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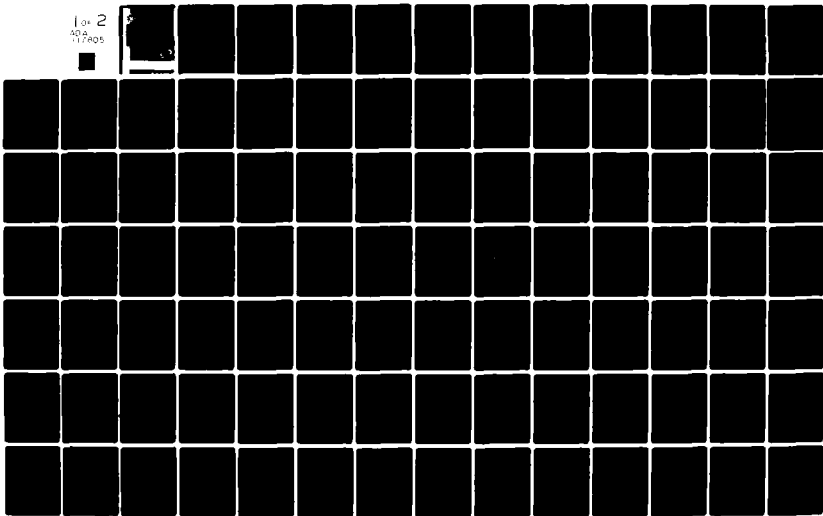
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ROWLAND & COMPANY, INC.
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use of CRT touch panels. Alternative 2 features a mixture of CRT touch panels and panel-mounted electronic touch pads. Advantages and disadvantages of each alternative are presented.

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SECTION I
INTRODUCTION

GENERAL

In the past decade the states-of-the-art in both training systems and simulator technology have advanced rapidly. Innovation in training systems has resulted from the use of the procedures and techniques inherent in Instructional Systems Development (ISD). Simulator hardware and software advances have been numerous and varied (e.g., computer and software capabilities, visual system technology, data entry methods and data manipulation techniques). These innovations and a variety of other factors (e.g., fuel costs, safety, etc.) have led to escalation in the use of training devices. Indications are that this trend will continue in the foreseeable future.

In many instances it appears that technology has been the driving force in training device design. Devices have been designed because the technology existed, not because an analysis based on training requirements determined the best candidate and its capabilities to meet the training requirement. The results have been that money has been spent for too little training effectiveness.

The Instructor/Operator Station (IOS) has been the recipient of much of the explosion of simulation technology. As technology has permitted higher fidelity simulation of more and more trainee tasks, it has also enabled expanded capabilities to control the simulation environment. These capabilities have been incorporated into the IOS. All too often selection and implementation of the capabilities have been based on insufficient analyses and data. As a result IOSs and the associated software have been poorly designed.

The purpose of this study was to collect data and information on IOS designs and operations, assess current and recent practice, and make recommendations for future IOS designs. It is recognized that the quality and efficiency of training are affected by the ability of the simulator instructor to control and monitor the training process. The goal of the study, therefore, was to develop generic IOS designs which would improve the instructor's ability to carry out his roles and responsibilities in the simulation environment.

It is emphasized that the alternative designs presented in this report are generic and embody specific design philosophies and features. Precise configurations and characteristics would be tailored to individual application. It should also be noted that this is not a detailed configuration report. Specific detail has been provided at selected points to facilitate understanding. Many other details would be required to complete the design process for a specific application.

BACKGROUND

The ever-increasing sophistication and complexity of weapon systems and the attendant rise in costs are parallel trends in the devices being procured to support weapon systems training. Compounding the situation is the explosion in simulation technology which has led to development of sophisticated training devices. Often the devices have resulted from the technology because it is available and not as a result of an analysis defining the specific training requirement.

In the development of a training device, the first step is an analysis of the training requirements which the device will satisfy. Over the years these analyses have been non-existent or when conducted have taken various forms with differing levels of accuracy and thoroughness. All too often the analyses have been a cursory assessment of the existing or projected training requirements. As a result the design and development of the devices have been left in the hands of engineering, computer, and software specialists. Their primary orientation and interest is the development of training hardware which operates in accordance with the approved specification. This does not, however, necessarily mean that the device satisfies the training requirements.

The emphasis on the engineering development of a training device has developed by default (i.e., the lack of an analysis of the training requirement). The lack of participation by human factors and training analysis personnel in providing the necessary input related to the training requirements, the instructor role, ease of operation, and in particular the design of the IOS, has been a major contributor to the situation.

As a result training devices have been delivered with IOSs which are complex and difficult to operate. For example, many IOSs have multiple data entry methods such as switches, light pens, numeric keyboards, alpha-numeric keyboards; multi-function switches; pages and pages of CRT information which must be called up before the specific item can be located, etc. Extensive formal training is required for the instructor/operator to become proficient. Daily use is required to remain familiar with the operation of the IOS. In the "real world" situation the instructor/operator may or may not have had formal training. More likely he has received an abbreviated on-the-job training program and does not use the device daily. Many instructors are, therefore, not qualified to administer training in the device. The result is that training quality, quantity, standardization, and efficiency suffer.

STATEMENT OF THE PROBLEM

The rapid advances in simulation technology, and the incorporation of this technology in devices without adequate analysis of the simulator training requirements, have resulted in IOSs which are complex and difficult for the Instructor/Operator to operate. As a consequence training in simulators varies widely in quality and effectiveness. In general it is safe to say that simulation training is less effective than it could and should be.

IOS design is not just the physical layout of a work place. It also encompasses consideration of instructional features, information management, software capabilities, and many other varied factors. To properly incorporate the many factors into an efficient training-effective design requires a systematic analysis process. It is apparent that many IOSs currently in use have not evolved through such an analysis and design process.

The purpose of this study is to conduct a systematic analysis of past and current IOS designs, assess their strengths and weaknesses, develop design principles to enhance the strengths and to eliminate the weaknesses, and implement the principles in alternative generic IOS designs. The orientation of the study is toward the identification of problems and the presentation of proposed solutions.

The primary product of this study is a set of recommendations for an instructor/operator station design which will consider the following:

- The role of the Instructor Pilot in simulator training.
- Capabilities of the IOS to meet specific training requirements.
- Simulator training to be based on a definitive syllabus.
- Reduction of Instructor Pilot workload during simulator training.
- Ease of IOS use by the Instructor.
- Minimizing the requirement for formal instructor/operator training in the operation of the IOS.
- Improvement in IOS Reliability and Maintainability.
- Reduction in procurement costs.

APPROACH

The approach taken in this study was to accomplish an ordered sequence of tasks. The sequence began with a literature review and proceeded through a set of steps terminating with alternative IOS design recommendations. The steps were as follows:

- Review available literature and studies pertaining to IOS design.
- Review representative operational flight trainer/weapon system trainer instructor handbooks.
- Survey on-site current-generation simulators and their IOSs.
- Analyze instructor/operator tasks relative to simulator training.
- Assess strengths and weaknesses of IOS designs and practices.
- Develop design(s) for a training-effective IOS.

The first task was to review and assimilate the data available on the subject. The review of a number of relevant studies^{2,3,4,5,6,7,8,9} was undertaken not only to preclude duplication of effort but to establish a data base and a point of departure. These studies, all containing information pertinent to IOS design, cover topics such as the instructor pilot's role in simulation training, the role of automated training in flight simulators, and development and design of IOS instructional support features. Assimilation of the data in these studies resulted in the following observations:

2. Caro, P. W., "Some Current Problems in Simulator Design, Testing and Use," HUMRRO-PP-2-77, Human Resources Research Organization, Alexandria, VA. March 1977.
3. Caro, P. W.; Pohlman, L. D.; and Isley, R. N., "Development of Simulator Instructional Feature Design Guides," (Seville Technical Report TR 79-12), Pensacola, Florida. October 1979.
4. Caro, P. W.; Shelnut, J. B.; and Spears, W. D., "Aircrew Training Devices: Utilization," AFHRL-TR-80-35, Wright-Patterson AFB, OH. January 1981.
5. Charles, J. P.; Willard G.; and Healy, G., "Instructor Pilot's Role in Simulation Training," NAVTRAEQUIPCEN Technical Report 75-C-0093-1. March 1976.
6. Charles, J. P., "Instructor Pilot's Role in Simulation Training (Phase II)," NAVTRAEQUIPCEN Technical Report 76-C-0034-1, August 1977.
7. Isley, R. N. and Miller, E. J., "The Role of Automated Training in Future Army Flight Simulators," (Final Report, Contract N61339-76-C-0050), Orlando, Florida: Project Manager for Training Devices, October 1976.
8. Semple, C. A.; Cotton, J. C.; and Sullivan, D. J., "Aircrew Training Devices: Instructional Support Features," AFHRL-TR-80-58, Wright-Patterson AFB, OH. January 1981.
9. Semple, C. A.; Vreuls, D.; Cotton, J. C.; Durfee, D. R.; Hooks, J. T.; and Butler, E. A., "Functional Design of an Automated Instructional Support System for Operational Flight Trainers," NAVTRAEQUIPCEN Technical Report 76-C-0096-1, January 1979.

- Current ISD procedures do not adequately address simulator training requirements.
- Analysis of simulator training requirements is not performed or is haphazard at best.
- A definitive simulator training syllabus is usually not available during the design and development of a simulator.
- Simulator technology tends to dictate the simulator operating configuration.
- Due to inadequate front-end analysis, engineering emphasis dominates the simulator development. Human Factors inputs are minimum.
- Instructor Pilots generally lack training in both simulator operation and instructional methods.
- The Instructor/Operator Station (IOS) is not designed for ease of instructor use and is not designed for instructional use.
- Many supposedly useful instructional support features are awkward to use and thus are not used. For example:
 - . Dynamic replay
 - . Performance measurement
 - . Print-out
 - . Timed or event-oriented malfunction activation
 - . Demonstrations

Next, a number of Instructor Handbooks for current flight simulators were reviewed and analyzed. The review included the modes of operation of the device, configuration of the instructor station panels, CRT displays and the amount and use of information displayed, the nomenclature used on the instructor station controls, and methods of data entry. Analysis of the data revealed the following:

- Modes of operation are not standard within equivalent capability devices.
- Nomenclature for controls are not standard and do not contain user oriented language.
- Information on CRT displays is often crowded and difficult to interpret.
- The amount of information available often requires the instructor to page through a number of displays to get to the desired information.

- Most of the sophisticated devices have up to four methods of data entry i.e., fixed function switches, light pens, numeric keyboards, and alphanumeric keyboards.

With the literature review as a base, an on-site survey of representative aviation devices at NAS Oceana was conducted. Device 2F95, F-14 OFT, Device 2F112, F-14 WST, Device 2F114, A-6E WST and Device 2E6, Air Combat Maneuvering Simulators were observed in operation. Discussions were held with training and maintenance personnel relative to the features of the IOS. The results of the survey provided the following observations:

- Device 2F95 has a definitive syllabus and is operated by the IP with very little assistance by the TD. This was the best example of training-effective implementation.
- The remainder of the observed devices have no definitive syllabus. IPs depend on the TD for operation of the device.
- CRT displays appear cluttered and difficult to read.
- Multi-data entries are required, with the light pen as the primary means of data entry.
- Utilization rates are low and erratic.
- Availability of spare parts is a problem.

The remaining steps in the study (i.e., analyze instructor/operator tasks, assess strengths and weaknesses, and develop designs) involved taking all data collected from the literature, handbooks, and surveys and using it to develop design approaches and concepts. The following two sections contain discussions of this process and its results.

SECTION II

DESIGN APPROACH

OVERVIEW

As a result of the data collection efforts weaknesses in flight simulator IOS design and operation and other related areas were identified. Each weakness was not necessarily found in each device or training situation. Collectively, however, the weaknesses characterize flight simulators in general. The weaknesses listed below are a compilation of those identified at the different steps in the study. They were presented in the previous section at different points and are presented collectively here. They are as follows:

- Layout, labelling, coding, etc. do not optimize device operation and minimize instructor workload.
- Steps required to access many CRT displays are time consuming and inefficient.
- Delays in display access cause inefficiencies in training problem control and monitoring.
- Data entry methods are confusing, redundant, and inefficient.
- Many features and capabilities are not needed, not used, or difficult to use.
- Instructor training does not adequately prepare instructors for their roles and responsibilities in using simulators.
- Instructor roles and responsibilities are not completely defined and implemented.
- Student training syllabi are poorly developed and used. Standardization, organization, efficiency, and quality of instruction are, therefore, impaired.
- Simulator capabilities are not keyed to the training requirements (i.e., objectives) of the training system in which it will be used. The simulators are, therefore, not properly integrated into the training system as an efficient element which fills a clearly-defined need.
- Instructor handbooks are not properly organized and formatted to provide instructor assistance in operating the device in a training situation. They are massive informational volumes, not training tools.

When taken together across the devices which were surveyed, the clear impression is conveyed that the total concept of design for the instructor

is very "loose" (i.e., the systematic principles of man-machine interface, human factors, and training technology have not been properly applied). The net result is that planning and design for operation of the device are secondary components of the total simulator development process. Actual operation of the device and training using the device, therefore, suffer.

Curricula for training fleet pilots generally range from 10 to 20 hours or 10 to 20, 1.5 hour training session in an OFT/WST; yet each modern simulator has the inherent capability to simulate several hundred malfunctions and be called up at the IOS. It is apparent that due to the limited time only a small portion of the malfunctions will ever be utilized. It is further apparent that the Instructor Pilot task is complicated not only by the mechanism of trying to call up and select a single malfunction, but his attention to the training problem and instructional role is distracted. Each modern OFT/WST usually has a minimum of 500 simulated ground communications facilities able to be called at the IOS. To meet the training requirement only a small representative number of ground facilities are used during any training session. Again a complex mechanism is required to ultimately select the desired ground facilities for the specific training exercise. Instructor pilot workload and distraction are increased. These examples typify the use of available simulator technology without necessarily responding to a training requirement.

In many cases it was evident that a number of the features and capabilities were included, not because they were clearly required to accomplish the desired level of training, but because no one really knew whether or not they should be there; so they were put in. This tendency toward overkill has resulted from two primary causes: (1) failure to perform the proper training analysis efforts leading up to device design and (2) the explosion in potential device capabilities resulting from technological advances in the state-of-the art. The former can be characterized as follows: "We're not completely sure what we need to teach in the device or how we should teach it, so we'll stick these characteristics in just to be sure." The latter could go something like this: "We do not know just how we'll use these instructional features, but we'll put them in anyway. They're neat." The overkill increases the requirements for software and/or hardware and escalates cost.

The easy way is to allow simulator technology to dictate and include everything that it permits and hope every contingency is included. The rationale sometimes expressed "we may need it someday" or "its nice to have" or "it doesn't cost anymore". This approach is the development of a substitute aircraft and not a training vehicle, with the result that due to the complexity of the IOS, the instructor pilot has neither the skill, the time nor the inclination to utilize the capabilities of the simulator. Thus the training capabilities of the simulator are degraded.

While the capabilities and features may be very desirable on paper, they tremendously complicate device operations and increase costs. Complications result from the amount of information which must be handled, the variety of data presented to the instructor, the complexity of simulator control, the amount of training required for instruction, and human limitations.

The process of designing an aircraft cockpit is very precise, systematic, and thorough. It is essential that all the elements of human factors, information processing, and technology be integrated to design the best possible environment for the pilot to carry out his mission. Likewise the IOS should receive the same type of attention. Complex systems require complex training. Only through effective IOS design and selection of instructional capabilities and features can the required complex training be effectively and efficiently administered.

ASSUMPTIONS

Based on the collective experience of the investigators on the project and conclusions drawn from the data, a set of assumptions was developed. The purpose of the assumptions was to establish the boundaries and conditions in which future simulators will be procured. The assumptions were guidelines which provided input to the development of IOS design recommendations. They are as follows:

- A specific simulator training syllabus will be developed as part of the overall planning, design, and fabrication of the device. The syllabus will result from a systematic front end analysis in which the simulator is treated as a component of an integrated training system. It will be approved by the user and will form the basis for implementation of training on the completed device. Admittedly this assumption does not always embody the way things are usually done. Rather it embodies the way simulator acquisitions should work and is a direction in which acquisition policies and procedures are moving. A well-designed syllabus is an important prerequisite to good simulator design.

- Training system and human engineering personnel will participate in the design of the IOS. It is further assumed that these personnel will have the skills required to develop and validate the training tasks and syllabus and to convert the validated data into an efficient IOS station. The emphasis is that the IOS will be keyed to the training requirements and situation, not to technology, excess capabilities, and designer whims.

- IPs will continue as simulator training instructors for the foreseeable future. This assumption has both positive and negative aspects. Positively, it means that tactically and with respect to flight skills, the instructors will be highly qualified. They will possess the ability to closely identify with student problems. Negatively, they may not be highly motivated and trained to perform the roles and responsibilities of simulator instructors. IOS design must, therefore, encompass instructor aid features which minimize instructor shortcomings and which maximize their strengths.

- Training of IPs will not improve in the future. As noted previously, most instructor training is insufficient to properly prepare them for their role in administering, monitoring, and evaluating training exercises. IOS hardware and software must, therefore, be easily interpreted and used, and must provide instructor support to offset the effect of insufficient training.

- Simulator technology will continue to advance in rapid strides. It will, therefore, be increasingly important for analysts and designers to stay abreast of technological developments and to closely evaluate their applications to individual simulator acquisitions.

- Simulators will be used as training vehicles and not as substitutes for the aircraft. They will, therefore, contain only those attributes which contribute to training. The attributes will be determined through a systematic analysis of the training requirements and the training system.

DESIGN PRINCIPLES

The flight simulator design and operation weaknesses, and the assumptions formed the basis for the IOS design principles. These two types of information were pulled together to develop the principles. The design principles serve two primary purposes: (1) to provide a summary of what should be done to correct the weaknesses discussed previously and to implement the assumptions and (2) to provide a set of guidelines which will direct the development of IOS design recommendations. The design principles are as follows:

- Reduce the instructor/operator requirements for formal training by providing an instructor/operator instructional aid system at or near the IOS. This feature will not only provide training in the operation of the device but will actively assist the IP throughout the training exercise.
- Emphasize the use of automated training as the normal mode of training.
- Reduce the instructor/operator workload by automating the ancillary tasks.
- Reduce the number and type of data entry methods at the IOS.
- Use "touch" panels on CRTs and electronic "touch pads" on the IOS console as the primary data entry methods.
- Design IOS layouts to enhance operation, interpretation, sequences of actions, etc.
- Eliminate the use of multi-function controls/switches.
- Standardize the nomenclature used on controls to reflect IP terminology.
- Investigate the use of color on CRT displays to highlight important points.
- Upgrade student and instructor training and operating materials.
- Improve Reliability and Maintainability by use of touch controls, eliminating light pens, alphanumeric keyboards, etc.

- Reducing cost by limiting IOS capabilities to defined training requirements.

Each of the IOS design principles is discussed in the following paragraphs.

INSTRUCTIONAL AID SYSTEM. To implement the principle to reduce the need for formal training of IPs, it is proposed that a computer aided instructional (CAI) system be incorporated as an integral part of the IOS. This Instructional Aid System (IAS) will have the capability of presenting instructional programs to the IP for operation of the device; provide the necessary instructions to the IP in the set-up, operation, and conduct of instructional exercises for a selected mode of operation; and cue the IP as necessary during a training exercise.

As a pure instructional tool it will be programmed to present instruction on basic operations of the device to include topics such as, control locations and operations, display formats and interpretation, exercise control, and use of related training material (e.g., instructor guides and checklists.) During set up and conduct of exercises it will aid the instructors via prompts which guide them through the required operational steps. For example, set-up on most devices requires the instructor to make a sequence of decisions which establish the characteristics of the exercise. The IAS would step instructors through this process, thus reducing instructor training requirements and reducing error rates. During exercises the IAS would provide cues and instructions to enhance instructor performance, decision making etc., as he monitors, controls, and evaluates.

AUTOMATED OPERATIONS. The most sophisticated simulator, which will be efficient to use in achieving the training objectives and which will simplify the instructor workload, allowing him to concentrate on instruction versus operation, is the trainer which incorporates automated (programmed) training exercises. The apprehension that automating training will be highly structured and thus rigid can be eliminated by astute planning in the development of a simulator training syllabus and the specific training exercises. By using the analytical approach, the planning will consider all the variables and contingencies required for achieving the training objectives and, therefore providing all the required flexibility in simulator training.

Use of an automated simulator instructional system, by its very nature, will promote standardization. The training exercises are the same for each trainee. The information presented to the trainee is consistent and in the correct format and the performance measurement parameters and scoring procedures are the same for each trainee. Evaluation of the trainee performance is more objective and, therefore, more valid. Due to simplicity of the design of the IOS, Instructor Pilot activity at the IOS is greatly reduced, allowing him to concentrate on his instructional role.

The use of automated instruction will require a reorientation in the concept of simulator training. This requires the recognition that the simulator is a training vehicle and not a poor substitute for the airplane. As a training vehicle it should be responsive only to the determined training requirements as defined by specified training syllabus.

The use of automated training exercises, specifically designed to provide training in achieving designated training objectives, will eliminate excessive trainer set-up time required in a "free flight" mode. In the "free flight" mode of operations in many devices, the instructor must determine, select and insert every parameter such as, initial conditions, aircraft location, fly-to points, ground communications facilities, geographic displays, environmental factors, and others. A manual set-up time of 15-30 minutes is not unusual; this situation not only is non-productive time for the trainee but deprives him of scheduled training.

It is recommended that automation go one step further. There would be no "free flight" mode as currently defined. Free flight would be a cross between current free flight and automation (i.e., certain operations would be automated, and instructor prompting would be provided). For example, the instructor could not enter initial conditions on-line. Rather, he would always select from the programmed set of initial conditions. To accommodate this feature the set of initial conditions would be large and would be systematically derived from an analysis of the training requirements.

Selection of initial conditions to begin an exercise would automatically branch the IOS to pre-determined displays and instructions for instructor actions. This basic philosophy of pre-selecting those displays and actions which can be predicted ahead of time, based on the syllabus and type of training to be conducted, would be carried throughout the free flight mode.

IOS LAYOUT. At first sight the IOS for a sophisticated aircrew simulator may be overwhelming in its size and complexity. The numbers of switches, displays, keyboards, and other assorted input/output features may be ominous to the potential simulator instructor. Even after the instructor has become familiar with operation of the device, there may still be a feeling of being overwhelmed.

The IAS and emphasis on automation are features which will reduce the complexity of the IOS. Even with these features, however, there will still be requirements for enough controls and displays to present a confusing operating situation. In order to reduce confusion and increase the efficiency of operation, the IOS design must be developed through a systematic human factors analysis. The analysis is not just to meet the requirements of MIL-STD 1472A (Human Engineering Design Criteria for Military Systems, Equipment, Facilities). It is intended to yield the most efficient training/operating environment possible for the instructors. Principles such as placement based on frequency, criticality, and sequence of use, must be used.

Characteristics of the CRT displays must be closely considered. Many of the displays used in the devices, which were surveyed were cluttered and difficult to interpret. One salient point raised by simulator instructors was the possibility of using color to highlight selected portions of displays.

DATA ENTRY. Data entry in many OFTs and WSTs is needlessly complicated. For example, in some devices combinations of light pens, fixed function keys, and variable function keys are required interchangeably throughout an exercise. This mixing of modes increases the time required to gain proficiency and the probability of error and confusion.

To remedy this weakness it is recommended that data entry modes be limited to a set of fixed function electronic touch pads on the IOS console and touch panels on the IOS CRTs. The touch pads available on each CRT display would be a function of the training situation as reflected on the CRT and would vary from display to display. Basically the fixed function keys would provide simulator control. The CRT touch pads would provide training exercise control.

STANDARDIZED NOMENCLATURE. Operating inefficiencies may be caused by unclear, confusing, ambiguous, or unfamiliar terminology. To help remedy the problem, it is recommended that standardized terms be adopted and used. Since IPs are the primary operators of the simulators, the terms used should be in "pilotesque". Abbreviations should be avoided when feasible. Coding should be minimized and when used should be used in a clearly interpretable, easily remembered scheme.

SUPPORTING MATERIALS. Although the student and instructor materials are not directly involved in IOS design, they do play an indirect role in that they will be used in conjunction with the IOS to carry out training exercises. They should, therefore, be designed to prepare the students and instructors to carry out their roles during training exercises.

The IAS is intended to take over some of the functions served by the instructor training and operating materials. Adjunct written materials, however, will still be required. These materials include the instructor handbook, exercise guides, and checklists. As noted previously, the quality of these materials for existing simulators is generally inadequate. Their shortcomings contribute to simulator utilization problems. For emerging systems they must be upgraded.

RELIABILITY AND MAINTAINABILITY. Reliability and maintainability will be enhanced by the application of the design principles, stated above, to the IOS which in turn will be reflected in the total simulator. The elimination and/or reduction of switches and replacement with touch controls; elimination of complex keyboards; and light pens will make the IOS more reliable and require less maintenance.

COST. Reduction in cost for the IOS/simulator is a primary goal in the application of the design principles. Eliminating the overkill capabilities inherent in current simulators will result in lower procurement, operating, and maintenance costs.

SUMMARY

The survey results, assumptions, and design principles presented in this section of the report provided an overview of current practice and experience and laid the foundation for specific application. The principles are appropriate for many types of simulators, both aircrew trainers and others and may, therefore, be useful in many applications. The next section presents an application for one type of simulator.

SECTION III

INSTRUCTOR/OPERATOR STATION CONCEPT

DESIGN PROCESS

The design process for an IOS should follow essentially the same procedures as those used in the design of the trainee station, or, for that matter, those which are used in the design of most components of a training system. That is, characteristics of the station, system, etc. are derived from the training requirements as specified in a listing of the operational and training-specific tasks. Task training requirements in conjunction with other considerations, such as technology, guidelines/principles, and external constraints, form the basis for design. A basic model for IOS design is shown in Figure 1.

The application chosen for this study was an OFT with visual and motion system. This generic OFT has the capability of providing training in the following:

- Normal procedures
- Emergency procedures
- Engine start
- Taxi
- Take-off: shore-based and shipboard catapult
- Visual navigation
- Instrument flight
- UHF homing
- Night visual approaches: shore-based and shipboard
- Ground-controlled and carrier-controlled approaches
- Landings: shore-based and shipboard
- Bolter and wave-off
- Engine shutdown

Devices with similar capabilities are the F-14 OFT (2F95), which has been in use for a number of years, and the F-18 OFT which is currently being fabricated. Considering only pilot functions other related devices are the F-14 WST (2F112), the A-6 WST (2F114), and the EA-6B WST (2F119).

