Technical Report: NAVTRAEQUIPCEN 77-C-0005-1

ANALYSIS OF REQUIREMENTS AND METHODOLOGY FOR DECISION TRAINING IN OPERATIONAL SYSTEMS

Joseph Saleh, Antonio Leal, Luigi Lucaccini,
Peter Gardiner, Rosemarie Hopf-Weichel
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, California 91367

FINAL REPORT JANUARY 1977 - FEBRUARY 1978

February 1978

DoD Distribution Statement

Approved for public release;
distribution unlimited.

NAVAL TRAINING EQUIPMENT CENTER
ORLANDO, FLORIDA 32813

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER
NAVTRAEQUIPCEN 77-C-0005-1

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE *(and Subtitle)*
Analysis of Requirements and Methodology for Decision Training in Operational Systems

5. TYPE OF REPORT & PERIOD COVERED
January 1977 - February 1978

6. PERFORMING ORG. REPORT NUMBER
PFTR-1044-78-2

7. AUTHOR*(s)*
Joseph Saleh, Antonio Leal, Luigi Lucaccini, Peter Gardiner, Rosemarie Hopf-Weichel

8. CONTRACT OR GRANT NUMBER*(s)*
NAVTRAEQUIPCEN 77-C-0005

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91367

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
6754-2P1

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Training Equipment Center
Code N-71
Orlando, Florida 32813

12. REPORT DATE
February 1978

13. NUMBER OF PAGES
207

14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*

15. SECURITY CLASS. *(of this report)*
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

A classified supplement on tactical operation

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Decision Training Methodology
LAMPS ASW System
Decision Task Identification
Instructional System Development (ISD)
Multi-attribute Utility Analysis
Protocol Analysis
Decision Training Behavioral Objectives
Instructional Guidelines Generation Sys
Decision Task Classification
Cognitive Level Weighting

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

To an ever-increasing extent, the operators of advanced military systems, such as aircraft, ships, weapons, C3, etc., act primarily as decision makers. Such job characteristics demand inclusion of decision training into the conventional military training programs. Within the past several years, the general rules of effective decision making have been consolidated into the technical area termed "decision analysis." During the same period, the systems approach to training has established a generalized methodology for dealing with diverse content areas in the design of training courses. This report describes the results of a one-year research and development program aimed at bringing these two areas together in order to define the decision training objectives of typical military systems and to specify ways of meeting them in terms of a set of guidelines for generation of instructional materials for decision training systems.

The program is divided into four phases: (1) Job Analysis Phase, (2) Decision Task Analysis Phase, (3) Development and Evaluation Phase, and (4) Documentation Phase. In the first phase, the SH-2F Light Airborne Multi-Purpose System (LAMPS) helicopter training system was analyzed. Based on this analysis, the decision situations that occur during emergency and tactical system operations were identified, and a number of decision tasks required to resolve a selected set of decision situations were chosen. These decision tasks were the input to the second phase where they were analyzed to identify the required facts, the underlying concepts, the decision rules, and the step-by-step procedure that determine the optimal choice of alternatives. Based on the results of this analysis, instructional guidelines were produced in the third phase. An evaluation plan was developed and decision aid systems, to enhance the effect of the decision training program, were suggested.

During the one-year program a system to generate instructional guidelines for a task-specific decision training program, in any training environment, was developed. The system selects the most effective instructional method and media and provides required instructional contents for any specific decision task, subject to training in a specific training environment. The project has been aimed not only to develop a systematic procedure for providing instructional guidelines for decision tasks encountered in LAMPS Anti-Submarine Warfare (ASW) operation, but also to design a task-independent methodology in order to make application of the system in other task domains subject to minimal modification effort. Such a methodology allows incorporation of general purpose decision training components into task specific decision training programs. This incorporation provides trainees with the basic skills required for making task-specific decisions within a new domain, in case of their transfer to other domains. Furthermore, since the characteristics of decision tasks within any specific domain are subject to change with time, the methodology will allow development of more effective training programs even in the case where there is no possibility of transferring the trainees to other task domains.

The program concentrated on two major areas in the Navy LAMPS (ASW) Operation: emergency operations and tactical operations. The methodology for both areas as well as the specific activities for the emergency operations are included in this report. The results of the specific activities for the tactical operations are described in a separate classified supplement.

SUMMARY

This report presents the results of a one-year research and development program in the area of decision training. The project covers two areas of the Navy SF-2F Light Airborne Multi-Purpose System (LAMPS) Anti-Submarine Warfare (ASW) operation: emergency and tactical operations. This report describes the unclassified results of the project. Other materials have been presented in a separate, classified report.

This report is organized into five chapters. The first chapter is an introduction which includes an overview of the project, background, and technical approach. Chapters 2, 3, and 4 correspond to the first three phases of the program. The results of the job analysis phase is in Chapter 2. In this phase, the tasks involved in the Navy SH-2F (LAMPS) helicopter training system were analyzed, decision tasks were identified, and a number of the identified tasks were selected for further analysis. Chapter 3 describes the second phase of the project: decision task analysis. The selection decision tasks were analyzed to identify the required facts, the underlying concepts, the decision rules, and the step-by-step procedures that determine the optimal choice of alternatives. Based on the results of this analysis, a system for instructional guideline generation was developed. The instructional guideline generation system is presented in Chapter 4. The system provides a procedure to generate essential information to be incorporated in the production of instructional materials for any decision task subject to training in any specific instructional environment. Each of the chapters 2 through 4 starts with a presentation of the general approach and activities associated with the corresponding phase. The following sections cover the methodology designed and utilized in the corresponding phase of the project. Technical details and the results of the phase appears in the remaining sections. The last chapter of the report presents the conclusions of the project. The dimensions for improvement of the system developed during the project are identified and a computerized instructional guideline generated aid, as a means to achieve improvements in all of these dimensions, is briefly described. Also included are suggestions for decision aids based on the results of the analyses, an evaluation plan for the instructional materials developed for decision tasks, and the results of the instructional guideline generation system. The primary results of the analysis and decision trees appear in the appendices.

