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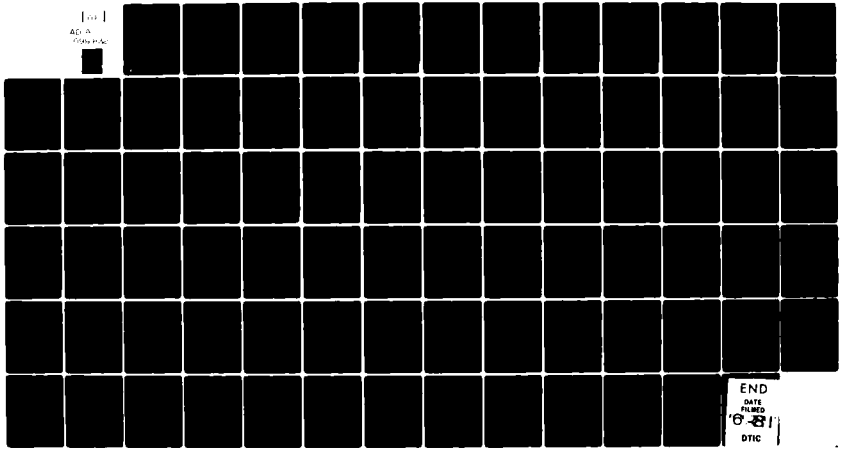

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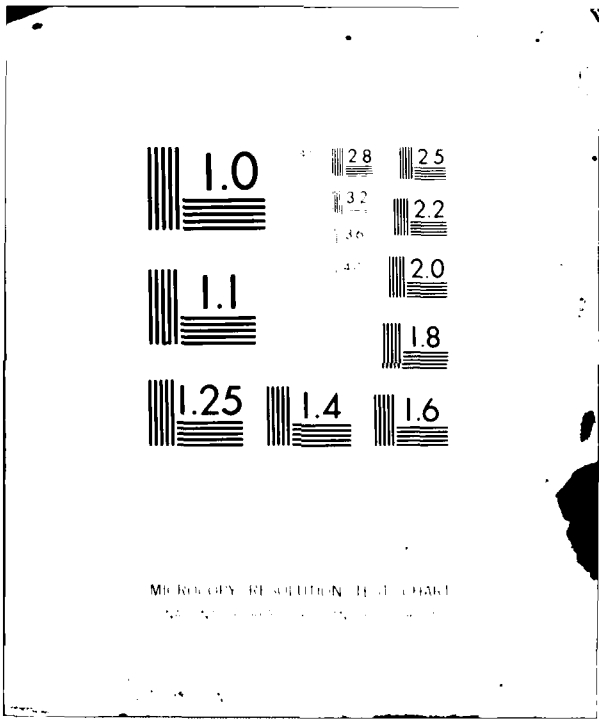
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F-16 AIRCREW TRAINING DEVELOPMENT PROJECT

Contract No. F02604-79-C8875

11) Mar 82

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F-16 MEDIA SELECTION AND UTILIZATION PLAN REPORT

(9) DEVELOPMENT REPORT No. 205
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Prepared in partial fulfillment of CDRL nos. B036, B038, and B047

by

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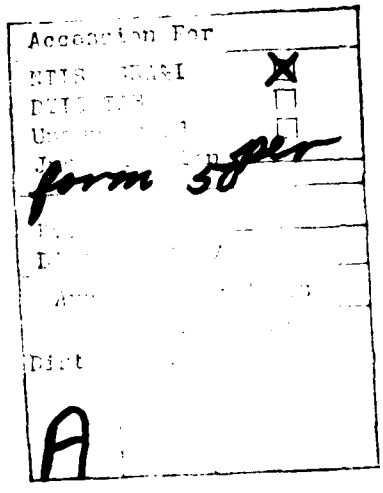
PREFACE

This report was created for the F-16 Aircrew Training Development Project contract no. F02604-79-C8875 for the Tactical Air Command to comply with the requirements of CDRL nos. B036, B038, and B047. The project entailed the design and development of an instructional system for the F-16 RTU and instructor pilots. During the course of the project, a series of development reports was issued describing processes and products. A list of those reports follows this page. The user is referred to Report No. 34, A Users Guide to the F-16 Training Development Reports, for an overview and explanation of the series, and Report No. 35, F-16 Final Report, for an overview of the Instructional System Development Project.



F-16 AIRCREW TRAINING
DEVELOPMENT PROJECT REPORTS

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EXECUTIVE SUMMARY

Media selection is the process of minimizing the costs due to media acquisition, use, or maintenance while maximizing the likelihood of consistent instructional effectiveness. Media selection for aircrew training involves two major categories of media:

1. Media intended for use in learning centers, ranging from workbooks to computer-assisted instruction.

2. Simulator or training devices which are intended to provide 'hands-on' practice.

Factors which must be considered in the media selection process include cost, ability of a device to implement specific instructional strategies, motivating capabilities, and the popularity of the media device with the student population. Some of the constraints to be considered in the F-16 environment include the necessity of premature media decisions, the late arrival of training devices, the varying availability of media cross training sites, the exisiting media production facilities, the tentative nature of the instructional content, the required mixture of type 'A' and 'B' aircraft, and the varying availability of flight time across training sites.

The media selection process begins with a complete list of the criterion-referenced objectives (CROs) from the objectives hierarchy analysis. These objectives are divided into academic (i.e., learning center learning activities) and training device categories, and then classified in terms of taxonomic levels. Instructional strategies appropriate for each level of learning required are then specified.

Associated with each strategy is a media requirements profile. All constraints affecting media selection for each objective are also specified. The available media are listed, and those media which meet the strategy requirements and constraints are retained. The instructional requirements for each objective are then identified and alternative media configurations are determined. The production, use, and maintenance costs associated with each alternative are estimated. A media decision model is then used to identify alternative media for each objective. The total costs of each media assignment alternative are then computed and reviewed.

For those objectives identified as requiring training devices, additional media selection steps are required. It is necessary to identify behavior elements contributing to task difficulty. These elements are mapped into corresponding levels of training devices ranging from low fidelity, non-interactive

devices (e.g., cardboard mock-ups) to high fidelity, highly interactive devices (e.g., operational flight trainers). The F-16 aircraft is assigned only when complete fidelity is instructionally necessary. The possible configurations for each training device are specified, along with the time requirements associated with each configuration. The cost of each configuration is then estimated and the best configuration selected.

The media selection process is a dynamic one and the procedures described extend over the lifetime of the F-16 training system. To aid in the standardization and documentation of the media selection process, a set of forms are provided which assist in the data collection and decision-making steps.

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F-16 MEDIA SELECTION AND UTILIZATION PLAN REPORT

1.0 INTRODUCTION

Media selection is a process of minimizing costs attendant to media acquisition, use, and maintenance while maximizing instructional effectiveness. It is an engineering process in which the benefits which can be realized through application of learning principles and instructional research are balanced against the lessons of experience and economics in designing real-world instructional systems and providing for the necessary equipment and instructional materials.

Media selection is one stage of the instructional development process which is partly administrative in nature and partly governed by the principles of psychology and learning. On one hand it uses factor optimization decision-making techniques to produce a "best" media decision in the presence of conflicting goals. This resolution of the conflicting demands for instructional sophistication, economy, and ease of administration is very much an administrative concern. On the other hand media selection must take into account the creative application of the principles of instructional strategy and materials development that allow it to happen. Without a judgment along this dimension, two competing media selection plans must be assumed equally effective, regardless of the sophistication of the media devices chosen.

Few processes affect an instructional system's cost and practical utility as profoundly as media selection. The development of an instructional system for aircrew training commonly involves the expenditure of thousands of dollars for learning center media, the expenditure of still other thousands of dollars over the lifetime of the system on the development and update of mediated instruction, and multi-millions of dollars for aircraft simulation training devices. Decisions made during the media selection process have a tremendous financial impact.

In direct proportion to the economic importance of media selection as a process is the frustration and confusion caused for instructional developers and their clients because of its many unresolved issues. These frustrations arise from the fact that many factors are balanced against each other in the making

of media selection decisions and there are few, if any, firm guidelines for determining media which are absolutely required for a given instructional goal. A large volume of research has been conducted to determine the superiority of certain media over others, with no conclusive results. In fact, media specialists themselves do not agree on which media are preferred for which application, and there seem to be few selections which cannot be rationalized away by some form of argument. On the contrary, instructional developers with creative imaginations can often invent ways to reconfigure media devices and training sequences to achieve approximately equal effectiveness from different media. The problems of media selection have had so few definite answers that many prominent texts on instructional development avoid the topic altogether. Yet, in view of the obvious effects of media selection on training budgets, the problems and uncertainties of media selection cannot be ignored.

1.1 Purpose

The purpose of this paper is to outline a method and rationale for the selection of both learning center and training device media for use in the F-16 instructional system. A report containing actual media selection decisions will be issued as project reports no. 24, "F-16 Media Selections and Syllabi" and no. 26, "F-16 Instructor/Course Managers Media Selection and Syllabus Report."

General decisions and policies made during the F-16 media selection process and decisions relative to individual objectives will be contained in reports no. 24 and 26, which will be issued upon completion of the media selection and sequencing process.

The F-16 instructional developers have attempted to address several main problems which presently exist in the media selection process: (1) the problem of striking a balance between the instructional and economic factors which influence media decisions in such a way that one kind does not suffer unduly at the hands of the other, (2) the problem of systematizing consideration of these major factors in the context of an organized process, and (3) the problems attendant to basing the specification of simulator-type training devices on bodies of data generated during instructional development rather than on more subjective means.

The result is a guideline and general procedure for the media selection process which may be used by instructional system personnel who possess a background in instructional development. Though the methodology reported here was developed in the context of instructional system development for a single-seat aircraft, it is felt that minor adaptations can render the methodology usable for multi-person crews of any number and non-aircrew training applications as well.

1.2 Organization

The main body of this report is contained in Sections 2.0 and 3.0. Section 2.0 is introductory. It outlines the media selection problem and relates the media selection process to other instructional development processes. In particular, the media selection document is characterized as a "living" document to be maintained on a continual basis along with several other instructional system data base documents. This maintenance procedure insures that the instructional development principles built into the system during its design remain there during its operation. This section also names the set of factors and constraints which need to be balanced during media selection. Section 3.0 describes the media selection process. Modifications to this basic procedure and the data generated by the selection process are documented in Development Report No. 26, "F-16 Pilot Media Selection". The final media profile utilized in the F 1600B course is reported in Development Report No. 31, "F-16 Training Media Mix".

2.0 RATIONALE

This section relates the media selection process to other development, practical, and economic concerns. It begins with a statement of the scope of media selection activities, describes how media selection influences and is influenced by other instructional development activities, and discusses the balancing factors and constraints which operate within media selection.

2.1 The Scope of Media Selection Activities

Media selection for aircrew training consists of two main categories of activity. The first deals with selection of media for use in learning centers for information and knowledge conveyance and practice. This includes well-known standard media types varying from the very simple and inexpensive (e.g., charts, worksheets, and summary pages) to the complex and costly (e.g., computer-assisted instruction, cue-see type systems, and videotape recording). It includes media which are intended for use by isolated students (e.g., workbooks, worksheets, and tutorials), students in small groups (e.g., discussion groups and problem-solving exercises) and students in large groups (e.g., lecture).

A second area of media selection centers in the configuration of simulation training devices which are intended to create to some degree a real-world-like performance environment in which the student may practice either fragmented or complete behaviors. Examples in this area also range from the simple (e.g., isolated realia, dead systems, mock-up panels, displays), to the complex (e.g., operational flight trainers, computer avionics simulations, weapon system trainers), depending on the scope of the enviromental factors being simulated.

There is much uncertainty and debate in the training device design area of media selection because of the growing complexity of training devices and simulated environments and the uncertainty surrounding the actual instructional effectiveness of given optional configurations. In the past no systematic body of research data or detailed record has been compiled to guide developers in specifiying training device characteristics, and the practice of determining device characteristics in a non-subjective, organized fashion from a statement of the training requirements has not been widely adopted.

Because of the indefiniteness involved in both areas of media selection and the inability to supply firm answers to either learning center or training device media selection questions, the process of selection is not generally looked upon as a very precise activity. Subjective approaches to selection abound, although some highly systematic methods have been created (Braby, et. al., 1975). For the most part, the problem faced by the developer is a matter of distinquishing between necessities and non-necessities.

2.2 Media Selection in Relation to Other Instructional Development Processes

While earlier stages in the instructional development process are analytic phases which gather and correlate data for use by the developer, media selection is a synthetic, or design, stage in which plans are formulated which give structure to the instructional system. Media selection builds on the products of previous development stages, and takes place interactively with other development tasks, therefore it is appropriate to describe its relation to other stages of instructional development.

