LEVEL II

1

F-16 AIRCREW TRAINING DEVELOPMENT PROJECT

Contract No. F02604-79-C8875

OBJECTIVE HIERARCHY ANALYSIS METHODOLOGY REPORT

DEVELOPMENT REPORT No. 8

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by

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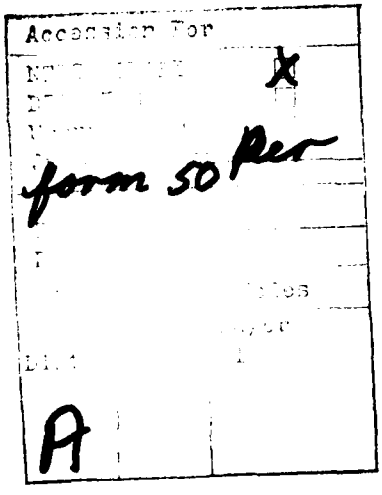
PREFACE

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 no. B013. Tne 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

Objective hierarchy analysis is the process of identifying the specific instructional performances students must achieve in order to master the behaviors indicated in a task listing. The objectives identified in the hierarchy analysis should include all of the categories of behavior required to prepare students for on-the-job performance. These categories include verbal behaviors, motor behaviors, and intellectual skills. The objective hierarchy analysis procedure used in the F-16 project included the following steps:

1. A task is selected.
2. Subtasks are listed.
3. Decision-making behaviors (classification and rule using) are identified.
4. Motor control behaviors are identified.
5. Verbal support (summarization) requirements are identified.
6. Minor tasks are grouped for instruction.
7. Dangerous and excessively expensive behaviors are scaled back.
8. Knowledge-base requirements are determined.
9. Remaining tasks are eliminated (pruning).
10. A new task is selected and processing begins again.

In order to facilitate the updating and revision of the objectives hierarchies, the maintenance responsibilities of various ISD personnel and the related support requirements are described.

CONTENTS

OBJECTIVE HIERARCHY ANALYSIS METHODOLOGY REPORT

1.0 INTRODUCTION

This report describes the objective hierarchy analysis methodology used during development of the F-16 objectives hierarchies and references the methodology recommended for its maintenance throughout the life of the F-16 instructional system. This report is related to other project reports which describe development methodology and especially to those reports related to task analysis and criterion-referenced objective writing and update. (See project reports no. 7, "Task Analysis Methodology Report", and no. 5, "Derivation, Formating and Use of Criterion-referenced Objectives (CROs) and Criterion-referenced Tests (CRTs).") These reports stress the importance of the instructional system manager's understanding the methods used in analysis and the importance of implementing them in a continual update process aimed at preserving both the currency of the analysis and the currency of the instructional materials based on the analysis.

This report is written in four sections describing the objectives hierarchy process used during system development and the maintenance procedure for the hierarchies. Section 2.0 of the report describes the purpose and characteristics of the objectives hierarchies and the relation of the analysis process to other instructional development processes. Section 3.0 describes in a step-by-step fashion the objective hierarchy analysis procedure used for generation of the F-16 pilot and instructor pilot hierarchies. Section 4.0 summarizes the need for continual update and maintenance of the hierarchies, refers to a generalized procedure for that published in another project document, and recommends maintenance organizational roles for accomplishing the task as well as stating required items of logistic support.

2.0 RATIONALE

This section describes the purpose of objectives hierarchy analysis, the desirable qualities of analysis, and the relation of objectives hierarchy analysis to other instructional development processes.

2.1 Purpose

Objectives hierarchy analysis is a process which begins with the product of task analysis (the task listing or inventory) to identify in a logical, consistent way the individual instructional goals students must reach as they progress toward mastery of behaviors contained in the task listing. The task listing behaviors used as the beginning point for analysis usually represent intermediate level course behavior goals, so the objectives identified during analysis represent a lowest-level set of instructional goals for the training scheme. The objectives identified through analysis should include all of the varieties of behavior required to prepare students for performance, including verbal behaviors, motor behaviors, and intellectual skills required for performance.