During the one year project period, a system to generate instructional guidelines for a task-specific decision training program, in any training environment, was developed. The system selects the most effective instructional method and media and provides required instructional contents for any specific decision task, subject to training in a specific training environment. The project has been aimed not only to develop a systematic procedure for providing instructional guidelines for decision tasks encountered in LAMPS ASW operation, but also to design a task-independent methodology in order to make application of the system in other task domains subject to minimal modification effort. Such a methodology allows incorporation of general purpose decision training components into task specific decision training programs. This incorporation provides trainees with the basic skills required for making task-specific decisions within a new domain, in case of their transfer to other task domains. Furthermore, since the characteristics of decision tasks within any specific domain are

subject to change with time, the methodology will allow development of more effective training programs even in the case where there is no possibility of transferring the trainees to other task domains. Finally, the methodology will provide for carry over of the decision making capability into incidential functions, which are usually left untrained.

PREFACE

Decision task training is currently not receiving required emphasis in formal training environments, most probably due to a lack of appropriate training technology. The training of decision tasks still takes place on the job, a costly process in terms of dollars and time.

The work summarized in this technical report represents an attempt to meld decision theoretic concepts with operational knowledge in order to advance the state-of-the-art in the area of decision task training. It is anticipated that the procedures which have been developed under this contract, after subsequent validation and refinement, will be incorporated into the Instructional Systems Development (ISD) process.

Appreciation is expressed to the following individuals who enthusiastically participated as subject matter experts in their areas of expertise: Mr. A. Gibbons of Courseware, Inc., San Diego, and the personnel of HSL 31, NAS North Island, San Diego -

LCDR K. Burns
LCDR J. Sullivan
LT M. Avery
LT M. Clapsadl
LT J. Denson
LT C. Erickson
LT P. Gorman
LT C. Josefson
LT H. Matthew
LT L. Wahl
LTJG T. Matthews
LTJG A. Seifert
ENS T. Naple

Robert H. Ahlers
Scientific Officer

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

SECTION I

INTRODUCTION

OVERVIEW

A one-year research and development program in the area of decision training is described in this report. The program investigated the use of decision analysis techniques in the design of instructional materials for decision training in military systems. The long range goal is to define a decision training approach that can be applied to a wide variety of system training courses. As a first step toward that goal, the present program focused on the decision training requirements of the Navy SH-2F Light Airborne Multi-Purpose System (LAMPS) Anti-Submarine Warfare (ASW) helicopter. In this environment, decision analysis techniques were used to (1) identify and select critical decision making situations during helicopter operation, (2) define the decision making tasks required of the Pilot, Airborne Tactical Officer (ATO), and the Sensor Operator, and (3) specify the skills and knowledge necessary to make effective decisions.

To an ever-increasing extent, the operators of advanced military systems, such as aircraft, ships, weapons, C3, etc., act primarily as decision makers. That is, the operator's most important functions are to select from alternative data sources and to choose among alternative courses of action. Although he may be well trained to carry out each alternative procedure, he is virtually never trained in how to most effectively make the crucial decision among them. Traditionally, acquiring the judgment to make sound decisions has been considered an art, which must be developed over years of experience, or through long apprenticeship to a veteran decision maker. This approach, aside from being of dubious validity, is inappropriate in today's military environment, where an operator must step into a job and function well from the start.

Within the past several years, the general rules of effective decision making have been consolidated into the technical area termed "decision analysis." During the same period, the systems approach to training has established a generalized methodology for dealing with diverse content areas in the design of training courses called Instructional System Development (ISD). Accordingly, it is the objective here to bring these two areas together in order to define the decision training objectives of typical military systems and to specify ways of meeting them. Successful joining of the two technologies should have a profound effect on future system performance and lifetime cost.

The current program has the following major objectives:

a. To analyze a specific military training system, the SH-2F (LAMPS) helicopter, in terms of specific decision analysis techniques.

b. To identify the decision situations that occur during regular and emergency system operations.

c. To isolate the decision tasks that are required to resolve a selected set of decision situations.

d. To identify, for each decision task, (a) the required facts, (b) the underlying concepts, (c) the decision rules, and (d) the step-by-step procedures that determine the optimal choice of alternatives.

e. To contribute to the production of training materials for one or more of the decision tasks, to include: (a) training analysis, and (b) production of instruction.

f. To evaluate the materials produced for this test case, and to analyze the implications for (a) similar system-oriented courseware, (b) courseware for generalized decision training, and (c) decision-aiding software for the SH-2F and related systems.

RATIONALE

The term "decision making" has been used to describe a wide range of cognitive processes. Building upon the classification of others, Nickerson and Feehrer (1975) have conceptualized decision making as a collection of problem solving or decision tasks which involve: "information gathering, data evaluation, hypothesis generation, problem structuring, hypothesis evaluation, preference specification, action selection, and decision evaluation."

Study of human decision making behavior reveals deficiencies accomplished with the different decision making components (Hammell and Mara, 1970). In the literature, the term "deficiencies" has been used in two ways: (1) to refer to stereotypes ways of behaving suboptimally, such as the tendency of humans to be overly conservative in their application of probabilitistic information to the evaluation of hypotheses, and (2) to refer to basic human cognitive limitations such as memory, attention span, and processing limits such as the inability of most people to weigh more than some small number of factors in arriving at a preference among alternatives without procedural help.

Different approaches to correct deficiencies in human decision making process have been suggested (Schrenk, 1969). There are basically three ways to improve the performance of the human decision element in a system:

a. Selection: insure that decisions are made only by individuals who are competent to make them.

b. Decision Aiding: provide decision makers with procedural and technical aids to compensate for their own limitations.

c. Decision Training: attempt to improve the decision-related skills of people in decision-making positions.

Decision aiding and decision training can be viewed as complementary to one another. While decision training attempts to improve decision making behavior by training out deficiencies and highlighting limitations, decision aiding provides the decision maker with procedural and technical aids which let him go beyond his own limitations in the process of decision making. Much of the research work has been performed on decision aiding while decision training has been rarely investigated. One objective of the present research program was to narrow this gap.

There are a number of decision training programs that are being pursued with some success. These programs are either limited to the abstract decision making subprocesses without an integration of the decision training with the area of the trainee's expertise, or they highly concentrate on the task-specific knowledge and fail to provide the trainees with a competent generalized decision making behavior. Training programs based on the first approach do not provide the required link between decision training and the application area. Programs with the second approach suffer from their shortcomings in three areas:

a. Lack of decision training relevant to a new domain, in case of the trainee's transfer to other task domains.

b. Loss of decision training effectiveness over time, since the characteristics of decision tasks within any specific domain are subject to change with time.

c. Lack of carry over of the decision making capability into incidental functions, which are usually left untrained.

To avoid the shortcomings of the existing programs, a decision training methodology must be developed that allows incorporation of general purpose decision training components into task specific decision training programs. Since many problems encountered in the development of such a decision training methodology have not been previously addressed, and since the development process involves a cross-section of different disciplines, such a development provided a desirable area for research and development.

