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ABSTRACT

This report is the second of two volumes which document the research and analysis project that resulted in the development of Instructor Support Feature (ISF) Guidelines. These guidelines are intended to aid operational users from the Air Force major commands, Simulator Systems Program Office procurement personnel, and contractors in the development and procurement of instructor support systems for future aircrew training devices (ATDs). The first of four sections in this volume introduces the contents and purpose of these guidelines and provides an overview of their background and development. The second section explains the concept of the Instructor Support System (ISS) and the functions it serves, while the third presents a systematic approach for the selection of instructor support features. Intended for use during system development, the fourth section presents and discusses a format for providing the operational information needed to implement the instructor support system features selected. Also included are: a list of six primary references; a glossary of terms; a list of abbreviations and acronyms; a subject index to the report; and seven appendices. Appended materials include a list of documents pertaining to specific aircrew training devices; a four-page bibliography; a sample specification illustrating the use of these guidelines; a list of training sites visited with dates; a task commonality analysis; and samples of two basic task module types--flight and procedural. (DJR)

AFHRL-TR-85-57(II)

AIR FORCE HUMAN RESOURCES LABORATORY

INSTRUCTOR SUPPORT FEATURE GUIDELINES

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The Public Affairs Office has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report documents the development of specification guidelines for aircrew training device (ATD) Instructor Support Feature (ISF) requirements. Thirteen advanced instructional systems and ATDs provided data for identification and definition of ISFs. These operational definitions and a recommended specification procedure were written to aid operational users from the major commands, SimSPO procurement personnel, and contractors. One conclusion reached as a result of the specification procedure development is that both student training and instructor requirements be analyzed comprehensively. Other study results point to the need for instructor training in the use of ISFs. The data, methods, and analysis used to reach these conclusions, and others are reported. Volume I documents the research and development effort and presents methodology, results, conclusions, and recommendations. Volume II contains the ISF Guidelines. The ISF Guidelines is a "living" document. The current version of the Guidelines can be obtained from the Simulator Systems Program Office, ASD/YWEE, Wright-Patterson AFB, OH.

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SUMMARY

This report documents the research and analysis project that resulted in the development of Instructor Support Feature (ISF) Guidelines. The guidelines are intended to aid operational users from the Air Force major commands, Simulator Systems Program Office procurement personnel, and contractors in the development and procurement of instructor support systems for future aircrew training devices (ATDs). During the 12-month technical effort, the Guidelines content and format were defined, data were collected and analyzed for inclusion within the Guidelines, and the Guidelines document was written. Thirteen advanced instructional systems and ATDs provided data for identification and definition of ISF requirements. Volume I documents the research and development effort and presents methodology, results, conclusions, and recommendations. Volume II contains the ISF Guidelines. The ISF Guidelines is a "living" document. The current version of the Guidelines can be obtained from the Simulator Systems Program Office, ASD/YWEE, Wright-Patterson AFB, OH.

PREFACE

This document is the final report of the Performance Measurement System (PMS) Guidelines for Aircrew Training Devices (ATDs) project conducted under Contract Number F33615-84-C-0054, sponsored by the Air Force Human Resources Laboratory (AFHRL). The project focused on the development of the Instructor Support Feature Guidelines to aid in the specification of requirements for ATD acquisitions.

Drs. Wayne Waag and Gary Thomas of AFHRL/OT provided technical direction during the course of the study. Mr. Craig McLean and his staff at the Simulator Systems Program Office made valuable contributions to the contents of the Instructor Support Feature Guidelines.

The authors wish to express their gratitude to the many operational personnel at the training sites visited for their time and assistance. Their input greatly added to the operational validity of this report.

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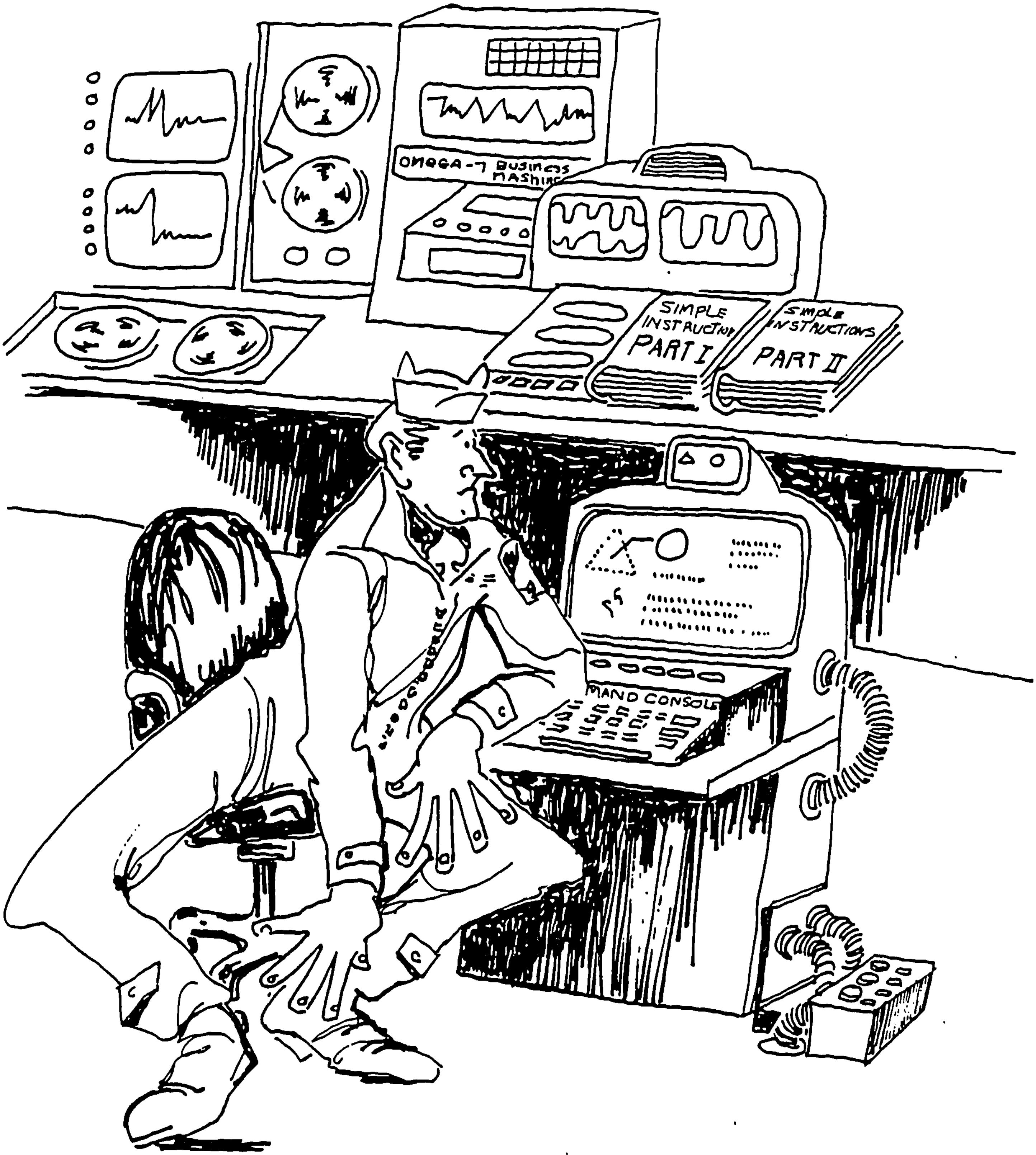
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PART I
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PART II
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SECTION I
OVERVIEW

Introduction

Aircrew training devices may be conceptualized as consisting of two main components: the simulation system and the instructional system. Within the simulation component, the major issue is fidelity. In other words, to what extent should the training situation be a faithful reproduction of the aircraft and the flight environment? To date, the majority of R & D efforts have focused on this component.

The other component, the instructional system, is what makes the simulator a training device. It consists of those capabilities specifically designed to enhance the training process by providing instructor support features (ISFs). The purpose of these features is to increase the instructor's efficiency and effectiveness by reducing the workload involved in conducting the training exercise. Thus through the implementation of a set of such features, the instructor is freed to devote more of his attention to the training function.

However, attempts to develop and provide a comprehensive instructional system have sometimes created more problems for the instructor than solutions. Attempts to build ATDs with features to support every possible aspect of instruction have often resulted in instructional systems, including instructor/operator stations (IOSs), which are difficult if not impossible to understand and use. Such systems often have not been developed according to user specified needs. These attempts have been overenthusiastic and premature.

The instructional system has more recently been the focus of several development efforts. In particular, advanced systems have been developed in which traditional instructor support features (ISFs) have been enhanced and new features have been added. These efforts are based on user defined needs, lessons learned from existing instructional systems, and state-of-the-art training technology. The resulting systems, with expanded and enhanced ISFs, are referred to as Instructor Support Systems (ISSs).

Purpose

The purpose of the "ISF Guidelines" is to effectively transition lessons learned from the advanced systems into the operational training environment. It is anticipated that through these guidelines effective communication among operational users, procurement personnel, and system developers can be established. By promoting a better understanding of what instructor support features can provide, and by providing a means to communicate operational needs, it is hoped that these guidelines will help to avoid the pitfalls of the past.

A second major purpose of these guidelines is to emphasize the importance of specifying instructional systems on the basis of functionality rather than technology. The definitions and recommendations made throughout these guidelines are based on the functional needs of the instructor and are not made in terms of the current, "state-of-the-art" technology. Hardware and software technology is changing at an accelerating rate. Over-specification on the basis of today's technology can unnecessarily restrict tomorrow's design. Specification of functionality and performance from a user's perspective is imperative to allow contractor latitude in providing SimSPO with a spectrum of alternatives which will maximize the application of current technological advances and current standards.

How to use this document

This document is organized into four sections:

I. Overview,

II. Instructor Support Features,

III. Selecting Instructor Support Features, and

IV. Providing Operational Information.

The document is not designed to be read from cover to cover. Rather, the sections are intended for different users at different times in the ATD procurement process.

Section I

The remainder of Section I introduces the contents and purpose, the background and the development of these guidelines.

Section II

Section II, "Instructor Support Features," explains the concept of the ISS and the functions it serves. A set of definitions of instructor support features is provided. The information in this section is important to those tasked with laying out initial ISS requirements, to those tasked with developing the System Specification, and finally, to those involved in system development. Intended users of Section II include Operational personnel at the using command, MAJCOM personnel, SimSPO personnel, and finally, contracting personnel involved in system development.

Section III

Section III is entitled "Selecting Instructor Support Features." It guides the reader through a procedure to analyze instructor support requirements. This procedure should form the basis for the selection of instructor support features in the development of the specification for the ISS. Intended users of Section III are those tasked with developing a Statement of Need, the System Specification, and ultimately the ISS.

Section IV

Section IV, "Providing Operational Information," is intended to be used during system development. If instructor support features are to be programmed into an ATD system, then certain specific operational information must be provided to implement these features. This information must be provided by prospective Operational Users of the ATD to ensure that the resulting ISS is tailored to their unique requirements. A format for providing this information is discussed and provided.

Background

In 1981 the Simulator Systems Program Office (SimSPO) of the Aeronautical Systems Division (ASD) stated a need for enhancing the instructor's capability to assess student performance in ATDs. The need for improved instructional capabilities within ATDs was also clearly identified by the Defense Science Board 1982 Summer Panel Study Report on Training and Training Technology.

Prototype training systems have demonstrated the utility of features which provide the instructor with greater ability to control and monitor student activity and therefore make simulators more effective training systems. These systems have much to offer insofar as lessons learned during their development, test and evaluation, and operation. A means for capitalizing upon these lessons learned and introducing proven technology into the operational environment was sought. Development of a set of guidelines addressing the design, development, and incorporation of instructional capabilities within ATDs was the proposed solution.

Development of the Guidelines

The development of the guidelines took place in several steps. The first was the collection and review of a large number of documents. Documentation collected and reviewed included training documents and syllabi from nine aircrew training programs, relevant sections from recent ATD specifications, and research and informational literature on the use (and failure of use) of instructor support features incorporated into operational and research based ATDs. Over 100 documents were reviewed for the final version of the guidelines (Appendices A and B).

SECTION I
OVERVIEW

A series of meetings were held with SimSPO and MAJCOM personnel, including instructors and training requirements personnel, to determine ATD specification requirements. Meetings were also held with an Operational Using Command during the development of a sample specification (Appendix C).

Data were also gathered during a series of data collection trips to operational ATD sites and prototype ISS sites (Appendix D). At least one representative site was selected for each MAJCOM. During each site visit ATD training requirements, including aircrew training objectives, simulator characteristics, and instructor control and informational requirements were collected and assessed. Visits to prototype systems supplied information on lessons learned in the use of instructional features. Survey results cited throughout these guidelines refer to the collection of this data and also to surveys reviewed during the first phase of the guidelines development.

Finally, a commonality analysis was performed to determine the types of tasks trained across the surveyed ATD sites and the prototype ISS systems. The results of this analysis are presented in Appendix E.

SECTION II

INSTRUCTOR SUPPORT FEATURES


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Introduction

The purpose of the Instructor Support System (ISS) is to transform the simulator into a more effective training device. The ISS consists of the set of instructor support features (ISFs) present in the simulator. Through the implementation of a carefully selected set of ISFs, the ISS increases the instructor's efficiency and effectiveness by reducing the workload and providing support in the total instructional process of simulator training. This includes exercise preparation, simulator control, performance measurement and recording, and student performance feedback both during training and during debriefing. Through the presence of an ISS, the instructor may devote more attention to providing personal, high quality, one-on-one instruction, rather than dividing his time among the student and countless other required activities.

Design to User Needs

A properly designed ISS is responsive to user needs. In the past, some attempts to design a comprehensive instructional system have created more problems for the instructor than solutions. Instructor Support System designs based on specifications of a set of features to support every possible aspect of instruction are not based on functionality. They are not based on an analysis of the instructor's needs. Such designs can result in an instructional system which is difficult to use and understand, improperly tailored to the training application, and difficult to keep concurrent with training requirements.

The goal of this document is to guide the reader through a process of selecting instructor support features based on function and required training needs. Therefore, the definitions of features provided here emphasize function and are not intended to reference hardware, software or human factors engineering considerations.

Purpose

The first step in the proper design of an ISS is to ensure that all personnel involved in the specification process have a clear understanding of what each feature is, and what it is not. The purpose of this section is to present a set of clearly defined ISFs. The definitions included here are stated in operational terms to facilitate the decision as to when a particular feature will properly support the required training function. In addition to the operational definition, the purpose, additional considerations, related features, examples, lessons learned, and a specification oriented definition are also provided in the description of each feature. This information is provided to promote clear communication among operational personnel stating training requirements, procurement personnel involved in final specification definition, and contracting personnel involved in system development.

Organization of Section II

The ISF definitions are organized according to instructor function and presented in the order they would most likely be used by an instructor proceeding through a training exercise. This order is also used to facilitate the use of this section by those readers stepping through the procedure to select ISFs presented in Section III. The features are presented as follows:

<u>Pre-Training Requirements</u>

- Instructor Training
  - ISF: Tutorial
- Briefing
  - ISF: Briefing Utilities

<u>Training Requirements</u>

- Control Function
  - ISFs: Scenario Control
    - Initial Conditions
    - Real-Time Simulation Variables Control
    - Malfunction Control
    - Reposition
- Monitor Function
  - ISFs: IOS Display Control and Formatting
    - Procedures Monitoring
- Instruct Function
  - ISFs: Freeze
    - Simulator Record/Replay
    - Automated Simulator Demonstration
- Evaluate Function
  - ISFs: Automated Performance Measurement

<u>Post-Training Requirements</u>

- Debrief Function
  - ISFs: Hardcopy/Printout
    - Remote Graphics Replay
- Record Function
  - ISF: Data Storage and Analysis

Format of ISF Descriptions

The section describing each ISF contains the following:

- Definition: Stated in functional terms.
- Purpose and Intended Use: Stated in operational terms. Further describes each feature. This section can also be used when justification and rationale for inclusion of a feature are desired.
- Additional Considerations: Important additional points to consider when including this feature. These points also will help to "fine tune" the feature to the current training application.
- Related ISFs: ISFs that can affect or be affected by the inclusion of the present feature.
- Examples: Examples of the operational use of this feature.
- Lessons Learned: Experiences gained (positive and negative) from the use of this feature in operational settings. Please note that readers with further lessons learned are encouraged to forward them to SimSPO to be added to this document. In this way the Guidelines will continue to be kept up to date on experience with ISFs in operational applications.
- ATD Specification: A definition of this feature stated in language that can incorporated into a specification. It should be noted that this is a suggested wording. If "fine tuning" of the feature is required (e.g., as a result of additional considerations), the ATD specification should be restated to reflect these needs.

Feature	Tutorial
Definition	This feature provides the instructor/student with self-paced and self-administered programmed instruction on the capabilities and use of the flight simulator and its instructional support features.
Purpose and Intended Use	A problem noted in several ATD surveys is that most simulator instructors are not aware of all of the functions including the instructional support features available to operate the ATD. In many cases, the full capability of a device is not being utilized due to lack of knowledge and understanding. This is unfortunate because system operating functions and instructional support features, properly designed and implemented, can significantly relieve instructors of routine and non-productive tasks. A built-in tutorial for system operation aids in the overall understanding and acceptance of the system for new instructors while providing valuable hands-on training. It also helps the intermittent user by providing on-line guidance for "refresher training". If self-practice is an objective of the ATD, then this feature may also be used by the student.
Additional Considerations	Tutorial designs should take into consideration the following: o <u>Help Function</u>. A "help" function which can be readily accessed during an exercise can provide valuable system information about individual capabilities of the system and training objective descriptions. The HELP feature is intended for the user who already has a basic knowledge of the system and wishes to review a specific area of the ISS during runtime. o <u>Tutorial</u>. A complete tutorial which gives a step-by-step introduction to all the capabilities of the simulator can be conducted at the instructor console to provide hands-on experience. However, it is highly desirable that this feature be conducted on similar equipment such as a remote briefing/debriefing console. Using a remote console for the tutorial frees the simulator for continuing training and does not detract from the self-paced advantages of a tutorial.

- Modification and Update of Tutorial. Due to the fact that ATDs are often changed and updated, tutorial procedures should be modifiable. The use of a data base common to the actual system (e.g., common use of the display of a procedure or a graphic depiction of a SID) would provide simulator and tutorial concurrency.

Related ISFs — All instructional features should be covered by the tutorial.

Example — An instructor completed his training on how to use the ATD several weeks ago and hasn't yet used it with a student. Since he is scheduled with his first student in a few days, he utilizes a remote console to obtain some refresher training. He employs the tutorial feature in a refresher mode to ensure that he is prepared to efficiently operate the ATD in support of the scheduled training period.

Lessons Learned — Help functions have been incorporated into a recently installed operational system. Although not enough operational data has been collected to provide lessons learned, the initial instructor response at implementation was very positive.

When instructors have been surveyed as to the potential training value of a tutorial, they have rated it very highly. The maximum potential of ATDs will only be attained when instructors are provided with the proper training in the usage of the simulator and its instructional features are part of the total training system. A built-in system tutorial is a step in this direction.

ATD Specification — The tutorial feature shall provide the instructor/student with a user-friendly, interactive, self-paced and self-administered program of instruction on the capabilities and use of the flight simulator and its instructional support features. The tutorial feature shall include a "help" function in the form of an easily accessible prompt. The tutorial design shall result in step-by-step instruction and shall be provided off-line at a remote console or at the IOS. On-line instructional system operation shall also be provided (for the novice or infrequent user) and be accessible to the user as required.

Feature	Briefing Utilities
Definition	Briefing utilities are any aids provided by an ATD which are designed to assist the instructor in briefing a student for an upcoming simulator session.
Purpose and Intended Use	The main purpose of the briefing is to prepare both the student and instructor for a particular exercise. This is normally accomplished by reviewing the student's past performance, his readiness for the upcoming event, and a review of the training objectives to be accomplished. Typical materials used are lesson guides, training program outlines, instructor guides, and student (ATD) training records. Briefings can be improved by the inclusion of a briefing utility which will provide those materials mentioned. This is normally accomplished on a CRT with both alphanumeric and graphics capabilities.

Additional Considerations

If the Briefing Utility is selected, then the following additional considerations should be specified.

- The Briefing Utility should be accessed via a separate console away from the IOS so as not to interfere with an exercise which may be in progress. Providing a separate console will eliminate any scheduling conflicts, thus not taking away any valuable "hands on" time. On some existing systems, this console serves the dual purpose of briefing and debriefing when a remote graphics capability exists.

- It is important that the method of interaction with the briefing utility be as similar as possible to the main IOS. This will ensure instructor familiarity with the device. It must be user-friendly. For example, the briefing materials required to cover the training objectives for a particular ATD may be very extensive. These materials must be easily accessed and functionally grouped in user terms or this feature may become cumbersome to use. The data and displays should be identical to realtime data wherever possible. For example, approaches and departures shown at a briefing station should look identical to corresponding IOS displays during the exercise.

- It is most important that briefing data be easily modifiable. Procedures and flight profiles change routinely. Briefing materials which cover these objectives must be up-to-date, or they are of little value. An automated means of updating the material should be provided.

- Briefing for Instructorless Training: With more sophisticated software and hardware, briefings may be presented without an instructor. Computer-assisted interactive briefings would be especially appropriate for simulators which allow unsupervised practice or when there is a need to otherwise reduce instructor workload.

Related ISFs

Scenario Control. Scenario Control should be related to the briefing utility for efficient accessibility. By selecting a particular scenario for review during the briefing process, the instructor would have available the training objectives for that particular exercise and any other pertinent information (e.g., threat characteristics during the ingress leg of an interdiction mission).

Automated Performance Measurement. If the ATD has an automated performance measurement feature, then the algorithms, measurement criteria, and any other information relevant to this feature should be made available via the briefing utility. This will provide an insight as to the method of measurement and will help in the general understanding and user acceptance of automated performance measurement.

Data Storage and Analysis. If the ATD has a data storage and analysis feature which records performance and retains this information by student, the instructor should be able to access this information by student name or number via the Briefing Utility. In this way, both the student and instructor will be informed of the student's progress and previous performance.

Examples

An instructor and student scheduled for a formal syllabus trainer event would arrive at the facility in time for the briefing. They would proceed to a Briefing/Debriefing console and log on to the system. The instructor would then select the syllabus event. The Briefing Utility would display an outline of the exercise. From here the instructor would have access to the training objectives, performance criteria, and any other pertinent information. If the system had a data storage and analysis feature, he would have the option of reviewing the student's previous performance.

If the upcoming event were not part of a formal syllabus, the instructor may still access the briefing utility and review briefing materials by training objective and or other subject headings, e.g., "aircraft system descriptions."

Briefing Utilities

Lessons Learned

The use of prerecorded briefings has been attempted in isolated circumstances; however, surveys have revealed that instructors believe this feature is unnecessary and prefer to brief students themselves.

Briefing materials should be modified and updated reliably and efficiently as needed. This will encourage use of the briefing utility. A positive result would be to provide standardization at the briefing level. Unfortunately, some existing devices with a Briefing Utility have not been updated, and therefore the positive aspects of this feature have been lost.

ATD Specification

Briefing utility aids shall be designed to assist the instructor in briefing a student for an upcoming simulator session. The aids shall prepare both the student and instructor prior to a particular exercise and consist of the following materials: lesson guides, training program outlines, instructor guides, and student training records. The aid shall serve as a briefing and debriefing utility accessed on an off-line remote graphics console. The method of interaction shall be similar to the main IOS and shall be easily accessible by the instructor. Presentation materials shall be functionally grouped in user terms to ensure optimal usability and easy modifiability for future update.

Feature	Scenario Control
Definition	The Scenario Control feature supports the instructor by controlling the ATD to meet established training criteria. This feature configures and controls the ATD to accomplish specific training objectives. The objectives are activated in a predefined order and under prespecified conditions.
Purpose and Intended Use	During the conduct of an exercise, instructor workload is divided among providing instruction in the form of explanations and feedback to the student, monitoring and evaluating student performance, and controlling the simulator. The purpose of scenario control is to relieve some of this workload by the automation of certain ATD control inputs and by automatically presenting information which is appropriate to the current training objective. When training is conducted with scenario control, a properly constructed ISS can determine where the student is in the training exercise. This allows the ISS to present appropriate displays and graphics to the instructor at appropriate times. It also allows the ISS to automate the control of simulation variables. For example, at the beginning of certain training objectives, environmental conditions may require change. Rather than requiring instructor input at these times, the ISS may automatically reinitialize those variables. In sum, under scenario control it is possible to automate wherever possible those tasks which do not directly relate to personal instruction.
Additional Considerations	Levels of Automation of Scenario Control. There are varying levels of automation of scenario control. The level that should be selected will depend on the nature of the training to be conducted on the ATD. The levels are described below: o Fully Automated Scenario Control. Fully automated scenario control is equivalent to a totally preprogrammed mission scenario. This level of scenario control automatically controls an entire exercise (e.g., cross-county navigation flight, strike mission with high and low altitude segments, etc.). To use fully automated scenario control, the instructor must simply select a specific scenario at the beginning of the training exercise. The ATD will be automatically programmed for the entire exercise. All inputs usually required from the instructor during the exercise (e.g., environmental conditions, malfunctions, checklists, threat, departure and arrival facilities, enroute way points,

display content, display options, etc.) are automatically programmed to occur when specific conditions have been met.

This type of control is supportive of a formalized training syllabus, instructorless training, and trainer events requiring rigid standardization requirements.

- Semi-Automated Scenario Control. Semi-automated scenario control is designed to provide the instructor with some flexibility during the exercise. A specific scenario is selected in preparation for the training exercise identically to the fully automated mode. However, inputs during the exercise may be selectable (e.g., activating a malfunction from a pre-selected list), they may be modified or overridden (e.g., removing a SAM threat from a battle scenario), or messages may be presented informing the instructor that inputs are about to be made and confirmation is requested prior to activation (e.g., reducing visibility to field minimums).

  This type of control is supportive of continuation training where the exercise requires "real-time" tailoring to conform to student needs.

- Scenario Control by Objective. Scenario control by objective requires the instructor to pre-select specific training objectives prior to an exercise. These objectives will be made readily available to the instructor during the exercise for manual selection. When selected, displays appropriate to the training objective will be automatically displayed, and variables such as environmental conditions relative to the training objective will be automatically set.

  This type of control is supportive of specialized part-task training or training situations which require instructor flexibility.

Related ISFs

Initial Conditions. The initial conditions at the beginning of a scenario should be made part of this feature such that when a specific scenario is selected, the initial conditions will be automatically set when the exercise is started.

Automated Performance Measurement. In a well-designed ISS, the performance measurement computer programs are directly linked to and run concurrently with the scenario control feature.