Early stages of instructional development supply the substance which the media selection process works with. Media selection for F-16 occurs following: (1) the generation of a job task inventory or task listing, (2) selection of a set of terminal training tasks, (3) generation of a list of difficult-to-operationalize behaviors called "goals", (4) generation of criterion-referenced objectives (CROs) to be used as terminal performance measurement points, and (5) generation of objectives hierarchies. The results of these processes taken together form a data base of instructional requirements for F-16 pilots (and also for F-16 instructor pilots, since the same data base was created for that position as well). The data base documents are used as inputs to the media selection process. They list the instructional events for which media needed to be selected. Those foundation documents and the details of their generation are described in separate F-16 project reports.

Concurrent with media selection and interacting with it, a process of syllabus-building or "sequencing" takes place. For sequencing the same base of documentation from previous stages is used as an input. Sequencing is the process of arranging those instructional events taken from the CROs and objectives hierarchies in the order students encounter them in the course of instruction. Ideally, the sequence (syllabus) promotes the best obtainable gradual progression of student behavior from the time of entry into training to the point of mastery of all terminal course behaviors. Media selection and sequencing are closely related to each other. The order of instructional events in training often makes particular media selections more practical. Media selection decisions determine the types of instructional events and environments which can be used in the sequence. Special attention in both processes is given to adjusting the student's instructional experience to within certain parameters which the student will find tolerable or agreeable in terms of variety, pace, redundancy, and practical usability.

The results of the selection and sequencing processes are a course syllabus and a list of individual media assignments by instructional event. These documents lead to further instructional system development activities, although they represent by themselves a significant addition to the fundamental data base documentation referred to earlier. Throughout the lifetime of

the instructional system these documents should have a life of their own, changing as the documentation which acts as input to them changes (i.e., the task listing, goal analysis, CROs, objectives hierarchies) and in turn influencing other documents. An instructional system which does not maintain these documents, though derived through the application of good instructional development practices, cannot remain functional and efficient for long.

The media selection document, taken in conjunction with the sequencing document, serves several purposes. It serves as an inventorying base during the actual production of instructional materials. Prior to that it serves as a base for calculating projections of the production organization and costs which will be required during production planning. For instance, the types and numbers of instructional presentations (called "segments") can be determined only after media selection, as well as projection of the number and types of media devices required to present instruction for a given volume of students. Indirectly, these figures lead to the partial projection of numbers and types of instructors, administrators, and technicians who will be required to staff the student learning center, simulator locations, media equipment repair facilities, and media revision, production, and reproduction facilities. All of these items have both short- and long-term financial implications. In fact, the financial impact of these decisions is the major cost factor in the instructional system operation. For a full description of the impact of syllabus and media selection costs on total system cost, see project report no. 21, "F-16 Instructional System Cost Study Report."

2.3 Factors in Media Selection

In minimizing the costs and maximizing the benefits of media selections many factors must be considered. Media selections must be a "best" solution based upon stated criteria, the optimization on a set of sometimes conflicting demands. "Make it inexpensive" often leads to different solutions than "make it effective," and frequently both disagree with "make it interesting." Ideally, the media selection process insures that each selection factor is properly considered in the decision-making process.

The media selection process described in Section 3.0 of this report is structured in such a way that consideration of these demands takes place in an orderly fashion and seeks to insure that each factor is considered in proportion to its relative importance to the development task at hand. Failure to consider all relevant factors in media selection, or undue and disproportionate emphasis on one factor can lead to wasteful spending or can produce media systems which are unpalatable to the student, difficult to use, instructionally ineffective, or any combination of these. Plentiful examples of each can be found in the history of instructional development.

The major factors which have been considered during the F-16 media selection process are listed below along with a statement of the relative priority of each within the F-16 context.

2.3.1 Ability to Implement Effective Instructional Strategies

The ability of a device to implement a specific instructional strategy is a factor of media selection too often ignored or diminished in importance, even though it should logically rival or even outweigh cost in determining which devices are selected. One reason for this is probably the primitive state of affairs with respect to instructional strategy prescription. Psychologists interested in instruction have only recently turned their attention from the study of how people learn to the study of how to instruct and establish new behaviors. Therefore, the practice of specifying instructional strategies is in its infancy, and the idea that media should be constructed specifically to implement strategies is relatively new.

F-16 media candidates will be selected following the specification of a set of generic instructional stragegies (see Attachment I). Media are preferred if they demonstrate a capability for implementing these strategies, and possible media combinations and reconfigurations are considered where strategies can not be accommodated in an attempt to produce media as capable as possible in implementing them. Characteristics of a media device which take part in the implementation of strategies are: (1) the ability to generate appropriate stimulus conditions, (2) the ability to receive student responses, (3) the ability to process those responses, and (4) the ability to provide appropriate counter-responses (feedback and/or subsequent stimulus conditions). Depending upon the strategy being used, these requirements may be simple or complex. They may call for the ability to present simple pictorial, detailed photographic, or complex moving computer-generated graphics as stimuli. They may call for the reception of responses from the student which are simple yes/ no answers, or complex verbal expressions, or coordinated manipulation of aircraft-like controls. They may call for response processing and feedback which ranges from simple correct answer comparisions followed by knowledge of results, to complex computerized calculation routines followed by simulated aircraft response. In addition, all of these characteristics may be required under timed conditions and at varying levels of fidelity to real-world performance environments.

2.3.2 Cost

The cost factor is of extreme importance in media selections because cost is most often the only upward limiting factor. This is true of the F-16 project. Media selections entail not only immediate costs but delayed costs, some of which continue throughout the lifetime of the media system.

Figure 1 summarizes the costs associated with media device procurement and operation. The table identifies media costs during five main time frames: (1) during the design of media systems and instructional materials, (2) during the procurement of a media system, (3) during development of the media system and instructional materials, (4) during initial implementation of the system, and (5) during ongoing use of the media system and materials. It identifies major categories also, under which expenses might occur during each phase.

Media vary widely in the exact values of each entry in this table. Even for the same medium, expenses vary with differing training conditions, such as already-available resources, different geographic locations, differences in manpower availability, and differing organizational patterns. Not all media require all of the listed expenses, but all media will have a subset of the expenses. The more sophisticated the medium, the more expenses are likely to be attached, in both the short and the long terms. For learning center media the acquisition costs are comparatively minor, but the maintenance costs for instructional materials can be substantial for aircrew training. For training devices acquisition costs are often very large, even more so when multiple training sites and therefore multiple copies of a device are called for.

2.3.3 Attention- and Interest-generating Qualities

Since media devices and the presentations made by them represent a main communication link during instruction, it is important not only that the message be clearly stated but that the presentation arouse attention and interest in the user. Inherent in most instructional strategies is an interaction between student and device that require active participation by the student. This requirement for interaction can serve as an attention-generating tool. In addition, if the mode of interaction is interesting to the student or facilitates a student's personal learning goal, it can act as an interest-generating tool as well.

Many media selection decisions are made without considering the impact of the decision upon student attention and interest. Still others are made upon incorrect assumptions of what the developer thinks will be attention-getting or interesting to the student rather than upon data from student trial and reactions. Results of such selections are media selections which: (1) offend students because they are inappropriate to student's taste and learning styles, (2) bore students because they operate too slowly, because the student has no opportunity to interact, or because there is too much use made of one medium, (3) are a distraction to students because they require too much attention just for operation, or (4) are too fast for students' learning pace and cannot be controlled by the student, thus forcing the student to move at the presentation's rate or repeat the instruction--which some media do not allow.

TIME PHASE / CATEGORY OF COSTS	DESIGN	PROCUREMENT	DEVELOPMENT	INITIAL IMPLEMENTATION	ON GOING USE
Non development personnel costs	–cost of equipment design personnel –cost of administrative personnel during design	–cost of personnel required to administer procurement	–cost of subject matter expert personnel –cost of development management and administration –cost of documentation of systems and its operation	–cost of instructional system administrative personnel –device instructor costs –cost of post installation device testing and trouble-shooting –cost of initial device instruction and operation	–cost of instructional system administrative personnel –device instructor costs –device technical representative costs –repair personnel costs –cost of training device operators and instructors
Facilities costs	–cost of facilities design or remodeling –cost of planning use of existing facility	–cost of facilities for housing procurement team –cost of temporary procurement team sitting during travel	–cost of facilities to house development activities –cost of special development technical shops (e.g. VT studios, printing shops)	–facilities maintenance costs –costs of media device installation –facilities overhead & operating costs –cost of repair facility maintenance –equipment operating costs	–facilities repair costs –facilities overhead and operating costs –facilities maintenance costs –cost of repair facility maintenance –facilities periodic renovation cost
Equipment purchase				–cost of initial media devices and desk or carrel equipment –cost of initial spare parts inventory	–cost of replacement of worn media devices –cost of procurement for replacement aquisition –cost of spare parts for repair –cost of purchase of additional media devices to meet high student loads
Materials development	–cost of instructional materials design personnel	–cost of design personnel consultation and review during procurement	–cost of instructional development and production personnel –cost of producing supplies	–cost of duplication of instructional materials –cost of evaluation personnel	–cost of developing obsolete material replacement –cost of replacing worn materials with duplicates –cost of replacing student kept materials
Student expenses			–expenses incurred in trying out materials using typical students	–cost of maintaining students dislocated for media device use –student salary –student dislocation expense	

Figure 1 – Media-related Costs

2.3.4 Use of Standard Systems

Several potential benefits encourage utilization of existing, standard media systems where possible. Procurement of devices, maintenance service, acquisition of spare parts, and acquisition of replacement devices is facilitated when the media system being dealt with is well-known and widely-available. Moreover, for the production and reproduction of media presentations for such standard systems, specialized equipment and trained service personnel are much more likely to be available than for an exotic and little-used medium.

2.4 Constraints Upon Media Selection

Ungoverned by real-world constraints, the media selection process can produce interesting and effective but practically unusable solutions. Resource and personnel availability levels, costs, and personnel capability are all constraints which exist in nearly all media selection activities. Many other constraints exist as well due to policy, regulations, or limited supply of some critical resource. Some are hard constraints which cannot be changed, and some are soft. With the proper justification many can be modified.

Certain constraints existed at the onset of the F-16 media selection. Some of these were due to the late timing of the contractor's involvement in the F-16 development effort, and others were due to general USAF policies or programs. This section contains a study of the F-16 constraints related to media selection. Those listed are a subset of the constraints active within the context of the F-16 project. The total list of constraints and developer response to them, is contained in project report no. 15, "Program/System Constraints Analysis Report."

2.4.1 A/B Model Aircraft Mix

Considering the aircraft as a training device, the proportional mixture of standard A models and the two-cockpit B models can be a media constraint. The ability of the B model to accommodate an instructor pilot is a definite advantage for training purposes for most of the exercises RTU students will engage in. The non-availability of B model planes for training purposes necessitates the use of two A model planes: One for the student and one flying chase. The net effect of additional B models will be on the overall number of sorties available for training purposes. To the extent that A models predominate the aircraft acquired for RTU training purposes, a constraint will be felt. The reduction in available sorties may effect the media by placing a greater load upon simulation equipment, increasing the requirement for such equipment or, as the more probable case, reducing the amount that can be accomplished using available equipment. Selections for F-16 media must allow for the A/B

model mix in determining the level of simulator support required. A heavy production of B models early and for training purposes should be planned.

2.4.2 Highly Volatile Instructional Content

Because F-16 is a highly complex emerging weapon system, it can be expected that numerous changes will be made to the aircraft and to the procedures for its operational use. Changes in instructional content are dictated by these system and procedural changes that in turn dictate a change in instructional materials. Since changes will be constant, this indicates a constraint will be placed upon media presentations. It means they must be economical to revise, not only in turnaround time and personnel time, but in terms of special equipment or technical ability required to complete revisions.

2.4.3 Requirement for Premature Media Decisions

The difficulty of coordinating instructional development schedules with procurement schedules sometimes affects learning center media and simulator device decision-making. To allow the construction and equipping of learning center facilities to proceed on an operationally tolerable schedule, the numbers and types of media devices and the architectural plan of the learning center for F-16's first training site had to be determined and announced before the media selection process was executed. These data were provided when requested and formed the basis for ordering learning center equipment and specifying learning center layout. Data are not available on whether the decisions were correct. The requirement for an early announcement, however, with the knowledge that the figures provided would be used to order media equipment, placed a constraint upon learning center media selections actually resulting. It is likely that the types of devices selected in that early selection were correct. It is not likely, however, that the numbers of media devices was as accurate in the light of continually-revised student load figures, actual media selections, and updates to critical task listing and objectives hierarchy documentation.

2.4.4 In-progress Training Devices

The coordination of instructional development decision-making with the logistics of procuring complex media devices, for instance simulator equipment, has been difficult in the past as mentioned in the previous section. Often decisions on such devices take place before the arrival of instructional systems development personnel. Alternately, such decisions are often made by developers acting with inadequate information or analysis upon which to base their recommendation. The F-16 project has involved instructional developers at a very early phase of air-

craft system design and implementation. Nonetheless, the deadlines for procuring simulators came earlier, and many features of the F-16 OFT/WST, CFT, and EPT were determined in advance of developer arrival.