Objectives hierarchy analysis is closely related to task analysis but possesses important similarities and differences. First, objectives hierarchies are similar to task analysis because both processes are performed for similar purposes. Both are designed to identify only that minimum of content and behavior required for training while excluding the unnecessary. As well, both are designed to exhaustively identify all those things which are necessary. Both processes consist of: (1) A set of guidelines and procedures for guiding the thought and decision-making processes of the developer and (2) a notation system for capturing the thought and decision produced using the guidelines on paper for later reference and examination. Neither is the substitute for thought, but rather a channel to guide it and a means of representing the resulting decisions.

Objectives hierarchy analysis is also related to task analysis in that both may be displayed in the same notational system, a hierarchy diagram. Since the objectives hierarchy analysis process begins with the task analysis process product and continues on, the resultant product of both processes might resemble the diagram in Figure 1. The diagram shows that not only do objectives appear appended to tasks at the lowest levels of the task analysis but appear within the body of the analysis as well.

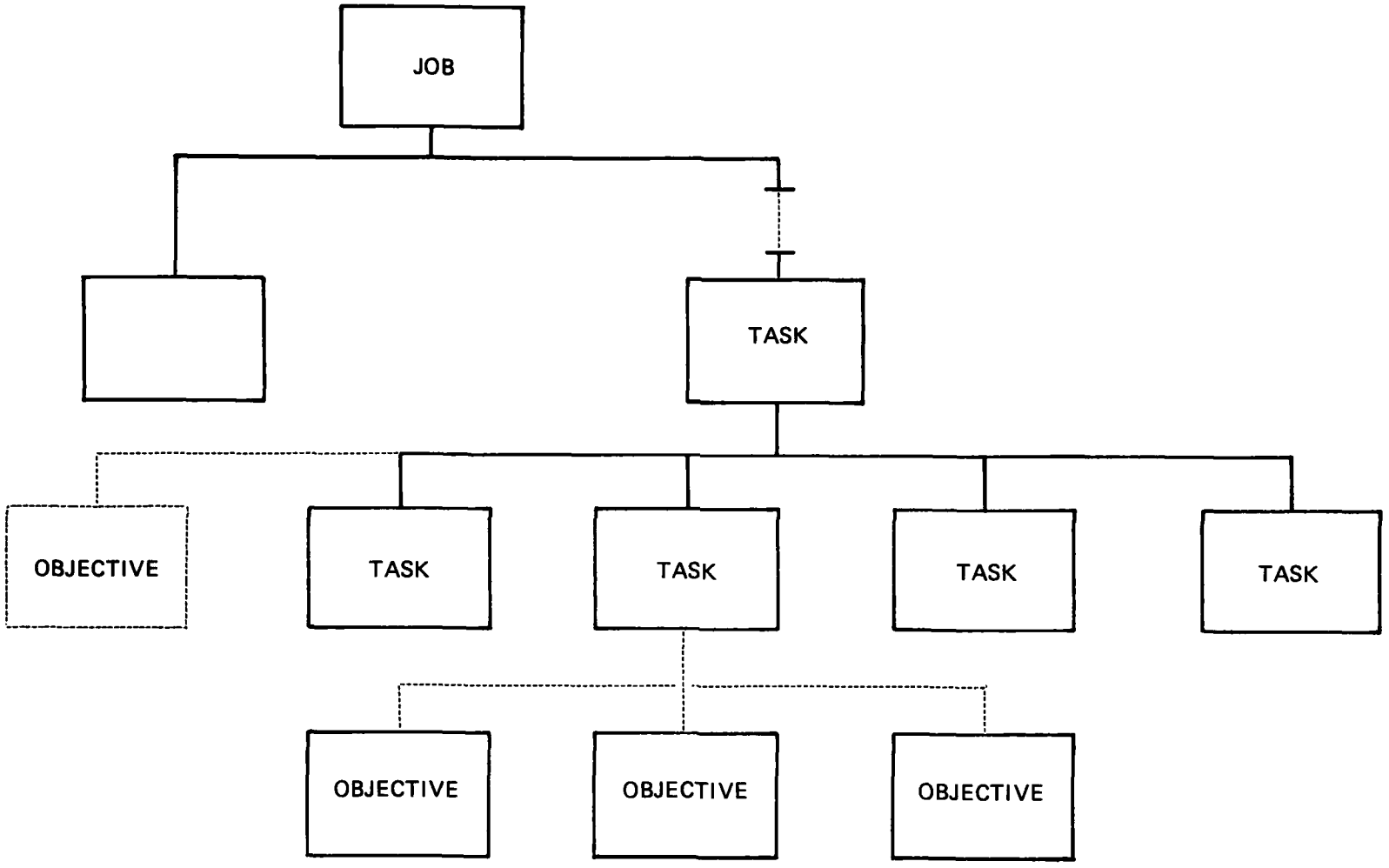

Figure 1 — A Graphic Representation of the Relationship Between Task Analysis and Objectives Hierarchy Analysis

Though the representation of the two analyses may be the same, the processes and logic of each are vastly different. Task analysis is a logical decomposition process of tasks into smaller tasks. This is achieved by identifying either the steps in sequence of the larger task or sub-varieties of the larger task. Objectives hierarchy analysis, in contrast, proceeds by a logic which takes the list of sub-tasks for a given task and asks questions relative to the specific training difficulty and strategy for each. Because of this difference in logical processes between the two analyses, many find task analysis to be quite easy while finding objectives hierarchy analysis to be difficult. The reason is most likely a familiarity with the logic of the first, which is simple, and a lack of familiarity with the logic of the second, which is also conceptually simple but not as common.