Real-time Simulation Variables Control. These variables may be preprogrammed to be inserted automatically if desired. Simulation variables may also be grouped according to the active objective and made readily available for instructor activation or adjustment.

Examples

Fully Automated Scenario Control. The following is an operational description of an instrument training exercise at the undergraduate level. The student will:

- o Take off from a training base via a standard instrument departure (SID)
- o Fly an instrument "round robin" in the jet route structure, to arrive back at his departure field
- o Fly a jet penetration with an ILS final to minimums
- o Execute a missed approach at minimums
- o Terminate the exercise by flying a GCA precision final
- o Demonstrate his knowledge of the normal checklist procedures
- o Demonstrate his knowledge of the procedures covering the electrical system malfunctions

This exercise can be conducted under fully automated scenario control. Table II-1 presents a list of the task objectives which would be automatically tracked by the ISS. The appropriate displays and required simulation variables control are also presented. As the student flies the scenario, these displays are automatically presented and the variables are automatically initialized as the student enters the phase of the scenario related to each task objective.

Semi-Automated Scenario Control. Under semi-automated scenario control, the same displays and variables control would occur for each phase of the exercise. The instructor would be given options at each phase, however, to select, modify, or cancel the automated inputs. This would give the instructor more control over the simulator exercise than in the fully automated case described above.

Scenario Control by Objective. Scenario control by objective would be used in a part-task training situation. For example the training objective could be a GCA Precision Final to Williams AFB (See training objective listed in Table II-1). Using this type of scenario control, the instructor could repeatedly ask the student to perform the task objective. Each time the student repeats the task, the instructor would reselect the appropriate objective and the ISS would present the appropriate displays (Glideslope/centerline and historic trail of A/C) and reinitialize the simulator variables (Set Wx to above minimums).

Lessons Learned

Canned exercises which provide fully automated scenario control have been incorporated in ATDs and have been useful in certain specific training applications. These are usually limited to standardization/evaluation exercises, instructorless training, and a certain undergraduate level of training where there is a formalized syllabus.

A great part of the training conducted on ATDs requires a more flexible control, however. Tailoring an exercise to an individual's need is often a basic operational requirement. A semi-automated level of control or control by objective would allow for modifications to the scenario (e.g., reset back or forward in a mission profile, delay or delete a malfunction,) and to allow for modifications to the simulation variables (e.g., change weather at a destination field) during an exercise without having to re-initialize the system to some other operational mode.

For every level of scenario control a means should be specified for the instructor to review scenarios before selection to see exactly what objectives are to be performed and to determine how the scenario will develop. The instructor should also be able to review the scenarios via the remote briefing/debriefing console if one exists.

Finally, for any type of scenario control, the scenarios should be relatively easy to create and to modify. The basic system design should acknowledge that training requirements change, and provide for modifications of preprogrammed scenarios accordingly.

ATD Specification

The Scenario Control feature shall support the instructor by controlling the ATD to meet established training criteria. This feature shall configure and control the ATD to accomplish specific training objectives. The objectives shall be activated during training in a predefined order and under prespecified conditions.

TABLE II-1

SCENARIO TABLE

TASK MODULE NAME	DISPLAY CONTROL	VARIABLES CONTROL
Takeoff Checklist	Display of checklist with updated student actions.	
Takeoff	Display visual scene. Cockpit instrument information.	Set environmental conditions. Wx & Winds.
SID No . from Williams AFB.	Display of departure. Historic trail of A/C.	Set cruise winds.
Leg A to B	Display of Jet Route structure. Historic trail of A/C.	
Leg B to C	Display of Jet Route structure. Historic trail of A/C.	
Leg C to D	Display of Jet Route structure. Historic trail of A/C.	
Descent Checklist	Display of checklist with update of student actions.	
Hi TACAN No. 1 Williams AFB	Display of approach Historic trail of A/C	Set landing winds. Set runway lights. Wx to below field minimums.
Landing Checklist	Display of checklist with updated student actions.	

TABLE II-1

SCENARIO TABLE (Continued)

ILS approach to Williams AFB	Display of glideslope/ centerline. Historic trail of A/C.	
Missed Approach at Williams AFB	Display of missed approach. Historic trail of A/C.	
GCA Precision Final to Williams AFB	Display of glideslope/ centerline. Historic trail of A/C.	Set Wx to above field minimums.
Landing Checklist	Display of checklist with updated student actions.	
Generator Failure	Display of emergency procedure with updated student actions.	
D.C. Buss Failure	Display of emergency procedure with updated student actions.	

Feature	Initial Conditions
Definition	This feature enables the instructor to set initial values for many parameters within the simulation. Initial values for environmental factors such as wind, turbulence, visibility, etc. and vehicle dynamics such as altitude, airspeed, position, weapons load and fuel can be established before the training session (during lesson initialization procedures) or during the training session (by calling up by the reset facility).
Purpose and Intended Use	The primary value of the initialization/reset capability is that it enables the instructor to devote his time to instruction rather than inserting variables which have been predefined.
Additional Considerations	o For any moderately complex simulator, it is necessary that a library of initial conditions be stored for use in actual training sessions. The number of initial conditions varies according to the training requirements specific to that device. o The instructor should be able to review the initial conditions before executing them, to see exactly what conditions are specified and to determine how the training activity will develop. To add flexibility, he should also be able to modify the prestored data before execution (and save it for later use if desired), so that a particular lesson could be tailored to the training situation.
Related ISFs	Scenario Control. If a scenario control feature is specified for a specific ATD, then the initial condition sets may be incorporated as part of this feature. Total System Freeze. The state of the simulator should be in total system freeze while the initialization process is being conducted. This will allow the student to reorient himself with respect to this new configuration. The freeze condition may then be removed by instructor control.
Example	After reviewing the student's records, the instructor decides that several of the predefined values for scenario conditions need revising to make the scenarios more challenging. He then makes the appropriate changes so that he is not burdened with this task during the training session.

Lessons Learned	Because the I.C. reset is often-used method to reposition the ATD to a specific point within the training scenario, it should be designed so as not to be restrictive, time consuming and difficult to access.
ATD Specification	Initial conditions feature shall enable the instructor to set initial values for a set of parameters which shall define a starting point for a mission scenario. Parameters whose values are set shall include the following types: a. Air vehicle configuration b. Air field and runway characteristics c. Radio/navigation aids d. Environmental conditions e. Air vehicle flight characteristics The initial conditions sets shall include preprogrammed sets and programmable sets capable of temporary storage, modification and recall of pre-selected parameters. Initial conditions sets shall be created off-line and stored for call-up by the instructor at the beginning of a mission scenario. An on-line capability shall also exist for temporary modification, review and recall of pre-selected values during the training session.

Feature	Real-Time Simulation Variables Control
Definition	This feature provides control for the insertion, removal, and alteration of simulation variables while the simulator is in operation. The simulation variables include such variables as environmental conditions; aircraft configuration, maneuvering, and positioning (ownship, wingmen, and adversary); target data; airfield data; and threat data. The methods of control range from complete automation where no instructor action is necessary, to manual selection from a set of variables which have been grouped according to the needs of a particular exercise. The degree of automation depends on the training application and requirements. Control by continuous interaction via an input device is also included.
Purpose and Intended Use	Control of the simulation variables can be provided through several different instructor support features in addition to this feature. For example, Reposition offers control of aircraft position parameters; Malfunction Control offers the instructor control over insertion of malfunctions; Initial Conditions provides for the setting of initial conditions; and Scenario Control offers several levels of automation in the control of these variables. Therefore, simulation variables control should be specified when control of certain variables is not adequately covered by means of any of the features identified above.
Additional Consider-ations	o Controlling the simulation variables in a completely automated mode, in a semi-automated mode, and by objective are covered under the discussion of scenario control. See the definition of Scenario Control in this section. o Another potential means of control is continuously through an interactive device at the instructor console. This is the means that would be employed to control the movement or position of other aircraft or surface vehicles. For example, control of the target could be by movement of a cursor over a graphics display. o Finally manual control may be required in specific instances. If so, access to these controls should be made convenient by functional grouping according to the active training objectives.

Related ISFs

Automated Performance Measurement. The simulation variables to be controlled may impact task difficulty. This would directly affect the performance measurement output and should be made explicitly clear to instructors as the results of the performance measurement are presented to him.

Reposition, Malfunction Control, Initial Conditions, and Scenario Control. These features are also means of offering the instructor control of the simulation variables in real-time. See discussion under "Purpose and Intended Use."

Example

An instructor may activate and position an airborne adversary by positioning the cursor over a graphic depiction of a hostile environment.

Lessons Learned

It was observed that the manual selection of the simulation variables is best suited for informal training, e.g., continuation training. This feature was available on all of the systems visited. The amount of usage depended on the accessibility of the variable and whether it had any training value with respect to the objectives being taught.

Using the preprogrammed sets of initial conditions to control simulation variables has been observed. However, the selection of variables by "re-initializing" the simulator seemed to break the flow of training and detracted from the realism of flight. The initialization feature is designed primarily to set up the simulator at the start of an exercise. The use of this feature to change simulation variables during training was observed to be more of a "work around."

ATD Specification

This feature shall provide control for the insertion, removal, and alteration of simulation variables while the simulator is in operation. The simulation variables shall include such variables as environmental conditions; aircraft configuration, maneuvering, and positioning (ownship, wingmen, and adversary); target data; airfield data; and threat data.

Feature	Malfunction Control
Definition	Malfunction Control enables the instructor to fail, partially or totally, simulated aircraft equipment or to introduce an abnormal equipment condition during the simulation in order to train the student in recognizing and responding to such malfunctions.

Purpose and Intended Use

ATDs provide the student with a safe, controlled learning environment for training responses to equipment malfunctions and resultant emergencies. Control of malfunctions can be partially or completely taken over by the simulation computer, thus freeing the instructor for other important instructional activities. In addition, if malfunction control is even partially automated then students can practice malfunction and emergency procedures without the aid of an instructor. Thus students can benefit from additional practice whenever ATD time is available.

Malfunction control can either be manual, partially automated or fully automated. Under manual control, the instructor is required to select and activate malfunctions as the simulator mission proceeds. While this method offers the instructor maximum flexibility in controlling malfunctions, it also imposes the greatest workload. Automated malfunction control includes several different possible variations. The following list suggests various ways malfunction control can be automated and the purpose of each.

- o Malfunction control can be partially automated by allowing the instructor to select the set of malfunctions to be used in advance of the simulator mission. This preselected list is then made readily available during the exercise. The number of alternatives for selection during the mission is reduced while still allowing instructor control.

- o In another possible variation of partially automated control, the instructor may pre-select both the malfunctions to be used and when they should be activated. During the mission the instructor takes no action except to cancel or postpone an upcoming malfunction he has decided not to impose on the student. This method of selection further reduces the instructor's workload.

- Under a completely automated version, malfunction control would be preprogrammed according to each specific simulator exercise in the training program. The instructor is only required to select the exercise. All selection and activation of malfunctions is predetermined and preprogrammed. Ideally, automated malfunction control significantly reduces the instructor's workload both in setting up the mission and in conducting it. This method also promotes standardization within the training program by ensuring that such lessons are always presented in the same way.

Additional Consider-ations

If Malfunction Control is selected, then the following additional considerations should be specified.

- It is assumed in these guidelines that through the ISD process, training objectives, task listings, and media selection have been completed for your training program before the specifications for the training devices have been developed. Malfunctions should be included in the simulator based on these task listings. The decision to manually or automatically control the selection and activation of malfunctions should at least partially be based on the types of malfunctions that are presented in these analyses.

- If malfunctions are to be selected by the instructor either before or during the simulator mission, then they should be presented in groups organized according to the previously identified tasks or training objectives. They should also correlate to the TO-1 sections for emergency procedures.

- If malfunctions are to be automatically activated, then all conditions to start, stop, identify correct and incorrect procedures, and any other factors (e.g., environmental conditions) should be identified in advance by the using command.

- Instructors may require the capability to cancel or postpone malfunctions which have been pre-selected for automated insertion. To make it possible to override previously programmed malfunctions, the system must provide a warning to the instructor that a malfunction is about to occur.

- Whether or not the type of malfunction control is manual or automated, the instructor should be provided with a list that shows which malfunctions are presently active. In addition to the above, if in the automated mode, a means should be provided which will preview the remaining malfunctions and conditions under which they will be activated.

Related ISFs

Scenario Control. Automated malfunction insertion and removal requires a real-time scenario control capability. This control is required for malfunction insertion/removal because the conditions for initiating the malfunction must be sensed and compared against insertion/removal criteria.

Procedures Monitoring. Similarly, if the malfunction is to be automatically removed after the student has successfully coped with it, a procedures monitor is necessary for assessing when the correct procedures have been completed. If the malfunction is to remain in effect (e.g., engine out), then a procedures monitoring system designed to monitor student performance must know this so that appropriate standards of flight performance can be used.

Examples

The following are examples of malfunction control:

- Manual Control. During a training session the student had difficulty with an engine failure so the instructor decides to introduce the malfunction again later in the session for remediation. At an appropriate time the instructor manually selects and activates the engine failure.

- Semi-Automated Control. Based on his review of student records the instructor decides that extra practice of the hydraulic system failure procedure is needed. He therefore pre-selects the malfunction but does not specify when it is to be inserted. This places it in a "ready" status. Later in the training session at a time when it does not interfere with other training, the instructor introduces the hydraulic failure with a simple command.

- Fully Automated Control. A trainer event on airways navigation includes training objectives concerned with TACAN failure and lost communications procedures. At a predefined point in the route, the TACAN failure is automatically introduced. After the student has demonstrated the proper procedures or at a predefined point in the route, the TACAN is restored. At a later point in the route the simulated radio failure is introduced automatically.

Lessons Learned

Automated malfunction control is valuable only if it is well designed. Problems have been experienced with time-based automated malfunction insertion/removal since time does not always correlate with mission events in a meaningful way. For example, in a tactical situation, particularly one with modeling of enemy forces and tactics, the student will be expected to take actions which are based upon the situation rather than the clock. Therefore logic-controlled automated malfunction insertion/removal is preferred, as long as the allowed decision logic is flexible enough to specify appropriate conditions completely. With logic-controlled procedures, it may be possible to specify probabilistic malfunction insertion. For example, under certain conditions one of a small list of malfunctions will occur, or under certain conditions a malfunction may or may not occur.

Manual malfunction insertion tends to produce a high instructor workload. Therefore when manual control is specified, the method of selecting and activating malfunctions becomes very important. Grouping by objective or training task would help to reduce the workload.

Automated malfunction control is seldom used by some groups of instructors who prefer manual control. Their comments indicate that automated malfunctions are sometimes unreliable and can be difficult to implement. In general, instructors prefer the flexibility to tailor training to student response and needs.

As stated in the above paragraphs, there are basic problems with both extremes, from manual insertion, where instructor workload may hamper his instructional tasks, to fully automated which restricts his flexibility in tailoring the exercise in response to student needs.

Instructional personnel should determine what malfunctions should be trained on the ATD to meet the training requirements. Too often, malfunctions are inserted to "increase the student's workload" without any specific training objective in mind. Malfunctions can then be organized in logical groups either for later presentation to instructors using the simulator or for simulator designers' and programmers' use when programming the simulator for automated insertion by task or training objective.

ATD Specification

Malfunction control shall provide the instructor the capability to preprogram a sequence of abnormal aircraft equipment conditions and/or emergency conditions before or during the training session. The time and number of actions required on the part of the instructor to select, alter, and enter malfunctions shall be minimized to the greatest extent possible.

Feature	Reposition
Definition	This feature provides the ability to position the ATD to a specific point in space that has some significance to the training scenario. All flight parameters will be capable of adjustment to meet the new condition, and the ATD configuration will be automatically checked to ensure a crash condition will not occur as a result of repositioning.
Purpose and Intended Use	This feature promotes efficient use of available training time and other assets by not requiring the student to "fly" the ATD to the desired location. Having the ability to reposition the ATD to meaningful positions in the exercise will allow the instructor to modify the exercise to meet the student's needs. This can be done in an effective manner by providing reposition options associated with the training objectives, e.g., initial approach fix, final approach fix, or end of the runway after an aborted takeoff.
Additional Consider-ations	o Method of Selection. Older ATDs required lengthy manual procedures such as slewing to reposition the ATD. Some newer devices incorporate dedicated controls (usually pushbuttons) that instructors use to select one of several sets of initial conditions. Others provide lists of combinations of initialization options displayed on CRT display which allow a single selection from a readily available menu. Regardless of the method used, it is important that the method chosen does not add to the instructor workload, and that the selections made available are clearly labelled and are appropriate to the objectives being trained. o Configuration Mismatch. If after a repositioning a crash condition exists, a message warning the instructor should be given and the device will not be moved until the configuration is corrected. For example, if the simulator is to be placed at the end of runway from a flight condition, and the landing gear is not down, a message will inform the instructor of the condition and the ATD will not be repositioned until the landing gear is placed down.
Related ISFs	Freeze. It is important that when the ATD is being repositioned, that the cockpit be placed in the freeze condition upon completion. This will allow the student time for re-orientation and the time of fly-ouc can be controlled by the instructor.

Scenario Control. If a scenario control feature exists, it must be made aware that the ATD is being repositioned.

Automated Performance Measurement. The automated performance measurement feature must be aware of any repositioning and simulator reconfiguration during resets. By repositioning the simulator to the beginning of a training objective with a known set of conditions, an APM can easily account for any modifications to a scenario and adjust accordingly.

Example

During a strike training mission involving a low-level navigation ingress to a target, the student flies most of the route correctly. However, he has difficulty in flying the proper airspeed and altitude profile in the final portion of the route leading up to the target. This adversely affects his performance in the attack phase and degrades the training value of the mission. The instructor then uses the reposition feature to position the aircraft at a point in the route where the student can re-fly the final portion of the mission.

Lessons Learned

Repositioning the simulator to a specific location is used on all devices and is mostly used for repetitive training (e.g., approaches). The most common way to reposition was accomplished via an I.C. reset. It is among the most frequently used and highly valued features at ATD sites. It is typically used in conjunction with flight system freeze and permits instructors to rapidly re-initialize the ATD to a particular configuration so that a student can repeat a particular maneuver or mission segment. However, if the I.C. reset is used, it must be designed so as not to be restrictive, time consuming, and difficult to access.

The most versatile design of the reposition feature was observed on a device where the simulator can be positioned anywhere within the active geographic graphics display by identifying the position with a light pen. Repositioning this device may also be accomplished by bearing and distance from a fix, latitude/ longitude, or by identifying a previous position by a "snapshot I.C." However, this may be over-designed for the training requirement.

ATD Specification

The reposition feature shall have the capability to position the ATD at any point in the mission training scenario. All flight parameters shall be capable of automatic adjustment to meet the new condition imposed by repositioning. After reposition, ATD configuration shall be automatically checked to preclude any crash condition or other adverse condition and shall remain in a freeze state until all incompatible conditions are corrected.

The reposition feature shall be designed to enhance instructor efficiency. The time and the number of actions required on the part of the instructor to select, alter and enter data shall be minimized.

Feature	IOS Display Control and Formatting
Definition	The IOS display control and formatting provides the instructor with a meaningful depiction of student performance during active mission training. The presentation of information is designed to be an easy-to-read, uncluttered, standardized format of the current status of graphical and instructional information. The information layout should be consistent with the limitations of human perception and memory in order to minimize user interpretational effort, alleviate confusion thereby ensuring quick recognition and maximizing readability.
Purpose and Intended Use	There is a basic requirement that the instructor "knows" what the crew is doing throughout the training exercise. He needs information regarding the current status of various facets of the simulation exercise. An IOS display which is formatted based on instructor needs and training objectives provides a more meaningful depiction of student performance.
Additional Consider-ations	Mission Status Displays. Computer-generated mission status displays can be tailored to the segment or task activity in progress. Some systems have switchable fields of view in the cockpit. Radar, for example, may use one screen for navigation and targeting modes. The capability to select and view modes independently of the student's choice allows the instructor to more clearly determine whether the student is using the appropriate mode. Such requirements should be stated clearly, since they may place additional demands on the computational system and require significantly different software designs. Manual versus Automatic Display Selection. A default display for the active training objective should be displayed automatically. However, alternate displays should be made available for selection from a group of displays appropriate to the active task being conducted. Automatically Activated. In most cases where the aircraft is geographically referenced on a display, an automated feature can provide the correct reference. For example, in the case where the simulator is repositioned to the beginning of an approach, an approach display will automatically come up. In cases when a geographic plot is being displayed and when the aircraft flight path approaches the edge, the display would change to the next appropriate display.

Display Formats. CRT displays can present many categories of information very concisely. In an attempt to provide the greatest amount of information at one time, display formats are sometimes so compact and complex that the results can be unreadable. In preparing display formats, one should consider the amount and appropriateness of the data. It must also be formatted for quick and accurate legibility. A "declutter" option also provides a method of separating "need to know" and "nice to know" information.

Related ISFs: Scenario Control. Although display options do not relate directly to simulator control, they do provide valuable evaluation information. The "smart" system would know which training objectives were currently being performed. The display options appropriate to the running task could be made readily available (SID plates, approach plates, optimum dive angle, single engine landing procedures, etc.).

Examples

During an instrument flight training mission, the student flies an IFR navigation route to an instrument approach at a destination airfield. During the navigation phase, actual aircraft track relative to the planned route is displayed to the instructor. The student's selections of NAVAIDs and radio frequencies are monitored and incorrect selections are also displayed to the instructor. When the student starts his final approach, the display formats change to provide graphic depictions of glideslope, lineup and airspeed parameters, and indications of aircraft landing configuration status. When an aircraft system malfunction occurs in the scenario, system indicators and student control activations are displayed to the instructor. All of the display format changes occurred automatically, based on the active training tasks and instructor information requirements for the tasks. This graphic information can be recorded and later replayed during debrief.

Lessons Learned

In the past, repeater instruments were the mechanism to satisfy the requirement for aircraft cockpit/control information. More recently, this type of information has been replaced with graphic displays. However, in many cases where graphics have been the primary method of displaying simulator configuration and cockpit activity, the design has been toward displaying anything and everything that "may" be of value. This has resulted in displays which are very difficult to interpret. The appropriate data is most likely contained on these displays; however, at times it is difficult to follow to evaluate student performance. This is especially true with the casual user. The most immediate user response to this design problem is to go back to the basic aircraft instrumentation and to lay out the instruments and repeaters as in the actual aircraft. This may be a valid alternative, however, care should be taken so as to take advantage of this feature and the state-of-art technology. For example, in an exercise where the training objective is to fly instrument navigation, the instructor may be provided with the navigation instruments to evaluate the student's performance. He must then interpret those instruments in order to know exact aircraft location. A properly designed display for this type of objective may provide both instrument readout and aircraft position with respect to a route or flight path being flown.

ATD Specification

The IOS display format shall provide the instructor with a meaningful depiction of student performance during active mission training. The presentation of information shall be an easy-to-read, uncluttered, standardized format of the current status of graphical and instructional information. The information layout shall be consistent with the limitations of human perception and memory in order to minimize user interpretational effort, alleviate confusion thereby ensuring quick recognition and maximizing readability.

Feature	Procedures Monitoring
Definition	Procedures Monitoring provides a method of monitoring student activity with respect to procedural performance, such as the accomplishment of checklist items. This feature may also provide performance measurement of these items.
Purpose and Intended Use	A major focus of flight training is to teach the student about normal and emergency procedures specific to the aircraft equipment to be operated. Typically, there are numerous checklist procedures the student must know thoroughly. The simulator provides the ideal tool to master these procedures, especially in the area of emergencies and system malfunctions. Procedures monitoring provides the instructor with the capability to observe and evaluate several facets of student performance simultaneously. It may also provide objective, standardized performance measurement of the student's accomplishment of procedural steps. A graphics display which summarizes the procedures attempted and procedural errors should be made an option to the instructor for monitoring student activity. This feature is especially useful when the instructor monitors the exercise from an off-board station where cockpit activity cannot be directly observed.
Additional Consider- ations	Many ATDs present (on real-time displays or hardcopy printouts) the actual sequences in which procedures are performed by students. It is the instructor's responsibility to determine whether or not the procedural sequences and timing are acceptable. State-of-the-art devices have been able to provide automated measurement of performance of procedural sequences. This has been accomplished by the development of "intelligent" start/stop logics which know when and what the crew is doing, thereby providing a more dynamic and accurate description of student performance. The meaningful measure of procedures requires relatively complicated computer measurement logics. A considerable and detailed task analysis must be accomplished prior to contractor development. Correct sequences must be determined in detail, and likely alternative sequences (both acceptable and unacceptable) must be defined so that computer measurement and scoring logics act fairly and do not penalize students for using occasional (but acceptable) departures from normal, textbook procedural sequences.

Related ISFs

IOS Display Control and Formatting. It is important that assessment of student performance of procedures be presented in an easy-to-read-and-understand format. Among the problems identified about displays were 1) that the volume of informational data displayed is too overwhelming, and 2) they were difficult to integrate and interpret by instructors. For example, on some devices, the last twenty actions in the cockpit were displayed at the IOS. At times, actions, which were both appropriate and totally irrelevant, rapidly scrolled past the instructor and were unusable.

Automated Performance Measurement. If training objectives require performance evaluation of student procedural activity, then these two features should be directly correlated.

Example

An instructor wishes to test a student on his ability to accomplish a pre-flight (before takeoff) checklist. He activates the performance monitoring feature to observe student actions. During the student's performance of checklist actions, a diagnostic message appears on the IOS CRT which indicates that the sequence of the steps the student performed are incorrect. The instructor might then call up the appropriate display which indicates exactly what the student error was so he can repeat the task. By using this feature, the instructor has obtained additional information to what he was able to see.

Lessons Learned

Many ATDs have the procedures monitoring feature. However, this feature is often not used because many of the procedures programmed in the simulator are quickly outdated and are not updated as they should be. It is mandatory, therefore, that data relating to aircraft procedures be easily modifiable.

Many of the actions related to procedural activity are not computer detectable. For example, many of the checklists involve scanning cockpit gauges and checking for proper aircraft configuration. In those cases, any automated performance algorithms must not try to assign a value which may be totally distorted. It is important that the Procedures Monitoring feature be used as an aid in these cases and to provide only useful information to the instructor for his overall evaluation.

ATD Specification

The procedures monitoring feature shall provide the instructor with a method of monitoring the sequential mission training activities of a student. The design shall be easily modifiable and include valid measures of monitoring procedural activity. The design may include an automated feature of measuring performance of sequential procedures. The assessment of student performance shall be displayed to the instructor in an easy-to-read and understandable format.

