual simulation system,

7. Motion/vibration simulation system,

8. Sound simulation system, and

9. Acceleration ("g") simulation system

Cockpit or Crewstation Familiarization Trainer (CFT) - a training device consisting of a crewstation mockup utilized to familiarize the aircrew member with the arrangement and location of controls and displays and to teach and practice tasks such as checklist use and normal and emergency procedures sequences. Controls and displays are not normally functional.

Part-Task Trainer (PTT) - a training device used to practice a specific task, generally a weapon system subsystem task such as normal and emergency operation. The device provides a mockup of relevant sections of the crewstation, consisting of control and display panels related to the subsystem learning objectives. Skills independent of other mission tasks are developed for later integration with other aircrew tasks.

Cockpit or Crewstation Procedures Trainer (CPT) - a training device consisting of a crewstation mockup utilized to teach the aircrew member specific system operation including normal and emergency procedures. Relevant controls and displays are functional, but no dynamic simulation of the platform or of complete weapon systems is implemented.

Operational Flight Trainer (OFT) - a training device consisting of a mockup of the aircraft cockpit, with complete simulation of aircraft flight characteristics and environment to permit training in aircraft handling, instrument flight procedures related normal and emergency procedures, and integration of piloting skills. Limited tactical maneuvers can also be trained.

Mission Trainer (MT) - a training device consisting of a crewstation mockup(s) which permits training on specific mission tasks in a simulated environment. The trainer provides weapon system operating modes or mission modes which require tactical decision making and provide for integration of system operating skills. The trainee is confronted with inflight situations that energize aircraft sensors for target acquisition, identification, tracking, evasion, and weapons management.

Weapon System Trainer (WST) - a training device providing complete simulation of the weapon system, with full mockup of crewstations and dynamic simulation of system and warfare environments. Complete missions can be trained as well as crew integration.

Instructor Operator Interface - the link between the instructor and the trainer hardware and software system. It includes the:

1. physical interface - the controls, displays, console/table, chair, and other hardware installed at the instructor's normal position during training.

2. simulation interface - the functional interface with the simulation system which provides the instructor control over the simulation program, including the motion and acceleration simulations, flight and weapon system simulations, and environment simulations.

3. instructional interface - the functional interface with the training system which provides the instructor control over the instructional features of the training device, from training event preparation and briefing to debriefing and training evaluation.

Instructor/Operator Station (IOS) - the designated position for the instructor for implementing the training functions assigned.

Instructor/Operator Console (IOC) - a display and control assembly designed to implement the instructor interface requirements.

Instructional Feature - an ATD hardware or software capability designed to unburden the instructor and enhance his/her performance in instructing tasks using the training device.

Operating Feature - an ATD hardware or software capability designed to unburden the instructor and enhance his/her operation of the training device in support of training functions.

Management Feature - an ATD hardware or software capability designed to unburden the instructor and enhance his/her management of training using the training device.

Simulator Instructor - a USAF-certified flight or weapon system instructor trained to utilize the simulator training system in the implementation of the designated training course.

Simulator Operator- a USAF designated person trained in the detailed operation of the training simulator, including computer system initialization, utility systems operation, ancillary simulation system (e.g., visual, motion) operation, training mission programming, and routine trainer operation in support of training implementation.

5.0 IOS CHARACTERISTICS

The characteristics of the IOS, as part of the ATD, are contingent on the training requirements allocated to the ATD as a training medium. No meaningful ATD or IOS can be specified in the absence of explicitly stated training objectives. The Instructional System Development (ISD) process normally identifies training objectives and allocates them to selected media. Therefore, the weapon system ISD effort must be completed to at least the objectives allocation stage prior to developing the ATD and the IOS functional description and subsequent detailed specification. This includes completion of the task analysis and development of the learning objectives.

IOSs are designed to meet specific interface objectives based on the following requirements and constraints:

1. Training system functional requirements,

2. Manning concept,

3. Training course level,

4. Training strategy, and

5. Instructor location relative to trainee station(s).

The parameters are not independent. For example, instructor location is partially a function of training strategy, which is in turn partially a function of training course level. However, each defines a characteristic reflecting a system constraint or requirement.

Each IOS must be functionally defined in terms of these requirements prior to design. The training device functional specification must integrate the IOS requirements into the total simulator training system functional specification. (The training system functional specification is developed from training objectives and requirements, not weapon system or simulation system characteristics and capabilities.)

The type and quantity of supporting training devices also determine what training objectives will be allocated to a specific device. The lack of separate familiarization and procedures trainers, for example, may result in the transfer of related training objectives to the WST. The result is the imposition of a different set of instructor interface requirements to the IOS. The WST trainee is assumed to have the skills and knowledge associated with basic position qualification, including subsystem normal and emergency operating procedures and basic tactical employment. The requirements interact with the training course. Continuation training, for example, assumes that the trainee meets the weapon system qualification entry skill and knowledge levels. Thus, operational units impose fewer constraints on IOS design in terms of training-level support than do replacement training units.

5.1 Training Functional Requirements

As a training system element, the training simulator must be specified in terms of training functional requirements. Although a variety of taxonomies have been utilized to structure these requirements, all reflect the basic training tasks from scheduling of the training event, through the conduct of the specific event, to documentation and user training. Figure 1 outlines a typical set of functions in flowchart format. Appendix A outlines these functions in greater detail.

A modern computer-based simulation training system is potentially capable of supporting all of the functions involved. Where other training systems are

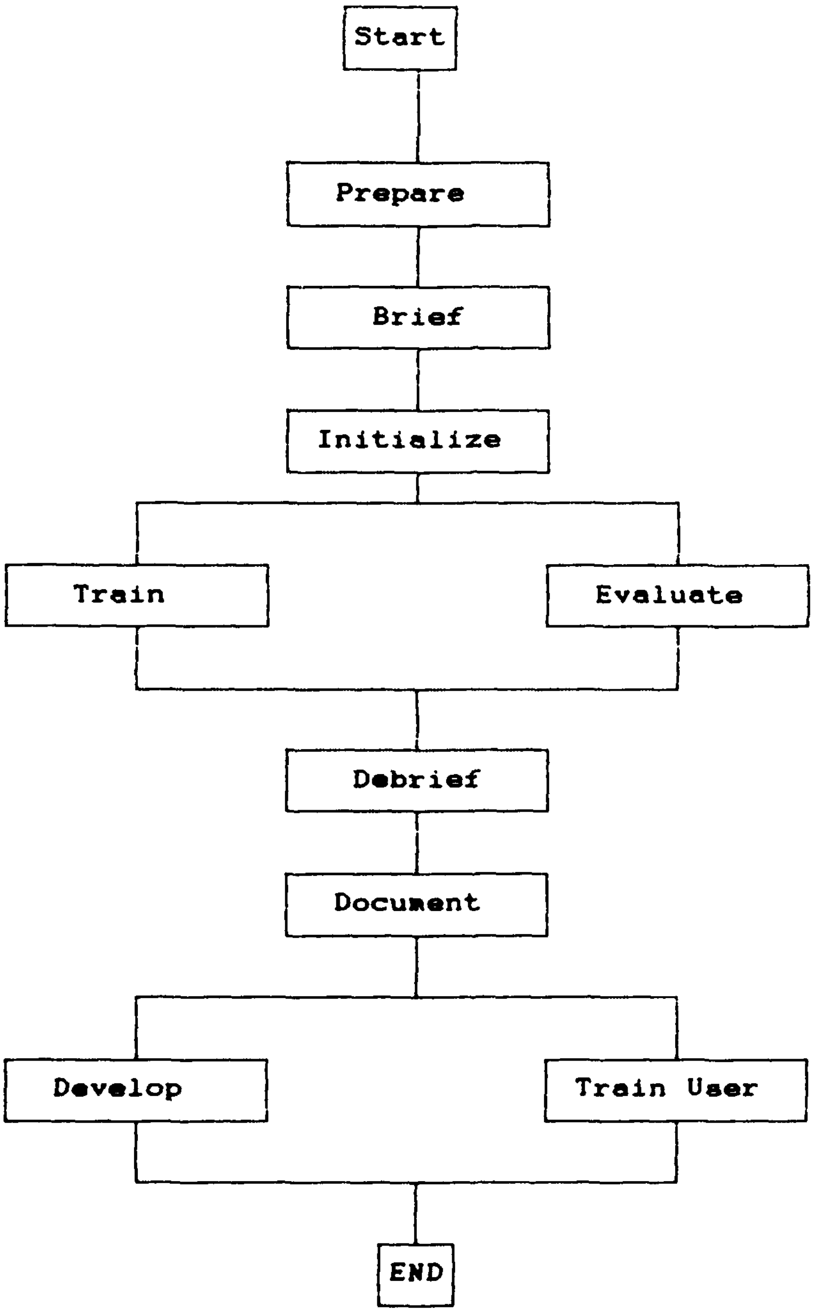


Figure 1. Simulator Training Function Flow.

utilized, such as a training management or data system, an interface can be utilized to integrate the trainer into the overall system. As a minimum, a terminal should be provided for simulator instructor use as the interface between the systems. To the extent that the ATD is not functionally supported as part of an overall training system, the ATD "system" must support the training functions if it is to be effective.

For IOS design, the required training functions have been categorized in terms of three major IOS functions. These functions and their subelements are shown in Table 1. The categories will be used in describing IOS design requirements where options for operators and instructors are reviewed.

Table 1. IOS Functional Requirements

Operating Functions

- System power up
- Program load (simulation/training program)
- System readiness checks
- System configuration for training
- System reset/reboot
- Data store/processing
- Scenario development/programming

Instructing Functions

- Event preparation
- Aircrew/staff briefing
- Crewstation/console configuration
- Scenario initialization
- Instructing/performance monitoring
- Performance evaluation/assessment
- Performance problem analysis/diagnosis
- Aircrew/staff debriefing
- Instructor training/standardization/certification

Managing Functions

- Trainer scheduling
- Aircrew scheduling
- Instructor/operator scheduling
- Aircrew training records maintenance/interface
- Instructor/operator records maintenance/interface
- Trainer syllabi development/control
- System utilization/status reporting
- Training effectiveness analysis
- Trainer configuration control

The three functional categories also define three different users in terms of jobs and qualifications (if the functions have been allocated to manual operation). These are:

1. System operator - typically a simulator technician/computer operator,

2. Simulation instructor - a weapon system position-qualified person who has completed instructor training including trainer utilization,

3. Training manager - typically a syllabus or course unit manager with experience and responsibilities in training operations and management.

Optimization of the manning of the IOS requires consideration of the functions involved and the skills and knowledge necessary. It also requires designing the IOS to reflect the three different jobs involved; e.g., grouping of controls and displays should be based on user characteristics and needs, as well as required integration with other types of users and stations.

5.1.1 Operating Functions. The operating functions are of two types:

1. System operation to establishing training system readiness; e.g., power-up, checkout, and configuration.

2. Computer system operation to conduct training, e.g., scenario programing, data processing and system modifications.

In summary, operating functions are concerned with the operation of the simulation subsystems (hardware and software) to support training.

5.1.2 Instructing Functions. Instructing functions are of three types:

1. Training preparation functions; e.g., review of training data, conducting briefings, initializing the trainer, and configuring the crewstation and IOS for the training exercise to be conducted.

2. Training functions; e.g., scenario modification to meet aircrew special requirements, monitoring and evaluating performance, implementing instructional features, and providing guidance and real-time feedback.

3. Terminating functions; e.g., debriefing, scoring/grading, and completion of training records.

In summary, instructing functions include all the functions related to implementing training, given an operationally ready training device.

5.1.3 Management Functions. Management functions are of four types:

1. Scheduling functions; e.g, scheduling the trainer, operators, instructor(s) and student(s).

2. Data functions; e.g., maintaining student, instructor, and trainer records and reports.

3. Design functions; e.g., developing scenarios, missions, and training events including, for example, initial condition options, performance measurement algorithms, offensive system characteristics, and environments.

4. Training functions; e.g., training of the instructors, operators, and other users in trainer operation.

In summary, management functions include all of the off-line or background functions required to schedule, design, and document training and trainer activities.

5.2 Manning Concept

The manning concept refers to both the quantitative and qualitative characteristics associated with IOS manning. The types of personnel utilized range from operational aircrew members to contract personnel. The implications for IOS design are significant and must be reflected in the IOS design requirements. The various manning options can be described in terms of four categories:

1. Operational instructors,

2. Simulator instructors,

3. Simulator instructor-operators,

4. Simulator operators.

5.2.1 Operational Instructors. Operational aircrew instructors are defined as AF personnel who are weapon system qualified and have completed instructor upgrade training. Included, for example, are instructor pilots, instructor navigators, instructor flight engineers, and instructor gunners. Operational instructors are typically also instructor qualified in the aircraft. They may also be qualified as academic instructors.

A relatively high instructor turnover rate will exist, in that the personnel will typically rotate out of the job in about 2 years (including training time). Thus, on-the-job experience cannot be utilized to achieve the required instructor capability or qualification.

Operational simulator instructors impose the following requirements on IOS design:

1. Since time in the job will be minimal, simulator operation training time must be minimal and should typically not involve more than 20 hours of academics and 20 hours of hands-on training (including the instructor qualification event). Qualification requirements will be contingent on the trainer design characteristics but will normally not include programming tasks, such as simulator mission programming, unless the task is integral to normal operation.

2. Positive transfer of operational weapon system skills to simulator operation must be maximized and negative transfer of simulator operating skills to weapon system operation minimized. This will require that:

a. Documentation language and operation terminology must be in aviation and especially, in weapon system terminology;

b. Repeater display arrangement and appearance should be identical to the weapon system aircrewstation involved, whether accomplished with actual or simulated system hardware;

c. Displays, controls, and control panels should be configured in accordance with aeronautical design standards and specifications, and the actual weapon system crewstation design;

d. Where conflicting design guides exist, the following priorities shall be used (in sequence):

- weapon system aircrewstation design;
- aeronautical design specifications, standards, and drawings;
- human engineering design criteria.

5.2.2 Simulator Instructors. The dedicated simulator instructor is one whose sole training function is conducting training using the training device. Personnel of two different backgrounds are utilized and impose differing requirements on IOS design: (a) AF personnel with flight, and possibly weapon system, experience; and (b) contract instructors who may have flight experience, but not necessarily weapon system experience.

Simulator operation training for AF personnel must be limited to about 40 hours of academics and hands-on training, with no more than an additional 2 weeks of observation and monitored instructing. Turnover of personnel will normally occur each 3 to 4 years.

Contract instructors can be required to be proficient in the operation of the trainer in all modes, and in its use in implementing the training course. Turnover is not a problem.

5.2.3 Simulator Operator/Instructors. Simulator operators/instructors have expertise in trainer operation, but limited system operational expertise. Therefore, this manning option provides individuals skilled in trainer technical operation, but not necessarily possessing instructional skill in system tactical or operational capabilities and nuances. A wide variety of personnel backgrounds can be utilized. Therefore, the IOS subsystem must be designed to the unique qualifications of the proposed manning. Typically, instructional tasks such as performance assessment and scenario tailoring may need to be supported by the training system software.

5.2.4 Simulator Operators. Simulator operators are trained in the details of simulator system/subsystem operation and "line-level" maintenance. The operator typically has no training or experience in the weapon system. The operator training course generally consists of the first level of the trainer maintenance course.

Simulator operators can perform two types of training functions; they can serve as a "training instructors" for automated mission/qualification simulator events and as instructor support "technical experts" on trainer capabilities implementation. Thus, a high level of automated instruction must be incorporated if a simulator operator manning concept is to be implemented.

5.2.5 Caveat. Though the established manning concept can be utilized to establish the IOS requirements, the possibility and probability of alternative console/station manning must be considered. For example, contract instructors permit greater freedom in design of the displays and controls, since an instructor specifically trained to utilize the trainer will be provided. However, an AF operational instructor may be required to conduct the simulator "check ride" event and most certainly will conduct the advanced tactics and mission qualification training events. Thus, the IOS must be designed with the potential for "novice operator" use under certain conditions. The required capability must be well defined.

5.3 Training Course Level

The type of training conducted has been shown to significantly alter the trainer control functions required and utilized. The trainer courses supported by ATDs include the following:

1. Initial Qualification Training (Phase I)

2. Qualification Training (Phase II)

3. Continuation Training (Phase III)

4. Upgrade Training

5. Special Training

Each level imposes different instructor requirements, especially in terms of instructor-simulator interaction.

5.3.1 Initial Qualification Training (Phase I). Initial qualification training provides basic training on a new system. The course can be divided into three phases:

1. Familiarization Training - concerned with acquainting the trainee with the general characteristics of the system and the configuration and layout of the crewstation. At the conclusion of training, the trainee is expected to know the location and function of all controls and displays, and be familiar with all subsystems and crewstation components, including seating, lighting, oxygen, and escape and restraint devices.

A "familiarization trainer" is normally used to support the training. The CFT exemplifies this type of trainer.

2. Procedures Training - concerned with teaching the trainee the normal and emergency operating procedures for the crewstation systems. At the conclusion of training, the trainee is expected to be able to power up, operate, power down, and perform specified emergency procedures for each system involved. No tactical use of the systems is involved.

Procedures trainers are normally used to support this type of training. Included are the CPT and specially designed equipment procedures trainers.

3. Position Training - concerned with teaching the trainee the tasks and functions required at the crewstation. Integration of subsystem procedural skills is involved. At the conclusion of training, the trainee is expected to be able to operate all of the equipment and perform all of the functions of the position independently of other crewmembers. Basic tactical employment can be

included. For pilots, for example, position training includes training in basic flight maneuvers and instrument flight.

Part-task trainers or position trainers are normally used to support this type of training. These include the OFT and the PTT type of trainers.

4. Crew Training - concerned with initial mission qualification. Integration of all skills and knowledges needed both individually and as a crew is required. Basic mission training and qualification training are included.

Full crew trainers are normally used to support this training. These include the WST and MT.

At the conclusion of Initial Qualification Training, the trainee is expected to be qualified in the crew position.

Phase I training also includes: "difference training," which is concerned with training crewmembers in a different series of the same aircraft in which they are currently qualified; and "upgrade training," which is concerned with training mission qualified personnel in new crew positions (e.g., plane commander or radar navigator).

5.3.2 Qualification Training (Phase II). Qualification training continues after initial qualification training and is concerned with the training and qualification of the crewmember to perform a unit's specific mission.

A WST or MT is used to support qualification training as appropriate, except that an OFT or PTT can be used to support subsystem/part-task or refresher training such as pilot and copilot instrument flight qualification and unusual flight maneuver training.

5.3.3 Continuation Training (Phase III). Continuation training is conducted at the operational unit and is concerned with maintaining crewmember position qualification and proficiency.

A WST or MT is used to support training, except that an OFT or PTT can be used to support specfic subsystem or tactics training, and refresher training such as pilot and copilot instrument flight qualification and unusual flight maneuver training.

5.3.4 Upgrade Training. Upgrade training is concerned with training for additional qualifications such as radar navigator, aircraft commander, and instructor. Position upgrade involves initial qualification training for the new position.

The same trainers as those used in the initial qualification training phase are used as appropriate for upgrade training.

5.3.5 Special Training. Special training involves unique training requirements in special tasks, systems, missions, or tactics. ATDs are used, as feasible, to support the unique training requirements.

5.4 Training Strategy

Training strategy refers to the mode of instruction employed by the instructor. The options range from instructor conducted demonstrations, with the student observing (student "hands-off"), to instructor observation of trainee performance (instructor "hands-off"). The modes can be grouped into three categories in terms of instructor level-of-involvement as follows:

1. Tutor level,

2. Interactive level, and

3. Monitor level.

The categories impose significantly different requirements on IOS design. For example, the monitor level or hands-off observation strategy imposes major requirements for trainee performance data collection for trainee debriefing, since little instructor interaction occurs during the training event itself. Direct interaction strategy, on the other hand, imposes major simulation control requirements, since, for example, the instructor requires options to freeze and modify the simulation and scenario in real time.

The instructing mode also interacts significantly with the type of training course involved, as will be discussed in the next section.

5.4.1 Tutor Level. At the tutor level, the instructor is imparting knowledge and procedures directly to the trainee, in a one-on-one approach. This method is used primarily for the weapon system familiarization, basic position training,and initial procedures phases of training. Trainer devices used vary from a CFT for familiarization and orientation training to procedures trainers providing segmented mission simulations.

5.4.2 Interactive Level. At the interactive level, the instructor is presenting problems, assisting in initial solutions as necessary, and providing practice and qualification problems. Direct instructor interaction with the trainee generally diminishes as proficiency is gained in the tasks being trained. The ATDs used are typically part-task trainers, which permit presenting task problems (part-mission tasks) to the student across the spectrum of tasks involved in the mission.

5.4.3 Monitor Level. At the monitor level, the instructor functions primarily as an exercise/scenario controller or trainee manager and evaluator. Interaction is minimal. Exercises and missions are well defined and typically involve full mission execution from mission briefing to mission debriefing.

5.5 Instructor Location

The location of the instructor is a major determinant of IOS requirements. Although a wide variety of specific locations are feasible, generally three variants are major determiners of IOS design:

1. Remote IOS - The IOS is remote from the trainee station; i.e., isolated physically from the trainee station(s). An instructor/operator console located in a place separate from the trainee mockup is an example.

2. On-board Remote IOS - The IOS is adjacent to or on-board the trainee station/mockup but remote from trainee activity. An instructor console located behind the trainee station is an example.

3. On-board Over-the-Shoulder IOS - The IOS is adjacent to or on-board the trainee stations and within visual observation of trainee activities/performance. A jump-seat instructor station located between the pilot and copilot is an example. Direct observation of trainee activity is an integral feature of such a station.

Varying combinations of the stations may be required where the trainer supports different phases of training with different manning constraints and training strategies.

The following discussion of each type of IOS assumes that a technician will be available "on-call" for troubleshooting, on-line maintenance, and technical operation support. Thus the IOS does not support maintenance functions in its normal mode of operation.

5.5.1 Remote IOS. The remote IOS is a self-contained simulator IOS. As such, it provides:

1. Controls for all instructor simulator operation and training event implementation; and

2. Displays for monitoring trainee performance, simulated system status, and training device status.

The remote IOS is not the computer system operating console, which is normally located with the computer equipment.

The remote IOS option is typically utilized for WSTs supporting continuation and mission qualification training where the trainees have the required position skills. They are being trained to function as a crew and for specific missions.

Figure 2 depicts a typical remote IOS in the form of a console. The console is designed for operation by one instructor. Two general-purpose cathode-ray tubes (CRTs) and cockpit repeater multifunction displays (MFDs) are used. Figure 3 depicts a typical overall layout using two remote consoles for the two trainee stations (flight and offensive systems).

5.5.2 On-Board Remote IOS. The on-board, but isolated instructor station performs the same functions as the remote IOS, except that space, weight, and operating design constraints normally limit the functions performed at the station. Over-the-shoulder instructing is often supported in this manner, and partially justifies the on-board location. Therefore, display requirements can be reduced to the extent that the instructor is provided the capability of directly viewing trainee activity and trainee displays and controls. The isolation of the instructor from ready access to the supporting training subsystem control generally imposes a requirement for the stand-by support of at

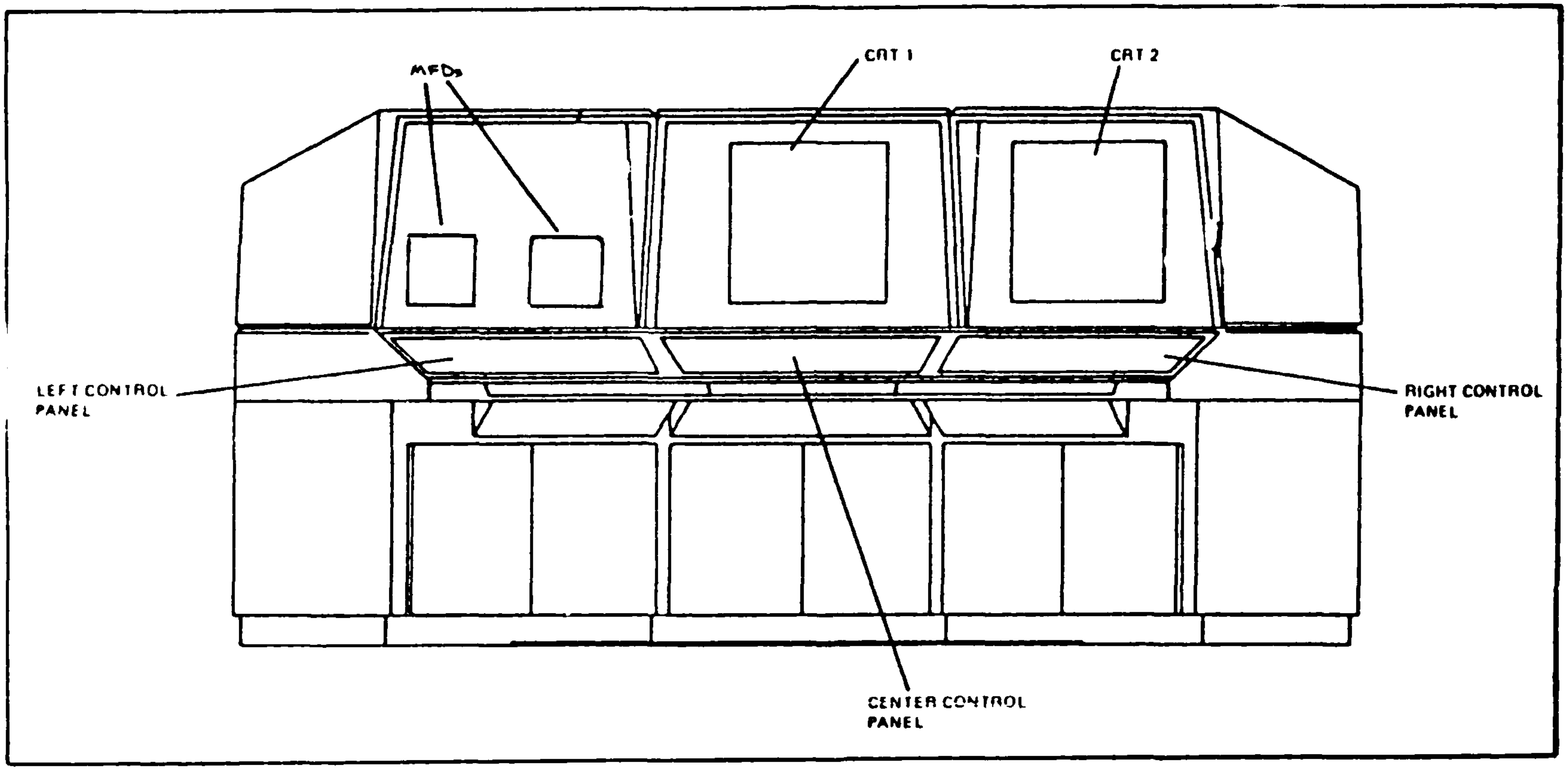


Figure 2. Sample Remote IOS.

MOTION BAY EVACUATION ROUTES

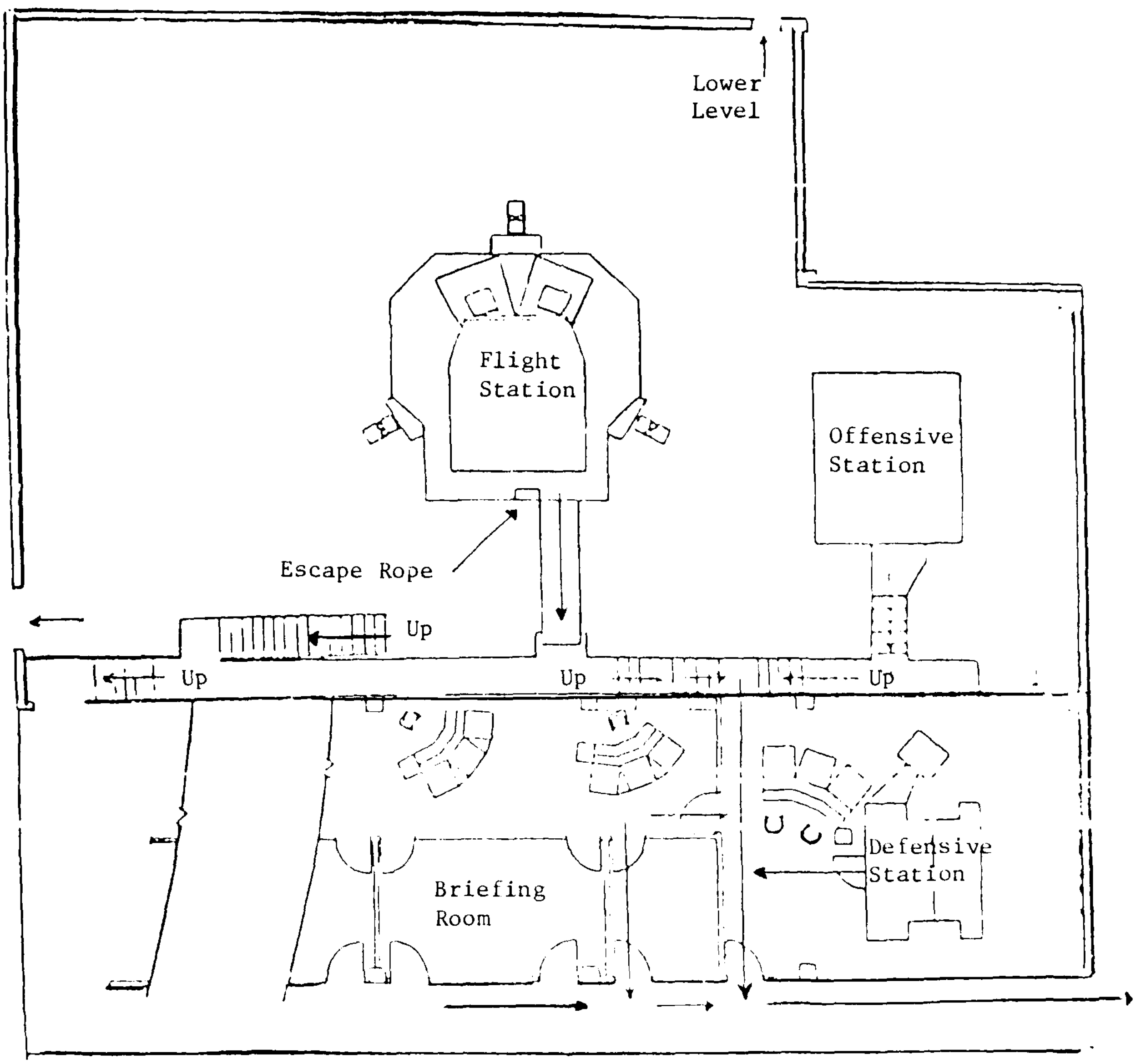


Figure 3. Typical Layout of a Remote TOS.

least a technician. This is especially true for motion-based systems where the instructor may not be able to access trainer utility system control panels without interrupting the on-going simulation.