The research and development process provided for incorporation of different areas of knowledge into the development of an universal decision training methodology. These areas of knowledge include decision analysis, psychology, training, and computer science. Different components of a decision process were analyzed and the required behaviors involved in these components were identified. The cognitive complexity of each identified behavior was recognized and the training behavioral objectives were defined. The best instructional method, media, and content for accomplishing the training objectives were identified.

CURRENT DECISION TRAINING PROGRAMS. There are a number of decision training programs that are being pursued with some success. These programs are either task specific or treat only limited aspects of the decision making process. Some of the programs are used in operational contexts.

Einhorn and Hogard (1975) developed an approach to teaching multi-attribute utility analysis to top-level executives and middle-level managers. While their system, termed "An Idiot's Guide to Decision Making" (Goodman et al, 1976), maintains a reasonable degree of independence with respect to any specific domain, it covers only one method of alternative evaluation. Other subprocesses involved in the decision making process, as well as the interrelationships among the subprocesses in the procedural body of the decision making system, are ignored.

Decisions and Designs, Inc. (DDI) has developed a Rapid Screening Decision Training System. The system involves an interactive computer program that simplifies a decision analysis by focusing on a limited number of alternatives and the major causes of uncertainty (Selvidge, 1976). The training aspect of the system consists of displaying the expected value associated with each alternative evaluation and does not cover other elements of decision making such as problem recognition, alternative development, and the optimal sequencing and effort allocation for these subprocesses.

Hammond, et al (1975) present judgment as the key elements of a decision making process. They assume that if people are taught the theory behind judgment analysis and then trained in increasingly difficult applications of task situations, they will eventually be able to analyze any problem properly. Based on this theory, their training system focuses strongly on judgmental aspects and ignores the other elements of the decision making process.

The Decision Analysis Group at Stanford Research Institute (SRI) conducts several different kinds of training programs for decision makers (Goodman, et al, 1976). Through these programs, trainees are expected to learn that the decision theoretic methodology exists, that uncertainties and utilities can be quantitatively estimated and that they can begin to structure and work through their own decision problems. While the programs are enriched by a reasonable degree of generality and completeness, they do not provide the required link between decision training and the specific application area.

Michigan State University's Medical School approach to the training of physicians is based on a total curriculum design wherein decision analysis is integrated within specific content areas (Allal, 1973; Elstein, Shulman, and Sprafka, 1977). It assumes that the diagnostic phase of medicine consists of generating hypotheses about what the medical problem might be, distinguishing the relevant from the irrelevant features of the case, and then systematically gathering information to test and compare alternative hypotheses. The program is highly task-specific and it relies heavily on the case-study method.

The Los Angeles Police Academy's "shoot/no shoot" training is an example of a task-specific decision training program. Although the program covers no formal training in either probability theory or decision theory, it includes extensive courses in the established important attributes that should be considered when deciding whether or not to shoot in a given situation. There is no relative weighting scheme for the attributes nor decision rules that translate the utilities of the attributes into a decision. There are, however, general guidelines that help the cadets make the decision. Due to time criticality, the cadets are taught to prune the decision tree before the actual decision situation arises. The training system is tailored for the specific task involved and lacks the generality and completeness desired in a decision training program.

The review of current decision training programs seems to reveal a lack of completeness, generality, and structural guidance in the system under development or currently in use. These three features are essential to a decision training program with reasonable generality. A research and development project for a decision training methodology embodying these three features was included in the objectives of this program.

REQUIREMENTS FOR A GENERALIZED DECISION TRAINING PROGRAM. Current efforts in the development of decision training systems have usually evolved in the context of task-specific systems (e.g., medical, tactical, managerial, etc.). A training system for decision makers that is developed within the context of such a task-specific domain, without incorporation of general purpose decision training components, does not provide trainees with the skills required for making task-specific decisions within other domains. Furthermore, since the characteristics of decision tasks within any specific domain may be subject to change with time, such training systems will not even provide useful long-term guidelines within the trainees' own domain. In these systems, the decision maker learns a tailor-made set of conceptual components, procedures, techniques, heuristic rules, parameters, and values unique to that particular system at the time of training. The set of concepts that the potential decision maker learns is in reality a very specific <u>sub-set</u> of more general conceptual components, procedures, and techniques. Yet, he never becomes aware that, in fact, it is a sub-set of the more general set because it is outside the training boundary. Hence, if a decision maker is transferred to a new decision making domain, or the characteristics of the decision tasks within his decision domain change, he typically has two choices: he must either enter a new task-specific decision training program (and learn another unique conceptual sub-set again without relaxing its relationship to the first sub-set learned), or he must learn to invent his own conceptual set without the benefit of a formal training program. In the latter case, the decision maker is without a formal guide and often attempts to "cram" his new world into a conceptual sub-set learned for an entirely different decision task.

Considering the fact that the characteristics of decision tasks within any specific domain are subject to change with time, even decision training systems designed for specific domains must include components of general purpose decision training. A comparative analysis of general purpose versus task specific decision training will identify the required components of domain independent decision training that must be included in a task specific decision training system. Such a comparative analysis was included in the proposed program.

BACKGROUND

PROBLEM STATEMENT. Instructional System Development (ISD) currently provides a systematic and scientific methodology for (1) identifying the tasks that operators must perform, (2) specifying the hierarchy of training objectives, and (3) developing the procedures and schedules for training the operators to perform the identified tasks. However, decision making tasks have typically not been among those identified and treated by the ISD methodology. Decision tasks are thus neglected in present training courses. In most cases, alternative selection has been considered as a well-structured "cookbook" response, rather than as a decision consisting of specific sequences of tasks to be trained. In those cases where critical decision points have been recognized, performance is assumed to come "from experience" rather than by explicit instruction. Research is definitely required to develop a methodology for identifying and isolating decision tasks in current system training functions, as well as for development procedures for training decision making.

DECISION MAKING. Investigation of human decision making has focused on the process of choosing among alternatives under various conditions of risk and uncertainty. Research has identified sequences of tasks included in the literature on decision making, the list given by Nickerson and Feehrer (1975) provides a comprehensive set for purposes of discussion and comparison. It consists of (1) information gathering, (2) data evaluation, (3) problem structuring, (4) hypothesis generation, (5) hypothesis evaluation, (6) preference specification, (7) action selection, and (8) decision evaluation.