A provision of the F-16 contract requires input from the instructional developer on the qualities and capabilities desired in the F-16 OFT. The formal portion of this input is contained in project report no. 22, "Recommendations for F-16 Operational Flight Trainer (OFT) Improvements". Though it has been found that some of the recommendations can be implemented in the final simulator system for F-16, many of them cannot because of the advanced stage reached in planning when the recommendations were produced. To the extent that the design of the simulator cannot be flexible to the developer's plans, a constraint is encountered which the developer must circumvent by adapting the instructional technique to the existing trainer capabilities.

2.4.5 Late Arrival of Ordered Training Devices

Delivery deadlines for already-ordered training devices fall after the beginning of training of F-16 pilots. Availability of the OFT is likely to be four to six months following the start of training. Availability of the first CFT is scheduled for January 1979. The Egress Procedures Trainer is to be installed and working by January 1979. The interim training course will begin in January 1979.

Interim simulation capabilities of various types have been proposed by F-16 agencies. Each has attached to it a set of constraints which will have major impact on F-16 training, particularly in the area of the syllabus sequence. Simulation capabilities operating at a distance from the central training site require extracts of the syllabus to be concentrated together for student work as the simulator becomes available. Moreover, instructors working at a distance from the main training site are likely to encounter communication problems with the main site. Students may also encounter the need for refresher instruction, depending upon the lag in simulator availability. Under these circumstances special configurations of the instructional materials, syllabus, and the instructor training and monitoring system may be called for.

Simulation capabilities operating at the main site but at a lesser degree of sophistication also require special interim syllabi and provision for later update of student capability as the full-capability simulator becomes available.

2.4.6 Variable Availability of Sophisticated Media Across Training Sites

The existence of sophisticated air combat monitoring and evaluation devices such as ACMR/I at some F-16 training sites and

their lack at others is almost certain. A variety of devices now exist at various locations, are scheduled to be installed, or are in various stages of development or procurement. The variability of these devices from site to site is a constraint upon media selection in the sites where less sophisticated systems exist. The F-16 training system will present unique opportunities for evaluating the relative effectiveness of several of these systems. It is recommended that evaluation be conducted and the results used to equalize the most effective of these systems across training sites.

2.4.7 Absence of Funding for Additional Equipment

Despite the presence of previously-made media decisions, the possibility that media studies during instructional development might reveal additional desirable training devices was not ruled out. Such devices might include extra copies of already-ordered devices, modified already-ordered devices, or totally new devices. Should any of these prove desirable and funding for them not be found, that lack of funding would require revision of media and syllabus plans and would constitute a limitation. To the extent that recommendations for changes and additions to the training device inventory are couched in cost and effectiveness terms, a decision should be possible on the desirability of modifying the cost constraints.

2.4.8 Available Media Production Facilities

The ready access of some types of media production capability and the difficulty of obtaining expertise and equipment for other types consitutes a constraint upon certain F-16 media selections. The instructional materials created for F-16 must be maintained, updated, and replaced as required. Choosing media for which production facilities and personnel were difficult to obtain or train would be wasteful.

2.4.9 Variable Availability of Operational Air Space Across Training Sites

In the broadest perspective, even the air space available for practice purposes must be considered a part of media decisions. Since the ultimate task of the developer is to place the student in a real-world operational environment as closely as possible for practice purposes, limitations in air space (a part of the real-world operational environment) constitute a limitation on the developer's ability to provide the student with a mediated experience. The climate at potential training sites limits to some extent the availability of air space. These limitations are more than trivial and have both cost- and capability-limiting effects upon the instructional system.

3.0 MEDIA SELECTION PROCESS

This section contains a step-by-step description of the media selection model used for F-16. The model contains a set of procedures along with the documentation aids necessary to support the decision-making process and record decisions made. The description which follows describes each step in the process separately at a level of detail that should enable the media selection process to be performed by other than those originating the process.

A main feature of the model is its division into two main activities (1) selection of academic or learning center media, and (2) creation of specifications for simulator-type training devices through a generative process using the inventory of tasks to be trained as an input. The two areas of media selection are treated as separate processes because of the different approach which is required for selections to be made in each area. For the selection of learning center media, decisions are made relative to an existing set of media device types which can either be used as is or reconfigured to suit strategy requirements. These devices are oriented toward the imparting of information, the formation of new concepts, the learning and practice of new rules, and other cognitive exercises. The amounts of engineering involved in their selection is minimal.

On the other hand, training devices which are not of this group, are not prepared mainly for the establishment of the conceptual and informational base but for the practice of actual job behaviors or behavior fragments in simulated job environments. These devices may be selected from a predetermined set of categories but must also be engineered individually to create this job-related environment. Off-the-shelf, unmodified media devices are not available ready-made to meet a particular training need, and "design" of devices may be a more appropriate term than "selection" for the process involved in determining what is needed for the training system. The training device design model presented in this report attempts to specify the best family of training devices for a given set of tasks to be trained, each engineered for its particular training function.

The general limitations in media selection methodology described in Section 1.0 of this report apply to both the learning center media selection and the training device design processes. At present the questions of media selection have no firm answers. For the selection of learning center media, few firm guidelines are provided to developers other than the rationale each one can establish. For the selection of simulator-type training devices, a body of coherent, consistent procedures meant to derive training device specifications from statements of job task requirements has begun to evolve, but the procedures are by no means complete, nor has the decision-making path and factor balancing mechanism the designer must follow as specifications

for such devices are derived been sufficiently discussed as an entity. The methodology in this report is offered as a best attempt at establishing a procedure. Much research and empirical testing must determine changes to it which will lead to better selection and designs.

Inherent in the procedures described in this report are certain assumptions:

(1) Learning center media should be selected with due proportional emphasis upon the instructional strategy to be used during instruction. Several media selection models acknowledge this principle and attempt to define the elements of instructional strategy which figure in media decisions. For the purposes of this report a perspective of instructional strategy is taken which examines the individual instructional displays to be received by the student, classifies them, and utilizes systematic rules for their delivery to the student. This assumption is necessary to avoid the evils of a cost-factors-only media selection model and to give balance to media selection by considering more of the relevant factors of media selection.

(2) Alternate media selections produced by this model are assumed to be equivalent in instructional effectiveness. This is a difficult assumption which virtually all developers reject on the basis of intuition. Given the present state of the art in measuring instructional effectiveness, however, and the inability of instructional psychologists to produce any scale measuring units of effectiveness for comparison purposes, this assumption is necessary. All media selection models which take cost into account must make this assumption or else account for variable effectiveness through an estimation method.

(3) Training device specifications can be generated from statements of job task requirements using a systematic procedure. If this is not possible, instructional developers and simulator builders must rely forever on best guesses and intuitive processes to produce trainer designs and the trainer consumer must be resigned to the unanswered question of whether or not the lowest training cost is being paid.

(4) The learning center and training device selection and design process can be improved through a process of validation which compares intended with actual outcomes in student performance. Though this sounds reasonable and desirable, the requisite research and real-world effectiveness studies have not been performed which supply the necessary data base. Cost figures and effectiveness indices are required which can be used as inputs to the selection and design process and relieve the best-guessing which otherwise must take place. The ability to select and design media through a process which involves considerations of cost and effectiveness requires either a beginning data base from which the figures can be derived or else an initial set of estimates which can be validated through experience. That data

base does not presently exist for aircrew training devices and must be built before more precise trade-off studies can be made. This is emphasized as a critically important point if progress is to be made in defining the technology of media device design and selection. The ability to do this further assumes: (1) The existence of an adequate performance measurement and record keeping system within training systems which is capable of collecting student performance data of fine enough detail and with sufficient reliability to produce dependable conclusions, and (2) that a data recording system is in place on a continuous basis as training devices are used to gather time and usage data to be used in conjunction with the performance data.

Figure 2 contains a flowchart representation of the media selection process. The description which follows refers to the individual steps in this chart. The initial input to the media selection process is a complete list of criterion-referenced objectives (CROs) and instructional objectives from objectives hierarchy analysis. Objectives are grouped together during syllabus building for combined mediation as instructional "segments". For F-16 these groups will not average over two to three objectives per segment, and the types of objective (and thus the type of instructional strategy required to teach it) will not be mixed within segments where it can be avoided. Though the word "objective" is used in this report to designate the instructional event to which a medium will be assigned, it should be understood that refers to an instructional segment. These segments make up the inventory of individual instructional events which must be mediated. The derivation of CROs and a description of their purpose is contained in F-16 Aircrew Training Development Project Report No. 5, "Derivations, Formatting, and Use of Criterion-referenced Objectives (CROs) and Criterion-referenced Tests (CRTs)". The same description for objectives hierarchy analysis is contained in project report no. 8, "Ojectives Hierarchy Analysis Methodology Report".

A final note on bookkeeping requirements and the handling of changes is in order. The execution of many ISD processes, particularly in large-scale instructional development where much information and data are generated, the bookkeeping process required becomes extremely important. It is unavoidable for the developer to become disoriented in the midst of a disorganized pile of data which he generates, but with an adequate bookkeeping process it is easy to make large numbers of media decisions systematically. It is also easy given appropriate bookkeeping practices to insert changes to the body of the data base created by media selection. On the other hand, without such systematic procedures, especially for bookkeeping on decisions made, change made can result in confusion, duplication of effort, loss of data, misplaced training requirements, and eventually produce wasteful results. The media selection process described in this document depends upon a bookkeeping system of forms and tables which collect and summarize data for individual objectives during the media selection process. These preserve a data trail for