The on-board remote station is typically used where there is the possibility that direct contact with and monitoring of the trainee may be required, but where control of complex training tasks is also required. Thus, it is often used with part-task trainers such as OFTs, PTTs, and position trainers. The trainee will generally have completed the familiarization and basic procedures training and thus have the basic knowledge and skill involved, but requires additional practice throughout the system's performance envelope.

Figure 4 depicts a typical on-board remote IOS. Figure 5 illustrates a typical layout of the console for a trainee station located on a motion platform.

5.5.3 On-Board Over-the-Shoulder IOS. The on-board over-the-shoulder station presents the most severe constraints to IOS design, since control and display area and instructor space are minimal -- especially on motion-based trainee stations, where the instructor is confined by a lap belt. Instructor eye-to-display/control distances can create readability problems. Trainee positions typically block the instructor's view of some control/display areas. Lighting conditions will generally be restrictive in that weapon system lighting will be used. Interphone communications and communication simulations present equally difficult implementation problems.

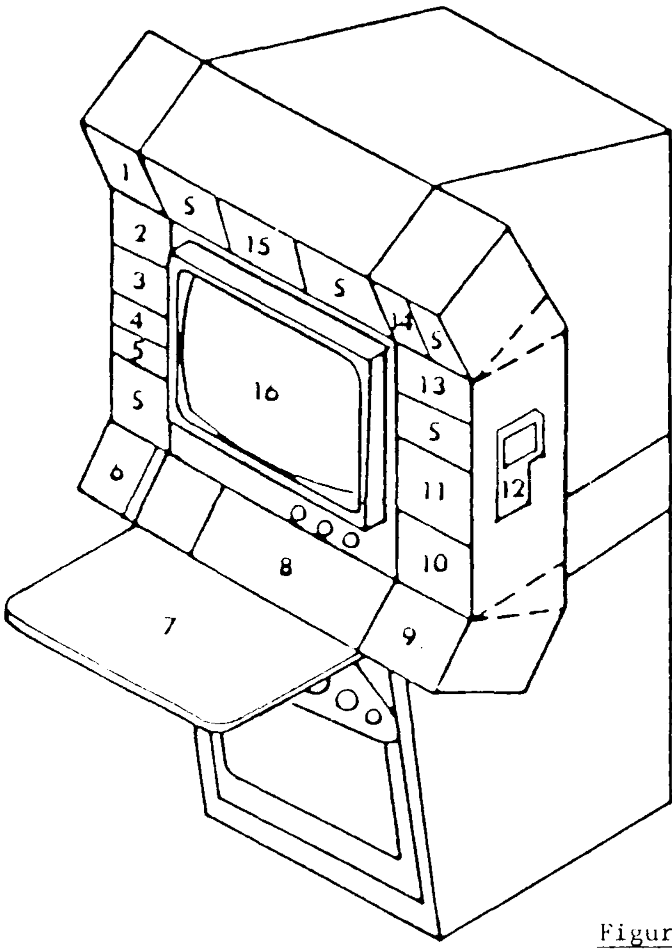
The station is typically used in the early stages of initial qualification training, where the instructor functions in the "tutor" mode and direct contact with the trainee is required both to impart knowledge and to observe and critique trainee performance. Thus, the station is typically used in familiarization, orientation, and initial procedures training.

Figure 6 depicts the typical layout of an on-board over-the-shoulder IOS. It consists of a seat on rails, which can be moved forward to a position between the two pilots; a work table; a control panel; and a remote control unit. Figure 7 shows a typical panel; this panel provides communication controls, lighting controls, and the trainer freeze control. Figure 8 depicts a typical portable unit used for controlling the trainer from the over-the-shoulder position.

5.5.4 Mixed Options. Providing both a remote and an on-board instructor station is an option. The approach results in a higher instructor/operator-to-student ratio but can simplify the control and display mechanization. Manning of the remote IOS by a simulator operator can reduce operating costs but requires the location of all instructor displays and controls at the on-board station.

On-board stations are often designed to function as both a remote and an over-the-shoulder station by mounting the instructor seat on tracks, which permit moving to a position close to the trainee.

Figure 9 depicts an on-board station that incorporates both the on-board remote and the on-board over-the-shoulder options. It consists of a console such as that shown in Figure 4. Each instructor's chair can be moved to an



LEGEND:

1. SPOTLIGHT ASSEMBLY
2. FLIGHT STATION CONTROL PANEL
3. LIGHTING CONTROL PANEL
4. INSTRUCTOR LIGHTS PANEL
5. VOLUME CONTROL PANEL
6. RELAY PANEL ASSEMBLY
7. DESK ASSEMBLY
8. CONTROL KEYBOARD
9. STUDENT CALL PANEL
10. AIC-10 INTERPHONE SYSTEM PANELS
11. INSTRUCTIONAL COMMUNICATIONS SYSTEMS
12. PORTABLE CONTROL UNIT
13. FLIGHT STATION MOTION OFF PANEL
14. EMERGENCY POWER OFF PANEL
15. FLIGHT DIRECTOR MODE PANEL
16. COLOR MONITOR WITH TOUCH SCREEN

S SPARE

Figure 4. On-Board IOS.

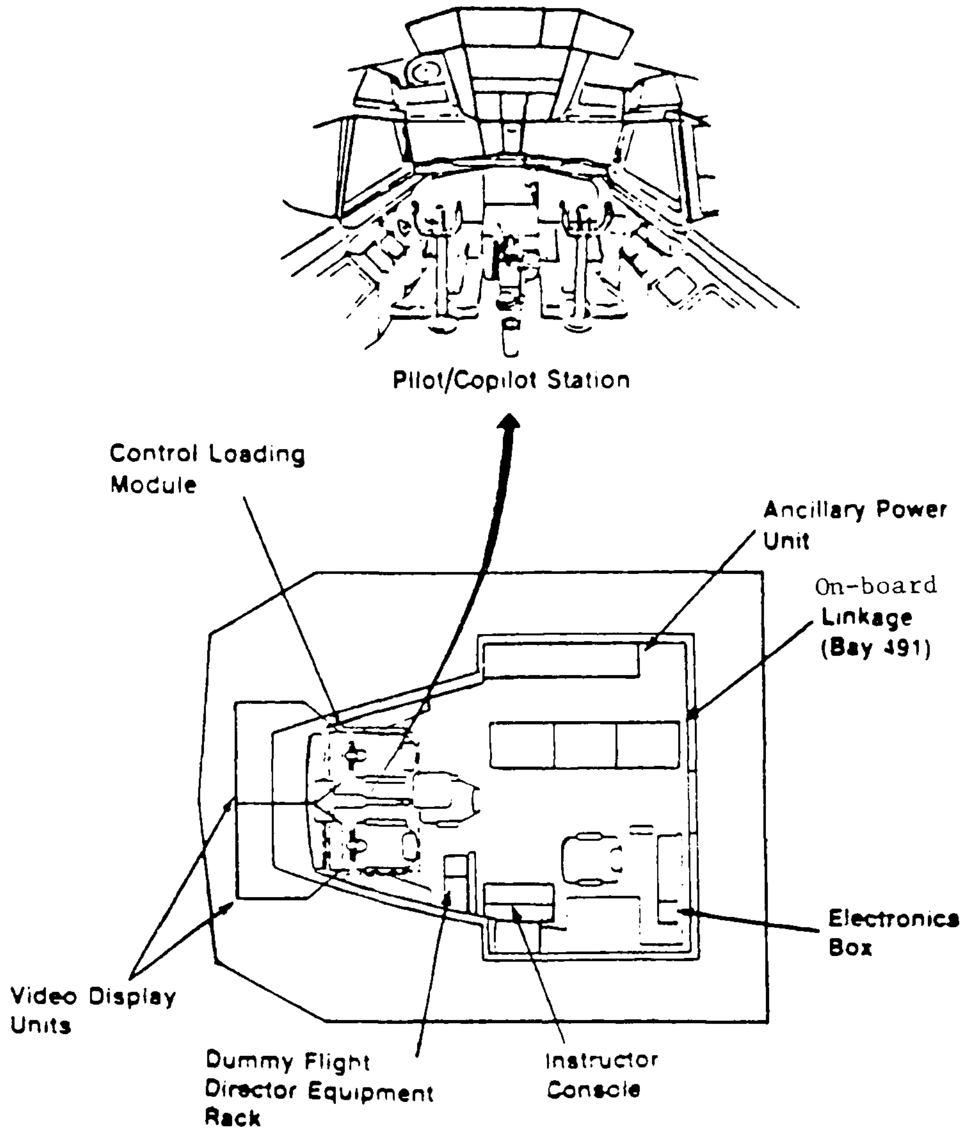


Figure 5. Typical Layout of On-Board Remote IOS.

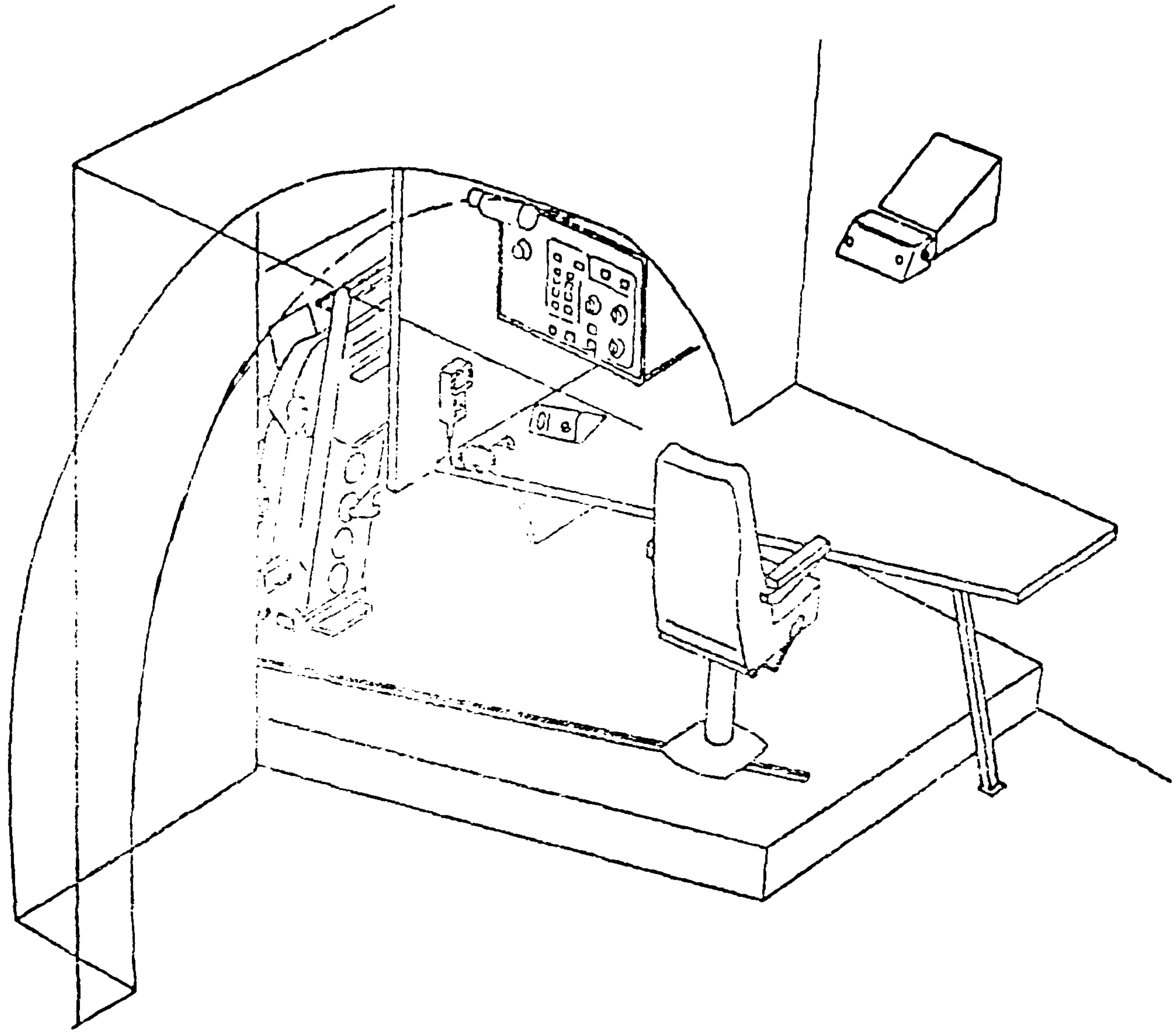


Figure 6. Typical Layout of On-Board Over-the-Shoulder IOS.

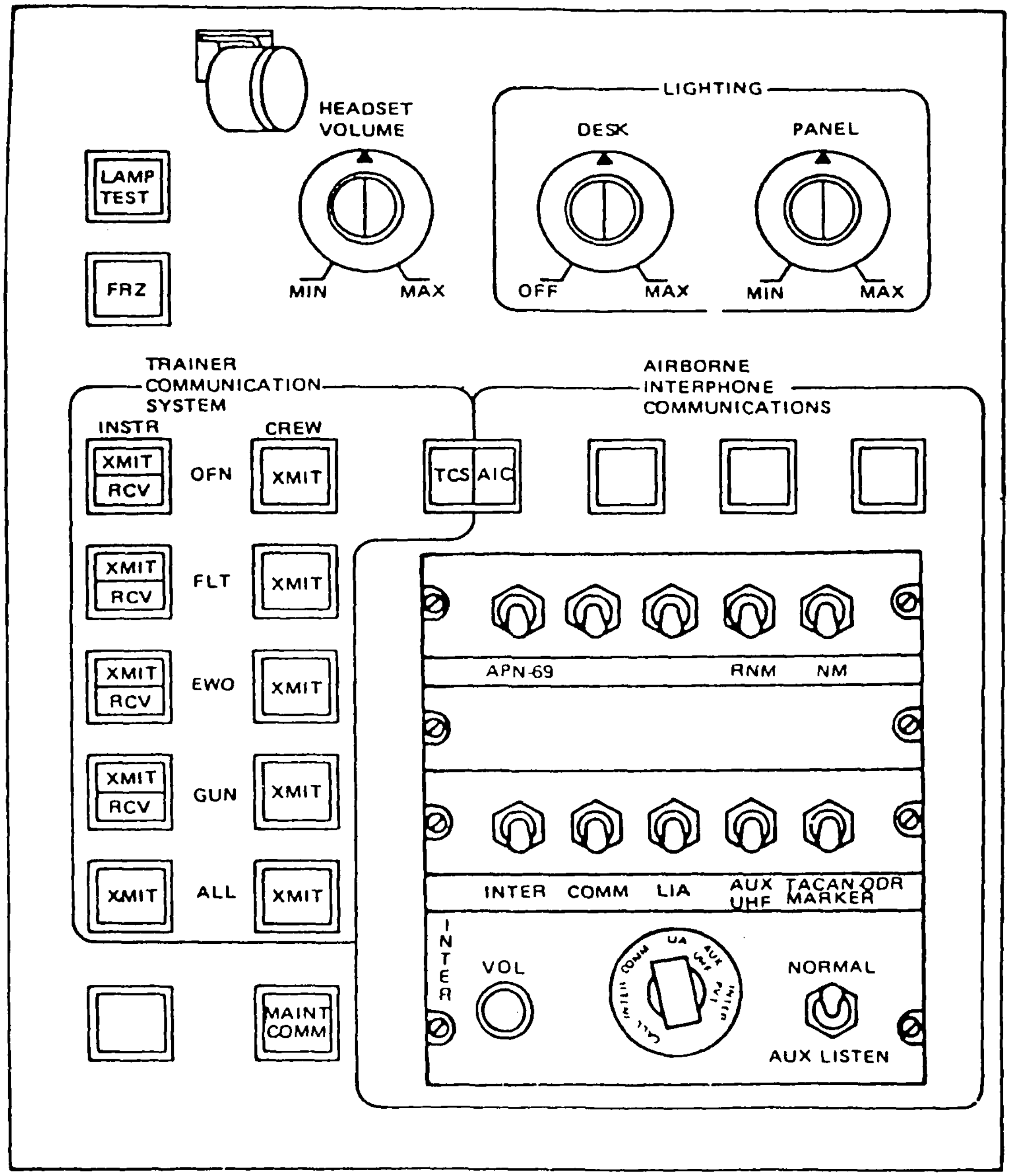


Figure 7. Typical Over-the-Shoulder Trainer Panel.

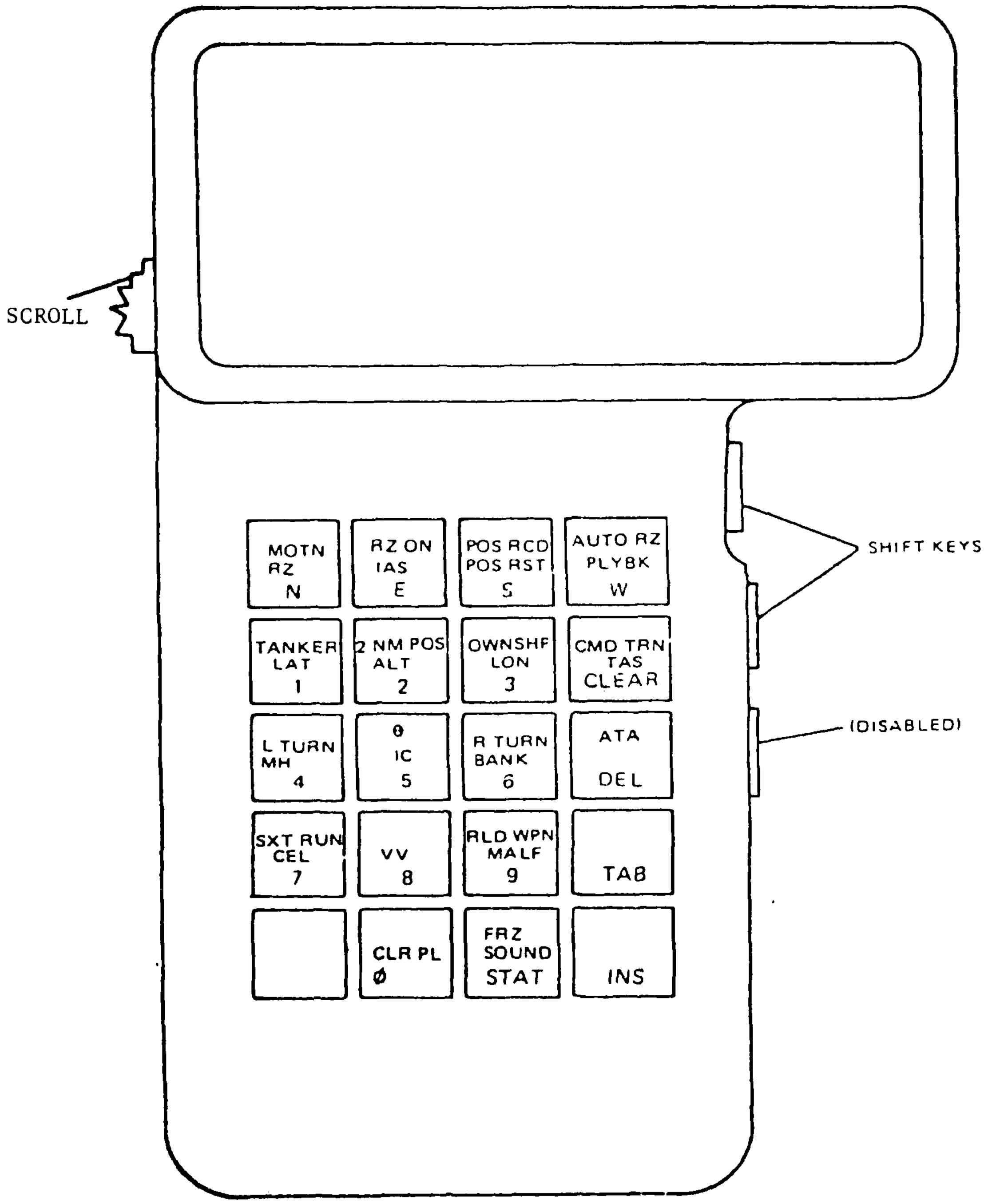


Figure 8. Typical Over-the-Shoulder Portable Control Unit.

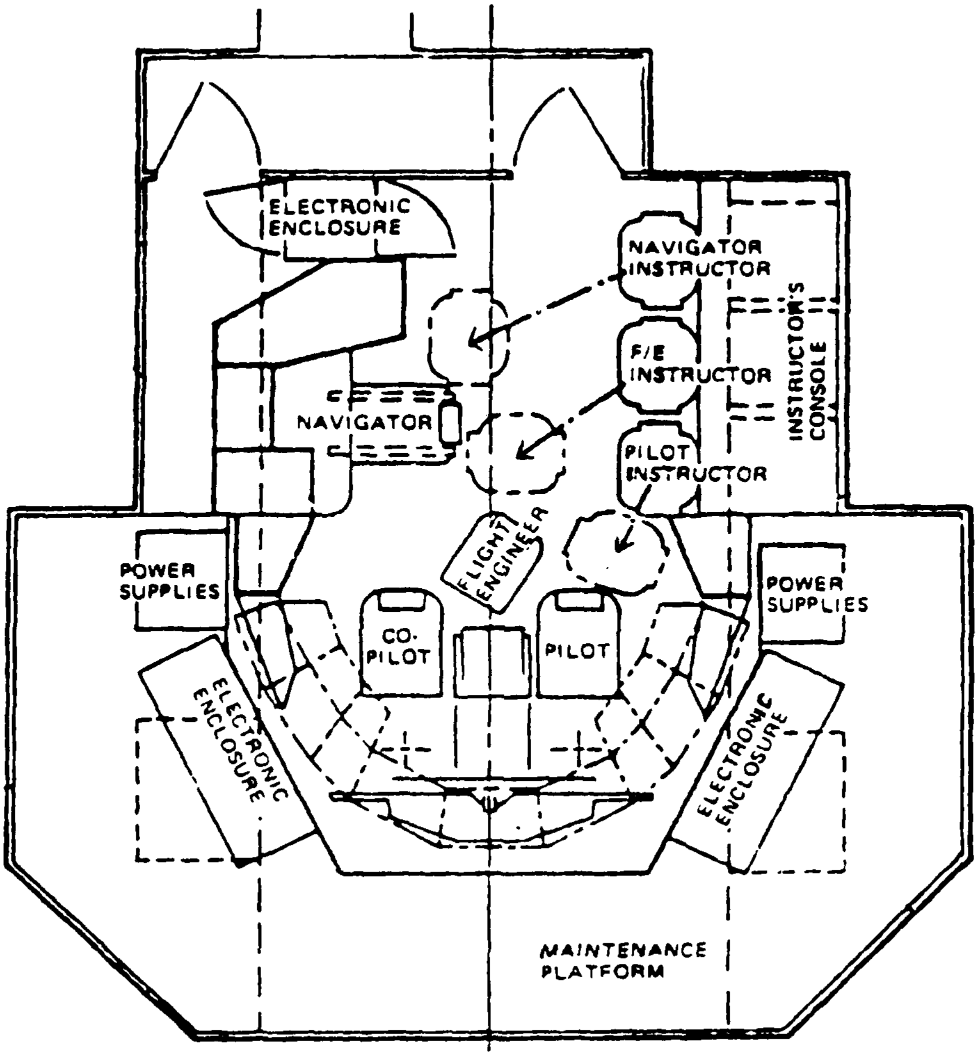


Figure 9. Sample Mixed Option On-Road Layout.

over-the-shoulder instructing position. A remote control unit such as that depicted in Figure 8 is provided for trainer control.

5.6 IOS Characteristics Summary

The parameters which determine the IOS requirements are:

1. Simulator training functional requirements

- preparing for training
- briefing trainees and staff
- initializing the simulation
- conducting training
- evaluating trainees
- debriefing trainees and staff
- documenting training conducted
- developing exercises/missions
- training instructors

The functions can be grouped under three categories as follows:

- operating requirements
- training requirements
- management requirements

2. Manning Concept

- operational instructors
- simulator instructors
- simulator instructors/operators
- operators

3. Training Course Level

- Initial Qualification Training
- Mission Qualification Training
- Continuation Training
- Upgrade Training
- Special Training

4. Training Strategy

- tutor
- interactive instructor
- monitor/debriefer instructor

5. Instructor Location

- remote from trainee station
- on-board station, remote from trainees
- on-board adjacent/over-the-shoulder

6.0 IOS FUNCTIONAL REQUIREMENTS

The generic functions involved in implementing training utilizing an ATD were outlined in Section 5.1. The translation of these into functional requirements for a specific trainer is accomplished through the analysis and synthesis of training requirements data. These data are developed utilizing the ISD methodology and include:

1. Training objectives allocated to the training device, with performance requirements;

2. Training course outlines;

3. Manning constraints and concepts;

4. Training system components (in particular, supporting training devices); and

5. Trainer facility conceptual layout.

Each training function must be analyzed in terms of these data to develop a functional statement or description of the ATD. The task is the first step in the ATD acquisition process and provides the basis for the development of the detailed acquisition specfication.

The synthesis process required is iterative, and each iteration refines and validates the system concept to be employed.

Feasible allocations of functions will be reviewed. The final choice(s) must reflect design constraints and training objectives. The feasibility of each set of allocated functions must be validated against all constraints, including manning.

6.1. Preparation Function

The preparation function includes the following training subfunctions:

1. Identifying the training event in terms of trainees, training time, trainer to be used, the course event, and the status of the simulator.

2. Assembling required training data, including trainee training history relative to the trainer, training event descriptions, performance recording forms, and initialization data.

3. Review of data by the instructor.

4. Development/formulation of the training session in detail, including detailed mission characteristics and trainee/staff briefing.

The preparation function can be implemented in three general ways:

1. The instructor can perform the function manually (e.g., collect the data required from schedules, printed course outlines and telephone calls to training and facility managers).

2. The instructor can use an independent computer-based training data management system (e.g., the required information can be reviewed at a separate data terminal).

3. The instructor can use a training data management subsystem incorporated into the training device and queried by the instructor from an IOS data terminal, provided the capability is available without interfering with ongoing training; i.e., it must be implemented in a background mode.

6.2 Briefing Function

The briefing function includes the following subfunctions:

1. Briefing the trainee on the objectives of the training event, procedures to be used, and any trainer problems.

2. Briefing the training support staff on the procedures to be employed and support functions to be provided.

The briefing function can be implemented in two ways:

1. The instructor can develop the briefing from printed materials and notes and deliver it as a lecture.

2. The instructor can employ a trainer briefing station utilizing stored course and exercise/scenario data, along with student training history data available off-line in trainer briefing areas. The terminal could utilize many of the instructional features available at the main IOS, such as demonstrations, replay, freeze, reset, and hard copy to support the briefing.

6.3 Initializing Function

The initializing function includes the following subfunctions:

1. Configuring the trainer system to meet the event requirements including configuring the simulation system, the trainee station(s) and the instructor station(s).

2. Initializing the simulation system to the training event starting conditions, including control loading, and motion and visual systems if used.

3. Establishing system readiness in terms of trainee, trainer systems (including communications), and staff and verifying area security.

The initializing function can be implemented in a wide variety of ways ranging from fully manual to fully automated. Effective implementation will fully address the IOS requirements, particularly manning, course level, and instructor location requirements.

6.4 Training Function

The training function includes the following subfunctions:

1. Controlling the simulation to implement the selected training event; this would include simulations of the environment (geophysical, electronic, warfare, etc.), controllers, threats and other aircraft/platforms, "missing" crewmember actions/inputs, and inserting/removing malfunctions.

2. Monitoring trainee performance, including procedures, techniques, skill level, attitude, and approach.

3. Monitoring simulator performance, including motion and visual systems.

4. Instructing the trainee, including providing of feedback, demonstrations, operational data, knowledge, and correct procedures.

5. Recording data for feedback, debriefing, scenario changes, hardware and software reports, and inputs to the trainee's training file.

The training function can be implemented in a wide variety of ways, from completely manual to highly automated. Manual implementation of the function is, in general, unsatisfactory since the instructor workload is generally high and limits the instructor's ability to accomplish trainee monitoring, performance evaluation, and diagnostic functions.

6.5 Evaluation Function

The evaluation function includes the following subfunctions:

1. Establishing whether trainee performance meets criteria or is within the learning "envelope."

2. Diagnosing learning problems.

3. Developing/modifying the training to remediate learning difficulties.

The evaluation function implemation can be manual or trainer computer system supported. The level of the training course is a major determinant of the support required by the instructor. Complex mission training generally necessitates support in terms of performance measures and summaries, such as weapon scores, jamming effectiveness, navigation accuracy, threat effectiveness, and subsystem utilization.

6.6 Debriefing Function

The debriefing function includes the following subfunctions:

1. Debriefing the trainees on the training mission, including a review of objectives, procedures, performance, problems, and recommendations.

2. Debriefing the training support staff in terms of problems, performance, and recommendations.

The debriefing function implementation may vary from completely manual to trainer system supported in terms of a "debriefing station" where support may range from replay of instructor displays and hard copy to instructional features such as freeze and performance measurement.

6.7 Documenting Function

The documenting function includes the following subfunctions:

1. Updating the trainee's training record.

2. Completing trainer utilization and discrepancy reports.

3. Completing reports on recommended changes to the training mission, problems encountered, and operating/training recommendations.

The documenting function implementation may vary from completely manual to data base support utilizing an IOS data terminal.

6.8 Developing Training Events Function

The developing training events function includes the following subfunctions:

1. Incorporating any changes and new missions.

2. Implementing the changes and new missions.

3. Validating the changes and new missions.

Implementation of the developing training events function is dependent on the implementation of the initialize and training functions. For example, the use of programmed exercises will involve two levels of interaction; i.e. the "novice user" and the systems programmer. To support the former the instructor must have the capability of modifying programmed material to meet specific training requirements prior to the training event, and to create new scenarios based on existing options. Systems programmer support includes the capability to implement modifications to the data bases and new exercises/scenarios.

6.9 Training of the Instructor Function

The instructor training function includes the following subfunctions:

1. Training of the instructor in trainer system operation.

2. Training of the instructor in use of the trainer, in implementing the training course, and in meeting the training objectives.

3. Training the instructor in training event/mission development and implementation on the system.

4. Verifying that instructional standards are implemented.

The training of the instructor function can be implemented in a variety of ways, ranging from classroom and guided hands-on training [illegible] supported computer-aided instruction.

6.10 Summary

The trainer system functional specification must address all of the training functions if an effective ATD is to be achieved. Standard systems design and development acquisition procedures can be utilized.

7.0 IOS DESIGN REQUIREMENTS

The following general guidelines have been developed to aid in IOS design. They reflect experiences with a variety of existing WSTs including CPTs, OFTs, PTTs, and WSTs. The major parameters which must be considered are reviewed.