Feature	Freeze

Definition

The freeze feature allows simulator parameters to be fixed at values existing when freeze is activated. Some or all device parameters can be fixed. The freeze feature can be operated either manually by the instructor, or it can be operated automatically. Automatic freeze occurs either when specified parameter values are exceeded, as in the case of a "crash/kill," or when the state of the simulator changes as in repositioning or going from replay to the normal operating mode.

Common variations of the freeze feature are defined below:

Total System Freeze. All system parameters are frozen, including flight control, propulsion, navigation and weapons. The entire simulation ceases to function from a training standpoint. For systems equipped with platform motion, the motion system is driven to a neutral position, at a safe rate.

Partial or Parameter Freeze. This type of freeze enables the instructor to fix the value of individual parameters. The values of one or more parameters can be frozen at any given time. Common variations of the parameter freeze feature include the following.

- o Flight System Freeze. This feature permits the instructor to simultaneously freeze flight control and propulsion systems, position, altitude and heading. The net effect is that the ATD ceases to "fly." However, all other simulated systems remain operational and can be used for instructional purposes without the burden of having to fly the ATD. This freeze variation functionally converts an OFT to a CPT.
- o Attitude Freeze. This feature permits the instructor to simultaneously freeze pitch, bank and heading.
- o Position Freeze. This feature permits the instructor to simultaneously freeze latitude and longitude. Thus, the ATD continues to "fly" but it "goes nowhere."

Purpose and Intended Use

Total System Freeze. The total system freeze is used in three ways:

- o to temporarily suspend the training session so that the instructor can provide feedback to the student,
- o to suspend training to re-configure the simulator, or
- o automatically as in the case of crash or kill.

Partial or Parameter Freeze. The partial freeze feature selectively freezes parts of the ATD system for the purpose of reducing the student's task load.

Additional Considerations

The following additional considerations should be specified:

- o Specify the type of freeze required. See descriptions under Purpose and Intended Use above.
- o In order to avoid confusion, the freeze status of the simulator must be made obvious to all participants in the simulator exercise.

Related ISFs

Simulator Record/Replay. The use of total system freeze is common in devices during replay. It has proved useful to stop the replay to allow for instruction and also when changing the state of the simulator from replay to the normal operating mode.

Automated Simulator Demonstration. As in simulator record/ replay, the total system freeze has proved useful to stop the demonstration to allow for student questions or instruction, and to allow changing the state of the simulator from automated demonstration to the normal operating mode.

Initialize ATD. Total system freeze is used in most ATDs to stop an ongoing exercise as the first step in reinitializing the ATD.

Examples

Partial Freeze. During a UPT navigation trainer period, the instructor suspects that the student is disoriented relative to his route of flight. He then activates "position freeze" so that he can discuss the problem with the student. Once the problem is resolved, the instructor "unfreezes" the ATD and the mission is resumed. Another example involves a student problem with an emergency procedure. The instructor activates "flight system freeze" so that he can point out system indicators related to the procedure. The student can pay attention to the instructor without the burden of flying the aircraft.

Total System Freeze. During an ACM trainer mission the student is having difficulty recognizing when he is in a missile firing envelope. As the student reaches the edge of the envelope, the instructor activates "total system freeze" so that he can provide instruction on envelope recognition cues and relevant aircraft parameters.

Lessons Learned

Total System Freeze.

- Manual. All ATDs observed in preparation of these guidelines had this feature. It was used in varying degrees depending on type of training. Freeze was used more frequently when tasks being trained were relatively or totally new to the student. Thus, at the undergraduate training level, freeze was used extensively by the instructor while providing direct feedback and corrective action. It is rarely used in total mission training at the continuation level.

- Automatic. All ATDs observed in preparation of this guidelines had an automatic freeze feature designed to be activated when a "crash" or "kill" occurred. However, the automatic freeze feature was not observed to be used. Instead, a crash/kill override was always set so that the simulator would not activate freeze when a crash or kill occurred.

Partial/Parameter Freeze. Evidence from several surveys suggests that, unless there is specific known application for parameter freeze in the training context, it will probably not be used. Partial/Parameter Freeze was found on many devices but was observed in use only at the undergraduate training level. Instructors expressed that there is little training value for this feature at the MAC/SAC/TAC sites.

A design consideration is to identify the uses to which freeze will be put to support training needs, and then to incorporate into ATDs the freeze variations that meet those needs. This approach simplifies instructor/operator tasks while ensuring meaningful control over the training environment. The following table presents uses of freeze together with the freeze variations that best match each use.

Freeze

Uses	Freeze Variations
Start and stop ATD to enter and exit, temporarily interrupt automated demos or replays, or prepare to reinitialize.	Total system freeze
Eliminate flight control and navigation task loading to better enable systems and procedures training.	Flight system freeze
Enable geographic reorientation of the student or demonstrate visual scene perspectives.	Position freeze
Exercise control over the number of axes of flight to be controlled simultaneously.	Parameter freeze

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ATD Specification

The freeze feature shall allow the values of one or more simulator parameters (select systems/parameters) to be frozen at any given time within a mission training scenario. The instructor shall have the capability to manually or automatically freeze the simulator or incur common variations of the freeze feature (total or partial system freeze) depending upon the intended purpose and use in supporting the training needs. Automatic freeze shall occur either when specified parameter values are exceeded or when the state of the simulator changes as in repositioning or going from replay to the normal operating mode.

Feature	Simulator Record/Replay
Definition	This feature enables the instructor to record a student's actions/inputs during a simulated mission. During a replay, all events which occurred as a consequence of student input to the simulator's controls will be reproduced. The replay will repeat the control movements, instrument values, displays, motion cues, visual scenes, sounds and voice communications which occurred during the period of recorded time selected for replay.
Purpose and Intended Use	Simulator Record/Replay allows the student to review his own behavior. The reduced student task load during replay provides a better environment for instructor feedback. For example, the instructor can review the student's performance, identify problems and resulting errors, analyze causes of the problems and give guidance. This feature is most useful when students have difficulty mastering a specific skill, when new maneuvers or tasks are being trained and when instructor critiques are necessary. Frequency of use will decrease as students become more proficient at performing the required tasks.
Additional Considerations	If Simulator Record/Replay is selected, then the following additional considerations should be specified. o The capability to freeze the ATD during replay is a required feature for most training applications. Total system freeze is typically used to stop the simulation prior to entering the replay mode and, on many occasions, to temporarily interrupt replay or to terminate replay for instructional interaction. o The means of exiting the replay is important. In addition to "freeze" and allowing the simulator replay to continue to the end of the recorded segment, the capability of allowing the student to resume control of the simulator at any point during the replay is also desirable. This feature is referred to as the capability to "fly out" of the replay. o The period of time replay has typically been available has ranged from the last three to five minutes of simulated activity. In addition to computation requirements and memory limitations, the amount of time to allow for replay

should be determined after careful analysis of how record/replay will be used and the training application specific to the device.

- How to index the starting point for a replay is very important. Its selection will often dictate whether or not the feature will be used. Replays have been traditionally started by time and usually at one minute increments. In many cases, this has proved to be cumbersome and considered a waste of simulator time. If a small replay capability is all that is required for an ATD, e.g., two to three minutes, the instructor may easily orient himself by time. However, if the recording requirement is relatively long, as in a mission scenario, orientation within the replay by time only may not be appropriate. In this case, orientation by training objective or some other specific identifiable event is more appropriate. Identifiable events might include such events as the beginning of an approach, surface-to-air missile launch or engine malfunction.

  Another method of indexing is by the instructor inserting an index flag.

- In simulators with a motion base, it should be specified whether or not motion is desired in the replay. Past experience suggests that motion is desired only at the undergraduate training level.

Related ISFs

Freeze (Total System). See Additional Considerations above.

Automated Simulator Demonstration. Simulator Record/Replay is used in some ATDs by instructors to create demonstrations. Automated demonstrations differ from demonstrations created using simulator record/replay in several important ways. (See Automated Demonstrations - Related ISFs.)

Example

During a Basic Fighter Maneuvering training exercise the instructor may ask the student to perform a particular maneuver. After completion of the maneuver, the simulator record/replay feature would allow the instructor to replay the maneuver exactly as the student performed it with the student sitting in the cockpit. This would allow the student to review his own performance while the instructor provides feedback to him.

Lessons Learned

It has been found in several surveys that student proficiency appears to be the primary factor in deciding whether to incorporate simulator record/replay into an ATD. It has the greatest training value when the cues, responses and task are new to the student. This feature tends to be used most at the undergraduate training level. During transition and continuation training, it is used for training of new and also relatively complex advanced flying skills such as those required for air-to-air combat maneuvering. Simulator record/replay was not used during transition training or continuation training where students have already developed the required basic skills. In these cases, students were generally able to identify their own performance deficiencies, diagnose the causes, and take corrective steps without the need for such a highly detailed memory and diagnostic aid such as record/replay.

It should be noted that although this feature is found on many of the devices, it is not a regularly and consistently used feature. Many instructors express that this feature may have some value, but that they would rather use the simulator for "hands-on" training. This is especially true at the MAC/TAC/SAC sites.

Slow motion replay capability has been incorporated in some ATDs, but has not been used because it is considered "unrealistic".

ATD Specification

The simulator record/replay feature shall enable the instructor to record a student's actions/inputs during a mission training session. The record/replay feature shall have the capability to record and reproduce all events which occurred as a consequence of student input to the simulator's controls. Recorded student events shall include control movements, instrument values, displays, motion cues, visual scenes, sounds and voice communications. The recorded time selected for replay shall be 10 seconds; and, the recording time shall be increased to a maximum of _______ minutes in 10-second intervals. A capability must exist to freeze the recording at any time during replay and to exit the replay at any point during or at the end of the recorded segment at the instructor's discretion. Such an exit shall be a smooth transition to the original simulator state prior to replay.

Feature

Automated Simulator Demonstration

Definition

The Automated Simulator Demonstration feature provides a prerecorded or preprogrammed aircraft maneuver, or series of maneuvers, that model desired student performance. The demonstration, as viewed from the cockpit station reproduces all simulated flight conditions that occurred when the maneuver was originally recorded or programmed. This includes the actuation of cockpit instruments, indicators, flight controls, motion system movement, visual display scenes, and crew communications.

Purpose and Intended Use

The purpose of this feature is to provide a model that the student can observe, analyze, pattern his own behavior after, and use as a reference for self-evaluation in subsequent training or during operational flying. Demonstrations identify the significant cues and discriminations the student must learn and provide instructional commentary that may facilitate task mastery. Demonstrations are normally used by the instructor to introduce a new maneuver to the student. Demonstrations are of greatest value when the student is unfamiliar with the task to be learned.

Additional Considerations

If Automated Simulator Demonstration is selected, then the following additional considerations should be specified.

- It is important to be able to modify the stored demonstration as aircraft and aircraft operating procedures change. Modifications should not require timely, expensive software re-development.
- The capabilities to freeze or stop a demonstration, to re-initiate it from the beginning, and to enter the demonstration at a desired point should also be specified.
- If the ATD has a motion base, then a safety warning for "Hands and feet clear" should be clearly issued whenever the demonstration is to be played.

Related ISFs

Simulator Record/Replay. Simulator record/replay is used primarily to record the last few minutes of a student's performance for replay and review by the student and instructor. Occasionally, the instructor will take the controls, fly the simulator from the cockpit or the IOS, and immediately replay his performance to demonstrate something to the student. This type of demonstration is different from an automated demonstration in several ways. Because only the last few minutes of simulator time are stored, this feature does not provide a permanently stored and available demonstration. Each time an instructor wishes to demonstrate something to the student, he must re-record it. Such demonstrations vary from instructor to instructor and from one recording to the next. Thus they each provide a slightly different model of behavior to the student, rather than a standard. Additionally, such demonstrations, recorded in the midst of an on-going training session, provide an approximation of the desired behavior rather than an optimal model.

Freeze. See Additional Considerations, above.

Example

An automated demonstration can be constructed for any segment of flight. For example, an ATD can be programmed to takeoff, fly straight and level, refuel inflight, perform aerobatic or air combat maneuvers, deliver weapons, fly a standard approach, or land without the student or instructor operating any primary controls.

Lessons Learned

Although automated demonstrations would appear to have great practical application, experience has shown that this is not true in certain cases. In two recent surveys of ATD use, automated demonstrations were found on many of the devices surveyed but their usage was minimal and inconsistent. One reason may be found in sentiments expressed by training personnel at the simulator sites. Many instructors felt that this feature might have some value. However, simulator time reserved for "hands on" training was too valuable to give up for such demonstrations.

Automated demonstrations are of greatest value when the student is unfamiliar with the basic task or characteristics of the aircraft he is learning to operate. Survey results indicate that demos are used mostly for undergraduate training. However, even this use was sporadic and not by all instructors.

Automated Simulator Demonstration

ATD Specification	The automated simulator demonstration feature shall provide a prerecorded or preprogrammed aircraft maneuver, or series of maneuvers, that model desired student performance. The demonstration shall reproduce all simulated flight conditions including activation of cockpit instruments, indicators, flight controls, motion system movement, visual display scenes, and crew communications, as viewed from the cockpit station. Demonstrations shall also include the significant cues and discriminations the student must learn and shall provide the instructional commentary that may facilitate task mastery. The design shall provide ease of software modification and shall provide the capability to freeze, stop, re-initiate at the beginning, or to enter the demonstration at a desired point.

Feature	Automated Performance Measurement
Definition	This feature provides quantitative measures of student performance in the ATD. It is intended to be used as an aid by the instructor in his overall evaluation of the student.
Purpose and Intended Use	Automated Performance Measurement supports the instructor during training by providing the following: precision, objectivity, standardization, and the capability to measure many facets of performance simultaneously. It can provide sensitive, reliable and valid measurements of student performance during times when the instructor may be preoccupied with other instructional tasks. Except for obvious objective measures (e.g., bomb score), the final evaluation rests with the instructor. This feature may also be used by the student during self-practice as a measure of his progress.
Additional Considerations	o Measurement by User-Defined Objectives. Most automated performance measurement capabilities on existing trainers, aside from being quite simplistic, require manual control by the instructor. There are no "intelligent" start/stop logics which "know" what the crew is doing and thereby know what parameters to measure. Practically all automated measurement capabilities in existing ATDs are best described as performance monitoring and data collection systems. These capabilities allow instructors to select tolerance bands (e.g., +/- 100 feet) around various performance parameters (e.g., altitude). The performance monitoring capability then monitors for cases that exceed the tolerance bands values, and records out-of-tolerance conditions for subsequent display at the instructor's console or for hardcopy printouts. Such rudimentary performance monitoring capabilities have been used to effectively drive automated performance alerting systems and automated cueing and coaching systems. However, they have found little acceptance as an aid for performance evaluation and learning diagnosis during training.

Performance measurement systems for aircrew training must be designed to support specific training objectives. They should be designed around user needs and requirements. Thus, the specific design of an APM will depend on its training application. In this context, the user can define performance criteria. When various measures are properly weighted and combined, the resulting measure set collectively can be quite useful to the instructor. The specification for an APM should include the requirement for a formal development and validation program where inputs by the end user are tried and refined using the fully developed system. The system must also be designed such that "fine tuning" performance algorithms may be accomplished on-site.

o Timely Feedback. An APM system designed for use in training must perform all statistical and other processing of performance data in real or near-real time so that students and instructors are provided with useful, concise and timely performance feedback information.

Measures may be displayed on-line for use during the training session. This type of information must be computed in a timely manner such that the results may be used by the instructor for immediate feedback.

The measures are also output as a summary to be used for debriefing purposes. On some of the devices, the output is also used for student recordkeeping. If this is a requirement, there must be a mechanism whereby the instructor can override or modify the measure as his overall evaluation.

Related ISFs: Remote Graphics Replay. A complete summary of the performance measurement output including what was measured, how it was measured, and an instructor input (override and/or modification) is required as part of the debriefing. The student and instructor will know precisely the means by which the results were attained. In this way the "black box" stigma of computer grading can best be eliminated.

Data Storage and Analysis. The data storage and analysis feature will derive much of its data from automated performance measurement.

Procedures Monitoring. If training objectives require performance evaluation of student procedural activity, then these two features should be directly correlated.

Example

An example of the use of Automated Performance Measurement by objective would be the evaluation of a basic air-to-surface weapons delivery (pop-up) using the example measurements listed below.

- o Attack run-in performance at closest point of approach to a pre-planned position along the run-in corridor, measure
  - altitude to be within tolerance band
  - airspeed to be within tolerance band
  - ground track to be within tolerance band
- o Pop-up performance, measure
  - distance from the target to be within tolerance band when vertical velocity exceeds defined parameters
  - highest altitude obtained to be within tolerance band (low enough to minimize exposure, high enough for safe and accurate delivery)
  - position at which highest altitude achieved to be within appropriate distance from target
- o Weapons delivery performance, measure
  - dive angle to be within tolerance band
  - release altitude to be within tolerance band (low enough for delivery accuracy, high enough for safe recovery)
  - airspeed at release point to be within tolerance band
  - yaw at release point to be within tolerance band
  - ordnance impact to be within lethal range of target
- o Exit performance at minimum altitude on pull-out, measure
  - altitude to be within tolerance band to avoid fragmentation pattern
  - ground track to be within tolerance band (with respect to pre-planned exit route)
  - altitude to be within tolerance band (with respect to pre-planned exit route)

This information should be used <u>in addition</u> to the instructor's judgement about the student's performance, <u>not in place of it</u>. Measures would be available to the instructor for each of the steps listed for this objective. As the student concluded each step, the instructor would be able to determine immediately if the step had been completed within the predetermined tolerances. If an overall score was desired, the output measures for each step could be weighted and combined to yield an overall score for performance on this objective. As in the case of the individual step measures, this score would be used in addition to the instructor's assessment of the student's performance. This objective summary and the individual measurements would then be made available for instructor review for his final evaluation.

The performance measurement information, when used with remote graphics replay, becomes a powerful debriefing and evaluation tool. While graphically viewing the route flown during the exercise and the visual HUD cues during the run and at release, the measures provide the basis for instructor feedback and discussion with the student. The instructor may then formulate his final evaluation.

Lessons Learned

Automated Performance Measurement is an instructional feature which has probably taken on the greatest variety of configurations. There are misconceptions as to what it can do and what it cannot do, and therefore it is a feature which is least accepted and used. If this feature becomes a requirement on a specific device, then there must be an educational process and complete understanding as to its purpose and intended use.

Some ATDs have a feature called performance measurement where bomb drops and missile shots are scored. However, this feature is not used because instructors feel that the basic simulation does not provide the cues necessary to properly launch the weapon. In order for automated performance measurement to have meaning, the APM has to take into account the fidelity and completeness of the simulation. For example, a visual system with only 48 degrees field of view may not be adequate to provide the visual cues for a conventional bombing pattern.

ATD Specification

The automated performance measurement shall aid the instructor in obtaining a valid and reliable measurement of student performance. The feature shall be designed to support specific training applications and to provide the instructor with a precise, objective standardized measure of student performance and a capability to simultaneously measure many facets of a mission event. The instructor shall be provided timely feedback of performance data in real or near-real time; and it shall be displayed on-line for use during a training session or off-line for debriefing purposes.

Feature	Hardcopy/Printout
Definition	Hardcopy/Printout provides for the retrieval of data from any specified source within the simulation - i.e., parameters, variables, real-time display content. It retrieves and creates a hardcopy print of the data upon demand and in such a way that no interruptions occur within the simulation and its displays.
Purpose and Intended Use	Hardcopy/Printout provides the instructor with a printed copy of selected information obtained during the training exercise. It can provide the instructor with information about the training exercise and the student's performance. Both graphic flight profile data and performance summaries can be provided. The copied data is especially useful during debrief for reviewing the exercise as a whole, for comparing the student's performance over the course of the exercise, and for looking for improvements in performance over several simulator exercises. Hardcopy/Printout supports permanent recordkeeping. Used in this way, it provides a means of comparing and reviewing all students' performance in the training program. Training managers can more easily determine whether or not students are meeting training objectives on schedule. In addition, through the ISD process, a comparison of this sort facilitates on-going evaluation of the training program itself.
Additional Considerations	Several problems have occurred in current implementations which have resulted in less use of this feature than would be anticipated. The printed information should be provided in a convenient format and under time and location constraints such that it is useful in the conduct of training, debriefing and recordkeeping. If this feature is selected, the following considerations should be specified. o If a printout of a graphics display is requested, neither real-time data being displayed nor the simulation should be interrupted or delayed. o The printer should be readily accessible to the instructor as he conducts the mission. In addition, the noise caused by the printout of information should not interfere with training activities.

- The printed information should be well formatted and organized around the instructor's needs. Organization according to training objectives is desirable.

- It would be highly desirable to allow some flexibility in the content and format of the printed information. For example, some applications or instructors might require more detailed information than others. Perhaps an option similar to a "declutter" option for displayed output would be desirable in such a situation. In addition, as flight procedures and subsequent training objectives change, it would be convenient to allow some modification of the information to be printed out.

Related ISFs: Automated Performance Measurement. If an ATD has the automated performance measurement feature, hardcopy performance summaries can be produced.

Example During a training session the instructor flags various graphic plots and sets of performance measurement data for use in conducting the debrief. During the debrief he uses the printouts of the plots and data to guide his feedback to the student when dynamic replay and feedback are not required. The printouts are also helpful in guiding use of the remote graphics replay feature.

Lessons Learned This feature is found on most ATDs. While a potentially useful feature, printout is seldom used at most sites. Problems in reliability and ease of implementation were noted. For some of the simulators observed, use of the printout feature requires that the system be taken down from the runtime programs prior to providing the hardcopy output. This was observed to be restrictive to actual training because by the time the copy is made, the instructor has already debriefed the student. In other cases, use of hardcopy required that the display being copied be frozen while output was produced. This was disruptive with respect to real-time feedback.

In some cases the reason instructors didn't use the printout feature was because they didn't know it existed or how to use it.

The ability to obtain a printout of graphic flight profile information for subsequent debriefing was viewed favorably and used by instructors. Graphic situational displays are generally more preferable than numeric summaries. Some ATDs produce performance alert symbols overlaying flight profile data. This too was viewed favorably as a debriefing aid.

Reports that do little more than list parameter data at a specified sampling rate are rarely used. For ATDs which include an automated performance measurement system, information should be summarized into a format meaningful to the instructor/console operator.

ATD Specification

The Hardcopy/Printout feature shall retrieve data from any specified source within the simulation - i.e., parameters, variables, CRT display content. It shall retrieve and create a hardcopy print of the data upon demand and in such a way that no interruptions occur within the simulation and its displays.

Feature	Remote Graphics Replay
Definition	This feature provides a post-mission graphic and dynamic re-creation of a training exercise which has been previously recorded. This replay is conducted at a remote computer graphics console and may be accessed concurrently while training is being conducted on the ATD.
Purpose and Intended Use	Debrief at the conclusion of a simulator session provides the student the greatest part of his performance feedback. Typically during the debrief, the instructor reviews student performance, reinforces instructional points, answers questions and points the student to the next instructional activity. This information is normally provided by instructor recall and his ability to take notes during the exercise. This type of debriefing varies accordingly. With the aid of a graphics replay, the instructor's ability to debrief is greatly enhanced. This feature will also relieve the instructor of note-taking during the actual conduct of an exercise. This type of debriefing feature also allows the instructor and the student to determine when and why the deviation occurred.
Additional Consider-ations	o <u>Replay Indexing</u>. It is important that a convenient method of indexing into a replay be designed into this feature. Positioning within a prerecorded exercise must be oriented toward the end-user. Indexing methods specifically tailored to training would include indexing by training objectives and/or instructor-inserted flags. For example, the instructor should be able to easily select an approach which had been previously executed. Upon selection, the graphics would replay from the starting point of the objective. In this case, the starting point would be at the initial approach fix. Instructor-inserted flags are also used to facilitate locating points of interest in the mission. o <u>Replay Control</u>. The control of the graphics replay should include the selection of optional graphics as provided during the exercise. In addition, the exercise should be able to be replayed at either normal or fast speeds and frozen at any point for review and feedback.

Related ISFs: Automated Performance Measurement. The remote graphics replay is used in conjunction with automated performance measurement review. These two features should be interconnected such that, in addition to replaying a training objective, any performance measurement associated with that objective can also be reviewed accordingly.

Example After leaving the trainer, the instructor and student proceed to a remote station for post-mission debriefing of a navigation training event. The instructor calls up selected portions of the navigation route for replay in a dynamic graphics format. He also calls up the performance measures which were taken during the recording of the training objective. The student and instructor observe the replay, and the instructor critiques the student and provides performance feedback.

Lessons Learned Instructors in general believe that time on a simulator is best spent doing "hands on" training. It is therefore most important that a replay feature include a remote console which can run concurrently with normal training.

Although not enough data has been collected to provide lessons learned with respect to this type of feature which includes a remote console, the operational feedback thus far has been positive.

ATD Specification The remote graphics replay feature shall provide the capability to recreate a graphic and dynamic replay of a training exercise either conducted at a remote briefing/debriefing console or conducted concurrently on the ATD. Automatic indexing by training objectives, in addition to instructor-inserted flags shall facilitate locating points of interest in the mission. The feature shall also provide normal or fast speeds for replay and a capability to freeze any point within the training exercise for review and feedback.

Feature	Data Storage and Analysis
Definition	This feature records information pertinent to student and crew performance during the training session as well as to certain aspects regarding the operation of the system. The data is grouped by student, student type, student class, etc., and includes the objectives attained, time/attempts to attain the objectives, and conditions under which the objectives were met or not met.
Purpose and Intended Use	This data serves up to three purposes depending on whether the device has the related features described below: o This information is used to "fine tune" the performance measurement algorithms. o The data storage and analysis feature will combine all of the data and categorize this information with respect to to student type, experience level, etc. This summary will be primarily for curriculum managers. The information provides dynamic feedback which can be used in gaining maximum training effectiveness from the ATD. o This information will be retained on the system as part of a student's record as long as desired. This information is available for instructor and student review via the Briefing Utility.
Additional Consider-ations	If the Data Storage and Analysis feature is selected, the following additional considerations should be specified. o The data summarized for analysis will have to be accessed via an output device that does not interfere with normal simulator operation. This is normally accomplished off-line via a computer system console and printer for hardcopy outputs. o The information for the Purpose and Intended Use cited above should be individually tailored to the end user. For example, a student's personal record should contain data specific to that student and should not contain the type of voluminous data summaries that are contained in the summary of simulator utilization/effectiveness.

- A utility in the form of a data editor is required to enter administrative data and interact with this feature off-line. Examples of this are entering new students, deleting old students and their records when they are no longer needed, and deleting other stored data when it is no longer required.

Related ISFs

Briefing Utility. The Briefing Utility is desirable to access the student performance data from this feature. If a debriefing utility/remote console is not available, this information may be accessed via a computer system console with hardcopy output. The hardcopy output may then be used by the instructor during briefing.