Theoretical research on normative (ideal) decision making has also identified sources of human decision-making deficiencies. Such deficiencies include stereo-typed choice sequences, conservative probability application, incomplete data acquisition, etc. Several investigators (Hammell and Mara, 1970; Kanarick, 1969; Pesch, Hammel, and Ewalt, 1974) have suggested that decision training programs can diagnose and give instruction regarding decision deficiencies.

DECISION ANALYSIS. Technqiues of decision analysis have been developed that can be used to identify the decision points in a sequence of action performed by a system operator. These techniques also provide a systematic method for identifying the decision parameters specific to the situation at hand (i.e., alternative, rules, attributes). Thus, the tasks and associated inputs of decision making can be explicitly defined for training purposes.

The multi-attribute utility approach to analyzing decision situations in one example of these techniques (Gardiner and Edwards, 1975; Gardiner, 1977). Essentially, this approach first establishes dimensions of value -- "attributes" for the relevant set of decision outcomes. Each outcome to be evaluated is located on each dimension -- i.e., assigned an attribute utility -- by means of observation of judgment. Utility can be thought of as gain to the operator; gains can be positive; negative gains are costs. An overall utility for the outcomes is achieved by aggregating the multiple utilities, most often by calculating a weighted average over attributes. The expected utility of an outcome is its aggregated utility multiplied by its probability of occuring, and the usual decision rule is to select the outcome with maximum expected utility, although in some cases other rules may be preferred.

DECISION AIDING. Introduction of decision aids to the decision environment provides a framework for familiarizing the operator with decision theoretical concepts and decision training approaches. It has been shown that adaptive decision aids can be an effective instructional tool for behavior change and performance improvement (May, Crooks, and Freedy, 1976). Adaptive decision aiding has also been effectively used to show that when decision models based on real operators are used for decision making, performance is superior to that of the operator himself, both in terms of performance scores and in terms of decision consistency (Dawes, 1970; Freedy, Davis, Steeb, Samet, and Gardiner, 1976).

TECHNICAL APPROACH

GENERAL. Attention has been initially focused on a single military system able to provide good examples of decision making tasks which are important to system operation and which are likely to be improved by training in an instructional program. This system is the Navy SH-2F (LAMPS) ASW helicopter. An instructional course for the LAMPS crew members (Pilot/ATO and Sensor Operator) has recently been developed by Courseware, Inc., San Diego. In effect, Perceptronics acted as "subject matter expert" in the area of decision making. The final output of the decision analysis, as presented in this report, is in a form suitable for incorporation into the specification of instructional objectives, the planning of strategies, the selection of media, and other other steps required for the production of instruction.

The main tasks involved in the current program effort are the following:

a. Analysis of LAMPS Operators' Functions

b. Decision Selection

c. Description of Decision Tasks

d. Recommendation of Decision Aids

These tasks are described separately in the following sections.

ANALYSIS OF LAMPS OPERATORS' FUNCTIONS. An analysis of LAMPS helicopter operators identified decision points that occur during execution of the operator's functions. This task corresponds to the Job Analysis phase of the instructional development process. Decision points in an operator's sequence of functions have the following characteristics:

a. The operator is required to make a choice between a number of alternatives.

b. The criteria for selecting among the alternatives are not completely specified, and may have significant judgmental components.

c. The operator is required to either define the possible choices (problem structuring) or evaluate the potential outcomes (action selection).

Indicators for identifying decision points in the operator's functions include the following:

a. Additional information may be necessary before a choice can be completely defined.

b. The possible outcomes of the choice are uncertain and some estimate of their likelihood may be required.

c. The consequences of the actions are composed of a number of factors that must be aggregated.

d. The alternative consequences of the current action will differentially affect future actions.

DECISION SELECTION. From the list of decisions identified in the job analysis, a limited number were selected for the examination of decision training methodology. Selection focused on highly critical decision. The criteria for selection were the following:

a. Safety Criticality

b. Time Criticality

c. Frequency of Occurrence

d. Current Decision Making Effectiveness

e. Tractability

f. Demonstrability

Candidate lists of potential decision tasks in the LAMPS emergency procedures were ranked by LAMPS expert instructors according to the above criteria. A composite ranking was then obtained and provided the basis for final decision task selection. The results of this selection are presented in Chapter 2. The decisions were thus chosen to represent both general classes of decisions and decisions that are specific to particular crew positions.

DESCRIPTION OF DECISION TASKS. This corresponds to the Task Analysis phase of Instructional Systems Development. Researchers in decision making have suggested various classifications of tasks that decision makers perform (Adelson, 1961; Drucker, 1967; Edwards, 1965; Hill and Martin 1971; Howard, 1968; and Schrenk, 1969). These classifications provide a framework for enumerating the tasks that the LAMPS operators must perform in each of the selected decisions. A preliminary list of subprocesses involved in generalized decision making include:

a. Recognize the decision point

b. Formulate the alternative courses of action

c. Establish the possible outcomes of each course

d. Estimate the multi-attribute utility (i.e., gains or losses) associated with each outcome

e. Estimate the probability of achieving the various outcomes

f. Apply decision rule(s) or criteria

g. Select a best course of action

A detailed analysis of the selected decision tasks were performed in the second phase of the project. The set of decision tasks includes both generalized tasks (i.e., decision problem structuring) and tasks that are unique to each specific decision (i.e., list of possible alternative classes). The results of this analysis appears in Chapter 3. The decision trees developed in this phase are included in the appendices of this report.

DEVELOPMENT OF INSTRUCTIONAL GUIDELINES. The steps involved in the actual production of training materials for decision tasks include the specification of:

a. Objective Hierarchies

b. Strategy Planning

c. Media/Method Selection

d. Course Sequencing

It is realized that training crew members for more effective decision making is no trivial matter. Many years of research have been spent on each of the subprocesses involved in decision making. Much work has been devoted to the area of probability assessment alone. Nevertheless, it has been realized that the effort in analysis of requirements and methodology for decision training in operational systems is justified by the following reasons:

a. The vast amount of theoretical and experimental work provides an invaluable guide to practical application.

b. It appears that much of the benefits to be derived from the decision analytic approach lies in problem definition itself, that is, in the operator recognizing that a decision problem exists, and evaluating it in terms of expected costs and expected gains. This aspect of decision making, concepts and basic rules, seems highly amenable to training.

c. By restricting initial effort to a specific system, the job of defining decision problems and prescribing procedures for training is simplified.

d. The potential payoff is great. Tactical decisions involve equipment and procedures of even-increasing cost. Any gain in decision effectiveness realized at the training stage will have a large multiplier effect over the total system life.