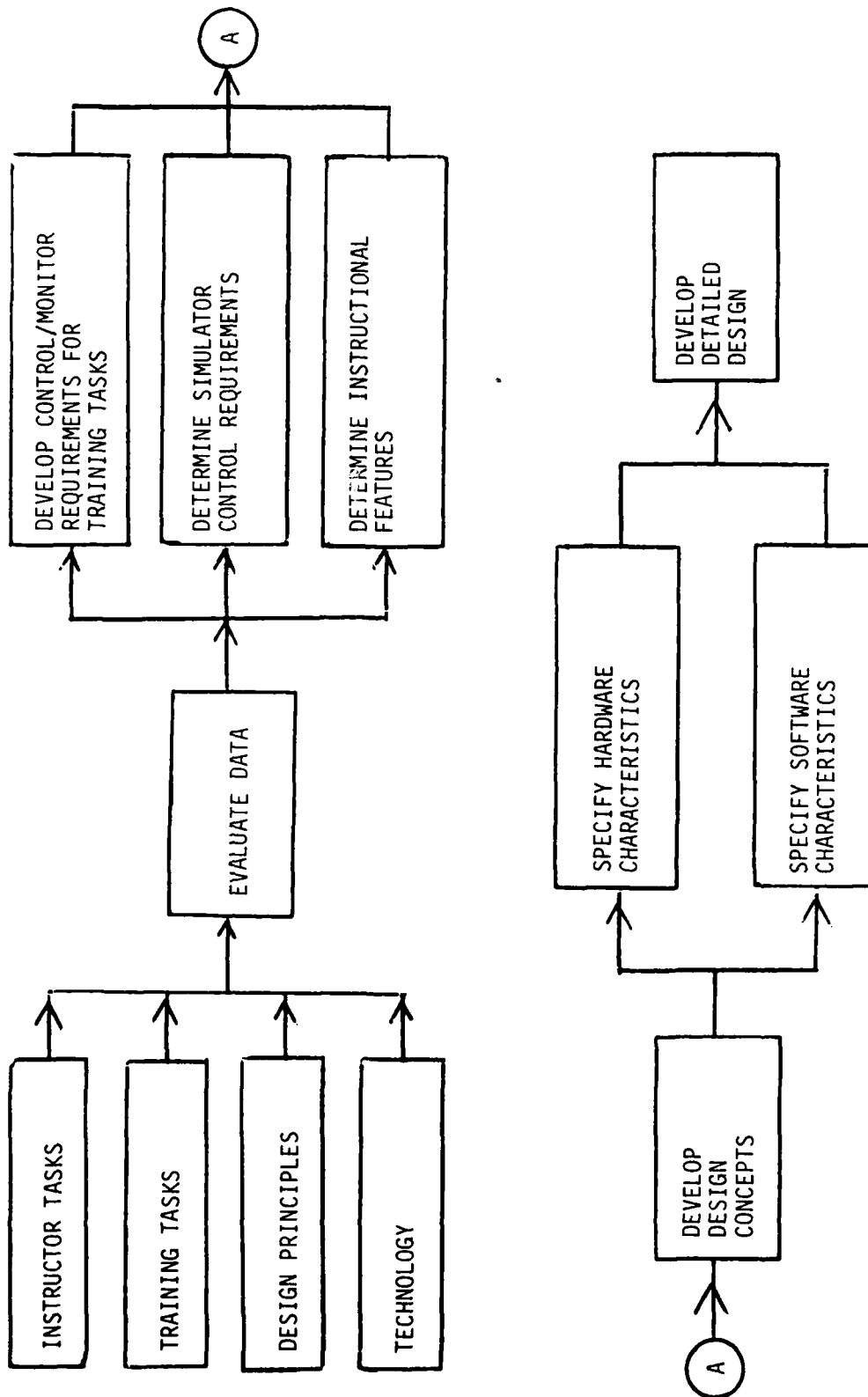


Figure 1. General IOS Design Model.

INSTRUCTOR TASKS

In order to define the roles and responsibilities of instructors and ultimately to determine the types of features the IOS should possess, specific instructor tasks must be identified. The tasks define the actions instructors must take to set up and run training exercises. The goal of the IOS design process is to identify the design solution which optimizes instructor performance of these tasks.

A generic list of instructor tasks was developed. The listing is as follows:

- Check trainer status
- Select trainer mode of operation
- Initialize trainer for selected mode
- Brief student
- Check on trainee station configuration
- Activate motion system
- Activate visual system
- Operate trainer in selected training mode
- Communicate with student
- Act as any ground facility
- Monitor student performance
- Freeze trainer to discuss problem or student performance
- Activate and remove malfunctions
- Evaluate student response to malfunctions
- Reinitialize trainer
- Monitor location and flight path of aircraft
- Monitor cockpit controls and aircraft systems
- Evaluate student performance
- Act as GCA/CCA operator
- Operate catapult

- Change environmental parameters
- Turn off trainer in an emergency
- Operate dynamic replay
- Record student performance
- Conduct post exercise de-brief

TRAINING TASKS

The training tasks provide critical information on what the trainee will be performing. Through a further analysis of the training tasks the IOS control/display requirements can be determined. The control/displays are those which will optimize the instructors' roles in administering, monitoring, and evaluating the student training tasks.

For the purposes of this study a generic task listing for a single-seat fighter/attack aircraft was developed. The task listing is not intended to be as rigorous as one validated during an ISD analysis. It does, however, contain an accurate listing consistent with the requirements of this study. The task listing is as follows:

- Perform cockpit interior inspection
- Perform ejection seat check
- Perform prestart procedures
- Perform starting engines
- Perform post-start checks
- Perform controls check
- Check aircraft systems
- Perform before tax checks
- Operate main/standby UHF radio
- Perform taxi
- Perform voice communications
- Perform pretake-off checks
- Perform take-off
- Perform after take-off procedures

Section 1: [Kern 1994, 1995]

- Section 1: Introduction (1994)
- Section 2: The Role of the Teacher (1995)
- Section 3: The Role of the Student (1995)
- Section 4: The Role of the Teacher (1995)
- Section 5: The Role of the Student (1995)
- Section 6: The Role of the Teacher (1995)
- Section 7: The Role of the Student (1995)
- Section 8: The Role of the Teacher (1995)
- Section 9: The Role of the Student (1995)
- Section 10: The Role of the Teacher (1995)

Section 11

- Section 11: The Role of the Teacher (1995)
- Section 12: The Role of the Student (1995)
- Section 13: The Role of the Teacher (1995)
- Section 14: The Role of the Student (1995)
- Section 15: The Role of the Teacher (1995)
- Section 16: The Role of the Student (1995)
- Section 17: The Role of the Teacher (1995)
- Section 18: The Role of the Student (1995)
- Section 19: The Role of the Teacher (1995)
- Section 20: The Role of the Student (1995)

Section 21

- Section 21: The Role of the Teacher (1995)
- Section 22: The Role of the Student (1995)
- Section 23: The Role of the Teacher (1995)
- Section 24: The Role of the Student (1995)
- Section 25: The Role of the Teacher (1995)
- Section 26: The Role of the Student (1995)
- Section 27: The Role of the Teacher (1995)
- Section 28: The Role of the Student (1995)
- Section 29: The Role of the Teacher (1995)
- Section 30: The Role of the Student (1995)

DESIGN CONCEPT

The design concept was developed through combining and integrating the four primary data sources (i.e., instructor tasks, training tasks, design principles, and technology). The design concept is an overview of the proposed solution for optimizing training in an OFT for a fighter/attack aircraft. The concept is also applicable to a wide range of other systems.

The design concept consists of two components: hardware and software. The components interact and are dependent one upon the other. A major issue in any design involving both hardware and software is establishing the proper functional balance between the two. In pointing out the distinction between hardware and software, there is an emphasis that IOS design is much more than using good human factors principles in determining what the IOS should look like. It is a systematic process of determining the information storage, retrieval, display, and manipulation requirements and implementing these requirements in a combination of hardware and software which optimizes instructor performance. Major design concepts are discussed in the following paragraphs.

HARDWARE. The IOS hardware must be reliable, maintainable and easy to operate and yet must contain the components required for control, monitoring, and evaluation. Major hardware components of the proposed IOS design concept are as follows:

- The main console. The main console is compact and is designed for a single instructor/operator. All layout is consistent with good human factors design principles. Particular emphasis is on ease of use of controls, orientation of CRTs for ease of display interpretation, and a functional work surface which accommodates instructor guides, checklists, etc.

- Instructor Aid Station (IAS). The IAS is a separate small CRT with associated controls. It is an integral part of the IOS and serves two functions: (1) present instruction on basic trainer operation and (2) prompt and guide instructors during the course of training exercises. It may also be used to display selected cockpit instruments (e.g., multi-function display, horizontal situation indicator, etc.).

- Two CRT displays. The primary means of data display is via two large CRTs (e.g., 25 inch diagonal). The CRTs provide the information necessary to control, monitor, and evaluate. They contain sensitized areas where touch panels are a primary means of simulation control.

- Visual system monitor. The visual system monitor enables the instructor to view the visual scene that the trainee is seeing. For wide angle visual systems the instructor may select which section of the scene he wants to monitor (e.g., left, center, or right). Heads-up display symbology is superimposed on the scene.

- Instructor's control panel. The instructor's control panel is the major "hard-wired" part of the IOS dedicated to simulator control. It consists primarily of fixed-function electronic touch pads.

Alternative configurations of these major IOS components are presented in Section IV of this report.

SOFTWARE. In order to combine simplicity of hardware with complexity of weapons systems and training problems, it is essential that software be designed to enhance instructor performance. The software must be simple to manipulate, present information in easily used formats, and facilitate problem control and monitoring. Major features of the proposed software design concept to meet these goals are as follows:

- Display continuity. A given display is always presented on the same CRT. There is no switching of displays between CRTs at the instructor's discretion. When a display is selected or is called up automatically by the software, it always appears in the same place.

- Standardized displays. Each type of display has a distinct, precisely prescribed format which is always used for that type of display. Formats are developed to enhance interpretation and use of the information presented. Display highlights are emphasized by spacing, graphics, bold alphanumerics, etc. It is also recommended that color be used to highlight portions of the displays.

- Automatic presentation of displays. Maximum use is made of software selection of displays, so that minimum instructor intervention is required. During pre-programmed modes all displays are software selected. During free flight the amount of instructor display selection is minimized through keying displays to trainee tasks.

- Minimize steps to change displays. As discussed above, display location is standard. There is, therefore, no concern with where a given display will appear. Also displays which are candidates to replace a given display which is being presented on a CRT are selectable using the touch pads on the CRT face. In most cases changing displays will require a one-step touch. In most other cases software design should minimize the number of decision points (i.e., steps) the instructor must handle.

- Minimum steps to manipulate training exercises. Minimum steps to manipulate is closely related to minimum steps to change displays. In this case, however, rather than changing displays for monitoring purposes only, the instructor is locating the display from which he will affect training problem control (e.g., locate and select a specific emergency, locate and activate a specific navigational beacon, etc.).

- Large selection of programmed exercises. One of the strengths of the proposed approach to IOS design and operation is a high-quality front-end analysis. Among other things, the analysis yields a realistic training

device syllabus which is keyed to the training requirements and training situation. The programmed exercises designed from the syllabus are, therefore, essential parts of the total training system and should be administered to each student. The large selection allows consideration of student skills and progress, a variety of equally difficult exercises for different students, standardized training, programmed exercise capability for all training phases, and elimination of time-consuming set-up required in conventional free flight exercises.

- Large selection of initial conditions. Setting up initial conditions in the free flight mode on many simulators is time-consuming and may be non-standard. A large set of initial conditions gives instructors the flexibility they desire and improves use of time and standardization. In the proposed IOS selection of a given set of initial conditions would key other responses from the IOS. For example, selecting initial conditions for an aircraft on the parking ramp may activate display of the normal cockpit checklist, or selecting initial conditions for an aircraft in marshall may activate the carrier approach display.

- IAS teaching and prompting. The IAS has two primary roles. The first is to teach instructors how to use the simulator. In this role it is a CAI terminal used to present information on the operation of the IOS and on the procedures for conducting training exercises. The second role is to prompt instructors during set up and execution of training exercises. In this role the IAS is a job aid which improves instructor efficiency and standardization of instruction.

A quote from the 2F114 (A-6 WST) instructor handbook is as follows: "This volume is designed to give the instructor the flexibility necessary to provide each student with the complex and repetitive training he requires." This emphasis on flexibility has led to IOS designs which are needlessly complex and which actually hinder training.

This is not to say that flexibility should be eliminated: certainly not. Degrees of flexibility are necessary to meet the variety of needs in a typical FRS training situation. A major thesis of this report, however, is that too much flexibility is a hinderance. To balance flexibility with ability to meet realistic training requirements, the IOS should be accurately programmed based on the results of a thorough front-end analysis. The software concepts presented above provide the guidelines for this programming. The more structured approach embodied in the analyses and resulting software will help ensure that simulator training is standardized yet sufficiently flexible to meet training needs, readily manageable, and is easy for instructors to learn to administer.

SECTION IV

DETAILED DESIGN ALTERNATIVES

OVERVIEW

Two generic alternative IOS configurations were identified. Both use fixed function electronic touch controls on the IOS panels and fixed and variable function touch panels on the CRTs as the methods of simulator control. The primary difference between the two alternatives is the division between the methods of simulator control. In alternative #1 the use of electronic touch controls is confined to basic simulator operation (e.g., power, motion system operation, freeze). Touch panels on the CRT faces are the primary method for controlling training exercises.

In alternative #2 there is an increased use of fixed function electronic touch controls mounted on the IOS vertical panel. These controls are used to carry out many of the functions for which CRT touch panels are used in alternative #1. CRT touch panels are also used in alternative #2.

Alternative #1 is an extension of the state-of-the-art being used to design the current generation of simulators. Emphases are on a minimum use of hard-wired controls and a maximum use of software control through input sources which are displayed as required. Alternative #2 is an update of the basic approach used in earlier generation simulators (i.e., extensive use of hard-wired controls). State-of-the-art technology is used in both the control methods chosen for alternative 2 (i.e., electronic touch pads and CRT touch panels) and problem control software.

The two alternatives are the two ends of a continuum, one extreme of which is CRT touch panels and the other extreme of which is console-mounted electronic touch pads. Although alternative #2 does not involve complete control via electronic touch controls, it is considered to contain the most extensive feasible use of electronic touch pads in light of the current technological state-of-the-art. More extensive use of electronic touch pads in lieu of CRT touch panels would lead to an IOS design which violates many of the principles of compactness, ease of use, and information management.

Other candidate alternatives in addition to those presented would fall between the two extremes (i.e., would consist of different mixtures of console-mounted electronic touch pads and CRT touch panels). These alternatives would constitute a set of virtually unlimited permutations of combinations of electronic touch pads and CRT touch panels. Presentation of all such alternatives would be virtually impossible.

By providing the anchor points of the continuum (i.e., the two feasible extremes), rather than numerous alternatives, the concepts of operation of each basic IOS type can be clearly presented along with the advantages and disadvantages of each. Variations of an IOS type for a specific application can be identified based on specific simulator requirements and personal preferences of Subject Matter Experts (SMEs), analysts, and engineers.

ALTERNATIVE NO. 1

The first alternative features a high level of automation to assist instructors, and simulator control via CRT displays which contain touch panels on the face of the CRT. The basic configuration of the IOS is shown in Figure 2 and subsequent Figures 2A and 2B. Appendix A provides the layout of the entire console.

Hard-wired controls are confined to:

- Operation of displays (e.g., power, brightness, contrast, etc.)
- Basic trainer control (e.g., power, freeze, motion)
- Communications with the trainee and maintenance
- Miscellaneous problem control (e.g., crash override, barrier arrest, catapult fire)
- Numeric keyboard
- IAS control

All other controls are programmed to use touch panels on the faces of the two CRTs. Specific touch panels for each display are programmed and are presented in the lower portion of the display.

The selection of touch panels by display is based on an analysis of the options which instructors may choose to exercise at a given point in a training exercise. The options are derived from the trainee and instructor tasks in progress and the associated displays used to monitor trainee performance. This philosophy is designed to enable instructors to select alternative displays, insert malfunctions, modify weather, etc. without having to carry out a multi-step selection process through a series of menus. Rather, selection alternatives have been built into the software and are readily available through the touch panels on the two CRTs. This feature will have a major positive effect on instructor workload and ease of IOS operation.

Although emphasis is on the use of pre-selected alternative actions during the course of a training exercise, the IOS has the capability to allow more flexibility of instructor action. Through the use of a series of menus which tie back to a master menu instructors are able to have greater control over simulator operation. It is essential to emphasize, however, that, through proper programming based on an accurate analysis, the normal method of operation will be through the programmed alternatives presented on the CRT touch panels. The more time-consuming, and potentially confusing processes of working through the selection menus is meant to be the exception rather than the rule.

Another feature which reduces instructor workload is extensive use of programmed exercises and a large set of initial conditions. The initial

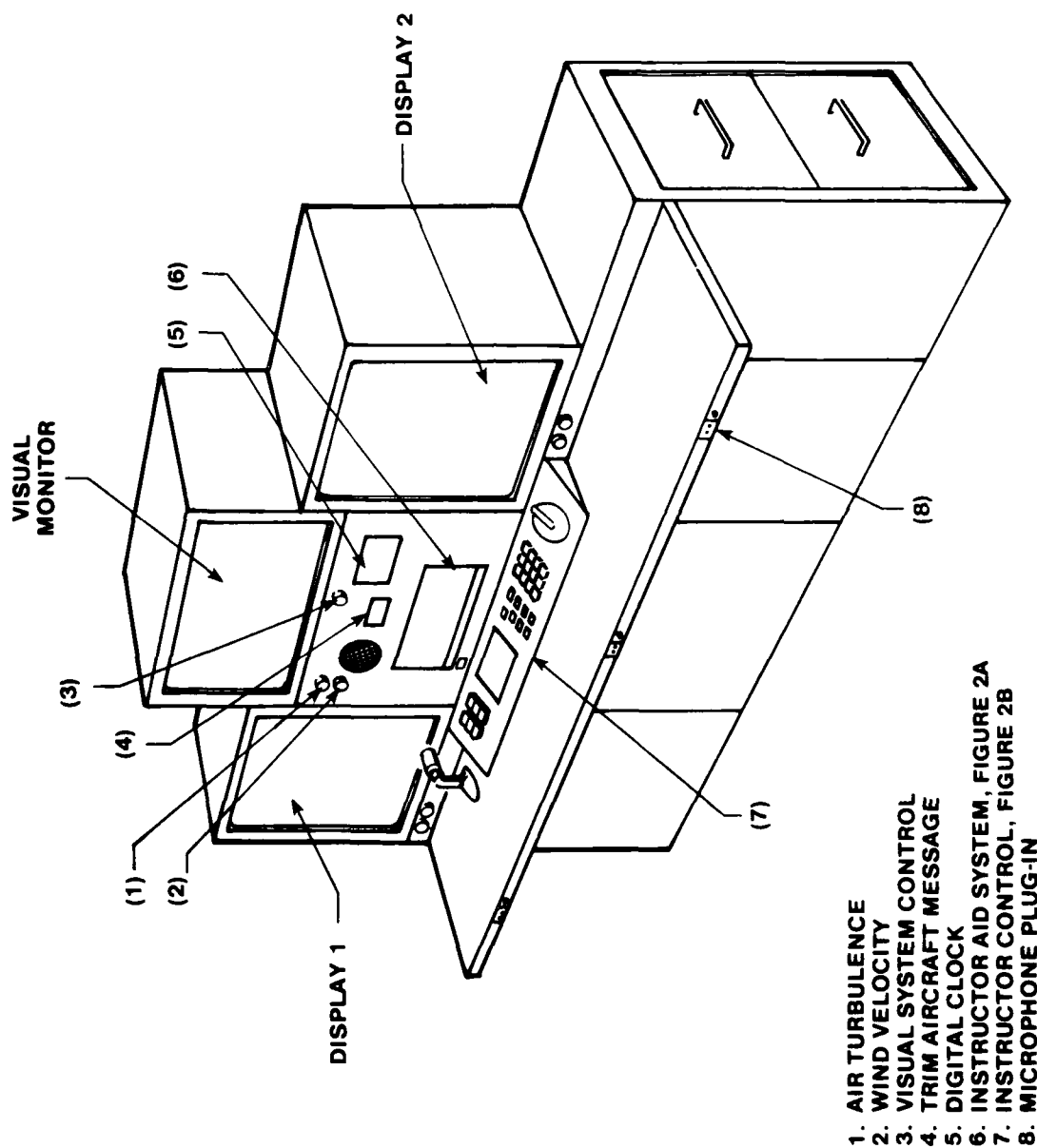


Figure 2. Generic Instructor/Operator Station - Alternative 1.

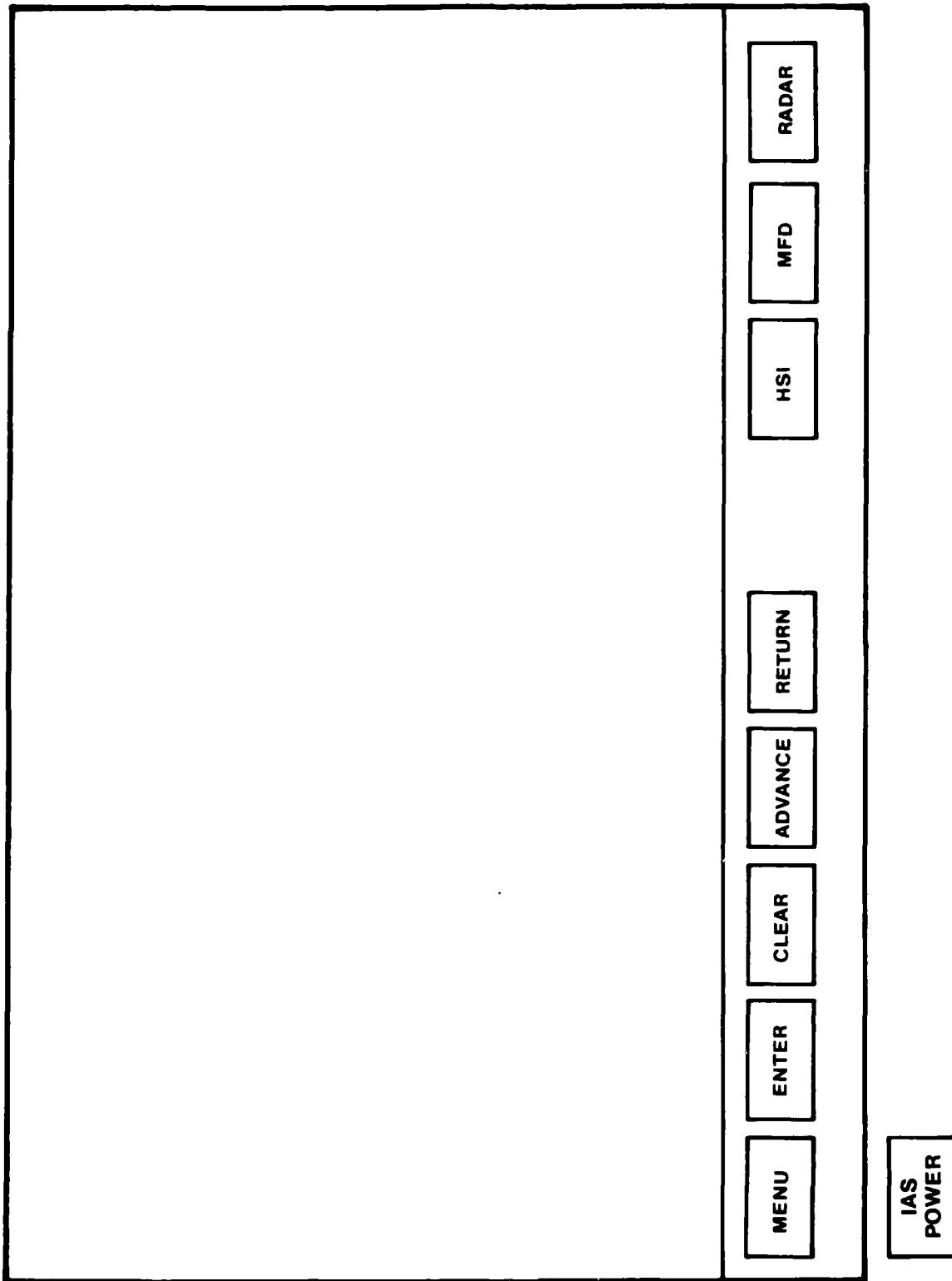


Figure 2A. Instructor Aid System (IAS).

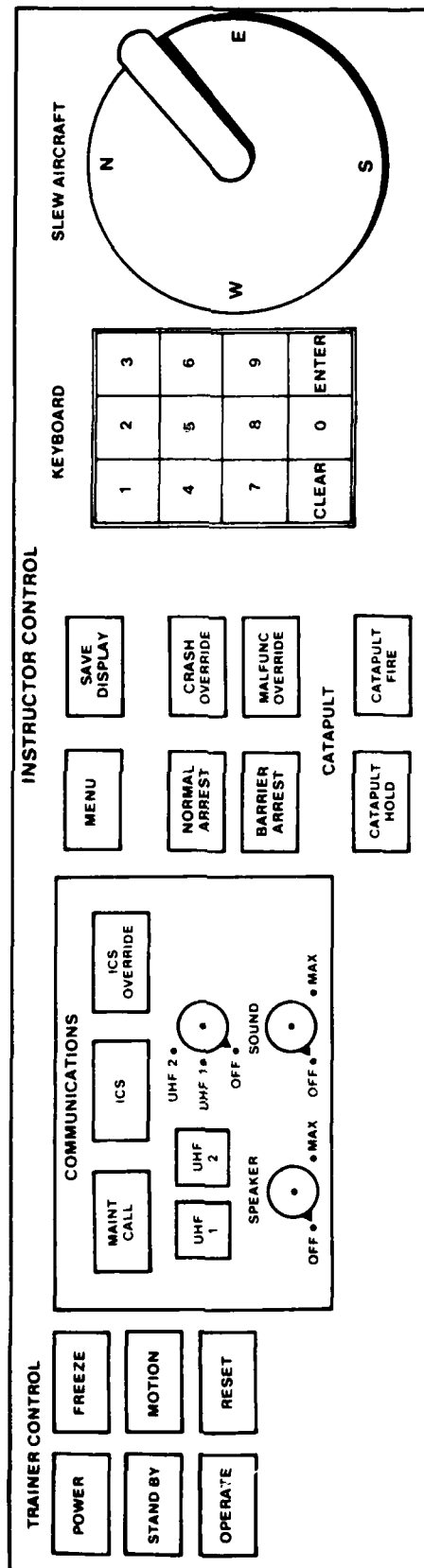


Figure 2B. Instructor Control Panel - Alternative 1.

conditions are easily selectable. Through the software they affect the displays and alternatives for trainee tasks carried out in the initial condition environment.