7.1 IOS Configuration

The configuration of the IOS includes its location and arrangement within the trainer complex and its configuration in terms of basic subsystems. The configuration must reflect the manning concept, the training course level or content, and the location of the instructor relative to the trainee. In general, the remote IOS is used for the monitor/debriefer instructor role; the on-board over-the-shoulder IOS, for the tutor instructor role; and the remote on-board IOS, for the interactive instructor role.

7.1.1 Remote IOS. The remote IOS is typically a console from which the instructor(s) can control and monitor the simulation and trainees. The following general requirements govern its configuration:

1. The console should be positioned such that the instructor can view the mockup area, especially if a motion platform is used, to ensure safety and to observe the behavior of the platform. If the console height is such that it would prevent instructor from viewing the area from a normal seated position, the console can be positioned in such a way that the area can be viewed to either the right or left side of the console.

2. The console should be located such that it does not block the path of trainees going to and from the trainee station.

3. The console should be located such that it is not in the same area where visitors and observers are brought to watch training operations.

4. Adjustable overhead lighting is essential.

5. IOS area temperature control must be provided.

6. Light locations must be such that no glare is produced.

7. If multiple consoles are utilized, console proximity must be such that voice communication between instructor personnel and sharing of displays (if required) are possible.

8. The console configuration should permit the instructor to operate all controls and view all displays without changing positions, other than turning to the console being used.

9. Instructor hard-copy devices should be located in ready proximity of the IOS.

10. The working surface/counter for the instructor should be at least 16 inches in width.

7.1.2 Remote On-Board IOS. The remote on-board IOS is typically a console located in the vicinity of the trainee station. The following general requirements govern its configuration:

1. The console configuration must permit the instructor to view all displays and operate all controls from a normal seated position. On motion-base platforms, this includes operation with restraint devices fastened.

2. General lighting for the console shall be adjustable from the console.

3. Lighting locations shall be such that no glare is produced. If the trainee station lighting produces a glare, nonreflective coatings and/or shields shall be provided.

4. Hard-copy devices should be located either adjacent to the console or in the vicinity of the entrance to the trainee station.

5. The working surface/counter should be at least 16 inches in width and equipped with restraints to prevent books, manuals, and pencils from sliding off the counter under normal use.

7.1.3 On-Board Over-the-Shoulder IOS. The on-board over-the-shoulder IOS is typically located adjacent to and behind the trainee station, such that the instructor can observe both the trainee's displays and control operations. The following general requirements govern its configuration.

1. The instructor seat should be located so as to maximize the viewing of trainee actions and displays. Instructor options for raising and moving the seat shall be provided if necessary to achieve the required positions.

2. Ancillary display(s) shall be provided to present display and control data beyond the viewing range of the instructor.

7.2 IOS Layout

The layout of the IOS includes the arrangement of the various control panels and display devices utilized at the station. The IOS layout varies as a function of the location, the training strategy, and the level of training being conducted.

7.2.1 Remote IOS. Because the instructor cannot see the trainee station displays and control actions, the remote IOS must contain all of the displays and controls required for training. This includes all displays required to monitor the trainee's performance relative to the training objectives. The console must provide the instructor with training system status and control, mission status and control, weapon system status, trainee station status, and trainee performance information. In general, the following guidelines shall govern the layout:

1. A plot display and a data display are required and should be located directly in front of the instructor. If repeater displays are utilized, they should also be located in front of the instructor. Time sharing of the plot display is not feasible for most systems.

2. Trainer utility system and subsystem operation panels should be located at the sides of the console, along with other displays and controls that are used infrequently or used only to initialize and terminate the operation of the training system.

3. The communication control panel (intercommunication system and radios) should be located in the center area of the console.

4. Instructional and feature controls should be located in the center area of the console.

7.2.2 On-Board Remote IOS. The same general requirements for layout as those used for the remote IOS should be used for the on-board remote IOS. In addition:

1. Trainer utility/subsystem controls and displays must be kept to a minimum. Power-up and checkout functions, for example, should not be located at the IOS.

2. The IOS should be located or screened such that students cannot view the IOS displays or observe instructor actions.

3. Storage, accessible to the instructor in a normal seated position, must be provided for required checklists, manuals, and instructional materials, especially on motion platforms.

4. Special attention must be paid to minimize reflections, especially of IOS displays at the student station such as on the cockpit windscreen.

7.2.3 On-Board Over-the-Shoulder IOS. The on-board over-the-shoulder IOS typically consists of a limited trainer control unit, communications panel, and ancillary display unit. The following general guidelines apply:

1. The controls must be accessible to and displays readable by the instructor from his/her normal position. On motion platforms, this will be from a seated position with restraint devices in place. On non-motion platforms, this will be from a normal instructing position.

2. The controls must provide for the basic operation of the trainer, including:

- emergency trainer shutoff
- freeze
- initialization of an exercise
- malfunction insertion/removal
- communications, both ICS and radios
- environment modification

7.2.4 Combination On-Board IOS. The combined requirements for the remote and over-the-shoulder IOS apply in general and include:

1. Seat rails or other secure means for permitting the instructor to move from the remote position to the over-the-shoulder position must be provided on motion-based stations. Implementation must ensure that the instructor can safely and securely move between the two positions with the motion base activated.

2. Lighting conditions at the remote IOS location shall be compatible with trainee position lighting.

3. Over-the-shoulder operations shall be activated when necessary by a single control located at both the remote and the over-the-shoulder positions.

7.3 IOS Panel Layout

IOS control and display panels shall be designed in accordance with the guidelines contained in Appendix B and utilize the abbreviation guidance contained in Appendix C.

7.4 Display Requirements

In general, displays can be grouped into three categories: (1) status displays, (2) plot displays and (3) control displays. Menus are considered control displays. Appendix C contains samples of display pages and lessons learned.

A critical consideration for displays is that the visual parameters (e.g., size, brightness, and contrast) must permit their use under the ambient lighting conditions at the IOS (when the display is used) and with the instructor at his/her normal operating position.

1. Status displays. Status displays present information on the state of a subsystem, and as such, the information's significance to the instructor varies with the role of the subsystem at the moment. For example, aircraft configuration data are of prime importance in the approach to landing, but not during the cruise phase of flight. Radio/NAVAIDS channel/frequency data are important throughout the mission. Procedures data are used only when the particular procedure is being conducted. Thus, status data vary in importance and use during the training event. Status displays are also required for trainer subsystems such as control loading, and motion and visual subsystems. Finally, a "status" display of keyboard entry is needed; i.e., an echo of keyboard actions for review prior to computer input.

Status displays can consist of trainee station repeater displays or CRT displays ranging from graphic portrayals of displays to alphanumeric display of data. Combinations are often used, with graphic presentation of flight displays, for example, and alphanumeric presentation of switch/control settings.

Information which must be displayed continuously should be displayed on each status page, and on each plot display which will be used (unless repeater displays provide the information.) Figure 10 depicts the layout of a typical CRT display page which accommodates the differing data requirements.

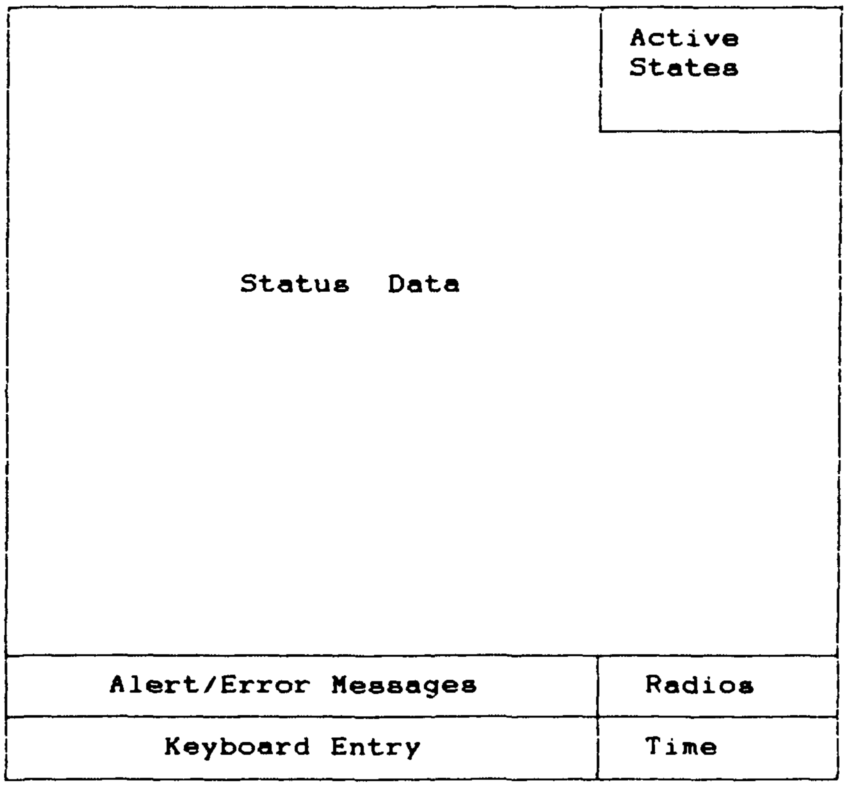


Figure 10. Sample Status Display Layout.

Graphics of cockpit displays and control panels, and graphs of student system performance, are considered status displays.

2. Plot display. Plot displays present position data in graphics format. Typical plot displays are two-dimensional projections such as cross-country maps, approach/departure plates, and tactical plots and three-dimensional projections of aircraft position in space. They should have the following characteristics:

a. Plot coordinates shall be indicated if the instructor is required to use the display in order to estimate position location for resetting, for vectoring, or for position error estimation.

b. Decluttering options shall be provided where display density can obscure needed information.

c. Track and variable track erase options are required.

3. Control displays. Control displays are used to present information on control options. If implemented as touch panels or light pens, for example, they also provide the means for implementing the control action.

a. Control displays shall group related control functions on the same displays.

b. Control inputs must automatically update all displays which are affected by the input.

c. Indications of control state shall follow the same guidelines used for labeling and abbreviations (Appendices B and C), especially in adhering to weapon system and aviation terminology, not engineering or software terms.

d. Use of a single number or letter to indicate state or condition shall be avoided.

e. Control page options should be specific to the training course and phase or stage of the mission. The user should not be presented with unrelated control options and pages.

f. If menus are used to index display pages, the following guidelines should be applied:

- The number of items on a menu should be limited as a function of the meaningfulness of the options. For example, if the options cannot be categorized (in instructor terms) or are presented in random fashion, the number of options per page should be limited, probably to less than 10. If the menu page(s) can be categorized, the number of entries per page can be significantly greater--as high as 50 or 60, as long as the number of options under each category is limited to about 8 to 10. Trade-off analysis of the number of entries and number of pages required must be made to minimize access time.

- Menu pages should not require scrolling to view the entire page; i.e., the page must be complete as displayed.

• Options for experienced users to circumvent the menu implementation must be provided.

• Menus should be relevant to the phase of mission involved. Selections and options that are not usable in the existing phase or mode should be transparent to the user. For example, weapons-delivery-related pages should not show on menus used for instrument flight training phases, and only those malfunctions related to the phase of flight being trained should be indexed.

7.5 Controls Requirements

In general controls shall be selected to provide the instructor the most direct and natural means for implementing actions. Keyboards are not optimum, especially for operational instructor personnel, since keyboards require some experience and training with QWERTY-type keyboards to be efficiently employed. Control options should, in general, not require that the instructor time-share his/her vision between the display being monitored and the control panel(s) being used. Thus, touch panel displays and cursor controls are superior to function keys and keyboards. Light pens are, in general, unsatisfactory, since they typically require fairly precise positioning, thus demanding eye-hand coordination which can be disruptive of trainee monitoring. For example, precise timing of inputs can be difficult, especially where pages must be accessed to display the option to be designated with the light pen.

The following general guidelines should be followed:

1. Mechanical control actuation shall be in accordance with MIL-STD-1472.

2. Control labeling shall be in accordance with Appendices B and C. Redundant switch labeling shall be avoided.

3. Instructor control of systems and subsystems shall be training-oriented, not system-operation-oriented. For example, motion system controls should be limited to an ON/OFF control, with indicators of system state (e.g., READY) if required.

4. Mechanical control labels should be illuminated (preferably back-lighted) for on-board IOSs and remote IOSs if reduced lighting is utilized to meet viewing requirements. The light level should brighten when the control is activated. Blinking of the illumination can be used to indicate a transition state for the function selected.

5. Positive, rapid identification of the state of the control is essential.

6. Control inputs should not result in apparent display/system "hang-up"; i.e., the control input should not result in any noticeable display or training freeze while the input is being processed.

7.6 Operating Feature Requirements

Operating features were defined as IOS design features which unburden the instructor and enhance the operation of the trainer in terms of simulation implementation. A wide variety of features have been implemented in existing trainers. The options are limited only in terms of technological capability, training effectiveness, and cost. Operational features are not IOS-characteristic-dependent in general. Among the features which have proven effective are the following:

1. Crash Override. Crash override is routinely used by instructors in most ATDs. Usage data indicate it should be designed as the default condition, mainly because in existing designs, the task of recovering from a crash has been difficult and far from user-friendly. Design of a "crash" which could be recovered from or removed without requiring reinitializing the trainer and which would permit use of the instructional features of reset, replay, and hard copy is needed and could result in more extensive use of the "crash" feature.

2. Event Manual Stack. Many training mission simulations can be initiated only in response to trainee actions and performance. This holds true, for example, for malfunctions, threats, traffic control, and environment changes. This feature provides the instructor the option to create a "stack" of selected inputs, which can then be implemented in sequence (with override) by means of a simple insert action. This is faster and easier than accessing menus and inputting each variable independently.

3. Flag Set. The option to "tag" for future use a location in the simulation exercise as it is conducted is required, whether it be for reset or for playback or for debriefing. Since the point at which the flag can be set is typically when the consequences are obvious, the flag should have a selectable preset increment which in effect moves the flag back in simulation time to the triggering factors. The default condition should be set at about a negative 5 seconds. The number of flags possible should be unlimited, or at least four per hour of simulation time. A means for tagging the flags in sequence is necessary.

4. Controller Models. Controller inputs play a major role in most training scenarios including, for example, ground-control approach (GCA) controllers, tower and ground controllers, traffic controllers, and tactical controllers. Instructors are required to provide the inputs not simulated by the computer system. Models of controllers can provide cues either to the IOS for manual output or to a speech generation system for automatic output. If automated, options for instructor override should be provided by an alerting system, with sufficient time for the instructor to cancel the output.

5. Freeze. Freeze of the simulation is commonly provided on trainers. It is considered an operating feature since it permits stopping and restarting of the simulation without reinitializing the trainer.

6. Instructor Aid (HELP). A programmed help feature should be provided for the instructor/operator. The feature should function in all modes and be associated with topics and control inputs (e.g., the option to press HELP, followed by entry of either a topic or a control input).

7. Instructor ICS. A trainer intercommunications system is required which permits the instructor to talk privately with trainees, other instructors, and maintenance personnel.

8. Adversary Models. Most tactical mission training scenarios include adversary systems, from radars and jammers to fighters. In the absence of models, the instructor is required to manually simulate the adversary actions. Models for automatic control of adversary activity, with the option (and alerts) for instructor override, are needed. Model characteristics should be selectable, from easy to difficult in terms of trainee task, to match the training scenario being implemented.

9. Malfunction. Although often treated as an instructional feature, the control of malfunction simulation is a control feature inasmuch as its mechanization unburdens the instructor. Whether automated or manually implemented, malfunction simulation must be constrained to the requirements of the training program and the specific mission involved. Instructors do not have the time to search through hundreds of malfunctions to identify the one desired. The implementation involves three requirements:

a. The malfunction must be named in operational terms, not design terms and must reflect the characteristics meaningful to training.

b. The malfunction options presented to the instructor should be filed by phase of flight/mission. Only those malfunctions feasible for each phase should be displayed; all others should be transparent. Thus, ground start malfunctions should appear in the index only during ground operations, and in-flight malfunctions only during in-flight. The objective is to constrain the options presented the instructor to a usable set for the timeframe available.

c. Malfunctions should be self-correcting in the same sense that they would be during actual flight; i.e., the malfunction will disappear if the trainee takes an action that would be correctly performed in the aircraft.

d. Malfunctions should become compounded in the same way as in the aircraft if corrective action is not taken or is delayed.

e. Options for automated malfunctions should be provided if meaningful "triggers" can be provided. The use of irrelevant triggers has in the past diminished the acceptance of the feature. For example, mission or training elapsed time, altitude, airspeed, etc. have proven unsatisfactory. Logical statements can be used if the implementation is kept simple and in instructor terms. An alert with instructor override must be provided.

10. Programmed Mission. Programmed training missions can provide the instructor the maximum time to observe and evaluate trainee/crew performance. They also provide the opportunity for employing performance measurement and related instructional aids. To be accepted, the mission must be capable of being modified on-line by the instructor, to adapt the mission to the particular training objectives and training approach used by the instructor. Typically this has been implemented by having the terminal conditions of a mission segment or leg become the initial conditions for the next leg. Each leg should have its own automated controller, tactical, and malfunctions options. The conditions of each leg should be modifiable by the instructor on-line prior to training.

11. Reset. The reset feature provides the capability for re-initializing the simulation to a specified set of initial conditions; e.g., a preprogrammed

set or a set defined by a "flag" during the training event. Preprogrammed sets include the initial set and the set for any of the programmed segments/legs. The feature simplifies the trainer initialization task.

12. Speech Generation. Control task simulation can be automated through the use of speech generation techniques. The options range from analog recordings to digital speech synthesis. The feature provides for the output of stored messages by means of "triggers" or as a function of controller models. It can also be used for background communications; i.e., radio communications between other platforms operating on the same channel/frequency.

13. Speech Understanding. Speech recognition/understanding provides a control implementation option which can respond to voice inputs by either the trainee or the instructor. Because system and tactical communications are very constrained in vocabulary and syntax, recognition algorithms might be used to control the simulation.

The application of control features to simulation-based training is a function of the training strategy and the level of training. Table 2 outlines typical as well as potential uses of control features as a function of mode of training. As can be seen, the tutor mode of training may not require extensive operational mechanization.

Table 2. Control Features by Mode of Training

Feature	Tutor	Interactive	Monitor
Crash Override		x	x
Event Manual Stack	x	x	
Flag Set		x	x
Controllers Models		x	x
Freeze	x	x	
Help	x	x	x
ICS	x	x	
Adversary Models		x	x
Malfunction	x	x	x
Programmed Missions		x	x
Voice Output		x	x
Voice Input	x	x	

Table 3 summarizes the operating features by training course level based on current utilization and potential applications.

As would be expected, qualification training, which involves the more complex training missions, utilizes the majority of feasible operating functions.

7.7 Instructional Feature Requirements

Instructional features include those design implementations which unburden and enhance the trainer instructor's role in teaching trainees. The features include, but are not limited to, the following:

Table 3. Control Features by Training Level

Feature	IQT	QT	Continuation	Upgrade
Crash Override	x	x	x	x
Event Manual Stack	x	x		x
Flag Set	x	x	x	x
Controllers Models	x	x	x	x
Freeze	x	x		x
Help	x	x	x	x
ICS	x	x		x
Adversary Models		x	x	
Malfunctions	x	x	x	x
Programmed Missions		x	x	
Voice Output	x	x	x	x
Voice Input	x	x		x

1. Auto-Freeze Envelope. The automatic freeze feature freezes the trainer whenever a pre-established parameter threshold is breached. The feature reduces the monitoring burden of the instructor to the extent that parameters and requirements of concern can be defined. A means for activation and editing of the envelope by the instructor is required.

2. Automated Syllabus. An automatic syllabus provides for identification of the next training mission and initialization of the trainer to that event, given the identification of the trainee. It assumes that trainee data for at least trainer events are maintained by the trainer computer system. The capability for instructor preview and override of designated training events must be provided.

3. Briefing. The briefing feature provides for the use of trainer-stored data for the trainee briefing. This can range from demonstrations, to recorded previous training performance, to mission preview. A separate "IOS" in the briefing area is required. It is necessary that trainer operation in the "background" mode not conflict with simulation training. Briefing features for the IOS may include the following:

- Freeze
- Reset
- Replay
- Controller models
- Programmed missions
- Communications recordings
- Hard Copy
- Programmed Flight
- Demonstrations
- Help

4. Communications Recording. Recording of radio communications is utilized to train voice procedures, as well as to enhance feedback and debriefing. Both analog and digital recording methods have been utilized. Digital recording is more user-friendly, providing that it is synchronized with replay options and

flags can be set for replay. Activation should be at the instructor's option, except where integrated with a simulation recording capability. Use of an independent tape recorder is unsatisfactory in terms of operation and synchronization with replay.

5. Debrief. The debrief feature provides for use of the simulation training data for the debrief function. The typical options include selected replay, demonstrations, performance measurement displays, and mission review. A separate "IOS" is required, with displays for trainee viewing. The option must be usable simultaneously with training operations. Similar options to those identified for the briefing feature should be provided.

6. Demonstration/Replay. Replay of recorded simulation events can be used both for demonstration and for feedback for the trainee. A means for flagging or identifying the time period to be used is required. Fixed time periods have been used but must be tailored to the training mission. Selectable record and save periods must be implemented such that the instructor can utilize the capability without degrading ongoing instruction performance.

7. Environment Modification. The capability to modify the mission environment during training includes modifying both the visual as well as the geophysical and warfare environment. The feature should provide for graceful, rather than abrupt changes, given an instructor input. Interdependent changes should be automatic; i.e., a change on any environmental parameter should automatically make changes to other related environment parameters, including those for other systems such as visual or motion.

8. Hard Copy. Printer output of data including display pages, mission data, performance data, parameter monitoring data, and plots, for example, will be provided. The "hard copy" is utilized in real time for feedback, and postmission for debriefing, and can be incorporated in the trainee's training file. To be effective, the hard-copy output must:

a. Be available in real time, not in an off-line computer mode.

b. Not degrade display or simulation performance. (For example, selection of hard copy of a display page should not freeze the display for a recognizable period of time.)

c. If black-and-white, provide for shades of gray to reflect color changes.

9. Initialization. Trainer initialization conditions (ICs) provide for setting the simulation initial conditions to a pre-defined or stored set of parameters. The number of sets which can be effectively used for any mission phase will be dependent upon the level and mode of training. IQT, for example, will require a wide variety of relatively simple ICs to meet procedures and position training objectives; whereas mission training may require fewer, more complex sets to initialize full mission scenarios.

10. Performance Diagnosis. The potential for on-line support to analyzing performance problems exists with performance measurement, performance models, and artificial intelligence applications. Relatively simple algorithms can identify the onset of performance problems. Heuristic models can assist in

capitalizing on training experience. Routines have been developed for basic and instrument flight maneuvers and approaches to landing. The feature can be of particular value when training is conducted by contract personnel or by simulator operators.

11. Performance Recording. Performance recording refers to the saving of selected trainer parameters over a specified period of time and at a specified sampling rate. It is of marginal use as an instructional feature unless parameter recording recommendations are made and some means of reducing the data is provided. Default sets of parameters for each mission phase should be provided based on ISD analyses. Data reduction algorithms should be incorporated which present to the instructor no more than one page of data for each phase or segment of the mission sampled. Options for the instructor to override and modify the parameter sets on-line are required.

12. Performance Measurement. Performance measurement is distinguished from performance recording, which only collects data on selected parameters for a specified period of time. Performance recording involves no processing of the data other than, for example, computing the percent of time the parameters were outside of established limits. Performance measurement,on the other hand, involves data reduction in terms related to training objectives criterion performance requirements. It is distinguished from evaluation which is performed by the instructor; i.e., no interpretation of the results is involved. Performance measurement design requires application of the results of the ISD efforts to structure performance measurement applications. Performance criteria are developed as part of the task analysis conducted during the ISD effort. In addition, the conditions under which the task must be performed are also identified. These can be utilized for designing automated performance monitoring and measurement. The objective is to provide the instructor with quantitative data on trainee performance relative to the specific training objectives.

13. Procedures Monitor. The capability of monitoring normal and emergency procedures has been implemented on many trainers. The monitor feature includes identifying completion and the sequence of completion. The display is typically a list of the actions which must be completed, and the sequence of completion. Identification of the crewmember completing the action must be possible where more than one crewmember is involved. Actions that cannot be monitored must be identified.

Since procedures can and do change, a means for modifying the monitoring feature must be provided. It must be usable at the operator level, preferably at the experienced instructor/operator level. This includes the capability of adding and deleting actions and changing the sequence.

14. Replay. Replay provides the capability of reviewing for the trainee at the trainee station a portion or all of the simulation completed. The feature is also used for creating demonstrations. All trainee displays and indicators and controls (as feasible and required) are driven during the replay. The feature is best implemented with automatic continuous recording of the simulation, with an instructor option to "flag" sections for subsequent replay, or to replay a selected period up to the point at which the trainer was frozen or replay selected. The replay period needed varies with the type of training involved. ISD data should be used to identify required replay characteristics

based on training tasks and objectives. In general, replay options will be relatively short in terms of the training period.

The procedure for using replay must be simple and rapidly executed. Lengthy reset times and complex procedures will not be tolerated by instructors. A "flag" approach should be used to indicate the start of the period to be saved and a subsequent flag or "stop" control, to indicate the end of the period to be saved. The start flag should add a variable increment of time, since the pressing of the flag by the instructor is generally seconds after the onset of the problem to be replayed. A default value of about 5 seconds is typically required in pilot training; however, longer periods will be required in tactical and warfare training. Analysis of the training problem will be required to identify the size of a meaningful replay period. Use of mission elapsed time is a second alternative for saving and replaying. If utilized, mission elapsed time must be continuously and conspicuously displayed. Fast reverse and forward have also been implemented for replay but have proven unsatisfactory because of the access time involved.

The following options for terminating the replay should be incorporated:

a. Stop replay and reset to point where replay was initiated.

b. Stop replay and initialize trainer for continuing training from that point in the replay.

c. Stop and replay the same segment again.

d. Save the replay segment for further use in debriefing or training. Labeling of the segment will be required.

15. Off-Line Replay. Off-line replay provides for accessing designated replay segments off-line, in the background mode or through a stand-alone system for debriefing/review purposes. The feature has proven valuable in a variety of training situations including air combat maneuvering. Off-line replay must be mechanized so as not to interfere with ongoing training. Options to replay instructor displays for the replay period are required. Instructor control of the replay should provide:

a. segment selection in terms of flags or mission time,

b. segment replay,

c. termination of replay,

d. fast forward and backward, and

e. hard-copy selection.

16. Prompting/Cuing. Artificial prompts and cues have been demonstrated to be of value in training, especially in complex weapon system operation. For example, prompts concerning the weapon envelope for training in optimum launch conditions, estimates of jamming effectiveness for both threats and own system, aircraft maneuvering envelopes, and control inputs have all been shown to be effective training features.

17. Adaptive Exercises. Recent studies have shown the feasibility of restructuring training exercise automatically based on the trainee's performance on the task. The algorithms utilize performance measurement data to trigger the adjustment in difficulty of the task conditions. Modifications of environmental conditions and aircraft parameters have been used to adjust difficulty. Applications have been limited to procedures and position training tasks.

Table 4 outlines the potential utilization of instructional features by training strategy.

Table 4. Instructional Features by Training Mode.

Feature	Tutor	Interactive	Monitor
Auto-Freeze		x	
Automated Syllabus	x	x	
Briefing	x	x	x
Communications Recording		x	x
Debrief	x	x	x
Demonstration/Replay	x	x	
Evironment Modification	x	x	x
Hard Copy	x	x	x
Initialization	x	x	
Performance Diagnosis		x	x
Performance Measurement		x	x
Performance Recording		x	x
Procedures Monitor		x	x
Replay		x	
Off-Line Replay		x	x
Prompting/Cuing		x	
Adaptive Exercises		x	

Table 5 outlines the potential utilization of instructional features by level of training.

7.8 Management Feature Requirements

The trainer management functions include scheduling of the trainer and documenting trainee data, instructor activity, and trainer utilization and status. Unless an independent training data system has been implemented, the training device computer system can provide support to the training management functions. However, the support must not interfere with the other training functions and must therefore be implemented either in a background or off-line mode.

The following training management features are involved:

1. Trainer Status. Each training event should have a necessary set of simulation requirements and trainer subsystems associated with it. These data should be developed as part of the training analyses. Identification of which training events can be conducted with the current operational configuration of the trainer should be available to the instructor. A trainer go/no-go test for any training mission should be made available to the instructor.

Table 5. Instructional Features by Level of Training.

Feature	IQT	QT	Continuation	Upgrade
Auto-Freeze	x	x		x
Automated Syllabus	x			x
Briefing	x	x	x	x
Communications Recording	x	x	x	x
Debrief	x	x	x	x
Demonstration/Replay	x	x		x
Evironment Modification	x	x	x	x
Hard Copy	x	x	x	x
Initialization	x	x		x
Performance Diagnosis	x	x		x
Performance Measurement	x	x	x	x
Performance Recording	x	x	x	x
Procedures Monitor	x	x	x	x
Replay	x	x		x
Off-Line Replay	x	x	x	x
Prompting/Cuing	x			x
Adaptive Exercises	x			

2. Trainer Schedule. Trainer scheduling can be supported in the off-line/background mode of the computer system. Algorithms to assist scheduling have been developed and used.

3. Instructor Qualifications. Tracking of instructor training qualifications and training history should be incorporated into the system to facilitate scheduling.

4. Trainer Utilization. Trainer utilization reports can be developed by the computer system with inputs from the instructors, technicians, and maintainers. Unburdening of the instructor in the area of forms completion and report preparation should be considered an integral part of the instructor interface.

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GLOSSARY

AFB	Air Force Base
AFHRL	Air Force Human Resources Laboratory
AFM	Air Force Manual
AFR	Air Force Regulation
ATD	Aircrew Training Device
CFT	Cockpit Familiarization Trainer
CPT	Cockpit Procedures Trainer
CRT	Cathode-Ray Tube (Display)
GCA	Ground Controlled Approach
ICS	Inter-Communication System
IOC	Instructor/Operator Console
IOS	Instructor/Operator Station
IQT	Initial Qualification Training
ISD	Instructional System Development
MAC	Military Airlift Command
MFD	Multi-Function Display
MT	Mission Trainer
OFT	Operational Flight Trainer
PTT	Part-Task Trainer
QT	Qualification Training
R&D	Research and Development
SAC	Strategic Air Command
SON	Statement of Need
USAF	United States Air Force
WST	Weapon System Trainer

APPENDIX A: TRAINING FUNCTION REQUIREMENTS

The following is a set of training functions developed as part of an analysis of training device development procedures.[1]

I. PREPARE FUNCTION

1.1 Identify Session
- aircrew(s)
- scheduled time
- trainer/mockup
- syllabus event
- simulator status

1.2 Assemble Materials
- aircrew training files
- event description
- event scripts
- scenarios
- checklists/guides
- initialization data
- data recording sheets
- grade sheets
- simulator utilization sheets
- flight plans, etc.