Automated Performance Measurement. The data storage and analysis feature would provide dynamic feedback to "fine tune" performance algorithms.

Example

Prior to a briefing, the instructor reviews student performance records to determine his training progress and to diagnose any aspects of performance which may affect this trainer event. For instance, prior to a scheduled event for advanced instrument approach training, he notes that the student has had problems with altitude and heading control. As a result, he decides to give the student some basic approach scenarios before proceeding to the more complex scenarios scheduled for the event. This "tailoring" of the event provides some remedial warm-up for the student and allows the instructor to confirm the student's readiness for advanced scenarios.

Lessons Learned

This is a fairly new feature which has been implemented on a only a few ATDs. On one new system, a data storage and analysis feature with a structured student tracking/comparative system is provided. Since this system was just recently installed, no data has been collected with respect to operational usage. However, user response was very positive during its introduction.

ATD Specification

The data storage and analysis feature shall record pertinent student and crew performance information during the training session and may also store information regarding certain aspects of system operation. The data may include information grouped by student, student type and class, the objectives attained, time/attempts to attain the objectives, and conditions under which the objectives were met or not met. Such information shall be retained on the system, for as long as required by the training program, as part of a student's record and accessed via an off-line output device as well as provide an overall dynamic feedback evaluation for curriculum managers. The design shall be individually tailored to the end user and shall provide an interactive data entry capability for administrative information update.

SECTION III

SELECTING INSTRUCTOR SUPPORT FEATURES


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SECTION III
SELECTING INSTRUCTOR SUPPORT FEATURES

Purpose

This section presents a systematic approach for the selection of instructor support features. Section II provides definitions of ISFs, their intended use, and lessons learned from surveys of current ATDs. ISFs are intended to support the instructor and improve the overall training effectiveness. To this end, ISFs must be identified which support instructor functions and are oriented to the specified training to be performed on the ATD.

In the past, ISFs have been specified without a thorough analysis of their need or how and when they should be used. They were included because it was felt they might be helpful, or because they were included on other similar ATDs. This approach does not allow for effective selection or design of the features, and generally results in a system that is cumbersome for the instructor to use. It also can lead to a device which includes many features which are seldom, if ever, used.

This section discusses the approach used to determine ISF requirements for the sample specification in Appendix C. It specifies the rationale for each ISF selection, and identifies how it is to be used. This is not the only way to approach this issue; rather, it provides a guide to be used in other specification efforts. More importantly, this procedure clarifies to the ISS designer how each feature should be used and hopefully produces a system to match user needs.

Overview

Simulator specifications have been developed under highly structured methodologies such as Instructional Systems Development (ISD). These methods primarily address the student interface with the training device. They relate device training characteristics to specific operational tasks, but do not consider training effectiveness requirements of the instructor. Specifying the instructional system for any ATD requires a firm understanding of ISFs, training requirements, and the role of the instructor in the training cycle.

To define the instructional system, an approach should be used which integrates the training requirements with the instructor's functional requirements to identify ISFs which would aid the instructor and enhance overall training effectiveness. This approach is similar in many respects to the task and mission analysis used to define aircrew training requirements. The following areas, to be addressed in this section, should be considered:

- o Front-End Training Analysis
- o Instructor Functions
  - o Pre-training Requirements
  - o Training Requirements
  - o Post-training Requirements
  - o Benefit Analysis
  - o Technology and Cost Considerations

Instructor support features are designed to facilitate the instructional process. They are intended to improve the "efficiency" of the training. Only those features which support the instructional objectives or instructor task should be included in the specification.

Front-End Training Analysis

Before any ATD is specified, a front-end training analysis must be accomplished to determine ATD capabilities to support training. This analysis provides valuable information which is necessary in determining ISF requirements to support the training program. The following information from the front-end analysis will be used as inputs to the training requirements phase:

- o Student skill and knowledge level - This identifies the ATD user groups and provides information on how training will be conducted and the use of various training methodologies. The general training objectives of the various user groups may be similar, but the content and conduct of the training events may be different.

- o Training task objectives - This specifies what is to be trained under what conditions and to what standards. This information is used to specify the instructor's control and information requirements in order to conduct the specified training.

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- Training syllabus - This information specifies how the training objectives will be tied together to form training events. It must be analyzed to determine what instructor controls and information will be required to perform each training event efficiently.

As can be seen, a thorough analysis of the training needs of the aircrew plays an important role in the ISF analysis. Without the front-end training analysis, it is difficult to determine the exact needs of the instructor and define design requirements to meet training efficiency.

Instructor Functions Analysis

The total training situation includes not only the training device and the trainee but also the training syllabus and most importantly, the instructor. He is the key to ATD training. The instructional effectiveness of the simulator is dependent, to a large degree, on the manner in which the instructional system is designed and implemented. Maximizing the instructor's ability to fully utilize the capabilities of the ATD is crucial to improving the effectiveness of the ATD.

Since most training features are designed for use by the instructor, it is necessary to have a good understanding of his role and job function. Instructor functions are implicitly known, but by explicitly defining the instructor functions according to specific training needs, one can identify design requirements which will enhance the total training system. Instructor functions should be analyzed in three distinct areas. These are:

- Pre-Training Requirements - instructor activities which are required prior to the actual training session on the ATD. This would include functions such as training session preparation and briefing.

- Training Requirements - this includes instructor activities required during the active training session on the ATD. It would include instructor functions such as controlling, instructing, monitoring and evaluating training activities.

- Post-Training Requirements - instructor activities required after the actual training session on the ATD. It includes such functions as debriefing and record keeping.

Each of these areas is discussed in detail in the following sections.

Pre-Training Requirements

Prior to conducting training on an ATD, an instructor has many requirements which must be accomplished to enhance the training session. These include:

- <u>Instructor Training Function</u> - The instructor must be capable of utilizing the instructional subsystem to provide effective training. This means that the instructor must be trained on console capabilities, operation, and the use of the capabilities to provide effective training. In addition, instructors will require refresher training at periodic intervals to maintain their proficiency. This requirement can be met through many ways: formal training, computer-assisted instruction, instructor handbooks, or the instructor support feature which is capable of providing self-paced instruction at the instructor console and/or a remote console:

    - Tutorial

- <u>Prepare Function</u> - The instructor must be familiar with all aspects of the planned training event prior to briefing the trainee. This includes a review of the event description, specific training objectives, performance criteria, procedures to be followed, and current status of the ATD. The instructor should review the trainee's performance records to determine his training progress and to diagnose any aspects of performance which may affect the current training event. This process is necessary so the instructor can plan how the training event will be conducted, identify control requirements, training methods, and possible event tailoring to meet the needs of the trainee.

    All required information should be available at a single location via hardcopy or a remote console/terminal.

- <u>Training Set-up Function</u> - This activity is normally performed at the instructor's console prior to the start of the training event. However, a capability could exist which allows the instructor to tailor the training event off-line (remote console) and recall the information at the instructor console for initialization of the ATD. A training system which utilizes the task module concept (see Section IV) could allow the instructor to tailor the training event by objectives, specify variables such as control of the environment and targets prior to the active training session. This capability would reduce the instructor's workload at the console and provide efficient use of the ATD training time.

Another consideration is instructorless training. If instructorless training is required, the instructional system must be designed to accommodate this need. It should allow the student to select and activate training scenarios to meet the required training needs. The objective based Scenario Control ISF could provide such a mechanism.

- Develop Training Function - This involves the identification of changes to the training syllabus, implementation and validation of these changes. This function requires design considerations which allow it to be performed easily in a timely fashion. This function should be capable of being performed from a remote location which will not interfere with the active training capability. A training system which utilizes a task objective data base provides a mechanism by which the instructor can easily modify and/or develop new training scenarios based on the existing training objectives.

- Brief Function - This involves reviewing with the student the training event, specific training objectives and performance criteria and known ATD discrepancies. Depending on the level of training, the instructor may be required to discuss common difficulties, specific procedures, techniques, displays and cues which would enhance the hands-on training in the ATD. As noted previously, training event information can be stored and retrieved from the ATD computer storage. Likewise, informational displays and graphics, which are useful to the briefing function can be retrieved for the instructor's use at a remote console. The instructor support feature which relates to the brief function is:

    - Briefing Utilities

The pre-training requirements deserve careful consideration in determining instructor support feature requirements. A training system which is designed around instructor needs and provides information in a meaningful easy-to-interpret format can benefit the instructor during his pre-training requirements. In particular, the preparation and briefing functions can dramatically affect the training process.

Training Requirements

The support requirements of the instructor for conducting simulator training vary from ATD to ATD. In one instance the instructor is onboard the simulator with the trainee; in another the instructor is located offboard at a remote console.

SECTION III
SELECTING INSTRUCTOR SUPPORT FEATURES

Even though there are configuration differences among ATDs, the role of the instructor remains the same. The instructor must control the training, monitor trainee activities, provide instruction and evaluate performance. These are the functional requirements of the instructor which must be performed to accomplish the active training task. The instructor's support needs will depend on his location relative to the trainee and the training requirements. These support needs will be expressed in terms of control and informational requirements of the instructor to provide effective training. These factors play a key role in the design requirements of the instructor's station and must be identified up front during ATD specification.

To determine instructor support needs, a thorough analysis of the activities performed by the instructor during training is necessary to ensure an optimum design. The front-end training analysis should be used to identify what has to be controlled and displayed to the instructor so he may perform the functions of controlling, monitoring, instructing and evaluating performance.

The following sections discuss considerations for each of the instructor functional requirements.

- Control Function - includes all activities pertaining to the control of the training exercise. It includes control of the content and conduct of the simulation exercise as well as basic simulation. An analysis of the training task and syllabus events will identify control requirements. It was observed on data collection trips for this document that instructors spent much of their time inputting and controlling simulation variables. This detracted from the primary responsibility of instructing. It should also be noted that in all cases instructor support features existed in these ATDs which would have eased the instructor's workload, but they were not designed effectively to meet his needs; thus the features were not used. Five instructor support features are defined in this manual which directly relate to the control function. They are:

    - Scenario Control
    - Initial Conditions
    - Real-Time Simulation Variables Control
    - Malfunction Control
    - Reposition

  The definition and supporting information for each of these features should be read thoroughly then compared with the control requirements identified for the task and syllabi to be trained to determine their applicability.

- <u>Monitor Function</u> - involves the presentation of information which is required by the instructor to perform the training functions. This information must be available when the instructor needs it and presented in a format which is easy to interpret. Two instructor support features which address the monitoring function are:

  - IOS Display Control and Formatting
  - Procedures Monitoring

  Information formatting is required of all ATDs. Currently CRT flexible format displays are the preferred mechanism for providing the instructor with cockpit and situational information. By defining the specific training requirements, display of relevant training activities can be specified to provide the instructor the necessary information. Without defining the instructor's specific needs, it is possible that the instructor could have the wrong information displayed at a critical point, or displayed in a format which is difficult to interrupt. For manual selection of displays, options should be kept to a reasonable number and grouped by training objective; otherwise the instructor will simply be unable to utilize the choices effectively.

- <u>Instruct Function</u> - involves those activities that direct the growth of skills and knowledge of the student while providing knowledge, information, and feedback in a systematic way. The training analysis identifies the training task and the skill and knowledge level of the students. This information must be considered when defining features to support the instructional capability of the ATD. Three instructor support features are defined which support the instruct function. They are:

  - Freeze
  - Simulator Record/Replay
  - Automated Simulator Demonstration

  It should be noted that these features are for on-line instruction. Off-line instruction, e.g., debrief, is considered under the Post-Training Requirements.

- <u>Evaluate Function</u> - involves monitoring relevant training parameters which reflect the performance of the trainee during the training session and assessing whether the observed performance meets specified training criteria. The evaluation function is closely tied to the monitor function in that the instructor requires the relevant training information presented at the appropriate time in a meaningful easy-to-interpret format. The IOS Display Control and Formatting ISF can aid the instructor by minimizing his workload, allowing more time for his primary tasks of instructing and evaluating.

Another method of evaluation is to let the ATD automatically provide performance evaluation data in terms of the standards defined in the training task analysis. Such a system can provide sensitive, reliable and valid measurements of the trainee's performance. The feature which supports the evaluate function is :

- Automated Performance Measurement

An Automated Performance Measurement feature should include a capability which allows the instructor to override or modify each performance evaluation. Not all training can be evaluated through APM. But on those tasks where APM can be applied, it reduces the instructor's workload and provides a greater degree of evaluation standardization.

Post-Training Requirements

At the completion of active training on an ATD, the instructor must perform certain functions to complete the training cycle. Two functions which must be performed are debriefing the student and recording pertinent data from the training session.

- Debrief Function - involves the review of the training session with emphasis on student performance evaluation and instruction. Debriefing is the most widely used form of feedback in military training. The debriefing function is an extremely valuable instruction method. The instructor can analyze student performance, identify problem areas and recommend corrective action for subsequent training. The instructor must have the relevant training information available during debrief to perform this function effectively. In many cases the only information available to the instructor for debrief are hand-written notes and specific items that the instructor can remember. This method can be cumbersome, detract from the active training session, and possibly cause the instructor to miss or omit key training points. Two instructor support features which can aid the debriefing function are:

- Hardcopy/Printout
- Remote Graphics Replay

Hardcopy can provide data and graphic printouts which are pertinent to student performance during the training event. For all printouts, information concerning content and format will be required during ATD development. Hardcopies provide "snapshots" of the training event at the time of selection. Where dynamic recreation of specific events is required, a remote graphics replay feature could provide this information. This replay would be conducted at a remote console so as not to interfere with active training on the ATD.

- Record Function - includes activities associated with obtaining and recording pertinent data associated with the training session in terms of student performance and device operation. The data storage and analysis feature can aid the instructor in the performance of this function. It can also provide student progress information necessary for the Pre-Training Requirement, and data pertinent to the management of the training system.

Benefit Analysis

The Instructor Functions Analysis, presented above, identifies where instructor support features can be used to aid the instructional efficiency of the ATD. Some of these features are required to perform the necessary training functions, e.g., IOS Display Control and Formatting, while other features would be considered "nice to have." At some point in the specification process, due to cost and other factors, the ISFs to be included must be prioritized. This requires that a benefit analysis be performed to identify which features should be included in the specification. The results of this analysis will produce a prioritization of features based on their overall contribution to training efficiency.

It should be noted that this prioritization does not take cost into consideration. Although cost will ultimately be a deciding factor with respect to the final ISS configuration, these guidelines are intended to emphasize selection based purely on functional requirements. In other words, the set of instructor support features selected and prioritized should be considered the "ideal set": those features which would be included if cost was not a factor. Subsequent "trimming" of the features, based on budgetary considerations, should be made from this baseline.

The benefit analysis should include the following training considerations.

- <u>Frequency of Identified Need</u>. The projected frequency of use should be considered in the prioritization of the selected instructor support features. Features which would be needed more often, in general, will have higher priority among those selected. However, if a feature is the only effective method of training a specific critical task or if it is by far the most efficient method, then it should be considered a higher priority feature.

- <u>Instructor Loading</u>. The impact on the instructor's workload is another important consideration in prioritizing features. Features which substantially reduce the instructor's workload should be given a higher priority.

- <u>Useability of the System</u>. This is related to instructor loading. It is important to consider what tasks the instructor will be required to do if the feature is not present. For example, if features supporting the control function are not included, the instructor would be required to spend more time and attention controlling the simulator and less time instructing the student.

- <u>Training Efficiency</u>. Some features directly affect the training efficiency of the ATD. For example, a remote briefing utility console or a remote graphics replay console would allow pre-training or post-training functions to be carried during the "hands-on" training. This type of configuration maximizes the total amount of training carried out on the ATD.

- <u>ISF Interdependency Requirements</u>. As pointed out in the section describing ISFs, the selection and design of one feature may impact the selection and design of other, related features. This should be a consideration in the prioritization of the selected features.

Technology and Cost Considerations

Personnel in the Simulator Systems Program Office will need to consider technology and cost issues at the point of finalizing the selection of ISFs. It is suggested that SimSPO personnel review the steps immediately above before proceeding.

The consideration of technology and cost has been reserved for the end of the selection procedure because ISF implementation costs should not drive the <u>upfront</u> analysis. Ultimately cost has a significant impact. Maximization of training effectiveness

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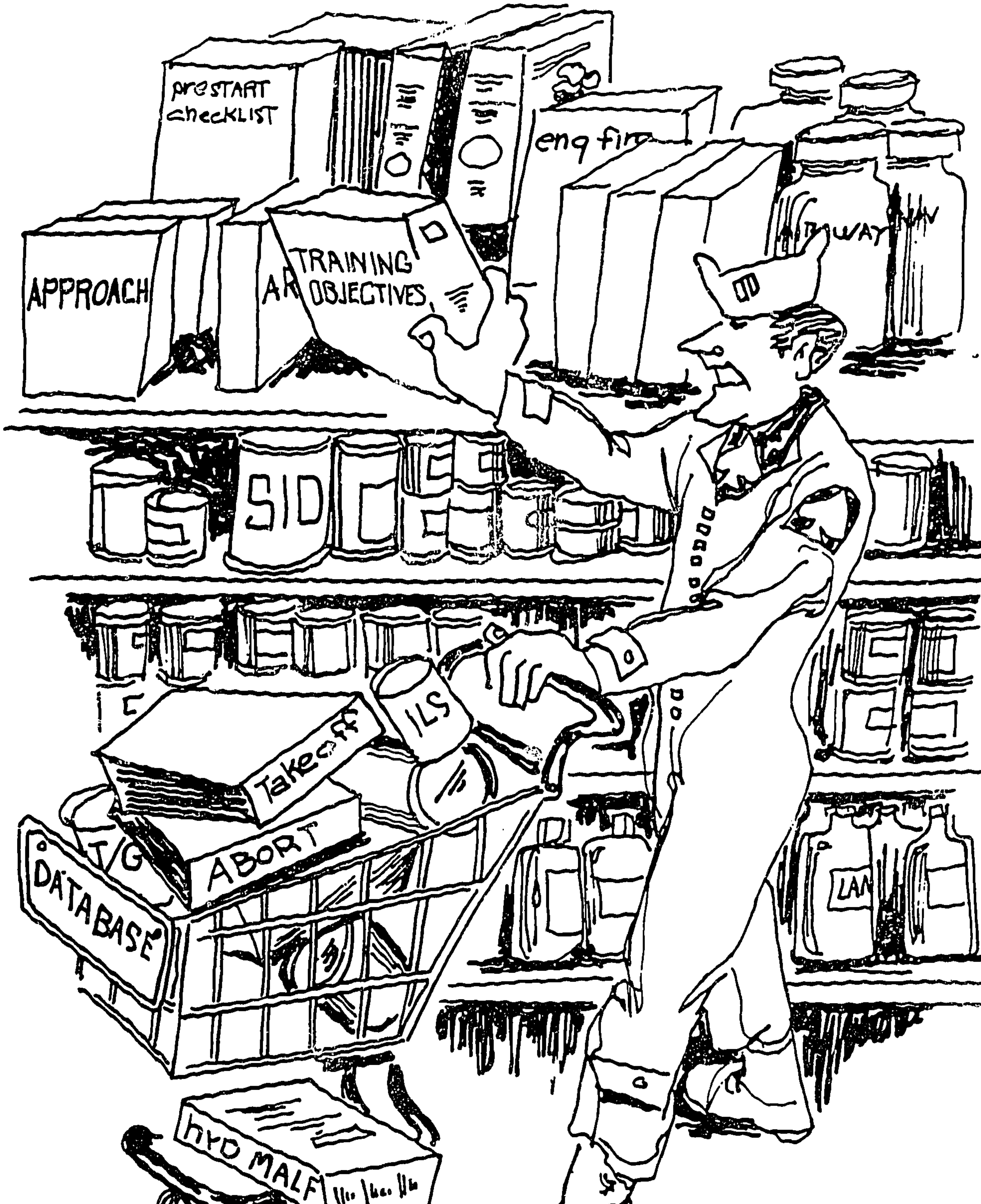
via ISS utilization results in cost savings over the life of the ATD. These cost savings and other ISF benefits are to be weighed against the ISF implementation costs. As features for Instructor Support are selected, justifications can be found in the "Purpose and Intended Use" section of the instructor support feature definitions. SimSPO personnel should work with Operational personnel after all upfront analysis has been completed and a complete assessment of justifications has been accomplished for the ultimate cost/benefit tradeoff.

Appendix F offers background information for SimSPO personnel who have technical backgrounds but have limited experience with ISS implementations. Major components of the ISS and their associated cost factors, implementation tradeoffs, and options are included. Sizing and performance information for software and hardware components are also given as examples from selected prototype system implementations.

SECTION IV

PROVIDING OPERATIONAL INFORMATION


prestart checklist
APPROACH
TRAINING OBJECTIVES
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Takeoff
ABORT
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Introduction

After the selection of instructor support features, it is necessary for operational personnel to provide more detailed information about the tasks to be trained and practiced. This section of the ISF Guidelines has three purposes: 1) to explain why task specific information is required, 2) to describe what type of information is required, and 3) to provide a format that is both convenient to use and that ensures that the information to be provided will be complete.

Background

Instructor support features (ISFs) are incorporated into a simulator by means of an Instructional Support System (ISS). The ISS is a subsystem within the ATD designed to reduce the instructor's workload during the training exercise. The ISS can support instruction in a number of ways. It can simplify control of the simulation and simulation variables, select displays appropriate to the phase of flight, monitor flight parameters and procedures, compute performance measures, and store data for debriefing and other purposes. In short, it can carry out any of the functions described in the definitions of ISFs in Section II of these guidelines. By taking over some of these functions, the ISS allows the instructor to use his time more effectively during the training exercise. He is freed to spend more time providing quality, one-on-one instruction, rather than dividing his time between the student and countless other required functions.

In the past, instructional features having a direct correlation to procedures and curriculum requirements have been incorporated into ATDs; however the design of these features did not allow for easy modifications. Changes in checklists, modifications to approaches/departures, etc, continually change and instructional features which supported these events were quickly outdated and therefore justifiably not used.

Modular Design:

Task Modules

To correct this major deficiency, a modular design was developed to allow straightforward modifications to the system without any software rewrite. The operational training requirements are separated into units called <u>task modules.</u> They have a direct correlation to a group of files which make up the data base for a modular data base driven system. This provides the capability to handle operational changes in a timely and economic manner.

Task modules have an additional advantage. Because they also have a direct correlation to training objectives, their incorporation into the system design will help to ensure that the ISS is designed to user needs.

The following paragraph should be added to the software section of the specification if the task module design is chosen:

> "A database shall be developed to parallel the syllabus training objectives. The ISS shall be driven from this data base. An editor for convenient update and modification of this database shall also be developed."

Required Information

If instructor support features are to be incorporated into an ATD using the task module concept, then the ISS needs certain information to be able to implement them. In designing an ISS, the user states what the ISS should do by specifying which ISFs to incorporate. However, in order to recognize how and when to activate/de-activate ISFs, the ISS also needs to have more specific information about the tasks to be trained and practiced.

Example

The following is a brief description of a TAKEOFF procedure and an example of the types of information which might be required:

- o Start conditions for the task:
  (e.g., Value for airspeed is greater than zero and accelerating)
- o Stop conditions for the task:
  (e.g., Airborne with gea and flaps up)
- o The displays to be presented to the instructor:
  (e.g., Plan view of runway and appropriate cockpit instruments)
- o Performance required:
  (e.g., Specify Maximum Centerline Deviation allowed)
- o Error messages:
  (e.g., Rotated below specified rotation speed)

This type of operational information must be supplied by the using command. Through the use of task modules, personnel in the using command can specifically state the conditions under which training support functions will be provided by the ISS.

Two types of task modules:

There are two basic types of task modules: flight and procedural. Modules related to the control of flight parameters and modules related to procedural actions are basically different from the viewpoints of both instruction and implementation.

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Flight

Flight task modules involve monitoring continuously changing flight variables and measuring the amount of deviation from a desired value.

Procedural

Procedural task modules involve monitoring events (either discrete switch actions or instantaneous values of variables) and measuring whether all the right actions were taken in a correct order.

While the basic distinction between task module types is flight and procedural, it may be convenient to further subdivide these types into categories for normal, emergency, and tactical flight.

Six Categories

The resulting six categories (with examples included) are listed below.

Normal Flight

Normal Flight Task Modules are the type of task modules which pertain to the flight segments of a training scenario. These are pilot actions which directly relate to the control of flight parameters. The following is a sample list of this type of module:

- Taxi
- Takeoff
- Climb (non-controlled)
- Climb (standard instrument departure)
- Cruise (non-controlled)
- Enroute (point to point controlled)
- Descent (non-controlled)
- Descent (controlled)
- Holding
- High Altitude Penetration
- Low Altitude Penetration
- GCA (precision final approach)
- GCA (non-precision final approach)
- ILS final approach
- Non-controlled visual approach
- Landing
- Landing roll out
- In-flight basic instrument maneuvering (S patterns)
- Aerobatic maneuvering
- Inflight refueling

Normal Procedures

Normal Procedures Task Modules are the type of task modules which pertain to the normal procedural events the student must accomplish. These are flight crew actions in the cockpit other than direct flight control. The following is a sample list of this type of task module:

- Pre-start checklists
- Start checklists
- Post start checklists
- Pre-taxi checklists
- Pre-takeoff checklists
- Takeoff checklists
- Post take off checklists
- Climb checklists
- Pre-descent checklists
- Penetration checklists
- Pre-landing checklists
- Landing checklists
- Post landing checklists
- Pre-shutdown checklists
- Shutdown checklists

Emergency Procedures

Emergency Procedures Task Modules are the type of task modules which pertain to the procedural events in handling aircraft system malfunctions. This type of task module is aircraft systems specific; therefore the following is a list of common aircraft systems which this type of task module would most likely fall under.

- Hydraulic malfunctions
- Electrical malfunctions
- Flight control malfunctions
- Fuel malfunctions
- Engine malfunctions
- Environmental control malfunctions

Emergency Flight

Emergency Flight Task Modules are the type of task modules which pertain to aircraft flight control while handling an emergency. The following is a sample list of this type of task module:

- Single engine landing (or less than all engines)
- Landing gear malfunction landings
- Land ASAP (e.g., low fuel - re-routing quick descent)
- Blown tire on landing
- Less than optimum configuration landing (e.g., no flaps)
- In-flight fire
- Engine failure on takeoff (abort)
- Engine failure on takeoff (no abort)
- Blown tire on takeoff
- Engine restart procedures (in flight)

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PROVIDING OPERATIONAL INFORMATION

Weapons Procedures

Weapons Procedures Task Modules are the type of task modules which pertain to the procedural actions in operating weapons related equipment in the cockpit. This type of task module is weapons specific; therefore the following sample list is very broad in scope.