It is recommended that the "normal" mode of operation be with programmed exercises. The exercises should be derived from a well-integrated, approved syllabus in which the simulator plays an integral role in the training sequence. The programmed exercises facilitate standardization of instruction, but retain the capability for on-line modifications in response to trainee performance (e.g., insertion of additional malfunctions, changing environmental conditions).

A large set (i.e., 25 or more exercises) should be programmed and updated as required to incorporate procedural changes, tactics changes, etc. The large set will give instructors the capability to vary the scenarios within a type and difficulty level and also to have a wide range of types and difficulty levels available.

The free flight mode requires the greatest instructor involvement. Operations in the free flight mode, however, are designed to reduce instructor workload. This is accomplished through the IOS software. Routine decisions and selections are made by the IOS. In many cases instructor intervention is by exception. For example, given that the trainee is performing a certain task which has been selected by the instructor, displays to monitor trainee performance will be selected and presented by the software. Also the most likely alternate selections and most likely subsequent trainee tasks will be available as CRT touch panels. Only if different alternatives are desired will instructor intervention be required.

A large set of programmed initial conditions (i.e., 40 or more) plays a major role in operation of the free flight mode. This set should be derived from a systematic analysis of the most likely conditions under which a training exercise will begin and conditions to which the simulator will be set to initiate training segments during the course of exercises. Through use of the programmed initial conditions, initial set up and reset times will be minimized.

The intent is to use the initial conditions as programmed, without modification. If the set of initial conditions is based upon an accurate analysis, this should be the case. The software, however, contains the capability for on-line changes to selected parameters. It is recommended that weather and stores be changeable on-line. Changes to any other parameters would be made off-line. The ability to make changes, both to initial conditions and programmed exercises, should be tightly controlled. Such changes should result only from periodic training conferences and should reflect the consensus of the training community. Otherwise the programmed events may be based upon the whims of the individuals who like to make changes.

There are seven modes of operation. Four involve administering training exercises: free flight, automated training exercises, checkride, and

demonstration. The other three modes involve testing, preparation, and data outputs: plan, daily readiness, and print. The operation of each in these modes is discussed in the following paragraphs.

FREE FLIGHT. The free flight mode requires the greatest amounts of instructor operations and decisions. An example based on free flight requirements, therefore, provides the best insight into the design concepts incorporated into alternative #1. It also provides a good basis for discussions of programmed modes of operation.

The example chosen is a "chock-to-chock" exercise in which the trainee begins on the ramp with pre-start checks and terminates on the ramp with engine shutdown. During the exercise he performs all normal checks, takes-off, departs, copes with a malfunction, navigates, descends, and lands. The intent of the example is to demonstrate IOS operations for all types of trainee tasks for which the simulator will be used (i.e., normal procedures, malfunctions and emergency procedures, and flight control procedures and skills).

The example is keyed to the instructor tasks which are required to set up, conduct, and monitor the training exercise. Figure 3 shows the sequence of instructor tasks as the guiding entry in the left column. The remaining six columns contain information on IOS uses, operations, responses, etc. which are required to carry out the instructor tasks. Column contents are as follows:

- Instructor Task: the instructor-initiated task to operate the IOS and control/monitor trainee task performance or the instructor's response to IOS or trainee actions.
- Student Task: the student task which initiates an instructor's task or is in response to an instructor's task.
- Instructor action: the instructor activity required to carry out the instructor task, and the location and type of that activity.
- Switch/Panel: the switch or panel activated to carry out the instructor task.
- IAS: information presented on the IAS CRT to guide the instructor through performance of the task.
- CRT 1: information on CRT 1 which is used by the instructor to carry out his task.
- CRT 2: information on CRT 2 which is used by the instructor to carry out his task.

INSTRUCTOR TASK	STUDENT TASK	INSTRUCTOR ACTION	SWITCH/PANEL	IAS	CRT #1	CRT #2
Check status of trainer	-	Check Trainer Control Panel	ICP*	-	-	-
Verify w/ maintenance	-	Call Maintenance Personnel	CP*	-	-	-
Check Status/Turn on IAS	-	Touch IAS Power Switch	IAS Control Panel	Procedures to call up IAS Menu	-	-
Call up IAS Menu	-	Touch IAS Menu Switch	IAS Control Panel	Instructions to select Mode & IAS Mode Menu	-	-
Select Mode	-	Touch Panel on IAS Mode Menu (FREE FLIGHT)	-	Procedures to set Trainer in Free Flight Mode	-	-
Select Master Menu	-	Touch MENU Switch	ICP*	Instructions to use Master Menu	Master Menu	-
Select Mode Select	-	Touch Panel on CRT 1	-	Instructions to Select Mode	Mode Select Menu	-
Select Mode	-	Touch Panel on CRT 1 (Free Flight)	-	Instructions to Select Initial Conditions (IC)	IC Index	-
Call up detailed IC set	-	Touch Panel on IC Index CRT 1	-	IC Overview & Change Procedures	Detailed IC Set	-
Select ICS	-	Touch Panel on CRT 1	-	Trainee Briefing Instructions	Detailed ICs	Geographic Situation
Brief Trainee at IOS	Participate in Briefing	Brief Trainee	-	Briefing Instructions	Detailed ICs	Geographic Situation
Prepare to Check Cockpit Configuration	Enter Cockpit, Buckle in, etc	Touch Panel on CRT 1	-	Instructions to Check Cockpit Configuration	Cockpit Displays showing Config	Cockpit Displays showing Config.

Figure 3. Sample, Free Flight Exercise

*See Legend

INSTRUCTOR TASK	STUDENT TASK	INSTRUCTOR ACTION	SWITCH/PANEL	IAS	CRT #1	CRT #2
Monitor Cockpit Configuration Check	Check Cockpit Configuration	CRT 1 & 2 Touch Panels to Change Cockpit Displays Monitor/Comm w/ Trainee	-	Instructions to Check Cockpit Configuration	Cockpit Displays showing Config	Cockpit Displays showing Config
Prepare to Start Exercise	-	IAS ADVANCE Touch Panel	-	Instructions to Start	Same	Same
Start Exercise	Prepare, double-check, etc.	Touch MOTION, VISUAL, OPER-AIE Switches	TSP*	Checklist Monitoring Instructions	Prestart Checklist	Geographic Situation
Monitor/Evaluate Pre-start Checks	Perform Pre-start Checks	Monitor CRT 1	-	Same	Same w/Evaluation	Same
Select Start Engines	-	Touch Panel on CRT 1	-	Instructions to Monitor Engine Start	Start Engines Checklist	Engine Instrument Display
Monitor/Evaluate Engine Start	Perform Engine Start	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select After Start Checks	-	Touch Panel on CRT 1	-	Checklist Monitoring Instructions	After Start Checklist	Engine Instrument Display
Monitor/Evaluate After Start Checks	Perform After Start Checks	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select Instrument Checks	-	Touch Panel on CRT 1	-	Checklist Monitoring Instructions	Instrument Checklist	Instrument Display
Monitor/Evaluate Instrument Checks	Perform Instrument Checks	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select Taxi	-	Touch Panel on CRT 1	-	Taxi Monitoring Instructions	Taxi Parameters	Geographic Display
Monitor/Evaluate Taxi	Perform Taxi	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select before Take-off Checks	-	Touch Panel on CRT 1	-	Checklist Monitoring Instructions	Before Take-off Checklist	Engine Instrument Display

Figure 3. Sample, Free Flight Exercise Cont.

*See Legend

INSTRUCTOR TASK	STUDENT TASK	INSTRUCTOR ACTION	SWITCH/PANEL	IAS	CRT #1	CRT #2
Monitor/Evaluate Before Take-off Checks	-	Monitor CRTs 1 & 2	-	Checklist Monitoring Instructions	Before Take-off Checklist	Engine Instrument Display
Select Take-off Checks	-	Touch Panel CRT 1	-	Same	Take-off Checklist	Same
Monitor/Evaluate Take-off Checks	Perform Take-off Checks	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select Take-off/Departure Display	-	Touch Panel CRT 1	-	Take-off/Departure Monitoring Instructions	Take-off Procedures/Parameters	Departure Display
Monitor/Evaluate Take-off/Departure	Perform Take-off/Departure	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select Cross-Country Display	Navigate as per Flight Plan	Touch Panel CRT 2	-	Navigation Monitoring Instructions	Navigation Procedures or Impending or Active Malfunctions Checklist	Cross-Country Display w/ A/C Trail
Monitor/Evaluate Navigation	Navigate as per Flight Plan	Monitor CRTs 1 & 2, Communicator	-	Same	Same	Same
Select & Enter Malfunction/Call up Master Menu	-	Touch MENU Pad	Instructor Control Panel	Menu Instructions	Master Menu	No Change
Select Malfunction Option	-	Touch Panel CRT 1	-	Malfunction Instructions	Malfunction Menu	No Change
Select System for Malfunction	-	Touch Panel CRT 1	-	Same	System Malfunction List	No Change
Select & Enter Malfunction	-	Touch Panel CRT 1	-	Same	Malfunction Procedures	No Change
Monitor/Evaluate	Identify & Respond to Malfunction	Monitor CRT 1	-	Same	Same w/Evaluation	No Change

Figure 3. Sample, Free Flight Exercise Cont.

*See Legend

INSTRUCTOR TASK	STUDENT TASK	INSTRUCTOR ACTION	SWITCH/PANEL	IAS	CRT #1	CRT #2
Terminate Malfunction	Continue Navigation	Touch Panel CRT 1 CLEAR	-	Return to Instructions for Mission Phase in Progress	Display before Malfunction	No Change
Select Before Descent Checks	-	Touch Panel CRT 1	-	Checklist Monitoring Instructions	Before Descent Checklist	Cross-Country Display
Monitor/Evaluate Before Descent Checks	Perform Before Descent Checks	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select Descent/Approach	-	Monitor CRT 2	-	Descent/Approach Monitoring Instructions	Same	100NM Approach Display
Monitor/Evaluate Approach/Descent	Perform Approach/Descent	Monitor CRTs 1 & 2 Communicator	-	Same	Same	Same
Select Landing Checklist	-	Touch Panel CRT 1	-	Checklist Monitoring Instructions	Landing Checklist	20NM Approach Display
Monitor/Evaluate Landing Checklist	Perform Landing Checks	Monitor CRT 1	-	Same	Same w/Evaluation	Same
Select Landing Data Displays	-	Touch Panels CRTs 1 & 2	-	Landing Monitoring Instructions	Landing Data Display	Glideslope/Directional Display
Monitor/Evaluate Landing	Perform Landing	Monitor CRTs 1 & 2 Communicator	-	Same	Same	Same
Select Taxi Displays	-	Touch Panels CRTs 1 & 2	-	Taxi Monitoring Instructions	Taxi Parameters	Engine Instruments
Monitor/Evaluate Taxi	Perform Taxi	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select After Landing Checks	-	Touch Panel CRT 1	-	Checklist Monitoring Instructions	After Landing Checklist	Engine Instruments

*See Legend

Figure 3. Sample, Free Flight Exercise Cont.

INSTRUCTOR TASK	STUDENT TASK	INSTRUCTOR ACTION	SWITCH/PANEL	IAS	CRT #1	CRT #2
Monitor/Evaluate After Landing Checks	Perform After Landing Checks	Monitor CRT 1	-	Same	Same w/Evaluation	Engine Instruments
Select Before Engine Shutdown Checks	-	Touch Panel CRT 1	-	Checklist Monitoring Instructions	Before Engine Shutdown Checklist	Engine Instruments
Monitor/Evaluate Before Engine Shutdown Checks	Perform Before Engine Shutdown Checks	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same
Select Engine Shutdown Displays	-	Touch Panel CRT 1	-	Engine Shutdown Monitoring Instructions	Engine Shutdown Procedures	Engine Instruments
Monitor/Evaluate Engine Shutdown	Shutdown Engines	Monitor CRTs 1 & 2	-	Same	Same w/Evaluation	Same

*Legend:

TCP = Trainer Control Panel

CP = Communications Panel

ICP = Instructor Control Panel

TSP = Trainer Status Panel

*See Legend

Figure 3. Sample, Free Flight Exercise Cont.

Within rows the columns taken together present a complete depiction of the primary elements of simulator operation as they relate to the IOS (i.e., instructor tasks, trainee tasks, and IOS controls and displays). The following discussions are keyed to the entries in Figure 3. Figures showing sample displays are grouped and presented at the end of this section of the report.

Set-up. The example begins as the instructor approaches the IOS. His first tasks are to check and verify the status of the simulator by monitoring the status indicators and talking to maintenance personnel. Next he checks the status of the IAS and turns it on. From this point on the IAS will provide information to instruct and prompt instructors in performance of their tasks.

The IAS has two basic modes of operation:

- To present basic instruction on simulator operation. In this mode it is a CAI medium and is designed for use in instructor training.
- To present tutoring and prompting information during the course of a training exercise. In this mode IAS displays are determined, through the IOS software, by the tasks that the instructor and student are performing. The IAS responds to the system. No selections are made at the IAS which directly affect simulator operations.

The IAS mode menu display sets the IAS in either a training mode or a prompting mode. From this menu the instructor selects either a CAI lesson on IOS operations, or an IOS operational mode. In this example he selects the free flight mode. The IAS then presents a set of instructions for selecting the free flight mode of simulator operation. This selection also initializes the IAS for presentation of free flight prompting and tutoring information.

At this point the simulator has been set up and instructions for selecting the mode of operations have been presented. The next step is to initialize the trainer.

Initialization. Touching the MENU electronic touch pad on the instructor control panel (Figure 2B) will call up the Master Menu Display. From the Menu Displays, the Mode Select display is selected. It will displace the Master Menu, displaying the simulator operating modes (i.e., free flight, programmed, checkride, demonstration, etc). Using the touch panels on the face of CRT 1, the instructor selects the mode: in this case free flight.

Selection of free flight activates display of the initial conditions index on CRT 1. At the same time instructions for selecting the desired set of initial conditions from the index are displayed on the IAS. The instructor may select the initial conditions from the index or he may call up the detailed parameters for one of the sets in the index for review or changes. Once he has selected and entered the desired set of initial conditions, briefing displays based on the selected initial conditions are displayed on CRTs 1 and 2. Briefing instructions appear on the IAS.

Briefing. The briefing information presented on all IOS displays is used to prepare the trainee for the training exercise. It is intended to help ensure that both the instructor and student are familiar with all the necessary initial situation information and objectives of the training exercise prior to the start of the exercise. Use of the briefing displays will upgrade standardization, improve preparation, and improve both instructor and student performance.

After the instructor has completed the briefing, the trainee proceeds to the cockpit and prepares to start the exercise. His first task is to check the cockpit configuration. The instructor touches a panel on the CRT 1 briefing display to call up the cockpit configuration check displays. Instructions are presented on the IAS.

NOTE: In the remainder of this example IAS instructions will be assumed rather than discussed. The continuing IAS functions throughout the example exercise are shown in the IAS column of Figure 3.

START. After the cockpit configuration has been checked and changed as required to be consistent with the requirements of the initial conditions, the exercise is ready to begin. NOTE: The "Trim Aircraft" message located on the IOS console will flash until configuration conditions are met. The instructor touches the appropriate electronic touch pads on the instructor's control panel to start the exercise.

Training Exercise. During the course of the training exercise the instructor's primary tasks are to monitor and evaluate student performance via the CRT displays and select trainee tasks. The displays are keyed to the trainee tasks in progress. Selection of displays is, therefore, only required when the instructor elects to monitor an alternate display or when he deviates from the "expected" sequence of training events.

The "expected" sequence of events is programmed in the simulator software and is implemented through the touch panels on the CRTs. Each set of displays, which is keyed to a trainee task, contains a touch panel which allows the instructor to go directly to the displays for the trainee task which is next in the normal mission sequence. This technique is demonstrated in the discussion later in this section.

In the example shown in Figure 3 the first trainee task is to perform the pre-start checks. The CRT 1 and 2, and IAS displays for the pre-start checks are displayed when the OPERATE switch is activated. This set of displays was keyed to the initial conditions and is presented automatically when training begins.

The principle demonstrated is that, in addition to containing the traditional initial condition parameters, the initial conditions software contains information on the "expected" content of the training exercise which starts with the initial conditions. Essentially the philosophy is to use all the information that the initial conditions imply to aid the instructor. In this example, why would the instructor choose initial conditions for the aircraft

shutdown on the ramp if he did not want the trainee to follow the mission task sequence of pre-start checks, start engines, after start checks, etc.? The pre-start checks are, therefore, displayed automatically.

If, for example, the instructor had desired to start the exercise with the aircraft in the take-off configuration at the take-off end of the runway, he would have selected another set of initial conditions for this situation. These initial conditions would most likely start the exercise with the pre-take-off checks. The principle of establishing sets of initial conditions which are systematically structured with respect to each other will provide the flexibility required for effective training, but will contain the structure to enhance instructor performance, improve standardization, and upgrade the quality of training.

During performance of the pre-start checklist the instructor will be able to monitor the accuracy and sequence of steps through the pre-start procedures display. Timing of steps, checking off completion of steps, or other measurement parameters will be displayed on one or both of the displays. Selection of the exact parameters would be part of the design process for a specific simulator.

After the trainee has completed the pre-start checks, the instructor has three options: (1) to continue to start engines; (2) to repeat the pre-start checks, or (3) to clear the system and begin again with initial conditions. These three options allow the instructor to respond to the most likely training situations. That is, continue with the mission sequence; poor student performance, try again; and end of the training sequence, reinitialize.

The next student task is to start engines. Touching the START ENGINES touch pad or CRT 1 changes all displays to those associated with starting the engines. The starting procedures are displayed on CRT 1 and the engine instrument display on CRT 2.

The display on CRT 2 for engine starts contains the engine instruments. There are options, through the CRT touch panels to select other sections of the cockpit instruments or controls. This is a sample of two design philosophies: (1) whenever a section of the cockpit instruments is displayed, options to select any one of the other sections are always available; and (2) many displays contain touch panels by which the instructor may select other displays which have been predetermined to be those most likely desired by instructors. Thus changing displays is generally a one-step rather than a multi-step process.

The remainder of the tasks in Figure 3 essentially follow the procedures discussed above for pre-start checks and start engines:

- Displays are automatically presented based upon the trainee task in progress.
- Alternate displays may be selected directly using the CRT touch panels.

- Options to select the next tasks in mission sequence, to repeat, or clear are always available.
- Other displays, procedures, malfunctions etc which can not be selected directly from the CRTs can be accessed through a branching process which originates from a central Master Menu. The characteristics of this process are discussed later in the report.

An automated feature is available for use in conjunction with descent and approach. When the simulated aircraft comes within 100 miles of an in-tune terminal navigation aid, the 100-mile approach display for that facility will be displayed. This feature will provide an automatic transition from monitoring cross-country navigation to monitoring navigation during descent and approach. Twenty miles from the facility the display will switch to the 20-mile approach display.

Malfunctions. A major emphasis in the use of OFTs is practice of malfunctions in a high fidelity simulated environment. Alternative #1 is designed to facilitate the insertion of malfunctions in the free flight mode. This is accomplished through ready access to candidate malfunctions, simple entry procedures, and constant monitoring of the status of malfunctions.

The Master Menu enables access to malfunctions and emergency procedures. By touching the MENU touch pad on the Instructor's Control Panel, the Master Menu is displayed. The instructor then selects procedures or malfunctions and through two more steps identifies the desired procedure or malfunction. Emergency procedures are broken down by phase of flight (i.e., ground, take-off, inflight, and landing). Malfunctions are broken down by aircraft system. Within systems the most probable and critical malfunctions are presented at the top of the list.

Traditionally there are three basic methods of malfunction insertion: (1) manually under instructor control, (2) timed and keyed to the mission clock, and (3) event (e.g., when the flaps are lowered). Results of data collected early in this study indicated that the last two methods are rarely used. It is recommended, therefore, that malfunction insertion in the free flight mode be accomplished by manual insertion only.

AUTOMATED TRAINING EXERCISES. The automated training exercise mode is intended to be the "normal" training mode. As noted previously, the content of automated training exercises should be based upon a systematic, comprehensive syllabus which spells out in detail the content of all training events (i.e., academic, simulator, and aircraft exercises). The syllabus should embody principles of training such as, academic instruction on a task preceding simulator instruction on the same task, simulator instruction preceding flight instruction, systematic integration of academic and hands-on events, general sequence of instruction from simple to complex and easy to hard, etc.

In the automated training exercise mode most of the functions requiring

instructor intervention in the free flight mode, are performed automatically by the software as the exercise progresses. No instructor intervention is required unless he desires to increase or decrease the difficulty of the problem. In this case he may change environmental parameters or insert malfunctions.

Selection of the automated training exercise mode is similar to that for free flight, and is as follows:

- The IAS provides instructions on procedures for mode selection.
- Select Master Menu mode on the instructor control panel.
- Select Mode Select from the Master Menu.
- Select Automated Training Exercise from the Mode Select display. The next display is an index of all available automated training exercises along with a brief statement of the contents of each.
- Select the desired automated training exercise from the index. The next display will be a listing of the segments which constitute the mission.

The instructor then proceeds to brief the trainee; the trainee and instructor check the cockpit configuration and the exercise begins.

The instructor may elect to start the automated training exercise at any one of the exercise segments. He can do this using touch panels at the bottom or the CRT. The segments are manually advanced in sequence until the desired segment is reached. The aircraft is automatically initialized at the beginning of the selected segment.

During the course of an automated exercise pre-selected displays are presented automatically. The displays are keyed to the task being performed by the trainee. As with the free flight mode selection of other than the pre-selected displays may be made by the instructor using the touch panels on the CRTs. Options not available on the CRTs may be selected through the Master Menu and associated branches. Selection of alternate displays has no effect on the trainee's task. The only possible changes to trainee tasks once the exercise has started are to environmental conditions and insertion of malfunctions.

CHECKRIDE. The checkride mode is a special case of automated training exercise. The difference between the two is that during a checkride no instructor intervention to change problem difficulty is possible. In essence a checkride is "hands-off" as far as the instructor is concerned. All parameters are controlled by the computer. As in the automated training exercise mode the instructor may change displays. These changes, however, have no effect on the trainee tasks.

The initialization procedure for the checkride mode is essentially the same as that for the automated training exercise mode. When CHECKRIDE is selected from the mode select display on CRT 1, an index of checkrides, along with a brief description of each, is displayed. If desired the instructor may call up a listing of the segments that make up a checkride. He may not, however, begin the checkride at any segment he desires. He must begin with segment 1 and proceed sequentially through the exercise. After he has identified the appropriate checkride, the instructor briefs the trainee; the trainee and instructor check the cockpit configuration, and the checkride begins.

DEMONSTRATION. In the demonstration mode the cockpit controls (i.e., stick, throttle, and pedals) and displays, and motion, visual, and sound capabilities exhibit the movements and indications that would be present if selected tasks were being flown in the actual aircraft. A pre-recorded verbal commentary of the demonstration contents is provided. The purpose of the demonstration mode is to show trainees or others (e.g., visitors, staff, etc.) how selected tasks should "look and feel" when performed properly. When in the demonstration mode the simulator will not respond to cockpit inputs. On the contrary, simulator operations are under computer control.

Initialization procedures for the demonstration mode are comparable to those for other modes. When DEMO is selected from the mode select display on CRT 1, an index of demonstrations, along with a brief description of each is displayed. The instructor selects the desired demonstration, briefs and checks the cockpit configuration as required, and starts the demonstration.

PRINT. The print mode is used after the exercise is complete to obtain printed outputs of CRT displays which were selected and stored during the exercise. The printouts provide hardcopy records of student performance for debriefing and student files. The process consists of three steps:

- Store displays during the exercise for later print out.
- Review stored displays at the end of the exercise.
- Print out the selected displays.

When the instructor wishes to save a display, he activates the SAVE DISPLAY touch pad on the instructor control panel. The display is then stored in the display buffer. After the exercise the print mode is initialized via the mode select on CRT 1. Selecting the PRINT touch panel enables the stored displays to be sequentially presented on the CRT. The displays are advanced using the ADVANCE touch panel and selected for printing using the PRINT touch pad on the CRT display.

PLAN. The plan mode enables the qualified personnel to make permanent data changes to displays, procedure monitor programs, programmed missions, initial conditions, malfunctions, demonstrations, and radio facilities. Plan mode

operations are carried out off-line in the maintenance area. They are, therefore, not a part of the IOS design considerations.

Plan mode operations should be tightly controlled. They should result only from changes agreed upon by the training community (e.g., after training conferences, steering committee meetings, etc.). Loose and uncoordinated changes will reduce the benefits available from the planning and programming factors which are major benefits of the design philosophy presented in this report.

DEVICE READINESS (DRED). The DRED mode enables the maintenance personnel to monitor and control the testing of the simulator real time input/output conversion equipment, cockpit indicators, indicator lights, digital readouts, and circuit breakers. The DRED tests are automatically performed in sequence. The tests and their results are displayed on the CRTs.

ALTERNATIVE NO. 2

The second alternative also features a high level of automation to assist instructors. The major difference is that many of the instructor actions which employed CRT touch panels in alternative 1, employ fixed function electronic touch pads on the IOS console in alternative 2. The basic configuration of the alternative 2 IOS is shown in Figure 4 and associated Figures 4A through 4I. Appendix A provides a layout of the entire console. Hardwire controls are used for the following functions. Note that the first six (marked with an asterisk) are the same as alternative 1. The remainder are in addition to alternative 1 and indicate the major hardware difference between the two alternatives.