1.3 Review Data
- aircrew history (e.g., performance problems, weaknesses, training needs)
- syllabus event (e.g., objectives, criteria, priorities implementation plans, contingency plans)
- simulator configuration and status

1.4 Develop/Formulate Training Session
- individualize event to meet aircrew needs
- modify initial conditions as necessary
- schedule/program/modify scenario event
- plan controller functions
- plan/develop tactical scenario options
- plan/program performance measurement
- develop contingency plans (e.g., crashes, missed check points, failed procedures, trainer failures such as fire, loss of communications)
- outline briefing (e.g., objectives, criteria, procedures, simulator problems)

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[1] Charles, J. P. (1977, August). Instructor Pilot's Role in Simulation Training (Phase II) (NAVTRAEQUIPCEN 76-C-0034-1). Orlando, FL: Naval Training Equipment Center.

II. BRIEF FUNCTION

2.1 Brief Aircrew

- planned training evolution
- training objectives
- performance/mission criteria
- simulator emergency procedures
- simulator status/configuration
- communications procedures
- use of instructional features (e.g., freeze, reset)

2.2 Brief Simulator Training Staff

- planned training evolution
- support responsibilities
- emergency procedures

III. INITIALIZE FUNCTION

3.1 Configure Simulator

- configure simulation system
- configure crew station(s)
- configure IOS

3.2 Initialize Simulator (enter/verify initial conditions)

- airfield location, runway/heading, etc.
- radio/navigation aids, locations, characteristics
- target locations, characteristics, behavior
- environment including weather, altitudes, temperatures, winds, magnetic variation, etc.
- aircraft configuration
- aircraft position and state
- preprogrammed malfunctions, emergencies
- data monitoring, recording

3.3 Establish Readiness

- aircrew strapped in cockpit
- area secure and safe
- scripts, scenarios, data sheets, etc. available
- communication check with students

IV. TRAIN FUNCTION

4.1 Control Simulator

- activate simulation
- provide manual simulations (e.g., communications, controller functions, ground crew functions, "missing" aircrew functions, other platform functions such as surface threats)
- activate/deactivate emergencies, malfunctions
- select and activate demonstrations
- set and select replay
- freeze simulator
- initialize and reset
- monitor safety of operation
- deactivate trainer at end of session

4.2 Monitor Performance
- procedures
- technique
- skill level
- simulator performance

4.3 Instruct
- provide feedback
- critique
- correct procedures, errors
- advise

4.4 Record
- data for feedback
- data for simulator control (i.e., reset, replay)
- data for debrief
- data for records

V. EVALUATE FUNCTION

5.1 Monitor relevant parameters for segment, phase, task

5.2 Establish if performance is within training performance envelope

5.3 Diagnose problem if performance is inadequate

5.4 Select instruction technique for remediation

5.5 Develop plan and data to implement remediation

5.6 Brief simulator crew and student(s) as required

VI. DEBRIEF FUNCTION

6.1 Debrief Student
- organize data collected
- assemble debriefing materials (e.g., hard copy)
- review performance problems (replay as required)
- review correct procedures
- outline corrective actions to be taken

6.2 Debrief Simulator Staff
- review event implementation problems
- review overall performance
- discuss simulator discrepancies

VII. MANAGE DATA FUNCTION

7.1 Aircrew Data
- prepare grade sheets, training sheets
- prepare training data sheets

7.2 Simulator System Data
- utilization data sheets
- discrepancy data sheets

7.3 Training Data
- problems encountered in event
- changes tried, recommended
- instruction problems, recommendations

VIII. DEVELOP SYLLABUS FUNCTION

8.1 Identify Changes Required

8.2 Format Changes

8.3 Implement Changes

8.4 Validate Changes

IX. TRAIN INSTRUCTOR FUNCTION

9.1 Simulator Operation
- console familiarization
- console operation
- operating procedures
- syllabus implementation

9.2 Simulator Training
- training functions
- training techniques
- evaluation
- simulator instructing

9.3 Simulator Syllabus Development
- training objectives embedding
- performance criteria allocation
- formatting/programming
- evaluation
- support material requirements

9.4 Training Standardization
- event implementation
- performance evaluation

APPENDIX B: CONTROL AND INDICATOR PANEL DESIGN GUIDELINES

The following guidelines apply to training simulator IOS control and indicator panel layout and labeling. MIL-STD 1423 applies and shall be used for control size, shape, lettering, and indicator colors.

Panel Layout

Simulator controls and indicators shall be functionally grouped in panels.

The layout shall be in terms of control/indicator normal sequential operation beginning at the top left of the panel and progressing to the right. Each new row shall duplicate this arrangement in that the left controls precede the controls and indicators to the right. Figure B-1 outlines the arrangement.

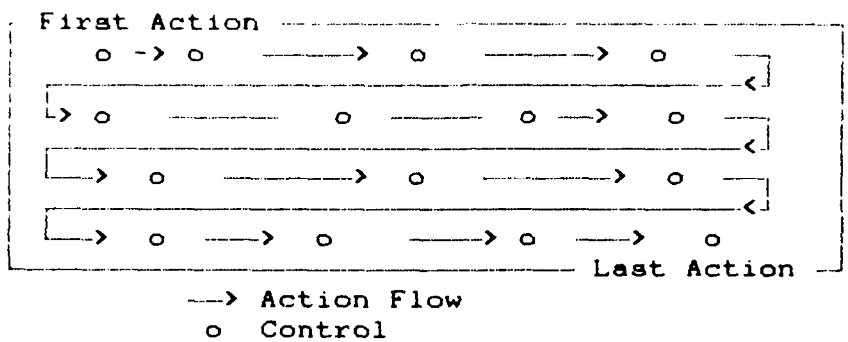


Figure B-1. Control Panel General Layout.

Indicator Lights

Indicator lights are used to display a state or condition of a subsystem. The brightness and color of indicator lights are defined in MIL-STD 1423.

1. The number of such lights shall be held to a minimum.

2. Redundant or inconsequential lights shall be avoided. For example, an indicator light shall not be used to show that a CRT is "on." The display itself serves the same function.

3. Indicator lights shall be designed to show a "fail-safe" condition; i.e., an indicator light shall show a power-on, not a power-off condition.

4. Warning (red) and caution lights (amber) shall be used only as defined in MIL-STD 1423. They shall be used for training system functions such as fire or dangerous motion system malfunction, not for training functions such as performance out-of-tolerance or printer out-of-paper.

5. The following additional utilization of colored indicator lights may be used:

- white - control/display identification
- blue - intercommunication active link identification
- green - temporary indication of option selection

6. When associated with the control, an indicator shall be located above the control or grouped in an indicator panel with related lights such as interlocks or readiness state.

7. Except for warning and caution indications, indicator lights shall only be used to display states which may continue after actuation and which are not obvious to the instructor. Examples are:

- radio/intercom selection
- parameter freeze
- automated function state

8. The brightness of indicator lights shall be in accordance with MIL-STD 1423. The brightness of indicator lights shall be balanced at the console. If console lighting dimming is provided, the indicator lights (except warning and caution indicators) shall dim at the same rate.

Controls

A control includes all means of actuating/inputting functions, whether by keyboard function key, switch, or rotary control. The following general guidelines in addition to those contained in MIL-STD 1472 shall apply:

1. All controls should visually, tactually, or aurally indicate actuation.

2. Controls shall not be utilized to implement a function which is not logically an instructor task and which should be implemented with software or hardware.

3. Control selection shall reflect the function to be performed; i.e., switches with capabilities or options beyond those required shall not be used. For example, a lever lock spring-loaded self-centering switch shall not be used for a normal on/off function. Controls for variable (continuous) functions shall also be continuous, not discrete, and vice-versa.

Labeling

Control and panel labeling shall be held to the minimum. The following guidelines shall be used:

1. For switches or knobs, the "off" position/state shall be used to label the function and the "on" position/state shall be labeled appropriately. For example, the power switch shall be labeled as shown in Figure B-2.

2. Abbreviations shall conform to the concept outlined in Appendix C. Abbreviations shall be consistent throughout the training simulator panels and documentation.

ON		UHF 1		
(switch)	or	(switch)	or	(knob)
POWER		RADIO		VOLUME

* *

NOT:

ON		UHF 1		------->
(switch)	or	(switch)	or	(knob)
OFF		OFF		<---------
POWER		RADIO		VOLUME

Figure B-2. Sample Switch Labeling.

3. Labeling shall be simulated weapon system referenced, not referenced in software language or hardware terms.

4. Color-coding shall be limited to no more than 8 colors. Color-coding may be used for functional identification, not software or hardware identification.

5. Each functional group of switches shall be labeled and the area delimited with lines as utilized in aircraft control panels. For example, the intercommunication system (ICS) panel should be labeled and have boundary markings as shown in Figure B-3.

I	o		o		o
C	o		o	o	o
S	o	o	o	o	

Figure B-3. Control Panel Identification.

6. The same syntax shall be used on all panels. For example a verb can be used first, followed by a noun or vice-versa:

"CLEAR CRASH"	or	"CRASH CLEAR"
"CLEAR MALF"	or	"MALF CLEAR"

The noun-first arrangement is preferred as being more rapidly interpreted.

7. Emergency (immediate action) controls shall have a striped panel background in accordance with MIL-M-18012 (31.1.9).

APPENDIX C: ABBREVIATIONS FOR USE AT IOSs

Abbreviations at trainer simulator Instructor/Operator Stations must be consistent and in accordance with MIL-STD-1472, and the following rules should be applied in sequence.

1. If an abbreviation is used, it shall be used throughout the IOS control and display panels and pages, not only where space necessitates its use.

2. If feasible, all nonweapon system terms will be spelled out. Weapon system acronyms and abbreviations as used in the crew station shall be used at the IOS.

3. If abbreviations are required, Table C-1 shall be used. Standard abbreviations for units of measurement may be used.

4. To abbreviate words, the following procedure shall be used; however, no abbreviation may conflict with Table C-1:

a. Four-letter abbreviations are a goal; however, ease of interpretation is the primary consideration.

b. Abbreviations shall use the phonetic rule; i.e., delete letters but retain pronunciation were possible.

c. Single-letter abbreviations will not be created.

d. Plurals will not be indicated by adding an "S."

e. The abbreviation will be used for all forms of the word; i.e., noun, verb, participle.

Table C-1. Approved IOS Abbreviations

AAA	Antiaircraft Artillery
AAM	Air-to-Air Missile
ABS	Absolute
AC	Alternating Current
ACM	Air Combat Maneuvering
ACTV	Active
ADF	Automatic Direction Finder
ADV	Advance
AFLD	Airfield
AGL	Above Ground Level
AGM	Air-to-Ground Missile
AIL	Aileron
ALGN	Align
ALT	Altitude
ANT	Antenna
APCH	Approach
APU	Auxiliary Power Unit
ASSY	Assembly

Table C-1 (Continued)

ATT	Attitude
ATTK	Attack
AUTO	Automatic
AWLS	Allweather Landing System
BARO	Barometric
BCN	Beacon
BRG	Bearing
C/B	Circuit Breaker
CAB	Cabin
CANL	Cancel
CAS	Calibrated Airspeed
CEIL	Ceiling
CG	Center-of-Gravity
CHAN	Channel
CKPT	Cockpit
CLR	Clear
CLSD	Closed
COMM	Communication
COND	Condition(s)
CONT	Control
CORD	Coordinate
CPLT	Copilot
CRS	Course
CRT	Cathode-Ray Tube
CTRL	Control
CURR	Current
DC	Direct Current
DECR	Decrease
DEG	Degree
DELE	Delete
DEMO	Demonstrate
DEPR	Departure
DIR	Direction
DIST	Distance
DME	Distance Measuring Equipment
DSPL	Display
DUR	Duration
DWN	Down
E	East
ECM	Electronic Countermeasures
ELEC	Electric/Electronic
ELEV	Elevator
ELEV	Elevation
EMER	Emergency
ENRT	Enroute
ENTR	Enter
EQP	Equipment
ESC	Escape
ESS	Essential
EW	Electronic Warfare
EXT	External
F	Feet

Table C-1 (Continued)

FAC	Facility
FCS	Fire Control System
FE	Flight Engineer
FLD	Field
FLT	Flight
FORM	Formation
FREQ	Frequency
FRZ	Freeze
FUS	Fuselage
FWD	Forward
G	Acceleration
G/S	Glideslope
GCA	Ground-Controlled Approach
GCI	Ground-Controlled Intercept
GEN	Generator
GMT	Greenwich Mean Time
GOV	Governor
GRND	Ground
GS	Ground Speed
HDG	Heading
HF	High Frequency
HIST	History
HR	Hour
HSI	Horizontal Situation Indicator
HVY	Heavy
HYDR	Hydraulic
IAS	Indicated Airspeed
IC	Initial Condition
ICS	Inter-Communication System
IFF	Identification Friend or Foe
ILS	Instrument Landing System
INCR	Increase
IND	Indicator
INDX	Index
INIT	Initial
INS	Inertial Navigation System
INSTR	Intructor
INT	Internal
INTEG	Integrated
IOC	Instructor/Operator Console
IOS	Instructor/Operator Station
ISOL	Isolation, Isolate
KEYBD	Keyboard
KTS	Nautical Miles per Hour, Knots
L	Left
LAT	Latitude
LDG	Landing
LON	Longitude
MAC	Mean Aerodynamic Chord
MAG	Magnetic
MALF	Malfunction
MAN	Manual

Table C-1 (Continued)

MAX	Maximum
MEAS	Measurement
MET	Mission Elapsed Time
MFD	Multi-Function Display
MIC	Microphone
MIN	Minute
MINM	Minimum
MISC	Miscellaneous
MISN	Mission
MSG	Message
MSTR	Master
N	North
NAV	Navigator, Navigation
NM	Nautical Mile
NO.	Number
NORM	Normal
OAT	Outside Air Temperature
OPER	Operator, Operating
OVCST	Overcast
OVHD	Overhead
OVHT	Overheat
OXY	Oxygen
PANL	Panel
PAR	Precision Approach Radar
PCT	Percent
PERF	Performance
PLT	Pilot
PLYBK	Playback
POS	Position
PRES	Pressure
PROB	Problem
PROC	Procedure
PROG	Program
PROP	Propeller
PWR	Power
PWT	Pressure, Wind and Temperature
QTY	Quantity
R	Right
RAD	Radar
RCVR	Receiver
REQ	Request
RLSE	Release
RNG	Range
RPM	Revolutions-per-minute
RSET	Reset
RUD	Rudder
RVR	Runway Visual Range
RWY	Runway
RZ	Rendezvous
S	South
SAM	Surface-to-Air Missile

Table C-1 (Concluded)

SAT	Satellite
Sec	Second
SEG	Segment
SEL	Select
SENS	Sensor
SGM	Surface-to-Ground Missile
SIM	Simulator
SPCL	Special
SPD	Speed
SPKR	Speaker
SPLRS	Spoilers
SSB	Single Sideband
STA	Station
STBY	Standby
SUMM	Summary
SYNC	Synchronous/Synchronized
SYS	System
T/O	Takeoff
TAC	TACAN
TAS	True Airspeed
TEMP	Temperature
THROT	Throttle
THRT	Threat
TRCK	Track
TWR	Tower
UHF	Ultra-High Frequency
UTIL	Utility
VAL	Value
VAR	Variation
VERT	Vertical
VHF	Very-High Frequency
VIBR	Vibration
VIS	Visibility
W	West
WHLS	Wheels
WPN	Weapon
WYPT	Waypoint
X-C	Cross-Country
XMIT	Transmit
XTRK	Cross-Track

Table C-2 IOS Abbreviated Terms

Above Ground Level	AGL
Absolute	ABS
Active	ACTV
Advance	ADV
Aileron	AIL
Air Combat Maneuvering	ACM
Air-to-Air Missile	AAM
Air-to-Ground Missile	AGM
Airfield	AFLD
Align	ALGN
All-Weather Landing System	AWLS
Alternating Current	AC
Altitude	ALT
Antenna	ANT
Anti-aircraft Artillery	AAA
Approach	APCH
Assembly	ASSY
Attack	ATTK
Attitude	ATT
Automatic	AUTO
Automatic Direction Finder	ADF
Auxiliary Power Unit	APU
Barometric	BARO
Beacon	BCN
Bearing	BRG
Cabin	CAB
Calibrated Airspeed	CAS
Cancel	CANL
Cathode-Ray Tube	CRT
Ceiling	CEIL
Center-of-Gravity	CG
Channel	CHAN
Circuit Breaker	C/B
Clear	CLR
Closed	CLSD
Cockpit	CKPT
Communication	COMM
Condition(s)	COND
Control	CONT
Coordinate	CORD
Copilot	CPLT
Course	CRS
Cross-Track	XTRK
Cross-Country	X-C
Current	CURR
Decrease	DECR
Degree	DEG
Delete	DELE
Demonstrate	DEMO
Departure	DEPR
Direct Current	DC
Direction	DIR

Table C-2 (Continued)

Display	DSPL
Distance Measuring Equipment	DME
Distance	DIST
Down	DWN
Duration	DUR
East	E
Electric/Electronic	ELEC
Electronic Countermeasures	ECM
Electronic Warefare	EW
Elevation	ELEV
Emergency	EMER
Enroute	ENRT
Enter	ENTR
Equipment	EQP
Escape	ESC
Essential	ESST
External	EXT
Facility	FAC
Feet	F
Field	FLD
Fire Control System	FCS
Flight	FLT
Flight Engineer	FE
Formation	FORM
Forward	FWD
Freeze	FRZ
Frequency	FREQ
Fuselage	FUS
Generator	GEN
Glideslope	G/S
Governor	GOV
Greenwich Mean Time	GMT
Ground Speed	GS
Ground	GRND
Ground-Controlled Intercept	GCI
Ground-Controlied Approach	GCA
Heading	HDG
Heavy	HVY
High Frequency	HF
History	HIST
Horizontal Situation Indictor	HSI
Hour	HR
Hydraulic	HYDR
Identification Friend or Foe	IFF
Increase	INCR
Index	INDX
Indicated Airspeed	IAS
Indicator	IND
Inertial Navigation System	INS
Initial	INIT
Initial Condition	IC
Instructor/Operator Station	IOS

Table C-2 (Continued)

Instructor/Operator Console	IOC
Instrument Landing System	ILS
Integrated	INTEG
Inter-Communication System	ICS
Internal	INT
Intructor	INSTR
Isolation, Isolate	ISOL
Keyboard	KEYBD
Landing	LDG
Latitude	LAT
Left	L
Longitude	LON
Magnetic	MAG
Malfunction	MALF
Manual	MAN
Master	MSTR
Maximum	MAXM
Mean Aerodynamic Chord	MAC
Measurement	MEAS
Message	MSG
Microphone	MIC
Minimum	MINM
Minute	MIN
Miscellaneous	MISC
Mission	MISN
Mission Elapsed Time	MET
Multi-Function Display	MFD
Nautical Miles per Hour, Knots	KTS
Nautical Mile	NM
Navigator, Navigation	NAV
Normal	NORM
North	N
Number	NO.
Operator, Operating	OPER
Outside Air Temperature	OAT
Overcast	OVCST
Overhead	OVHD
Overheat	OVHT
Oxygen	OXY
Panel	PANL
Percent	PCT
Performance	PERF
Pilot	PLT
Playback	PLYBK
Position	POS
Power	PWR
Precision Approach Radar	PAR
Pressure, Wind, and Temperature	PWT
Pressure	PRES
Problem	PROB
Procedure	PROC

Table C-2 (Continued)

Program	PROG
Propeller	PROP
Quantity	QTY
Radar	RAD
Range	RNG
Receiver	RCVR
Release	RLSE
Rendezvous	RZ
Request	REQ
Reset	RSET
Revolutions-per-minute	RPM
Right	R
Rudder	RUD
Runway	RWY
Runway Visual Range	RVR
Satellite	SAT
Second	Sec
Segment	SEG
Select	SEL
Sensor	SENS
Simulator	SIM
Single Sideband	SSB
South	S
Speaker	SPKR
Special	SPCL
Speed	SPD
Spoilers	SPLRS
Standby	STBY
Station	STA
Summary	SUMM
Surface-to-Air Missile	SAM
Synchronous/Synchronized	SYNC
System	SYS
Tactical	TAC
Takeoff	T/O
Temperature	TEMP
Threat	THRT
Throttle	THROT
Tower	TWR
Track	TRCK
Transmit	XMIT
True Airspeed	TAS
Ultra-High Frequency	UHF
Utility	UTIL
Value	VAL
Variation	VAR
Vertical	VERT
Very-High Frequency	VHF
Vibration	VIBR
Visibility	VIS
Waypoint	WYPT

<u>Table C-2</u> (Concluded)

Weapon	WPN
West	W
Wheels	WHLS

APPENDIX D

DISPLAYS AND LESSONS LEARNED

Background

Surveys of training device displays used in initial qualification and continuation training devices have revealed not only a wide variation in technological applications, but also a broad spectrum of user problems with the displays as mechanized. In general, the exploitation of advanced display technology has followed engineering and software design expertise, rather than training or instructor interface requirements. The following discussion reflects surveys of the major trainers used in the C-130, C-5, C-141, KC-135/R, and B-52 training programs.

The problems reflect not only problems in application of advanced technology, but equally important, shortcomings in understanding and meeting training needs and above all, user characteristics and training program constraints. Inadequate trainer documentation has compounded the problems.

The end result in many cases has been:

1. failure to utilize simulation capabilities,

2. failure to utilize control features, and

3. failure to utilize instructional features.

In summary, lack of an effective display interface, coupled with poor documentation and inadequate user training, has limited the cost effectiveness of training devices.

Trainer Displays

Displays used in training devices can be grouped into three categories:

1. Status Displays - displays that present information on the trainer, the simulated weapon system, and the training event;

2. Plot Displays - displays that present a graphic display of the operational simulated world in two or three dimensions; and

3. Control Displays - displays that present trainer control options.

Indicator lights, CRTs, mechanical plotters, and instruments are all used to present information. In general, trainer design has erred in the direction of presenting excessive information, in the anticipation of satisfying all current and future display requirements, and reflects a general lack of information requirements analysis.

Lessons Learned

The following paragraphs summarize lessons learned in terms of status, plot, and control displays.

Several problems are common to all displays and include:

1. The lack of consistent and meaningful abbreviations. The problems found frequently included:

- The same abbreviation with different meanings,
- Different abbreviations for the same word(s),
- Failure to follow weapon systems abbreviations, and
- No consistent method for creating abbreviations.

2. Non-standard and inconsistent use of color-coding including:

- Use of red for non-emergency conditions,
- Use of amber for non-caution conditions,
- Use of green for other-than-normal operation state, and
- Inconsistent use of colors such as blue and white.

3. Inconsistent brightening of switch-lights; e.g., sometimes using the feature to show the "off" state, sometimes the "on" state.

4. Failure to balance display light levels at the stations.

5. Failure to remove or at least blank control and indicator legends when no longer required as a result of modifications.

6. Failure to label control panel functions.

7. Use of redundant labeling on controls and indicators.

8. Co-locating high-priority displays with low-priority displays.

9. Locating maintenance technician displays at the IOS.

10. Failure to arrange repeater displays as they are at the crewstation.

Status Displays

Three different approaches have been utilized to meet the requirements for displaying information relative to the trainer, the simulated weapon system, and the training event. They reflect display technology history, rather than instructor/operator needs. Thus older trainers depend heavily on analog devices; the next generation added alphanumeric displays; and modern trainers depend heavily on graphics displays. The graphics displays are often used to simulate analog devices such as needle instruments, but substitute a digital readout in place of the pointer. The implementation is difficult for operational personnel to use because of the conflict created; i.e., an apparent analog of the crewstation display but not readable in the same manner. Instead of "reading" pointer position, the instructor is required to read numbers which may be changing very rapidly.

Trainer Status. Trainer status displays reflect system status displays in general and are typified by:

1. Advisory, caution, and warning indicator lights and legend lights.

2. Illuminated switch-lights.

Many of the subsystems monitored have no meaning to the instructor/operator. Figure D-1 is an example of the type of display that can result. Figure D-2 is another example and also shows the grouping of different control functions from basic training controls (e.g., freeze) to interlock indicators on the same panel.

1. Indicators and switches are identical in appearance. For example, CLEAR AURAL ALARM is a switch, whereas all of the units above it are indicators (Figure D-1).

2. Illumination of the system status indicators CMPTR, DISC, PLOTTER, and AUTO MSG indicates a no-go condition. Most other indicators illuminate when the function is selected or functioning. Of more importance, none of the computer systems status lights is required at the instructor console since they are a maintenance technician function.

Weapon System Status. Weapon system status pages typically present data on almost any subsystem and associated performance. The displays are engineering-oriented, not training-or instructor-oriented. They are typified by:

1. Excessive detail;

2. Irrelevant information for the training tasks involved; and

3. Grouping of displays by engineering systems, not training tasks.

Figure D-3 shows an alphanumeric status display of the hydraulic, air-conditioning, and pressurization systems of the simulated aircraft. Not only are the data presented in a unique format compared to the aircraft, they are presented in different units and labeled differently. Finally, the data are displayed in columns, which is typical of operational displays; and little attempt is made to group the data to facilitate access and interpretation.

Figure D-4 shows a typical graphics solution to weapon system status information except that it requires the reading of digital data for what is a needle position indication in the operating system.

Training Status. The presentation of training status in most existing devices is limited to optional printouts of selected parameters. The resulting data are difficult and time-consuming to interpret. Figure D-5 is a typical parameter data page. Figure D-6 is an example of a very limited display of procedures monitoring. Such data are not used by instructors.

Weapons delivery scoring data are normally provided, either in digital format or graphically for ground practice target areas.
The hit/kill calculations are normally of training value only, since no attempt is made to solve the complex equations involved.

No displays were found which reflected progress or status in terms of training objectives or performance criteria.

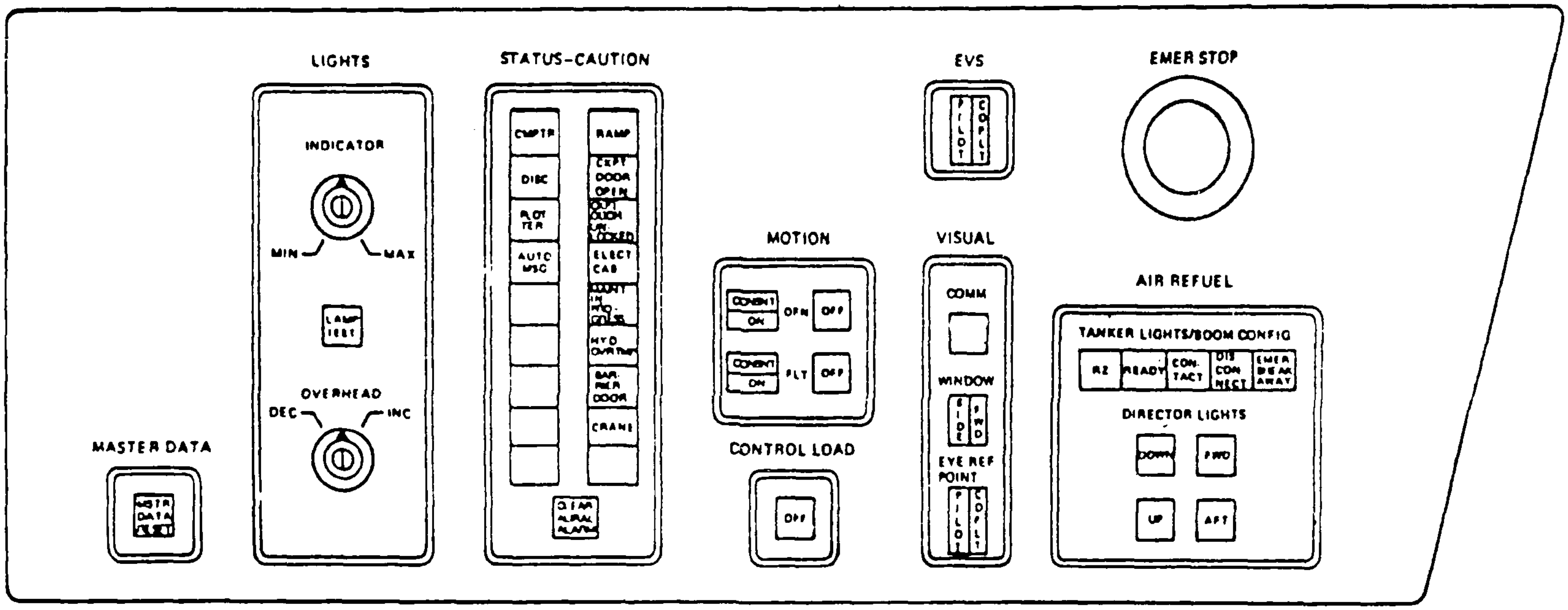


Figure D-1. Example of a Poorly Designed Trainer Status Display.

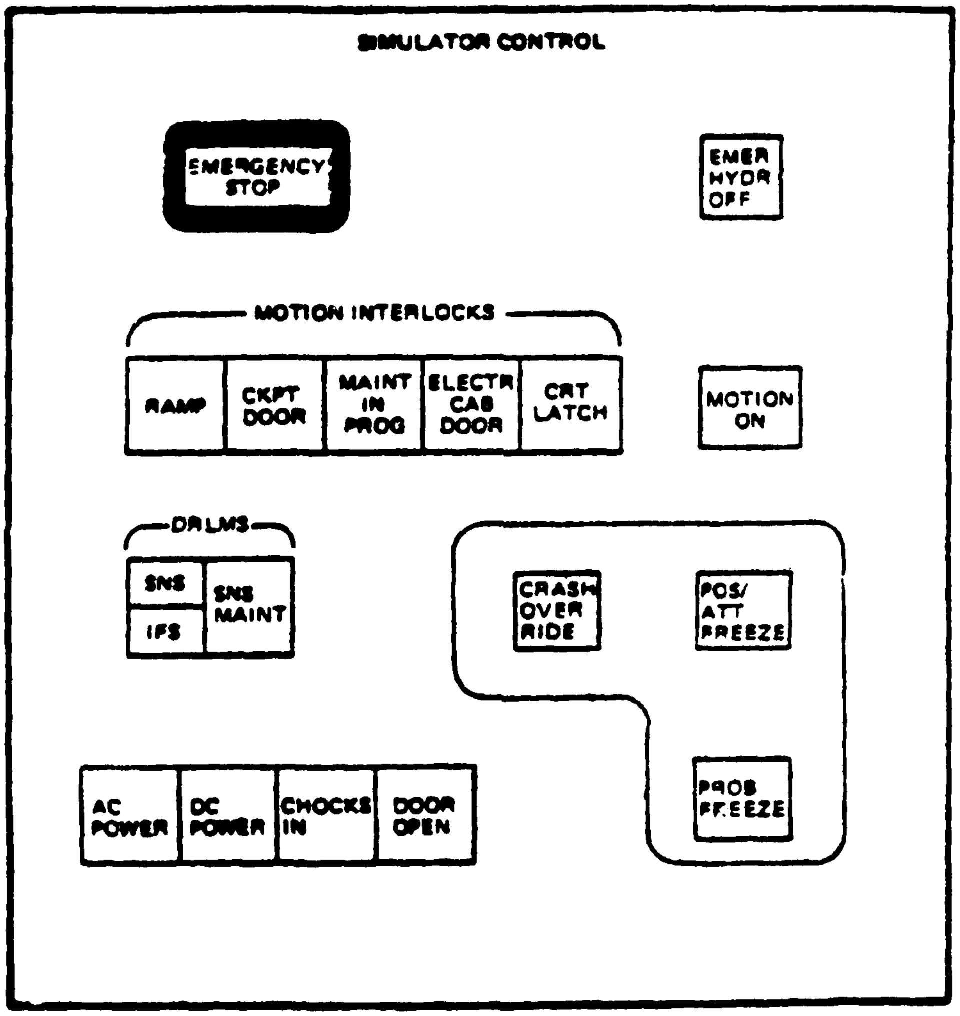


Figure D-2. Example of a Poorly Designed Trainer Control Panel.