The present method is intended to assist the technologist by providing an explicit procedure. With a modicum of training and supervision using this method the nonscientist can participate effectively in analysis and produce a logically consistent product. A product serviceable to developer and student alike.

The process outlined in this report is closely related to a widely used method of analysis proposed by Gagne (1968) and has the same end in mind. In Gagne's method, tasks from the task listing are analyzed through recursive asking of the question, "What must a person be able to know and do to be able to perform this task?". That procedure has been much used and misused, perhaps because of its lack of procedural specificity and its reliance on the bias and insight of the analyst. What the analyst feels the student "must know" encourages the injection of subjectivity into the process. A high dependence upon creative insight may be highly desirable for the scientist seeking new techniques, new theoretical systems, and new styles of analysis or to the expert and experienced analyst, but it is not satisfactory for the technologist who, with less training, is required to apply the process with some uniformity in the outcome. As a consequence of the lack of procedural guidance for this group, analysis products tend to be highly variable, and dependable analyses must be carried out in the main by highly trained persons.

2.2 Relation of Objectives Hierarchy Analysis to other Instructional Development Processes

Because objectives hierarchies are derived from the task analysis product and share its important function of defining the foundation of a training system, they rank in importance almost equally. The desirability of an adequate and accurate task analysis is emphasized in light of this dependent relationship. The diagram in Figure 2 (which also appears in project report no. 7, "Task Analysis Methodology Report") shows the relationship between objectives hierarchy analysis products and other instructional elements of a training system.