- Operation of displays (e.g., power, brightness, contrast, etc.)*
- Basic trainer control (e.g., power, freeze, motion)*
- Communications with the trainee and maintenance*
- Miscellaneous problem control (e.g., crash override, barrier arrest, catapult fire)*
- Numeric keyboard*
- IAS control*
- Mode control
- Selection of automated training exercises, checkrides, and demonstrations
- Selection of types of normal and emergency procedures
- Selection of malfunctions by system
- Selection of specific pre-determined malfunctions

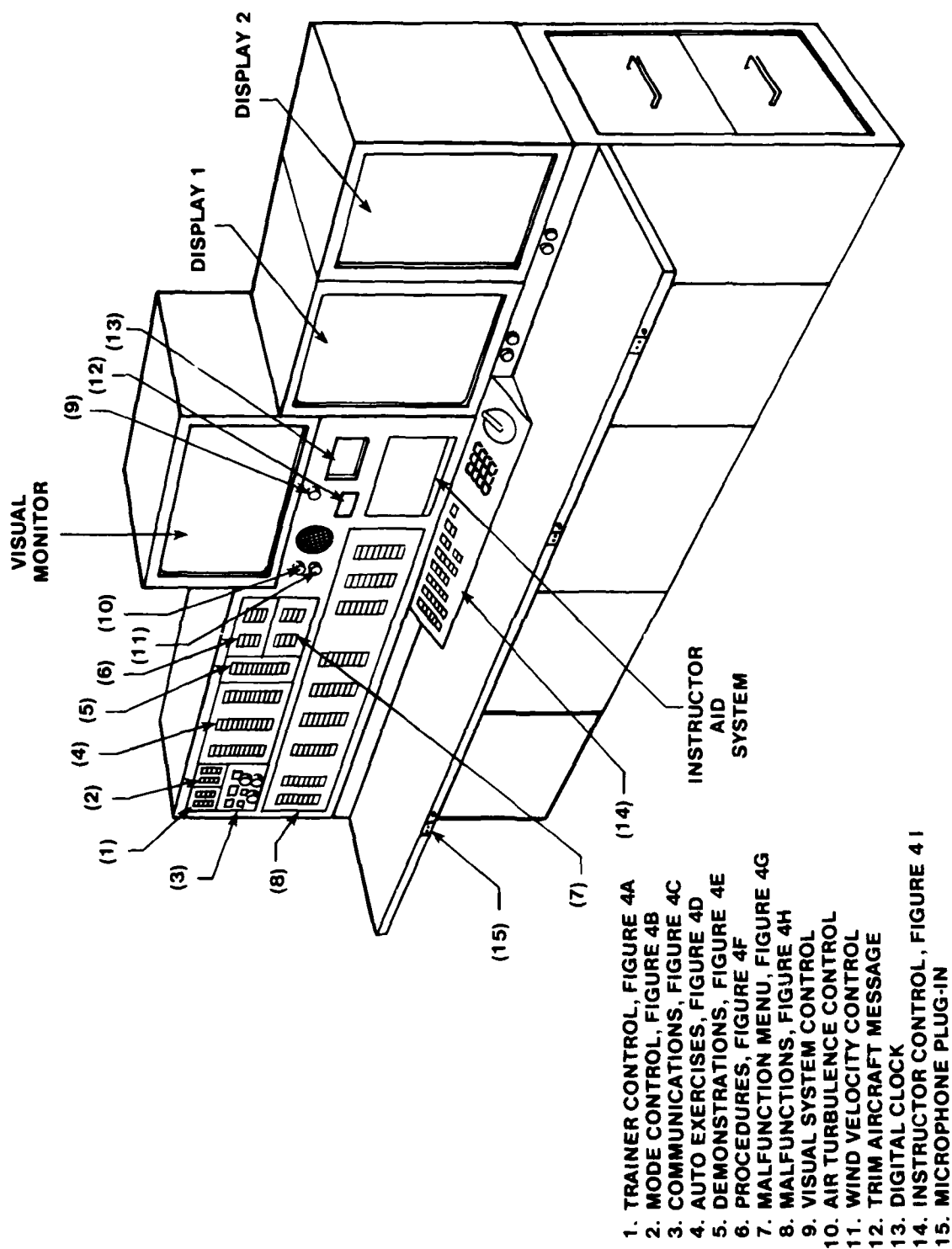


Figure 4. Generic Instructor/Operator Station - Alternative 2.

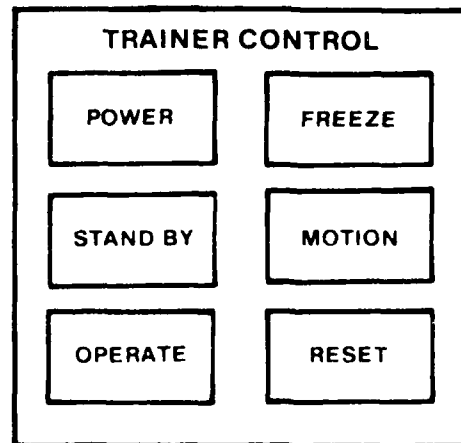


Figure 4A. Trainer Control Panel - Alternative 2.

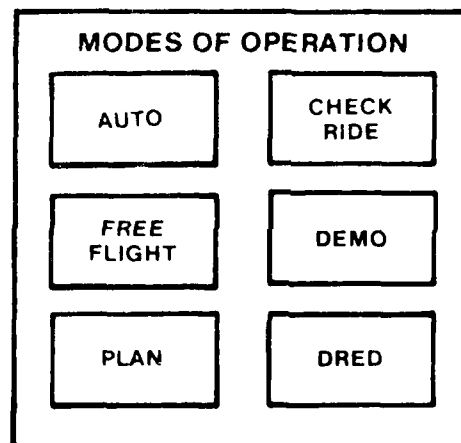


Figure 4B. Mode Panel - Alternative 2.

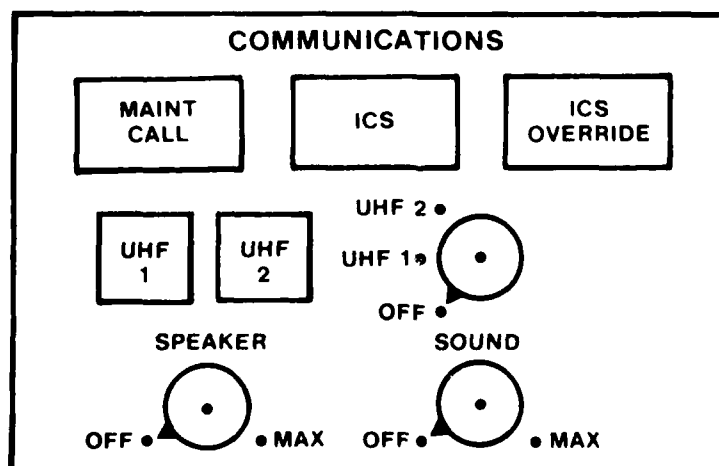


Figure 4C. Communication Panel - Alternative 2.

AUTOMATED TRAINING EXERCISES					
1.	FAM-1	11.	FCLP	21.	SPARE
2.	FAM-2	12.	CQ MODE 1	22.	SPARE
3.	FAM-3	13.	CQ MODE 2	23.	SPARE
4.	INST-1	14.	SID	24.	SPARE
5.	INST-2	15.	GCA	25.	SPARE
6.	INST/ NAV-1	16.	AIR TO GROUND	26.	SPARE
7.	INST/ NAV-2	17.	GROUND EMERG PROC	27.	SPARE
8.	AIRWAYS NAV	18.	GROUND NORMAL PROC	28.	SPARE
9.	LOWLEVEL NAV	19.	TACAN APPROACH	29.	SPARE
10.	HI-LOW NAV	20.	STALLS	30.	SPARE

Figure 4D. Automated Training Exercise Panel - Alternative 2.

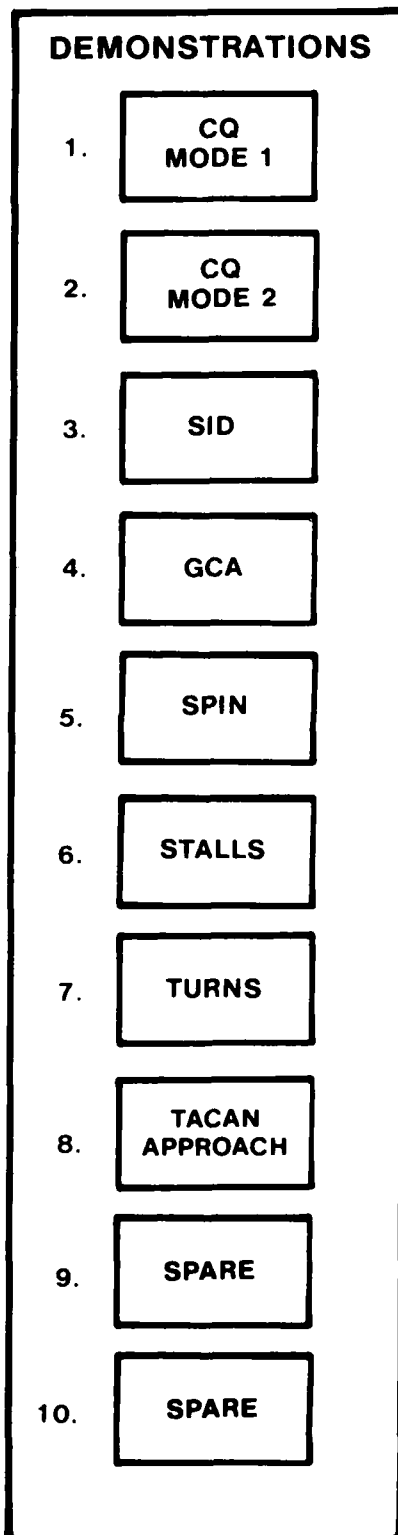


Figure 4E. Demonstration Panel - Alternative 2.

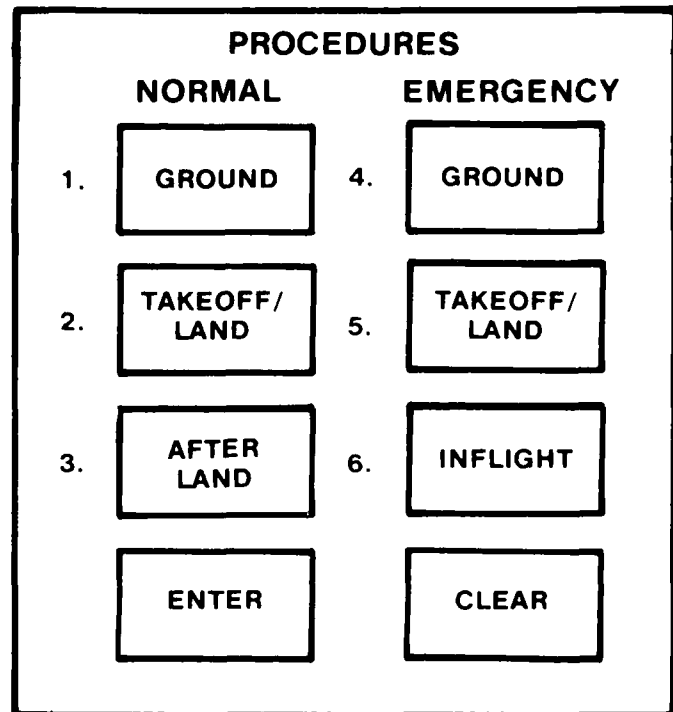


Figure 4F. Procedures Control Panel - Alternative 2.

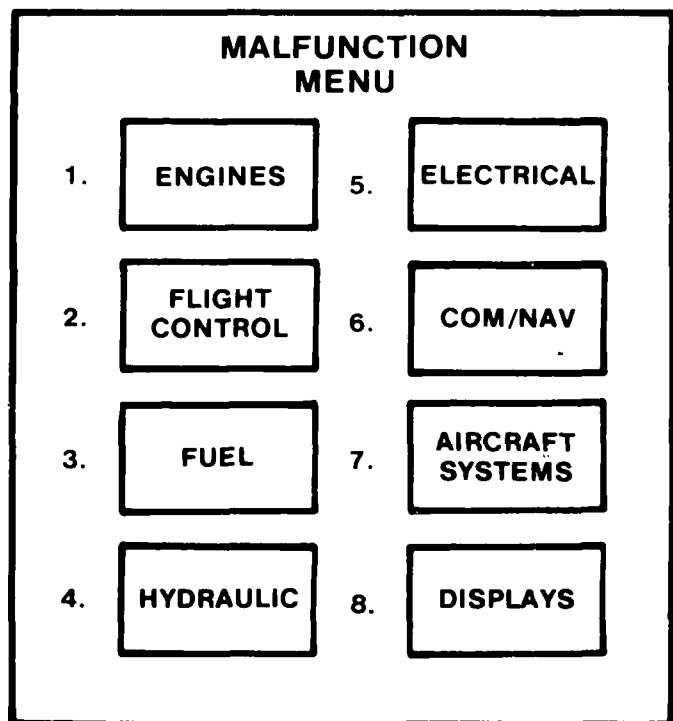


Figure 4G. Malfunction Menu Panel - Alternative 2.

MALFUNC

ENGINES		FLIGHT CONTROL		FUEL		HYDRAULICS	
L	R						
1. ☐ SELECT	11. ☐ SELECT	OIL PRESS LOW	1. ☐ SELECT	FLAPS LOCK UP	1. ☐	WING TANK L FAILS TO TRANSFER	1. ☐ HYD SYS 1 PRESS LO
2. ☐	12. ☐	OIL PRESS HIGH	2. ☐	SPEED BRAKE FAIL OPEN	2. ☐	DROP TANK L FAILS TO TRANSFER	2. ☐ HYD SYS 1 PRESS LO
3. ☐	13. ☐	OVERSPEED	3. ☐	RUNAWAY TRIM STAB	3. ☐	FUEL BOOST PRESS: LOW L	3. ☐ HYD SYS 2 PRESS LO
4. ☐	14. ☐	OVERTEMP	4. ☐	FCS HOT	4. ☐	BOOST PUMP FAIL - FWD	4. ☐ HYD SYS 2 PRESS LO
5. ☐	15. ☐	LOW T/O THRUST	5. ☐	AUTO PILOT NOT ENGAGE	5. ☐	BOOST PUMP FAIL - AFT	5. ☐ APU ACCU PRESS LO
6. ☐	16. ☐	EXCESS VIBRATION	6. ☐	AOA INOPERATIVE	6. ☐	FUEL HOT L	6. ☐ BRAKE ACC PRESS LO
7. ☐	17. ☐	FLAMEOUT	7. ☐	ROLL RATE LIMITER INOPERATIVE	7. ☐	FUEL HOT R	7. ☐ TBD
8. ☐	18. ☐	FLAMEOUT NO START	8. ☐	PCAS FAILURE	8. ☐	IFR PROBE UNLOCKED	8. ☐ TBD
9. ☐	19. ☐	ENGINE SEIZURE	9. ☐	TBD	9. ☐	INFLIGHT FUEL TRANSFER UNABLE	9. ☐ TBD
10. ☐	20. ☐	NOZZLES FAIL CLOSE	10. ☐	TBD	10. ☐	FUEL LOW	10. ☐ TBD
21. ☐ ADDITIONAL MALFUNCTIONS			11. ☐ ADDITIONAL MALFUNCTIONS		11. ☐ ADDITIONAL MALFUNCTIONS		11. ☐ ADDITONAL MALFUNG

Figure 4H. Malfunctions Con

MALFUNCTIONS

HYDRAULICS		ELECTRICAL		COMM/NAV		DISPLAY SUBSYSTEMS		AIRCRAFT SYSTEMS	
	HYD SYS 1A PRESS LOST	1.	BATTERY SW. INOPERATIVE	1.	INS ATTITUDE FAIL	1.	HUD FAIL	1.	LANDING GEAR NOT RETRACT
	HYD SYS 1B PRESS LOST	2.	GEN OFF LINE L	2.	AIR DATA COMPUTER FAIL	2.	UFC FAIL	2.	LANDING GEAR NOT EXTEND
	HYD SYS 2A PRESS LOST	3.	GEN OFF LINE R	3.	COMM 1 FAIL	3.	LEFT UDI FAIL	3.	MLG DOWN NLG UNSAFE
	HYD SYS 2B PRESS LOST	4.	DOUBLE GEN FAILURE	4.	COMM 2 FAIL	4.	RIGHT UDI FAIL	4.	BLOWN TIRE NOSE
	APU ACCUM PRESS LOW	5.	BATTERY CHARGE LOW	5.	TACAN FAIL	5.	HSD FAIL	5.	BLOWN TIRE L. MAIN
	BRAKE ACCUM PRESS LOW	6.	FCS CB OPEN	6.	ADF FAIL	6.	MISSION COMPUTER ONE - FAIL	6.	BRAKE FAIL LEFT
	TBD	7.	TBD	7.	RADAR ALT FAIL	7.	MISSION COMPUTER TWO - FAIL	7.	HOOK NO RETRACT
	TBD	8.	TBD	8.	DATA LINK INOPERATIVE	8.	CSC FAIL	8.	ANTI - SKID INOPERATIVE
	TBD	9.	TBD	9.	TBD	9.	TBD	9.	WINGS UNLOCKED
	TBD	10.	TBD	10.	TBD	10.	TBD	10.	OXYGEN FAIL
	ADDITIONAL MALFUNCTIONS 11		ADDITIONAL MALFUNCTIONS 11.	11.	ADDITIONAL MALFUNCTIONS 11.		ADDITIONAL MALFUNCTIONS 11.		ADDITIONAL MALFUNCTIONS

Functions Control Panel - Alternative 2.

2

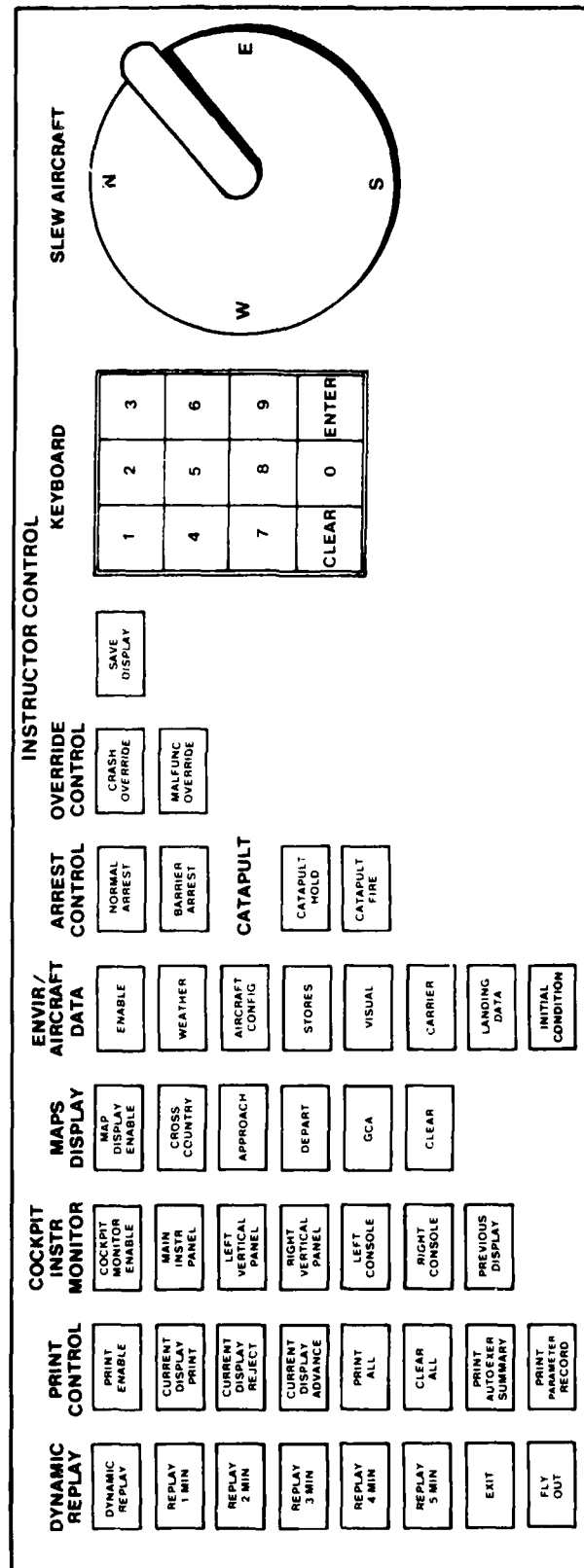


Figure 4I. Instructor Control Panel - Alternative 2.

- Dynamic replay control
- Print control
- Selection of cockpit instrument monitor by cockpit section
- Selection of map displays
- Selection of environment/aircraft data displays

Other controls are via the CRT touch panels, as used in alternative 1. Typically the IOS console touch pads are used to access the initial display. Alternatives emanating from the initial display are typically controlled from touch panels on the faces of the CRTs.

The identification of CRT touch panels for each display is based on an analysis of the options which instructors may choose to exercise at a given point in a training exercise. Determination of display content is based upon requirements to monitor trainee performance of specific training tasks and to control the training exercise. These philosophies are the same as those used in alternative 1. They are designed to enable instructors to select alternative displays, insert malfunctions, modify weather, etc. without having to carry out a multi-step selection process through a series of menus.

There are a number of other fundamental philosophies/techniques in alternative 2 which are consistent with those discussed previously for alternative 1. These are as follows:

- A set of menus and selection options for problem control.
- Large sets of preprogrammed exercises and initial conditions.
- "Normal" mode of operation with programmed exercises (i.e., automated training exercises).
- Extensive instructor prompting and pre-selected options in the free flight mode.
- Only limited capability to make on-line changes to initial conditions and programmed exercise parameters.

The training capabilities of both alternatives are the same. The instructor actions required to exercise the capabilities differ and center on CRT touch panels versus console-mounted electronic touch pads. The following paragraphs further elaborate on these differences through discussions of operations in the different modes. It should be noted that since CRT touch panels are used in both options and since the software and instructor support features are essentially the same, many of the operations are the same. The following paragraphs, therefore, highlight the differences in operations between the two alternatives. The major differences are summarized in Figure 5.

INSTRUCTOR ACTION	ALTERNATIVE 1	ALTERNATIVE 2
1. Initialize for training	Menu Control-Inst Control Panel	None
2. Activate menu control	Menu Display	None
3. Enter Mode Select	Mode Select Display	Mode of Operation Panel
a. Select Free Flight	" "	" "
b. Select Auto Training Exercises	" "	" "
c. Select Checkride	" "	" "
d. Select Demonstrations	" "	" "
4. Enter Free Flight	Initial Condition Index Display	Same as Alternative 1
5. Enter Auto Training Exercises	Auto Tng Exercise Index Display	Auto Training Exercise Panel
6. Enter Checkride	" "	" "
7. Enter Demonstrations	Demonstrations Index Display	Demonstrations Panel
8. Initialize for Procedures	Menu Display	None
a. Enter Procedures	Procedures Display (selection)	Procedures Panel
b. Enter selected Norm/Emerg Procedures	Norm or Emerg Procedures Display	" "
c. Select specific Norm/Emerg Procedures	" "	Same as Alternative 1
d. Enter specific Norm/Emerg Procedures	Procedure Monitor Display	" "
9. Initialize Malfunctions	Menu Display	None
a. Enter malfunctions	Malfunctions Display (Selection)	Malfunction Menu Panel
b. Enter selected system	System Ma.function Dis (Sel)	Malfunction Control Panel
c. Select specific malfunction	" "	" "
d. Enter specific malfunction	" "	" "

Figure 5. Major Differences Between IOS Alternatives.

INSTRUCTOR ACTION	ALTERNATIVE 1	ALTERNATIVE 2
10. Initialize Map Displays	Menu Display	Instructor Control Panel
a. Enter map display	Map Displays (selection)	" "
b. Select specific map	" "	" "
c. Enter specific map	Map Display e.g., x-country	" "
d. Select map scale	" " " " " "	" "
e. Enter specific map scale	Map Display with selected scale	Instructor Control Panel
11. Initialize Environment/Aircraft Data	Menu Display	Same as Alternative 1
a. Enter Environment/Aircraft Data	Environ/Aircraft Data Dis (Sel)	Instructor Control Panel
b. Select specific Environ Data Item	" " " " " "	" "
c. Enter selected item	Data item Display	" "
12. Initialize Cockpit Monitor	Menu Display	None
a. Enter Cockpit Monitor	Cockpit Monitor Display (Sel)	Instructor Control Panel
b. Select specific Cockpit Monitor Display	" " " " " "	" "
c. Enter specific Cockpit Monitor Display	" " " " " "	" "
13. Initialize Dynamic Replay	Mode Select Display	Instructor Control Panel
a. Enter Dynamic Replay	Dynamic Replay Control Display	" "
b. Enter time of replay	" " " " " "	" "
14. Initialize Print Control	Mode Select Display	Instructor Control Panel
a. Enter Print Control	" " " " " "	" "
b. Enter Print Control Parameters	Print Control Display	" "

Figure 5. Major Differences Between IOS Alternatives Cont.

FREE FLIGHT. As discussed previously, the primary philosophy in designing free flight operations for both alternatives was to provide more instructor support than is currently provided. This is accomplished through pre-selected alternatives and easy display and event manipulation. Differences between alternatives in the ways in which the free flight operations are implemented are highlighted in Figure 6. Listed in Figure 6 are the instructor tasks from Figure 3 which differ in the means of execution across the alternatives, the means in alternative 1, and the means used in alternative 2.

It is evident from Figure 6 that in the sample free flight scenario, there are very few differences in instructor actions required to conduct the exercise. The primary differences are in implementing the exceptions to the planned sequence of events and in using a number of the instructional features. Particular operations in Figure 6 which are controlled by CRT touch panels in alternative 1 but are controlled by IOS console electronic touch pads in alternative 2 and which are candidates for use during free flight are as follows:

- Selection of procedures on the procedures control panels.
- Selection of dynamic replay mode and the length of the replay sequence.
- Selection of the print mode and associated controls to review, select, and print previously stored displays.
- Selection of map displays for cross-country departures, approaches, and GCA.
- Selection of environmental and aircraft data: weather, configuration, stores, visual, carrier, landing data.

AUTOMATED TRAINING EXERCISE. Since automated training exercises are controlled by the simulator software, requirements for instructor intervention are minimum in both alternatives. There are three primary differences between the alternatives. In each, CRT touch panels in alternative 1 are replaced by IOS console electronic touch pads. The differences are as follows:

- Selection of an automated training exercise is via the mode panel and the Automated Training Exercise Panel. The former sets the trainer in the automated training exercise mode. The latter selects the specific automated training exercise.
- Increasing problem difficulty by inserting additional malfunctions is accomplished using the Malfunction Menu to identify the system and the Malfunctions panel to insert the specific system malfunction.
- Increasing problem difficulty by changing environmental parameters is accomplished by using the Environment/Aircraft Data touch pads.

INSTRUCTOR TASK	ALTERNATIVE #1	ALTERNATIVE #2
Select Mode Menu	MENU touch pad on Instructor Control Panel	Not required
Select Free Flight	CRT 1 Touch Panel	FREE FLIGHT touch pad on Mode Panel
Monitor Cockpit Configuration Check (Change Cockpit Displays)	CRT 1 & 2 Touch Panels	Touch pads on Cockpit Displays Panel
Select & Enter Malfunction	1. MENU touch pad on Instructor's Control Panel to get Master Menu. 2. CRT 1 touch panel to get index of systems for malfunctions. 3. CRT 1 touch panel to get malfunction index for selected system. 4. CRT 1 touch panel to select & enter malfunction.	1. Malfunction menu panel to select system. 2. Malfunction control panel to enter selected system malfunction.

Figure 6. Summary of Differences Between Alternatives for a Sample Free Flight Scenario

CHECKRIDE. As noted previously in the discussion of checkrides for alternative 1, these exercises are hands-off (i.e., all parameters, displays, performance measurement, etc. are controlled by the software). The only difference, therefore, between the two alternatives is in the procedures for checkride selection. In alternative 1 it is via CRT displays and touch panels. In alternative 2 it is via the mode panel and automated training exercise panel. The former sets the simulator in the checkride mode. The latter is used to select the specific checkride. Contents of candidate checkride exercises are the same as those for candidate automated training exercises. The difference is that in the checkride mode there is no capability for instructor intervention during the course of the exercise.