SYSTEMS PG 4 HYD,AIR COND,PRESS

LEFT MLDGR	DN	NOSE LDGR	DN	RIGHT MLDGR	DN
Ø1 L MLG MAN EXT	ØFF	Ø2 NLDGR EMER EXT	ØFF	Ø3 R MLG MAN EXT	ØFF
Ø4 L MLG MAN RET	ØFF			Ø5 R MLG MAN RET	ØFF
Ø6 LDG HYD OVD DN	ØFF			Ø7 LDG HYD OVD UP	ØFF
FLAPS (PCT)	5Ø	Ø8 FLAP MAN EXT	ØFF	Ø9 FLP HYD OVD DN	ØFF
1Ø FLAP BRK RLSE	ØFF	11 FLAP MAN RET	ØFF	12 FLP HYD OVD UP	ØFF
NRM BRK (PSI)	3Ø27	13 AUX HAND PUMP	ØFF	EMER BRK (PSI)	3ØØ3
LEFT BRK	ØFF	ANTI SKID	ON	RIGHT BRK	ØFF
RUD UTL (PSI)	3ØØ1			RUD BST(PSI)	3ØØ1
UTIL PR (PSI)	3ØØ1	AUX PR (PSI)	2999	BST PR (PSI)	3ØØ1
AIR COND MSTR	OFF				
CBN ALT (FT)	348	WG ANT ICE	ØFF	BLEED AIR (PSI)	Ø
CBN DIF(INHG)	Ø.Ø	EMP ANT ICE	ØFF		
CBN ROC (FPM)	Ø	P/E ANT ICE	AUTO		
14 LEFT WG ISOL	OPEN			15 RIGHT WG ISOL	OPEN
16 EXT AIR	ØFF	17 HYD REFILL	ØFF	18 OXYGEN QTY (LTR)	23.8
19 GRD TEST VALVE	CLSD				

Figure D-3. Example of a Poorly Designed Alphanumeric Status Display.

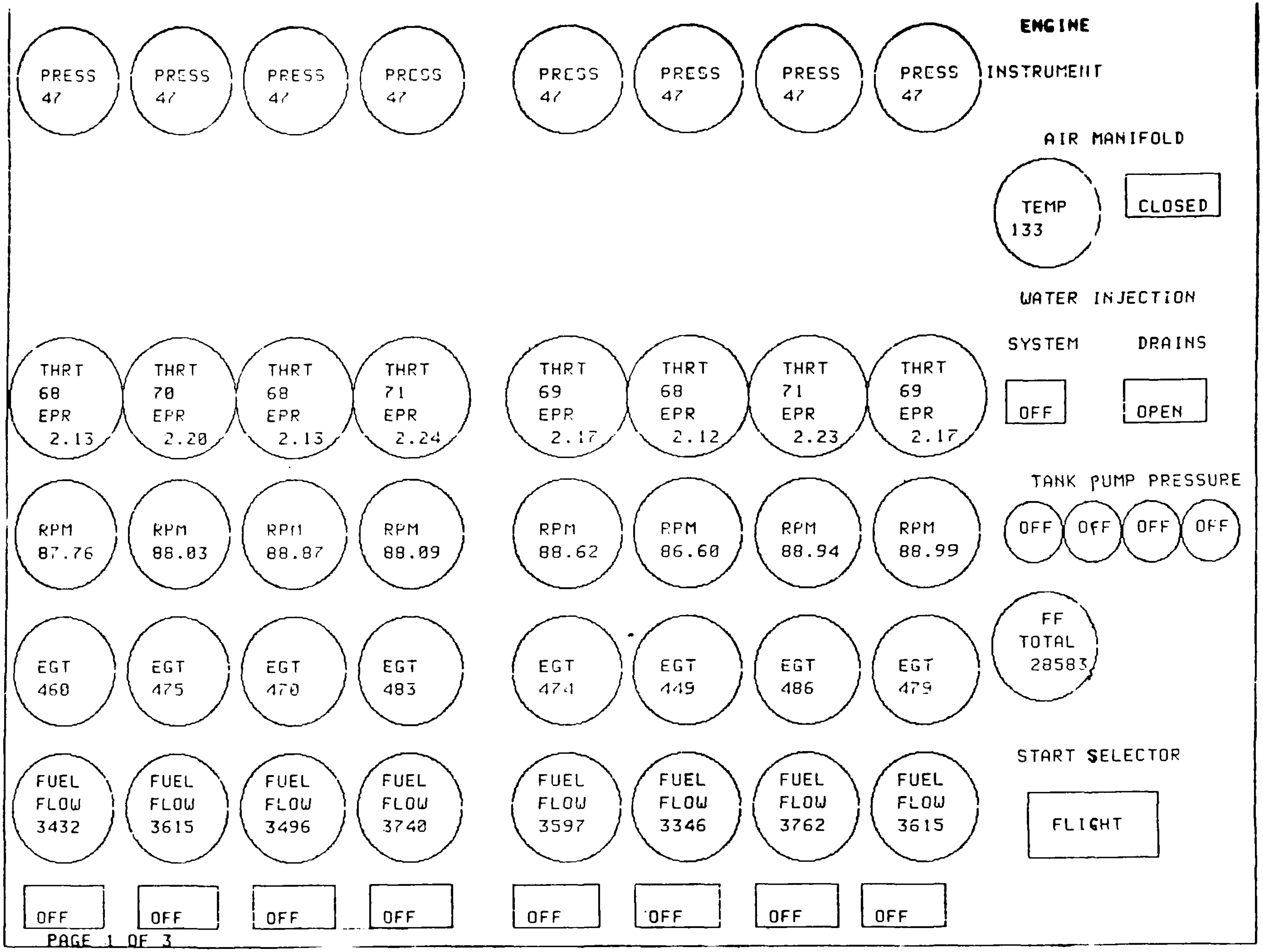


Figure D-4. Example of a Poorly Designed Graphic Status Display Page.

GMT 13:04:33 IFS SET NO. 10.

VARIABLE	CURRENT	MAXIMUM	AVERAGE	%OUTTOL
HDG(DEG)	N/A	N/A	N/A	N/A
ALT(FT)	1185.3	1213.0	397.5	0.0
ABS ALT	N/A	N/A	N/A	N/A
ROT(DPS)	N/A	N/A	N/A	N/A
IAS(KTS)	140.8	140.9	38.3	79.5
TAS(KTS)	N/A	N/A	N/A	N/A
OMG TASD	N/A	N/A	N/A	N/A
GLDSLO D	N/A	N/A	N/A	N/A
COURSE D	0.0	0.0	0.0	0.0
XTK D-NM	N/A	N/A	N/A	N/A
XTK D-YD	N/A	N/A	N/A	N/A
FD XTK-F	N/A	N/A	N/A	N/A
FD ITK-F	N/A	N/A	N/A	N/A
V/V(FPM)	N/A	N/A	N/A	N/A
PTCH ATT	12.8	12.9	2.1	17.9
YAW(DEG)	0.3	44.2	31.9	76.7
ELEV-RAT	0.0	0.1	- 0.0	0.0
AOB(DEG)	3.8	5.8	0.3	82.8
CBN ALT	N/A	N/A	N/A	N/A
CBN-P-VV	N/A	N/A	N/A	N/A
CBN-PR-D	N/A	N/A	N/A	N/A
XTK D-KM	N/A	N/A	N/A	N/A
TRQ1-INL	N/A	N/A	N/A	N/A
TRQ2-INL	N/A	N/A	N/A	N/A
TRQ3-INL	N/A	N/A	N/A	N/A
TRQ4-INL	N/A	N/A	N/A	N/A
TIT1-DGC	N/A	N/A	N/A	N/A
TIT2-DGC	N/A	N/A	N/A	N/A
TIT3-DGC	N/A	N/A	N/A	N/A
TIT4-DGC	N/A	N/A	N/A	N/A
THRT1RT	90.0	90.0	38.9	30.2
THRT2RT	90.0	90.0	38.3	30.2
THRT3RT	90.0	90.0	38.9	30.2
THRT4RT	90.0	90.0	38.6	30.2

SPECIAL PARAMETERS

GEAR		FLAPS	
AIR DEFLR DR		LDG LTS	
RAMP		TO ROLL	6340.
LDG ROLL		HOLD	
NSWHL LIFT	117.	THRSHD HT	
TCHDN IAS		TCHDN DIST	
TCHDN VV		CBN PRS DIF	
TCHDN HDG		TIMER	0.

Figure D-5. Example of a Poorly Designed Training Status Data Page.

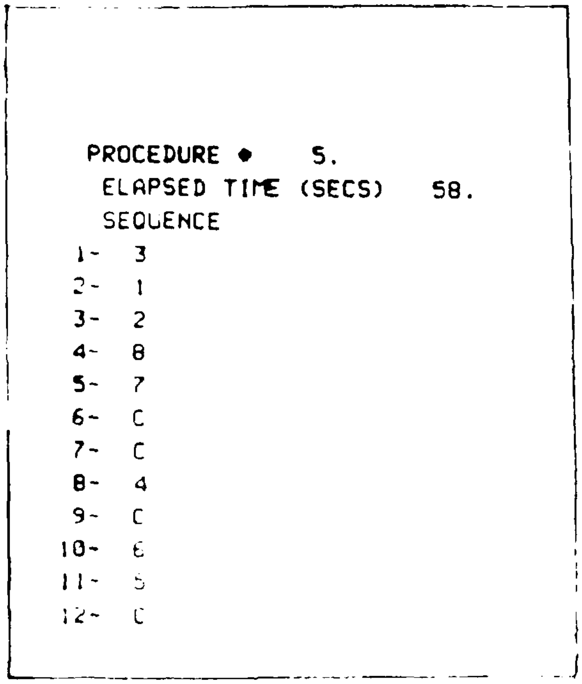


Figure D-6. Example of a Poorly Designed Procedures Monitoring Display.

Plot Displays

Both two-dimensional and three-dimensional plot displays have been used, the latter primarily for air combat maneuvering. Two-dimensional plots are either maps or plots of aircraft position in space.

Map Plots. Cross-country maps and tactical plots showing threats and targets are typically provided. Most exhibit the same type of problems, including:

1. Non-weapon system symbology,

2. No scale (needed for resetting),

3. No compass rose or heading reference (needed for vectoring),

4. Limited decluttering options (needed to resolve overlapping symbology and alphanumeric data),

5. Limited track erase options (generally all or none), and

6. Poor selection of map scales relative to training tasks.

Figure D-7 and D-8 depict typical cross-country plots.

ILS/GCA Plots. Figure D-9 is a typical ILS/GCA (Instrument Landing System/Ground Control Approach) plot page which also displays the recommended controller message. Most GCA controller models have been unsatisfactory in that the message is not sufficiently anticipatory. In general, instructors feel comfortable in conducting GCAs using these types of displays.

Control Displays

Both CRT and programmable display pushbuttons are included. The more common ones found in existing trainers are CRT control pages.

CRT Control Pages. Pushbutton keys are generally implemented with CRT display page access to call the basic control page. Once the control option display page is shown, a variety of options for implementing the control input have been used and are discussed in Appendix E. In general:

1. Menu-driven systems have tended to err to extremes in terms of breadth and depth of the menu option. Breadth refers to the number of choices on each page; depth refers to the hierarchical structure or number of levels. Both extremes result in slow and tedious operation, as is discussed in Appendix E.

2. The format of the menu pages in most existing trainers is not optimum. Figure D-10 provides a sample of a menu page which presents an excessive number of options in a poorly organized format. Although some grouping is used, it is not displayed as such. Figure D-11 depicts a better-organized page.

3. Terminology often does not reflect either the weapon system or operation. Malfunction and control titles are often not meaningful to instructors.

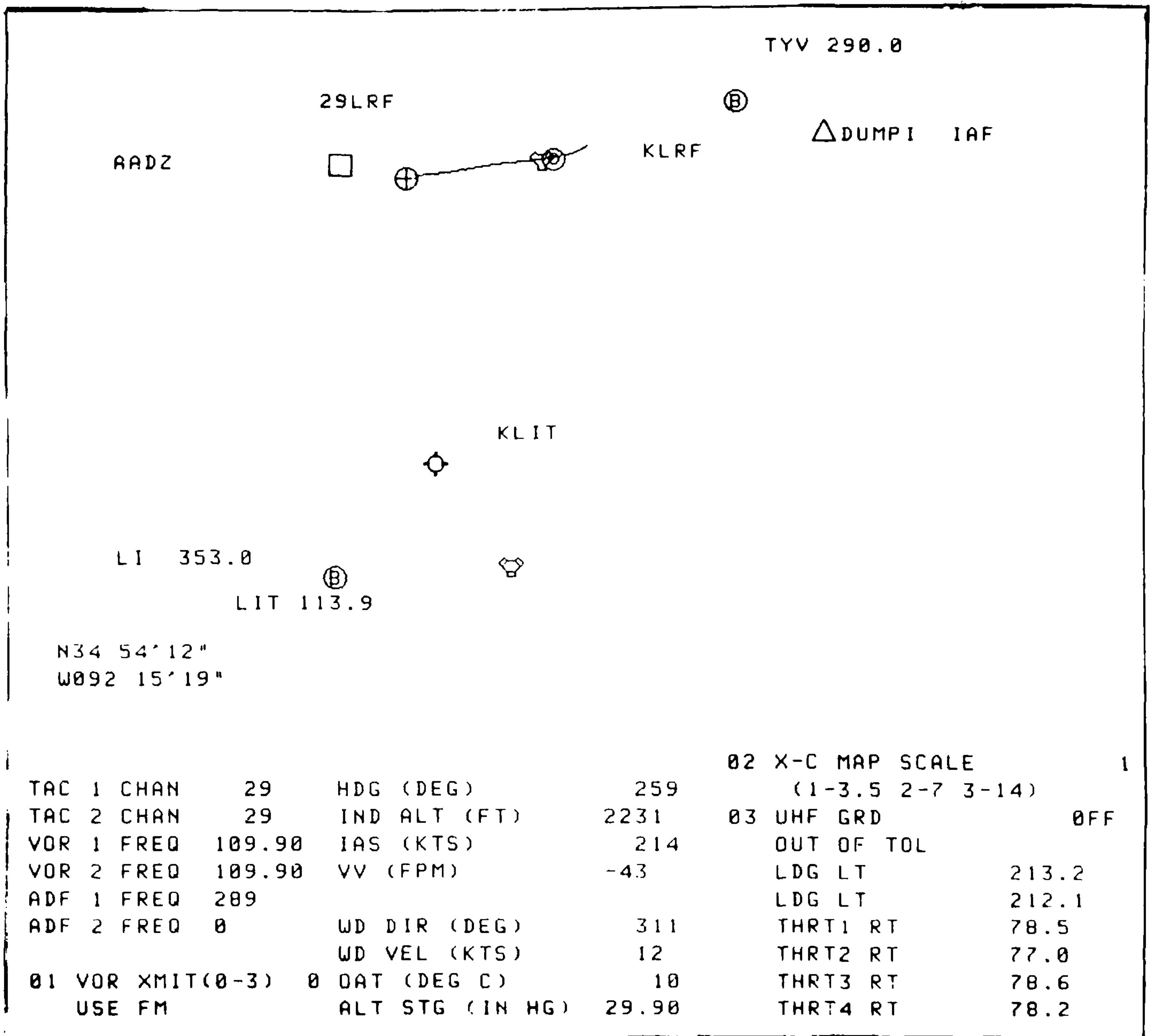


Figure D-7. Example of a Poorly Designed Cross-Country Plot.

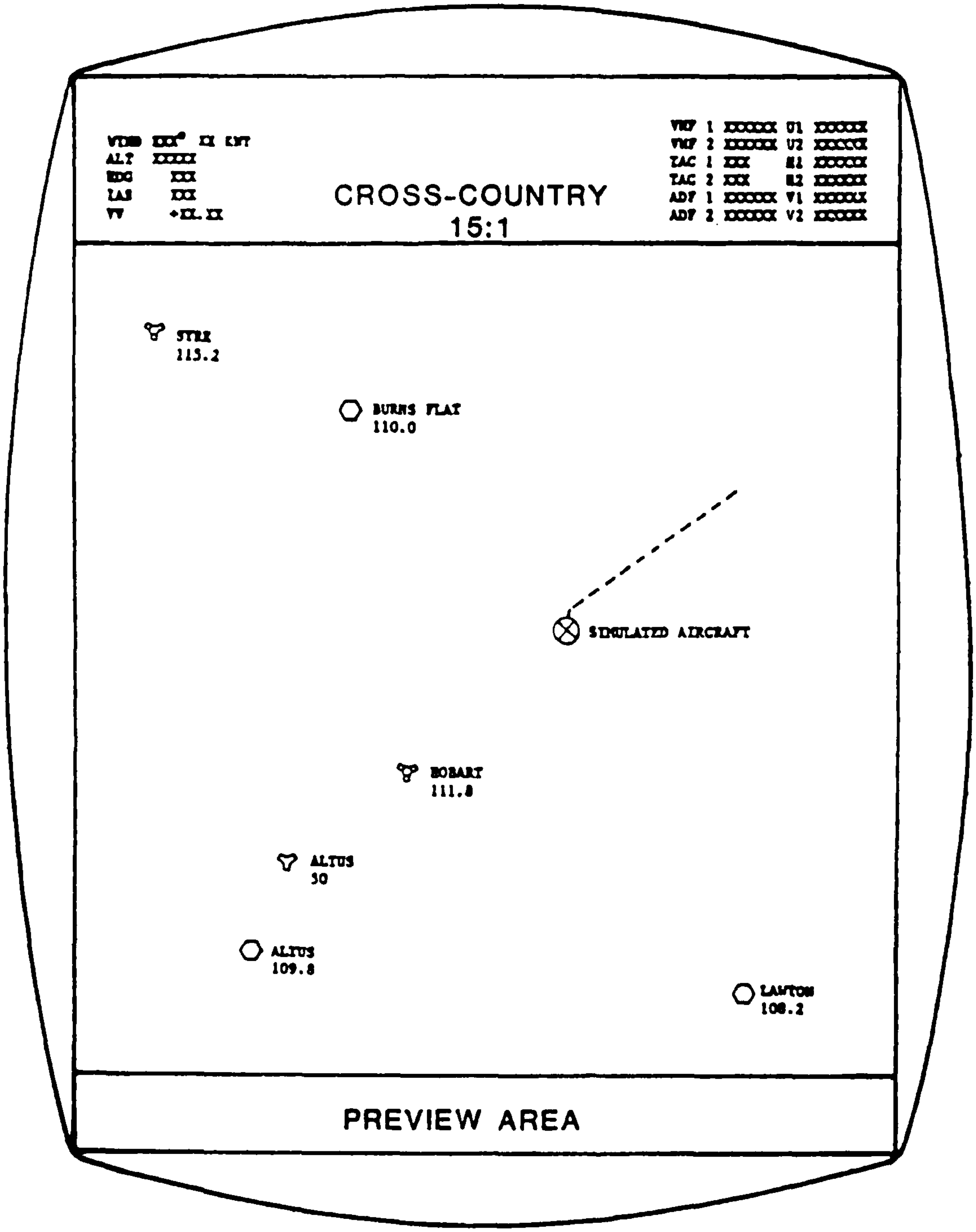


Figure D-8. Sample Cross-Country Plot.

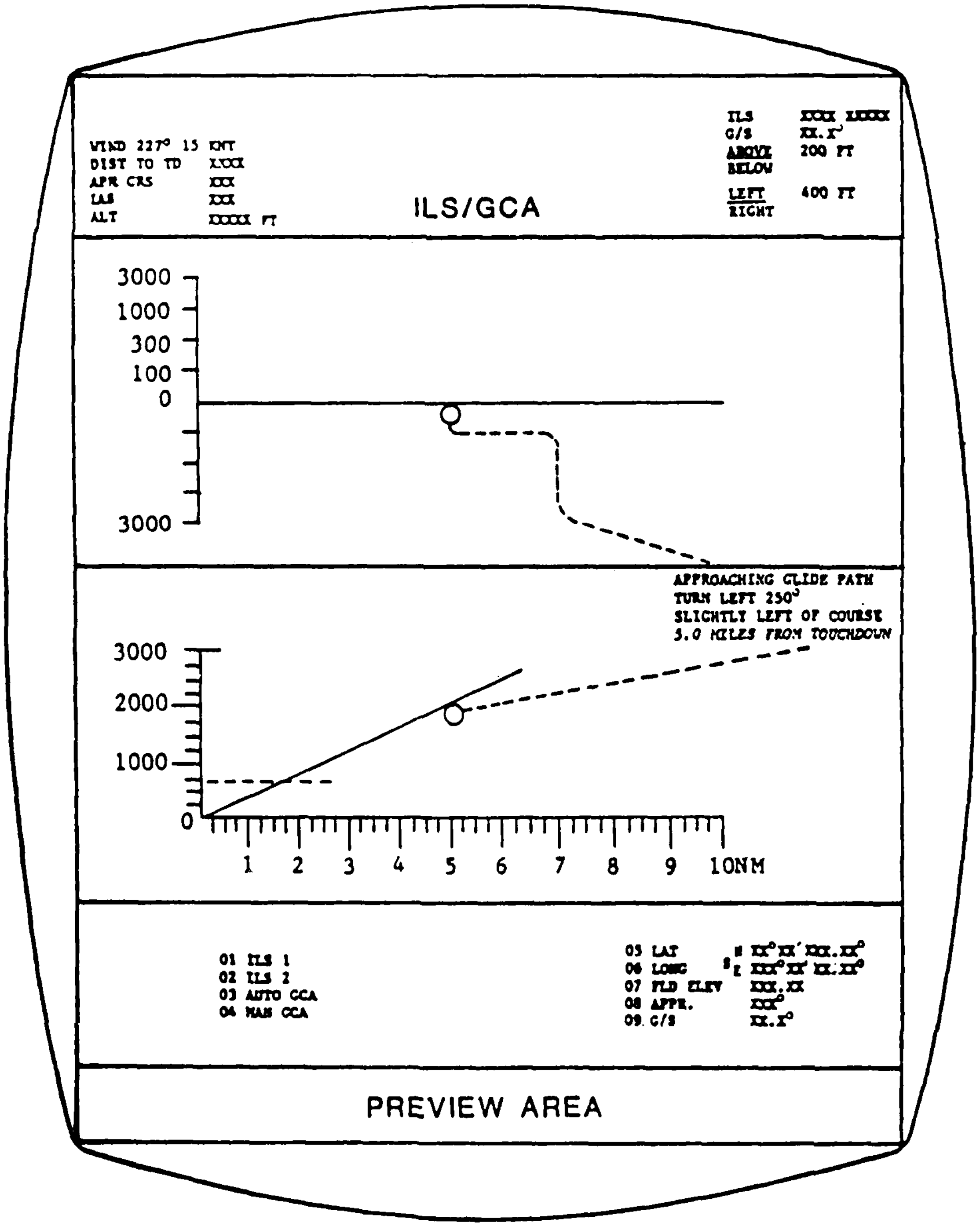


Figure D-9. Typical ILS/GCA Plot.

MANUAL MALFUNCTION INDEX

PAGE NO	
01	ENG- F PMPS,ENRICH VAL,SOV,IGN RLY F MANF PRES SW,16X SPD SW
02	ENG- SENS SWS CONT SFT TIT,DR VAL,ST CNTRL VAL,BL A VAL,BL CK VAL
03	ENG- ACCEL BL VALS,STALLED ST,-- ----,ST DUCT,ST SFT
04	ENG- OPRS PMPS,OLK,OTEMP IND,OIL TEMP,OCLR FLP
05	ENG- OCLR FLP,TD AMPL,TIT
06	ENG- F FL IND PWR SUP,TORM,TACH,STP RLY,LWSPD SOL,COND LVR,THOT,FLOL
07	ENG- BRG SEIZURE,GRBX,FIRE,NAC OVHT,TURB OVHT
08	PROP- OFSPD MG,N/G FLUCT&MG,LW O LGT,PL/K,REG,OVRSPD
09	PROP- SFTY CPLG,NTS,BRK,AUX FEATH MTR,FLS 2/FEATH,WDMLS,OVRD BTH,OFS
10	PROP- LW P STP CMPRN,REV TORQ
11	ELECT- EXT AC/DC,GEN GRWD FAU-REG-OUT-FLR-CNTOR-OT LGT
12	ELECT- GEN ATM,L/R AC, ESS AC,MN AC,BTRY,BUS TIE
13	ELECT- MN DC,ESS TR,MN TR,ACI/EFC,PWR XFMR,CP INSTR BUS
14	FUEL- F PRES,DMP MST,DMP,XFEED,BVP,PRMR,XFEED SEP VALS
15	FUEL- LW PRES SW,EXT LK,F QTY INDS
16	OVHT- OTR WG,CTR WG,WHL WELL,N WHL WELL,EMPEN,WG,W/W,ATM,CAR
17	ANTI-I- AI VL,L/E T IND,PR TMR,IDET,SPNR,BL,PR LC,PIT HT,STC PTS
18	PNEU- PRES CONT,OFTW&SFTY VALS,RLY,DCOMP,A COND,MANF,ISOL VAL
19	GTC- DOOR,OPPRES SW,LD CONT VAL BL A OVRSPD,FIRE
20	FLGT CONT- ELEV TM,TM TAB,A/P,ELEV TAB IND,AIL
21	HYD- BST PMP,SOV,CK VAL,PMP PRES,LK,GRND T VAL,AUX PMP,PR IND,BST SO
22	HYD- DIV VAL,FLP CONT DRI,FLP HYD L,ASYM FLPS,FLAP IND
23	LNDG GR- MN FLS,MTR,GR BOX,LK,CONT V,BRK,TIRE,SW,SOL,RLY,P IN,LGT,NB
24	LNDG GR- N GR UP LK N WHL STRNG SHIMMY
25	BRK & A/S- B SEL VAL,LKD,MTRG VALS,LINE,A/S VAL,TEST,IND

Figure D-10. Example of Poorly Organized Menu Page.

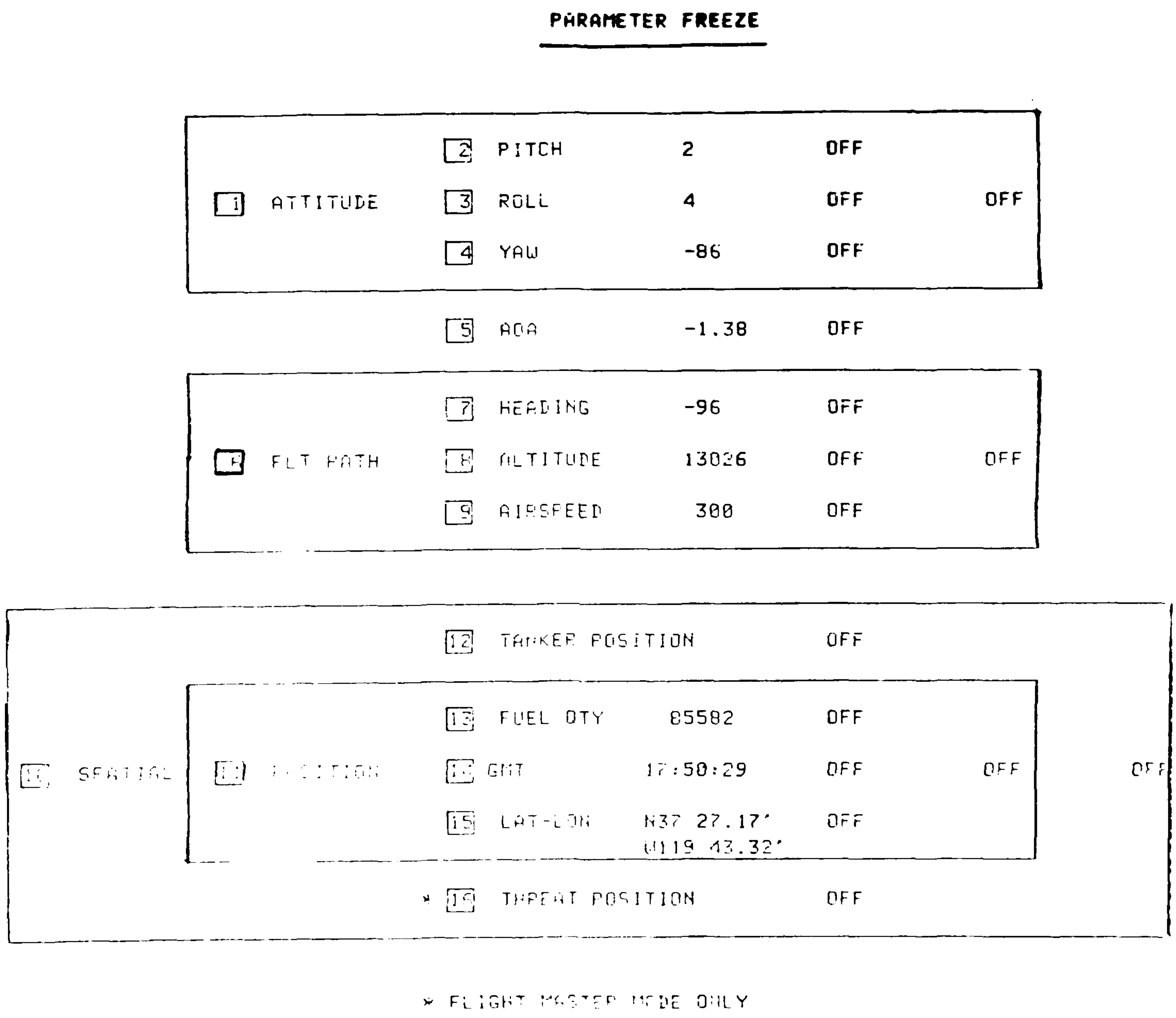


Figure D-11. Example of a Structured Menu Page.