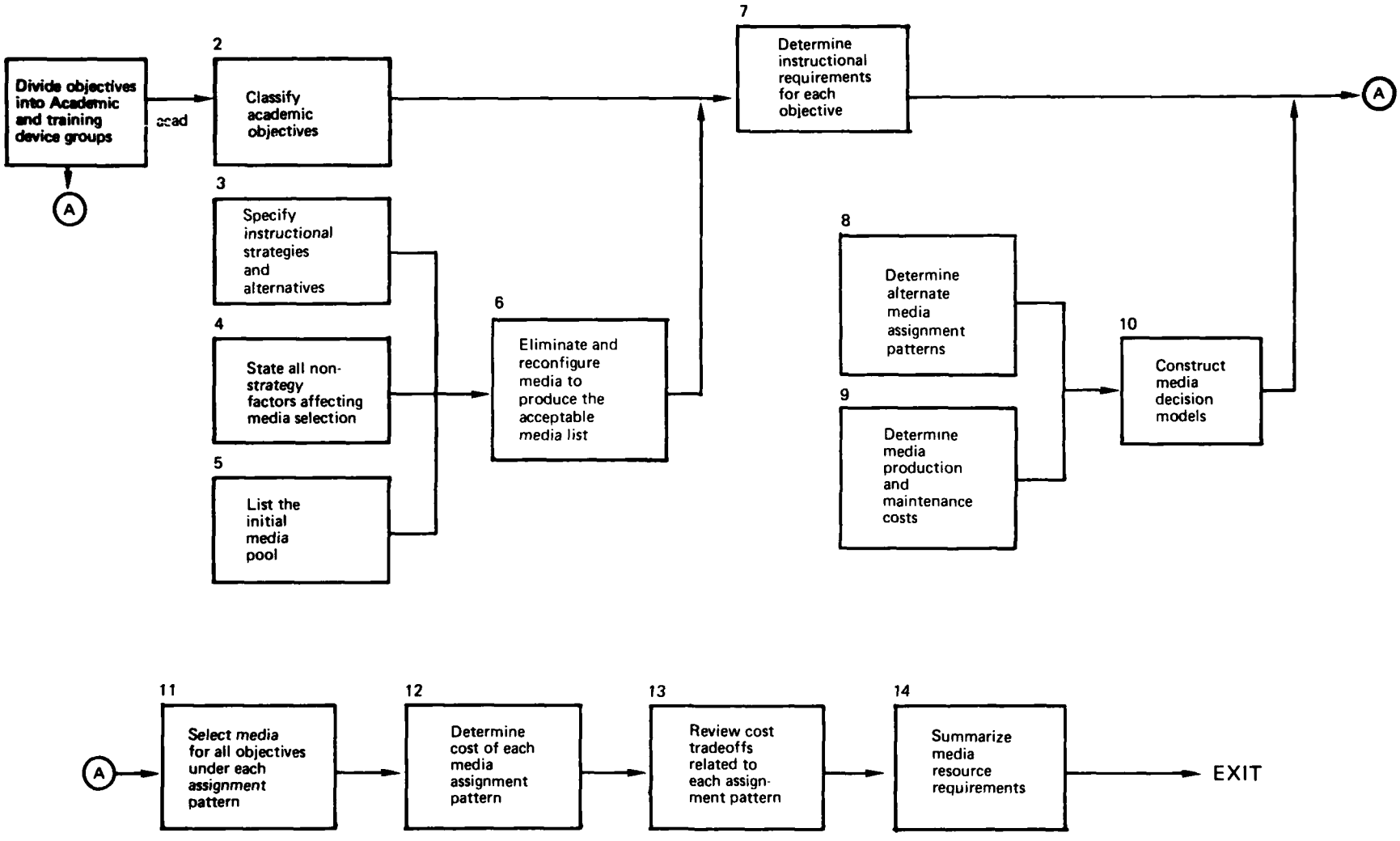

Figure 2 – Flow Diagram of the Media Selection Model

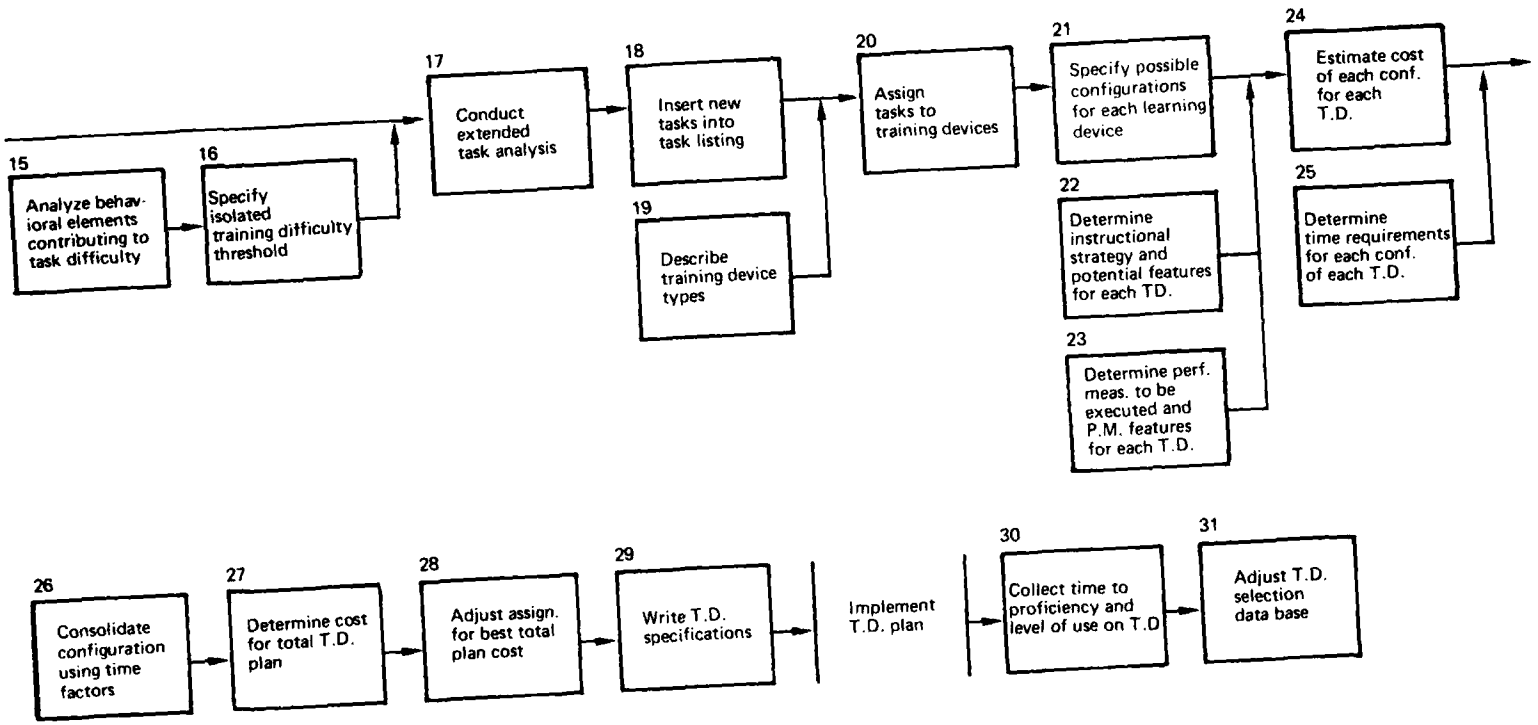

Figure 2 – (Con't)

review and use by those charged with revision responsibilities. There is nothing sacred about the system of forms beyond the fact that they represent a bookkeeping system which is adequate to record the decisions made without losing them. Alternate methods of bookkeeping, particularly computerization of the process, are acceptable and desirable to the extent that they minimize the bookkeeping effort without decreasing the developer's ability to execute the process and keep from losing his orientation within the vast process of media selection.

3.1 Step 1: Sort Objectives into Academic and Training Device Groups

During this step CROs and objectives are sorted into two classes. The first class is made up of all those objectives whose behavior requires real or simulated job environments or equipment. This is the "training device" group of objectives. The second class contains objectives whose behaviors can be performed without such equipment or environments. This is the "academic" group of objectives.

There are two keys to making this discrimination. The first is the exact wording of the behavior. If the behavior reads "perform the pre-takeoff inspection," then the behavior requires equipment to be inspected. If on the other hand the behavior reads "list the items to be inspected in the pre-takeoff inspection" no equipment is indicated, and the behavior can be accomplished outside of a real or simulated job setting.

Conditions and standards of an objective or CRO are the second key to making the discrimination. A condition may specify the type of display to be presented to the student. For instance, a condition may require the student to identify certain items from a radar return "given a photograph of a return". In this case the type of performance environment is specified. In the absence of such direction, a real-world environment should be assumed.

For those objectives requiring equipment, Steps 15 to 31 of the media selection process are applied next. For all others, Steps 2 to 14 are used. Worksheets to facilitate the bookkeeping chores of media selection are set up at this time. For each academic objective the appropriate numerical entry is made in Table 1, the academic objective analysis worksheet. Later steps will add data to this worksheet, which is only set up during this step. For each training device objective, a similar table will be generated as described in Steps 15 to 31.

3.2 Step 2: Classify Academic Objectives

Academic objectives are classified during this step according to a predefined scheme of categories. The categories are an

COURSE _____

ANALYST

DATE

REVIEW DATE

REVISION DATE

Academic Objective
Analysis Worksheet

ACAD. OBJ #	OBJ TYPE	Display Requirements						Control Req Stud	Response Requirements				Feedback				SUPERTASK NO.	EST. LRNG. TIME	SPECIAL REQUIREMENTS
		Audio	Still Vis	Mot Vis	Detail H M L	Size L M S	Color Y N		Alpha	M.C.	Y N	Stor Only	Kwl Feed	Kwl Auto	Kwl Auto Only	Kwl by Req			

Table 1 Academic Objective Analysis Worksheet

integral part of the objectives hierarchy analysis process, in that analysis normally takes place with a given set of objective types in the developer's mind as likely outcomes of analysis, and the categories of objectives to be produced through analysis are usually determined prior to analysis. If this is not the case, they may be classified in retrospect following it.

The classification of objectives at this point prepares the way for the assignment of instructional strategies. In subsequent steps of the media selection process, instructional strategies will be specified for each class of instructional objectives, with the assumption being that, a generic strategy pattern will be used (with local adjustments for content characteristics) for a given class of objectives. When the specific properties of the generic strategies are designed, the operational characteristics of media devices able to present those strategies will be defined in consequence.

For the F-16 project, academic objectives are classified according to the following types (see Attachment I for further elaboration and examples):

Remember/Procedure (verbatim)--these objectives require students to be able to recite, verbatim, procedures for operating the F-16. (RPV)

Remember/Procedure (paraphrase)--these objectives require the student to name only critical steps and critical values during a procedure. Emphasis is on paraphrased recall or on recognition of a correct answer when it is seen. (RPP)

Remember/Fact (symbol/name)--these objectives require the association between a symbol and a name or between a symbol and a definition. (RFSN)

Remember/Fact (function/location)--these objectives require the student to associate the name, function, and location of a given object. (RFFL)

Remember/Fact (limits/tolerances/critical values)--this objective requires the student to learn an isolated fact or numerical value. (RFC)

Remember/Fact (organized lists)--these objectives require the student to learn a list of events, items or objects which are in some way related to each other but not necessarily in sequence. (RFOL)

Remember/Fact (sequences)--these objectives require a student to recite a particular sequence of items in correct order. The sequence must be one that the student will not be called upon to perform,

for instance, the sequence of operation for a physical system. (RFS)

Use/Concept--these objectives require the student to identify examples and non-examples of a given class of things. All items classified must be previously unencountered. (UC)

Use/Rule--these objectives require a student to apply a computational rule or a general principle in the solution. (UR)

Once an objective type has been determined, the appropriate entry should be made on the Academic Objective Analysis Worksheet (Table 1) in the "OBJ TYPE" column. Abbreviations following the objectives descriptions above may be used.

3.3 Step 3: Specify Instructional Strategies and Alternates

The generic strategies are specified at this time for each class of instructional objective.

The F-16 instructional strategies evolve from a philosophy of strategy which regards instructional presentations as sequences of individual, classifiable packets of information (displays) having a consistent logical relationship to each other. The family of displays, interdisplay relationships, and response requirements which are needed in the teaching of a given objective can be identified. Since the medium is the device for presenting displays and handling all interactions between the student and display contents, the types of displays and the interactions required, are important to define.

When strategies have been specified, a Strategy Media Requirements Profile is filled out for each. This table summarizes display, response, and other characteristics of each strategy. A sample profile is given in Table 2.

3.4 Step 4: State All Nonstrategy Factors Affecting Media Selection

In Step 4 non-strategy factors affecting media selection are listed. These include many of the practical requirements arising from the patterns of day-to-day use. They take into account the needs of students using the media and the needs of administrators buying and maintaining the media devices and media presentations used on them. They take note of special environments for device use and help insure that devices which are picked are suited for use in all required environments. The factors affecting media selection must include constraints which will exist as media are selected. These constraints need not be looked upon as absolute barriers unless they have unequivocally been identified as that.

Strategy Media Requirements Profile

DISPLAY	RESPONSE		PROCESSING		FEEDBACK		INQUIRY		CONTROL AND PACE				
Present Display ?	Recieve Student Response to Display Content ?	Timed	Process Response R/W ?	Prucess Response Content ?	Provide F.B. R/W ?	Timed	Provide F.B. Based on Response?	Accept Student Inquiry ?	Respond to Inquiry ?	Can Student Stop Presentation ?	Auto Stop ?	Can Students Backup ?	Can student select within ?	Can student jump ahead ?

Strategy_____
(objective type)

SPECIAL DISPLAY REQUIREMENTS:

	COMMENTS:
☐ AUDIO	_____
☐ STILL VISUAL	_____
☐ MOTION VISUAL	_____
☐ COLOR	

OTHER SPECIAL REQUIREMENTS:

CANDIDATE MEDIA _____

1. _____	5. _____	9. _____
2. _____	6. _____	10. _____
3. _____	7. _____	11. _____
4. _____	8. _____	

Table 2 – Strategy Media Requirements Profile

It is possible that constraints may yield to a sound media rationale.

It is important to identify these factors in advance of media selection. When the factors are identified they should also be prioritized or given proportional weight as to their relative importance. These weights are used to balance the factors to ensure that more than one factor is considered and that undue emphasis is not placed on one factor. A process for externalizing these priorities is not offered here, for it is a complex judgement process, balancing factors agains each other. The main factors influencing media selection for F-16 have been presented in Section 2.3 and 2.4 of this report.

3.5 Step 5: List the Initial Media Pool

During this step a list is made of all the devices which will be candidates during media selection. All individual media types and combinations of types which are thought to be usable should appear on this list. In subsequent steps entries will be deleted from this list which (a) do not effectively implement instructional strategies and (b) do not support the factors listed in Step 4.

3.6 Step 6: Eliminate and Reconfigure Media to Produce the Acceptable Media List

Once the strategy and non-strategy factors have been stated which will limit or constrain media selection, the master list of all available media can be scanned for media which do not support the factors, or which are without the bounds of the constraints and for which there seems no possibility of removing them. These media are deleted from the candidate media list. Some possible reasons for eliminating a medium might be:

- The immediate or long-range costs associated with a medium for production, repair, acquisition, or operation are prohibitively high when weighed against the expected benefits.
- The expertise or equipment required to produce and modify instructional presentations is not readily available.
- The medium does not fall within the limits set by the constraints (see Step 4).
- The medium is as yet experimental in nature and has unknown operational properties (durability, student acceptance, etc).
- The production time for presentations in this medium is too long.

- The medium is not durable and is subject to breakdowns.

- The medium makes demands of students that are beyond their normal range of interest or ability.

- The medium is too complex to use and is likely to require too much of the student's time or attention for operation.

These are suggested media elimination criteria and do not comprise an exhaustive list. A complete list for a given media selection will depend upon factors local to the project.

A Media Elimination Table like that in Table 3 is filled out as a record of the rationale for eliminating a given type of media. This captures the logic of the developer for future re-evaluation of decisions. Only those media remaining on the list after this elimination and a screening for strategy capability will be considered for selection.