DEMONSTRATION. The only difference in the demonstration mode between alternative 1 and 2 is in the procedures for selection of the desired demonstration. In alternative 1 it is via CRT displays and touch panels. In alternative 2 it is via the mode panel and demonstration panels on the IOS console. The former sets the simulator in the demonstration mode. The latter is used to select the specific demonstration. There are no other instructor actions required in either alternative.

PRINT. As discussed previously under alternative 1, there are three steps in using the print mode: (1) store selected displays, (2) review stored displays, and (3) print out displays. Step 1, store displays, is the same in both modes (i.e., activate the SAVE DISPLAY touch pad on the instructor's control panel). In alternative 1 steps 2 and 3, review and print displays, are performed using CRT displays and touch panels. In alternative 2 they are performed at the instructor control panel using the PRINT control touch pads.

PLAN. Plan mode operations are carried out off-line in the maintenance area and, therefore, have no impact on the IOS design of either alternative.

DRED. In alternative 1 access to the DRED mode is gained through the CRT mode display and touch panels. In alternative 2 it is accessed at the mode panel on the IOS console.

INSTRUCTIONAL FEATURES

Although alternatives 1 and 2 contain different IOS configurations, the instructional features embodied in each are the same. Many of the features in this section have been referenced previously. They are presented here collectively, along with features not discussed previously, to provide an overview of the salient characteristics of the basic IOS design concept recommended in this report.

Three categories of instructional features are discussed in the following paragraphs. The first are those which are critical to the proposed IOS design concept. The second are those which are included in the two alternatives, but which are not critical for the viability of the concept. The third are those which are not included in the alternatives, but which are included in some

existing devices. The relevance and appropriateness of features in the latter two categories should be evaluated as part of the front-end analyses for each application.

CRITICAL FEATURES. The critical features are those around which the proposed IOS concept is developed and others which are important to enable effective and efficient use of an OFT or similar type of device.

Automation of Instructor Tasks. Many of the routine instructor tasks have been automated. Others which require instructor intervention have been simplified by pre-selecting and displaying the highest probability alternatives. This rise of automation and software support reduces the requirement for instructor training and reduces workload during operations.

Computer Aided Instructor Training and Prompting. The IAS is the primary means for training instructors in device operating procedures and for providing on-line prompting to upgrade instructor performance during the course of an exercise. The IAS is capable of CAI presentation on basic operating procedures. In this mode it forms an integral part of the Instructor Under Training (IUI) curriculum. In the on-line mode the IAS responds to the simulation situation by presenting information to guide instructors through their tasks which are associated with the situation.

Large Set of Programmed Exercises. The normal mode of operation is through the use of programmed exercises. In order to ensure flexibility and comprehensiveness of capability, the set of programmed exercises must be large and must be developed from a systematic analysis. An integral part of the analysis must be a complete training system syllabus, which has been approved by the Fleet Project Team, the training organization, or other responsible organization and which contains detailed information on training objectives, conditions, standards, and other relevant factors. Once the simulator has been put on-line a mechanism must be implemented to help ensure that revisions to the programmed exercises are made as required.

Large Set of Initial Conditions. The number and variety of initial conditions are important for free flight operations. As with the programmed exercises, the initial conditions must be derived from a systematic front-end analysis. They must give instructors the capability to start exercises or reinitialize during exercises under a wide range of conditions. These conditions must be keyed to realistic assessments of training requirements, student problems, and other factors. Proper design and use of the initial condition sets have a significant impact on instructor requirements to set up and reset exercises.

Easy Malfunction Control. A major use of an OFT is to provide training in recognizing and responding to aircraft malfunctions. To enhance training, malfunctions and associated emergency procedures are categorized and displayed for easy selection and insertion into training exercises. Constant readouts of active and impending malfunctions are provided in the lower section of CRT 2.

Procedures Monitoring. Whenever a trainee is performing normal or emergency procedures, the procedures checklist is displayed on CRT 1. Through an automated monitoring feature, steps are "checked-off" on the display as they are completed. The instructor "checks-off" those steps which can not be monitored by the software. In certain situations CRT 1 may be segmented to display two checklists.

Freeze. There are two types of freeze: manual and automatic. To initiate manual freeze the instructor activates the FREEZE touch pad on his control panel. Automatic freeze is activated when selected aircraft parameters exceed predetermined limits. Typically this is in a crash situation. In both manual and automatic freeze the simulator stops and retains the parameter values active at the point of freeze.

Dynamic Replay. Dynamic replay enables the instructor to replay the most recent interval of student performance. Intervals of one, two, three, four, and five minutes are available. The instructor freezes the simulator, selects the replay interval, and starts the replay. The selected interval is replayed with all controls and displays under software control, such as in the demonstration mode. Dynamic replay has a fly-out feature. This enables the student to fly out of the replay whenever the instructor activates the FLY OUT control.

DESIRABLE FEATURES. The second set of features are those which are desirable to complement the critical features. They are not essential to the design concept nor are they necessarily desirable in every application. Selection or rejection of these features should be a product of front-end analyses.

Demonstrations. Theoretically programmed demonstration exercises could be a useful teaching tool in which the simulator first demonstrates and then the trainee performs. In fact, they are not generally used in this manner. Perhaps a more useful application is for showing-off a device to guests, dignitaries etc. There are many opportunities for this application, especially with a new state-of-the-art device. Demonstrations may also help familiarize newly-assigned instructors, staff, maintenance personnel, etc. with the capabilities of the device.

Print for Operations. There are often two print capabilities: one for maintenance and the other for operations. The former is typically available away from the IOS in the computer area and is not of relevance here. The latter involves print capabilities to make hardcopies of selected displays, performance parameters, etc. This is generally done via a printer adjacent to the IOS. Most complex simulators have this capability. It is, however, rarely used in the training environment.

Landing Conditions. Landing conditions provide a read out of the performance parameters during landing (e.g., distance from centerline, distance from threshold, wire caught). Since OFTs, particularly those with visual systems, are often used extensively for landing practice, landing conditions data should be considered as a candidate feature.

Ejection Parameters. Ejection parameters provide a readout of conditions at the moment of ejection. The data indicate whether or not ejection was the correct course of action. Since ejection is a highly critical event, the ejection data may be desirable to training personnel.

Parameter Display. Parameter display provides the capability for a constant readout of selected aircraft parameters (e.g., airspeed, angle of attack, altitude, etc.). It enables the instructor to have ready access to important status and performance data.

OTHER FEATURES. The remaining instructional features are clearly not critical and in many applications may not be desirable. They should, however, be considered as part of the front-end analyses.

Parameter Recording. Parameter recording involves continuous recording for print out of selected aircraft parameters. This capability is related to and derived from parameter display capability discussed above. Often values of the selected parameters are plotted graphically, yielding large volumes of data which are difficult to use.

Automatic Malfunction Insertion. Automatic insertion of malfunctions is typically accomplished by keying the selected malfunction to mission time or an event (e.g., lower landing gear, raise flaps, etc.). This capability is available on many current-generation simulators, but is apparently used only sparingly. Instead, malfunctions are manually activated on instructor command.

Parameter Freeze. Parameter freeze is the capability to hold a selected performance parameter (e.g., altitude) at a fixed value. The other parameters continue to vary as a function of student performance. As a result, student performance demands are decreased since he is not responsible for control of one variable.

Record/Playback. Record/playback enables the instructor and student to review the IOS displays for an entire exercise or major portions of an exercise (i.e., one to two hours). It is used as a critiquing tool during debriefing. Utilization rates of this feature on existing devices are apparently low.

Remote Display. Remote displays in the operations area (as opposed to the maintenance area) provide the capability to brief and debrief a student while the simulator is in operation. Thus the simulator is not tied up with the briefing and debriefing functions. Theoretically, this is a good idea. In practice, it is generally not used.

Automated Performance Measurement. There are a number of different approaches to performance measurement. In the past some have been used and useful; many have not. Theory and practice in performance measurement often are quite different. Selection of performance measurement features for a specific application, therefore, should result from a realistic assessment of what is meaningful to instructors and what will be used.

Computer-Generated Voice. The technology for computer-generated voice messages is advancing rapidly. Applied to aircrew simulators, this technology can enable the software to assume some of the instructor roles. Current simulators contain automatic terminal information systems (ATIS) and automated ground control approaches (GCA). Automated speech applications should be considered for future applications in aircrew simulators.

CRT DISPLAYS. The primary mode of information display in both IOS alternative configurations is via CRT displays. With only a few exceptions in alternative 1 touch panels on the faces of the CRTs are the exclusive means of simulation control. In alternative 2 CRT touch panels also play a major role.

This section is presented to demonstrate contents and formats of sample CRT displays and controls. It does not contain an exhaustive set of all the displays which will be required to implement alternatives 1 and 2. Rather, the samples presented are illustrative of the recommended approaches to information presentation and simulation control.

The sample displays are discussed individually in the following paragraphs. Each paragraph contains a reference to the associated figure number. Rather than being integrated in the text where they are referenced, figures showing the sample displays are grouped at the end of this section of the report. The first set of displays (i.e., Figures 7 through 19) is applicable to alternative 1 only. In alternative 2 the functions of these displays and their CRT touch panels are carried out via the electronic touch pads on the IOS console. With only the few exceptions noted in the text, the remainder of the displays are applicable to both alternatives. In developing the format and content of the sample displays, ideas and information contained in existing simulator IOS CRT displays, where applicable, were used. General characteristics of the displays are as follows:

- Numbers adjacent to the touch panels are for use in the back-up mode: the numeric key board on the instructor control panel. On a few occasions the numeric keyboard is used to enter parameter values, even though primary control is via the touch panels (e.g., change weather conditions and stores).
- On primary monitoring displays (e.g., maps, checklists) the touch panels are located in the lower section of the CRT. On selection displays (i.e., menus) they are spaced across the entire display.
- In the free flight mode touch panels at the bottom of the displays generally include the next training event.
- In the programmed modes the touch panels are used sparingly. For checkrides they are not used. For automated training exercises they are used only to change problem idfficulty (i.e., change the environment or insert malfunctions) or to view displays other than those selected for display in association with the active training task.

ALTERNATIVE 1 ONLY DISPLAYS. There is a series of displays which are required in alternative 1 and not in alternative 2. In alternative 2 identical selections are made via the electronic touch pads on the IOS console. These alternative 1 displays are shown in Figures 7 through 19. They are part of a selection tree which starts with the Master Menu and from there branches to different sequences of displays. These sequences lead to specific monitoring displays. The branching process from the main menu is designed to give the instructor the capability to access any display in the system from a single start point.

Although the capability to access displays through the Master Menu encompasses all available displays, it is intended to be used as the exception rather than the rule. Direct and quicker access to displays is most often available through the touch panels at the bottom of active displays.

Master Menu. The Master Menu (Figure 7) is the start point where training exercises are initiated. At the start of an exercise the master menu is used to branch to mode selection. The master menu is also the start point for selection of any display in the system. It branches to map, malfunction, procedures, cockpit, and environment/aircraft data displays.

Mode Select. The Mode Select display (Figure 8) is used at the start of an exercise to select one of the four training modes (i.e., automated training exercise, checkride, free flight, and demonstration). During an exercise it is used to select dynamic replay. At the end it is used to select the print mode for print out of stored displays.

Map Displays. The Map display (Figure 9) enables the instructor to access maps stored in the software data base. Cross-country, approach, departure, and GCA maps are available.

Malfunctions. Malfunctions are stored by system. The malfunction display (Figure 10) contains the eight systems under which the malfunctions have been categorized. The systems are flight control, fuel, hydraulics, electrical, communication/navigation, displays, aircraft systems and engines.

Procedures. Procedures are divided into normal and emergency and within each into ground, takeoff/land, and post land. The procedures display (Figure 11) is used to access these categories of procedures.

Cockpit Monitor. The cockpit is divided into five sections. Any one section may be displayed on a CRT. The section to be displayed is selected on the Cockpit Monitor display (Figure 12). This display is the terminal mode of selection branching (i.e., there are no more interim displays required to select the desired cockpit section). The next display is the chosen cockpit section.

Environment/Aircraft Data. The Environment/Aircraft Data display (Figure 13) enables access to a wide variety of displays. The first five (i.e., weather, visual, aircraft configuration, stores, and carrier) deal with the simulated training conditions. Landing and ejection data are used to evaluate trainee performance. The initial conditions index is used to reset to new initial conditions during the course of an exercise.

Automated Training Exercise Index. The Automated Training Exercise Index (Figure 14) contains a listing of all the programmed exercises which are available in the system. It is called up by selection of either the automated exercise or checkride mode. Any exercise on the index can be either an automated training exercise in which the instructor has limited control or a checkride over which the instructor has no control for changes. Activating a touch panel in the ENTER Column calls up the selected exercise and prepares the simulator to start that exercise when the appropriate operating touch pads are activated on the IOS console. Activating a touch panel in the DISPLAY column calls up a listing of segments in the exercise without entering the exercise. The PREVIOUS DISPLAY touch panel returns the CRT to the Mode Select display. The AUTOMATED TRAINING EXERCISE SCENARIO touch panel is used only after an exercise has been entered. It calls up a display of detailed mission segment information.

Dynamic Replay Control. The Dynamic Replay Control display (Figure 15) is used to control the simulator's dynamic replay instructional feature. It is activated from the Mode Select display after the device has been frozen. Five replay intervals are available. The FLY OUT touch panel enables the trainee to assume control of the device and to resume flying the exercise at any point during the replay. The PREVIOUS DISPLAY touch panel returns the CRT to the Mode Select display.

Demonstration Index. The Demonstration Index display (Figure 16) contains a listing of all the programmed demonstrations which are available in the system. The CROSS-COUNTRY MAP, DEPARTURES, APPROACHES, and GCA touch panels activate displays associated with a demonstration that has been entered. They may be used to familiarize the instructor with the demonstration and to brief the student on what to expect. The PREVIOUS DISPLAY touch panel returns the CRT to the Mode Select display.

Print Control. The Print Control display (Figure 17) enables control of the print mode in which stored displays are reviewed, selected, and printed out. The ADVANCE, REJECT and PRINT touch panels are used to review, select, and initiate printing of selected displays. The next three touch panels enable control of the stored displays collectively. The PREVIOUS DISPLAY touch panel returns the CRT to the Mode Select display.

Malfunction Displays. There are eight malfunction displays: one for each of the eight systems. Figure 18 shows the representative engine malfunction display. Figure 19 shows the format for the other seven systems. Malfunctions are entered by touching the desired touch panel and the ENTER panel. Other touch panels in the lower section are the same for all displays. ADDITIONAL MALFUNCTIONS calls up more malfunctions for the particular system. REMOVE MALFUNCTION removes a selected malfunction which has not been entered. PREVIOUS DISPLAY returns the CRT to the Malfunctions display.

ALTERNATIVE 1 AND ALTERNATIVE 2 DISPLAYS. Displays discussed in this section are used in both alternatives. Most of the displays contain information which instructors use to monitor student performance. Others are the final step in the selection process which in alternative 1 began with the displays discussed above and in alternative 2 began with electronic touch pads on the IOS console.

Initial Conditions Index. The Initial Conditions Index (Figure 20) contains a listing of all sets of initial conditions that are available in the system. Activating a touch panel in the ENTER column is the method of selecting the desired set. Activating a touch panel in the DISPLAY column enables the instructor to review the specific parameters of the selected set of initial conditions without entering the set. The ADVANCE DISPLAY touch panel advances the display to the next page of the index. The PREVIOUS DISPLAY touch panel returns the display to either the Mode display or the Environment/Aircraft Data display, depending on which display was used to access the index.

Initial Conditions. The Initial Conditions display (Figure 21) contains the values of the parameters for the set of initial conditions selected for display. The ENTER touch panel enables the instructor to enter the initial conditions being displayed. The WEATHER DISPLAY touch panel calls up the weather data for the initial conditions set being displayed. The AIRCRAFT CONFIGURATION DISPLAY touch panel calls up aircraft data. PREVIOUS DISPLAY enables return to the Initial Conditions Index.

Automated Training Exercise. The Automated Training Exercise display (Figure 22) contains a listing of the segments which compose the selected exercise. The instructor may ENTER the automated exercise, return to the PREVIOUS DISPLAY (i.e., the Automated Training Exercise Index), or access more detail on each segment via the AUTOMATED TRAINING EXERCISE SCENARIO touch panel.

Automated Training Exercise Scenario. The Automated Training Exercise Scenario display (Figure 23) contains detailed information on the segments (i.e., legs) of the exercise. The PREVIOUS DISPLAY touch panel returns the CRT to the Automated Training Exercise Index or the Automated Training Exercise display. The LEG ADVANCE and LEG RETRACT touch panels change the legs displayed by either adding the next leg and deleting the lowest numbered leg displayed or adding the next lower leg and deleting the highest numbered leg displayed. The LEG SELECT-ENTER LEG NUMBER touch panel allows the instructor to start the exercise at the start of any of the legs. If this option is not used the exercise always begins at leg 1. The AUTOMATED TRAINING EXERCISE MAP display calls up a map of the gaming area for the selected exercise. The PRINTOUT touch panel is active only during the last leg of an exercise. If selected it will initiate a performance summary for the entire exercise.

Automated Training Exercise Map. The Automated Training Exercise Map display (Figure 24) contains the cross-country map of the exercise and the aircraft position trail. It is a basic monitoring display during automated exercises. It also contains a listing of errors keyed to the map location where they occurred, aircraft status information, and current active malfunctions. The CLEAR MALFUNCTION panel removes active malfunctions from the simulation. The AUTOMATED TRAINING EXERCISE SCENARIO panel calls up the scenario display for the exercise in progress. After the exercise is frozen the AIRCRAFT SLEW panel enables the instructor to relocate the aircraft using the slew control on the IOS console.

Cross-Country Map. The Cross-Country Map display (Figure 25) is used in the free flight mode. It shows the aircraft trail, all active navigation stations, and the in-tune navigation station (indicated by a circle). Aircraft status and malfunction data are displayed. The map scale may be altered by MAP SIZE touch panels, which select the size of the gaming area in nautical miles. When the Aircraft comes within 100 miles of an in-tune station, the approach display for the in-tune facility is automatically displayed. The INHIBIT APPROACH DISPLAY touch panel inhibits this function. The DEPARTURE touch panel enables access to departure displays. The AIRCRAFT SLEW and CLEAR MALFUNCTION functions are as discussed previously.

Approach Index. The Approach Index (Figure 26) contains a listing of all stored approach displays. Activating the touch panel adjacent to the desired approach calls up the display. The CROSS-COUNTRY MAP touch panel enables access to the map keyed to the ongoing simulation situation.

100NM Radius Approach. The 100NM Radius Approach display (Figure 27) shows the area within 100NM from an in-tune navigation station with the approach pattern indicated. Aircraft status and malfunction data are shown. Through the touch panels the instructor may slew the aircraft to a new location, access the associated cross-country map, clear malfunctions, and return to a previous display.

20NM Radius Approach. The 20NM Radius Approach display (Figure 28) shows the area within 20NM from an in-tune navigation station with the approach pattern indicated. Aircraft status and malfunction data are shown. Through the touch panels the instructor may slew the aircraft to a new location, access the GCA display for the facility, clear malfunctions, and call up detailed landing performance data.

Departure Index. The Departure Index (Figure 29) contains a listing of all the stored departure displays. Activating the touch panel adjacent to the desired departure calls up the display.

Departure. The Departure display (Figure 30) contains the departure station map and departure route. Aircraft status and malfunction data are also shown. Through the touch panels the instructor may access the associated cross-country map, clear malfunctions, and return to the previous display.

GCA/CCA. The GCA/CCA display (Figure 31) provides glide slope and directional information for ground and carrier controlled approaches. The aircraft trail is shown; aircraft status and malfunction data are displayed; and instructions for the instructor to act as controller are provided. The AUTO GCA VOICE touch panel activates the software driven controller to automatically provide glide slope and directional information to the student. The instructor may also clear malfunctions, call up detailed landing performance data, and access departure displays.

Normal Procedures. The Normal Procedures display (Figure 32) contains a listing of all normal procedures for which there are checklists stored in the system. They are grouped by phase of flight. Activation of the touch panel adjacent to the desired procedure calls up the checklist for that procedure.

Procedures Monitor. The Procedures Monitor display (Figure 33) contains checklists of active normal and emergency procedures. As required, the display may be split to contain two checklists. Sequence performance data are provided at the bottom of each section of the display. The PROCEDURE ADVANCE touch panel calls up the next named procedure in the mission sequence. Other touch panel capabilities are to remove malfunctions, access the procedures index, and recall the previous display.

Emergency Procedures. Figures 34, 35, and 36 contain lists of emergency procedures organized by phase of flight. Activation of the touch panel adjacent to the desired emergency will enter that emergency and will call up the associated emergency procedures checklist. Touch panels at the bottom of the display allow access to the other lists of emergency procedures and to the previous display.

Cockpit Monitor. Figures 37 through 41 show sections of the cockpit. The touch panels enable access to any other section of the cockpit and to the previous display.

Weather and Carrier. The weather and carrier display (Figure 42) is associated with the Initial Conditions display. It contains four weather condition sets that can form a part of a set of initial conditions. The one designated with an asterisk (*) is the active set. Individual parameters from the designated set may be changed by touching the associated touch pad and entering the change on the numeric key pad. Changes in carrier parameters are similarly implemented in the CARRIER DATA column. The lower touch pads enable selection of one of the weather condition sets, call up of the Initial Conditions Index, and return to the previous display.

Visual Scene Data. The Visual Data display (Figure 43) enables the instructor to change carrier and airfield lights, and the type and horizon intensity of the generic visual scene. Selections are made on a one to five scale by first touching the panel adjacent to the characteristic to be changed and entering the desired number at the numeric keypad. The lower panels enable access to map and approach displays and to the previous display.

Aircraft Configuration. The Aircraft Configuration display (Figure 44) enables the instructor to change selected parameters through use of the touch panels and the numeric keypad. Using the lower touch panels he may access initial conditions, cross-country map, and external stores.

External Stores. The External Stores display (Figure 45) is associated with the Initial Conditions display. Through it the instructor may change the stores at the six stations. Changes are made by touching the panel adjacent to the station and then "loading" or "removing" stores at that station by touching the desired panel in the PARAMETER section of the display. The current station loading is displayed to the right of the station designator. From the External Stores display the instructor may select the aircraft configuration, initial conditions, and the previous display.

Landing and Ejection Data. The Landing and Ejection Data display (Figure 46) contains performance evaluation data for both carrier and runway landings and for ejections.

IAS Menu. Emphasis in this report has been on CRT operations and displays with little reference to the IAS. This is the case for three reasons:

- The IAS is viable and should offer a significant improvement in future IOS designs. The basic concept is new, however, and has not been developed down to the detail of specific sample displays.
- Displays for training in the CAI mode must be developed from training curricula which do not exist.
- Displays for prompting instructors during the course of exercises are responsive to the simulation situation. They are, therefore, a step beyond the analysis level of this study which focuses on basic IOS information flow and characteristics.

To clarify the IAS concept one sample display is presented. It is the IAS Menu display (Figure 47). This display contains instructions and the selection options which must be considered at the start of a session. If one of the entries in the left column is selected, the IAS enters the prompting and tutoring mode. In this mode it responds to the simulation situation by guiding the instructor through his roles and responsibilities on-line as the training exercise takes place. Selection of an entry in the right column puts the IAS in the instructional mode. In this mode it acts as a CAI terminal to present instruction on the operation of the IOS.

Touch pads at the bottom of the IAS are fixed function. The left set is used to control prompting and instruction. The right set allows selected cockpit displays to be presented on the IAS. In the example the HSI, MFD, and radar may be displayed.