4. Numbers are typically used for control input but are typically of no meaning and often conflict with parameter numbers. For example, runway number, waypoint number, or malfunction number may not be used for entry; rather, a separate "list" number is used instead. Thus, to utilize shortcuts, the instructor is required to recall a number or read the manual to identify the number to enter.

Although definitive data on menu design are not available, existing evidence indicates that well-organized menu pages utilizing categories can exhibit up to eight and possibly more selections per page.

The use of touchpanels with an icon type of identification presents an alternative menu option. Figure D-12 depicts a touch panel status and menu page for cockpit controls. The right corner subpanel functions as the menu page. Since the screen performs almost all control functions, the number of pages required is generally more than for key-controlled menu pages. However, if designed in user terms, the approach can reduce instructor/operator training requirements.

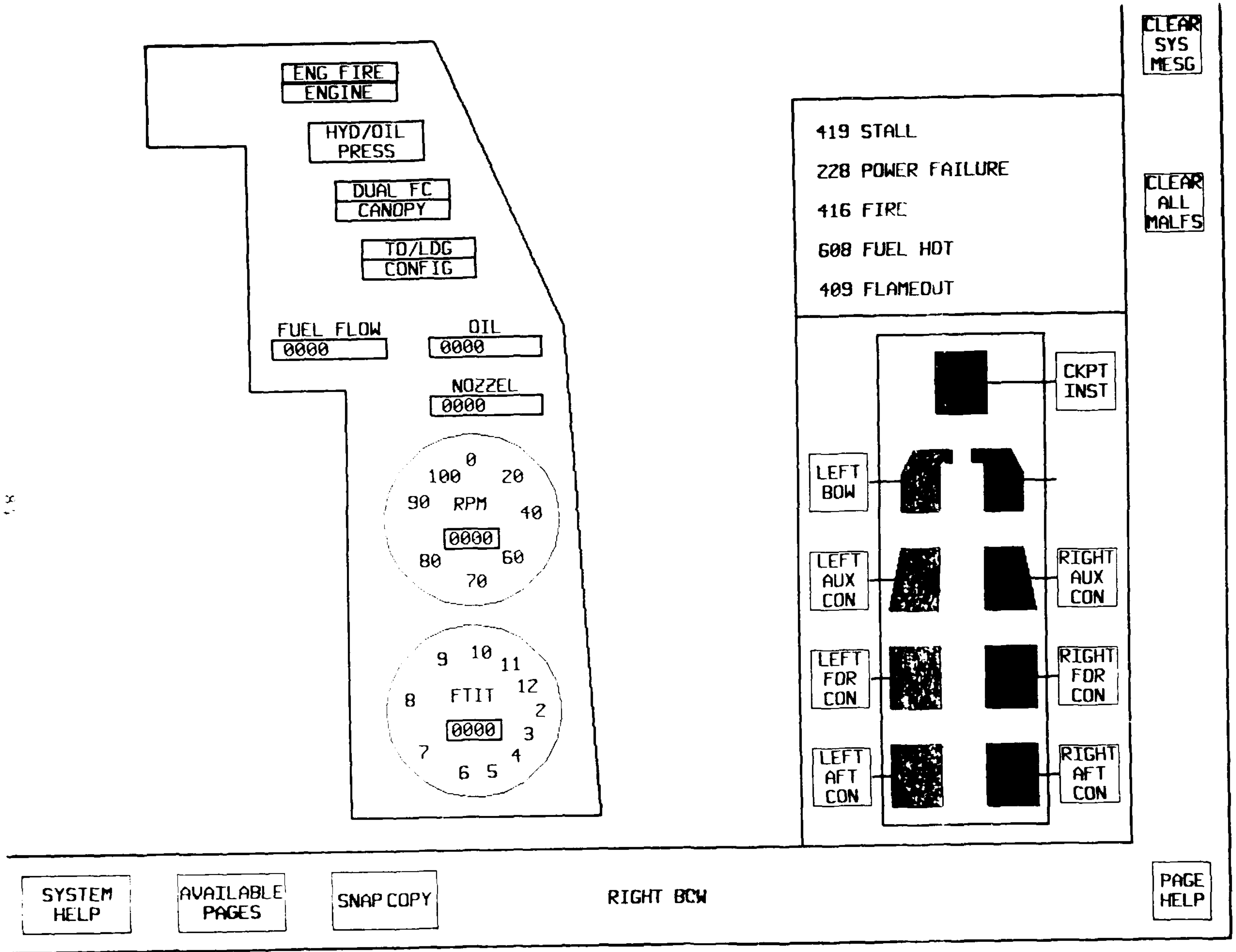


Figure D-12. Sample Touch Panel Page.

APPENDIX E: CONTROLS AND LESSONS LEARNED

Background

Surveys of training device displays used in initial qualification and continuation training devices have revealed not only a wide variation in technological applications, but also a broad spectrum of user problems. In general, the exploitation of advanced control technology has followed engineering and software design expertise rather than training or instructor interface requirements. The following discussion reflects surveys of major trainers used in the C-130, C-5, C-141, KC-135R, and B-52 training programs.

The problems reflect not only problems in application of advanced technology, but equally important, shortcomings in understanding and meeting training needs and above all, user characteristics and training program constraints. Overall poor documentation has compounded the problems.

The end result in many cases has been:

1. failure to utilize simulation capabilities,

2. failure to utilize control features, and

3. failure to utilize instructional features.

In summary, lack of an effective control interface, coupled with poor documentation and inadequate user training, has limited the cost effectiveness of training devices.

Trainer Controls

The trainers surveyed presented a wide variety of controls and their implementation, including standard computer keyboards, various function key panels, numeric keypads, light pens, track balls, joysticks and conventional switches and knobs. The most common devices used were pushbuttons and numeric keypads. In most applications, the controls were used in conjunction with a CRT display and the systems were menu-driven.

Controls can be grouped into five categories in terms of the functions performed. Different types of controls tend to be used for each. The five categories are:

1. Trainer system controls - e.g., computer, motion, control loading, visual, sound, and "g" systems;

2. Training controls - e.g., initialization, instructional features, and exercise control and modification;

3. Briefing/debriefing - initialization and feedback/debriefing features;

4. Management - record keeping, scheduling, and reporting; and

5. Development - exercise and scenario development and modification.

Lessons Learned

In general, in the same sense that trainer displays tended to present an excess of information, controls tended to provide a means of controlling anything and everything that was displayed and to provide the control at all times, whether relevant to the situation or not. Trainer control implementation has been likened to a pipe organ console in permitting access to all the capabilities of the system at all times.

Trainer System Controls

Trainer system controls include controls for the trainer subsystems such as the motion system, computer system, visual system, "g" system, audio system, lighting system, and any other system or subsystem of the training device. Only the controls required by the instructor/operator in conducting training should be included at the IOS.

In general, existing systems tend to include instructor controls for systems which are not related to training and controls not required at the IOS. As a result they compound the instructor tasks, expand the training required, and often present the possibility of "crashing" the system if operated incorrectly. The following guidelines should be followed for system controls:

1. No power-up, diagnostics or check-out controls for trainer systems should be located at the IOS. All systems required for training should be powered-up and operation verified by technician/operator personnel prior to the instructor's manning of the console.

Controls for trainer system operation should be located at well-designed consoles for that purpose. If instructor personnel are required to perform system power-up functions, they should be trained to perform those functions at the consoles involved.

2. The following system controls are generally required at the IOS. However, if no control and adjustment of the system is required during training, the control(s) should not be implemented at the IOS, unless they are placed there for safety reasons.

a. Emergency control. A single control which safely powers down the training crewstation must be provided at each IOS. Normally, the control will stop all simulation programs and simulation systems including motion, visual, "g," and control loading. The motion platform should be quickly brought to the rest condition. Crewstation general lighting is normally turned on automatically.

Note: The emergency system control is a manual instructor function and is not part of the system response to catastrophic events such as total power failure, fire, and accidents--although the instructor/operator can utilize the emergency off control in association with such events.

b. Motion system control.

• A single indicator should be provided to indicate that the motion system is ready for operation (i.e., the platform can be erected).

• A single control should be provided to activate and deactivate the motion system. State condition should be indicated.

• Controls for adjusting "roughness" of ride should be collocated with the environment controls, not with the motion system control.

Figure E-1 depicts a typical control panel for motion system and control loading system and illustrates the complexity and typical redundancy of controls and display involved.

c. Control loading control.

• A separate control to activate control loading should not normally be required. It should be activated when the aircraft dynamics program is loaded.

• No other controls for control loading are normally required.

d. Visual system control.

• A single activation/deactivation control is required which controls the projection of the visual scene.

• Controls for varying the visual scene should be incorporated as appropriate with the environment controls or other simulation controls such as the aerial refueling, weapons delivery, and threat controls.

Figures E-2 and E-3 depict typical visual system panels and illustrate both the complexity of the operation and the degree of compatibility which must be established between the trainer environmental control pages and the visual control panel. (It should be pointed out that these systems were added after the trainer was built.)

e. Sound system.

• A single control for loudness of simulated aural effects is required.

• No activation/deactivation control is required. Power should be applied to the sound system when power is applied to the trainee station.

Note: The sound simulation system is distinct from the communication simulation system.

f. "g" system.

None of the trainers surveyed utilized a g-seat or g-suit for acceleration simulation. However, existing "g" simulation systems incorporate various means of manipulating the seat pressure applied to simulate forces against the seat and restraint devices. Most of the systems have required inputs of trainee

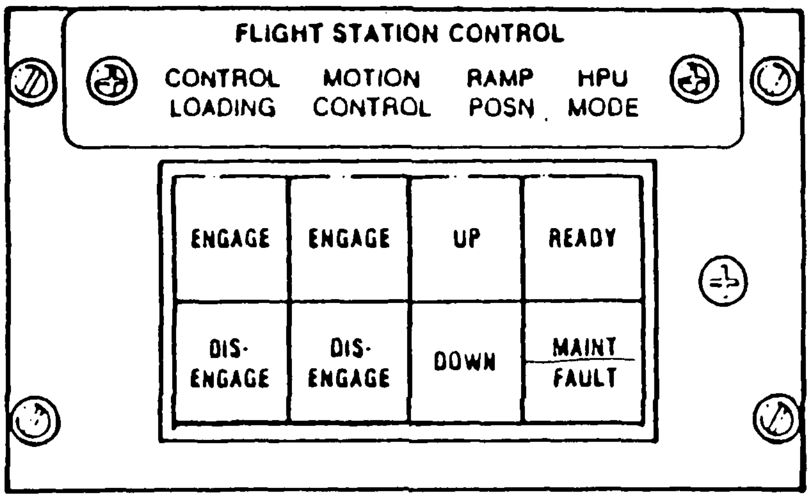


Figure E-1. Example of Poorly Designed Motion/Control Loading Panel.

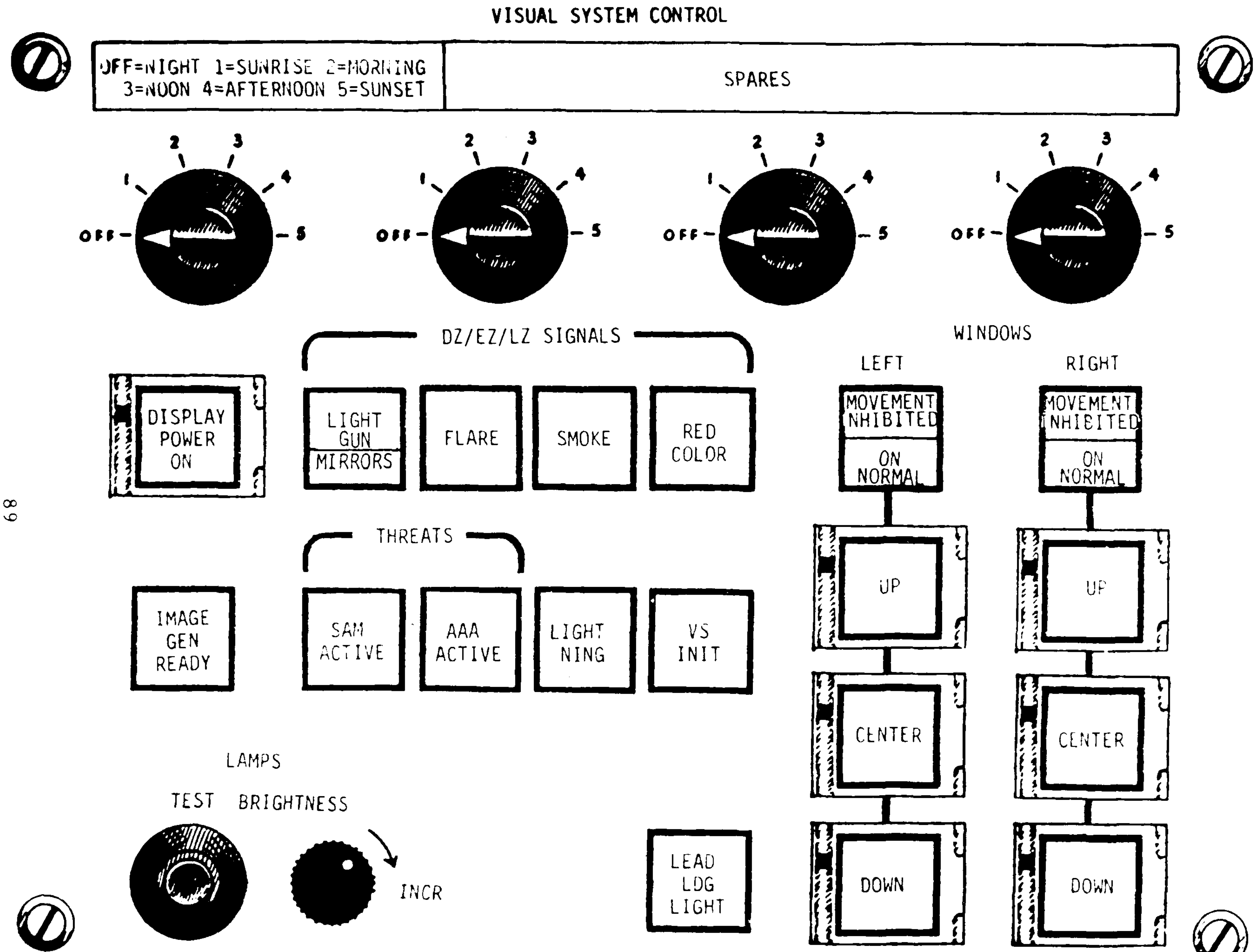


Figure E-2. Example of a Poorly Designed Independent Vision System Control Panel.

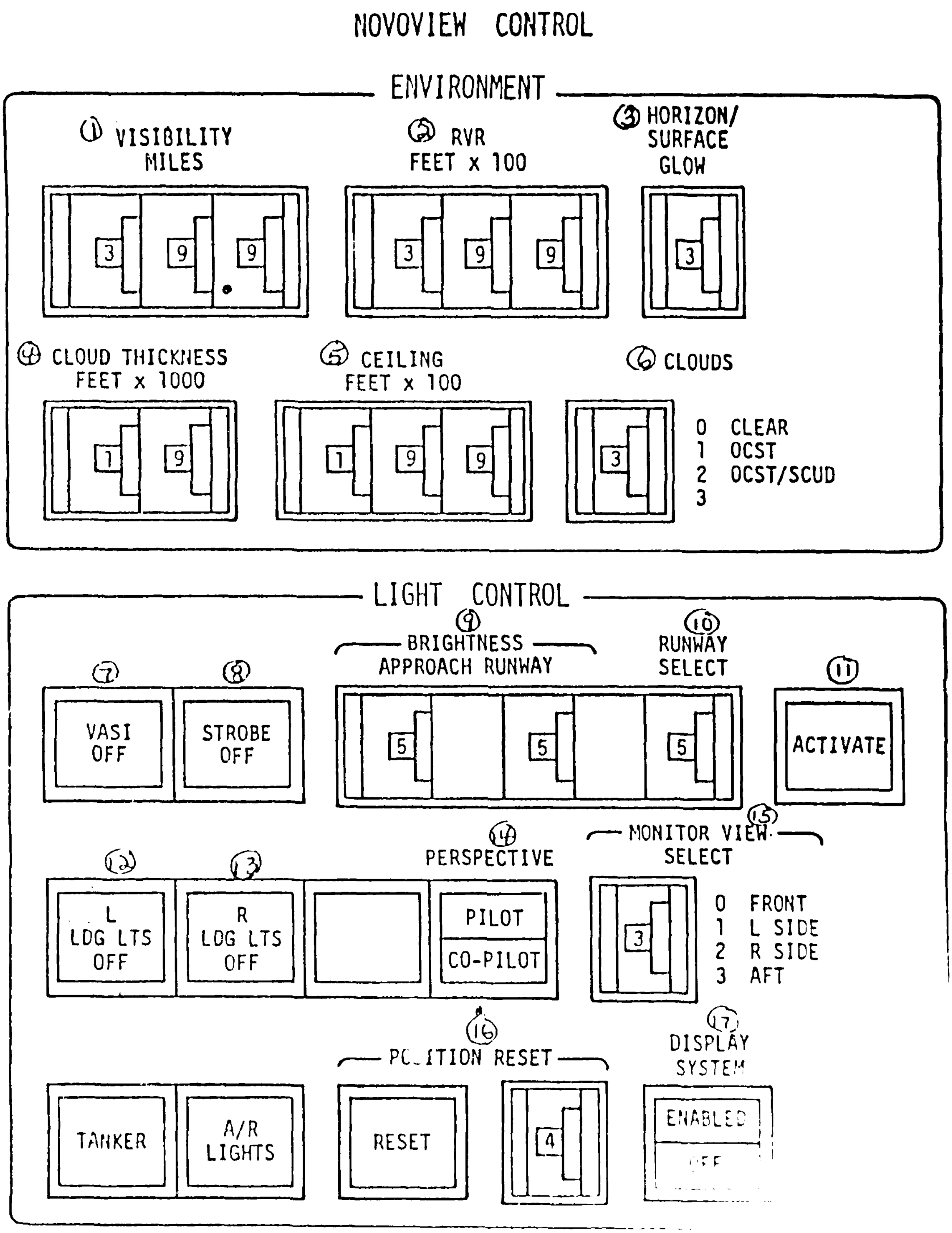
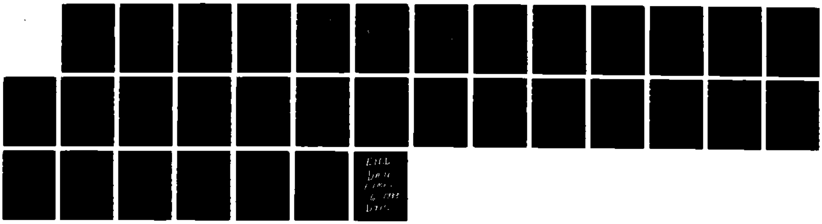
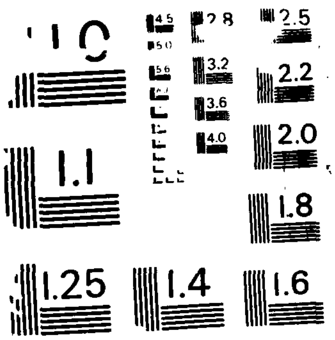


Figure E-3. Sample Vision [illegible]

AD-A192 055 INSTRUCTOR/OPERATOR STATION (IOS) DESIGN GUIDE(U) 2/2
DAYTON UNIV OH RESEARCH INST J P CHARLES FEB 88
AFHRL-TR-87-32 F33615-84-C-0066

UNCLASSIFIED F/G 5/9 NL




1.0
4.5
5.0
5.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

weight, desired onset threshold (in "g"), excursion limit controls, and pressure-per-g options. It is not clear that the settings are required.

- Only a single activation/deactivation control is normally required, since the simulation is not utilized for all training courses or events.

- If data inputs are required, they should be incorporated with the initial conditions controls.

Note: The g simulation system should be designed to simulate the acceleration environment. Modification of the simulation by the instructor should not be required, nor is it desirable since it degrades the simulation.

Training Controls

Training controls include the means provided to initialize, and conduct a training exercise. As pointed out, a wide variety of techniques have been used. Regardless of the type of control used, complex control procedures have generally been implemented and reflect hardware and software orientation rather than training. Computer keyboards and programmer-type actions are often used. Although this approach provides the maximum in control options, the result is generally a time-consuming process, which requires extensive training and practice, particularly for non-programmer personnel.

Decision-action flowcharts of the training implementation tasks for the trainers surveyed were developed. Samples are appended. The flows highlight the large number of inputs required to implement training functions and the consequences of errors.

Most of the trainers surveyed were menu-driven for training implementation and utilized function keys for initial menu access. Editing controls consisting of clear, delete, page forward, scroll, and enter were provided. Each trainer had a unique function key panel, keypad, and keyboard. Figures E-4 through E-8 depict typical trainer keyboards found. Figure E-4 shows a system which utilizes 30 numbered, programmable function keys in connection with functions numbered on the menu and data pages. As can be seen, all of the keyboards utilize function keys to access display pages (status, plot and control pages) and a keypad for numerical data entry and edit. The labeled function keys shown in Figure E-4 are also color-coded.

The following problems were found:

1. In almost all cases, data as entered were shown at the bottom of the display page, which then required an "enter" operation to insert into the data page and was followed by a second "enter" operation to insert the revised page into the program. While data echo may be desired in order to reduce erroneous inputs, direct editing of data on the page involved would save unnecessary "enter" operations.

2. In many cases, no "page back" option was provided, with the result that the instructor had to either exit and recall the display beginning at page one and page forward to the page desired, or page backward through all the pages. In many cases, such as malfunctions, this can involve a large number of operations and is unduly time-consuming.

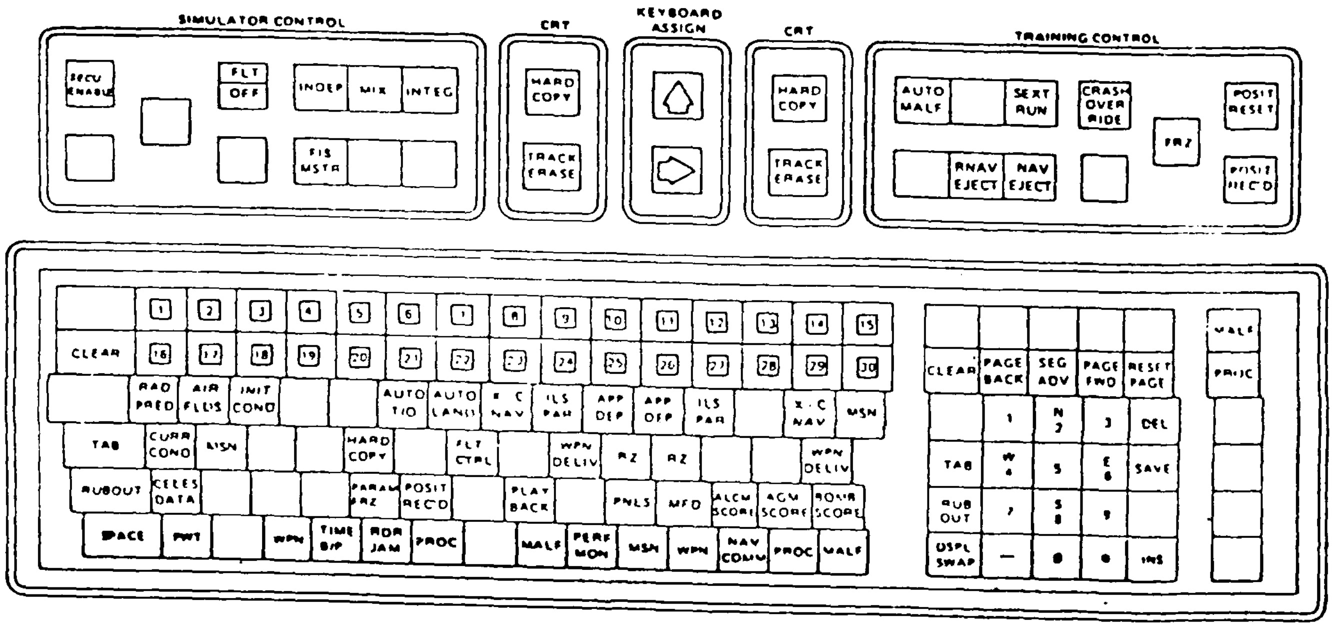


Figure E-4. Example of Poorly Designed Trainer Ke,board.

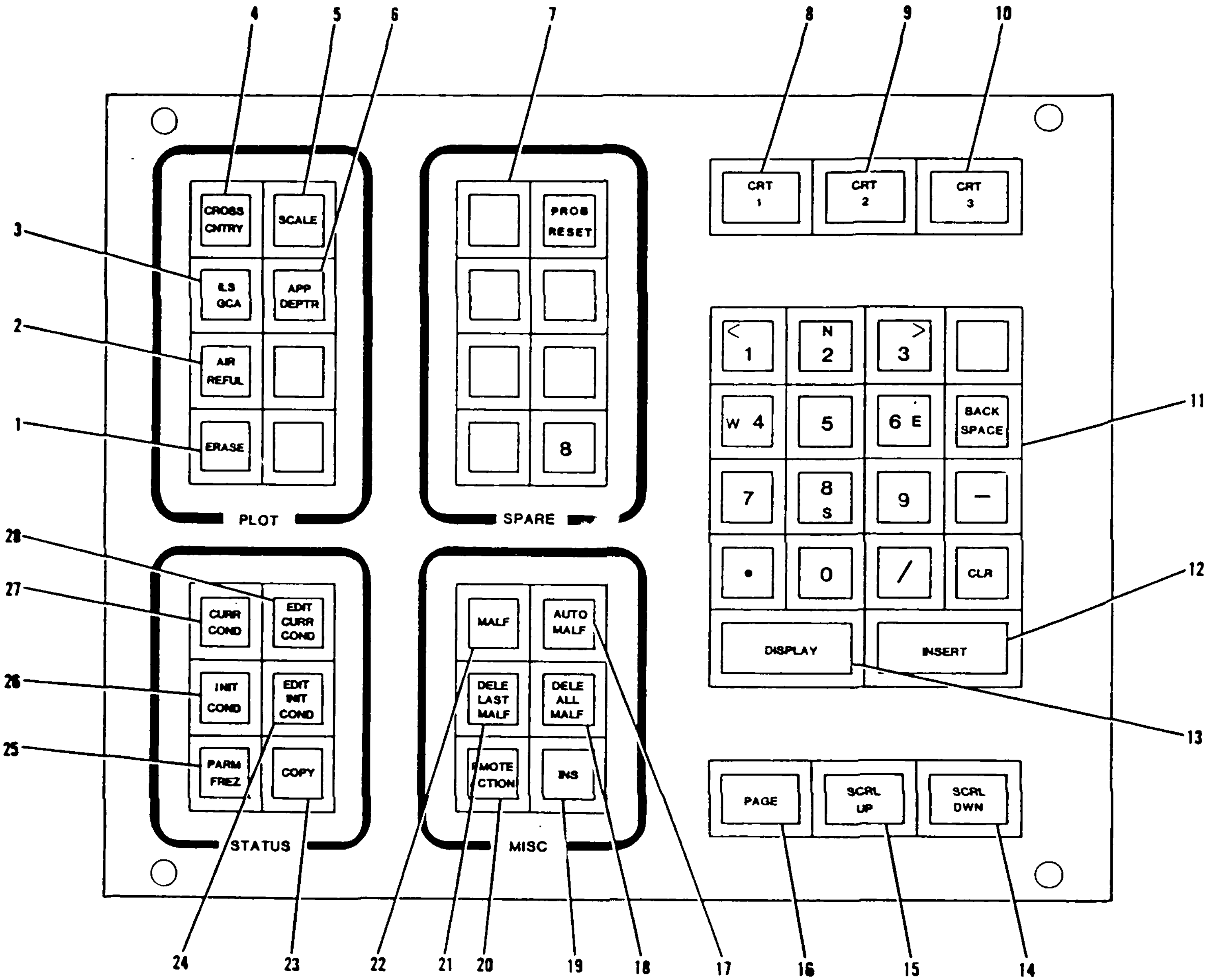


Figure E-5. Example of Functionally Organized Trainer Keyboard.