- AAI radar search procedures
- Weapons control panel procedures
- ECM systems procedures
- AEW systems procedures

Flight Tactics

Flight Tactics Task Modules are the type of task modules which pertain to aircraft tactical maneuvering. This type of task module is weapons Task Modules specific; therefore the following sample list is ver broad in scope.

- Low-altitude bomb run
- 2 v 1 VID
- SAM defensive maneuver

A task commonality analysis, found in Appendix E, may be used as an initial step in identifying task modules for specific ATDs.

Other Operational Considerations

As a detailed checklist of items to be included, the task module is an aid to the user and training analyst in specifying system requirements. The following are examples of some of the operational considerations which should be addressed when describing these tasks:

Display Requirements. Any graphic display requirements specific to the task module should be specified (e.g., HI TACAN NO.1 approach plate with a non-erasing history trail of the aircraft flight path)

Measurements. The measurements expected to be taken should be defined. The following are examples:

o Airspeed	(IAS, CAS, MACH)
o Heading	(degrees, true, magnetic)
o Altitude	(feet AGL, MSL)
o Vertical speed	(feet per second)
o Rate of turn	(degrees per second, standard rate)
o Acceleration	(Gs)
o Position	(lat/long, radial/distance)
o Angle of Attack	(units specific to A/C)
o Switch positions	(for procedural tasks)
o Aircraft configuration	

Measurement Types. How the measurements are to be taken should be addressed. The following are examples:

- Continuous over a period of time with start stop conditions.
- transform selection
  - sampling rate
- Single measurement (snap shot)
  - logic when to take the measurement
- Reaction time and time to complete a procedure (for procedural tasks).

Performance Algorithms. If automated performance measurement is to be applied, the following are some issues to address:

- Scoring Procedure
  - weight factors within the objective
  - weight factor within the exercise
- Task difficulty dependent on the environmental conditions
- Task difficulty dependent on other parallel running tasks

Task Module Start Stop Conditions. The following are some examples of how to define machine detectable start stop conditions:

- Machine detectable events
  - reaching a flight parameter or combination of flight parameters
  - arriving at a specified position (lat, long, fix) or the closest point of approach to a position
  - flying into a cone in space defined by radials of a nav facility and within an altitude band
  - any of the combination of the above
- Operator inputs
  - resets
  - changes to I.C.s
  - manual insertion of a checklist or malfunction

- Task Module Control where the termination of a task module will automatically start the next task module in sequence.

Formats

Task module formats for the two basic types of task modules, normal flight and normal procedure, are presented in Tables IV-1 and IV-2. They are provided as guides to be used in the development of the two basic types of task modules. These formats will also provide guides for emergency and tactical types of task modules. The reader is referred to Appendix G for examples of two task modules used in an operational system.

Table IV-1. Flight Task Module Format

An introductory heading provides general information relevant to the entire task module in the following format:

TYPE:	Normal Flight Task Module (e.g., approach, departure, ILS, etc).
NAME:	The operational name of this specific task module (e.g., HI TACAN ONE Luke AFB).
DESCRIPTION:	A concise summary description.
START CONDITIONS:	The flight parameters and or other conditions which start this module.
STOP CONDITIONS:	The flight parameters and other conditions which stop this module.
ISFs and RELATED INFORMATION:	The ISFs relating to this task module and operational information required. (e.g., IOS Display Control and Formatting to put up a graphic display appropriate to this task module and Real-Time Simulation Variables Control to change the environmental conditions).
TASK MODULE SCORING:	The list of weight factors for the steps within the task module. Specify if Automated Performance Measurement or Procedures Monitoring are to be used.

Table IV-1. Flight Task Module Format - Continued

Each task module is further broken down into measurable events called steps. This further breakdown provides more precise points whereby additional support features may become active. They are listed in logical order in the following format:

STEP NUMBER:	The unique sequential number identifying this step: 1,2,3, ...N.
DESCRIPTION:	A statement of the student action to be performed in terms of specific aircraft flight/configuration parameters (e.g., climb to FL 180 upon reaching "BIC" intersection).
START CONDITIONS:	The flight parameters and or other conditions which start this step. (e.g., in the case above, a start condition would be the closest point of approach to "BIC" intersection.)
STOP CONDITIONS:	The flight parameters and or other conditions which stop this step. (In the case above, when the simulator reaches 18,000 ft MSL.)
ISFs and RELATED INFORMATION:	The ISFs related to this step. (e.g., Malfunction Control to insert "cabin pressure failure"). Also specify operational information required for these ISFs. (e.g., Scoring procedures for Automated Performance Measurement, diagnostic messages if desired.)

Table IV-2. Normal Procedures Task Module Format

The heading provides introductory, general information regarding the entire task module in the following order:

TYPE:	Normal Procedures Task Module (e.g., engine start, taxi checklist, takeoff checklist, etc.)
NAME:	The specific name of the task module (e.g., takeoff checklist).
DESCRIPTION:	A concise summary of the content.
START CONDITIONS:	A description of the situation which defines the start of this task module; may consist of various switches being set, parameters being met, or by operator selection.
STOP CONDITIONS:	A description of the situation which defines the completion of this task module; may consist of various switches being set, parameters being met, or by operator selection.
ISFs and RELATED INFORMATION:	ISFs relating to this task module and required operational information. (e.g., IOS Display Control and Formatting to put up the appropriate display for this checklist)

Each task module is further broken down into steps. This further breakdown provides more precise points whereby additional support features may become active. They are listed in logical order in the following format:

STEP NUMBER:	The unique sequential number identifying this step: 1, 2, 3, ...N.
DESCRIPTION:	A statement of the checklist activity to be accomplished in this step, generally consisting of one checklist item which may or may not include several associated activities.
CONTINGENCIES:	If appropriate, a description of the events which must have taken place prior to the initiation of this step, i.e., prerequisite events.
EVENTS:	To be supplied.
ISFs and RELATED INFORMATION:	ISFs relating to this step and required operational information. (e.g., Procedures Monitoring to determine if correct procedure was followed and possibly to put up an error message if something was done incorrectly).

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GLOSSARY OF TERMS

AIRCREW TRAINING DEVICE (ATD): A term that refers to synthetic training devices (simulators) used in support of aircrew training programs. These devices range from simple procedures trainers to more complex training systems.

ALGORITHM: A precise characterization of a method for solving a problem or achieving a goal, e.g., a sequence of actions terminating in a solution.

BRIEF: Review of events, objectives and procedures with aircrew and instructional staff prior to simulator session.

CHECKLIST: series of distinct actions to be performed at discrete times.

CONTINUATION TRAINING: Training conducted routinely in operational squadrons, or proficiency training conducted periodically.

CONVERSION TRAINING: Initial qualifying training for a particular type of weapon system.

DATA-DRIVEN: A system that relies on general software which acts upon a database, such that a change to the database would not effect a change to the software.

DEBRIEF: Review of event results with aircrew and instructors subsequent to simulator session.

FIDELITY: How closely the simulation reflects the actual performance of the aircraft.

INITIALIZATION: Initialization involves specifying, usually from the instructor/operator console, the parameters of interest and their values for positioning and configuring an ATD within a gaming area.

INSTRUCTOR SUPPORT FEATURE (ISF): Features provided by the ISS to aid the ATD instructor in conducting the training exercise. See Section II for a complete list of ISF definitions.

INSTRUCTIONAL SYSTEMS DEVELOPMENT (ISD): Procedural approach to the analysis of training requirements and the development of training programs and systems.

INSTRUCTOR/OPERATOR STATION (IOS): The aircrew training device man-machine interface where active control and monitoring of training events occurs.

INSTRUCTOR SUPPORT SYSTEM (ISS): Automated system within the ATD designed to aid the instructor in performing the training function.

OFF-BOARD STATION: Instructor/operator station which is outside cockpit.

OFF-LINE: Any action not associated with active training on the simulator. (Operations on the remote graphics brief/debrief station is off-line)

ON-BOARD STATION: Instructor/operator station which is inside cockpit.

ON-LINE: Controlled directly by a computer.

OPERATIONAL FLIGHT TRAINER (OFT): A device which dynamically simulates the flight characteristics of the designated aircraft to train flight crews in cockpit procedures, instrument flight procedures, emergency procedures, communications and navigation procedures, and includes limited mission execution.

SAMPLING RATE: The temporal frequency at which a stated variable (parameter) may be recorded or examined by an automated performance measurement system.

SCENARIO: A predefined sequence of training events used to exercise the capabilities of an ATD in a specific area of intended training usage.

SIMULATION SYSTEM: That part of the ATD that provides aircraft dynamics and the environmental conditions.

STATEMENT OF OPERATIONAL NEED: A general statement of requirements prepared by one of the Air Force Major Commands.

TRAINING OBJECTIVES: Explicit statements of the goals of training including tasks to be performed, the performance standards for each task, and the conditions under which those tasks are to be performed.

TRAINING REQUIREMENTS: General statements of task performance skills required for operational proficiency. Also, general statements of performance skills that require periodic practice in order to maintain proficiency.

TRANSITION TRAINING: Training for aircrew members transitioning to different operational aircraft.

UNDERGRADUATE PILOT TRAINING: Initial pilot flight training.

ABBREVIATIONS AND ACRONYMS

A/C	aircraft
ACM	air combat maneuvering
AFB	Air Force Base
AFTS	Adaptive Flight Training System
AGL	above ground level
APM	automated performance measurement
ARPTT	aerial refueling part-task trainer
ASD	Aeronautical Systems Division
ASR	advanced surveillance radar
ATC	Air Training Command
ATD	aircrew training device
BFM	basic fighter maneuvers
CAS	calibrated air speed
CDR	critical design review
CPA	closest point of approach
CPT	cockpit procedures trainer
CRT	cathode ray tube
D.C.	direct current
ECM	electronic countermeasures
GCA	ground controlled approach
GCI	ground controlled intercept
HUD	head-up display
IAS	indicated air speed
I.C.	initial condition
IFF	identification friend and foe
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INS	Inertial Navigation System
IOS	instructor/operator station
ISD	instructional system development
ISF	instructor support feature
ISS	Instructional Support System
MAC	Military Airlift Command
MAJCOM	major command
MRM	medium range missile
MSL	mean sea level
NAVAIDS	navigational aids
NDB	non-directional beacon

OAP	offset air point
OFT	operational flight trainer
PAR	precision approach radar
PIDS	prime item development specification
R&D	research and development
REO	radar electro optical
SAC	Strategic Air Command
SAM	surface-to-air missiles
SID	standard instrument departure
SimSPO	Simulator Systems Program Office
SMS/FNCP	storage management system and fuel navigation control panel
SRM	short range missile
TAC	Tactical Air Command
TACAN	tactical air navigation
UPT	Undergraduate Pilot Training
WST	weapon system trainer
Wx	weather

ISF INDEX

APPENDIX A

AIRCREW TRAINING DOCUMENTATION

A-10

Flight Objectives Pamphlet (8/84)
Gradesheet
IOS Manual, Upgrade Training Course (not dated)
TAC Syllabus (8/84)

B-52

Console Familiarization Course (1984)
Test Option 5 Scenario Description (not dated)
Training Program WST Coursebook (not dated)
WST OIS Console Operations Guide Vol. I and II (8/84)
WST DDS Console Operations Guide (8/84)

C-130

Flight Simulator Operating Instructions (10/82)
Instructor Guide Part II, Pilot Requalification/Upgrade Course (1/83)
Instructor Guide, Navigator Mission Qualification (12/82)
Mission Profiles I - V (not dated)
Nullmeyer, R.T., and Rockway, M.R. Effectiveness of Weapon System Trainers for Tactical Aircrew Training. In Proceedings of Interservice/Industry Training Equipment Conference and Exhibition, October 1984.
Partial Preliminary Simulator Instructor Guide for Tactical Mission Qualification Training (12/82)
Pilot Study Guide Part I, Pilot Initial Qualification Course (10/82)
Student Study Guide Part II, Tactical Mission Qualification Training (12/82)

C-141

Flight Instructor Guide, Navigator Airdrop Mission Qualification Course (3/83)
Flight Instructor Guide, Pilot Initial Qualification Course (1/81)
Instructor Guide, Pilot Airdrop Qualification Course (11/83)
Instructor Malfunction Guide, Flight Engineer Initial Qualification Course (3/84)
SIM/CPT Instructor Guide, Pilot Initial Qualification Course (11/82)
Task and Objectives Document, Loadmaster Airdrop Qualification Course (10/81)

F-15

Instructor Operator Guide, F-15 Simulator (7/83)
Operational Training Course (10/81)
Simulator Instructor Pilot Upgrade Procedures (7/83)

F-16

Basic Operational Training Course (1/84)
Gradesheets
Instructor Handbook (3/82)
Wordstar Lesson Plans (1984)

KC-135

Navigator WST Coursebook (1/84)
Pilot WST Coursebook (1/84)

T-37

Instrument Program (3/83 and 9/84)
Syllabus of Instruction for Undergraduate Pilot Training (T-37/T-38) (8/83)
T-50 IFS Mission Guide (3/83)

T-38

Syllabus of Instruction for Undergraduate Pilot Training (T-37/T-38) (8/83)

Advanced Instructional Systems Documentation:

AFTS (F426000-77-C-2581)
AFT Program Description (5/72)
Automated Weapon System Trainer (6/70)
Grunzke, P. Evaluation of the Automated Adaptive Flight Training System's Air-to-Air Intercept Performance Measurement. AFHRL-TR-78-23. Air Force Human Resources Laboratory, Williams Air Force Base, AZ. July 1978.
Performance Specification for AFTS for A-7D (6/78)
Performance Specification for AFTS for F-4E (6/78)
Program Source Listings
Software Users Guide for AFTS for F-4E (4/79)
Training Specification for AFTS for A-7D (6/77)
Training Specification for AFTS for F-4E (7/78)

B-52 ARPTT ISS (F04604-81-C-0030)
ARPTT Training Program (5/84)
Functional Design Document - ARPTT ISS (11/84)
Instructor Guide, B-52 Training Program Pilot BPAT (not dated)
Program Source Listings
Study on the Refurbishment of Aerial Refueling Part Task Trainer (ARPTT) to Extend its Life Expectancy - Technical Report (10/81)

C-5A PMS (F33615-78-C-0027)

C-5 Course Summary Document, Pilot Initial Qualification Course (1/82)

C-5 Pilot Master Task Listing (3/83)

CPT/SIM/FLT Student Guide, Pilot Initial Qualification Course (2/81)

CPT/SIM/FLT Instructor Guide, Pilot Initial Qualification Course (1/83)

Operations Manual - PMS for the C-5A Simulator (9/83)

Program Source Listings

Swink, T.R., Butler, E.A., Lankford, H.E., Miller, R.M., Watkins, H., and Waag, W.L. Definition of Requirements for a Performance Measurement System for C-5 Aircrew Members. AFHRL-TR-78-54. Air Force Human Resources Laboratory, Williams Air Force Base, AZ. October 1978.

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F-14 ISS (N61339-78-C-0108)

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F-14 Instructional Support System (ISS) Final Technical Report. NAVTRAEQUIPCEN 78-C-0108-1. Naval Training Equipment Center, Orlando, FL. June 1982.

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F-14 ISS System Development Notebook Vol. I (not dated)

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APPENDIX B

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APPENDIX C

SAMPLE SPECIFICATION

The purpose of the sample specification provided, beginning on page C-12, is to illustrate the use of these guidelines in defining instructor support features for an ATD specification. It was developed using the procedures described in Section III of this document. The resulting specification is a functional baseline: Once budgetary constraints are known, SimSPO personnel can then perform cost, technology, and benefit tradeoffs.

Meetings were held with the TAC ISD Squadron's F-16 training program representatives at Luke AFB in order to identify their specific training and instructor support system requirements. This sample specification was developed using a general description of the device and training to be accomplished. The assumptions made include:

- A complete front end analysis has been performed.
- The instructor will operate and control the device.
- The anticipated use rate is between 8-12 hours per day.

FRONT END ANALYSIS

General Description - The sample specification is for an F-16 OFT-type device with a remote instructor/operator station. It will have a limited field-of-view visual system and a generic digital radar landmass presentation. The device will be used for basic weapon system training in addition to the basic safety of flight objectives. Continuation and conversion training will be conducted on this device. The following is a general description of the training capabilities required of this ATD.

Provide Basic Safety of Flight Training

- Emergency Procedures
- Degraded Flight Conditions
- Checklist and Procedural Training
- Normal Flight Training
- Instrument and Navigation Training
- Standardization Training/Evaluation

Provide Basic Tactical Training

- Air-to-Air Training Phase
  - Air-to-Air Intercepts (1 to 4 bogies)
  - Air-to-Air Sensors Use
  - Air-to-Air Weapon Employment
  - Intercept Tactics to Merge Plot (Visual on bogie)
  - Clear Air Environment (Non-ECM)

- o Air-to-Ground Training Phase
  - Low Altitude Tactical Navigation (DR/INS/sensors)
  - Air-to-Ground Sensors Utilization
  - Air-to-Ground Weapon Delivery

Student Skill and Knowledge Level - Continuation and conversion training will be taught on this device. Training will range from familiarization to full mission scenarios. The conversion student is most likely unfamiliar with the mission of the aircraft, weapon system use, and/or the cockpit controls and displays.

Training Task Objectives - The following training task objectives will be taught using this device. They are grouped according to task module type (see Section IV, "Providing Operational Information").

Normal Procedures

- o Cockpit Checks
- o Before Engine Start
- o Engine Start
- o Before Taxi Checks
- o Before Takeoff Checks
- o Penetration Checklist
- o Landing Checklist
- o Before Engine Shutdown Checks
- o Engine Shutdown Checklist
- o Radio Communications
- o INS Update

Normal Flight

- o Takeoff
- o Standard Instrument Departure
- o Instrument Navigation
- o Point to Point Navigation
- o Unusual Attitude Recovery
- o Steep Turns
- o Holding
- o Instrument Penetration
- o Instrument Final Approach (TACAN/ILS/PAR/ASR)
- o Missed Approach
- o Landing/Roll-out

Emergency Procedures

- o Abnormal Start
- o Engine Malfunctions
- o Electrical Malfunctions
- o Hydraulic Malfunctions
- o Flight Control Malfunctions
- o Airstart
- o Fire
- o Jettison Procedures
- o Landing Gear Malfunctions

Emergency Flight

- o Aborted Takeoff
- o Precautionary Landing
- o Degraded Flight Conditions
- o Arrested Landing
- o Minimum Fuel Profile
- o Asymmetrical Load Approach

Weapons Procedures

- o SMS/FNCP Programming
- o REO Set Up
- o Fence Check
- o Radar Set Up/Checks
- o Ordnance Arming
- o Radar Search Pattern
- o GCI/AWACS Procedures

Flight Tactics

- o Radar Target Acquisition
- o Collision Course Intercept
- o Stern Conversion Intercept
- o Vertical Attack
- o Weapon Selection/Employment
- o Intercept Control
- o Low Altitude Tactical Navigation

- Radar Position Update
- HUD Update
- Altitude Calibration
- Communication Procedures
- Air-to-Ground Ordnance Delivery (Level/Dives/Loft/Toss/OAP)
- System/Manual Ordnance Delivery
- Escape/Evasive Maneuvers

Training Syllabus - For the purpose of this sample specification, three training scenarios have been developed based on the training objectives and perceived user training requirements.

- Scenario 1 - End-to-end training from cockpit entry to engine shutdown. It includes normal procedures and flight objectives, emergency conditions and basic air-to-air intercepts and weapon employment. Training objectives include:

    - Cockpit Checks
    - Before Engine Start Checks
    - Abnormal Start
    - Normal Start
    - Before Taxi Checks
    - Before Takeoff Checklist

    - Takeoff
    - Standard Instrument Departure
    - Engine Emergency
    - Airstart

    - Radar Checks
    - Fence Check
    - Air-to-Air Intercept (single target)
    - Air-to-Air Weapon Employment

    - Holding
    - High Altitude Penetration
    - GCA
    - Missed Approach
    - ILS

    - Landing/Roll-out
    - After Landing Checks
    - Engine Shutdown

- Scenario 2 - The simulator is initialized at the end of the runway with the engine running. Emphasis is on normal flight task (T/O, SID, approach), low altitude tactical navigation and air-to-ground weapon delivery. The training objectives include:

    - SMS/FCNP Programming
    - Before Takeoff Checklist
    - Takeoff
    - Standard Instrument Departure

- INS Update
- Low Level Navigation Route
- Altitude Calibration
- Ordnance Arming
- Laydown Weapon Deliveries
- Escape Maneuver
- Selective Jettison
- Holding
- High Altitude Penetration
- TACAN Final Approach (Asymmetrical Load)
- Landing

- Scenario 3 - Emphasis is on air-to-ground tactical training. The aircraft is initialized airborne at the bombing range entry point. Air-to-ground ordnance delivery training, multiple runs. The training objectives include:

  - Ordnance Arming
  - Manual Deliveries
  - System Deliveries
  - LADD Deliveries

  - LOFT Deliveries
  - Manual Strafe
  - System Strafe
  - Emergency Jettison Procedures

After the oprational training requirements were identified, the instructor training requirements were analyzed according to the procedure described in Sction III, "Selecting Instructor Support Features". Each training objective was specified in terms of instructor control and monitoring requirements, and instruction and evaluation aids. An example of this process is shown in Table C-1. The identified ISFs for each training objective are listed in Table C-2. The following sections discuss the selection of ISFs according to instructor function.

PRE-TRAINING REQUIREMENTS

Instructor Training Function - A tutorial aid is necessary to maintain instructor proficiency. New instructors will require training at the console to become familiar with the system and its operation. Trained instructors will require refresher training after prolonged periods of not using the device, as this ATD will be used for continuation training where instructors tend to be "casual" users. Instructors require a tutorial capability that provides a variety of training levels. A tutorial feature which could be used at a remote console could satisfy this need. Additionally, the instructor will require an on-line "Help" function at the IOS to access system operation reference material during training.

Table C-1. Instructor Training Objective Requirements

raining bjective	Control	Monitor	Instruct	Evaluate
ke-Off	o Environment	o Visual Scene o Instruments o A/C Configuration	o Freeze	o Procedures Monitoring (Take-off parameters)
andard strument parture	o Environment	o Flight Profile o Instruments o Nav. Equip.	o Freeze	o Automated Performance Measurement o Procedures Monitoring (Navigation/Flight Parameters) o Display Format (map w/ Historical Trail)
r to Air	o Target and Fighter Relative position o Target Flight Parameters	o Tactical situation o Cockpit tactical displays, sensors and controls o Target/Fighter Flight Parameters	o Freeze o Record/Replay	o Display Format (Tactical situation w/ Historical Trail) o Procedures Monitoring (Flight and Geometry Data at various ranges)
r to Ground apon livery	o Environnment	o Visual Scene and HUD o Flight Parameters o Weapon Status and Selections	o Freeze	o Automated Performance Measurement (Weapons Scoring) o Procedures Monitoring (Aircraft Release Parameters) o Display Format (HUD Display)

Table C-2. Identified ISFs for Training Objectives

Training Objective	FRZ	REC/REP	DEMO	VAR CTRL	MALF CTRL	APM	PROC MON	DSPL FRMT
NORMAL PROCEDURES								
o Cockpit Checks	X						X	X
o Before Engine Start	X						X	X
o Engine Start	X					X	X	X
o Before Taxi Checks	X						X	X
o Before Takeoff Checks	X						X	X
o Penetration Checklist	X						X	X
o Landing Checklist	X						X	X
o Before Engine Shutdown	X						X	X
Checks	X							
o Engine Shutdown	X						X	X
Checklist	X							
o INS Update	X						X	X
EMERGENCY PROCEDURES								
o Abnormal Start	X				X	X	X	X
o System Malfunctions	X				X	X	X	X
o Airstart	X				X	X	X	X
o Fire	X				X	X	X	X
o Jettison Procedures	X				X	X	X	X
TACTICAL PROCEDURES								
o REO Checks	X							X
o Fence Checks	X						X	X
o Radar Set-Up Checks	X							X
o Ordnance Arming	X						X	X
o Radar Search Pattern	X							X
o HUD Update	X							X
o Altitude Calibration	X							X
NORMAL FLIGHT								
o Takeoff	X						X	X
o SID	X					X	X	X
o Enroute Nav	X					X	X	X
o Unusual Attitude	X	X					X	X
Recovery								X
o Steep Turns	X					X	X	X
o Holding	X					X	X	X

FRZ - Freeze
REC/REP - Record/Replay
DEMO - Demonstration
VAR CTRL - Variable Control
MALF CTRL - Malfunction Control
APM - Automated Performance Measurement
PROC MON - Procedures Monitoring
DSPL FRMT - Display Format

Table C-2. Identified ISFs for Training Objectives - Continued

Training Objective	FRZ	REC/ REP	DEMO	VAR CTRL	MALF CTRL	APM	PROC MON	DSPL FRMT
NORMAL FLIGHT (Continued)								
o Inst. Penetration	X					X	X	X
o Inst. Final App.	X					X	X	X
o Missed App.	X						X	X
o Landing Roll-Out	X						X	X
EMERGENCY FLIGHT								
o Aborted Takeoff	X				X	X	X	X
o Degraded Flt. Conditions	X				X		X	X
o Minimum Fuel Profile	X					X	X	X
o Precautionary Approach	X				X		X	X
TACTICAL FLIGHT								
o Air-to-Air Intercept	X	X		X			X	X
o Radar Utilization	X			X				X
o Air-to-Air Weapon Employment	X			X		X	X	X
o Low Alt. Tactical Nav.	X					X	X	X
o Air-to-Ground Attack Profile	X	X	X					X
o Air-to-Ground Weapon Delivery	X	X	X			X		X

FRZ - Freeze
REC/REP - Record/Replay
DEMO - Demonstration
VAR CTRL - Variable Control
MALF CTRL - Malfunction Control
APM - Automated Performance Measurement
PROC MON - Procedures Monitoring
DSPL FRMT - Display Format

Prepare Function - To prepare for a training event, the instructor must review the training requirements, the event description and student progress in order to determine a training strategy. This function could be accomplished at a remote console using the Briefing Utility and Data Storage and Analysis features. Performing this function at a remote console would also allow the instructor to tailor the event (see Training Set-up Function) prior to briefing.

Training Set-up Function - A capability to tailor the training event off-line (at a remote console) can provide more available training time. It is anticipated that available training time is at a premium due to the high utilization rate assumed. This requires that the instructor be able to select, modify and develop training scenarios using Scenario Control, Initial Conditions and Malfunction Control features.

Develop Training Function - As mentioned above in the Training Set-up Function, the instructor must have the capability to tailor training to meet the students need. In addition, there must be a utility which allows the training curriculum managers to develop totally new training objectives to meet changes in aircraft equipment, tactical tapes and defined mission requirements. These modifications to the set of training objectives must be able to be made easily and in a timely manner.