In making deletions some judgement is required. Decisions are not likely to be clear-cut, and some trade-offs may be considered before eliminating media. For instance, some media may be clearly unaffordable, too delicate, not portable, or in some other way beyond practicality. Other media, on the other hand, may appear to be out of bounds on some factors but yet have such a strong positive recommendation from others that they may be retained on the list. A medium which is expensive in acquisition but yet can implement instructional strategies far better than other media may be retained as a candidate. A medium which has found itself in this situation in the past is computer-assisted instruction (CAI). The initial cost of a CAI system is often troublesome, but the attraction of the strategy versatility of a computer and the side uses of a computer, for instance, in computer-managed instruction (CMI), make a CAI system very desirable despite cost. (Surprisingly, when total actual costs are compared for various media some CAI systems turn out to be comparatively less expensive. This is because actual costs are in fact higher than usually estimated and CAI costs lower than expected.) This combination could cause a medium to be left on the candidate list despite some factors legislating against it. This has been the case for F-16. When media are for some reason desirable but cannot fit the requirements imposed by the factors, reconfiguration of a medium by combination with another medium or by different patterns of use should be considered. Two media used in combination may be more effective than a single medium.

Instructional strategies are considered at this time. Media are eliminated from the candidate list which are unable to implement the display, response, and other requirements of at least one strategy. At the bottom of the Strategy Media Requirements Profile pages already filled out in Step 3 (see Table 2) those media capable of implementing each one are entered, along with any notes on how each medium can be changed or used differently to fill some or all requirements of the strategy. Because some

MEDIA ELIMINATION TABLE

MEDIA TYPES	ELIMINATION FACTORS																												
	COST						EFFECTIVENESS & APPEAL											EFFICIENCY					OTHERS						
								specifications					demands																
	design	development	procurement	implementation	on-going use	repair	unavailable	stimulus	response	feedback	experimental	not durable	motor	psycho-motor	cognitive	affect	too complex	production	aquisition	repair	operation	student response							

Table 3 – Media Elimination Table

strategies may require complex capabilities not readily available, media which can implement significant portions of a strategy should be listed.

The media which are listed on the bottoms of the profile pages following this procedure comprise the final media list.

3.7 Step 7: Determine Special Instructional Media Requirements for Each Objective

The Academic Objective Analysis Worksheet (Table 1) lists specific media considerations under the headings of display requirements, control and pace requirements, response requirements, scoring requirements, and feedback requirements. During this step, under each of these headings, a mark is placed next to the requirement for instruction for each objective. In Step 3 completing the Media Strategy Requirements Profile (Table 2) made a general statement of required media characteristics for a generic strategy. Now during this step, the additional effect of the specific content of an objective is taken into account. Some objectives may deal with content which requires more detailed illustrations or color or motion in a way which departs from the general strategy pattern. Using the media strategy requirements profile as a general guide, the developer should identify requirements for each objective under each heading. Requirements which deviate from the general pattern should be noted in the rightmost column so that special adjustment may be made at the time of media decision-making.

Some general guidelines may be provided for specifying the requirements. For display capability choose the least complicated or expensive level of effort which will accomplish the instruction. Unfortunately there is some subjectivity in this decision. The instruction to choose the least complicated capability arises from the tendency of media research to find little or no difference in learning attributable to more complex or finely finished instructional displays (Travers, 1970). Simple line drawings are in many cases as instructionally effective as complex renditions or even photographs. There is even some evidence that during training the more complex the display, the more difficult it is for the student to detect the main message or salient points.

For pace and control decisions, student control should be favored, depending upon the anticipated motivation and self-directedness of the students. Research in military training environments has found time efficiencies attendant to students being given control of instructional order and speed (Walker, 1978). For students who are highly motivated and self-directed this effort would be expected to be very strong. On the other hand, for dealing with low-motivation students or students who are not self-directed, student control may be inappropriate.

3.8 Step 8: Determine Alternate Media Assignment Patterns

As non-strategy factors affecting media selection (e.g., cost, time of revision, production facilities required for revision) change, the desirability for different media assignment patterns also changes. When videotape production facilities are readily available and relatively inexpensive, the desirability of using videotape as a medium increases. When the capability does not exist or ceases to exist, the desirability of that mixture diminishes, and the media assignment pattern will specify a lower percentage of videotape instruction. This step involves the specification of desirable patterns of media assignment growing out of priorities and constraints found in the media selection factors.

A variety of priority orderings of media are possible given different priorities in the factors which are operating on media selection. The developer may create several media assignment patterns prior to media selection in hopes of finding the best balance of cost, strategy, and other selection factors. The creation of patterns for this testing and fitting process entails either (1) the ordering of the media listed on the Strategy Media Requirements Profile (Table 2) in order of preference according to a particular factor balance, or (2) the setting of specific ceiling percentages for specific media on that list beyond which assignments will not be allowed to go. A developer may wish to favor media which can implement specific instructional strategies despite their cost and will arrange media on all the profiles in that ordering. At the same time the developer may also wish to see the effects of taking cost into account as the main factor and so will order the media in a second assignment pattern in order of cost. In a third pattern the developer may wish to test the effects of stipulating that tape/slide presentations will not take up more than 30% of the total media assignments.

Table 4 contains a form for the purpose of writing down media assignment patterns. One form is completed for each pattern created. All media still in consideration are gathered from the bottoms of the Strategy Media Requirements Profiles (Table 2) and entered in the left-hand column. Each objective type is entered at the head of its own column. For each objective type an entry is made after the media to be used with that type of numerical priority (1st choice, 2nd choice, etc.) of each. Ceiling percentages are entered where that is a priority factor. As well as keeping a record of the patterns of interest, a record should be made for each pattern of the benefits and drawbacks associated with each. The back of the record form is used for this. This record will become an important aid to decision-making in the final balancing of media factors in Step 13.

MEDIA ASSIGNMENT
PATTERN RECORD FORM

Media Pattern #_____

Media Type	Objective Type							
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
14.								

Table 4--Media assignment pattern record form.

3.9 Step 9: Determine Media Production and Maintenance Costs

The costs attending the use of each medium must be known. Thses costs include development and operation costs.

3.10 Step 10: Construct the Media Decision Models

Media selection decision models are constructed, one for each media assignment pattern. The factors balanced in this model include instructional strategy, cost, and any other factors the developer has wished to include in media assignment patterns. Media suitable for each strategy type have been chosen in earlier steps of the selection process, and various priority orderings have been created to test the effects of different developer decisions on media mixtures. The media selection model is the specific rule for assigning media to objectives and takes into account all of these earlier decisions.

A media selection decision model may be represented as a sequence of decision points which executes the following: (1) identification of the objective by type, (2) matching of specific instructional content demands to display, response, and other media characteristics for each objective, (3) filtering of the total number of objectives assigned to one medium if percentages have been specified as part of assignment patterns, and (4) assignment of a specific medium.

Each assignment pattern created during Step 8 requires a separate model, since the order in which media are preferred is different in each one.

3.11 Step 11: Select Media for All Objectives Under Each Assignment Pattern

At this point media selection proceeds for each objective under each assignment pattern. Selection of media for each media plan takes place separately. Each objective is passed through the logic of each assignment pattern decision model and has a medium assigned to it. If there are four assignment patterns used, each objective must be passed through four models. Computerization of this process may be desirable for large volumes of objectives.

A record of media selections is kept for each objective under each pattern. Table 5 contains the table used for this purpose. It may take the form of an overlay to Table 1 to eliminate duplication of records.

A summary is made of media selections once they have been made and recorded. Table 6 contains a summary table used to report the number of objectives selected for each medium under each assignment pattern.

MEDIA SELECTION RECORD TABLE

Objective Number	Media Assignment Pattern						
	1	2	3	4	5	6	7

Table 5--Media selection record form.

MEDIA SUMMARY TABLE

Media	Media Assignment Pattern					
	1	2	3	4	5	6

Table 6--A media summary table.

For media whose data on the Academic Objective Analysis Worksheet (Table 1) showed a divergency from the general strategy pattern prescribed for its objective type, adjustments in selections are made on an individual basis as needed.

3.12 Step 12: Determine the Total Cost of Each Media Assignment Pattern

Using the cost figures for each medium derived in Step 9, the cost of each media mixture derived through the assignment process in Step 11 is determined. These costs may not be sensitive to variations in volume, and adjustments should be made for a higher or lower volume of production than was used to derive the original cost figures.

3.13 Step 13: Review Cost Tradeoffs Related to Each Assignment Pattern

The positive and negative factors listed for each media assignment pattern in Step 8 and attached to it are now examined along with the costs derived in Step 12. It is possible to conduct an informal cost tradeoff study at this time. The developer should choose that media configuration for recommendation which presents the best set of positive instructional, cost and use features. No set of guidelines should be set down for this because it involves a decision-making process on the part of the developer and the instructional system consumer which may involve many external factors to the system itself.

By producing the media assignments and the cost data attendant to each for several assignment patterns the developer has laid the foundation for orderly decision-making and comparison of several ways to proceed. Further assignment patterns may be generated at this point to test new possibilities for media mixtures, and it is assumed that a negotiation between the developer/consumer and the real-world contingencies will take place at this time until the best combination of media for the funds available is determined. Moreover, when the decision is reached, both developer and consumer will have an understanding of the capabilities and limitations of the resulting media system.

3.14 Step 14: Summarize Media Resource Requirements

A summary should be made containing the numbers and types of media devices to be acquired along with list of the media production facilities required to support the production and revision of media.

3.15 Step 15: Analyze Behavior Elements Contributing to Task Difficulty

In the performance of any task, there are certain things which may make the task difficult. The difficulty may arise from any number of causes: the complexity of task integration, heavy drains on memory, complex and/or precise motor performances which are part of the task, difficult discriminations, complex calculations or decision making algorithms, noise or interference in the task environment, timing constraints, or other task factors.

During this step those task elements which contribute to task difficulty are identified and isolated. Two general types of factors are considered: (1) specific difficult within-task elements, and (2) general condition of task execution.

Difficult within-task elements. Pilot tasks are structurally quite similar. They usually consist of much the same behaviors repeated in a cyclic fashion. A generic pilot task can be specified containing these seven or eight common behaviors. Then task difficulty can be shown primary cases to be attributable to a difficult sub-element of the tasks. For instance, "operate controls" is a behavior common to most aircrew tasks. Control operations for some tasks requires only the pressing of a button or throwing of a switch. For these tasks, task difficulty is probably not because of the difficulty of the control operation. For other tasks, however, the required operation of the controls may require split-second timing and high precision, or it may require precise movements. The contribution of control operation to the difficulty of this task is far greater.

Major subdivisions of the generic task for F-16 are: (1) reading of interior cockpit indications, (2) reading of exterior cockpit indications, (3) determining of the next course of action, (4) locating controls, and (5) operating controls.

General conditions of task executions. Conditions during task execution may also make tasks difficult. A general condition of stress during execution, the requirement for precise timing, interfering noise, and the requirement to act without looking are conditions which may make a task difficult.

The analysis of task element difficulty factors produces a table like that in Table 7, a Task Element Difficulty Rating Sheet. The factors shown on this table are those which appear to influence difficulty of F-16 tasks most regularly. This list was determined by a walk-through of representative F-16 tasks. Not all task elements appearing on the difficulty rating sheet are part of every F-16 task, but it is expected that for the majority of F-16 tasks the elements contributing to their difficulty will be found in this list. If a task is encountered which has unusual difficulty elements, these elements should be added to the list.

TASK ELEMENT DIFFICULTY RATING SHEET

Task or objective No. ____

Analyst _____ Date_____ Notes

Read External Indicator (Cockpit Ext.)
- Perceive alarm
- Perceive object (isolated)
- Search and identify [PRE] _____
- Locate and track [PRE] _____

Read Internal Indicator
- Perceive alarm
- Perceive subtle indicator change
- Read Discrete or binary valve
- Read continuous scale
- Classify element of a display [PRE] _____

Determine Course of Action
- Retrieve from memory
- Simple calculation
- Complex calculate [PRE] _____
- Complex integrate [PRE] _____

Locate Controls
- Visually
- Blind [PRE] _____
- Untimed
- Timed [PRE] _____

Operate Controls
- Discrete
- Continuous [PRE] _____
- Continuous integrated [PRE] _____

Overall Difficulty Factors
- Noise or interference in environment
- Competing tasks
- High stress on pilot (psych)
- High stress on pilot (phys)
- Timing

High Degree of Automaticity required
- Visionless performance required
- Length of task procedure (high memory load)
- Highly branched task procedure (several alternate paths)

Table 7--Task element difficulty rating sheet.

3.16 Step 16: Specify Isolated Training Difficulty Thresholds

Once difficult task elements are identified, a determination must be made of those levels of difficulty which are severe enough to require isolated practice and mastery of the individual sub-elements before performance of the entire task is required --that is, the threshold difficulty level which will cause the developer to pretrain a subtask in isolation from its parent task. Failure to identify and isolate such difficult task elements results in placing the student in the situation of learning both the complicated subtask and the integrated larger task at the same time.

Each element on the Task Element Difficulty Rating Sheet (Table 7) which exceeds the threshold set for F-16 purposes is marked with a [PRE] to indicate that isolated pretraining of the task should be conducted.