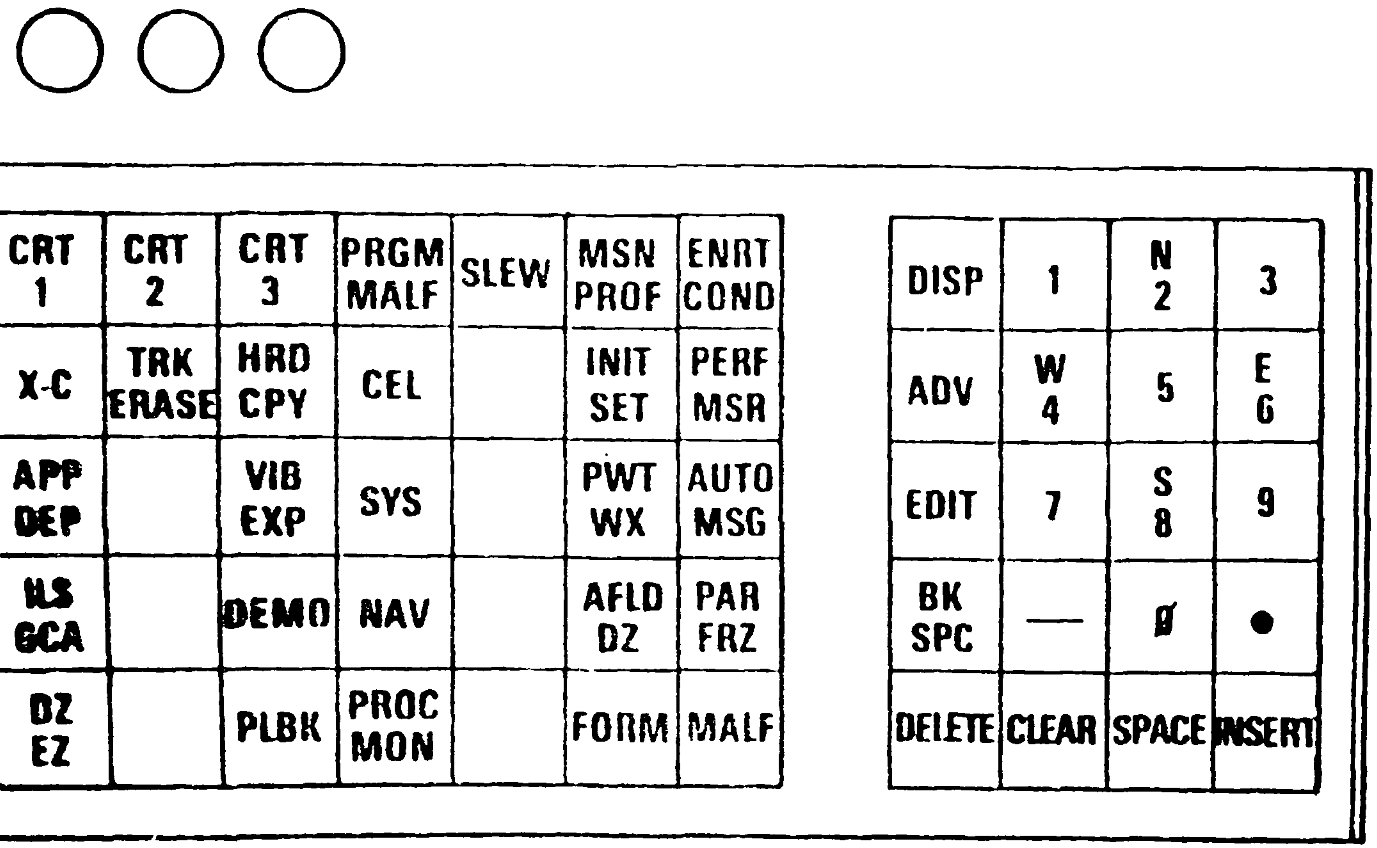
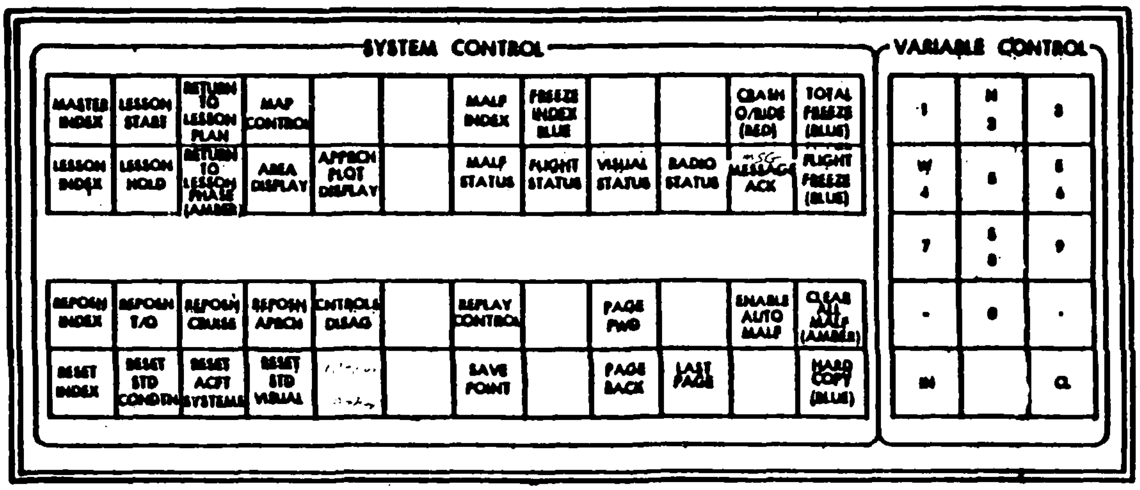


Figure E-6. Example of Functionally Organized Trainer Keyboard.



INSTRUCTOR KEYBOARD PANEL
Figure 11

Figure E-7. Example of Functionally Organized Trainer Keyboard.

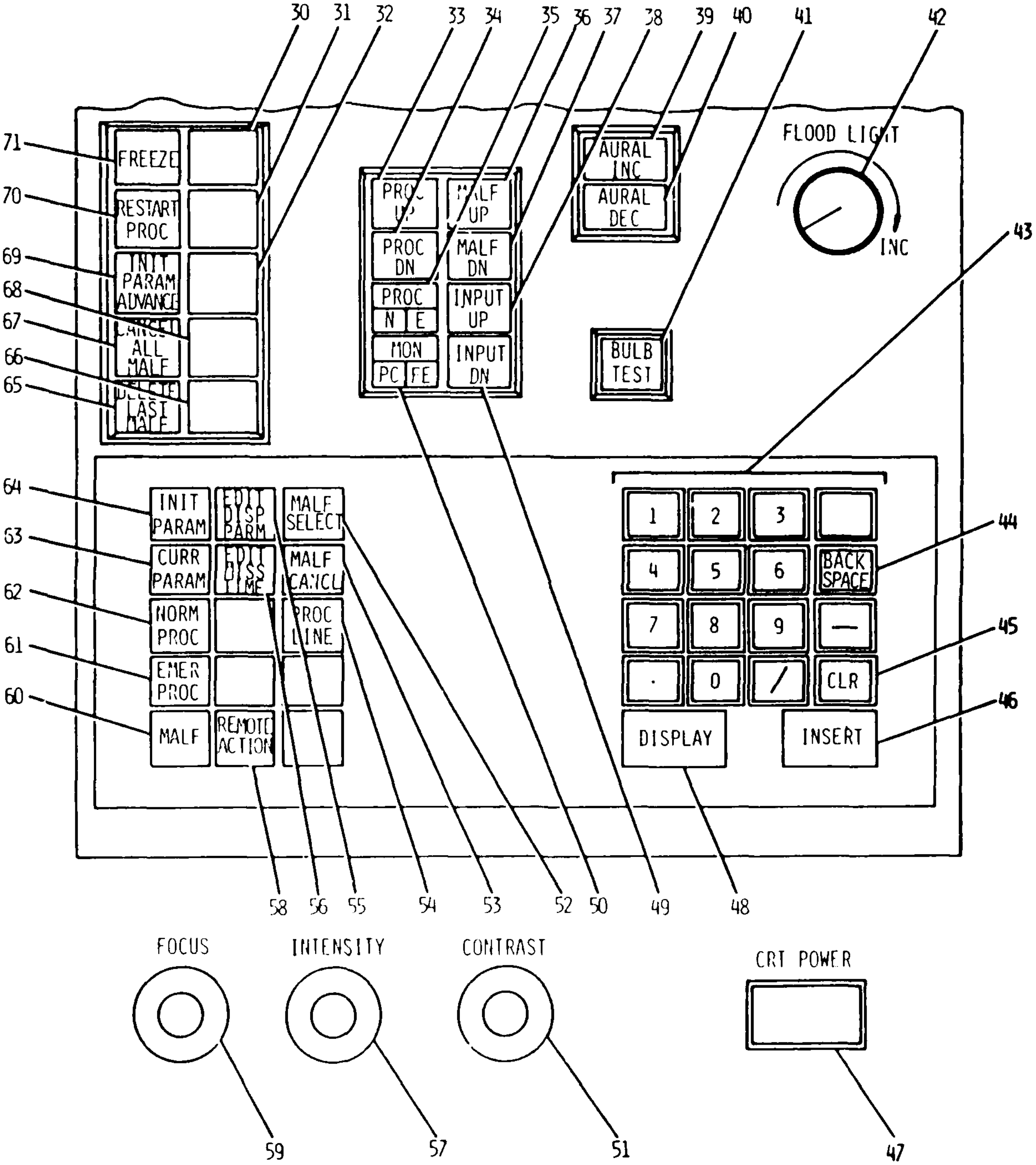


Figure E-8. Example of Functionally Organized Trainer Keyboard.

3. Many systems require preceding zeros to be entered for data, a time-consuming and unnecessary operation.

4. Although shortcut operations were typically implemented, in all cases they required that the instructor know the numbers to be entered to implement the desired function. This requires that the instructor either keep a record of frequently used codes or utilize a trainer operator's manual. Neither method is satisfactory.

5. To implement the shortcut operations to avoid using menu indexes, most trainers require that a "display" key be pressed after the function key has been depressed. Figure E-9 depicts the type of sequence that results. As can be seen, it is a time-consuming and cumbersome procedure, especially when the simulation is running, and presents many possibilities for error. The steps required to correct an entry error using erase and clear keys is not included. In no case could the shortcut method be used to edit the data or function to be entered. Timely entry of a malfunction, for example, is difficult. In addition, a display must be used for the operation.

6. In no case was a "help" routine implemented. Any operating problems required either contacting a technician or utilizing the operator's manual. None of the trainers surveyed provided storage for manuals used in training. None provided a useful operator's console guide. Only the voluminous operation manual (which was typically out of date) could have been used.

7. The function keys on some keyboards were not illuminated, which posed identification problems under dim lighting at on-board stations.

8. On some trainers, the keyboard provided no indication of which key had been pressed, thus requiring use of the display key to identify what function had been selected.

9. The instructor is required to know on what display page the data and control functions are located. Some pages are utilized for widely disparate data and functions.

10. In some cases, two different display pages were required to activate the condition and to view the condition.

11. Communications control mechanization varied widely. In general, none was considered "user-friendly" by the instructors. As a result, most of the capabilities of the system were not used. The instructors operated in the open or active microphone mode. While most communication panels provided an indication as to which radio was being used by the trainee, data on frequency or channel and "in-range" status were displayed only on a CRT, often requiring selection of a unique page. Output of control messages by the instructor over the correct channel/frequency was typically a time-consuming operation. Figure E-10 depicts sample communication control panels.

12. Hand-held units were commonly utilized for on-board over-the-shoulder training control. Figure E-11 depicts the unit typically used. Shift keys at the side of the unit are used to select one of the multiple functions on each key. The display consists of two lines. The bottom line is always used as the echo. Thus, only one line is available for data display.

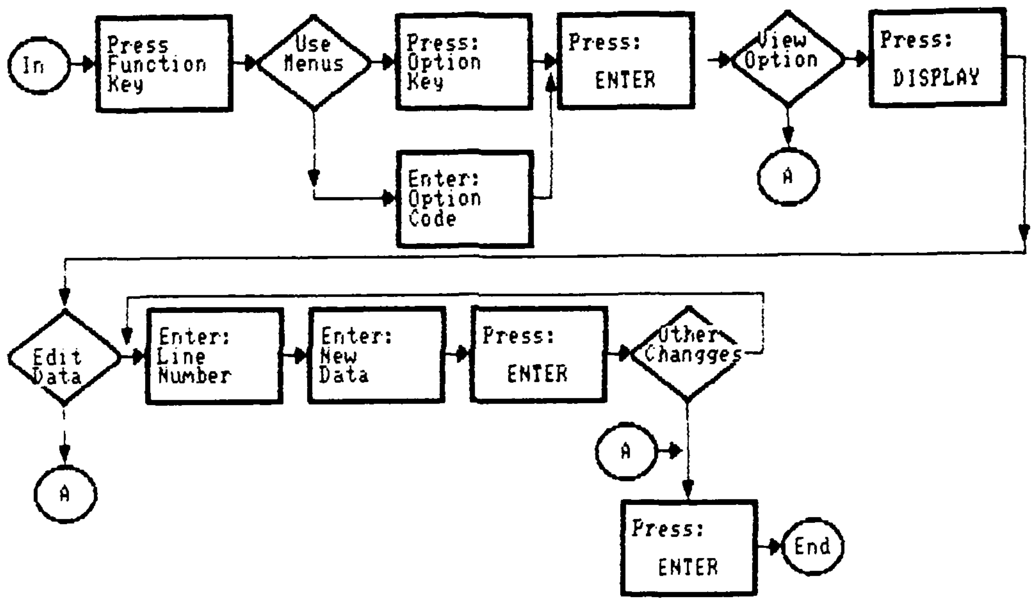


Figure E-9. Typical Menu Operation Procedure.

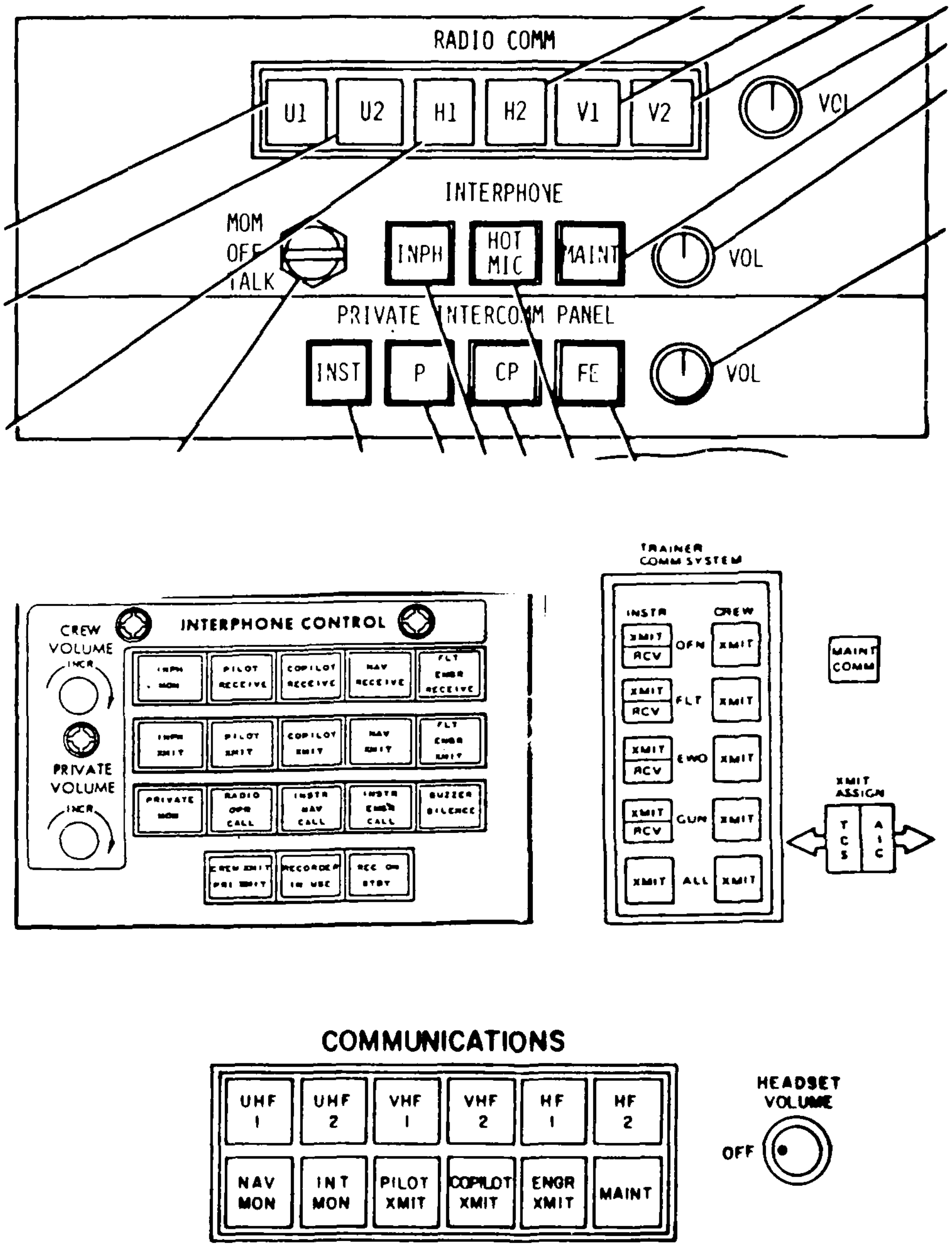


Figure E-10. Example of Poorly Designed Communication Panels.

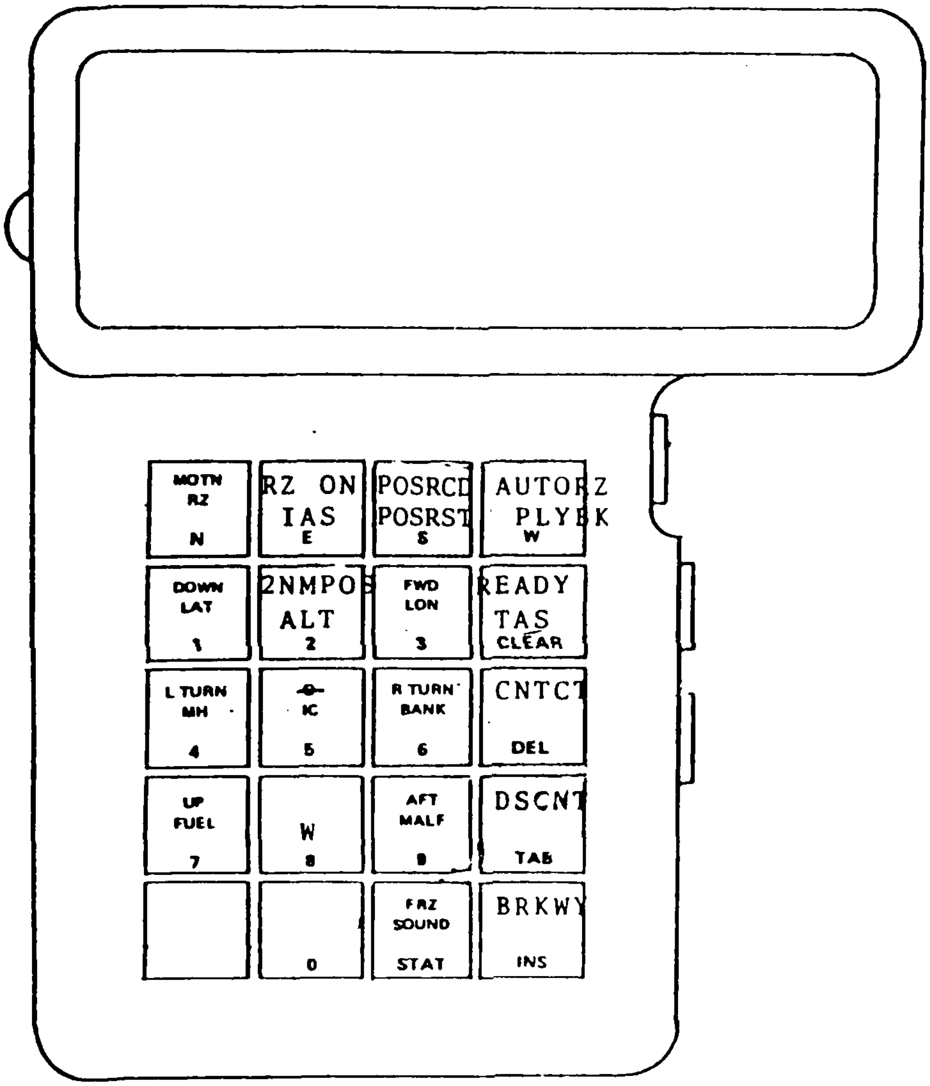


Figure E-11. Typical Hand-Held Control Unit.

In general, such units have proven inadequate for training control. Where used, instructors depended on another instructor at a console to provide the required training implementation and only used the hand-held unit for freezing the trainer and for malfunction insertion and removal. However, the latter use was limited to malfunction identification numbers that the instructor had preplanned or remembered.

13. Control Features. The implementation and usage of control feature is summarized as follows:

a. Crash override - All trainers provided a crash override feature. It was generally used in all exercises. Therefore, it appears the crash override should be the default condition, with crash simulation being the option.

b. Event manual stack - None of the trainers provided a true manual stack for planning upcoming changes. Several trainers provided the capability of entering up to five items such as malfunctions on a single line for simultaneous insertion (or deletion) when the "enter" key was depressed.

c. Flag set - None of the trainers provided the capability for the instructor to insert "flags" for later use in briefing or review.

d. Controller models - In general, no controller models were implemented, although several trainers provided GCA control messages on the display for instructor output. In general, most instructors preferred to generate their own commands.

e. Freeze - All of the trainers provided a freeze function. Use varied widely as a function of training course objectives and individual instructors. Freeze was rarely used in mission training but was frequently used in procedures training.

f. Instructor Help - None of the trainers provided an on-line "help" function. One trainer incorporated some operation instruction with some of the display pages.

g. Instructor ICS (Intercommunication System)- All of the trainers provided a separate instructor ICS system; however it was rarely used as designed. Communication between instructors at remote consoles was generally direct. The system was used by on-board over-the-shoulder instructors to communicate with remote console instructors. The ICS was rarely used for communication between the instructor and the students. Complex operation of radios and ICS typically resulted in use of overrides and open microphone modes.

h. Malfunction Insertion/Removal. All trainers provided for entering and deleting malfunctions and emergency conditions. Most of the trainers provided an option for automated malfunctions and sets of malfunctions. Automated malfunctions were rarely, if ever, used. The instructors, in general, consider the triggers inadequate and feel that the timing of malfunctions can be done only in real time by the instructor.

i. Programmed Mission. Most of the trainers surveyed provided multiple programmed missions. Where full mission training was conducted, the capability was used. However, few of the trainers surveyed were used for mission training. Many instructors felt the programmed missions were too rigid and did not provide the instructor the option to tailor the training to meet the trainee's needs. The programmed missions were, however, often used to initialize the trainer, after which it was used in the manual mode by the instructor. The missions provide a rapid and simple means of initializing the trainer. The difficulty of modifying or creating new missions further limited their use.

j. Speech Generation/Understanding. None of the trainers utilized this feature, which is just becoming available in acceptable quality.

14. Instructional Features. The implementation and utilization of instructional features may be summarized as follows:

a. Automatic Freeze. Automatic freeze capability to meet training performance objectives was not available on any of the trainers.

b. Automatic Syllabus. Automated syllabi were not incorporated on any of the trainers.

c. Briefing and Debriefing. None of the trainers supported trainee briefing or debriefing, other than providing hard copy.

d. Communications Record. Several trainers were equipped with the capability for recording trainer communications, generally in connection with simulation recording for demonstration development. The capability was not used.

e. Demonstration. Many of the trainers had the capability for developing and recording demonstrations. The capability was not used in training.

f. Environment Modification. All of the trainers provided the capability to modify the environment including the geophysical environment, as well as the tactical and warfare environment. The capability was used extensively, even where the implementation was cumbersome to use.

g. Hard Copy. Most of the trainers provided a hard-copy capability. However, in almost all cases, hard-copy output could not be accomplished until training was complete and the trainer put into an off-line mode. In addition, selection of hard copy typically resulted in the display being frozen for a short period of time. As a result, the capability was not well or often used. Most instructors agreed that on-line, close-at-hand copy would be useful, especially for debriefing.

h. Performance Measurement. Several of the trainers provided some performance measurement capability. In none of the trainers was it used for training.

i. Performance Recording. Most of the trainers provided a means for recording selected parameters, either in terms of selected sampling rates or time outside of a preset tolerance band. The capability was seldom, if ever, used.

j. Procedures Monitor. Most of the trainers provided the capability of monitoring procedures by displaying the procedure and the sequence in which actions were completed. The capability was rarely used at on-board stations, for several reasons including:

- The procedures were not correct and had not been updated. No capability for updating of procedures by instructors or operators was available.

- The instructors preferred to observe the trainees rather than use the monitor capability.

- The procedures monitor required the use of a CRT which was required for other functions.

Remote console instructors indicated the need for a monitor feature but again, generally found it unusable because the procedures were not correct and could not be readily (and had not been) updated.

k. Replay. Most of the trainers provided some capability for replay of the simulation. The most common implementation provided continuous recording of some limited period of operation, such as 7 to 10 minutes. Two implementation options were provided: (a) selection of "reset" initialized the trainer to the beginning of the recorded section; and (b) a portion of the recorded section could be identified, generally in terms of mission elapsed time, and saved separately. Use of the feature varied greatly as a function of type of training conducted and individual instructors. The feature was used frequently in part-task training such as approaches and landing, and procedures training. It was rarely used in mission training. The segment-saving procedures were generally complex and time-consuming.

l. Prompting/Cuing. Prompts and cues for trainees were not implemented on any of the trainers.

m. Adaptive Training. Adaptive algorithms were not implemented on any of the trainers.

Briefing/Debriefing Controls

None of the trainers supported trainee briefing or debriefing, unless it was done at the trainee station. The high utilization of the trainers in general precluded its use for this function.

Management Controls

None of the trainers surveyed supported any aspect of training management functions.

Development Controls

Most of the training devices surveyed provided two modes of training, a preprogrammed or mission mode and a manual mode. The preprogrammed mode provided for initialization of the trainer and a sequence of segments or legs to be conducted. Programmed malfunctions were generally available.

The manual mode generally provided a variety of initial conditions, with the option to edit any set. Other training conditions had to implemented manually. In general, a modified initial condition set could not be saved permanently.

None of the trainers surveyed provided a means for instructor or operator personnel to construct new missions or initial condition sets either on-line or off-line. As a result, most trainers did not utilize the mission mode as designed, since the programmed missions provided neither the scenarios desired nor the flexibility to meet the instructional needs. It should be noted that most of the trainers surveyed were being used to support initial qualification training.

Instructor Training

None of the trainers uniquely supported instructor training. Because of high utilization, most instructors observed some ongoing training, conducted some instructing under supervision, and were then qualified.

ANNEX

SAMPLE FLOW CHARTS

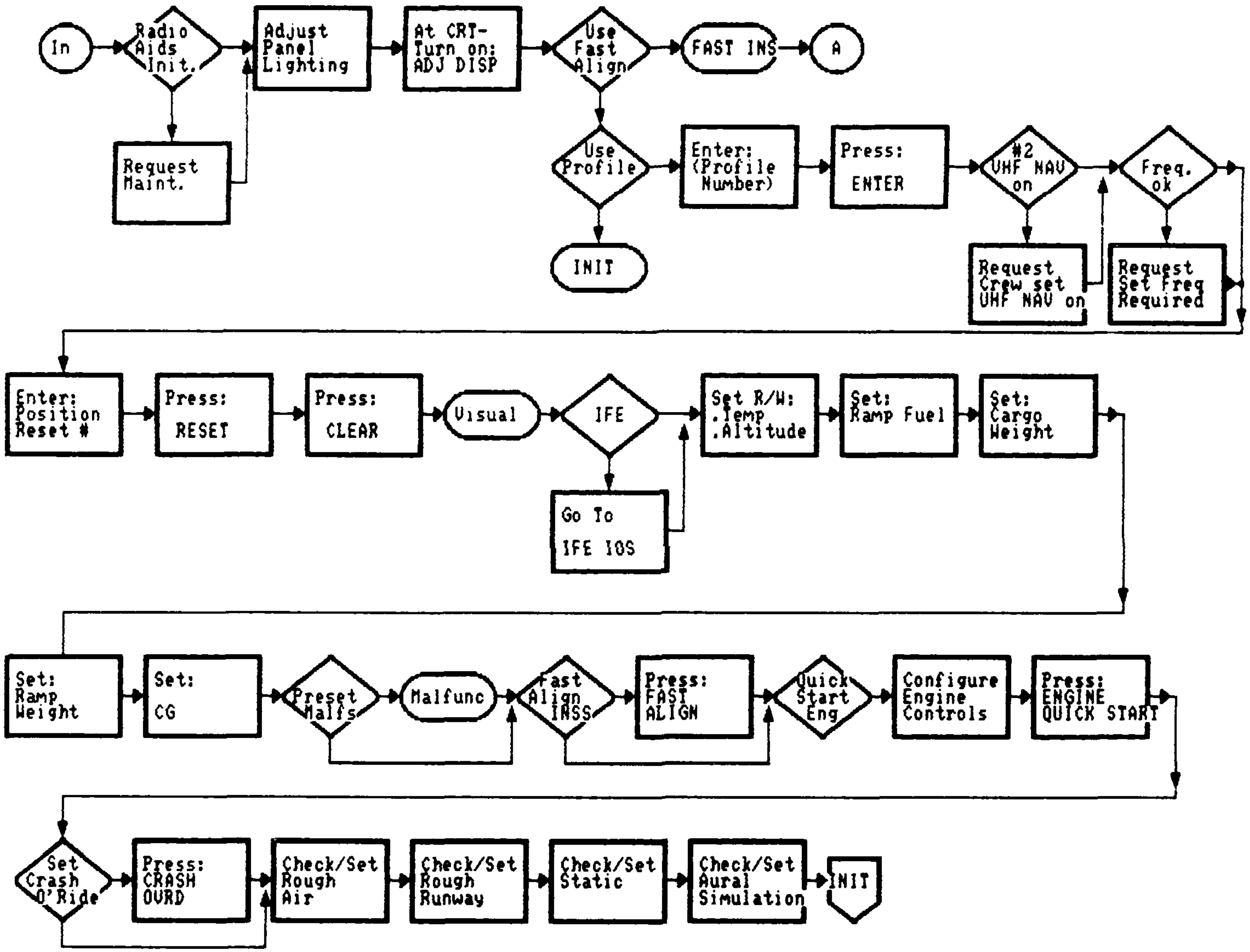


Figure E-12. Sample Initialize Function Flow.

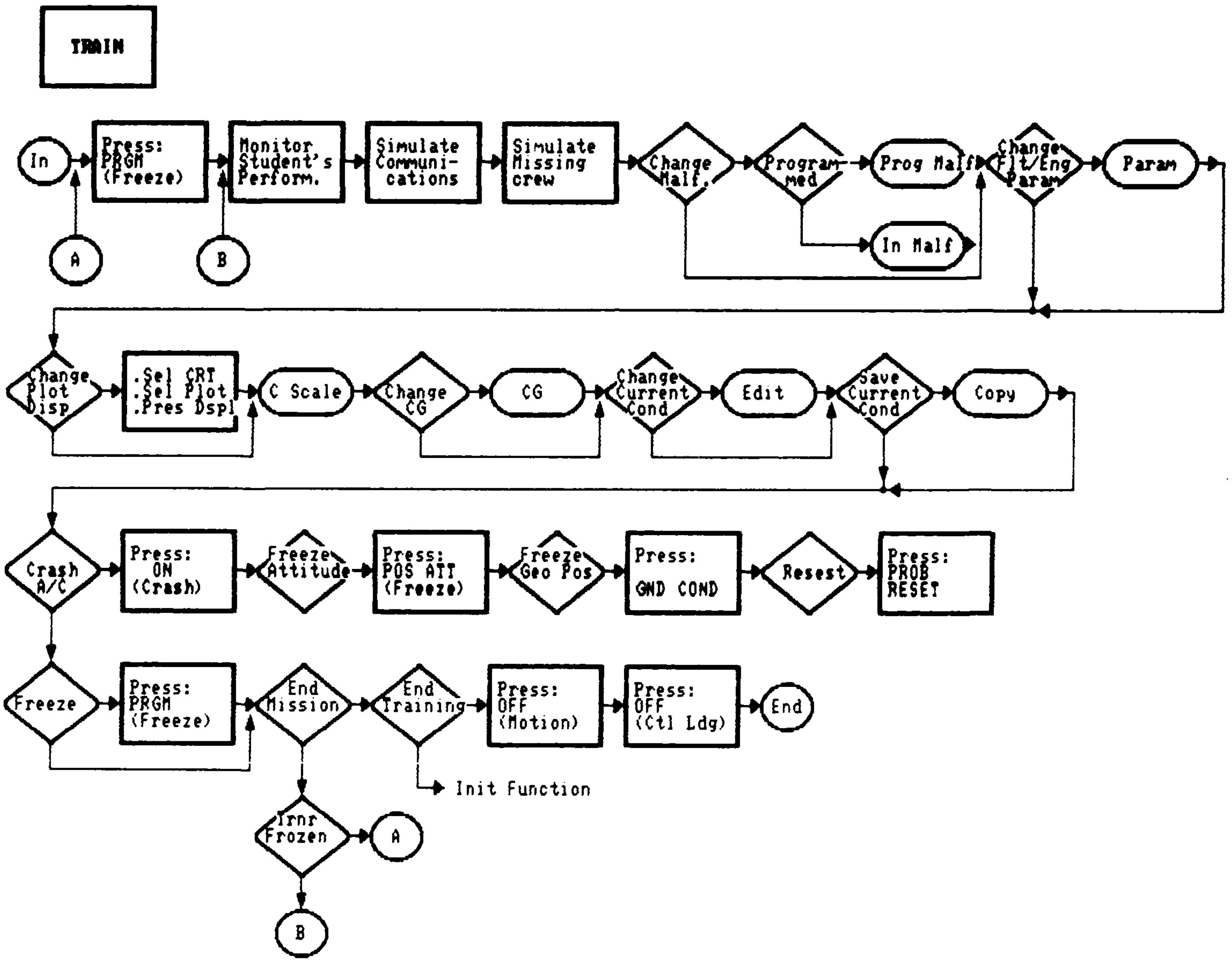


Figure E-13. Sample Train Function Flow (Page 1 of 2).