Brief Function - The training effectiveness of any system is directly related to the quality of the briefing and debriefing functions. For conversion training in particular, the brief function sets the tone for the entire training event. The Briefing Utility feature provides the student with a complete overview of the training event, plus graphic displays of task relevant information. A capability to present dynamic demonstration of tactical displays used during intercept and air-to-ground training is considered to be beneficial to conversion students. These students are unfamiliar with the weapon system and associated displays and will require coaching on how to interpret and use the information presented. This capability will allow the instructor to demonstrate how to use the information and develop a "scan pattern" essential to mission training.

TRAINING REQUIREMENTS

Control Function - All five identified control features (Scenario Control, Initial Conditions, Real-Time Simulation Variables Control, Malfunction Control and Reposition) are required for this ATD. Scenario Control by training objective provides the greatest benefit to the instructor by minimizing his workload while allowing the flexibility to make real-time changes. A fully automated Scenario Control capability is required for standardization and evaluation training and can be used during instructorless training. Scenario Control provides a wide variety of initial conditions identified by training objectives (e.g., Hi-ILS Rwy 03R at Luke AFB). Malfunction Control is required for training and should include the capability to preprogram sets of malfunctions at the remote console for manual insertion by the instructor during the training event. Real-Time Simulation Variables Control and Reposition provide the instructor added flexibility during training to control the training event and efficiently use available training time. The Freeze feature may be required to perform some of these control functions.

Monitor Function - Due to the instructor offboard location, the IOS Display Control and Formatting and Procedures Monitoring features are required. Task specific and training-related information should be presented to the instructor in a meaningful format.

Instruct Function - The Freeze feature will be used the most to provide instruction during training. Due to the student skill level, only total system freeze and crash/kill freeze are appropriate for this ATD. The Simulator Record/Replay and Automatic Simulator Demonstration features can be used for conversion training of tactical intercepts, air-to-air weapon employment, low altitude tactical navigation, and air-to-ground weapon delivery. These new training tasks require the use of many cockpit controls, displays and cues which are new to the student.

Evaluate Function - The instructor must analyze training relevant information to determine if student performance has met specified criteria. This requires that the instructor be provided the information in a content and format which meet his needs. IOS Display Control and Formatting and Procedures Monitoring are required to aid the instructor perform the evaluation function. Procedures Monitoring, as defined in Section II, includes the monitoring of flight diagnostics which would provide the instructor with a parameter monitoring and performance alerting capability. For tactical training, weapons scoring is necessary for performance results feedback. An Automated Performance Measurement feature is required for this capability. Automated Performance Measurement should be designed to support specific training objectives as would be provided by the Scenario Control by objective feature. This would provide an objective, standardized performance measuring capability which the instructor can modify if required. It will reduce the instructor's workload as well as provide a training effectiveness measure for training curriculum managers.

POST-TRAINING REQUIREMENTS

Debrief Function - This function requires the instructor to provide the student with a detailed analysis of the training event, identifying strengths, problem areas and corrective actions. Performance information is extremely useful during debrief and can be provided by the Hardcopy/Printout feature. The Remote Graphics Replay feature provides a debriefing tool which allows dynamic replay of specified events. This can be very training effective, especially for conversion students.

Record Function - The instructor is required to record the student's progress and any device deficiencies at the completion of the training event. The Data Storage and Analysis feature can provide the mechanism for recording student performance and progress and storing pertinent training data (e.g., student records and automated performance measurements, recording and storage of training device information). This feature supports the requirements of pre-training, curriculum managers, and the ATD managers.

BENEFIT ANALYSIS

The benefit analysis will determine the final selection of ISFs for ATD specification. ISF selection must be based on specific training requirements and the functional needs of the instructor and training system managers to enhance training efficiency. Specific items to consider are outlined in Section III under the "Benefit Analysis" heading. These items lead to further justifications, prioritization, and subsequent selection and rejection of ISFs. The results of the benefit analysis for the sample specification are shown in Table C-3.

Table C-3. Benefit Analysis

Instructor Support Feature	Select	Reject	Reason
Tutorial	X		To maintain instructor proficiency.
Briefing Utility	X		Instructor aid to review syllabus training and relevant displays, cues and procedures for student preparation.
Freeze	X		Required for instructional control.
Simulator Record/Replay		X	Low identified need. Need associated with use of tactical displays. Alternative: Remote Graphics Display.
Automated Simulator Demonstration		X	Low identified need. Alternative, Remote Graphic Display.
Scenario Control	X		Provides objective-based training which minimizes instructor work-load; provides syllabus tailoring capability to meet student needs.
Initial Conditions		X	This control will be incorporated as part of the scenario control feature.
Real Time Simulation Variables Control	X		Required to allow instructor control of variables.
Malfunction Control	X		Required for training.
Reposition	X		Provides efficient use of available training time and training flexibility.
Automated Performance Measurement	X		Aids the instructor in evaluating student performance.
Procedures Monitoring	X		Required for instructor to monitor cockpit activities. Instructor evaluation aid.

Table C-3. Benefit Analysis - Continued

Instructor Support Feature	Select	Reject	Reason
IOS Display Formatting	X		Required for instructor effectiveness.
Hardcopy/Printout	X		Feedback mechanism for student debrief.
Remote Graphics Display	X		Dynamic debriefing capability. Used as an alternative for Simulator Record/Replay and Automated Simulator Demonstration.
Data Storage Analysis	X		Student records and progress information. Supports curriculum managers by providing data to measure training effectiveness.

3.7.2 Instructional Subsystem - The F-16 OFT shall be provided the follow instructor support features to enhance the efficiency of training.

3.7.2.1 Briefing Utilities - Briefing utility aids shall be designed assist the instructor in briefing a student for an upcoming simulator sessi The aids shall prepare both the student and instructor prior to a particu exercise and consist of F-16 training material to be used for preparat (e.g., lesson guides, training program outlines, and instructor guides). Briefing Utilities shall provide the capability to review training ev graphics (e.g., SID and approach plates and emergency procedures), and al demonstrations of specific dynamic events (e.g., intercept tactical displ and air-to-ground weapon delivery displays). The instructor shall also be a to access student training records recorded by the Data Storage and Analy feature described in paragraph 3.7.2.13. This feature shall be accessed on off-line remote graphics console and shall not degrade normal training perfor on the main IOS. The method of interaction shall be similar to the main and shall be easily accessible by the instructor. Briefing materials shall functionally grouped in user terms to ensure optimal usability; data displays shall be easily modifiable for future updates. A detailed descr tion of the briefing data shall be made available at CDR.

3.7.2.2 Freeze - A total system freeze feature shall allow all simula parameters to be frozen at a given time within a F-16 mission train scenario. The instructor shall have the capability to manually or automatica freeze the simulator. Manual total system freeze shall be capable witl single action on the part of the instructor. Automatic total system fre shall occur either when specified parameter values are exceeded or w the state of the simulator changes, as in reposition or when changing operat modes. An automatic freeze override feature shall be incorporated wh allows the training event to continue uninterrupted, while displayin message to the instructor that the automatic freeze criteria were met. override feature will be the normal setting for automatic freeze.

3.7.2.3 Scenario Control - Scenario Control shall support the instructor providing efficient control of the simulation during training and by provic student activity by automatically displaying information relevant to training being accomplished. It shall provide the capability to configure control the ATD in accordance with predefined scenarios covering the I simulator curriculum. Scenarios shall include the initial conditions for exercise and the training objectives to be activated in a predefined o and/or under prespecified conditions. The scenarios shall be made avail for review of content and for selection at both the remote graphics con and the IOS. The full range of scenario control automation shall be available. This range covers total automation with no instructor inputs minimal automation where flexible instructor interaction is provided, inclu the options of repeating, deleting, and adding certain objectives. interaction shall not require re-initializing the simulator and should detract from the overall simulation. ATD configuration changes caused by feature shall be automatically checked to preclude any crash conditior other adverse condition and shall freeze the state of the simulator until all incompatible conditions are corrected. A list of scenarios and the data specified within each scenario will be made available at CDR.

3.7.2.4 Real-Time Simulation Variables Control - The instructor shall be provided the capability to insert, delete or alter simulation variables in real time. This shall include variables associated with environmental conditions, airfield data, target data (controllable adversary and friendly radar targets) and aircraft flight and positional data (ownship, wingman or adversary). In addition to preprogrammed profiles, friendly and adversary data shall be capable of changes in altitude, attitude, speed, acceleration, and heading, and positioned in relative range and bearing from the fighter aircraft via an interactive input device (joystick, trackball, light pen, etc.).

3.7.2.5 Malfunction Control - Malfunction control shall provide the instructor the capability to select a sequence of abnormal aircraft equipment conditions and/or emergency conditions before or during the training session. The method of insertion during runtime shall depend on the level of scenario control automation. In the case of total automation, insertion shall be automatic and triggered by preprogrammed events. In the case where scenario control provides instructor flexibility for insertion and removal of certain training objectives, the preselected malfunctions shall be made readily available for runtime accessibility. The time and number of actions required on the part of the instructor to select, alter, and enter malfunctions shall be minimized to the greatest extent possible. This feature shall provide an optional graphics which allows the instructor to monitor student procedures related directly to the active malfunction.

3.7.2.6 Reposition - The Reposition feature shall provide the capability to position the ATD to any point in the mission training scenario. All flight parameters shall be capable of automatic adjustment to meet the new condition imposed by repositioning. After reposition, ATD configuration shall be automatically checked to preclude any crash condition or other adverse condition and shall remain in a freeze state until all incompatible conditions are corrected. The reposition feature shall be designed to enhance instructor efficiency. The time and the number of actions required on the part of the instructor to select, alter and enter data shall be minimized.

3.7.2.7 Automated Performance Measurement - The automated performance measurement feature shall aid the instructor in obtaining a valid and reliable measurement of student performance. The feature shall be designed to support specific training applications and to provide the instructor with a precise, objective and standardized measure of student performance and a capability to simultaneously measure many facets of a mission event. The instructor shall be provided timely feedback of performance data in real or near-real time; and as an instructor option, shall be displayed on-line for use during a training session or off-line for debriefing purposes. The instructor shall have the option to override or modify performance measurements provided by this feature. F-16 curriculum managers shall have the capability to modify ("fine tune") performance algorithms on-site. Final determination of automated performance measurement algorithms including the parameters to be measured, the methods of measurement, and evaluation criteria shall be made at PDR.

3.7.2.8 Procedures Monitoring - The Procedures Monitoring feature shall provide the instructor with a method of monitoring the procedural training activities of the student. This includes the procedures involved with both normal and emergency procedures as specified in the F-16 Flight Manual. The data to be monitored shall be easily modifiable to reflect current procedures and valid measures of these procedural activities. Final determination of procedures monitoring activities including a list of the procedures and associated data shall be made at PDR.

3.7.2.9 IOS Display Control and Formatting - This feature shall automatically provide the instructor with a graphic representation of student action appropriate to the active training objective. This feature shall also provide optional graphics associated with the scenario currently being trained. The presentation of information shall be an easy-to-read, uncluttered, standardized format of the current status of graphical and instructional information. To the greatest extent possible, informational display formats shall replicate that which the aircrew normally uses (e.g., a graphic depiction of the F-16 HUD should replicate the actual aircraft). The information layout shall be consistent with the limitations of human perception and memory in order to minimize user interpretational effort and alleviate confusion, thereby ensuring quick recognition and maximizing readability. The default and optional displays, display content and display formatting will be determined at PDR.

3.7.2.10 Hardcopy/Printout - The instructor shall be capable of retrieving data from any specified source within the simulation - i.e., parameters, variables, display content. It shall retrieve the data in such a way that no interruptions occur within the simulation and its displays and shall create a hardcopy printout of the collected data upon demand without simulation disruption. The time and number of actions required on the part of the instructor to activate hardcopy/printout shall be minimized.

3.7.2.11 Remote Graphics Replay - The remote graphics replay feature shall provide the capability to recreate a graphic replay as viewed from the IOS during an active exercise. This feature shall also include the optional graphics which were made available regardless as to whether they were accessed. This feature shall be accessed via a remote briefing/debriefing console. It shall be capable of operating concurrently with active training without any degradation to the performance of the simulator and the IOS. Indexing into the playback data by training objectives, in addition to instructor inserted flags during realtime, shall facilitate locating points of interest in the mission. The feature shall also provide viewing in normal or fast speeds. An option to freeze any point within the playback shall also be provided.

3.7.2.12 Tutorial - The tutorial feature shall provide the instructor/student with a user-friendly interactive, self-paced and self-administered program of instruction on the capabilities and use of the flight simulator and its instructor support features. The tutorial feature shall include a "help" function in the form of an easily accessible prompt. The tutorial shall be provided off-line at a remote console or at the IOS. On-line instructional system operation in the form of a HELP function shall also be provided (for the novice or infrequent user) and be accessible to the user as an option.

The data provided by this feature shall be easily modifiable to reflect the current F-16 training objectives, performance criteria, F-16 aircraft/ATD configuration, etc.

3.7.2.13 Data Storage and Analysis - The data storage and analysis feature shall record pertinent student performance information during the training session. Access to this information shall be available in a variety of ways: grouped by student, student type and class, phase of training, the objectives attained, time/attempts to attain the objectives, and conditions under which the objectives were met or not met. Such information shall be retained on the system as part of a student's record and accessible via the Briefing Utility. This feature shall also store information regarding certain aspects of system operation (e.g., use of instructor support feature options) to be used by curriculum managers to assess overall ATD training effectiveness and use. This feature shall provide an interactive data editor capability for administrative information update at an off-line device which does not interfere with normal simulator operation. The actual data to be stored and analyzed will be determined at CDR.

NOTE: The following paragraph is added to support task module-based design:

"A database shall be developed to parallel the syllabus training objectives. The ISS shall be driven from this data base. An editor for convenient update and modification of this database shall also be developed."

APPENDIX D

TRAINING SITES VISITED

Training Device	Location	Date
AFTS A-7D	Davis-Monthan AFB	12/7/84
A-10	Davis-Monthan AFB	12/7/84, 1/30/85
ARPTT ISS	Castle AFB	1/15/85
B-52	Castle AFB	1/15/85
C-5A PMS	Altus AFB	12/12/84
C-130	Little Rock AFB	12/11/84
F-15	Luke AFB	11/15/84, 1/29/85
F-16	Luke AFB	11/15/84, 1/29/85
T-37 (T-50)	Williams AFB	11/13/84
T-38 (T-51)	Williams AFB	11/13/84

APPENDIX E

TASK COMMONALITY ANALYSIS

Tables E-1 through E-6 present a listing of tasks which are trained in ATDs within the four major Air Force Commands and those incorporated into four ISSs. The purpose of this task listing is to compare tasks which are commonly trained utilizing ATDs with tasks incorporated into recently developed ISSs. This task listing can be used to determine what types of tasks have been monitored using an ISS and what types have not. In order to determine commonality of tasks, only pilot flight station tasks were included in this analysis. This is due to the fact that five of the nine aircraft training systems investigated perform pilot only training.

SCOPE OF THE ANALYSIS

The identification of training tasks involved a detailed review of training documentation, including the simulator training syllabi and instructor guides. This documentation describes the general training scenario and the specific training objectives for each event. In many cases this documentation did not describe the training event on a task-by-task basis. Therefore, to further amplify training task requirements, extensive instructor interviews were conducted to determine which tasks were monitored during the training sessions.

The task listing is organized according to task type: Normal Flight, Normal Procedures, Emergency Flight, Emergency Procedures, Tactical Flight and Tactical Procedures. The tasks which are monitored in the ISSs were identified from existing documentation and compared with the previously defined task listing.

ANALYSIS RESULTS

A strong commonality of simulator training tasks exists throughout normal flight, normal procedures, emergency flight and emergency procedures. This commonality of tasks is consistent across the Air Force major commands. This is as would be expected, since these types of tasks reflect a basic flight training philosophy. This philosophy includes ensuring that the aircrew has a firm understanding of procedures and limitations of the aircraft, and can demonstrate this knowledge plus the motor skill ability to safely operate the aircraft under normal and abnormal conditions prior to the first flight.

The task listing matrix indicates that conversion training encompasses all UPT training task requirements. The aircrew is becoming familiar with the new systems at their disposal, and is utilizing them to perform the same task required in UPT. Primary emphasis is on safety of flight, and the aircrew's ability to safely operate the system within the procedures and guidelines set forth. This includes starts, take-offs, landings, instrument and basic airwork skills, navigation, use of checklists and abnormal situations. Once this performance has been demonstrated, the aircrew is introduced to basic tactical skills.

Most tasks identified for tactical flight and tactical procedures are unique for each tactical mission. These tasks, as taught in conversion training, provide the basic foundation for continuation training in the operational squadrons. The tactical phase of training does contain some common tasks which would be applicable across all major operational commands. Such mission-related tasks are encompassed in Air-to-Ground Attack and Electronic Warfare.

Nearly all conversion training tasks in the first four task categories (normal flight, normal procedures, emergency flight and emergency procedures) are incorporated into the ISS systems under study. Tasks which are not identified as monitored by an ISS, were not done so by design. The ISS systems for the F-14, B-52 ARPTT and C-5A could be easily modified to monitor these conversion training task requirements.

The AFTS for the A-7D and F-4E are the only ISSs designed to monitor tactical training. These systems provide air-to-air and air-to-ground training, and meet the needs of conversion training in these areas.

A commonality of tasks exists for all ATDs in the Normal Procedures, Normal Flight, Emergency Procedures and Emergency Flight task module categories. The ISS devices under study currently monitor the major portion of these identified task requirements. The task module approach utilized by these ISS devices provide a user-oriented system which can be easily modified to encompass all tasks in these categories.

Tasks that address motor skills, e.g., Normal and Emergency Flight, and tasks that deal with performance of procedures, e.g., Normal and Emergency Procedures, can be addressed by the current ISS technology. Some tactical tasks can also be addressed utilizing the same technology.

Tactical training is composed of unique training skills for each aircraft and tactical mission. Tactical training at the conversion level consists of defined parameters and established guidelines which must be demonstrated in the ATD. Certain tactical training tasks, i.e. low-level navigation and EW training, are applicable to all major operational commands.

Task taught and parameters monitored in conversion training are directly applicable to continuation training. Standardized evaluation of operational aircrew is required to ensure that they can perform the mission in a safe and effective manner. Much of this evaluation can also utilize the current ISS technology.

Table E-1. NORMAL PROCEDURES TASK MODULE CATEGORY

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Before Interior Checks	X	X	X	X	X	X	X	X	X					X
Interior Checks	X	X	X	X	X	X	X	X	X					X
Before Engine Start												X		X
Engine Start	X	X	X	X	X	X	X	X	X			X		X
Before Taxi Checks	X	X	X	X	X	X	X	X	X			X		X
Taxi Checks						X	X	X	X					X
Engine Run Up Checks						X								
Before Take Off Checks	X	X	X	X	X	X	X	X	X			X		X
Runway Line Up Checks						X								X
After Take Off Checks	X	X	X	X	X	X	X	X	X			X		X
Climb Checks	X	X	X	X	X	X	X	X	X			X		X
Cruise Checks						X	X	X	X					X
Descent Checks	X	X	X	X	X	X	X	X	X			X		X
Approach Checks														X
Landing Checks	X	X	X	X	X	X	X	X	X			X		X
After Landing Checks	X	X	X	X	X	X	X	X	X			X		X
Before Engine Shutdown	X	X	X	X	X	X	X	X	X			X		X
Engine Shutdown	X	X	X	X	X	X	X	X	X			X		X

Table E-1. NORMAL PROCEDURES TASK MODULE CATEGORY (continued)

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52C5 ARPTTPMS
Before Leaving Cockpit													X
Inflight Refueling Checks				X		X		X				X	
Crew Coordination					X	X	X	X			X		X
Crew Briefing					X	X	X	X					X
Pilot Not Flying Resp.					X	X	X	X					X

Table E-2. NORMAL FLIGHT TASK MODULE CATEGORY

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Take Off														
Normal	X	X	X	X	X	X	X	X	X			X		X
Afterburner		X		X	X							X		
Reduced Power								X						X
Assault						X								
Basic Instruments														
Climbs	X	X	X	X	X	X	X	X	X	X	X	X		X
Descents	X	X	X	X	X	X	X	X	X	X	X	X		X
Level Offs	X	X												
Straight and Level	X	X												
Airspeed Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Altitude Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Heading Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Airspeed Changes St/Lvl	X	X												
Airspeed Changes Lvl Turn	X	X												
Turns	X	X												
Steep Turns	X	X	X	X	X	X	X	X						
Unusual Attitude Recovery	X	X	X	X	X			X				X		

Table E-2. NORMAL FLIGHT TASK MODULE CATEGORY (continued)

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Slow Flight	X	X				X		X						
Vertical S Pattern	X	X												
Approach to Stall	X	X				X		X						
Instrument Navigation														
Course Intercept	X	X	X	X	X	X	X	X	X	X	X	X		X
Course Maintenance	X	X	X	X	X	X	X	X	X	X	X	X		X
Arc Intercept	X	X	X	X	X	X	X	X	X	X	X	X		X
Arc Maintenance	X	X	X	X	X	X	X	X	X	X	X	X		X
Fix to Fix	X	X	X	X	X	X	X	X	X	X	X	X		X
Point to Point	X	X	X	X	X	X	X	X	X		X	X		X
Ground Speed Check	X	X					X	X	X					
DF Steer						X								
Standard Instrument Dept.	X	X	X	X	X	X	X	X	X	X	X	X		X
Enroute Navigation	X	X	X	X	X	X	X	X	X	X	X	X		X
INS Navigation				X	X			X						
Holding	X	X	X	X	X	X	X	X	X	X	X	X		X
Penetration	X	X	X	X	X	X	X	X	X	X	X	X		X
Procedure Turn	X		X			X	X	X	X					X

Table E-2. NORMAL FLIGHT TASK MODULE CATEGORY (continued)

TASK	T37 OPT	T38 OPT	A10 OPT	F15 WST	F16 OPT	C130 WST	KC135 WST	C141 OPT	B52 WST	A7 APTS	F4 APTS	F14 ISS	B52 ARPTT	C5 PMS
Precision Approach														
ILS	X	X	X	X	X	X	X	X	X	X	X	X		X
GCA	X	X	X	X	X	X	X	X	X	X	X	X		X
Coupled						X		X						
Non-Precision Approach														
TACAN/VOR	X	X	X	X	X	X	X	X	X	X	X	X		X
ASR	X	X	X	X	X	X	X	X	X	X	X	X		X
Back Course						X	X	X						X
NDB						X		X						X
Surveillance Approach								X						
Missed Approach	X	X	X	X	X	X	X	X	X	X	X	X		X
Airborne Radar Approach					X	X								
Circling Approach						X	X	X						
Formation						X			X					
Windshear								X						
Confidence Maneuvers														
Loops				X	X									
Wing Overs				X	X									

Table E-2. NORMAL FLIGHT TASK MODULE CATEGORY (continued)

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Aileron Rolls				X	X									
Afterburner Climbs				X	X									
Air Refueling Rendezvous					X		X		X					
Air Refueling Track							X							
Radar Trail Departure				X	X									
Auto Pilot Utilization						X		X	X					
Lost Wingman IFR			X											
Inflight Refueling														
Maintain Position					X		X		X				X	
Change Position					X		X		X				X	
Breakaway					X		X		X				X	
Landings														
Full Stop	X	X	X	X	X	X	X	X	X	X	X	X		X
Touch and Go	X	X	X		X	X	X	X	X	X	X	X		X
Stop and Go						X								
Assault						X								
Landing Roll Out	X	X	X	X	X	X	X	X	X	X	X	X		X

Table E-2. NORMAL FLIGHT TASK MODULE CATEGORY (continued)

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Communications														
Clearance	X	X	X	X	X	X	X	X	X	X	X	X		X
Ground	X	X	X	X	X	X	X	X	X	X	X	X		X
Tower	X	X	X	X	X	X	X	X	X	X	X	X		X
Traffic Controller	X	X	X	X	X	X	X	X	X	X	X	X		X
GCI				X	X	X			X		X			
IFF Squawk										X	X			X
Navigation ID/Tuning	X	X	X	X	X	X	X	X	X	X	X	X		X
INS Setup				X	X			X		X		X		X
INS Update				X	X			X		X				X
TACAN Update					X									

Table E-3. TACTICAL PROCEDURES TASK MODULE CATEGORY

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Weapons System Checks				X	X				X	X	X			
Fence Check				X	X									
Ordnance Arming/Dearming				X	X				X	X	X			
Electronic Warfare														
Preflight Procedures			X	X	X									
Inflight Procedures			X	X	X				X					
Threat Identification			X	X	X				X					
Threat Evaluation			X	X	X									
Air-to-Ground														
Radar Position Update					X									
HUD Update					X									
Ground Speed Check					X									
Radar Calibration					X									
Altitude Calibration					X									
Weapon System Configuration					X					X	X			
Computer Data Entry					X					X				
Special Weapons Proced.					X				X					

Table E-3. TACTICAL PROCEDURES TASK MODULE CATEGORY (continued)

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Air-to-Air														
Scramble				X							X			
Radar Calibration				X										
Radar Search				X	X						X			
Radar Look-on				X	X						X			
Radar Interpretation				X	X									
Target Sorting				X										
Weapon System Configuration				X	X						X			

Table E-4. TACTICAL FLIGHT TASK MODULE CATEGORY

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Electronic Warfare														
Tactical Employment			X	X	X				X					
Evasive Maneuvering			X	X	X	X			X					
Chaff and Flares			X	X	X				X					
Defensive Coordination Exercise									X					
Drop Zone														
Slow Down						X								
Run In						X								
Air Drops						X								
Target/Drop Zone Escape						X					X			
Air-to-Ground														
Low Level Navigation					X	X			X	X	X			
Airspeed Control					X	X			X	X	X			
Altitude Control					X	X			X	X	X			
Time Course Corrections					X	X			X	X	X			
Radar Employment					X									
Target Acquisition					X									
Time Over Target					X	X			X	X	X			

Table E-4. TACTICAL FLIGHT TASK MODULE CATEGORY (continued)

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 ARPTT	C5 PMS
Weapon Release Parameters					X				X	X	X			
Laydown					X									
Loft					X									
LADD					X									
Strafe					X									
Weapon System Solution					X				X	X	X			
Radar Bombing					X				X	X	X			
Radar Offset					X					X				
Navigation Bombing					X				X	X	X			
Fighter Turn Rendezvous					X									
Air-to-Air														
Radar Search				X	X						X			
Radar Lock-on				X	X						X			
Target Sorting				X										
Response to GCI				X	X						X			
Geometry Control				X	X						X			
Head-on Intercept				X	X						X			
Fwd Qrt Intercept				X	X						X			

Table E-4. TACTICAL FLIGHT TASK MODULE CATEGORY (continued)

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 [illegible]	B52 ARPTT	C5 PMS
Beam Intercept				X	X						X			
Stern Conversion				X	X						X			
Hi Alt/Hi Spd Target				X							X			
Search Only Intercept											X			
Target Identification											X			
MRM Launch				X							X			
SRM Launch				X	X						X			
Gun Attack					X									
Energy Management				X	X									

Table E-5. EMERGENCY FLIGHT TASK MODULE CATEGORY

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 AFTS	F4 AFTS	F14 ISS	B52 AHPTT	C5 PMS
Degraded Flight Conditions	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Engine Out Approach	X	X	X	X		X	X	X	X			X		X
No Gyro Approach										X	X	X		
Aborted Take Off	X	X	X	X	X	X	X	X	X			X		X
Minimum Fuel Profile					X							X		

Table E-6. EMERGENCY PROCEDURES TASK MODULE CATEGORY

TASK	T37 OFT	T38 OFT	A10 OFT	F15 WST	F16 OFT	C130 WST	KC135 WST	C141 OFT	B52 WST	A7 APTS	F4 APTS	F14 ISS	B52 ARPTT	C5 PMS
Immediate Action Emergencies	X	X	X	X	X	X	X	X	X	X	X	X		X
System Malfunctions	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ordnance Malfunctions					X									
Abnormal Start	X	X	X	X	X	X	X	X	X			X		X
Air Start	X	X	X	X	X	X	X	X	X			X		X
Fuel Jettison							X	X						
External Stores Jettison				X	X									

APPENDIX F

ISS IMPLEMENTATION CONSIDERATIONS

ISS IMPLEMENTATION CONSIDERATIONS

Introduction

The purpose of this appendix is to provide technical readers with a general understanding of ISS cost and implementation considerations. Since technology is advancing rapidly, many cost factors are being reduced, and there can be little confidence in quantitative predictions of the future. As a consequence, the state of the art must be periodically investigated to assess issues about the feasibility and desirability of specific ISS implementations. With this in mind, the appendix attempts to provide a framework for documenting those cost and implementation considerations which should not be forgotten.