A system for generating guidelines to aid development of instructional materials for each decision task is developed in this report. This system provides essential information to be incorporated in the production of instructional materials. Such information includes:

a. Identification of decision tasks in objective hierarchies

b. Classification of decision tasks

c. Identification of task-specific and basic instructional contents

d. Selection of the most effective instructional method

e. Selection of the most effective instructional media

RECOMMENDATIONS OF DECISION AIDS. Identification of decision points and decision tasks suggests decision aids that could be incorporated in the operational system. Decision aids can be used in a variety of ways to improve the logical soundness and the speed of decision making. In general, aids are directed toward eliminating deficiencies and limitations in human cognitive performance. As an example of eliminating deficiencies, an aid can be used to remind a decision maker to seek more information or to help avoid a stereotyped response. As an example of overcoming limitations, decisions aids can help evaluate a larger number of alternatives than an unaided decision maker could consider. A variety of decision aiding techniques are available, ranging from printed decision trees and flow diagrams, through paper-and-pencil mathematical procedures, to interactive computer-based techniques. The computer-based techniques include database retrieval and bookkeeping functions, graphical problem representation, hypothesis generation, simulation of outcome sequences, etc. Operational decision aids have implications for training, since (1) they would be expected to reduce or change the elements of the identified decision tasks, and (2) the operators would also require training on the use of any software or hardware aids introduced to the operational system.

SECTION II

JOB ANALYSIS

GENERAL

Since the objective of the program was to develop a methodology for the development of decision training programs in specific areas, a task-specific appraoch for the research and development program was employed. The project started with an analysis of tasks involved in the operator's job and constituted the "Job Analysis" phase.

During the "Job Analysis" phase, the attention was focused on identification and selection of decision tasks in the SH-2F (LAMPS) ASW operation. An in-depth study of the entire LAMPS operation was conducted. Figure 1 presents a detailed diagram of the approach followed during this phase. The following is a summary of this approach in which the individual items are numerically indicated in the figure.

a. A preliminary methodology for the identification and classification of decision tasks was developed. This methodology enables the separation of decision-related LAMPS tasks from procedural non-decision tasks.

b. Two volumes of LAMPS instructional "objective hierarchies" were analyzed for the purpose of isolating potential areas for decision tasks. These two volumes taken together comprise the document: "Instructional Design and Development Objective Hierarchies for Pilot/ATO and Sensor Courses," SH-2F (LAMPS) Instructional Systems Development Project No. N68221-75-PR-S1201, Data Item No. A001, prepared by Courseware, Inc., 7851 Mission Center Court, Suite 220, San Diego, CA 92108.

c. The result of the objective hierarchy analysis was a list of potential areas for decision tasks.

d. An in-depth analysis of the available instructional materials for the LAMPS training course was conducted. This consisted of the review of 49 Pilot/ATO tape slide courses, 34 crewmen tape slide courses, and 187 Pilot/ATO workbook courses.

e. The result of the instructional materials analysis was a second list of potential areas for decision tasks in the LAMPS operations.

f. From the two preliminary decision area lists, composite detailed list of decision tasks was compiled.

g. To prepare for final decision task ranking and selection, two experienced LAMPS instructors and two student LAMPS trainees were interviewed with prepared questionnaires.

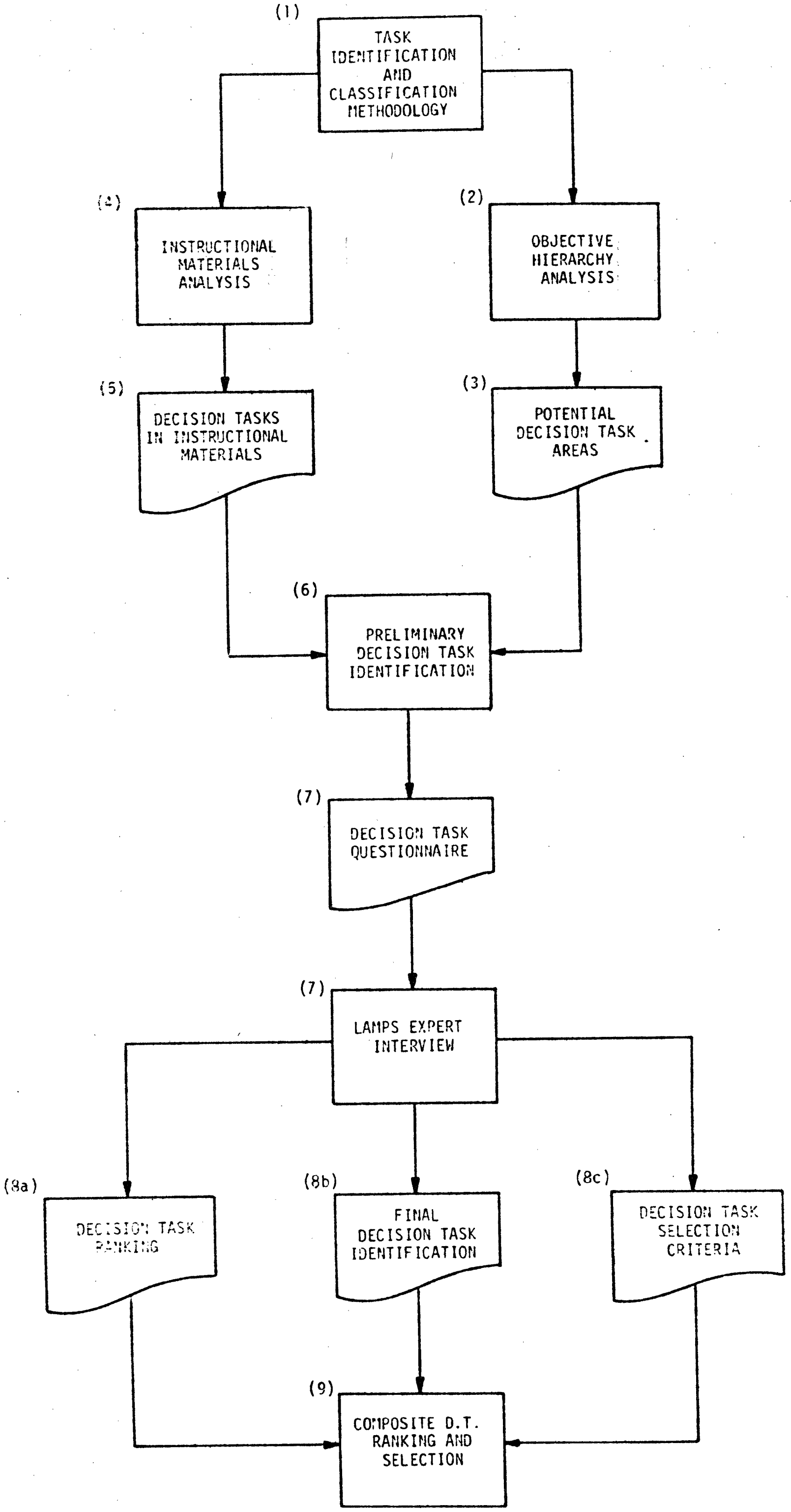


Figure 1. Work Flow For Job Analysis Phase

h. The results of the questionnaires provided:

   - a ranking of the tentative decision tasks in order of importance and criticality,
   - An identification of major decisions in each potential area, and
   - criteria for final selection.

i. A final composite decision task ranking and selection was made based upon all of the analysis information.

METHODOLOGY

The functions of both the Pilot/ATO and the Sensor Operator were the subjects of the analysis performed in the first phase of the project. A preliminary analysis of the job situation specified the required steps in the technical approach. These steps include the definition of decision tasks, classification of decision tasks, and identification of decision task areas.

Performance of an operator in a decision/non-decision task-pool environment obeys the scheme presented in Figure 2. As the input to this scheme, a set of tasks is introduced to the operator as part of the normal LAMPS operational procedures. The set contains both decision and non-decision tasks. Since processing of a decision task requires a procedure considerably different from the one for non-decision tasks, the first responsibility of the operator is to identify the task as either a decision or a non-decision. Block 1 (Figure 2) shows such a dichotomization. This block acts as a "filter" which identifies decision tasks and passes them to block 3 for classification.

Non-decision tasks will also be identified in block 1 and passed to block 2 for processing. It is assumed that block 2 contains a strict set of predefined procedures for processing non-decision tasks. Instructional objectives, outlines and materials for these procedures have already been developed by Courseware, Inc., as a part of the current LAMPS pilot training course.

The tasks identified as decision-related are input to block 3, where they are classified as Type 1, 2, or 3. Processing of a Type 1 decision task requires consideration of problem structuring; a Type 2 decision task represents action selection. Type 3 decisions represent a combination of both Type 1 and Type 2 in which both problem structuring and action selection must be considered. Blocks 1 and 3 form part of the methodology to identify and classify decision tasks in the job analysis phase. The methodology will be described in the following section.

DECISION TASK DEFINITION AND CLASSIFICATION. The mechanism of decision task identification is similar to that of a "filter" which passes all, and only, decision tasks. The characteristics of such a filter are described by the definition of a decision task:

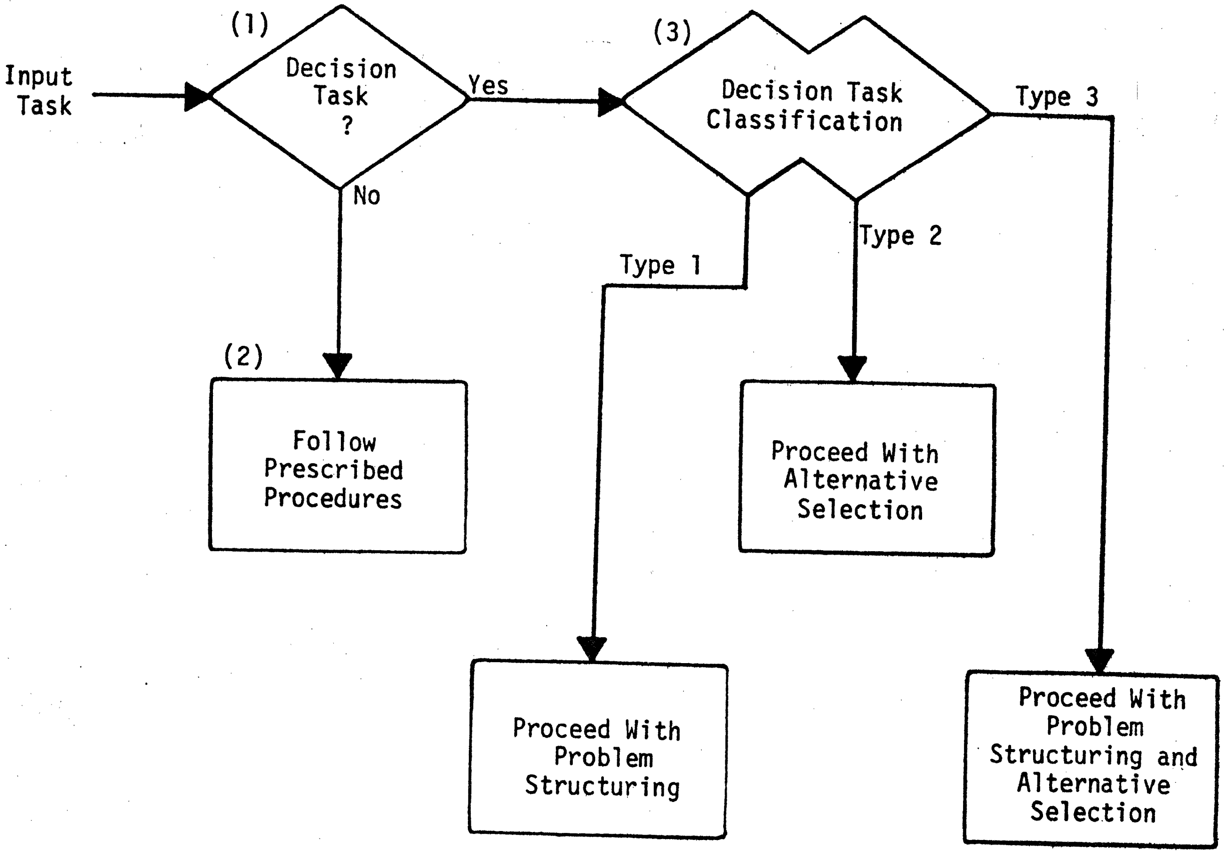


Figure 2. Task Processing Scheme

a. The objective of a decision task is to select an alternative from a specified set of alternatives.

b. This selection may require the formulation of alternatives (problem structuring).

c. There is a lack of completely specified criteria for either alternative formulation or alternative selection.