3.17 Step 17: Conduct Extended Task Analysis

Using the Task Element Difficulty Rating Sheet (Table 7) tasks are rated individually to identify their difficult elements (if there are any). When a [PRE] level element is identified within a task, it is isolated as an individual, trainable task itself.

Analysis should be particularly aware of judging task difficulties from the point of view of a new student and should reflect on their own experience to find those elements which made it difficult when they were learning complex tasks. Levels of difficulty should be judged for students in early phases of training and not on the basis of experienced pilots. For experienced pilots, even difficult tasks assume a level of easiness born of large amounts of practice.

Those elements identified and isolated for training which require equipment for training are cycled to Step 15. This means that each one will itself be subject to analysis to determine trainable sub-elements.

Isolating subtasks in this manner constitutes an extension of the task listing to incorporate tasks whose training importance was not readily apparent during the original analysis.

3.18 Step 18: Insert New Tasks into Task Listing

Each isolated element from Step 17 in entered as an independent task in the task listing. The procedure for doing this is found in project report no. 10, "Data Base Update Procedures Report." If this record keeping chore is not completed the task listing will be incomplete, and major trainable tasks will not appear in the syllabus.

Steps 15 through 18 may be considered to be as steps in either the the task analysis or sequencing process. They are included here as part of the media selection process as a safety precaution to back up the task listing process, which is often subtle and can easily be incomplete. Some subtasks which are not initially identified during task analysis may have a high training impact. Their omission may cause student performance difficulties and, as a consequence, expenditive of unnecessary personnel and training device time.

3.19 Step 19: Specify Training Devices

When it is determined that pre-set categories of training devices will be used as the beginning point for device design, the first step is the defining of the categories. Several sources may suggest categories: previous known training device configurations; regulations, policies, and position papers; and studies of training device media characteristics such as the F-18 (Hughes, 1977), B-1 (Sugarman, 1975), and TAEG (Braby, 1965) studies.

Figure 3 is a categorization scheme for training devices based on three characterisitics of devices: (1) dimensionality of the display presented to the student (2 vs. 3), (2) responsiveness to student manipulation (responsive vs. non-), and (3) scope of simulation of system (isolated systems vs. integrated and full systems). The major categories of devices resulting from crossing these characteristics are described below. This category scheme will be used for F-16 purposes.

A. Two-dimensional, non-interactive display in near-real size, proportion, and degree of realistic appearance. An example of this device would be a photographed or line-drawn display of a cockpit interior pasted upon a wood or cardboard surface in such a way that preserved spatial and proportional relationships of individual components and panels (paper tiger).

B. Two-dimensional, responsive schematic panel consisting of one isolated system. This device makes available to the student isolated system to be manipulated. Through a two-dimensional display manipulations of the system are not topologically the same as real-world behavior but can be cognitively equivalent. An example of this type device would be a two-dimensional CRT presentation of a given aircraft control panel driven by a computer and capable of simulating control panel action and reaction with high fidelity.

C. Two-dimensional, interactive, partially to fully integrated schematic panels. In this device a number of systems are integrated in one instructional training device which operates the same as device "B". This

device, however, is capable of simulating the operation of multiple systems and their interactions with high fidelity.

D. Three-dimensional, non-interactive model of isolated systems. Parts of this model may be movable manually just as real equipment, but there is no automated modeling of responses to user manipulations. One example would be a model of a physical system or a non-physical phenomenon intended to show operation of parts during a cycle of activity. A second example would include isolated pieces of equipment intended for manipulation, such as realistic models of equipment to be repaired or cockpit panels and equipment taken from or resembling an aircraft system.

E. Three-dimensional, non-interactive model of multiple systems. Parts of the model may be made to move in a way simulating real motions within the object during operation, but modeling of responses to user manipulations is not made. An example of this system is the dead A/C system or a CFT, representing physical aspects of multiple systems.

F. Three-dimensional, interactive, limited scope. This is a simulation of a realistic (within some range of fidelity to real world operation) performance environment in which only selected portions of the environment are simulated. Examples of this include isolated equipment systems placed in working order or combinations of systems in working order either separately or with interactions between them being duplicated. Examples also include the Egress Procedures Trainer.

G. Three-dimensional, interactive, limited to broad scope simulation of a realistic performance environment in which either extensive or all portions of the environment are simulated. Examples of this type range from limited operational environmental scope to operational flight trainers which simulate to some degree of fidelity a real operational environment. The IPTT, OFT and WST are examples.

H. F-16 Aircraft.

3.20 Step 20: Assign Tasks to Training Devices

During this step a preliminary decision will be made on two points: (a) on which training devices is it possible to execute each task at some level and (b) the estimated desirability of having students perfom each task in a given training device during actual training. This step approximates closely an activity which will also go on during syllabus building: That of assign-

	DEVICE TYPE CLASSIFICATION						
DIMENSIONS	2–DIMENSIONAL			3–DIMENSIONAL			
Response to Student	NO	YES		NO		YES	
Scope of Simulated Systems	Full Integrated Isolated	Isolated	Integrated Full	Isolated	Integrated Full	Isolated	Integrated Full
Device Types (see text)	A	B	C	D	E	F	G
Examples	Paper Tiger (Varying Scope of Simulator)	INCOS Electrical Trouble-Shooting	IPTT Fully Simulated on CRT	Isolated Equipment	CPT Dead Aircraft	Isolated Equipment (LIVE)	IPTT OFT WST

Figure 3 – Device Type Classifications

ing tasks to specific training devices for practice purposes. The products of this estimation for media selection purposes will become the inputs to syllabus building.

During this step it must be indicated, for each task, whether or not the task can be performed to some level in a given training device. This indication is made in the columns labelled "Training Device Capability and Desirabilities" on the Task Listing Data Worksheet (Table 8) by placing a check in the column for each device on which the task can performed.

A built-in assumption for each training device type is that only certain varieties and levels of practice will be attainable. A cockpit procedures trainer, for instance, will not allow a student timed performance of a basic procedure under full stimulus conditions. However, some preliminary practice is possible on the mechanics of the procedure. As decisions are made concerning which device may be used for each task during this step, it should be kept in mind for each device what level of practice is possible. It may be desirable to record for each device type the kind of practice possible.

The second activity in this step, using the same form, is to specify, given the entry-level behavior of the student population and the course mastery model, the likelihood that it will be desirable from the student point of view to actually use the training devices indicated in the first part of this step. Some guidelines for making this decision are: (1) tasks should be practiced in the least complex simulator (to lower overall training costs), (2) practice in simple environments on tasks for which students have had some degree of previous experience should be minimized or omitted to avoid wasteful and unnecessary training time, and (3) practice should always be escalated up to the level of training device which can most fully simulate actual conditions which will occur on the job during performance of the task.

Indication of the desired training devices for a given task is made by placing a circling around the x's made earlier on Table 8 in columns which indicate training devices should actually be used for a task. These circles indicate the task assignments which will be used to determine number of training devices required and cost trade-offs to be used in future steps.

It is necessary to specify the systems required for performance of each task. This information is available on the criterion referenced objectives (CRO's). A check should be conducted to insure that each CRO contains this information. Then indication of the systems required for the task is made by checking the appropriate columns under the heading "Systems Required" on Table 8. Under this general heading, each control and indicator or panel accessible to the pilot should be placed at the top of a column. To economize effort, it is recommended that panels be used as the unit of indication where a control or indicator

TASK NO	TRAINING DEVICE CAPABILITY AND DESIRABILITY A	B	C	D	E	F	G	H	SYSTEMS REQUIRED

Table 8 -- Task Listing Data Worksheet

TD TIME REQUIREMENTS

A						B						C						D						E						F						G						H					
Per	Su	Gr	PS	E	R	Per	Su	Gr	PS	E	R	Per	Su	Gr	PS	E	R	Per	Su	Gr	PS	E	R	Per	Su	Gr	PS	E	R	Per	Su	Gr	PS	E	R	Per	Su	Gr	PS	E	R	Per	Su	Gr	PS	E	R

Table 8 (Con't)

appears as part of a panel. For controls and indicators which occur isolated and not part of a panel, it is recommended these be listed separately.

3.21 Step 21: Specify Possible Configurations for Each Training Device Type

During this step a list is made of training devices required to carry out the practice needs indicated in Step 20. This is not the final list of devices which will be obtained but rather a preliminary working list. This listing is made by identifying all device types and the versions of each which are indicated by the marks on Table 8. A recommended procedure is:

1. Place the name of each device type at the head of a separate training device configuration record (Table 9).

2. For device types which span only one or a small number of systems (the "isolated systems" devices from Step 20; this would be devices B, D, and E) an entry is made on the appropriate record to show which isolated system must be simulated. Each unique system or set of systems is given a configuration number and treated as a separate device. The frequency of the requirement should be shown for each item.

3. The device types which simulate a larger range of systems, those combinations of systems called for on Table 8 should be listed, along with the frequency with which the combination is called for on Table 8. Each unique set of systems is given a configuration number and treated as a separate device.

A Training Device Configuration Worksheet like that in Table 10 is filled out for each entry in Table 9. This worksheet will serve as a gathering point for data on specific device configurations as they evolve. All available data is recorded on the worksheet. At this point, systems required should be noted in the appropriate space.

3.22 Step 22: Determine Instructional Strategies to be Used in Each Training Device and the Potential Instructional Features for Each Training Device

The same training device may be used in several different ways instructionally. Some plans for device use entail a high degree of instructor involvement and interaction with the student. Others require the student to work alone. Still others require presentation of mediated instruction by the device. Moreover, it may be desirable for the device to demonstrate a procedure to the student, recall a student performance and display it, or stop execution of a task and reset to beginning conditions.

TRAINING DEVICE CONFIGURATION RECORD

Device Type _____

Config. No.	Freq.	System Required

Table 9--Training device configuration record.

TD NAME _____

Performance Measurement Features	Instructional Features	REQUIRED SYSTEMS
Cost data		

Table 10 – Training Device Configuration Worksheet

Since devices are normally used in the context of a training session, the pattern of a device session should be planned at this time at a general level if that did not already occur during Step 20. The profile of this generic device session will recommend particular instructional characteristics for each device which should be listed at this time. Desired features may include some of the following: special provision for student-instructor communication, special instructor displays showing student control displays or student performance summaries, special positioning of the instructor, instructional feature control access for students and instructor (for control of pace, exercise termination, etc.), special provision for problem set up, special provision for briefing and debriefing capabilities, or provided instructor working space.

Table 11 may be used as a worksheet to generate this information. Session type and session activities sequence is recorded for each device type. Space is provided to record the instructional features which correspond to each part of the sequence. Once desired instructional features have been selected, they should be entered onto the appropriate Training Device Configuration Worksheet generated in Step 21 (Table 10).

3.23 Step 23: Determine Performance Measurement to be Executed in Training Devices and the Potential Performance Measurement Features for Each Training Device

Performance measurement may be instructor-administered or machine-administered. It may measure tolerances, specific values, steps in a procedure, or logical conditions. For each training task a standard will have been written prior to this step which states the performance level expected of the student. This standard will suggest what must be measured during performance measurement. During this step for each task a decision is made as to the evaluation agent (instructor/student/training device) and the variables to be monitored during evaluation (tolerance bands, times in tolerance, trends, paths, etc.). This information is recorded on the appropriate Training Device Configuration Worksheet from Step 20 (Table 10).

At the same time as measurement agents and variables are specified, the form of the desired measurement output must be specified to the extent it is known. That output may consist of printouts or readouts of various kinds and at various levels of sophistication. Preferences on output are also entered in the device worksheets.

3.24 Step 24: Estimate the Cost of Each Configuration for Each Training Device

There are several sources that may be contacted for making cost estimations of the various device configurations. They are

TABLE FOR RECORDING INSTRUCTIONAL STRATEGIES
AND FEATURES FOR EACH TRAINING DEVICE

Device Type	Session Type	Session Sequence	Required Device Instructional Feature

Table 11--Table for recording instructional strategies and features for each training device.

(a) other training systems which have recently acquired similar equipment, (b) training device contractors, or (c) training device procurement agencies within the military. These estimates are registered for each device on the appropriate Training Device Configuration Worksheet (Table 10). Estimates should take into consideration the cost of desired instructional and performance measurement features for each training device and represent cost breakdowns where possible.

3.25 Step 25: Determining Time Requirements for Each Configuration of Each Training Device

The total amount of time required for each training device must be determined. This time will be found by adding up the time requirements for each task assigned to one device. The following data must be collected for each task and entered in the appropriate columns in Table 8:

Time to perform--this figure represents the amount of time that it takes to perform the task once through. Since training devices are used for new students and proficient students and pilots both, the time is determined by taking the amount of time estimated for the student's first performance of the task, adding that to the time estimated for a competent performer to execute the task, and then dividing by two. This gives a rough initial estimate of the average amount of time required to perform the task using the equipment.

Time to set up--this figure represents the amount of time required to set up the training device prior to each task execution.

Number of grouped executions--When a task is performed during training, it most likely will not be performed once only. This figure is an estimate of the number of times that the task will be repeated when it is being practiced, averaged over the training span for that task. The training span begins with first practice of the task and ends with evaluation and certification of a task in a given training device.