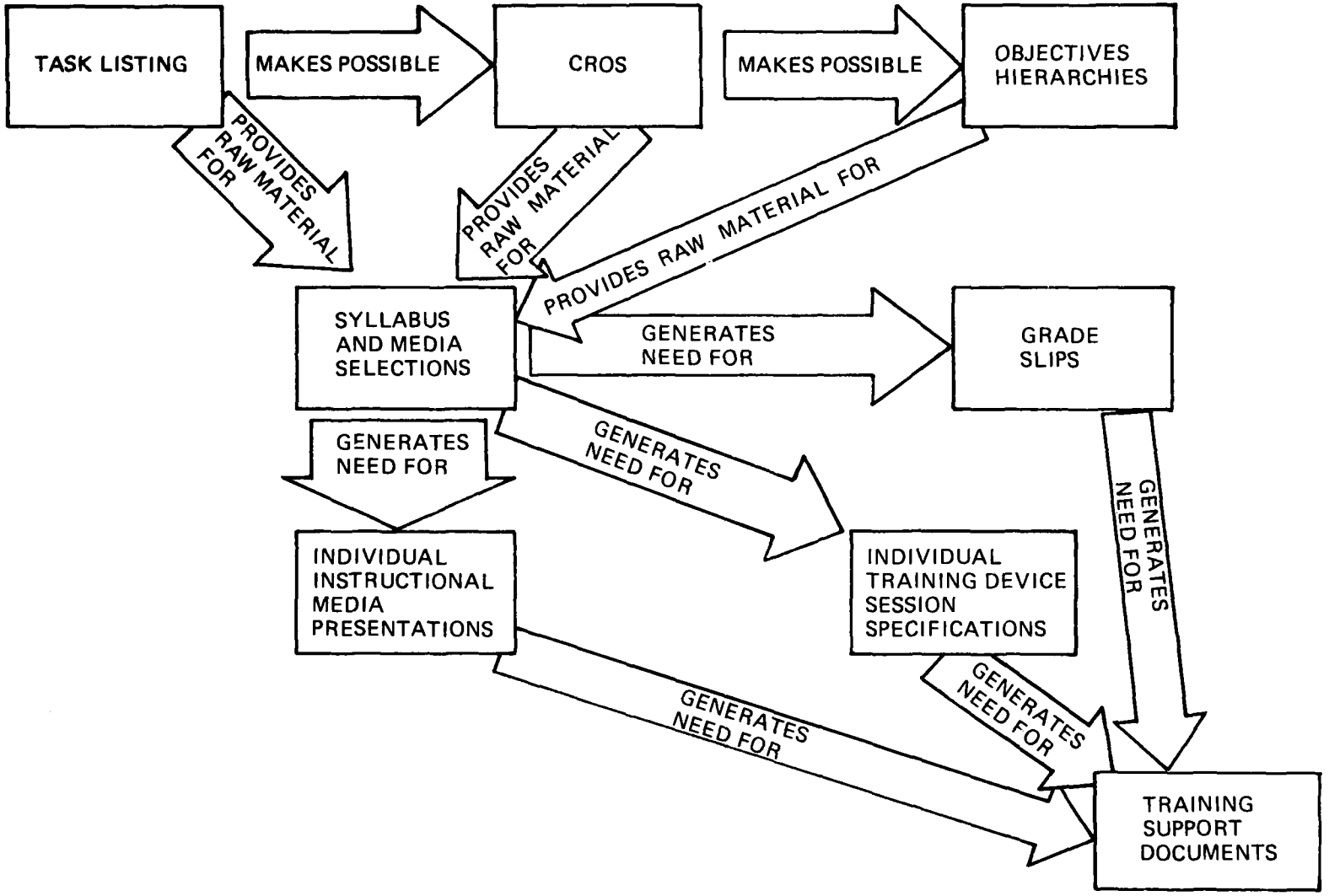

Figure 2 — Relations of Training Products to Objectives Hierarchies

From the diagram it should be apparent that a proportional share of the effects of analysis on instruction are caused by objectives hierarchy analysis. Mainly, its influence is felt in the syllabus, because all of the syllabus academic instructional events derive from the hierarchies.

3.0 OBJECTIVES HIERARCHY ANALYSIS PROCEDURES

This section presents a step-by-step description of the procedure for hierarchy analysis used for F-16.

3.1 Overview

The method described produces hierarchies of objectives beginning from stated performance tasks by extending the task listing of which the tasks are a part to a lower level of detail. These lower level tasks are then transformed into instructional objectives according to a set of transformation rules applied in an orderly sequence.

As stated earlier in this report, the beginning point of the analysis, a completed task listing (sometimes called "task inventory", "job task analysis", "job analysis", and various other names), provides the individual tasks for which objectives hierarchies can be created. The exact nature of the tasks suitable as input to the analysis is difficult to describe due to the somewhat vague definition of "task" and the difficulty encountered by analysts in naming the exact characteristics of tasks at any given level or sub-level.

The desirable point for terminating the task analysis depends upon the purpose of the analysis. For the purpose of developing objectives hierarchies, task analysis may be terminated as tasks are identified which constitute independent, unitary behavior sequences of job behavior for which precise standards of measurement may be specified and for which measurement of performance is likely to be made during training. (In the F-16 development procedures, tasks which have been assigned such standards for measurment purposes are called criterion-referenced objectives (CROs). See project report no. 5, "Derivation, Formating, and Use of Criterion-referenced Objective (CROs) and Criterion-referenced Tests (CRTs).") The highest levels of the task listing generally name behaviors so complex and broad that they cannot conveniently be measured, nor can precise measurement standards be formulated for them. On the other hand, at the lowest levels of a very detailed task listing the tasks found are often so minute that it would not be sensible to consider measuring them in a real-life training situation, even though very clear measurement standards are capable of being written. Selecting tasks at this measurable, intermediate level for the beginning point of analysis gives the benefit of defining the major performance measurement "gates" which will become an important part of the training course syllabus. Deriving objectives starting at these points relates the learning which must take place (stated in the objectives) directly to the desired terminal performance. This becomes a tremendous asset as the developer defines the instructional sequence in the syllabus.