Organization and Scope

The organization used in this appendix is derived from high level architectural components identified from previous ISS implementations. Each section of this appendix represents a major ISS component. What is truly important to an effective ISS implementation is the development of a task modules database and the software which supports it. These components are thus presented first. The computer system and station which support the database and software, and allow the user to work with the ISS are included next. Additional components which are necessary and unique to ISS implementation are included last; they are the simulation interface and the life cycle cost component.

Other traditional system development components such as project management, data requirements, integration and test, system test and evaluation, and site activation are not specifically addressed here because ISS-unique considerations were minimal. However, the components should be included in any final cost analysis.

Format

For each component, the discussion includes:

- Component. Name given to the component.
- Definition. A definition of the component.
- Purpose and Intended Use. What role the component plays within the implementation and costing of an ISS.
- Cost Factors. General cost factors which should not be overlooked are included. In order to produce more precise cost estimates, it is recommended that future procurements utilize strictly standardized work breakdown structures

with costs reported to levels which address the instructor support features so that accurate historical records may be preserved.

- Options and Tradeoffs. Implementation options and tradeoffs which may affect the cost and performance of the ISS.

- Example. Past implementation example based on the F-14 ISS. It is used throughout this appendix as an example of ISS technology because it was designed to provide state-of-the-art instructor support functions in the areas of monitoring, analysis, debriefing, graphics replay and record keeping, in addition to instructor-oriented simulation control. ISFs supported by the ISS include the briefing utility, total and partial freeze, scenario control, initial conditions, automated and manual malfunction control, reposition, automated performance measurement, procedures monitoring, IOS display control and formatting, hardcopy/printout, remote graphics replay, data storage and analysis, and a tutorial. Although the F-14 ISS was added on to an existing F-14 OFT, the concepts presented in the examples can also be applied to an ISS that is procured as part of a new ATD.

- Lessons Learned. Lessons learned during/from the implementation of the four prototype systems. Readers are encouraged to submit their own lessons learned to be added here.

Component	Task Modules Database
Definition	The task modules database consists of computer files representing task modules (see Section IV, "Providing Operational Information") which are used by ISS software to determine the logically related series of events that combine to meet the criteria of a specific objective. For example, if the task module builder defines the task module carefully, there should be a one-to-one correlation between each training objective and a task module. See Table F-1 for a basic chocks-to-chocks scenario relating these two elements.

Table F-1: Partial Scenario

TRAINING OBJECTIVE	TASK MODULE	TYPE*
Perform takeoff checklist	Takeoff checklist	Normal Procedures
Take off successfully	Takeoff	Normal Flight
Fly appropriate departure flight path	Departure	Normal Flight
Identify and correct hydraulics malfunction	Hydraulics failure	Emergency Procedures
Fly appropriate initial approach vector	Approach	Normal Flight
Perform descent checklist	Descent checklist	Normal Procedures
Fly final approach to ground	Final approach	Normal Flight
Perform postlanding checklist	Postlanding checklist	Normal Procedures

* See Section IV for an explanation of task module types.

Purpose and Intended Use

The task modules represented within the task modules database specify what ISF-related functions the software is to perform; how, when, and under what conditions the function is to be performed. For example, a takeoff task module might begin when an aircraft exceeds 0 knots and terminates when the aircraft achieves a positive rate of climb. Within this task module would be appropriate triggers for displays, scenario control, and other ISFs.

From a system resources point of view, the task modules reduce the amount of data that requires monitoring to encompass only those events that are critical at a specific point in time. For example, during an engine failure at 30,000 feet the position of the landing gear is not important; but during an approach, the position of the landing gear may be associated with a primary training objective. By reducing the monitored events, there is more processing time available for ISFs.

Task modules may be consecutive or concurrent. For example, the departure task module may start upon completion of the takeoff task module. An emergency procedures (malfunction) task module, however, may take place at any appropriate time and may overlap both the takeoff and departure task modules.

In addition to the basic training objectives related task modules there can be one other task module running at all times. In past implementations this has been referred to as an umbrella task module. The umbrella can monitor hypercritical events that must be associated with the entire scenario. For example, a crash would trigger a diagnostic message and possibly a reset if desired from the umbrella task module.

Pseudo-task modules unrelated to training objectives may be used to reposition the aircraft or reset initial flight parameters for the instructor's convenience. See Table F-2 for a partial task module event chart of a typical scenario.

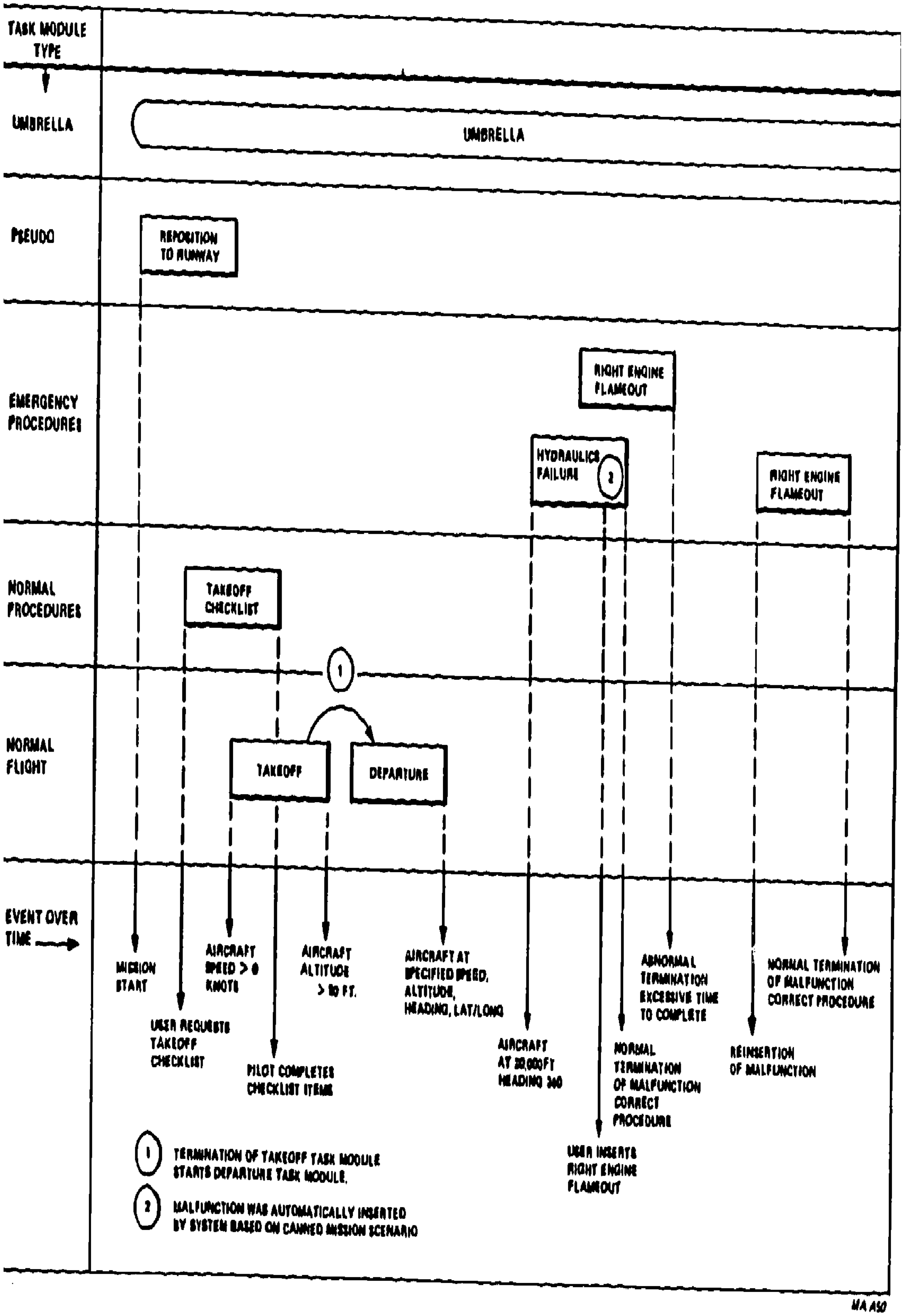

Table F-2. Task Modules Within a Partial Scenario

Cost Factors

The cost of development of the task modules database will depend on the number of unique task modules and the number of different training event scenarios in the training syllabus.

Options and Tradeoffs

The cost of developing and maintaining a task modules database can be reduced by providing a highly functional database editor. This may increase the initial procurement cost of software but may result in savings over the life of the system.

Example

From a software point of view, the task modules database can be implemented as several files which contain different types of information. Files used for the F-14 ISS are listed below:

- Mission Profile File. This file contains data needed to define an entire exercise (mission). It consists of a series of records which define the task modules in the exercise and the events or conditions which will trigger the execution of the task modules. When an exercise is initiated, this file is transferred to memory and is used to control the activity of the ISS.

- Reposition File. This file is for task modules that require a certain location. For example, the takeoff task module requires the aircraft to be on a runway to start.

- Initial Conditions File. One file for each task module defined in the system. Describes the events and other starting conditions that allow the system to determine when a task module is to start execution.

- Events File. One file for each task module defined in the system. Describes the events to be detected when that task module is running.

- Sequence File. One file for each task module defined in the system. Describes the relationships of the events to each other under a varying number of circumstances and provides the information on action to take when the event occurs.

- Performance Measurement File. This file contains performance parameter data including limits and tolerances for each task module.

- Scoring File. One file for each task module defined in the system. Describes the grading criteria that will be used when scoring a task module.

- Display File. One file for each task module defined in the system. Contains a list of pictures to be displayed when the task module is initiated.

- Text File. One file for each task module defined in the system. Contains descriptive and error text messages to be displayed when events occur during the execution of a task module.

Other files associated with the F-14 ISS task modules database include:

- Display Template Files. One file for each basic display frame defined in the system. Serves as a template to locate both the picture on the screen and in the display list.

- Picture Touch Files. One file for each picture defined. Contains information needed to properly react to the operator touching the "select" areas of the screen.

- Picture Display List Files. One file for each picture defined. Contains information which describes the picture to be displayed, including the binary data used to generate the graphic displays.

Lessons Learned

The manual formulation of task modules proved to be costly and an editor to aid in generating data files was recommended.

Component	Software
Definition	Software refers to the sequence of instructions and data used to direct the computer to perform a desired operation or sequence of operations.
Purpose and Intended Use	Software is required to develop and run the task modules database on the ISS. To develop and build task modules, it is essential that an editor be implemented to obtain event and procedural data, generate text files, build graphic displays, and define parameters for all related ISFs. To run task modules two or three primary software modules are required for system event detection and monitoring. Software modularity is encouraged in that each independent ISF can have its own associated software module. For example, IOS display control and formatting would be independent of automated performance measurement. Such a modular approach provides flexibility and ease of execution. Other support modules such as a graphics software module may be required to provide for actual display device dependent output capabilities.
Cost Factors	The cost associated with this element includes the time required to design, write, integrate, and test software. ISS software complexity is largely determined by the number and types of tasks that are to be taught and the instructional features which are incorporated in the ISS. The magnitude of software development will depend on whether the ATD is intended for part task training, operational flight training, single seat weapon system training, or full crew mission training. It will also depend on which of the ISFs has been selected and the additional considerations which must be taken into account for their customized implementation.
Options and Tradeoffs	Software modularity allows for functionality in phases. During system development, as soon as an ISF is programmed, it can be used. For example, automated performance measurement, procedures monitoring, remote graphics replay, and data storage and analysis capabilities can be added after an initial delivery of IOS display formatting, initial conditions, scenario control, malfunction control, freeze, and reposition. A tutorial can be a final addition.

Commercially available operating systems and utilities can be integrated into the ISS to reduce software development costs. The commercial products, however, may require additional tailoring to be effective in the ISS environment.

Example

The basic architecture of the F-14 ISS utilizes event triggers for initiating processing activity. Messages are passed to activate responses to the events as defined within the task module files (see the Task Modules Database example). Simulation system variables are evaluated five times a second to detect events.

- <u>On-line Mission Conduct.</u> Mission conduct is the execution of a predefined exercise in one of three modes of operation (CANNED, Instructor Select (ISEL), Specialized Part Task Training (STT)).

  - <u>Instructor Control.</u> Receives messages from the graphics display module (see below). Controls operation of the simulator interface. Controls the execution of the task modules. Controls repositioning. Updates and maintains environmental options. Maintains, updates and formats a list of task modules comprising an exercise. Creates and terminates applications processes.

  - <u>Converter-Detector.</u> Converts cockpit device values from the simulator to formats usable by applications programs. Detects discrete events associated with pilot actions or changes in aircraft parameters.

  - <u>Procedures Monitor.</u> Determines the correctness of various cockpit procedures based on a predetermined template. Events will be checked for legality within the current procedural context and for correct order of occurrence. The Procedures Monitor will support a separate monitor task for each active task module.

  - <u>Performance Measurement.</u> Samples, processes, and records aircraft parameters. The measurements are divided into two groups: primary--those used in scoring the flight, and secondary--those measured and recorded for research purposes.

  - <u>Kernel.</u> Handles hardware interrupts and transfers data from the simulation system.

- Aircraft Monitor. Maintains displays concerning aircraft position, key parameters, important instrument values, and configuration.

- Controller Model. Generates voice output to emulate the following human controllers during execution of an exercise: tower, departure, approach, final.

- Scoring. Scores the student's flight and procedures performance for each task module executed.

- Event/Replay Recorder. Records display data generated during run-time by task module executions as well as miscellaneous system events.

o On-line Exercise Setup and Debriefing. Includes logging onto the ISS, reviewing student performance prior to mission setup, constructing an executable mission (ISEL and STT modes), and debriefing the mission after completion. Debriefing entails review of ISS assigned grades and replay of all or selected task modules from the exercise.

  - Exercise Definition. Builds a mission definition file to describe an exercise for the ISEL and STT modes, or select from a list of predefined CANNED missions, and conducts mission briefing functions for all three modes.

  - Logon - Student Performance Review. Controls access to the ISS and conducts an interactive review session of previous student performance.

  - Debriefing. Permits the instructor to review a particular training session, approve/modify grades given by the ISS, and replay portions of the exercise.

o On-line Graphics Display. Controls the graphics chores during all on-line ISS operations.

o Off-line Support. Programs that are intended to be run in the off-line mode. Includes introduction of predefined task modules into the ISS by the generation of the required control and data structures, analysis of data recorded in the daily audit file, maintenance of student record files and system software, and functional integrity verification of the ISS prior to on-line operations.

- Procedure Definition. Translates procedural descriptions into the control structures required to execute a given task module (see the previous component discussion on the Task Modules Database). The tables so generated will drive logics for procedures monitoring, event detection, and performance measurement.

- Event Stream Analysis. Data recorded by the Event Recorder task in the Applications Processor will be used to provide ISS usage data, program debugging aids, and operating environment data for research purposes.

- Housekeeping. Disk file maintenance and changes in user access lists.

- Confidence test. Checks functional integrity of the ISS prior to initialization of on-line operations.

Lessons Learned

The manual formulation of task modules proved to be costly and an editor to aid in generating data files was recommended. Languages and simple editors are often difficult and tedious to use. A menu-driven, nonprogrammer oriented program to allow operational users to define their requirements could be easier to use. Although it may be more costly to implement initially, the cost savings may be realized through use during the life of the ISS.

Synchronous execution of software can cause problems in detecting events for an ISS. For example, a 200 millisecond cycle was found to be insufficient for monitoring momentary switches and a 50 millisecond cycle was recommended to account for the momentary switch. An ISS can be implemented on an asynchronous basis, as accomplished by the F-14 ISS and ARPTT-ISS, to account for critical events as they occur.

Component	Computer System
Definition	The computer system performs all logical and numerical processing for the ISS. It usually consists of a processor or processors, storage, and input/output channels.
Purpose and Intended Use	The computer system provides the means for adding instructional support to a simulator capability by executing software which permit monitoring simulator variables, instructor controls, student actions, and making the instructional responses desired of the ISS. The types of ISFs which may be implemented in this way are listed earlier in this document. If the ISS computer system did not exist, these features either would be impossible with the basic simulation facility or, in some cases, would be only by manual instructor action.
Cost Factors	Programs which execute within the computational system require adequate processing capacity, main memory and mass storage. A thorough analysis of system functional requirements, with provisions for growth, is required for estimation of these parameters.

- o <u>Processing capacity.</u> The processing capacity of a computer takes into account the number of instructions which can be executed per second and the rate at which input/output information can be transferred. The latter is also a function of the devices added to the system, such as mass storage devices.

- o <u>Main memory.</u> Main memory size is usually expressed in terms of the total number of bytes which may be stored. Fast processing is normally accomplished with information in main memory.

- o <u>Mass storage.</u> Primary mass storage is used for storage of programs and data that are necessary for daily use of the ISS and for short term storage of data collected for a training event. Secondary mass storage is used to form an archive of programs and data that are not required for daily use of the ISS. Primary mass storage might emphasize fast access to a disk system whereas secondary storage could be relegated to slow devices such as tape drives.

Contributions to the storage requirement by each ISF should be estimated using the stated functional requirement and the expected utilization. For example, the storage requirements for Simulator Record/Replay are large and need to accommodate the total number of minutes which are to be recorded (see the Simulator Record/Replay ISF).

Function complexity, that is degree of interaction among ISFs and task module concurrency requirements, may affect the cost of implementation of the basic ISS software architecture and dictate the computer system capacity and storage requirements.

Expected system performance also determines the computer system cost. For example, display update rates of 1 to 2 times a second are sufficient for ISS implementations. Displays need not be updated if the display content need not be altered. Given these performance requirements the ISS could be implemented using less costly computer systems. If performance requirements requiring higher update rates were unnecessarily imposed, the cost would increase.

Options and Tradeoffs

Processing may be distributed among less costly, less capable computer systems rather than one costly centralized system. Tradeoffs would be experienced in the computer-to-computer interface cost.

Oftentimes a tradeoff exists between the hardware and software costs. For example, lots of programmer time can be wasted trying to scale down program sizes to fit into limited main memory. As memory costs have decreased and programmer labor costs increased, purchase of additional memory can realize cost savings.

Example

The F-14 ISS utilized two computer systems. One was dedicated to On-line Graphics Display (see example for the Software component) and the other performed all other processing tasks.

- Applications Computer System
  - Data General Eclipse S-250
    (1.23 million instructions per second)
  - 1024 KB main memory
  - 96 MB disk storage
  - 1/2 inch magnetic tape drive

- o Display Computer System
  - Data General Eclipse S-130 (1.23 million instructions per second)
  - 384 KB main memory
  - 10 MB disk storage

Lessons Learned

Large program sizes may cause system response to be too slow. This can be alleviated by tuning the operating system, adding more memory, and reorganizing files on mass storage to optimize data file access.

The processing speed of the selected computer may affect the Simulator-ISS interface. For example, data may have to be buffered from the interface in order to allow time for processing.

Component	Stations
Definition	Stations provide a person-machine interface between all users of the ISS and the ISS. Components of the station include input devices, such as keyboards and touch panels, and output devices, such as hardcopy printers, speech generation equipment, and graphic and tabular displays.
Purpose and Intended Use	Stations can be used for: o ISS and simulation system control o Monitoring of student activity while training o Display of student activity after training o Retrieval of performance information o Preparation of a preprogrammed mission scenario o Update of the task modules database o Maintenance of the ISS
Cost Factors	Devices located at the station, the number of stations, and the location of the stations are factors which affect their cost. o <u>Station devices.</u> The intended station functions will determine the devices located at the station. Identification of functions requires an analysis of user tasks. o <u>Number of stations.</u> Candidate stations include on-board (in cockpit), off-board (outside cockpit), dedicated briefing/debriefing (see the Briefing Utilities and Remote Graphics Replay ISFs), mission-generation, training objective database generation, and programmer/maintenance stations. o <u>Location of station.</u> Cost may be influenced by the location of a station and on any constraints on the size of the components. Replacement of an existing operator console may also be a cost factor.
Options and Tradeoffs	The number of stations, locations, functions to be performed, concurrent operation, information displayed, control actions, specific control/displays, and human engineering design, present a multitude of options to be considered for ISS stations. An analysis of training functions, training load, personnel characteristics, and specific training constraints

will be required to identify specific options to be considered for tradeoff study.

The functionality, maintainability, reliability, and cost of currently available devices should be surveyed to arrive at cost estimates. State of current commercial offerings should be considered to keep costs at reasonable levels. For example, 1985 technology offers color, raster graphics displays with antialiasing features (to minimize stairstepping).

An important input device consideration is that a single input method be adopted at each station so as not to confuse the user.

Example

Two similar instructor stations were used on the F-14 ISS. The Primary ISS Station was placed next to the existing Instructor Operator Station (IOS); the Remote Station was used for setup, brief/debrief and grading. Each consisted of upper and lower graphic displays with a touch pad on the lower for operator control inputs. A separate printer/plotter was used for hardcopy needs. Additionally, the system included voice generation capabilities for controller models, and two maintenance terminals.

Note that future ISS implementations should incorporate ISS station requirements into main and remote IOS requirements, striving towards an ISS that is fully integrated into the ATD.

Lessons Learned

The touch panel design has received good user acceptance, requires no special input skills, and allows only legal inputs to be made. Touch panel technology has been found to be reliable for ISS use.

Display resolutions of 512 x 512 picture elements and 16 colors have been found to be sufficient for symbolic information.

Component	Simulation System Interface
Definition	The simulation system interface is that portion of the system which allows the ISS to transmit to, and receive data from, the rest of the ATD.
Purpose and Intended Use	The simulation system interface allows the ISS to communicate with the remainder of the ATD to: o initiate control of the simulation scenario o monitor flight variables, such as altitude and airspeed o monitor discrete actions, such as switch actions
Cost Factors	The simulator interface can be a major hardware cost when the ISS is to be added to an existing simulator capability. There is a major engineering challenge to find a least costly way to obtain needed data and exercise required control. The solution varies on a case-by-case basis since it depends on how the ATD is built. Lower cost can be expected if the ISS can be designed as an integral part of a new ATD acquisition.
Options and Tradeoffs	The following are alternative methods for the simulator interface. Only the first two methods have been used in the four prototype systems as additions to existing ATDs. o <u>Data Acquisition System/Switch Unit.</u> This type of interface interrupts the data path(s) between the central processing unit (CPU) of the ATD and the hardware device which distributes CPU outputs to the flight station, visual system, motion system, and operator/instructor station, and funnels inputs from these systems to the CPU. The interface therefore allows communication with the ISS CPU and acquires data traveling in either direction at the ATD, totally transparent to the simulation system. o <u>Shared memory.</u> A portion of the ATD CPU memory can be shared with the ISS CPU. The shared memory would contain all data originated by the operator/instructor and all pertinent ATD flight information. o <u>Conventional data link.</u> A possible alternative is the use of a high speed data link which connects the simulation system computer(s) and the ISS computer(s). Both systems must have software which handles the required communications protocols.

Example	To assist the Instructor in training, the F-14 ISS had to monitor all information transmitted between the Sigma 5 simulator system computer and the Instructor Console-Cockpit. All of this information passes over a channel between the Sigma 5 main memory and an Input/Output Processor. A Data Acquisition System/Switch Unit was constructed for placement in this channel. In addition to monitoring the information on this channel, it was also necessary to alter some of the information coming from the Instructor Console to allow the ISS to generate sequences of inputs which would otherwise require the Instructor to press buttons and turn knobs. This required detecting data before data is transferred, and making changes at the time of transfer. Finally, the Data Acquisition System/Switch Unit had to be able to read information from the Sigma 5 memory to provide the ISS computer with information on the configuration of the trainer and the flight situation.
Lessons Learned	If an ISS is added to an existing ATD, the simulation system interface involves risks and possible interference with the operation of the ATD. The risks can be minimized if the ISS is designed into the initial procurement of an ATD.

Component	Life Cycle Cost
Definition	Life cycle costs are incurred over the operational life of the ISS. Of primary importance to an Instructor Support System are those personnel considerations which affect operator/instructor performance in the use of the ISS. Included are considerations of the number and type of personnel required to use the ISS, operational design for effective instructional use, and training for the new or infrequent operator/instructor.
Purpose and Intended Use	The ISS must be usable by the specified personnel and allow maximum instructional effectiveness. This, in turn, requires that the ISS be designed for the number and characteristics of operating personnel; the system must be designed for easy use and support the instructional process without burdening the instructor; and, training must be provided so that the operator/instructors can effectively use the instructional features of the ISS.
Options and Tradeoffs	Personnel, design, and personnel training aids are among the options and tradeoffs to consider:

- Personnel. The number of people required for instruction will depend on the ATD configuration and the design of the ISS. The number of people will depend on whether instructors are required inside the cockpit as well as outside and whether an operator will be assigned for the duties of simulator operation and communications. If desired, the ISS can include features to simplify simulator operation and automate functions which can eliminate the need for a separate Operator, and minimize the burden on the Instructor, including the burden of coordinating with a separate Operator. People are also needed for maintenance and update/revision of the ISS, especially those needed for courseware update/revision (e.g., task module creation and navigational display definition). The number of people associated with the ISS are major factors in determining total life-cycle costs.