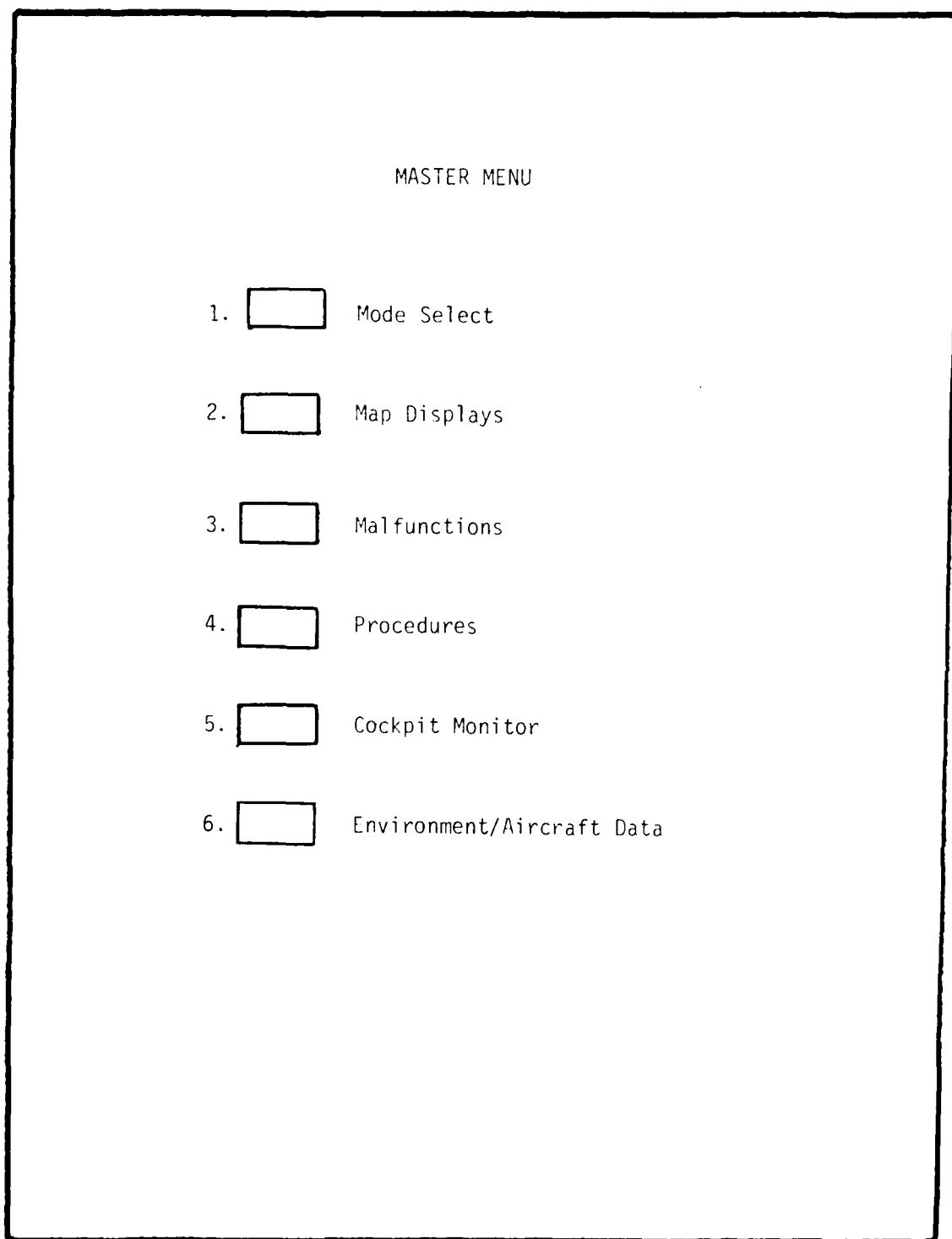


Figure 7. Master Menu Display

MODE SELECT

1. ☐ Automated Training Exercise
2. ☐ Checkride
3. ☐ Free Flight
4. ☐ Demonstrations
5. ☐ Dynamic Replay
6. ☐ Print

Figure 8. Mode Selection Display

MAP DISPLAYS

1. ☐ Cross-Country
2. ☐ Approaches
3. ☐ Departures
4. ☐ GCA

Figure 9. Map Display Selection Display

MALFUNCTIONS

1.	☐	Flight Control
2.	☐	Fuel
3.	☐	Hydraulics
4.	☐	Electrical
5.	☐	Communication/Navigation
6.	☐	Displays
7.	☐	Aircraft Systems
8.	☐	Engines

Figure 10. Malfunction Selection Display

PROCEDURES

NORMAL

1. ☐ Ground

2. ☐ Take-off/Land

3. ☐ Post Land

EMERGENCY

4. ☐ Ground

5. ☐ Take-off/Land

6. ☐ Post Land

Figure 11. Procedures Selection Display

COCKPIT MONITOR

1.  Main Instrument Panel
2.  Left Vertical Console
3.  Right Vertical Console
4.  Left Console
5.  Right Console

Figure 12. Cockpit Monitor Display

ENVIRONMENT/AIRCRAFT DATA

1.	☐	Weather
2.	☐	Visual
3.	☐	Aircraft Configuration
4.	☐	Stores
5.	☐	Carrier
6.	☐	Landing Data
7.	☐	Ejection Data
8.	☐	Initial Conditions Index

Figure 13. Environment/Aircraft Data Selection Display

ENTER		DISPLAY	
1.		Instrument Check #1	11.
2.		CQ - USS America	12.
3.		SID - NAS Oceana	13.
4.		TBD*	14.
5.		TBD	15.
6.		TBD	16.
7.		TBD	17.
8.		TBD	18.
9.		TBD	19.
10.		TBD	20.
21.		Previous Display	
22.		Automated Training Exercise Scenario	
*TO BE DETERMINED			

Figure 14. Automated Training Exercise Index Display

DYNAMIC REPLAY CONTROL	
START REPLAY	
1. ☐	One Minute
2. ☐	Two Minutes
3. ☐	Three Minutes
4. ☐	Four Minutes
5. ☐	Five Minutes
6. ☐	Stop Replay
7. ☐	Fly Out
8. ☐	Previous Display

Figure 15. Dynamic Replay Display

DEMONSTRATION INDEX		
ENTER		
1.		ACLS to USS America
2.		TACAN Approach to NLC 28L
3.		Instrument Take-off and Climb to Cruise Altitude
4.		TBD*
5.		TBD
6.		TBD
7.		TBD
8.		TBD
9.		TBD
10.		TBD
11.		Cross-Country Map
12.		Departures
13.		Approaches
14.		GCA
15.		Previous Display
*To be determined		

Figure 16. Demonstration Index Display

PRINT CONTROL

1. ☐ Enable Print

Current Display

2. ☐ Advance

3. ☐ Reject

4. ☐ Print

5. ☐ Clear All

6. ☐ Print All

7. ☐ Stop Print

8. ☐ Mode Select

Figure 17. Print Control Display

ENGINES MALFUNCTION			
	L	R	
1.		11.	Overtemperature
2.		12.	Overspeed
3.		13.	Low T/O Thrust
4.		14.	Oil Pressure Low
5.		15.	Oil Pressure High
6.		16.	Flame Out
7.		17.	Excess Vibration
8.		18.	Engine Seizure
9.		19.	Nozzles fail open
10.		20.	Nozzles fail closed
21.		Additional Malfunctions	24. Enter
22.		Remove Malfunctions	
23.		Previous Display	

Figure 18. Engines Malfunction Display

AIRCRAFT SYSTEMS MALFUNCTION		
1.		Oxygen Fail
2.		Radar Altimeter Fail
3.		Windshield Hot
4.		TBD*
5.		TBD
6.		TBD
7.		TBD
8.		TBD
9.		TBD
10.		TBD
11.		Additional Malfunctions
12.		Remove Malfunction
13.		Previous Display
14.		Enter

*To be determined

Figure 19. Representative Malfunction Display

INITIAL CONDITIONS INDEX			
	ENTER		DISPLAY
1.		NAS Oceana Parking Ramp	11.
2.		NAS Oceana T. O. RWY 162	12.
3.		USS Nimitz - Case III Marshall	13.
4.		NAS Cherry Point - SID Departure	14.
5.		TBD*	15.
6.		TBD	16.
7.		TBD	17.
8.		TBD	18.
9.		TBD	19.
10.		TBD	20.
21.		Advance Display	
22.		Previous Display	
*To be determined			

Figure 20. Initial Conditions Index Display

INITIAL CONDITIONS NAS OCEANA RAMP

LAT N 36:49:35

Weather
CAVU

LONG W 76:01:20

Altitude MSL 225

External Stores
Clean

True Heading 120

True Airspeed 0

Visual Scene
Dusk

Landing Gear - Down

Flaps - Up

Speed Brakes - In

CARRIER

LAT:

LONG:

Mag Course:

Speed:

1.
2. Weather Display
3. Aircraft Configuration Display
4. Previous Display

Figure 21. Initial Conditions Display

INSTRUMENT CHECK #1

1. TAKEOFF RUNWAY 32R LEMOORE
2. SID: RAG THREE DEPARTURE TO BAKERSFIELD CLIMBING TO FL 270
3. J-5 TO LOS ANGELES
4. DIRECT EL TORO
5. DIRECT EL TORO 120/20
6. HI-TACAN 1 RWY 34R
7. GCA PICK-UP AT 8NM
8. GCA 10 MISSED APPROACH
9. SID: ISLAND-NINE DEPARTURE TO VENTURA CLIMBING TO 310
10. DIRECT PALMDALE
11. DIRECT GEORGE 346/24
12. HI TACAN RWY 16
13. MISSED APPROACH
14. SID: TWENTY-NINE PALMS - ONE DEPARTURE TO PALMDALE
CLIMBING TO FL 220
15. J-65 BAKERSFIELD
16. DIRECT LEMOORE 140/40 DIRECT 140/30
17. ENROUTE DESCENT
18. ACLS TO FULL STOP LANDING

1.
2. Previous Display
3. Automated Training Exercise Scenario

Figure 22. Automated Training Exercise Display

AUTOMATED TRAINING EXERCISE SCENARIO			
LEG NUMBER	DESCRIPTION	PARAMETERS MONITORED	LEG END CONDITIONS
2	CLIMB TO 10,000 FT MAINTAIN HDG 128 DEG	HDG, 128 DEG IAS .8 IMN ROC 10,000 FPM AOA 9 UNITS	ALT 10,000 FT
3	TURN LEFT TO 070 DEG MAINTAIN 10,000 FT	IAS .9 IMN ALT 10,000 FT AOA 2 UNITS SRT 3 DEG/SEC AOB 45 DEG	HDG 070 DEG
4	CLIMB TO FLV 370 MAINTAIN HDG 070 DEG	IAS .92 IMN AOA 9 UNITS ROC 12,000 FPM HDG 070 DEG	ALT FLV 370

1. ☐	Previous Display	6. ☐	Print out
2. ☐	Leg Advance		
3. ☐	Leg Retract		
4. ☐	Leg Select-Enter Leg number		
5. ☐	Auto Training Exercise Map		

Figure 23. Automated Training Exercise Scenario Display

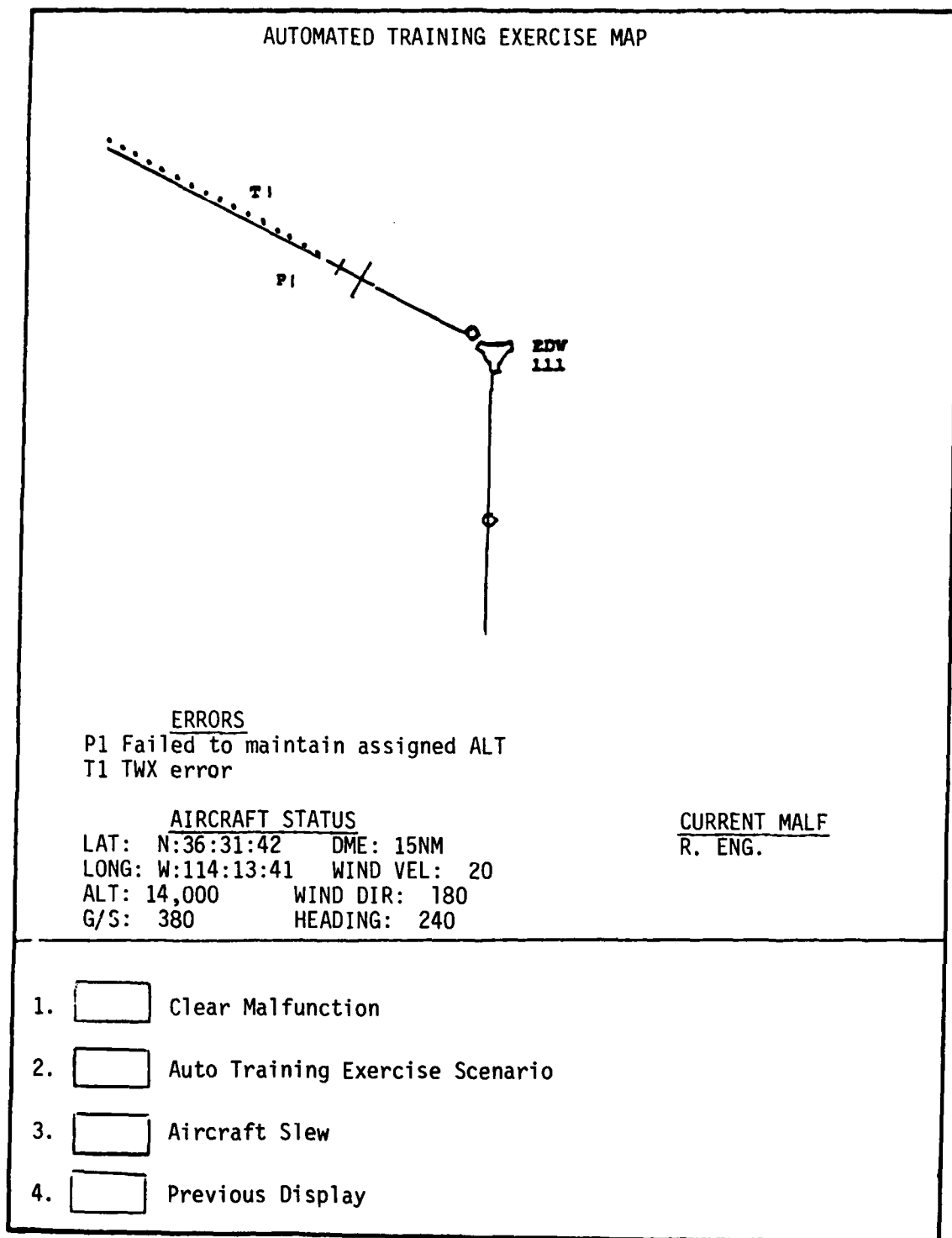


Figure 24. Automated Training Exercise Map Display

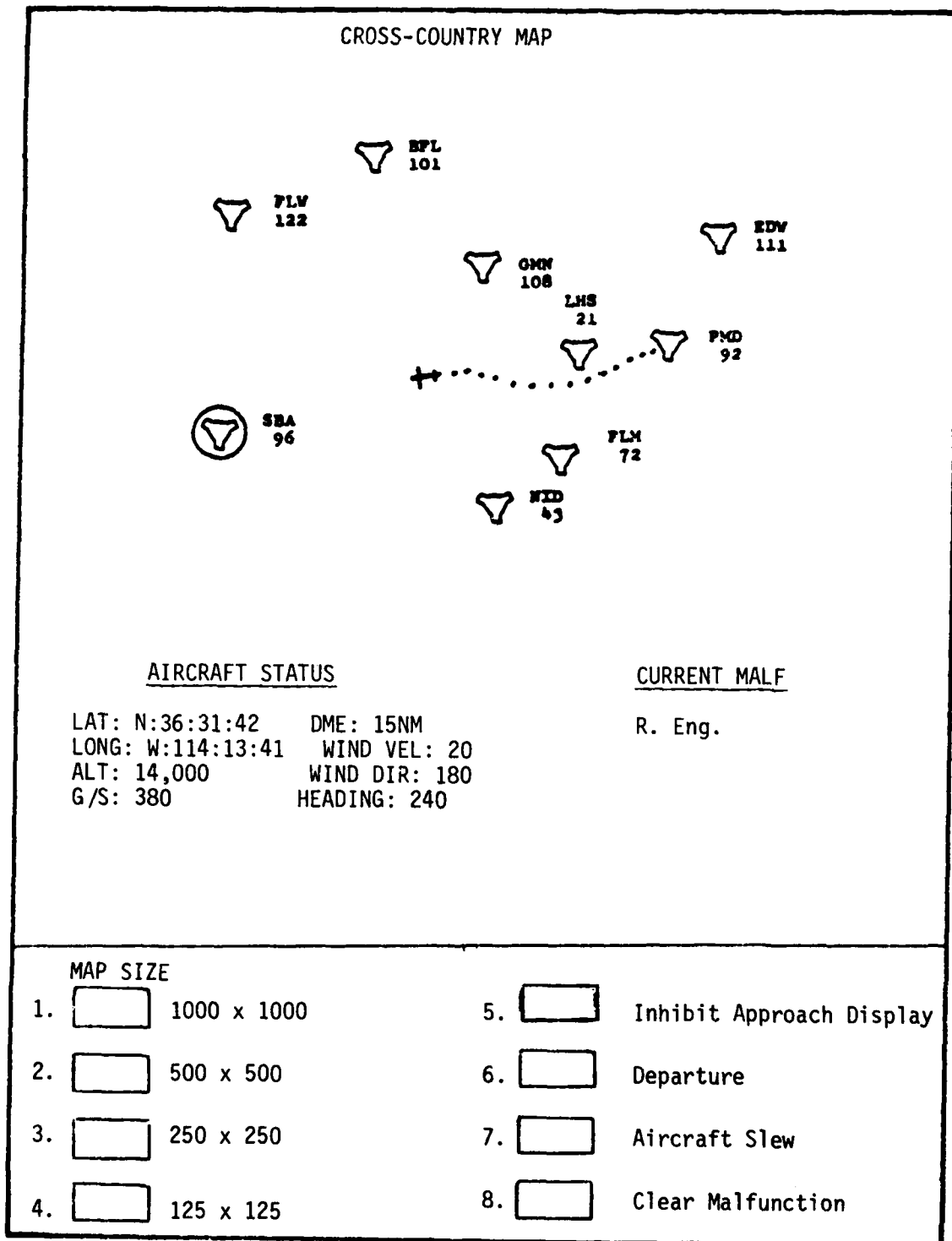
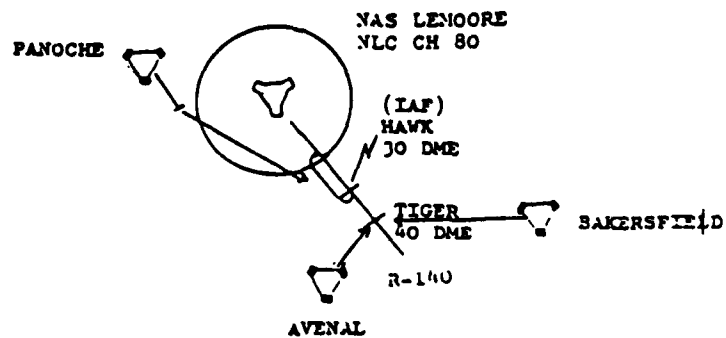


Figure 25. Cross-Country Map Display

APPROACH INDEX		
1.	☐	NAS Oceana TAC 20
2.	☐	NAS Miramar TAC 1 24
3.	☐	NAS Miramar TAC 2 24
4.	☐	TBD*
5.	☐	TBD
6.	☐	TBD
7.	☐	TBD
8.	☐	TBD
9.	☐	TBD
10.	☐	TBD
11.	☐	TBD
12.	☐	TBD
13.	☐	TBD
14.	☐	TBD
15.	☐	TBD
16.	☐	Cross-Country Map
17.	☐	Previous Display
*To be determined		

Figure 26. Approach Index Display

100 NM RADIUS APPROACH



AIRCRAFT STATUS

LAT: N:36:31:42 DME: 15NM
 LONG: W:114:13:41 WIND VEL: 20
 ALT: 14,000 WIND DIR: 180
 G/S: 380 HEADING: 140

CURRENT MALF

R. ENG.

1. ☐ Aircraft Slew
2. ☐ Cross-Country Map
3. ☐ Clear Malfunction
4. ☐ Previous Display

Figure 27. 100NM Radius Approach Display

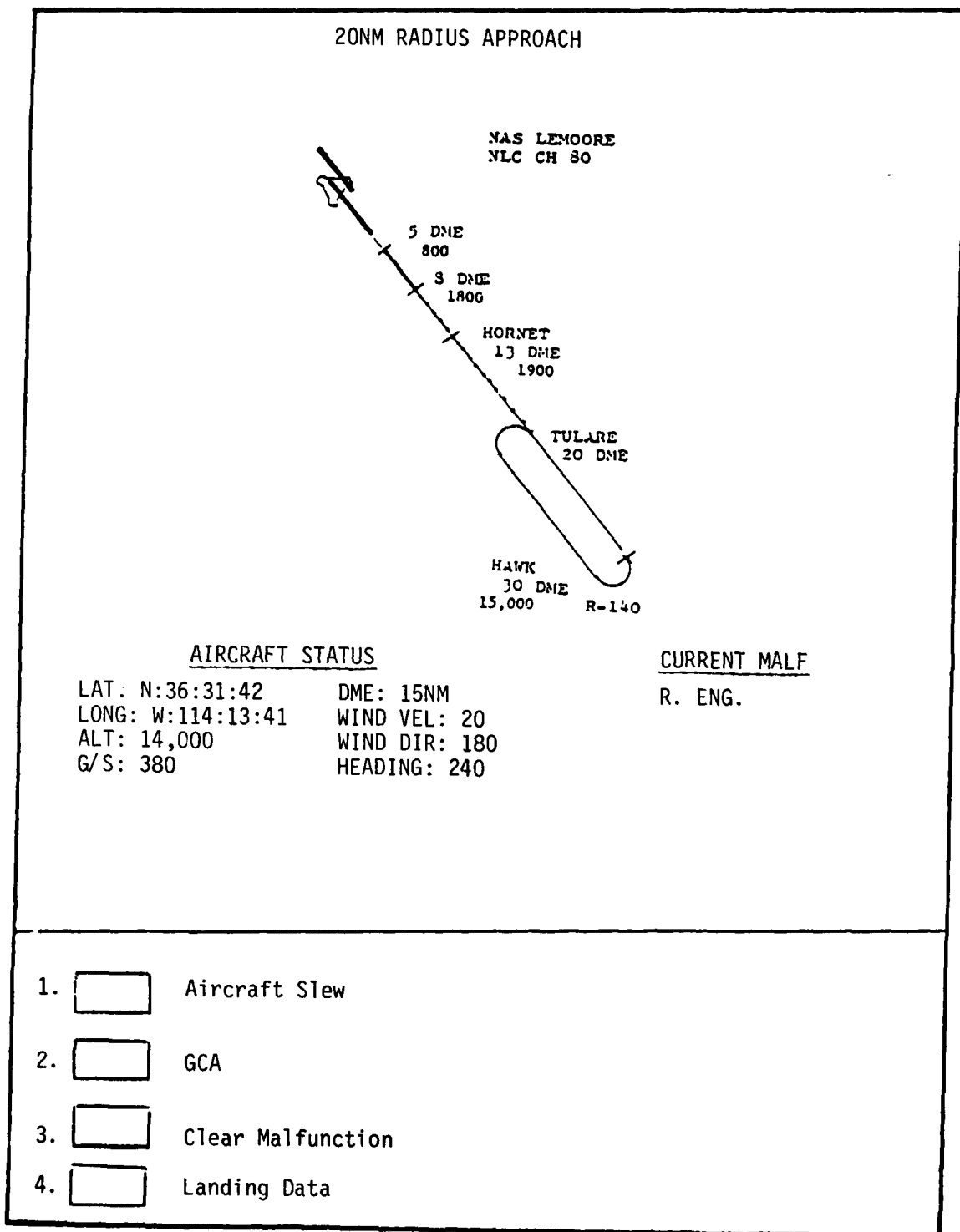


Figure 28. 20NM Radius Approach Display

DEPARTURE INDEX		
1.		NAS OCEANA
2.		MCAS Cherry Point
3.		NAS MIRAMAR
4.		NAS Pensacola
5.		TBD*
6.		TBD
7.		TBD
8.		TBD
9.		TBD
10.		TBD
11.		TBD
12.		TBD
13.		TBD
14.		TBD
15.		TBD
16.		Previous Display

*To be determined

Figure 29. Departures Index Display

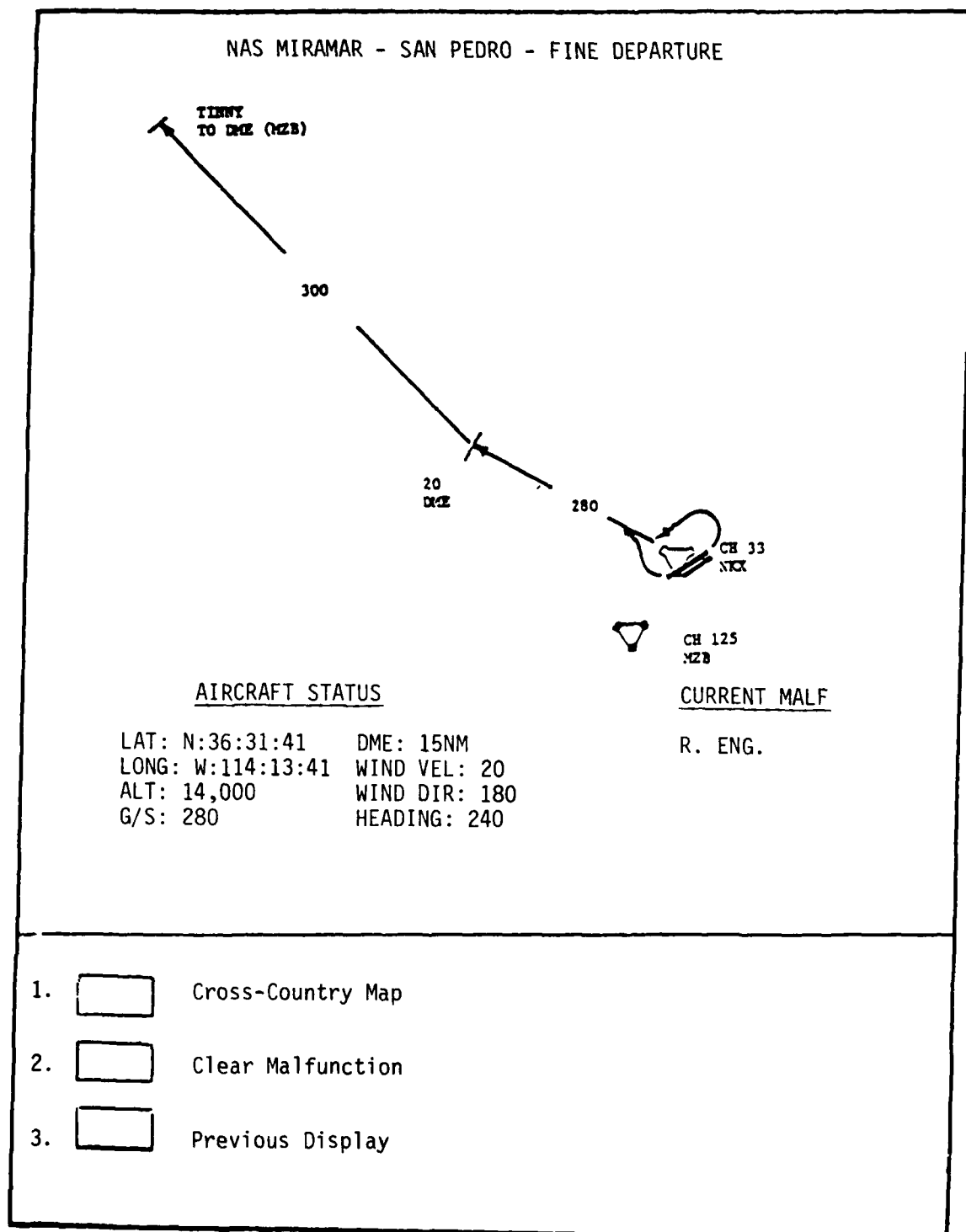


Figure 30. Departure Display

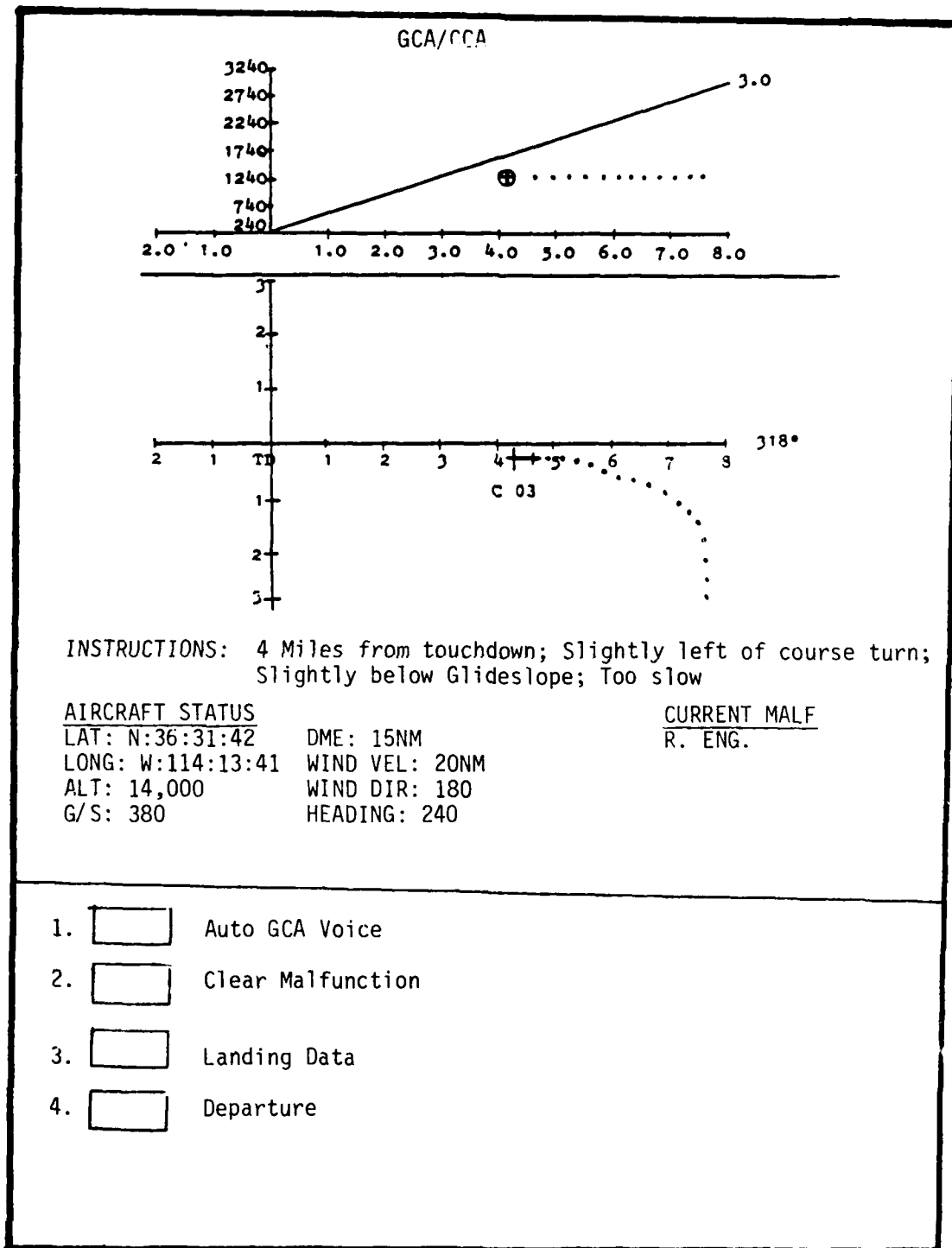


Figure 31. GCA/CCA Display

AD-A117 805

ROWLAND AND CO HADDONFIELD N J
INSTRUCTOR/OPERATOR STATION DESIGN STUDY.(U)
APR 82 W M HINTON, W M KOMANSKI

F/G 5/9

N61339-80-D-0009

NAVTRAEQUIPC-80-D-0009-1

NL

UNCLASSIFIED

2 of 2

AD-A117 805



END
DATE
FILMED
9-82
DTIC

NORMAL PROCEDURES		
<u>GROUND</u>		
1.	☐	Before Start
2.	☐	Start
3.	☐	After Start
4.	☐	Before Take-off
<u>TAKE-OFF/LAND</u>		
5.	☐	Take-off
6.	☐	After Take-off
7.	☐	Before Descent
8.	☐	Landing
<u>AFTER LANDING</u>		
9.	☐	After Landing
10.	☐	Before Engine Shutdown
11.	☐	Engine Shutdown
12.	☐	Previous Display