3.2 Procedures

Transformation of the task listing into an objectives hierarchy tak s place through (1) extension of the task listing one additionl level, (2) scanning of these extended tasks for particular types of tasks, and (3) converting particular types of tasks into instructional objectives and adding other objectives to supplement the identified tasks or in some cases new but related tasks.

3.2.1 Step 1: A Task Is Selected

A task is selected for analysis to begin with. If appropriate measurement standards have not been written previously, they are written at this time. In their absence, particular constraints upon behavior such as timing or the need for overlearning which may affect an instructional objective, its condition, or standard, may not be apparent. It is suggested that larger more complex tasks be selected early in analysis to avoid later duplications of effort. Eventually all tasks, even tasks at the highest levels of the task listing must be analyzed.

3.2.2 Step 2: Subtasks Are Listed

The task listing for the selected task is continued to one further level. This further list of tasks provides the substance for the analysis. The procedure for task listing is described in project report no. 7, "Task Analysis Methodology Report".

3.2.3 Step 3: Decision-making (Classification and Rule-using) Behaviors Are Identified

Within the newly extended list of tasks there are possibly decision-making behaviors which are complex enough to require isolated instruction. The list is scanned for these, and objectives are written for them. The decision-making behavior may concern when or how to use a rule, which of several rules or procedures to use, or difficult discriminations or classifications which the student must learn to make. Very cften instruction focuses inadequately on this variety of behavior, leaving the student capable of carrying out procedures but incapable of deciding when to use them or incapable of making certain decisions (discriminations being an important impact) which constitute a major step in procedural execution.

Most often decisions made during performance of a task require only simple instructions to the performer and do not require direct, isolated instruction and practice in making the decision. For these decisions no objective needs to be written. For complex decisions or classifications, however, an objective should be written, which will in turn give rise to the appropriate instructional presentation.

The extended task list itself should be critically examined at this time to ensure that less readily-visible decision-making behaviors have not been omitted through oversight. Very often complex decision-making behaviors accomplished as second nature by experienced persons are subtle and hard to detect during analysis.

3.2.4 Step 4: Motor Control Behaviors Are Identified

In the same way that the extended task list was scanned for complex decision-making behaviors, it is now scanned for complex motor control behaviors. Objectives of two types are written for these behaviors: (1) An objective calling for the performance of the behavior itself, in isolation from the other behaviors involved in task execution and (2) an objective of the type described in step 5 below intended to establish the information and memory base requisite for performance. The informational objective is prerequisite to the performance objective, and though some will argue that the two objectives are in fact only one objective, consideration of the instructional strategy, training device, and practice requirements implications of each objective will show that they are in fact independent instructional requirements, each of which should be accounted for by its own objective.

3.2.5 Step 5: Verbal Suppport (Summarization) Requirements Are Identified

Summarization objectives are those which insure that the student is acquainted at the verbal level with the sequence, parameters, and critical values associated with safe and adequate task performance. The behavior in a summarization objective may take any one of several forms requiring the student to recall, identify, order, or otherwise manipulate verbal information concerning task performance. For critical or dangerous tasks, exact recall should be required. For other tasks, less rigorous forms of behavior may suffice. Summarization objectives serve two purposes: (1) They provide the student the information and memory component which are prerequisite to task performance (i.e., the student cannot perform the task unless he is told what the task is and how to perform it) and (2) they ensure that tasks on the extended task listing become the subjects of instruction even though the tasks themselves are not complex or important enough to require isolated instruction by themselves. At a later point in the procedure these other tasks will be dropped as separate entities from the extended task list ("pruned"), but the summarization objective will keep them from being lost to instruction. As a rule a summarization objective should be added for each task being analyzed.