Number of practice sessions--This figure estimates the number of times massed practices should be repeated--that is, the number of different training sessions in which the student will perform the task prior to the end of the training span.

Number of evaluations--Evaluation and certification of task performance adequacy in a given training device ends the training span for the task in a given device. This figure gives the number of evaluation trails required before a given task may be assumed mastered. The figure will

increase for more difficult, more complex, or more critical tasks.

Number of review practices student per year--This figure states the number of review practices required by each student and course graduate using a given training device per year.

All of the figures called for are difficult to produce. Estimates may be based upon subject matter exterts' best knowledge and experience, and should represent the amount of practice required to bring a student to the desired standard of behavior (as stated in the course mastery model, see project report no. 23, "F-16 Instructional Sequencing Plan Report.")

More sophisticated ways of determining time to perform can be implemented once training equipment is in use. Data may be gathered from pilots actually executing a timed performance of each task and then fed back to the media selection process. Steps 30 and 31 in this media selection sequence are designed to provide a feedback loop to the media selection process. As real data begins to be gathered on actual times to train, estimates made initially for media selection can give way to more accurate figures, benefitting not only F-16 media selections but future aircrew training selections as well. For obtaining the initial figures, however, the estimating method appears to be the most practical one.

The total time required for each training device is found by adding the total training times for tasks assigned to each and multiplying by the yearly flow of students. Task training times are found by multiplying and adding times to perform and repetition together appropriately. The result of this step will be a total amount of time required for use for each training device listed in Step 20.

3.26 Step 26: Consolidate Configurations Using Time Factors

A consolidation is made at this time to eliminate unnecessary devices and economically unjustifiable ones by combining them where possible.

The total time demanded for one training device is determined by adding the total times for tasks assigned to the device. Since the time obtained in this addition represents the training time on the device required for one student, each total must be multiplied by the anticipated annual student throughput. The resultant figure indicates the number of minutes per year the device will be required to supply strictly for training.

To determine whether or not that amount of time is sufficient to warrant a training device follow this procedure:

1. Take the total operating day time for the device and subtact maintenance time, down time, and time expected to be allocated for other training courses and multiply this by the number of training days per year to obtain the total available time for training with the device.

2. Divide the total required time for the device by the total available time, calculated in no. 1. This number indicates the number of training devices required for each configuration.

If the above calculated number is within a given range (.85 and 1.00 for F-16) the configuration should stand alone. If the calculated number is less than the lower range value tasks from the configuration can be combined with another configuration in which the required systems are available or can be made available most easily. This consolidation of training devices should continue until all devices remaining are rated within the desirable range. Ca e should be taken to see that as devices are consolidated that important performance measurement and instructional features are also consolidated, and time required for consolidated devices should be calculated and subjected to a test of ratios to insure that they fall within the justification range. Also, as consolidations are made, the costs of the consolidated device must be estimated.

The effects of the setting of the range should be noted. For a high, immediate student surge capability in the instructional system the range should be kept low for more complex, more difficult, and expensive to obtain training devices. If training devices are fully scheduled or over-scheduled there is little room for expansion of the student number without decrementing training. A balance must be set between having some training device time available in reserve for use for a surge and allowing training devices to go unused.

3.27 Step 27: Determine Cost for Total Training Device Plan

The necessary information to complete this step has been determined in previous steps. The cost per device configuration was estimated in Step 24 and entered on the Training Device Configuration Worksheet (Figure 9). The number of confiugrations needed was determined in Step 26, and revised cost figures were generated.

To determine the cost for the total training device plan, the costs of the training devices left in consideration should be multiplied by the number of devices required and the total cost for all devices added up.

3.28 Step 28: Adjust Assignments for Best Total Training Device Plan Cost

Adjustments should be made at this point to increase the practicality of the training device plan. Since cost is usually the main constraining factor in training device designs, it may be used as a filter of the practicality of the plan. Adjustments to the total plan, however, should be accompanied by corresponding shifts in training events to acceptable training alternate media or corresponding reductions in expected performance from course graduates. It should not be assumed that simply reducing training devices is making the training more efficient, since efficiency cannot be guaranteed unless effectiveness is first obtained.

3.29 Step 29: Write Training Device Specifications

Once a satisfactory assignment of tasks to training device configurations has been reached and a desirable group of devices is selected, it is necessary to prepare a more detailed specification of the required capabilities of each training device. The instructional presentation capabilities and the hardware/software capabilities should be specified in detail. These descriptions should be complete so that they can serve as input to the engineering personnel responsible for development of the trainer functional specifications.

3.30 Step 30: Collect Time to Proficiency and Level of Use Data on Training Devices

Once the training devices have been implemented, it is necessary to collect information pertinent to the accuracy of original estimates.

1. The original time estimates must be validated. This task can be carried out as part of the evaluation activity of the instructional system. The actual time to perform tasks can be averaged across a class of students to use in comparison with the original estimates.

2. Data should be collected on the level of use of each training device.

3. Valuable time and cost information can be gained by experimenting with trade-offs to see if tasks can be learned with fewer trials on varying training device combinations. Studies should indicate effective configurations, instructional strategies, performance measurement features, etc.

3.31 Step 31: Adjust Training Device Selection Data Base

The data gathered in the previous step is fed back into the media selection process. This information is used to correct the present media selection process as much as possible and guide any needed task reallocations between devices. It is also added to a data pool for future media selection device type and amount levels. Over time, as the data base builds, it can provide instructional developers of other weapon systems a valuable pool of information out of which syllabus parameters may be derived.

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ATTACHMENT I

F-16 ACADEMIC OBJECTIVE CATEGORIES AND
INSTRUCTIONAL STRATEGIES

ATTACHMENT I

F-16 ACADEMIC OBJECTIVE CATEGORIES AND INSTRUCTIONAL STRATEGIES

I-1.0 INTRODUCTION

This section enumerates the academic objective types used during objectives hierarchy analysis for the F-16 project. There were nine classes of objectives used:

Remember/Procedure (verbatim)
Remember/Procedure (paraphrase)
Remember/Fact (symbol/name)
Remember/Fact (name/function/location)
Remember/Fact (limits/tolerances/critical values)
Remember/Fact (organized lists)
Remember/Fact (sequences)
Use/Concept
Use/Rule

To place these classes in perspective, they are related in Figure I-1 to a simplified category system for academic objectives. In this system there are two levels of objective: (1) those which require exercise of some form of memory recall, labelled "remember" objectives and (2) those which require application of some variety of intellectual or procedural skill, labelled "use" objectives. These two levels are crossed with four varieties of instructional content: fact, concept, rule, and procedure. This cross produces the eight general types of academic instructional objectives to which the F-16 objectives types relate directly as shown.

For the development of F-16 instruction, each objective type corresponds to an instructional strategy. For each strategy the following are specified: (1) a set of instructional display types to be made available to the student in instruction and (2) a prescription for the manner in which these displays should be presented to the student, including prescriptions for learner versus system control, pace and timing, and other options available to either the student or the instructional device. The instructional strategy for each of the objective types is described below.

I-1.1 REMEMBER/PROCEDURE (VERBATIM) OBJECTIVES

I-1.1.1 Objective Form

Remember/Procedure (verbatim) objectives are those which are worded: "State the procedure for _____." Objectives of

VARIETIES OF INSTRUCTIONAL CONTENT

LEVELS OF BEHAVIOR	FACT	CONCEPT	RULE	PROCEDURE
USE	USE/FACT OBJECTIVES No F-16 Varieties (See Section I.1)	USE/CONCEPT OBJECTIVES One F-16 Variety -Use/Concept	USE/RULE OBJECTIVES: One F-16 Variety -Use/Rule	USE/PROCEDURE OBJECTIVES: These objectives are found in the "training device" group of objectives as described in section 3.1 of the main body of this report.
REMEMBER	REMEMBER/ FACT OBJECTIVES Five F-16 Varieties --symbol/name --name/function/ location --limits/tolerances/ critical values --organized lists --sequences	REMEMBER/ CONCEPT OBJECTIVES no F-16 varieties instruction for these objectives is included in use/concept objective instruction.	REMEMBER/ RULE OBJECTIVES No F-16 varieties instruction for these objectives is included in use/rule objective instruction	REMEMBER/ PROCEDURE OBJECTIVES Two F-16 Varieties: --verbatim --paraphrase

FIGURE I-1.

A SIMPLIFIED CATEGORY SYSTEM FOR CLASSIFICATION OF INSTRUCTIONAL OBJECTIVES SHOWING OBJECTIVES TYPES USED FOR F-16.

this type are written for those procedures which the student must know verbatim and from memory.

I-1.1.2 F-16 Example

Examples of F-16 objectives which will fall into this category are "know cold" emergency procedures: "know cold" checklists; and complex, high memory load procedures which must be committed to memory before performance is attempted.

I-1.1.3 Strategy Components

Components which will be used for constructing strategies for this type of objective will be:

Generality--the information to be memorized.

Mnemonic (generality help)--a specific verbal or pictorial device designed as an aid to memory.

Demonstration--a recorded or live execution of the procedure step-by-step, complete with initiation cues, processes, and termination cues defined for each step.

Drill and practice--an exercise requiring students to respond to a particular memory stimulus before a timeout procedure disqualifies answering. Such procedures can be conducted by the student in a self-monitoring mode, by instructors, by other students, or by a device which has a timeout capability.

I-1.1.4 Control and Pace Considerations

Control and pace considerations required for the administration of this strategy are centered in the requirement for a timeout procedure to be exercised as the student uses the drill and practice. In considering which of the various options should be used to administer the drill and practice (self, instructor, other students) allowance should be made for those options which are less expensive (self, other student) and those which are most likely to recieve high student acceptance (self, instructor, media device).

I-1.1.5 Display Considerations

For the generality and the mnemonic there must be the capability to present verbal and pictorial information of an uncomplicated type if the material to be memorized is primarily verbal in nature. The realism and technical detail of these displays is important only in cases where the generality contains a complex graphic representation to be committed to memory. During drill and practice the same display considerations hold.

I-1.1.6 Response, Scoring, and Feedback Considerations

The response considerations for this strategy require that some monitoring or recording capability must be available to the student. It must be capable of accepting binary (yes/no) or verbal responses, grading them, and providing feedback on their correctness within a matter of seconds.

I-1.2 REMEMBER/PROCEDURE (PARAPHRASE) OBJECTIVES

I-1.2.1 Objective Form

Remember/Procedure (paraphrase) objectives will be worded: "State the procedure for_____", or "Given a list of steps, some of which are steps in the _____procedure, select those steps which are in the _____procedure and arrange them in the proper order", or "Given a statement of the steps in the _____ procedure, determine whether all steps are present and all expressed critical values accurate." This type of objective differs from Remember Procedure (Verbatim) in that some "understanding" on the part of the student is expected in paraphrase recall, whereas rote memorization is all that is required for verbatim recall. Although the student may "understand" rotely memorized procedures, that is of secondary importance to the student's ability to recall the procedure without hesitation and exactly.

I-1.2.2 F-16 Example

Examples of F-16 objectives which fall into this category include most of the procedures which will be taught, including takeoffs and landings, refueling procedures, approach and navigation procedures, and most checklists and emergency procedures, specifically those which are not "know cold". These objectives constitute a large portion of the F-16 objectives.

I-1.2.3 Strategy Components

The components of strategy which will be used for this type of objective are:

Generality--a verbal statement of the steps in the procedure.

Demonstration--a recorded or live execution of the procedure step-by-step, complete with initiation cues, processes, and termination cues defined for each step.

Cause/effect (Generality Help)--a display showing within-system responses to manipulations during a procedure. This is to be used where appropriate as a mnemonic for procedure recall.

Practice help--assistance to the student in determining misconceptions or mis-information causing incorrect practice

I-1.2.4 Control and Pace Considerations

Control for this strategy may be entirely in charge of the student since there is no requirement for pacing or for a timed-response input.

I-1.2.5 Display Considerations

Display considerations for the generality require the presentation of verbal information either auditorily or in print. Demonstrations for some procedures will require no more than a step-by-step graphic illustration, particularly where the procedure is made up of relatively common or already well-mastered student behaviors. In some cases the demonstration will require highly detailed still-illustrated or motion-illustrated presentations of procedures being performed. Live demonstrations may be appropriate here, but care should be taken of the difference in information processing loads placed upon the student by live demonstrations not placed upon him by recorded demonstrations. Note should also be made of the fact that most demonstrations performed live are difficult or expensive to playback or repeat due to operational factors. Procedures especially requiring more extensive demonstrations will be those involving behaviors new to the student, critically-timed, or requiring difficult or tricky manipulations.

I-1.2.6 Response, Scoring, and Feedback Considerations

Response considerations for these objectives are less sophisticated than for verbatim recall objectives. Students have no need to make timed responses or to receive timed feedback from the instructional device. An answer key used by the student to correct his own responses is sufficient as a minimum. An instructor may be used for this function, entering into a dialogue with the student. Feedback can be provided as a part of an answer key or by an instructor.