Figure 32. Normal Procedures Display

PROCEDURE MONITOR TWO ENGINE START 1. L & R GENERATOR SWITCHES...NORM 2. BATTERY SWITCH - ORIDE THEN ON (BATT SW LIGHT ON) 3. EXTERIOR LIGHTS MASTER SWITCH...ON 4. FIRE & BLEED AIR TEST SWITCH...TEST A, TEST B 5. ATSCV CAUTION LIGHT...OFF *6. APU SWITCH...ON 7. APU READY LIGHT...ON (WITHIN 20 SEC) 8. ENGINE CRANK SWITCH...R 9. THROTTLE...IDLE (AT FIRST INDICATION RPM) 10. EGT...BELOW 760 11. ENGINE INSTRUMENTS...CHECK 12. R ENG HYD PRESS...2800 + 200 13. ENG CRANK SWITCH...CHECK RETURNED TO OFF 14. BLEED AIR SWITCH...BOTH 15. START L ENG AS PER ITEMS 8-13 Run 1 - 123587 Run 2 - 123456 Run 3 -	
GENERATOR FAILURE 1. GENERATOR SWITCH - CYCLE 2. IF STILL FAILED GENERATOR SWITCH - OFF 3. AMAD - MONITOR 4. LAND AS SOON AS POSSIBLE Run 1 - Run 2 - Run 3-	
1. 2. 3. 4.	Procedure Advance Remove Malfunction Procedures Previous Display

Figure 33. Procedure Monitor Display

EMERGENCY PROCEDURES (GROUND)

1. ☐ Engine fails to start
 2. ☐ Hot start
 3. ☐ Hung start
 4. ☐ TBD*
 5. ☐ TBD
 6. ☐ TBD
 7. ☐ TBD
 8. ☐ TBD
 9. ☐ TBD
 10. ☐ TBD
-
11. ☐ Emergency Procedures Take-off/Land
 12. ☐ Emergency Procedures Inflight
 13. ☐ Previous Display

*To be determined

Figure 34. Emergency Procedures Gound Display

EMERGENCY PROCEDURES		
<u>TAKE-OFF</u>		
1.	☐	Landing gear will not retract
2.	☐	Blown tire
3.	☐	Abort
4.	☐	Low T.O. thrust
5.	☐	Aircraft settling off catapult
<u>LANDING</u>		
6.	☐	Landing gear will not extend
7.	☐	Brake failure
8.	☐	NLG unsafe
9.	☐	Arresting hook unsafe
10.	☐	Blown tire
11.	☐	Emergency Procedures - Inflight
12.	☐	Emergency Procedures - Ground
13.	☐	Previous Display

Figure 35. Emergency Procedures T.O./Landing Display

EMERGENCY PROCEDURES (INFLIGHT)

- | | | |
|-----|--------------------------|----------------------------------|
| 1. | ☐ | Engine Vibration |
| 2. | ☐ | Flame out |
| 3. | ☐ | Stuck throttle |
| 4. | ☐ | A/B failure |
| 5. | ☐ | Flameout |
| 6. | ☐ | Compressor stall |
| 7. | ☐ | TBD* |
| 8. | ☐ | TBD |
| 9. | ☐ | TBD |
| 10. | ☐ | TBD |
| 11. | ☐ | TBD |
| 12. | ☐ | TBD |
| 13. | ☐ | TBD |
| 14. | ☐ | TBD |
| 15. | ☐ | TBD |
| 16. | ☐ | Emergency Procedures - Ground |
| 17. | ☐ | Emergency Procedures - T.O./Land |
| 18. | ☐ | Previous Display |
- *To be determined

Figure 36. Emergency Procedures - Inflight Display

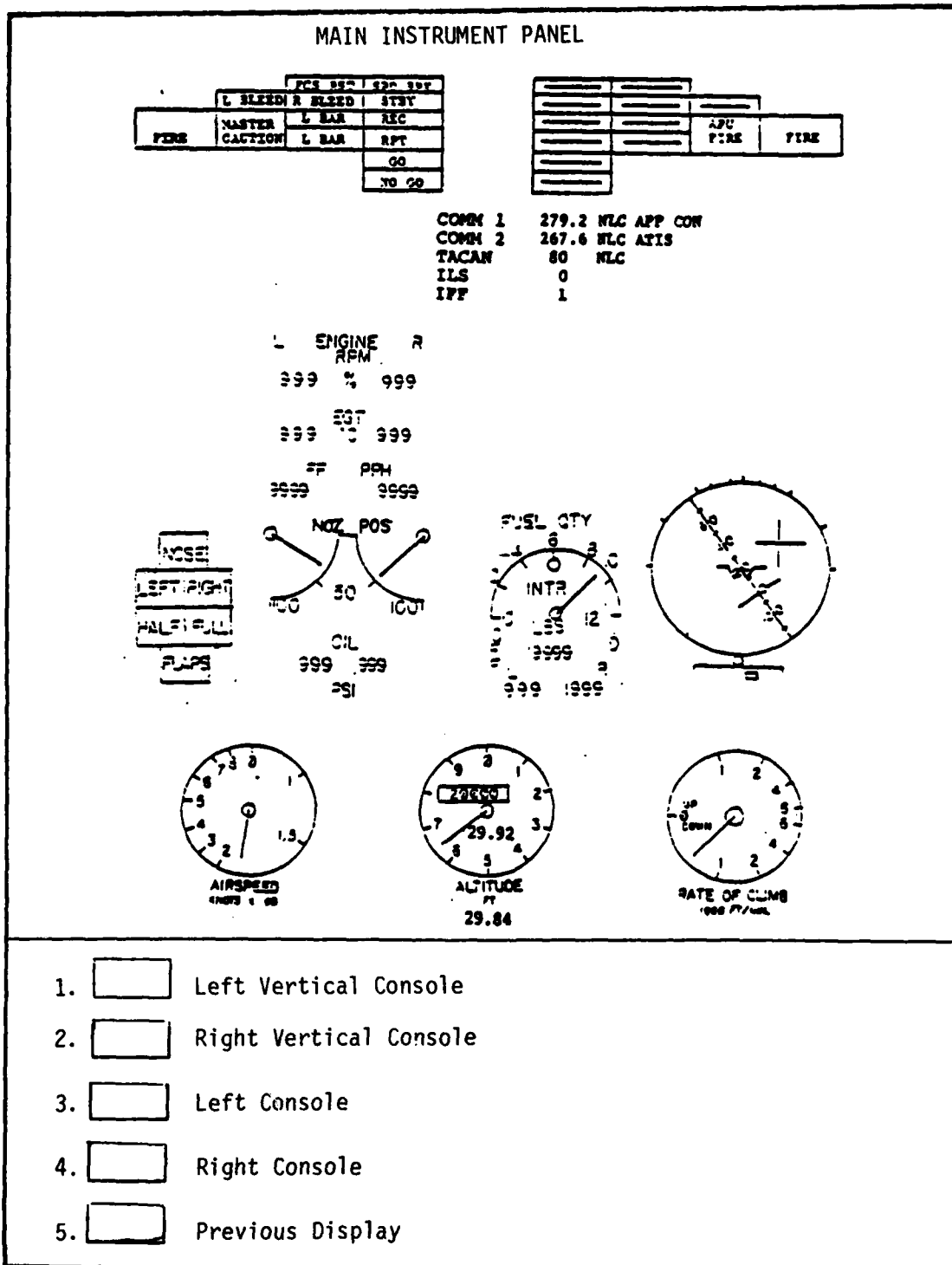


Figure 37. Main Instrument Panel Display

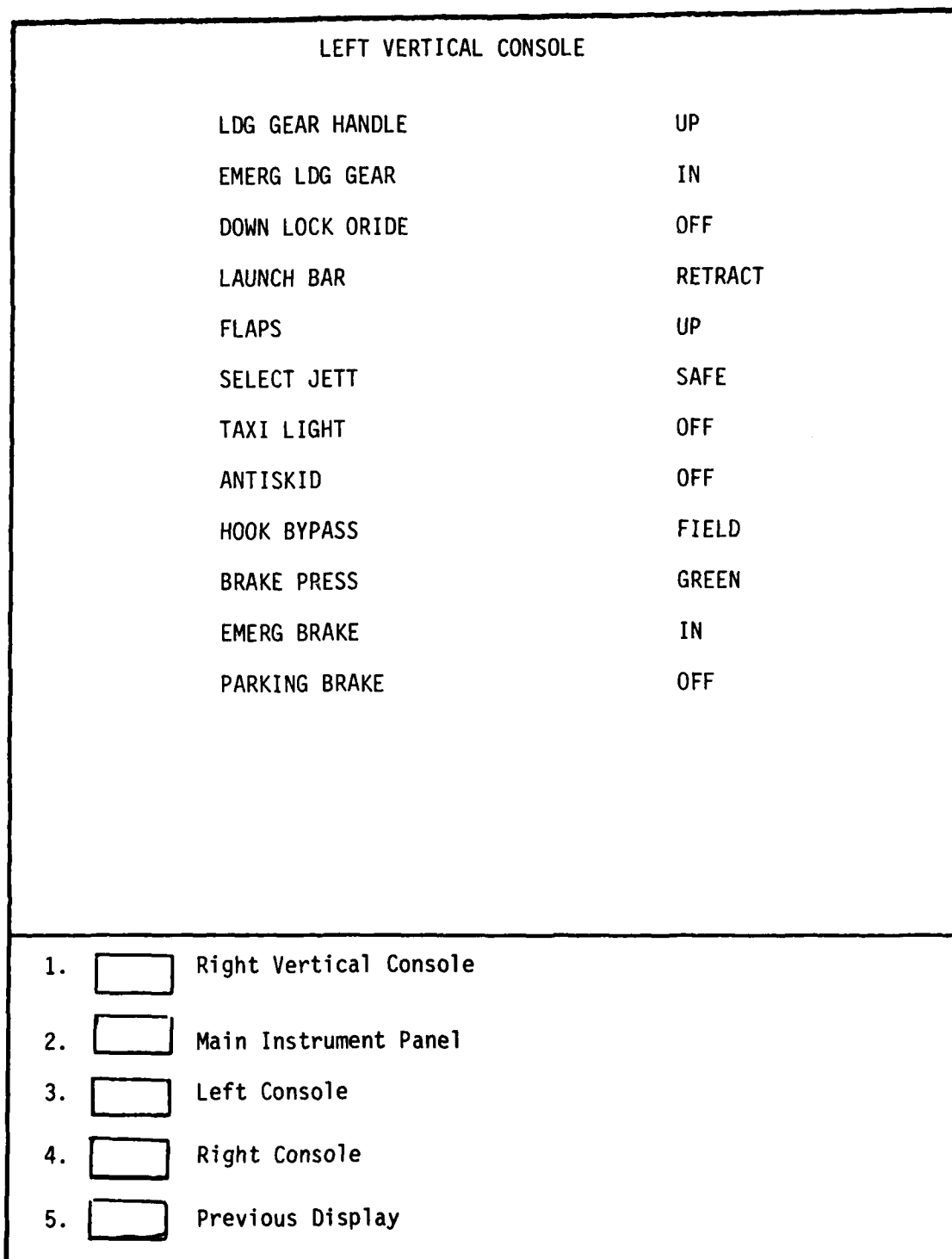


Figure 38. Left Vertical Console Display

LEFT CONSOLE

	PIRE TEST	NORM
GND PWR	GND PWR 1	AUTO
	GND PWR 2	AUTO
	GND PWR 3	AUTO
	FLT CONTR	AUTO
	EXT PWR	NORM
APU	APU	OFF
	ENG CRANK L	OFF
	ENG CRANK R	OFF
FUEL	PROBE	RETRACT
	EXT WING TANKS	NORM
	EXT CTR TANK	NORM
	DUMP	OFF
FCS	PITCH	OFF
	ROLL	OFF
	YAW	OFF
	ARM	OFF
HYD ISOL	MC 1	NORM
	MC 2	NORM
	HYD ISOL	NORM
CIRCUIT BREAKERS	FCS CHAN 1	IN
	FCS CHAN 2	IN
	SPD BPK	IN
	LAUNCH BAR	IN

1. ☐ Main Instrument Panel
2. ☐ Left Vertical Console
3. ☐ Right Vertical Console
4. ☐ Right Console
5. ☐ Previous Display

Figure 39. Left Console Display

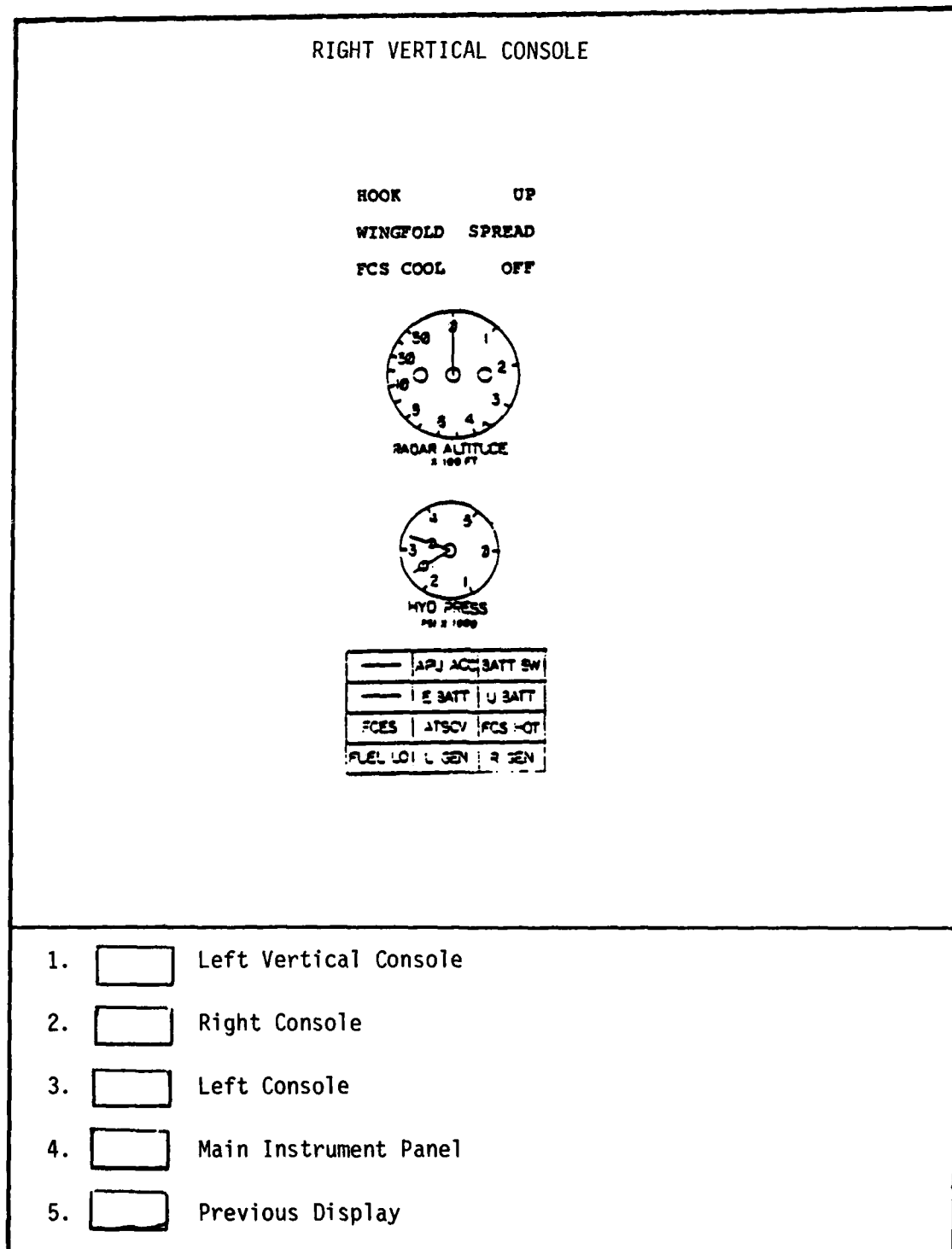


Figure 40. Right Vertical Console Display

RIGHT CONSOLE		
ELEC	L GEN BATT R GEN	NORM ON NORM
ECS	MODE CABIN PRESS PILOT ANTI ICE ENG ANTI ICE BLEED AIR	AUTO NORM AUTO OFF BOTH
INS	MODE	NAV
COMM	COM 1 FREQ ILS CHAN COM 1 ILS	220.4 15 UFC UFC
CIRCUIT BREAKERS	FCS CHAN 3 FCS CHAN 4 HOOK LG	IN IN IN IN
	CANOPY	DOWN

1. ☐ Main Instrument Panel
2. ☐ Left Vertical Console
3. ☐ Right Vertical Console
4. ☐ Left Console
5. ☐ Previous Display

Figure 41. Right Console Display

WEATHER AND CARRIER				
<u>Weather Condition Sets</u>				
	<u>Set 1</u>	<u>Set 2</u>	<u>Set 3</u>	<u>Set 4*</u>
Ceiling	CAVU	2000	500	0
Visibility		5	.5	0
Fog			Yes	Yes
Rain			Yes	
Surf Wind	320/15	200/10	Calm	Calm
Upper Winds	300/30	250/30	180/20	300/20

<u>Individual Weather Parameters</u>	<u>Carrier Data</u>
1. Ceiling_____	7. Latitude_____
2. Visibility_____	8. Longitude_____
3. Fog (yes/no)_____	9. Course_____
4. Rain (yes/no)_____	10. Speed_____
5. Surf Wind_____	
6. Upper Winds_____	

11. Set 1	15. Initial Conditions Index
12. Set 2	16. Previous Display
13. Set 3	
14. Set 4	

Figure 42. Weather and Carrier Data Display

VISUAL SCENE DATA		
Carrier Lights		
1.	☐	Ball _____
2.	☐	Centerline _____
3.	☐	Datum _____
4.	☐	Deck Edge _____
		1 - Minimum Intensity 5 - Maximum Intensity
Airfield		
5.	☐	Runway _____
6.	☐	Approach _____
7.	☐	Centerline _____
8.	☐	Ball/VASI _____
Generic Scene		
9.	☐	Horizon _____
10.	☐	Land on/off _____
11.	☐	Sea on/off _____
12.	☐	Cross-Country Map
16.	☐	Previous Display
13.	☐	Approaches
14.	☐	GCA
15.	☐	Auto Training Exercise Map

Figure 43. Visual Data Display

AIRCRAFT CONFIGURATION

- Parameters
- | | | | |
|----|----------------------|------------------|--------------------|
| 1. | <input type="text"/> | Magnetic Heading | <u>070</u> |
| 2. | <input type="text"/> | Altitude | <u>14,000</u> |
| 3. | <input type="text"/> | Airspeed | <u>400</u> |
| 4. | <input type="text"/> | Total Fuel | <u>10,000</u> |
| 5. | <input type="text"/> | Latitude | <u>N:34:35:36</u> |
| 6. | <input type="text"/> | Longitude | <u>W:119:20:40</u> |
| 7. | <input type="text"/> | TBD* | |
| 8. | <input type="text"/> | TBD | |
| 9. | <input type="text"/> | TBD | |

- | | | |
|-----|----------------------|--------------------|
| 10. | <input type="text"/> | Initial Conditions |
| 11. | <input type="text"/> | Cross-Country Map |
| 12. | <input type="text"/> | External Stores |

*To be determined

Figure 44. Aircraft Configuration Display

EXTERNAL STORES		
<u>Current Configuration</u>		
1.		Station 1 <u>SW</u>
2.		Station 2 <u>MK 82</u>
3.		Station 3 <u>MK 82</u>
4.		Station 4 <u>MK 82</u>
5.		Station 5 <u>MK 82</u>
6.		Station 6 <u>SW</u>
<u>Parameters</u>		
7.		SW
8.		SP
9.		MK 82
10.		MK 83
11.		MK 20
12.		B57
13.		Remove
	Aircraft Configuration	
	Initial Conditions	
	Previous Display	

Figure 45. External Stores Display

LANDING DATA	
<u>Carrier</u>	
2	WIRE CAUGHT
107	HOOK CONTACT FROM ROUNDDOWN
14	HOOK TO RAMP CLEARANCE
9	LAT DIST FROM CENTERLINE
13	ROD AT DECK CONTACT (FPS)
	ACFT ATT AT DECK CONTACT
12 DEG ANU	PITCH
5 DEG RWD	ROLL
2 DEG ANL	YAW
CENTERED	BALL POSITION
0	DRIFT RATE AT TOUCHDOWN
<u>Runway</u>	
800	CONTACT FROM THRESHOLD
10	LAT DIST FROM CENTERLINE
10	ROD AT TOUCHDOWN (FPD)
	ACFT ATTITUDE AT TOUCHDOWN
6 DEG ANU	PITCH
0	ROLL
0	YAW
0	DRIFT RATE AT TOUCHDOWN
CENTERED	BALL POSIT/VASI
<u>Ejection Data</u>	
400	INDICATED AIR SPEED (KTS)
8140	ALTITUDE (FT)
-23000	VERTICAL VELOCITY (FPM)
70LWD	BANK ANGLE (DEG)
-80	PITCH (DEG)
YES	SUCCESSFUL?
1. ☐ Previous Display	

Figure 46. Landing/Ejection Data Display

MENU

Instructions: Select desired program to assist you in the operation or providing instruction in the trainer.

1. Touch the "Select" control on CRT.
2. Touch the "Enter" control.

Display will advance to the selected program.

SELECT	Free Flight	SELECT	General Overview
SELECT	Auto Training Exercises	SELECT	TBD
SELECT	Checkride	SELECT	TBD
SELECT	Demonstration	SELECT	TBD

MENU ENTER CLEAR ADVANCE RETURN HSI MFD RADAR

Figure 47. Sample IAS Menu Display.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

The two alternative IOS designs presented in the previous section contain the same basic instructional capabilities and features. They differ in the ways in which these capabilities and features are implemented in the hardware and software design. Inherent in the implementation approaches selected and the resultant designs are advantages and disadvantages of one design versus the other. The advantages and disadvantages provide a basis and rationale for recommending one alternative over the other.

ADVANTAGES AND DISADVANTAGES

Tables 1 and 2 contain the advantages and disadvantages of alternatives 1 and 2 respectively. The following paragraphs contain discussions of the advantages and disadvantages in the two tables.

ALTERNATIVE 1. Alternative 1 is characterized by minimum use of fixed function electronic touch pads and maximum use of CRT touch panels. The emphasis is on simplicity of the IOS, and simulation monitoring and control via displays and their associated touch panels.

Advantages. As a result of the low number of fixed-function controls on the IOS console the IOS is simple and compact. Also contributing to the compact design is the clustering of the CRTs into what is essentially a single-position station. The appearance of the IOS does not overwhelm new instructors. On the contrary, it presents a positive image for ease of operation.

The compact size of the IOS enhances the instructor's span of control and enables him to easily scan all controls and displays. All operations can be carried out while the instructor is seated at a single position. The station is designed to meet human factors specifications for reach envelope, instructor anthropometry, visibility, etc.

Alternative 1 takes full advantage of available control, display, and software state-of-the-art technology. Its design and operation are not driven by the technology. Rather, they are intended to take full advantage of what is available and in doing so to further advance the state-of-the-art in IOS design.

The software capacity of alternative 1 provides for maximum flexibility in use of the trainer. Controls and displays are readily accessible through the software associated with the displays and touch panels. Efforts have been made to use concepts which minimize the number of decision steps in making selections. This results in increases in the ease of taking advantage of the design flexibilities.