3.2.6 Step 6: Minor Tasks Are Grouped (Collocated) for Instruction

Collocation is the collection of tasks to one point which (1) are similar in intent and form and differ only in specific content and (2) are not substantial enough to stand alone in instruction but can be combined with other behaviors closely related in content to form a significant body of instruction. Many tasks in an extended task listing are at the level of "manipulate control X" or "locate control X". These tasks are not of sufficient scope to deserve separate instruction, but the location of a group of controls related to one functional system may be. Collocation gathers together tasks which are content-related in this fashion and groups them under an appropriately-worded objective.

3.2.7 Step 7: Dangerous and Excessively Expensive Behaviors Are Scaled Back

This step is necessitated by the fact that:

a. Some behaviors are too dangerous to execute with students during training.

b. Some behaviors are too expensive in time, resources, or personnel to execute or simulate for training purposes.

c. Some behaviors are too difficult to be executed by students at the experience level they will attain during the projected course of instruction.

During this step each task under analysis and each entry in the extended task listing are examined to see if any of these conditions apply. For those tasks which are too dangerous, expensive or complicated, an objective must be written. The objective should state, however, the acceptable behavioral level (performance or cognitive) students must attain to show that they have had sufficient experience with less dangerous, less expensive behaviors to be expected to perform adequately when the real behavior is required.

3.2.8 Step 8: Determine Knowledge-base Requirements

Knowledge-base determining is a process which is carried out for areas of the hierarchy in which specific procedures to be performed are not clearly defined or where skilled performers are likely to be required to perform procedures under unusual or nonstandard conditions. In situations where a set procedure is not prescribed, or in nonstandard conditions, students and skilled job performers are thrown onto their own judgement as to how to proceed in accomplishing tasks. In many cases unusual conditions will force a performer to modify procedures in a way

to make them suitable for use in the nonstandard situation. Instructional developers cannot anticipate these situations and instruct performance under all conditions. Instead, in such cases a substrata of information, concepts, and principles must be provided which the student can consult when determining how to modify standard procedures to meet unique conditions. Familiarity with this knowledge base by students is ensured by incorporating objectives appropriately in the hierarchy.

Knowledge-base determining can increase the likelihood of competent performance. It should also be realized that the addition of knowledge bases is an easily abused procedure. Its strength is in producing job holders who can act appropriately in nonstandard conditions. Its weakness is that it can easily add to a curriculum large volumes of instruction of questionable value. A tendency of the well-informed is to place too much value on their information and to appreciate it for its own sake. Since the aim of creating objectives hierarchies is to define the necessary-and-only instruction, the knowledges which are taught only for appreciation value must be eliminated.

Knowledge-base determining is, unfortunately, a somewhat intuitive process and must be carried out with much skepticism. For instance, it is commonly assumed by trainers that a knowledge base consisting of extensive machine mechanical descriptions is necessary for machine operators. The result of such reasoning is usually a lengthy course on machine function and engineering which teaches information for which the operator finds little or no subsequent use. Logically, it is reasonable that some knowledge of machine mechanics would help machine operators perform more adequately as operators, for instance in responding to emergencies. Knowledge-base determining should seek to establish those elements of information which are relevant to performance and those which are not and incorporate only those which enhance the student's performance capability into the hierarchy of objectives as appropriately stated verbal or higher-order knowledge-using objectives. Non-subjective principles for determining knowledge-bases have not been specified at this point, but a systematic procedure for doing it is possible and will require more extensive efforts than were possible during the F-16 project.

3.2.9 Step 9: Remaining Tasks Are Eliminated from Consideration (Pruning)

During pruning, tasks are dropped from consideration which do not require individual coverage in instruction as the subject of one instructional sequence. Along with identifying major, trainable behaviors, task listing generally identifies details of task performance which are not large enough bodies of behavior to require separate instruction. These are prevented from being lost by the previous activities of summarizing (step 5) and collocation (step 6). Pruning consists of a final examination of

the extended task listing to determine whether major behaviors (cognitive, psychomotor, or affective) which are of trainable scope have been overlooked and require objectives to be written. Any such objectives are added at this time.