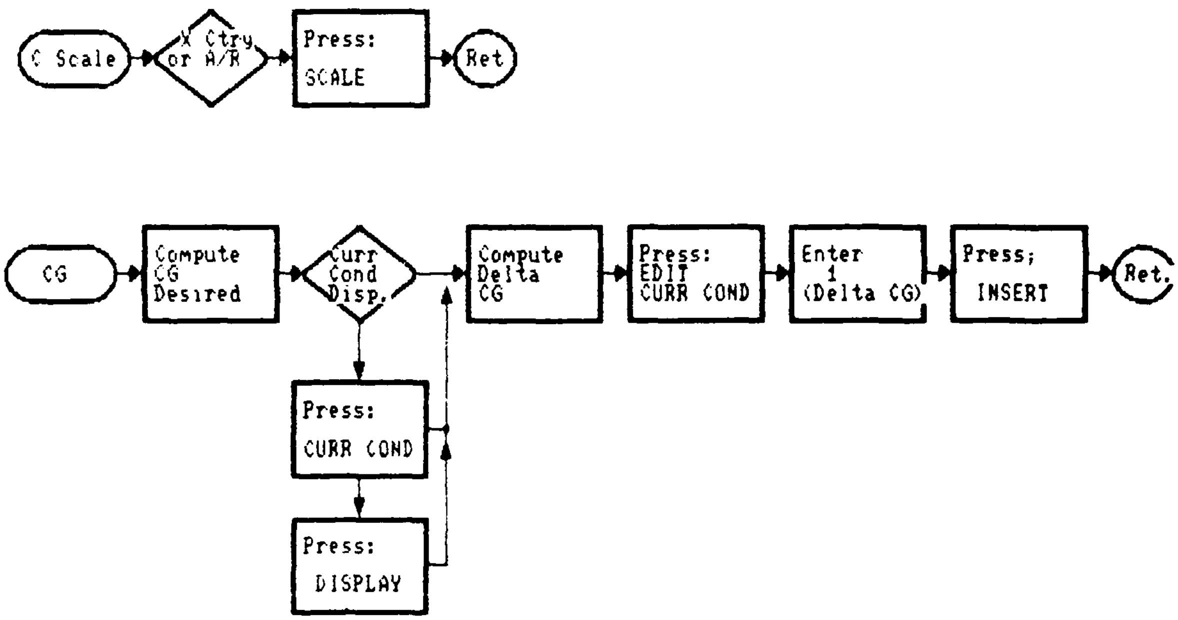


Figure E-13. Sample Train Function Flow (Page 2 of 2).

APPENDIX F: SAMPLE IOS SPECIFICATION

C-XX FLIGHT SYSTEM TRAINER

1.0 SCOPE

1.1 This specification covers the requirements for the design of the Instructor/Operator System (IOS) for the C-XX Medium Lift Transport Flight System Trainer (FST) and forms a part of the FST Detailed Specification ___________ dated __________.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of the invitation for bids for proposal form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-M-18012	Markings for Aircrew Station Displays, Design and Configuration of
MIL-T-23991	Training Devices, Military, General Specification for
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Specification for
MIL-C-29025	Communication Systems for Training Devices, General Specification for
MIL-C-29053	Training Requirements for Aviation Weapon Systems
MIL-S-38039	Systems, Illuminated, Warning, Caution, and Advisor, General Specification for
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-C-81774	Control Panel, Aircraft, General Requirements for
MIL-T-82335	Trainer, Fixed-Wing, Flight: General Specification for

STANDARDS

Federal

FED-STD 595	Colors

Military

MIL-STD 1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

MIL-STD 411 Aircrew Station Signals

MIL-STD 783 Legends for Use in Aircrew Stations and on Airborne Equipment

MIL-STD 203 Aircrew Station Controls and Displays for Fixed Wing Aircraft

MIL-STD 1333 Aircrew Station Geometry for Military Aircraft

MIL-STD 721 Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety

U. S. AIR FORCE PUBLICATIONS

AF Regulation 50-11 Management of Training Systems

AF Regulation 57-1 Statement of Operational Need (SON)

AF Regulation 60-12 Planning and Scheduling Aircrews and Equipment

AF Regulation 800-2 Acquisition Program Management

AF Regulation 51-series - Aircrew Training

OTHER PUBLICATIONS

Charles, J. P. (1987). Instructor/operator station (IOS) design guide. AFHRL-TR-87-32). Williams AFB, AZ: Operation Training Division, Air Force Human Resources Laboratory.

Diffrient, N., Tilley, A. R., & Bardagjy, J.C. (1974). Human scale 1/2/3. Cambridge, MA: MIT Press.

Diffrient, N., Tilley, A. R., & Harman, D. (1981). Human scale 4/5/6. Cambridge, MA MIT Press.

Diffrient, N., Tilley, A.R., & Harman, D. (1981). Human scale 7/8/9. Cambridge, MA: MIT Press.

Galitz, W. O. (1985). Handbook of screen format design (2nd ed.). Wellesley Hills, MA: QED Information Sciences.

Kinkade, R. G. & Anderson, J. Ed. (1984) Human Factors Guide for Nuclear Power Plants Control Room Development. Palo Alto, CA: Electric Power Plant Research Institute. 1984.

McCormick, E. J. (1976). Human factors engineering (4th ed.). New York: McGraw-Hill.

Morgan, C. T., Chapanis, A., Cook, J. S., III, & Lund, M. W. (1976). Human factors in engineering and design. New York: McGraw Hill.

3.0 REQUIREMENTS

3.1 System Definition

The Instructor/Operator System (IOS) comprises the user interfaces with the training simulator system hardware and software of the flight system trainer (FST). It consists of three specialized interfaces:

1. trainer operator interface,

2. training instuctor interface, and

3. training data management interface.

Each of the interfaces is implemented in terms of a user station which is provided with the required displays, controls, and work area.

3.1.1 Trainer Operator Station (TOS). The trainer operator station provides the displays and controls and work area required to operate the simulation and data base computer system(s), peripherals, and trainer utility systems.

3.1.2 Instructor Stations (IS). The instructor stations provide the controls, displays, and work station used by the training instructors to conduct aircrew training. Three types of ISs are required for the C-XX WST. These are:

1. Remote Instructor Stations (RISs) - the ISs which are located apart from and physically separate from the training cockpit mockup.

2. On-Board Instructor Stations (OISs) - the ISs which are located within the training cockpit mockup.

3. Briefing/Debriefing Instructor Stations (B/DISs) - the ISs which are located in the aircrew briefing/debriefing spaces and which permit use of stored and recorded data for aircrew briefing and debriefing of training missions/events.

3.1.3 Data Management Station (DMS). The data management station provides the displays, controls and work station required by the simulation training data manager to utilize the trainer computer system(s) in support of simulation training management.

3.1.4. Interface Definition. Three different user interfaces are required.

1. TOS Interface - interfaces the TOS with the trainer computer and utility systems. It includes the computer operating consoles and the control panels for the peripherals and utility systems.

2. IS Interface. The IS interface includes:

a. physical interface - the controls, displays, console/table, chair and other hardware installed at the instructor's normal position during training.

b. simulation interface - the functional interface with the simulation system which provides the instructor control over the simulation program including the motion and visual simulations, aircraft simulations, and environment simulations.

c. instructional interface - the functional interface with the training system which provides the instructor control over the instructional features of the training device from training event preparation and briefing through training and debriefing and training evaluation.

3. DMS Interface. The DMS interface consists of a data management terminal which accesses the training data base and associated application programs to perform the management functions. The interface must be functional whenever the computer system is operating and not interfere with ongoing training or training development operations.

3.1.5 Major Components. The IOS system will consist of the following components:

1. Trainer Operator Station

2. Instructor Pilot (IP) On-Board Station

3. Instructor Flight Engineer (IFE) On-Board Station

4. Instructor Pilot Remote Station

5. Instructor Flight Engineer Remote Station

6. Briefing/Debriefing Station

7. Data Management Station

Each station will consist of the controls, displays, and subsystems required to meet the requirements identified in this specification.

3.2 IOS Functions

Three different types of IOS functions are required in support of training:

1. trainer operating functions which include activating the trainer subsystems, loading the operating programs, conducting readiness tests, and configuring the system for training. Operating functions are implemented through the trainer control console.

2. instructing functions which implement the instructor interface for conducting training from briefing to debriefing and training mission/scenario development. Instructing functions are implemented through the IOSs.

3. management functions which provide for student tracking; trainer, student, and instructor scheduling; and training documentation, including reports and configuration control. Management functions are implemented through the trainer operating console or ancillary data terminal.

3.3 IOS Characteristics

The IOS shall be designed to meet the training courses manning, trainee input, and facility configuration requirements specified in the following paragraphs.

3.3.1 Training Courses. The trainer will be utilized for four different levels of training:

1. aircrew Initial Qualification Training (IQT). IQT provides basic system training leading to mission qualification.

2. aircrew Mission Qualification Training (MQT) and Continuation Training. MQT leads to squadron mission qualification. Continuation training is refresher training required to maintain Mission Qualification.

3. aircrew Upgrade Training. Upgrade training provides position upgrade (e.g., aircraft commander) training including instructor qualification training.

4. tactical mission training consists of special training in the squadron's mission and special functions and leads to Mission Capable qualification.

3.3.2 Manning. The trainer interface stations will be designed to meet the following trainer manning constraints:

1. Trainer Operator Station. The TOS will be manned by a maintenance technician who has completed the trainer maintenance course. The trainer operating console manning will consist of one technician during all training hours.

2. Instructor Stations. The IQT and MQT courses will utilize contract pilot and flight engineer instructors who have completed the instructor training course including certification by the squadron STAN/EVAL department. The contract instructors will be dedicated to instructing on the trainer. The tactical mission course will utilize USAF Instructor Pilots and Instructor Flight Engineers. The USAF instructor's training will be limited to a trainer familiarization course with no more than 4 hours of hands-on training. The instructors will be part-time trainer instructors and will also be performing as flight instructors.

3. Data Management Stations. The data management terminals will be manned by squadron Operations Department personnel with responsibilities for scheduling, records management, and training reporting. Training will be limited to a terminal familiarization course with 2 hours of hands-on experience.

3.3.3 Trainee Input. Trainee input to the courses will consist of the following:

1. IQT Course - graduates of the undergraduate pilot training program, pilots who have not previously flown transport aircraft, and flight engineers with no qualification in transport aircraft.

2. MQT Course and Continuation Training Courses - graduates of the IQT course and currently MQ pilots requiring refresher training.

3. Upgrade Courses - aircrew who have completed the C-XX IQT course and are mission qualified in the C-XX.

4. Tactical/Special Mission Course - aircrew who are mission qualified. Completion will result in designation as Mission Capable or a special qualification.

3.3.4 Training Strategy. Training strategy refers to the role of the instructor in implementing training at the ISs. The strategy varies as a function of the training course. The station design must be tailored to meet the requirements of the instructional strategy involved.

Three strategies or instructor training modes will be utilized in C-XX aircrew training courses.

1. Tutor Instructor Mode - Initial Qualification Training. IQT will be conducted in two phases: aircraft transition and basic transport mission training. Aircraft transition includes basic flight, unusual attitude, confidence maneuvers, and instrument flight training including airways navigation. Basic transport missions include point-to-point delivery, aerial drop, and low-altitude drop training. Validation of normal and emergency operating procedures performance is conducted in both phases. Aircraft transition training is position training. Transition training is conducted independently for pilots and flight engineers, with instructor pilots training student pilots and instructor flight engineers training student flight engineers. Basic transport mission training will be conducted with a complete flight deck crew utilizing both pilot and flight engineer instructors.

The IS for IQT is an on-board station which permits the instructor to tutor the student in the required tasks. The station will consist of two positions: one will be directly between the two pilots at a "jump seat" with a retractable work table; the other will be a console directly behind the pilot position and aligned fore and aft to permit partial viewing of the cockpit from the instructor's seated position. The jump seat station will incorporate sufficient trainer controls to implement IQT transition training missions. The console shall contain displays and controls to perform all instructor functions for the IQT course.

2. Interactive Instructor Mode - Upgrade Training. Upgrade training, including instructor training, will be conducted with only one instructor; i.e., an instructor pilot for pilot upgrade training and an instructor flight engineer for flight engineer upgrade training. The on-board station will be utilized for upgrade training.

3. Monitor instructor mode - Mission Qualification Training. MQT will be conducted as complete missions from cockpit pre-start inspection to after-landing checks and with a complete aircrew. Instructor interaction with the aircrew during training is minimal. The IS will be the RIS for both pilot and the flight engineer training.

3.3.5 Facility Configuration. The FST will be located in the trainer support building. The space consists of a high bay area for mockup location, adjacent first floor spaces for computer and utility systems, and second floor spaces for remote instructor stations, briefing/debriefing spaces, and data management terminals. Figure F-1 depicts the spaces involved.

The RIS spaces include a large window area for observing the mockup area. The RIS is arranged such that the instructor at the RIS can observe the cockpit mockup area to monitor area security and safety from a normal seated position.

A portion of the computer space will be set aside for a contract instructor office.

3.3.6 TOS Configuration. The trainer operator station is located in the computer room and consists of the computer operating console and the controls and displays required for control of the computer system peripherals and the trainer utility systems (e.g., pneumatics, hydraulics, and electrical). The TOS provides for the trainer operating functions.

3.3.7 IS Characteristics. The instructor stations implement the trainer instructing functions. The following general requirements shall be implemented.

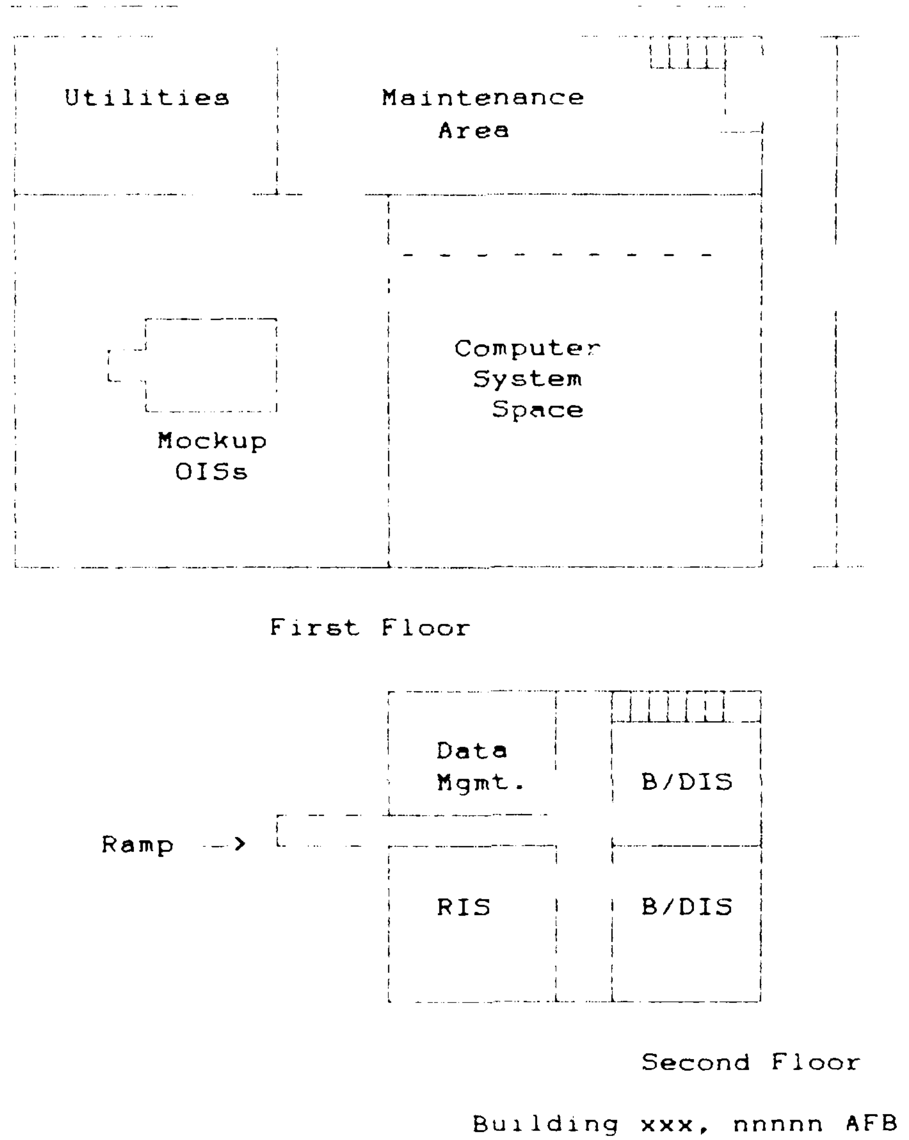
1. Displays must meet the information requirements identified in the instructor task analysis; the viewing requirements contained in MIL-STD-1472 Human Engineering Design Criteria for Military Systems, Equipment and Facilities; and the display and control requirements contained in the Instructor/Operator Station (IOS) Design Guide (AFHRL-TR-87-32).

2. Controls shall be arranged in accordance with the Control and Indicator Panel Design Guidelines contained in the Instructor/Operator Station Design Guide. Control selection shall meet the control requirements identified in the task analysis, including operating time and time-sharing constraints.

3. Color-coding of indicator lights and controls shall be in accordance with MIL-STD-1472 Human Engineering Design Criteria for Military Systems, Equipment and Facilities; MIL-STD-411 Aircrew Station Signals; and the Instructor/Operator Station (IOS) Design Guide (AFHRL-TR-87-32).

4. Station design shall meet the anthropometric requirements outlined in MIL-STD-1472 Human Engineering Design Criteria for Military Systems, Equipment and Facilities and the Instructor/Operator Station (IOS) Design Guide (AFHRL-TR-87-32).

3.3.7.1 Remote Instructor Station. The RIS consists of a console with positions for the instructor pilot (IP) and the instructor flight engineer (IFE), although the console shall be operable by the IP alone. The console will consist of all displays and controls required to conduct training in the monitor instructor mode or strategy. In addition, controls for area and console lighting and temperature shall be provided in accordance with MIL-STD-1472 Human Engineering Design Criteria for Military Systems. A printer for training data hard copy shall be adjacent to the console. An 18-inch work counter shall be provided. Storage space for the aircraft flight and system manuals, pilot and flight engineer checklists, trainer console operating guide, trainer lesson guides and grade sheets shall be provided within standing reach of the instructors. The IP and IFE positions shall be arranged so that each instructor can utilize all displays and controls required during a training mission from the



Key:

RIS Remote Instructor Station
B/DIS Briefing/Debriefing Instructor Station
OIS On-board Instuctor Station

Figure F-1. Trainer Facility.

normal seated position. Console legends and abbreviations shall be in accordance with the Abbreviations For Use at IOSs contained in the Instructor/Operator Station (IOS) Design Guide (AFHRL-TR-87-32).

3.3.7.1.1 Displays. Three types of displays are required: (a) plot displays, (b) status displays, and (c) system data displays. Plot displays cannot be time-shared with status or data displays. High-priority displays shall be located in the central viewing area of the instructor requiring the information.

3.3.7.1.2 Controls. Controls shall be functionally grouped in terms of trainer operation and training instruction. Trainer operation controls required only for initializing the trainer at the start of the training mission shall be placed in a low-priority console area.

3.3.7.2 On-Board Instructor Stations. On-board instructor stations will provide for two instructor locations, one behind or adjacent to the student (over-the-shoulder) and one at the on-board console for both the IP and IFE. The instructor chairs will be rail-mounted and movable between the two instructor locations. The chair will be designed to meet the maximum forces encountered from the motion platform and shall be lockable at the two positions and at two positions in between. The over-the-shoulder position shall optimize the instructor's view of the student's displays and control consoles. If required, the instructor chair shall incorporate elevation options. The over-the-shoulder position will be used for the tutor instructor mode of training; the console position, for the interactive mode of training. A means for isolating the instructor console displays shall be provided to prevent reflections and glare at the IS or at the aircrew positions, and to isolate instructor displays from the students.

3.3.7.2.1 Displays. The console displays shall include a separate plot display and a display which can be shared for status and data display. The over-the-shoulder position shall incorporate displays only of information which is not directly available by viewing the student position.

3.3.7.2.2 Controls. The console position shall include operating and instructing controls required to conduct training support. The over-the-shoulder position shall include only those operating controls essential for trainer operation while the exercise is running, instructional feature controls, and communication controls.

3.3.8 <u>Features</u>. The ISs shall provide both operating and instructing features to unburden the instructor and enhance the operation of the trainer and the quality of the instruction provided. Table F-1 outlines the operating features required at the IS. The features are described in Section 6.0.

Table F-2 outlines the instructional features required by the IS.

3.3.9 <u>Physical Characteristics</u>. The characteristics of the IOS shall meet the display and control requirements to implement the training courses and training strategy.

3.3.10 <u>Reliability</u>. IOS reliability shall meet the overall flight system trainer reliability requirements.

Table F-1. IS Operating Features

Feature	RIS	On-Board Console	On-Board Over Shoulder
Crash Override	x	x	x
Manual Stack	x	x	x
Flag Set	x	x	
Controller Models	x	x	
Freeze	x	x	x
Help	x	x	
Malfunctions	x	x	x
Programmed Missions	x	x	
Instructor Tutorial	x	x	

Table F-2. IS Instructing Features

Feature	RIS	On-Board Console	On-Board Over Shoulder
Brief/Debrief	x	x	
Communication Record	x		
Cued Communications	x	x	
Demonstrations			x
Environment Change	x	x	
Flyout		x	
Hard Copy	x	x	x
Initial Condition Sets	x	x	x
Performance Measurement	x	x	
Performance Record	x		
Procedures Monitor	x	x	x
Reset		x	x
Programmed Flight[1]	x	x	
Record/Replay	x	x	

[1] Programmed actions for missing crewmember.

3.3.11 Maintainability. IOS maintainability shall meet the FST maintainability requirements.

3.4 Design and Construction

Design of the IOS shall be in accordance with human engineering design criteria. Construction shall meet the requirements of MIL-T-23991.

4.0 QUALITY ASSURANCE

4.1 General

The IOS will meet the same quality assurance criteria outlined in the FST design specification. In addition, the IOS will be tested to training missions utilizing personnel trained in accordance with the operator, instructor, and data manager training programs.

4.2 Responsibility for Tests

The USAF will test the operability of each part of the IOS as part of the OT&E.

5.0 PREPARATION FOR DELIVERY

5.1 The provisions of the FST design specification apply.

6.0 NOTES

6.1 The following definitions for operating and instructing features apply:

6.1.1 BRIEF - provides support to the briefing of the aircrew regarding training mission objectives, criteria, mission characteristics, training approach, and safety considerations. The feature is interactive and allows the instructor to access the relevant data.

6.1.2 CONTROLLER MODELS - provides simulation of human controller functions. Instructors are typically relied on to provide most human controller inputs to the student aircrew, to the detriment of their basic instructing function. This feature provides for the simulation of the relevant characteristics of air traffic and other ground controllers, other crewmembers, and friendly aircraft. RECORDED COMMUNICATIONS and/or SPEECH GENERATION or CUED COMMUNICATIONS are needed to effectively implement the feature.

6.1.3 COMMUNICATIONS RECORD - provides for the recording of aircrew communications during training for replay either during debrief or by the student as another type of feedback. It is particularly useful in reviewing crew coordination, communications procedures and discipline, and audio-related threat data.

6.1.4 CRASH OVERRIDE (ORID) - prevents a "crash" from occurring; i.e., permits the simulation program to continue flight even though the crash envelope has been breached.

6.1.5 CUED COMMUNICATIONS (CUE) - provides for the output to the instructor of prompts for unique communications relevant to the training mission.

6.1.6 DEBRIEF - provides support to the instructor for the debriefing of the aircrew following the training session. It normally provides for accessing any of the instructor displays, as well as specially formatted debriefing displays and data. Graphics replay, communications replay, and flag reset features are generally incorporated.

6.1.7 DEMONSTRATION (RPLY/DEMO)- provides for replay of selected portions of a training event (or prerecorded demonstrations) for the aircrew in the cockpit station, with controls and displays repeating the conditions being replayed.

6.1.8 ENVIRONMENT MODIFICATION (MODS) - permits the instructors to modify the environment (e.g., threat, meteorological, and geographical conditions) while the simulation program is running. (Note: changes during the freeze state involve the use of RESET and/or a modified initial condition (IC).)

6.1.9 FLAG SET (FLAG) - provides the instructor a means of inserting a marker or flag in the simulation program which can be subsequently accessed to identify a reset condition, a debriefing point, etc. The feature should include a selectable initial increment of time to be added to the reset, since the flag is normally set when the condition exists rather than when it began.

6.1.10 FLYOUT (FLY) - provides for unfreezing the trainer from a reset condition other than an initial conditions set.

6.1.11 FREEZE/RUN (FRZE) - provides for the freeze and unfreeze of the simulation program (not parameter freeze).

6.1.12 HARDCOPY (COPY) - provides for the output of printed copy of a designated display or formatted data.

6.1.13 INITIALIZE (INIT) - provides for the selection of the simulation program initial conditions to either a pre-stored initial and sufficient condition set (with defaults) or to ICs associated and identified with an addressable training mission event.

6.1.14 INSTRUCTOR AIDS (HELP) - provides multilevel computer generated instructional assistance concerning simulation and trainer control options at the instructor/operator's request. The data are normally provided on an IS display and accessible while the system is operating in the training mode(s).

6.1.15 INSTRUCTOR ICS (ICS) - provides a selective communications system for the instructors. Because of the many alternative communication links possible with two instructors, three student aircrew positions, and the simulator/maintenance console, the system must provide some means of precluding interruptions of high-priority communications. At least three priority levels are probably involved. Low-priority communications should be "storable" for recall when time is available, without requiring the sender to repeat the data.

6.1.16 INSTRUCTOR TUTORIAL (OPTR)- provides a computer-based instructional program for training instructors in the operation of the trainer.

6.1.17 MALFUNCTION INSERT/REMOVAL (MALF) - provides for the selection and insertion of a system malfunction(s), either manually or under program control, and for the cancelling or removal of the malfunction(s) and effects. When automated, an alert should be provided to the instructor of the impending onset of a malfunction.

6.1.18 MANUAL STACK (STAK) - provides for creating a list of events to be initiated by the instructor. Many training environment and system characteristics are modified during flight; some of them preferably are under manual control because of the difficulty of defining and setting required "triggers." Yet, implementing a characteristic such as a malfunction or threat modification, for example, normally requires accessing relevant data pages and activating the characteristic from that page. Where display capacity is limited, this may involve losing the situation display on which the characteristic is based. The event manual stack is, in effect, a "scratch pad" which permits the instructor to assemble characteristics which he expects to implement in the near future and then to activate them by a single control action.

6.1.19 MISSION PROGRAMMING (PROG) - provides the capability of "assembling" and/or modifying programmed missions at the consoles by instructor personnel who are not trained in programming.

6.1.20 PERFORMANCE MEASUREMENT - provides for the collection and processing of aircrew performance data into a format usable by and meaningful to the instructor in evaluating aircrew performance. The feature reduces the multitude of data generated by the relevant variables for the training tasks.

6.1.21 PERFORMANCE RECORDING (PERR) - provides for the collection and storage of selected systems parameters such as missile launch parameters, bombing accuracy and navigation errors, and for output to the instructors, either in hard copy or on displays.

6.1.22 PROCEDURES MONITOR (PROC)- provides for the monitoring and display of systems normal and emergency procedures such as checklists, and the actions taken by the aircrew relative to the designated procedures.

6.1.23 PROGRAMMED FLIGHT (AFC) - provides for automatic flight to support non-flight aircrew training; e.g., support to the aircrew station(s) of the WST during independent modes of operation.

6.1.24 PROGRAMMED MISSION/EVENT - provides a highly preprogrammed training mission which frees the instructor to monitor aircrew performance. Interaction is limited and is program controlled to preclude the instructor from inducing environment changes which, for example, are incompatible with later events in the programmed mission scenario. The missions are normally developed to the detailed requirements of the specific training objectives involved.

6.1.25 RECORDED COMMUNICATIONS (RCOM) - provides for the output through the aircrew communications system (radio and ICS) of pre-recorded communications, under either program or manual control.

6.1.26 REPLAY (graphics) (RPLY)- provides for a replay of selected instructor console displays from either the start of the event or from a selected point in the recorded event. (This should not be confused with dynamic mission replay for the aircrew in the cockpit, as provided on many trainers.)

6.1.27 RESET (to IC/Mission) (RSET) - reinitialization of a "frozen" simulation program to the previously selected set or to a sufficient preprogrammed set of initial conditions, either stored individually or as part of a training event (sufficient refers to the required set, which may include default conditions).

6.1.28 SPEECH GENERATION (SPK) - provides voice outputs to the aircrew. Computer-driven speech synthesis can provide support to controller models, as well as output of routine communications to the aircrew regarding the evolution of the training event. Support to the instructor ICS feature is a possibility.

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