TABLE 1. ALTERNATIVE 1

ADVANTAGES	DISADVANTAGES
1. IOS appearance is simple and compact.	1. More and complex software required.
2. Ease of scan and IP span of control.	2. More IP knowledge and skill initially required to operate the trainer
3. Utilize computer and simulation technology state-of-the-art.	3. More selection steps required to access certain display, and to make control and data entries.
4. Provides maximum flexibility in use of the device.	
5. Reauily revised/updated through software changes.	

TABLE 2. ALTERNATIVE 2

ADVANTAGES	DISADVANTAGES
1. Majority of controls are mounted on the vertical panel of IOS console. Can be visually observed by the IP.	1. Due to the number of controls mounted on the IOS vertical panels, the console will appear cluttered.
2. Less complex software required.	2. Span of control and IP scan may be affected by the increased size of the IOS.
3. IP knowledge and skills requirements are simplified.	3. More difficult to revise and update.
4. Number of steps to access certain controls and displays is minimized.	4. Control is divided between two modes: panel mounted electronic touch pads and CRT touch panels.

Programmed scenarios, procedures, alternatives, etc. are readily updated through software changes. This flexibility is afforded through the use of variable-function touch panels, as opposed to fixed-function touch pads, and the use of a variety of software support features.

Disadvantages. Alternative 1 required more and complex software. This greater software requirement in comparison to alternative 2 is necessary to enable scenario selection and control through a central master menu.

More initial IP training is required to allow full operation of the trainer. This training primarily involves use of the menus, familiarity with selection alternatives, and anticipation of decision points. Through proper programming and use of the IAS, and a limited amount of experience, it is anticipated that this disadvantage would be minimized.

In certain situations more steps are required to select desired displays and make data entries. The steps are required to branch through the menus and indices to access the desired end point.

ALTERNATIVE 2. Alternative 2 is characterized by extensive use of fixed-function electronic touch pads on the IOS console. The touch pads serve the same functions as many of the menus, indices, and touch panel selection options in alternative 1. The major IOS configuration difference is the prevalence of these electronic touch pads.

Advantages. Most of the basic simulation controls are located on the IOS console. They are, therefore, always available for observation, study, and activation. Through their presence and labelling many of the capabilities of the device are displayed without reference to manuals or the software.

The software required in alternative 2 is less complex than that in alternative 1. This results from the use of fixed-function electronic touch pads on the IOS console in lieu of menus, indices, and CRT touch panels which are used in alternative 1.

Since many of the device controls and capabilities are "hard-wired" on the IOS console, IP skill and training requirements are reduced. It is anticipated that IOS familiarization training would be simplified, retention improved, and maintenance and upgrade of skills improved.

The use of fixed-function electronic touch pads, in many cases, minimizes the number of steps required to access controls and displays. The touch pads enable the instructor to go directly to the final selection index or the desired end display without branching through a sequential set of menus. Thus efficiency is enhanced.

Disadvantages. Alternative 1 contains a large number of fixed-function electronic touch pads on the IOS console. Even with a layout based on good principles of human factors, the IOS will appear cluttered and may in certain situations be inefficient to operate or lead to confusion. The clutter may have a psychological impact on instructors (i.e., the complexity of the device operations may appear overwhelming).

To accommodate the layout of console-mounted electronic touch pads the IOS will be larger than that in alternative 1. This increased size may affect the instructor's span of control and ability to scan the IOS controls and displays. It may also reduce the instructor's capability to conveniently control all operations from a seated position.

The greater use of fixed-function controls rather than software driven variable-function panels makes revision and update more difficult. Some revisions/updates will require hardware changes. These same revisions/updates in alternative 1 would require only software changes.

Control of exercises is divided between two modes: panel-mounted electronic touch pads and CRT touch panels. It is anticipated that operations using the two modes will be less efficient than the same operations using a single mode (e.g., CRT touch panels in alternative 1).

RECOMMENDATION

Alternative 1 is the preferred of the two IOS alternatives presented in this report. It incorporates state-of-the-art advances in simulation control without allowing technology to drive the design. The alternative 1 design facilitates simulation control from a compact, easy-to-operate station. Factors supporting the selection of alternative 1 are as follows:

- The minimum requirement for surfaces on which to mount fixed-function controls and the clustering of the four displays facilitates implementing good human factors design principles for anthropometric design, reach envelope, scan patterns, display interpretation, etc. The IOS workplace will be well "human-engineered" for the instructor.
- Prompting and instructions provided by the IAS cue the instructors to effectively carry out their roles and responsibilities. This cuing function will enable efficient use of the IOS displays and CRT touch panels. Cuing will be particularly relevant to guide instructors through the selection processes emanating from the master menu.
- The IOS design, features, displays, etc. are based on the state-of-the-art and on emerging trends in IOS operations. The applications embodied in alternative 1 are consistent with directions for improvement which have been recommended in recent and ongoing studies.

As noted previously, the two alternatives are examples which represent the ends of a continuum. The continuum spans the feasible range of use of hard-wired controls (i.e., electronic touch pads). One end, minimum use, is embodied in alternative 1. The other end, maximum use consistent with human factors considerations, is embodied in alternative 2.

Since the alternatives are examples, rather than specific, unchangeable configurations, focus of the recommendation of this report is on the concepts presented for alternative 1 and on the advantages of the end of the continuum of which alternative 1 is an example. The primary recommendation of this report, therefore, is that the preferred approach to IOS design for an OFT or similar trainer is to incorporate the fundamental principles which are contained in alternative 1. These principles provide the best blend of state-of-the-art technology, capabilities based on training requirements, flexibility, ease of operation, and simplicity of design.

CONCLUSIONS

IOS design has suffered from the same malady that has plagued the design of many other pieces of sophisticated hardware: insufficient analysis efforts and data on which to base decisions. As a result many previous IOSs have not been designed to facilitate training. They have contained the shortcomings discussed in Section I of this report.

The purpose of this report has been to develop an approach to upgrading IOS design and to present sample designs derived through the approach. The emphasis of the developmental process has been on the necessity for good front-end analyses and the use of the analysis data in the design process. Major sources of data were training tasks, instructor tasks, design principles, and technology. The output was design alternatives derived through combining, accessing, and using the data. The alternatives are certainly not exhaustive. They are good, representative examples.

The primary conclusion of this report is that the design of an efficient, functional IOS requires systematic application of a variety of human factors and training data. The recommended alternative presented previously resulted from such a process. Future IOSs should be derived through a similar analysis process and should benefit from the techniques and results of this study. Alternative 1 is considered an optimal solution within the assumptions and constraints of the study.

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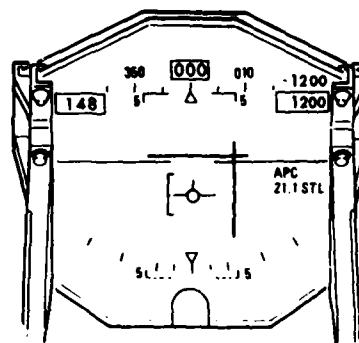
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APPENDIX A
GENERIC INSTRUCTOR/OPERATOR STATION LAYOUT
ALTERNATIVES 1 AND 2

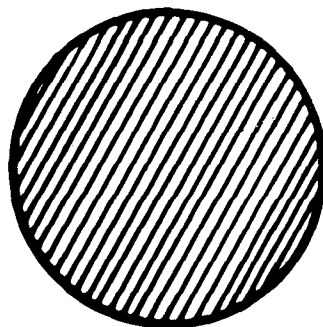
DISPLAY 1

VISUAL MONITOR



HEAD-UP DISPLAY

INCREASE
OFF • 
TURBULENCE
INCREASE
OFF • 
WIND VELOCITY



SPEAKER

FRONT • • LEFT FWD
OFF •  • RIGHT FWD

TRIM
AIRCRAFT

INSTRUCTOR AID SYSTEM

DISPLAY 2

DIGITAL CLOCK

2.

DISPLAY 2

00

5

INSTRUCTOR AID SYSTEM

MENU

ENTER

CLEAR

ADVANCE

RETURN

HSI

IAS
POWER

TRAINER CONTROL

POWER

FREEZE

STAND BY

MOTION

OPERATE

RESET

COMMUNICATIONS

MAINT CALL

ICS

ICS OVERRIDE

UHF 1

UHF 2

UHF 1

UHF 2

SPEAKER

SOUND

OFF

MAX

OFF

MAX

INSTRUCTOR CONTROL

MENU

SAVE DISPLAY

NORMAL ARREST

CRASH OVERRIDE

BARRIER ARREST

MALFUNC OVERRIDE

CATAPULT

CATAPULT HOLD

CATAPULT FIRE

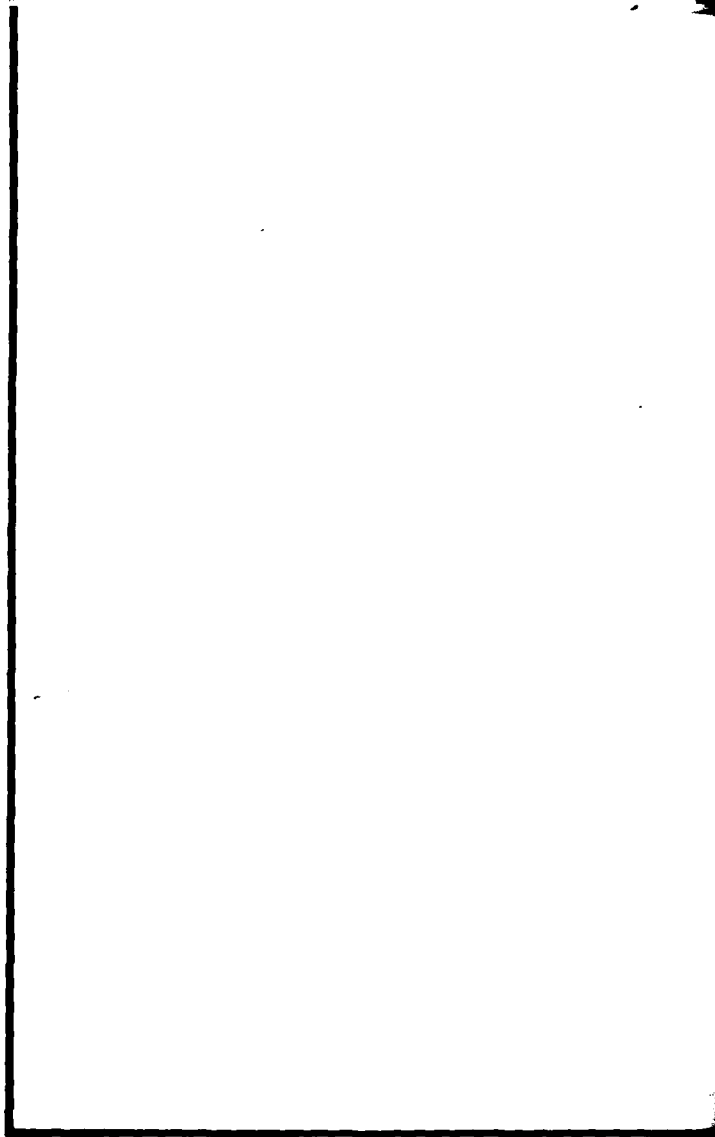
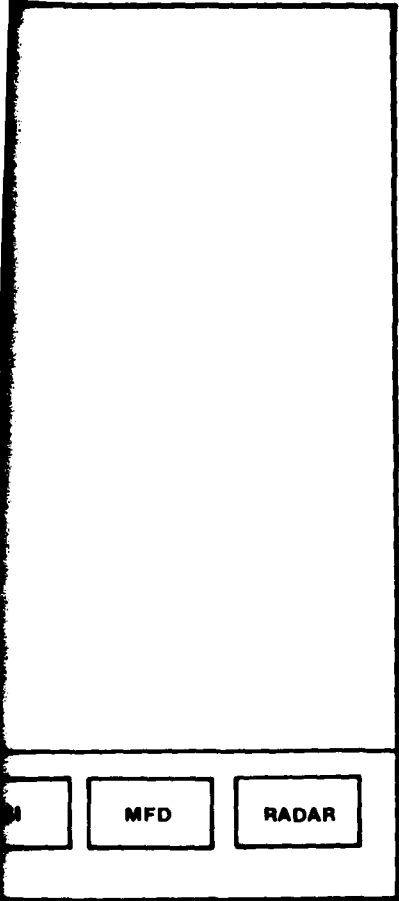
1

4

7

CLEAR

6

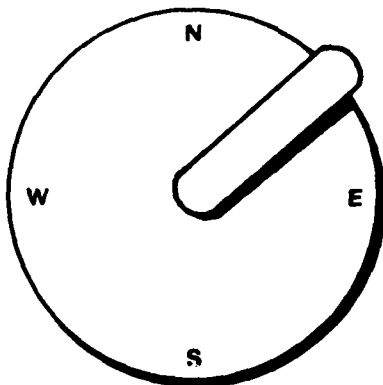


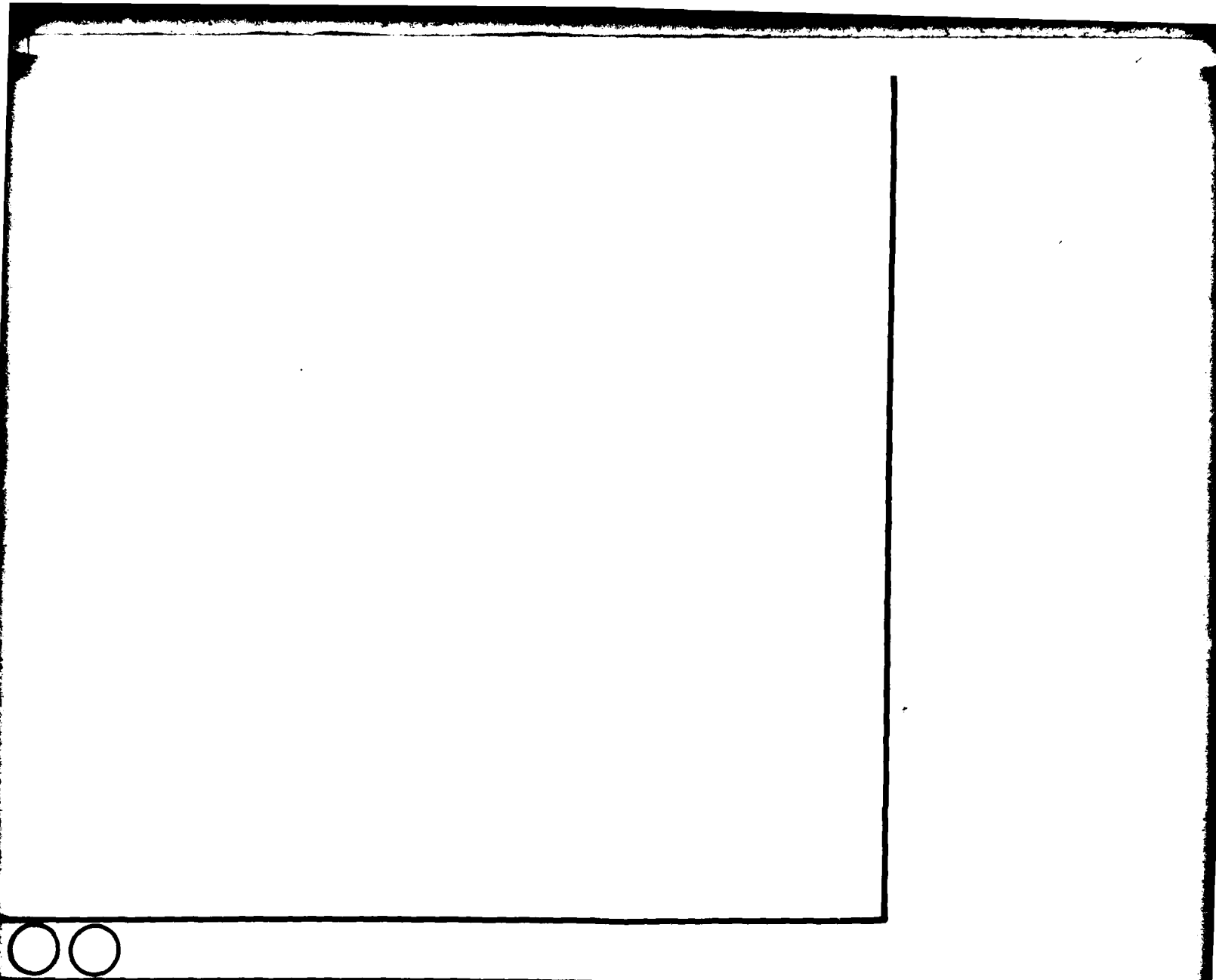
KEYBOARD

SLEW AIRCRAFT

WORK SUR

1	2	3
4	5	6
7	8	9
CLEAR	0	ENTER



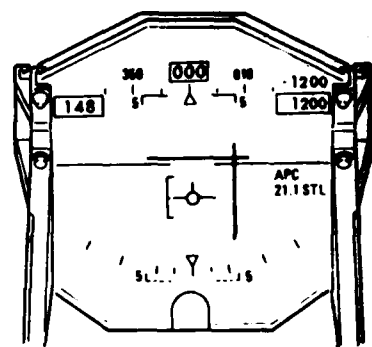


WORK SURFACE

8

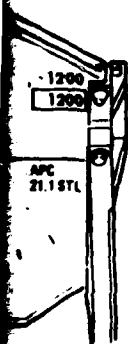
GENERIC INSTRUCTOR/OPERATOR STAT
LAYOUT - ALTERNATIVE 1

VISUAL MONITOR



HEAD-UP DISPLAY

NTOR



3

FRONT • • LEFT FWD
OFF • • RIGHT FWD

TRIM
AIRCRAFT

DIGITAL CLOCK

4

DISPLAY 1

5

DISPLAY 2

MALFUNCTION

ENGINES			FLIGHT CONTROL		FUEL		HYDRAULICS	
L	R							
1. ☐ SELECT	11. ☐ SELECT	OIL PRESS LOW	1. ☐ SELECT	FLAPS LOCK UP	1. ☐	WING TANK L FAILS TO TRANSFER	1. ☐	HYD SYS 1A PRESS LOST
2. ☐	12. ☐	OIL PRESS HIGH	2. ☐	SPEED BRAKE FAIL OPEN	2. ☐	DROP TANK L FAILS TO TRANSFER	2. ☐	HYD SYS 1B PRESS LOST
3. ☐	13. ☐	OVERSPEED	3. ☐	RUNAWAY TRIM STAB	3. ☐	FUEL BOOST PRESS: LOW L	3. ☐	HYD SYS 2A PRESS LOST
4. ☐	14. ☐	OVERTEMP	4. ☐	FCS HOT	4. ☐	BOOST PUMP FAIL - FWD	4. ☐	HYD SYS 2B PRESS LOST
5. ☐	15. ☐	LOW T/O THRUST	5. ☐	AUTO PILOT NOT ENGAGE	5. ☐	BOOST PUMP FAIL - AFT	5. ☐	APU ACCUM PRESS LOW
6. ☐	16. ☐	EXCESS VIBRATION	6. ☐	AOA INOPERATIVE	6. ☐	FUEL HOT L	6. ☐	BRAKE ACCUM PRESS LOW
7. ☐	17. ☐	FLAMEOUT	7. ☐	ROLL RATE LIMITER INOPERATIVE	7. ☐	FUEL HOT R	7. ☐	TBD
8. ☐	18. ☐	FLAMEOUT NO START	8. ☐	PCAS FAILURE	8. ☐	IFR PROBE UNLOCKED	8. ☐	TBD
9. ☐	19. ☐	ENGINE SEIZURE	9. ☐	TBD	9. ☐	INFLIGHT FUEL TRANSFER UNABLE	9. ☐	TBD
10. ☐	20. ☐	NOZZLES FAIL CLOSE	10. ☐	TBD	10. ☐	FUEL LOW	10. ☐	TBD
21. ☐	ADDITIONAL MALFUNCTIONS		11. ☐	ADDITIONAL MALFUNCTIONS	11. ☐	ADDITIONAL MALFUNCTIONS	11. ☐	ADDITIONAL MALFUNCTIONS

6

FUNCTIONS

ELECTRICAL

COMM/NAV

DISPLAY SUBSYSTEMS

AIRCRAFT SYSTEMS

HYD SYS 1A PRESS LOST	1.	☐	BATTERY SW. INOPERATIVE	1.	☐	INS ATTITUDE FAIL	1.	☐	HUD FAIL	1.	☐	LANDING GEAR NOT RETRACT
HYD SYS 1B PRESS LOST	2.	☐	GEN OFF LINE L	2.	☐	AIR DATA COMPUTER FAIL	2.	☐	UFC FAIL	2.	☐	LANDING GEAR NOT EXTEND
HYD SYS 2A PRESS LOST	3.	☐	GEN OFF LINE R	3.	☐	COMM 1 FAIL	3.	☐	LEFT UDI FAIL	3.	☐	MLG DOWN NLG UNSAFE
HYD SYS 2B PRESS LOST	4.	☐	DOUBLE GEN FAILURE	4.	☐	COMM 2 FAIL	4.	☐	RIGHT UDI FAIL	4.	☐	BLOWN TIRE NOSE
APU ACCUM PRESS LOW	5.	☐	BATTERY CHARGE LOW	5.	☐	TACAN FAIL	5.	☐	HSD FAIL	5.	☐	BLOWN TIRE L. MAIN
BRAKE ACCUM PRESS LOW	6.	☐	FCS CB OPEN	6.	☐	ADF FAIL	6.	☐	MISSION COMPUTER ONE - FAIL	6.	☐	BRAKE FAIL LEFT
TBD	7.	☐	TBD	7.	☐	RADAR ALT FAIL	7.	☐	MISSION COMPUTER TWO - FAIL	7.	☐	HOOK NO RETRACT
TBD	8.	☐	TBD	8.	☐	DATA LINK INOPERATIVE	8.	☐	CSC FAIL	8.	☐	ANTI - SKID INOPERATIVE
TBD	9.	☐	TBD	9.	☐	TBD	9.	☐	TBD	9.	☐	WINGS UNLOCKED
TBD	10.	☐	TBD	10.	☐	TBD	10.	☐	TBD	10.	☐	OXYGEN FAIL
ADDITIONAL MALFUNCTIONS	11.	☐	ADDITIONAL MALFUNCTIONS	11.	☐	ADDITIONAL MALFUNCTIONS	11.	☐	ADDITIONAL MALFUNCTIONS	11.	☐	ADDITIONAL MALFUNCTIONS

MEMO

IAS
POWER

DYNAMIC REPLAY

PRINT CONTROL

DYNAMIC REPLAY

PRINT ENABLE

REPLAY 1 MIN

CURRENT DISPLAY PRINT

REPLAY 2 MIN

CURRENT DISPLAY REJECT

REPLAY 3 MIN

CURRENT DISPLAY ADVANCE

REPLAY 4 MIN

PRINT ALL

REPLAY 5 MIN

CLEAR ALL

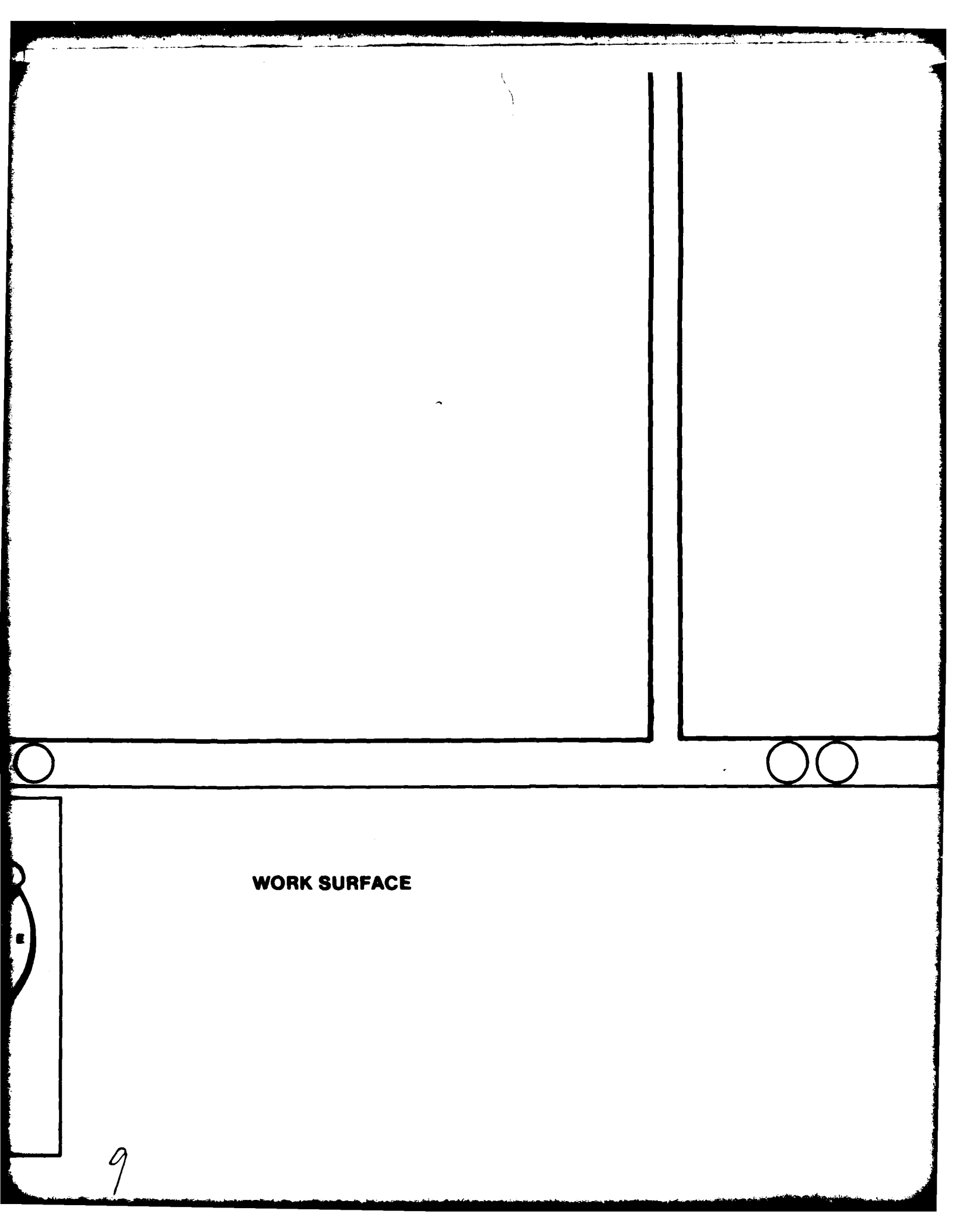
EXIT

PRINT AUTOEXER SUMMARY

FLY OUT

PRINT PARAMETER RECORD

7



WORK SURFACE

9

**GENERIC
INSTRUCTOR/OPERATOR STATION
LAYOUT - ALTERNATIVE 2**

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