Additionally, it may be observed at this time that other tasks listed in Step 2 are themselves complex or extensive enough to merit the task listing process. That need should be noted during pruning. The task in question should be turned into a performance objective (a new task in the task listing), and the analysis procedure should be applied to it in its turn.

3.2.10 Step 10: Cycle to a New Task

With analysis of the original task being complete, the process may cycle on to a new task until all tasks have undergone analysis. This must include, as was mentioned earlier, examination of higher-level tasks in the task listing which very often require decision-making or summarization objectives to be written.

3.3 Limitations

Some argument may be made with the analysis method described above. An attempt is made here to answer some anticipated objections.

3.3.1 Built-in Assumptions

The reader familiar with analysis will recognize several assumptions built into the method described. For example, the assumptions are made that instruction at the verbal level should precede instruction and practice at the performance level and that instructional objectives should be of sufficient substance and importance to merit independent, specifically designed instructional presentations. To the extent that the reader disagrees with those or any other assumptions, that disagreement will constitute a limitation of this method.

3.3.2 Proceduralization

It will occur to some that being so specific and deliberate about the act of analysis and suggesting that nonscientists may participate in analyses will produce a host of inadequate and shallow analyses. That is inevitably true, but it is true of any method of analysis. A host of inadequate and shallow analyses will result from the indiscriminate and thoughtless application of any analysis procedure (or nonprocedure) in any hands.

Analysis is a process of guided thinking, decisions-making, and representation of decisions in recorded form. A "method" of analysis can be no more than a guide to thinking, and never a substitute for thought. If only the high degree of proceduralization attending this method is relied upon to produce quality, bad analyses will result. On the other hand, if the procedural aspects of the analysis remind the analyst to consider worthwhile objectives which otherwise might have been omitted, then the procedure functions as a strengthening supplement to the analysis and is very desirable. It is the intention that this be the case.

4.0 OBJECTIVES HIERARCHY ANALYSIS UPDATE

This section repeats briefly a position already stated in project report no. 7, "Task Analysis Methodology Report." That position places emphasis on the importance of maintaining all of the foundation documents of the F-16 instructional system in a continuously updated condition so that the system may be kept current and efficient.

4.1 Procedure for Objectives Hierarchy Update

A procedure for regular objectives hierarchy update is contained in project report no. 10, "Data Base Update Procedures."

4.2 Organizational Responsibilities for Objectives Hierarchy Maintenance

Organizational responsibilities for maintenance of the objectives hierarchies are nearly identical to those for task listing maintenance. (See Table 1.) Personnel responsible for task listing maintenance are also responsible for objectives hierarchies maintenance. Remarks pertaining to the need for training of responsible personnel apply to objectives hierarchies as well as task listings.

4.3 Support Requirements for Objectives Hierarchy Maintenance

Those requirements listed in project report no. 7 as requsites for task listing maintenance are also requisites for objectives hierarchy maintenance.

TABLE 1--Organizational roles for F-16 objectives hierarchy (OH).

Organization/Person	Responsibility
OTDT/OH Specialist (same person as TL specialist)	1. Identify changes to TL or data from evaulation influencing need for update.
	2. Execute OH changes as required by incoming information.
	3. Conduct content and technique validation of the OH with extra-OTDT instructional development specialists.
	4. Obtain agreement of OTDT and other controlling agencies on OH changes.
	5. Oversee insertion of changes into OH data base.
	6. Produce new OH versions and disseminate to appropriate persons.
OTDT/Leader	1. Coordinate and arrange extra-OTDT OH assistance contacts, such as experts for validation and information-producing organizations.
	2. Ensure use of standard OH modification procedures.
	3. Train new OTDT OH specialists or obtain training for them.
	4. Approve OH changes at OTDT level.
TAC HQ/DOOS	1. Supply OTDT with current information regarding concept of aircraft employment and desired training emphasis.

Table 1--(cont.)

Organization/Person	Responsibility
	2. Supply command emphasis necessary to establish and keep open direct information channels.
4444th OS (Luke)	1. Periodically conduct review of F-16 TL to insure updated OH condition and observance of standard OH modification procedures.
	2. Supervise dissemination of updated OH documents.

Reference

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