  For example, in the ARPTT ISS procurement it was shown that the ISS eliminates a console operator. Cost savings are expected over the 15 year life of the ISS.

- ISS Design. The design process consists of the following steps:

  - Functional Analysis: Definition of the specific functions to be performed by the ISS, that is, what the ISS is to do.

  - Operational Design: Definition of the controls, displays, and procedures to perform each of the required functions, that is, how the ISS is to be used

  - System Design: Definition of the hardware and software to be used in constructing the ISS.

  Of particular interest at this point is the second step, that of operational design. Many options and tradeoffs are identified at this stage which will ultimately determine how well the ISS can be used for instruction by those who must use it. It is recommended that representatives of the users become actively involved in the operational design process. Note that human engineering of the ISS can reduce user workload and special knowledge/skill requirements, and in turn increase training effectiveness while reducing life-cycle costs.

- Training, Helps, and Documentation. An ATD may be used in some curricula by instructors who infrequently use the simulator as an adjunct to inflight training and they may need some training and help in using the ISS/ATD each session. An instructor new to the ISS/ATD will require training in use of the system and the expertise of the former instructor may depart with him. One way of coping with these situations is to incorporate training features in the ISS. See the discussion on the Tutorial ISF for suggested training features.

  System documentation can also be provided as a database which can be selectively retrieved when detailed reference material is needed.

Example

While the optimum operational design used for one system may not be best for another, the Instructor-ISS interface used in the F-14 ISS (and the ARPTT) may be broadly applicable. The basic interface is a CRT with a touch panel and control is exercised through a sequence of menu selections. This has several inherent advantages:

- o the available control options at any given time are displayed on the display screen; the instructor does not have to remember specific commands.
- o only legal options can be selected; there is no need for error checking or the display of cryptic error messages.
- o because of the touch panel, no special input devices or skills are required; one only needs to point at the selected menu item on the display screen.
- o built-in "helps" are easily implemented.

Such systems in the field have met with good user acceptance.

Lessons Learned

Difficulties were encountered with the C-5A PMS when those trained in its use were rotated to new duties; understandably, the PMS option was not used by those who did not know how to use it. It is common experience that systems are not effective when users are not adequately trained in its use, or if system design has not been accomplished with the requirements of the using personnel in mind.

APPENDIX G

SAMPLE TASK MODULES

Samples of the two basic task module types (flight and procedural) are given in this appendix. The tacan approach task module is a normal flight task module. The engine start task module is a normal procedures task module. A review of Section IV, "Providing Operational Information", is recommended before reading these samples.

The samples are taken from the F-14 ISS. An ISS requires certain information to be able to provide Instructor Support Features (ISFs). These task modules provide the operational information required for the F-14 ISS to support the following features:

- IOS Display Control and Formatting
- Procedures Monitoring
- Automated Performance Measurement

Although beyond the scope of these guidelines, information for an automated voice controller is also included.

NORMAL FLIGHT TASK MODULE

TYPE: NORMAL FLIGHT TASK MODULE (TACAN APPROACH)

NAME: HI-TACAN ONE APPROACH TO RUNWAY 24 R/L AT MIRAMAR

DESCRIPTION: STRAIGHT IN APPROACH ON THE 068R STARTING AT 16K FT

START CONDITIONS: WITHIN 5 MI OF THE IAF 068R 26 DME (TAC 33) AND ALTITUDE GT 14,500 FT.

STOP CONDITIONS: CPA 068 RAD 1.7 MI (TAC 33)

RELATED ISFs: IOS DISPLAY CONTROL AND FORMATTING, AUTOMATED PERFORMANCE MEASUREMENT, INITIAL CONDITIONS, AND REPOSITION.

TASK MODULE SCORING:

STEP	WEIGHT FACTOR
1. CROSS IAF	5
2. ALT AT IAF	5
3. HDG AT PUSH OVER	5
4. AIR SPD AT IAF	5
5. APPROACH AIR SPD	15
6. INBOUND TRACK	15
7. ALT AT 22 NM	5
8. ALT AT 14 NM	5
9. ALT AT 13 NM	5
10. ALT AT 6 NM	5
11. FINAL APP AIR SPD	15
12. ALT AT 3.3. NM	5
13. ALT AT 1.7 NM	10
TOTAL	100

STEP NO. 1

DESCRIPTION: CROSS "FEEGA" IAF

START CONDITIONS: CPA 068 RAD 26 DME (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:

DISCREPANCY: NM FROM "FEEGA" GREATER THAN 2 MI
ERROR: POOR NAV CONTROL
RULE: CROSS "FEEGA" 068/26 FROM TAC 33
DISCREPANCY: FREQ NOT EQUAL 281.8
ERROR: WRONG UHF FREQUENCY
RULE: SD APP - 281.8

AUTO VOICE:

CONTROLLER: DIEGO APPROACH / FREQ - 281.8
TEXT: "Y ZERO ONE CLEARED FOR TACAN APPROACH TO RUNWAY TWO FOUR RIGHT CALL WHEN LEAVING ONE SIX THOUSAND FEET"

MEASUREMENT PACKET:

CPA 068R 26 NM / TYPE - SNAPSHOT / OPTIMUM - 0

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.8
MEASURE	<.5	<.75	<1.0	<2.0	->2.0

STEP NO. 2

DESCRIPTION: CROSS "FEEGA" NO LESS THAN 16,000 FT.

START CONDITIONS: CPA 068 RAD 26 MI (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT.

DIAGNOSTICS:

DISCREPANCY: ALTITUDE LESS THAN 15,500 FT.
ERROR: POOR ALT CONTROL
RULE: CROSS"FEEGA" 068/26 AT 16,000 FT. OR GREATER

AUTO VOICE: N/A

MEASUREMENT PACKET:

ALTITUDE / TYPE - SNAPSHOT / OPTIMUM - 16,000 FT.

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	<16,500 >15,950	<16,750 >15,900	<16,850 >15,850	<17,000 >15,250	-<15,250

STEP NO. 3

DESCRIPTION: START DESCENT WITHIN 45 DEG OF APPROACH HEADING

START CONDITIONS: VSI GT 3000 FPM, ALT. LT 15,000 FT AND DME DECREASING

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
DISCREPANCY: HDG LT203 OR GT 293
ERROR: POOR NAV CONTROL
RULE: START APP WITHIN 45 DEG OF INBOUND HDG.

AUTO VOICE: N/A

MEASUREMENT PACKET:
HEADING / TYPE - SNAPSHOT / OPTIMUM - 248

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	>203 <293	>198 <298	>193 <303	>193 <308	-<193 ->308

STEP NO. 4

DESCRIPTION: CROSS "FEEGA" IAP AT 250 KIAS

START CONDITIONS: CPA 068 RAD 26 MI (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
DISCREPANCY: KIAS GT 265 OR LT 235
ERROR: POOR AIR SPD CONTROL
RULE: CROSS "FEEGA" 068/26 AT 250 KIAS

AUTO VOICE: N/A

MEASUREMENT PACKET:
AIRSPEED TYPE - SNAPSHOT / OPTIMUM - 250 KIAS

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	<255 >245	<260 >240	<265 >235	<270 >230	

STEP NO. 5

DESCRIPTION: MAINTAIN APPROACH AIRSPEED 250 PRIOR TO LANDING CHK. LIST

START CONDITIONS: "FEEGA" 068R 26 MI (TAC 33)

STOP CONDITIONS: LANDING GEAR HANDLE DOWN

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
DISCREPANCY: KIAS GT 265 OR LT 235
ERROR: POOR AIR SPD CONTROL
RULE: MAINTAIN 250 KIAS DURING APPROACH

AUTO VOICE: N/A

MEASUREMENT PACKET:
AIRSPEED TYPE - RMS / OPTIMUM - 250 KIAS

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	<255 >245	<260 >240	<265 >235	<270 >200	<28

STEP NO. 6

DESCRIPTION: TRACK INBOUND ON 068R

START CONDITIONS: CPA "FEEGA" 068R 26 MI (TAC 33)

STOP CONDITIONS: CPA 068R 1.7 DME (TAC 33)

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
DISCREPANCY: RAD GT 073 OR LT 063
ERROR: POOR NAV CONTROL
RULE: TRACK INBOUND 068R

AUTO VOICE: N/A

MEASUREMENT PACKET:
RADIAL / TYPE - RMS / OPTIMUM - 068

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	<70 >66	<73 >63	<78 >58	<83 >53	>83 <53

STEP NO. 7

DESCRIPTION: 5,200 ALTITUDE RESTRICTION AT 22 DME

START CONDITIONS: CPA 068 RAD 22 NM (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED
INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
DISCREPANCY: ALTITUDE LESS THAN 5,000 FT
ERROR: POOR ALT CONTROL
RULE: CROSS 22 DME AT OR ABOVE 5,200 FT

AUTO VOICE: N/A

MEASUREMENT PACKET:
ALTITUDE / TYPE - SNAPSHOT / OPTIMUM - 5,200 FT

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	<5,700 >5,200		<6,000 >5,150	<6,300 >5,000	<6,600 >5,000

STEP NO. 8

DESCRIPTION: 4,700 FT ALTITUDE RESTRICTION AT 14 DME

START CONDITIONS: CPA 068 RAD 14 NM (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED
INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:

DISCREPANCY: ALTITUDE LESS THAN 4,500 FT.
ERROR: POOR ALT CONTROL
RULE: CROSS 14 DME AT 4,700 FT OR GREATER

AUTO VOICE: N/A

MEASUREMENT PACKET:
ALTITUDE / TYPE - SNAPSHOT / OPTIMUM - 4,700 FT

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0	
MEASURE	<5,000 >4,650	<5,300 >4,550	<5,600 >4,450	<5,900 >4,400	-<4,400	

STEP NO. 9

DESCRIPTION: 4,400 FT ALTITUDE RESTRICTION AT 13 DME

START CONDITIONS: CPA 068 R 13 NM (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:

DISCREPANCY: ALTITUDE LESS THAN 4,200 FT.
ERROR: POOR ALT CONTROL
RULE: CROSS 13 DME AT 4,400 FT OR ABOVE

AUTO VOICE: N/A

MEASUREMENT PACKET:
ALTITUDE / TYPE - SNAPSHOT / OPTIMUM - 4,400 FT.

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0	
MEASURE	<4,700 >4,350	<5,000 >4,300	<5,300 >4,2500	<5,600 >4,200	-<4,200	

STEP NO. 10

DESCRIPTION: 2,300 FT ALTITUDE RESTRICTION AT 6 DME

START CONDITIONS: CPA 068 RAD 6 MI (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
- DISCREPANCY: ALTITUDE LESS THAN 2,100 FT.
- ERROR: POOR ALT CONTROL
- RULE: CROSS 6 DME AT 2,300 FT OR ABOVE

AUTO VOICE: N/A

MEASUREMENT PACKET:
ALTITUDE TYPE - SNAPSHOT / OPTIMUM - 2,300 FT.

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	<2,500 >2,250	<2,750 >2,200	<3,000 >2,150	<3,300 >2,100	-<2,100

STEP NO. 11

DESCRIPTION: MAINTAIN FINAL APPROACH AOA WHEN IN LANDING CONFIGURATION 14.5 UNITS

START CONDITIONS: WHEN GEAR AND FLAPS DOWN

STOP CONDITIONS: CPA 068R 1.7 NM (TAC 33)

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
- DISCREPANCY: IF AOA GT 17 OR LT 11
- ERROR: POOR AIR SPD CONTROL
- RULE: MAINTAIN FINAL APPROACH AOA WHEN ON FINAL

AUTO VOICE: N/A

MEASUREMENT PACKET:
AIRSPEED / TYPE - RMS / OPTIMUM - 14.5 UNITS

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0
MEASURE	<15.0 >14.0	<15.5 >13.5	<16.0 >13.0	<17.0 >12.5	->17.0 -<12.5

STEP NO. 12

DESCRIPTION: 1,240 FT ALTITUDE RESTRICTION AT 3.3 DME

START CONDITIONS: CPA 068 RAD 3.3 NM (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
- DISCREPANCY: ALTITUDE LESS THAN 1,200 FT.
- ERROR: POOR ALT CONTROL
- RULE: CROSS 3.3 DME AT 1,240 FT OR ABOVE

AUTO VOICE: N/A

MEASUREMENT PACKET:
ALTITUDE / TYPE - SNAPSHOT / OPTIMUM - 1,240 FT.

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0	
MEASURE	<1,340 >1,230	<1,440 >1,220	<1,540 >1,210	<1,648 >1,200		-<1,200

STEP NO. 13

DESCRIPTION: 860 FT ALTITUDE RESTRICTION AT 1.7 DME

START CONDITIONS: CPA 068 RAD 1.7 NM (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
- DISCREPANCY: ALTITUDE LESS THAN 840 FT
- ERROR: POOR ALT CONTROL
- RULE: CROSS 1.7 DME AT 840 FT OR ABOVE

AUTO VOICE: N/A

MEASUREMENT PACKET:
ALTITUDE / TYPE - SNAPSHOT / OPTIMUM - 840 FT

SCORING:

SCORE	4.0	3.5	3.0	2.5	2.0	
MEASURE	<940 >830	<1,040 >820		<1,148 >818	<1,240 >800	-<800

STEP NO. 14

DESCRIPTION: MISSED APPROACH POINT

START CONDITIONS: CPA 068 RAD 1.7 DME (TAC 33)

STOP CONDITIONS: N/A

ISFs and RELATED INFORMATION: AUTOMATED PERFORMANCE MEASUREMENT

DIAGNOSTICS:
DISCREPANCY: IF CPA > .5
ERROR: POOR NAV CONTROL
RULE: MISSED APPROACH POINT - 068 RAD 1.7 DME

AUTO VOICE: N/A

MEASUREMENT PACKET:

NORMAL PROCEDURES TASK MODULE

TYPE: NORMAL PROCEDURES TASK MODULE

NAME: ENGINES START

DESCRIPTION: NORMAL GROUND START OF BOTH ENGINES

START CONDITIONS: COMPLETION OF THE PRE-START TASK MODULE, OR EXTERNAL AIR ON.

STOP CONDITIONS: EXTERNAL AIR DISCONNECTED +30 SEC.

ISFs and RELATED INFORMATION: PROCEDURES MONITORING

TASK MODULE SCORING:	4.0	3.5	3.0	2.5	2.0	WT
CRITICAL ERRORS						
SEQUENCE ERRORS	0	2	4	6	8	30
%MANDATORY COMPLETE	95	90	80	70	60	40
%OPTIONAL COMPLETE	100	97	95	90	80	10
TIME TO FIRST EVENT (sec)	6	10	15	25	30	10
TOTAL TIME (sec)	60	90	120	240	360	10

STEP NO. 1

DESCRIPTION: CRANK LEFT ENGINE TO BUILD UP AUXILIARY BRAKE PRESSURE

CONTINGENCIES: EXTERNAL AIR AND EXTERNAL POWER ON

EVENTS: 1. ENGINE CRANK SWITCH - LEFT

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) ENGINE CRANK LEFT"

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF CRANK SW - RIGHT
ERROR: CRANK SW - SWITCH POSITION ERROR
RULE: CRANK L ENG. TO BUILD AUX. BK. PRESS.

MEASUREMENT:
EVENT 1 - MANDATORY
SEQUENCE - N/A
TIME: START FOR TOTAL PROCEDURE

STEP NO. 2

DESCRIPTION: POSITION CRANK SWITCH TO OFF AFTER BRAKE PRESSURE HAS BUILT UP TO SAFE

CONTINGENCIES: ENG CRANK - LEFT

EVENTS:
2. AUX BRAKE PRESSURE SAFE
3. ENGINE CRANK SWITCH OFF

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) ENGINE CRANK OFF"

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF 3 < 2
ERROR: AUX BRAKE PRESS UNSAFE
RULE: CRANK PORT ENG. TO BUILD AUX. BRAKE PRESSURE TO SAFE

MEASUREMENT:
EVENT 3 - MANDATORY
SEQUENCE - 2,3
TIME: N/A

STEP NO. 3

DESCRIPTION: EMERGENCY HYDRAULIC CHECK AND VERIFY CONTROL OF FLIGHT CONTROL SURFACES

CONTINGENCIES: EXT. AIR & POWER/EMERG FLT HYD SW - AUTO (LOW)

EVENTS:
4. EMERG FLIGHT HYD. SWITCH - LOW
5. STICK DEFLECTION - FORE/AFT LEFT/RIGHT
6. RUDDER - LEFT, RIGHT
7. EMERG FLIGHT HYD. SWITCH - HI
8. STICK DEFLECTION - FORE/AFT LEFT/RIGHT
9. RUDDER - LEFT, RIGHT
10. EMERG FLIGHT HYD - SWITCH AUTO (LOW)

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) EMERG. FLT. HYD. SW LOW/HI/AUTO

PROCEDURES MONITORING

DIAGNOSTICS:
IF 9<7<4
ERROR: IMPROPER CHECK OF EMER. FLT HYD.
RULE: SWITCH ERROR (SW. - LOW/HI/AUTO)

DIAGNOSTICS:
IF 5, 6, 8 OR 9 DO NOT OCCUR
ERROR: NO CONTROL MOVEMENT
RULE: MUST CHK FLT CONTROLS

MEASUREMENT
EVENTS 4, 5, 6, 7, 8, 9, 10 MANDATORY
SEQUENCE - 4, 5, 6, 7, 8, 9, 10
TIME: N/A

STEP NO. 4

DESCRIPTION: ENGINE CRANK TO RIGHT ENGINE FOR START

CONTINGENCIES: STEP 1 & 2 COMPLETE

EVENTS: 10. ENGINE CRANK - RIGHT

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) ENGINE CRANK RIGHT"

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF ENG. CRANK - LEFT
ERROR: ENG. CRANK (POSITION)
RULE: START RIGHT ENG. FIRST

MEASUREMENT:
EVENT 9 - MANDATORY
SEQUENCE - 9,10
TIME N/A

STEP NO. 5

DESCRIPTION: RIGHT THROTTLE IDLE AT 20% FOR IGNITION

CONTINGENCIES: STEP 4 COMPLETE

EVENTS:

11. R RPM - >20%
12. RIGHT THROTTLE - IDLE
13. ENG. CRANK - OFF
14. R RPM - 50%
15. R OVSP/VALVE LT - OUT
16. RT GEN LT - OUT
17. R FUEL PRESS LT - OUT
18. R TIT < 750

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: EVENTS 12, 13, 15, 16, 17

PROCEDURES MONITORING

DIAGNOSTICS:

DISCREPANCY - EVENT 12 < 11
ERROR: R THROTTLE IDLE BEFORE RPM 22%
RULE: R THROTTLE IDLE AFTER RPM - 22%

DISCREPANCY: R TIT > 750
ERROR: R TIT - (VALUE)
RULE: MAX START TEMP - 750

MEASUREMENT:

EVENT 12 - MANDATORY
EVENT 18 - CRITICAL
CRITICAL SEQUENCE - 11, 12
CRITICAL SEQUENCE - 13, 14
TIME: N/A

STEP NO. 6

DESCRIPTION: IDLE ENGINE INSTRUMENTS CHECK

CONTINGENCIES: RIGHT THROTTLE - IDLE

EVENTS:

19. RPM - 63% - 74%
20. TIT - 600 +/- 150
21 F/F - 1000 +/- 200
22. NOZZLE - 5
23. FLT HYD. - 3000 +/- 175

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: ONLY FOR DIAGNOSTICS

PROCEDURES MONITORING

DIAGNOSTICS:

DISCREPANCY: IF 19 THROUGH 23 NOT WITHIN RANGE THEN:
ERROR: - (VALUE) COCKPIT DEVICE (NAME) - (VALUE)
RULE: (DEVICE NAME) (RANGE) NORMAL

MEASUREMENT:

EVENT: N/A
SEQUENCE: N/A
TIME: N/A

STEP NO. 7

DESCRIPTION: DISCONNECT EXTERNAL POWER

CONTINGENCIES: RIGHT RPM 63% - 74% (RIGHT ENG. STARTED)

EVENTS: 24. EXTERNAL PWR - DISCONNECT

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) EXT. PWR. DISCONNECTED"

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF 16 NOT COMPLETE
ERROR: RIGHT GEN. NOT ON
RULE: NEED ELECT. PWR TO START PORT ENG.

MEASUREMENT:
EVENT 24 - MANDATORY
SEQUENCE: 16,24
TIME: N/A

STEP NO. 8

DESCRIPTION: CRANK LEFT ENGINE TO PRESSURIZE COMBINED HYD. PRESS.

CONTINGENCIES: STEP 7 COMPLETE

EVENTS: 25. ENGINE CRANK - LEFT
26. COMB. HYD. PRESS => 3000
27. ENGINE CRANK - OFF

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) ENG. CRANK LEFT /OFF"

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: 27 OCCURS BEFORE 26
ERROR: INVALID TEST
RULE: COMBINED HYDRAULIC PRESS MIN, 3000 PSI FOR VALID CHECK

MEASUREMENT:
EVENTS 25,27 - MANDATORY
SEQUENCE: 25,26,27
TIME: N/A

STEP NO. 9

DESCRIPTION: CHECK HYDRAULIC TRANSFER PUMP

CONTINGENCIES: STEP 8 COMPLETE

EVENTS:
28. COMB HYD PRESS > 2100 PSI
29. HYD. TRANS. SW. - NORMAL
30. COMB. HYD. PRESS - 2400-2600

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) HYD TRANS SW NORMAL "

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF HYD PRESS < 2000 PSI
ERROR: INVALID HYD PRESS CHECK
RULE: MAINTAIN AT LAST 2100 PSI COMB HYD PRESS

DISCREPANCY: IF EMERG HYD SW (TRANSIT)
ERROR: SWITCH ERROR
RULE: BI DI SW. FOR TRANS. CHK

MEASUREMENT:
EVENTS 29 - MANDATORY
SEQUENCE: 28,29
TIME: N/A

STEP NO. 10

DESCRIPTION: HYDRAULIC TRANSFER SWITCH TO SHUTOFF

CONTINGENCIES: STEP 9 COMPLETE

EVENTS: 32. HYD. TRANS. PUMP - SHUTOFF

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) HYD RANS PUMP SHUTOFF"

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF EMERG HYD SW (TRANSIT)
ERROR: SWITCH ERROR
RULE: BI DI SW. FOR TRANS. CHK

MEASUREMENT:
EVENT 32 - MANDATORY
SEQUENCE: N/A
TIME: N/A

STEP NO. 11

DESCRIPTION: ENGINE CRANK TO LEFT ENG. TO START.

CONTINGENCIES: RIGHT TO ENG 63 - 74% RPM

EVENTS: 33. ENGINE CRANK - LEFT

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) ENGINE CRANK LEFT "

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF ENG CRANK SW - R
ERROR: SWITCH POSITION ERROR
RULE: ENG CRANK TO LEFT

MEASUREMENT:
EVENT 33 - MANDATORY
SEQUENCE: 32,33
TIME: N/A

STEP NO. 12

DESCRIPTION: LEFT THROTTLE IDLE AT 22% FOR IGNITION.

CONTINGENCIES: STEP 11 COMPLETE

EVENTS:
34. RPM -> 22%
35. LEFT THROTTLE - IDLE
36. ENG. CRANK - OFF
37. RPM - 50%
38. L OVSP/VALVE LT - OUT

39. L GEN LT - OUT
40. L FUEL PRESS LT - OUT
41. LEFT TIT < 750

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: EVENTS 35 THRU 41 UPDATE

PROCEDURES MONITORING

DIAGNOSTICS:

DISCREPANCY: IF 35 < 34 THEN :
ERROR: THROTTLE IDLE BEFORE RPM 22%
RULE: THROTTLE IDLE AFTER RPM - 22%

DISCREPANCY: IF L TIT > 750 THEN:
ERROR: L TIT - (VALUE)
RULE: MAX START TEMP - 750

MEASUREMENT:
EVENT 35 - MANDATORY
EVENT 41 - CRITICAL
CRITICAL SEQUENCE: 34,35
CRITICAL SEQUENCE: 36,37
TIME: N/A

STEP NO. 13

DESCRIPTION: IDLE ENGINE INSTRUMENTS CHECK

CONTINGENCIES: LEFT THROTTLE IDLE

EVENTS:
42. L RPM - 63% - 74%
43. L TIT - 600 +/- 150
44. L F/F - 1000 +/- 200
45. L NOZZLE - 5
46. L FLT HYD. - 3000 +/- 175

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: ONLY FOR DIAGNOSTICS

PROCEDURES MONITORING

DIAGNOSTICS:
DISCREPANCY: IF 42 45 NOT EQUAL RANGE THEN :
ERROR: DEVICE (NAME) - (VALUE)
RULE: DEVICE (NAME) (RANGE) NORMAL

MEASUREMENT:
EVENT: N/A
SEQUENCE: N/A
TIME: N/A

STEP NO. 14

DESCRIPTION: DISCONNECT EXTERNAL AIR.

CONTINGENCIES: L&R RPM - 63 - 74% RPM

EVENTS: 47. EXTERNAL AIR - DISCONNECTED

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) EXT. AIR DISCONNECTED"

PROCEDURES MONITORING

DIAGNOSTICS: N/A

MEASUREMENT:
EVENT 47 - MANDATORY
SEQUENCE: N/A
TIME: N/A

STEP NO. 15

DESCRIPTION: HYDRAULIC TRANSFER PUMP TO NORMAL

CONTINGENCIES: L&R HYD PSI - 3000 PSI

EVENTS: 48. HYDRAULIC TRANSFER PUMP - NORMAL

ISFs and RELATED INFORMATION:

IOS DISPLAY CONTROL & FORMATTING

DISPLAY UPDATE: "(TIME) HYD TRANS PUMP NORMAL"

PROCEDURES MONITORING

DIAGNOSTICS:	IF EMERG FLT HYD SW (TRANSIT) WITHIN 30 SEC OF AIR DISCONNECT
ERROR:	SWITCH ERROR
RULE:	BI DI PUMP TO NORMAL

MEASUREMENT:

EVENT 48 - MANDATORY

TIME: TIME FOR TOTAL TIME TO COMPLETE THE TASK MODULE.