I-1.3 REMEMBER/FACT (SYMBOL/NAME)

I-1.3.1 Objective Form

Remember/Fact (symbol/name) objectives are those which are worded: "Given to symbol (or signal) for _____, produce the name or meaning of the symbol," or "Given the name or meaning of a symbol (or signal), produce or identify the symbol."

I-1.3.2 F-16 Example

Examples of F-16 objectives of this type are those dealing with hand signals both from ground crew members and for use between members of a flight. Objectives on visual aircraft, ship, and ground installation or map symbol identification fall into this category. These objectives include also symbology used on HUD or radar displays and attached meanings.

I-1.3.3 Strategy Components

The components of stategy which will be used with this type of objective include:

Generality--a verbal and graphic statement of each symbol and its associated name or meaning.

Mnemonic (Generality Help)--a verbal or graphic memory aid where appropriate.

Drill and practice--a timed-response drill of the type described in Section I-1.1.3.

I-1.3.4 Control and Pace Considerations

The drill and practice required for this type of instruction is timed practice like that described in Section I-1.1.4 for Remember/Procedure (verbatim) strategies. The need for periodic review and practice which is common to verbatim memorizing must be taken into account when assessing the amount of instruction of this variety.

I-1.3.5 Display Considerations

Display considerations for this type of objective must take into account the fact that body motions are in some cases the subject matter. For some hand signals, for instance motion is required for displaying the signals, particularly those that are unusual and where the signal cannot be represented unambiguously in non-motion media.

I-1.3.6 Response, Scoring, and Feedback Considerations

Response considerations for instructional strategies involving drill and practice where the stimulus involves motion are much more demanding if mediated instructional means are used. The use of instructors seems to be a reasonable way to administer instruction such as this, given the provision that instruction must take place in group mode for it to be efficient, and students must take responsibility for their own drill and practice. Some media

devices are capable of administering this type of instruction and monitoring drill and practice also.

In drill and practice routines which are machine controlled, scoring considerations become important and some mechanism must be included in the medium for scoring student responses in a cumulative fashion. This is especially true for each item being memorized if a replacement-type strategy is used in which elements which have been memorized are dropped from the list and new items are added.

I-1.4 REMEMBER/FACT (NAME/FUNCTION/LOCATION)

I-1.4.1 Objective Form

Remember/Fact (name/function/location) objectives are those which are worded: "Given the name of an object (or system), state its function and location", or "Given the function of an object (or system) produce its name and location". That is, given any one of the three elements of information this student is required to supply the other two in some mode of responding.

I-1.4.2 F-16 Example

Examples of this type of instruction relative to the F-16 are found in objectives which pertain to the location of controls within the cockpit, inspection points on the aircraft, and the location and function aircraft subsystems such as the radar or HUD.

I-1.4.3 Strategy Components

The strategy components for this type of objective will include:

Generality--a verbal and graphic statement of the name, function and location data to be learned.

Practice--a set of verbal exercises accompanied by a set of graphic memory exercises. A variety of devices may be used to create these exercises such as those described in Section I-1.2.3.

Practice help--same as "practice help" under Section I-1.2.3.

I-1.4.4 Control and Considerations

Control and pace considerations for this type of instruction are the same as described in Section I-1.2.4, concerning Remember/

Procedure (paraphased) objectives. Time drills may be used which are controlled either by the student or by the instructional media device, but the nature of the desired recall behavior does not require recall under such conditions.

I-1.4.5 Display Considerations

Display considerations for this type of objective are simpler than for the (symbol/name) objectives described in Section I-1.3. Motion is not required and graphic illustration is normally sufficient.

I-1.4.6 Response, Scoring, and Feedback Considerations

Response considerations for this type of objective are the same as those for Remember/Procedure (paraphrase) objectives as described in Section I-1.2.6.

I-1.5 REMEMBER/FACT (LIMIT/TOLERANCE/CRITICAL VALUE)

I-1.5.1 Objective Form

The distinquishing feature of this type of objective is that it requires the student to learn an isolated fact normally appearing as a specific, individual value. During the planning of the F-16 mission there are several of these individual facts which must be known by the pilot and objectives must be written to ensure the students are aware of these values. Objectives of this sort are worded: "State the (value)."

I-1.5.2 F-16 Example

Examples of this objective type from the F-16 objectives would be those asking the student to state the maximum crosswind limits for takeoff in the F-16, the maximum roll speed, the minimum roll distance, the maximum wing loadings, and so forth. More-involved objectives of this type may require students to state weapon envelope parameters or aircraft operation envelopes.

I-1.5.3 Strategy Components

Objectives of this variety are critically important and can affect safety of flight and life. Instructionally, however, these individual objectives are often not substantial enough to stand alone as the major focus of an instructional presentation. For instructional purposes these objectives will probably be grouped together or else be combined with objectives of other types so that instruction and practice on these lesser objectives will take place

in the context of instruction and practice on the more inclusive objectives.

Because objectives of this variety will be piggybacked in this fashion, the strategy requirements for them will be simple, including:

Generality--a statement of the individual value to learned. For single values this is a simple sentence. For more involved sets of values, this may be a table or chart. For many of the more involved sets, the objective will be stated as a Remember/Procedure (paraphrase) objective and instructed as such.

Practice--exercises in the recall of the value(s) will be mixed in with exercises for the other objectives which are being instructed concurrently.

Practice help--See Section I-1.2.3.

When instruction on these objectives is embedded in other instruction appropriate emphasis must also be treated as an element of the strategy, both in the instruction and in the testing which follows instruction. This emphasis will constitute a major part of the instructional strategy and can be obtained either by visual effects or verbal instructions to attend.

I-1.5.4 Control and Pace Considerations

Control and pace considerations are not relevant to this objective, since instruction will take place in the context of another objective.

I-1.5.5 Display Considerations

Display considerations require only the ability to state simple verbal and sometimes tabular or simple graphic data.

I-1.5.6 Response, Scoring, and Feedback Considerations

Scoring considerations are governed by the controlling strategy within which instruction on the value objective takes place.

I-1.6 REMEMBER/FACT (ORGANIZED LISTS)

I-1.6.1 Objective Form

Objectives of this type are worded: "State the ____," where the object refers to a list of events, items, objects which are

in some fashion related to each other by some principle other than sequence. Though there may be sequence in some parts of the list, the sequence itself is not the organizing principle of the list. A second form in which this objective will appear could be called the interference form of the objective. It is used after several objectives of the type have been mastered and when it is desired that the information pertinent to all of them be practiced together. This form of the objective states: "Given the learned list of items, name the phenomenon which they indicate." This is very close to a use/concept behavior because the student is asked to name an object or event by its relevent characteristics. It is not exactly use/concept behavior, however, because the student is asked to respond from memorized information, rather than generalizing a response across a class of unencountered objects.

I-1.6.2 F-16 Examples

Examples from the F-16 objectives which are of this type include those which ask students to list the indications of a certain emergency, the varieties of search for enemy aircraft, or the main principles of energy management.

I-1.6.3 Strategy Components

Strategy components for this type of objective will include:

Generality--a statement of the elements of the list and the definition of each as appropriate.

Organizing Principle (Generality Help I)--a statement either verbally or graphically of the principle which relates the elements of the list together. This is provided as a mnemonic.

Mnemonic (Generality Help II)--a verbal or graphic memory aid artifically contrived for further use by the student as a memory aid during recall.

Discussion (Generality Help III)--additional information relative to each item on the list either (a) elaborating the definition of each, or (b) providing further memory-aiding information.

Practice--verbal or timed drill and practice exercises as described in previous sections. No priority is placed on the timed exercises, and they should be used only if a media device is available which can administer such exercises.

Practice help--See Section I-1.2.3.

I-1.6.4 Control and Pace Considerations

Control and pace considerations for this variety of objective are identical to those discussed earlier in Section I-1.1.4 and I-1.2.4, whichever applies, since either machine- or student-administered instruction and practice may be used.

I-1.6.5 Display Considerations

Display considerations for Remember/Fact (organized list) are restricted to verbal or simple visual presentations.

I-1.7 REMEMBER/FACT (SEQUENCE) OBJECTIVES

I-1.7.1 Objective Form

Objectives of this type are similar to Remember/Procedure (paraphrase) objectives in that the context being learned consists of steps in a sequence. The major difference between them is that Remember/Procedure (paraphrase) objectives, state a sequence to be remembered made up of steps the student will perform. For Remember/Fact (sequences) objectives the sequence is not one which will be performed by the student but one which the student is expected only to observe and recall. In such objectives the interrelation of cause and effect between steps is often an important feature of the sequence.

The wording of Remember/Fact (sequence) objectives is: "State the sequence of _____".

I-1.7.2 F-16 Examples

Examples of this type of objective from F-16 would be objectives requiring the student to know the operational sequence of any aircraft system or sub system, such as the radar.

I-1.7.3 Strategy Components

The strategy components for this type of objective will include:

Generality--a verbal statement, with appropriate graphic support, of the sequence to be learned.

Supporting Detail (Generality Help)--additional information on each step of the sequence emphasizing the cause and effect flow from one step of the sequence to the next and the interrelations between elements involved in each step of the sequence.

Practice--appropriate verbal exercises such as those described in Section I-1.2.3.

Practice Help--See Section I-1.2.3.

I-1.7.4 Control and Pace Considerations

See Section I-1.2.4.

I-1.7.5 Display Considerations

Motion is not required for displays for this variety of instruction, but it can be looked upon in many cases as a facilitating factor for student uptake of the information being presented. If motion is not possible, still graphic displays should suffice.

I-1.7.6 Response, Scoring, and Feedback Considerations

See Section I-1.2.6.

I-1.8 USE/CONCEPT

I-1.8.1 Objective Form

Use concept objectives are those objectives which have the form: "Given a previously encountered instance or noninstance of a class, state whether it is a member of the class," or, "Given a series of items previously unencountered as exempliers of any given class, identify each by the name of its class."

I-1.8.2 F-16 Examples

Examples of this type of objective for F-16 will not be the most numerous, but, in aircrew training applications they tend to be the more important objectives. Specific examples will deal with the interpretation of radar screens, and the classification of tactical situations by type of strategy planning purposes.

I-1.8.3 Strategy Components

Strategy components for this type of objective include:

Generality--a verbal definition of the class of things the student is learning to classify.

Elaboration (Generality Help I)--an extended description of each main attribute of the class definition. This ensures that non-comphrehension is not due to inadequate prerequisite terms and concepts.

Attribute Isolation (Generality Help II)--a walk-through of the classification of one example showing the application of the definition and identification of each attribute separately.

Example--the presentation of a member of the class, sometimes matched with non-members for emphasis.

Emphasis (Example Help)--an answer to the students' possible question "Why is this an example?" For each example this display will be created showing the relevant elements of each example that cause the example to be an example.

Practice--a drill in which the student is asked to identify examples and non-examples of the class on his own.

Practice Help--a display for each practice item showing why each practice item was or was not a member of the class.

I-1.8.4 Control and Pace Considerations

Control and pace for this type of instruction may reside with the student or with the instructional device. There is research evidence (see Walker, 1977, Chapter III) to show that students given free access to the strategy components and allowed to select from them in any order complete their instruction in less time and with better mastery of the material. A media device which allows this type of student control should also be able to administer device-controlled instruction. In the absence of a free control training device, instructional order can be built-in to instructional presentations.

I-1.8.5 Display Considerations

Display considerations for this type of objective include a requirement for graphic representation, occasionally high detail, and a heavy verbal component.

I-1.8.6 Response, Scoring, and Feedback Considerations

Response capability need only consist of a multiple choice selection mechanism for concept learning. Scoring or responses may be machine- or student-administered.

I-1.9 USE/RULE

I-1.9.1 Objective Form

Use/Rule objectives are worded: "Apply the rule," where a rule is a series of steps in a procedure executed on unencountered and changeable input.

I-1.9.2 F-16 Example

Examples of F-16 rules are computational rules, or general principles used to determine specific solutions, such as in a tactical problem.

I-1.9.3 Strategy Components

Strategy components used for Use/Rule instruction are essentially the same as those for Use/Concept instruction:

Generality--a statement of the rule.

Elaboration (Generality Help I)--a walk-through of the application of the rule to one problem.

Example--presentation of further worked examples using the rule.

Emphasis--a walk-through for each example of the individual steps in applying the rule.

Practice--problems to which the student may apply the rule.

Practice Help--a walk-through for each practice item of the correct application of the rule step-by-step.

I-1.9.4 Control and Pace Considerations

The considerations described in Section I-1.8.4 for Use/Concept instruction apply to Use/Rule instruction also.

I-1.9.5 Display Considerations

Considerations listed in Section I-1.8.5 for Use/Concept instruction apply here also with the additional requirement for occasional display of tabular material.

I-1.9.6 Response, Scoring, and Feedback Consideration

In addition to the capability described in Section 1-1.8.6, a capability to review and process alphanumeric responses from the student would be required should an automated device be used. Otherwise the student could check answers on a provided answer key.


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