The operator actions necessary for processing a generalized decision task may involve considerations such as establishing possible outcomes and consequences of each alternative, determining utilities and probabilities of the various outcomes, evaluating major attributes of each available alternative, and applying established decision rules for selecting the best course of action. Some of these operator actions are shown in Figure 3 with their relationships to problem structuring and alternative selection. In general, the actions of alternative formulation and outcome formulation are related to problem structuring while actions such as utility and probability assessment are related to the action selection process.

Since there is a considerable distinction between the two tasks of problem structuring and alternative selection, there is a plausible classification scheme for decision tasks. Such a scheme is created by representing a boundary between the decision tasks requiring problem structuring and the ones requiring alternative selection. The boundary is defined by the types of operator actions necessary to process the decision task. It is this distinction which is used to identify and classify specific tasks in the LAMPS operational procedures.

DECISION TASK SELECTION. Once the decision tasks were identified, a composite ranking method was used to select the final LAMPS decision task areas to be used for in-depth study. Preliminary lists of potential decision task areas were initially ranked by LAMPS expert instructors according to the following criteria:

a. safety criticality

b. time criticality

c. frequency of occurrence

d. current decision making effectiveness

Perceptronics' analysts then ranked the same preliminary list according to the following criteria:

a. tractability

b. demonstrability

A composite ranking was then obtained and served as the basis for final decision task selection.

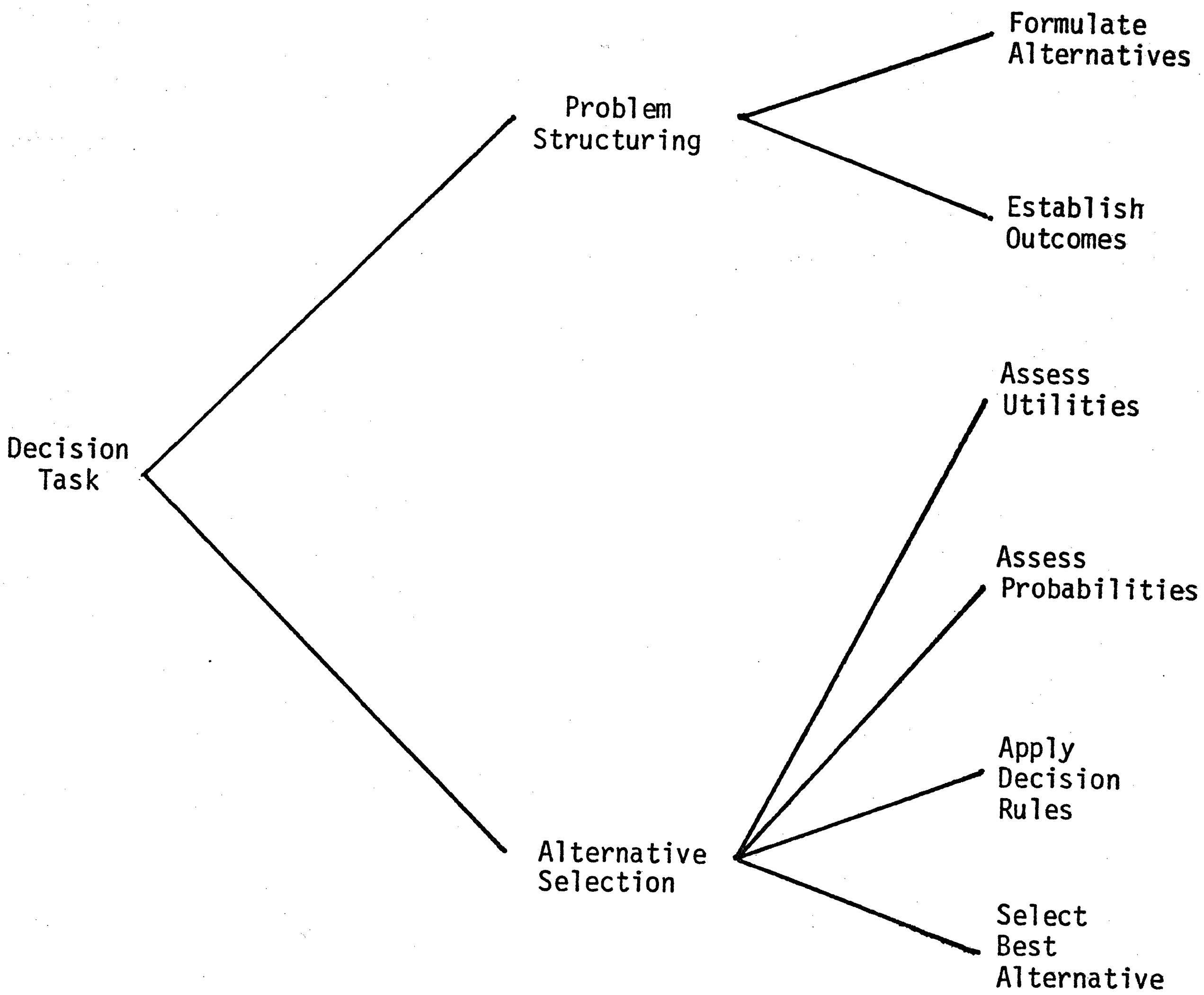


Figure 3. Decision Task Components

INFORMATION SOURCES

The main information sources used in the job analysis phase originated from three main categories:

a. Objectives Hierarchies

b. Instructional Materials

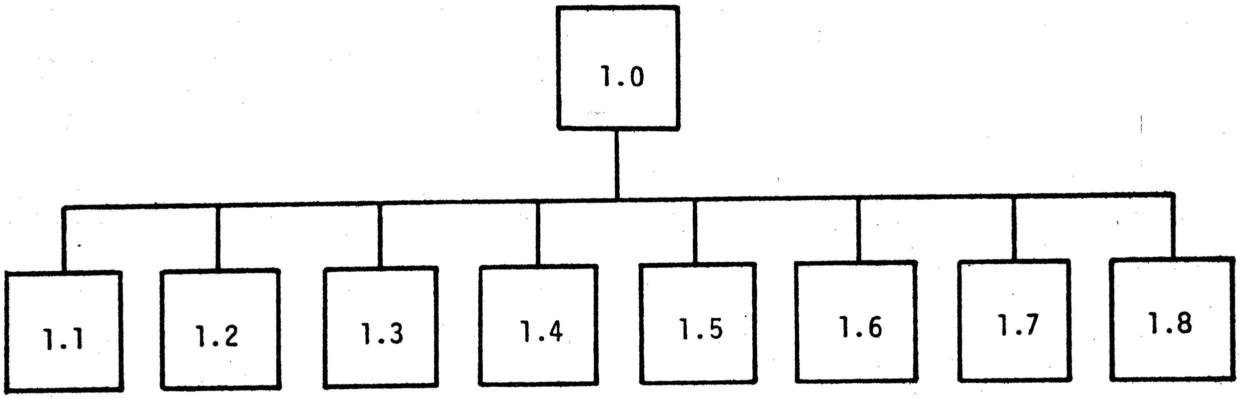
c. LAMPS Instructor Interviews

Objective hierarchies for Pilot/ATO as well as Sensor Operator courses were used as the starting point. They consist of a complete organization of all LAMPS helicopter operations and are used as a basis for creating training courses. The result gained from the analysis of objectives hierarchies led to promising LAMPS decision task areas. Among instructional materials, Pilot/ATO workbooks were the subjects of detailed studies. The tape slides and workbooks deal with specific training subjects and are presented in an informal manner conducive to efficient training. LAMPS instructor interviews provided the required information not existing in the previous two sources. Potentials, limitations, and efficiency of training elements of the present instructional system were part of the information data captured through these interviews. Besides the three major sources of information, informal interviews of LAMPS student trainees and inspection of actual LAMPS helicopters provided additional data for the job analysis. Results from each of these information sources is presented in the succeeding sections. A detailed listing of decision tasks appears in the appendices.

OBJECTIVES HIERARCHIES

Instructional design and development of SH-2F LAMPS operation has been represented thoroughly in Pilot/ATO and Sensor Operator Objectives Hierarchies. The objectives are structured in expanding levels of detail with each objective decomposed into component sub-objectives. Development of instructional materials for courses as well as course sequence are based on these hierarchies. However, every element of the most detailed level of the hierarchical does not necessarily correspond to a single course. A course of instruction may cover many training objectives at different hiearachical levels. An example of objectives hierarchies is shown in Figure 4. In some cases, as many as 11 levels of objectives are given. The sample shown in the figure is only the top-most level.

The objectives hierarchies were a primary subject of analysis. This methodology for decision task identification was used to identify those objectives which could be classified as potential decision tasks. A complete list of results of this analysis of Pilot/ATO and Sensor Operator appear in tables in Appendices A and B. In these tables, every identified decision task is classified as Type 1, Type 2, or Type 3. The tasks are organized into related groups in which a problem/sub-problem relationship exists between consecutive pairs of elements. The first element of each group represents the decision task captured at a higher level. Only the task area for the first element of every group is identified since the other elements of the group consist of the subproblems of the first element.



1.0 Perform all Pilot/ATO functions flying an SH-2F.

1.1 Fly an SH-2F to complete an ASW mission.

1.2 Fly an SH-2F to complete an ASMD mission.

1.3 Fly an SH-2F to complete a surveillance mission.

1.4 Fly an SH-2F to complete a search and rescue mission.

1.5 Fly an SH-2F to complete an external cargo mission.

1.6 Fly an SH-2F to complete an Internal cargo/passenger transfer mission.

1.7 Fly an SH-2F to complete a Naval gunfire spotting mission.

1.8 Describe the main components and operation of SH-2F aircraft systems.

Figure 4. Objectives Hierarchies

The identification and classification process for decision task followed the methodology explained earlier. Due to the large number of existing tasks, the plausibility of computerization of such an analysis was considered. A correspondence between the decision-related tasks in the objectives hierarchies and certain "keywords" used in the description was noted during the analysis. A keyword, in this case, refers to an element of a set of verbs appearing in an imperative sentence, for example, "Determine whether to land the aircraft or to abort the recovery" (p. 112, Pilot/ATO Objective Hierarchies) or "Perform a search in accordance with NWP-37 and NATOPS" (p. 130 Pilot/ATO Objective Hierarchies). The description of every task appearing in objectives hierarchies includes at least one of these keywords.

The result of examination of objectives hierarchies, however, revealed an inconsistency in the use of keywords. Some critical keywords appeared in both decision tasks as well as non-decision tasks. For example, "state" and "calculate" appeared mainly in non-decision tasks; however, about 20% of their applications were in definitions of decision tasks. Future consistency in the use of keywords for decision and non-decision tasks is strongly recommended. A list of the two classes of keywords appears in Table 1. In spite of the inconsistency in use, the keywords provided a reasonable starting point for identification of decision tasks. The use of a computer program for this part of decision task identification could be a means of increasing the efficiency of identification process.

In summary, the analysis of the objectives hierarchies led to the conclusion that most of the decision tasks would be found in the emergency and tactical operational procedures. Furthermore, the Pilot/ATO tasks contained many more decision-related situations than the sensor operator tasks.

INSTRUCTIONAL MATERIALS

Analysis of objectives hierarchies identified the major areas for decision making tasks. In this section of the job analysis, the study was focused on the instructional materials. Two out of four existing types of course materials have the major role in the instruction of LAMPS operation.

a. Tape Slides (TS)

b. Work Book (WB)

c. Computer Aided Instruction (CAI)
(not included in the analysis due to unavailability)

d. Visual Tapes (VT)
(not included in the analysis due to unavailability)

TAPE SLIDES. A series of audio cassette tapes together with corresponding synchronized slides are used to cover part of the course instruction in LAMPS operation. Tape slides for Pilot/ATO, as well as crewmen, were the subject of a detailed analysis. Tape slide materials mainly represent technical and introductory courses. The majority of tape slide courses cover the procedural tasks with no decision making steps. These were

TABLE 1. OBJECTIVES HIERARCHY KEYWORDS

DECISION MAKING KEYWORDS

DETERMINE
CALCULATE
STATE
PRESCRIBE
IDENTIFY
CLASSIFY
ESTIMATE
INTERPRET
REVISE
SELECT
INDICATE
RECOGNIZE

NON-DECISION MAKING KEYWORDS

CALCULATE
PERFORM
RECOVER
PLAN
CONDUCT
DEMONSTRATE
LIST
NAME
DESCRIBE
STATE

termed Non-Decision Tasks (ND). Some of the courses represented by tape slides covered decision situations in which the pilot has the full responsibility of decision making (Decision Making Tasks, DM). In the remainder, the decision making tasks were assumed to be performed by the pilot through the execution of a predefined procedure. These were termed Decision Execution Tasks (DE).

In some cases, the decision making characteristics of a particular situation are explicitly emphasized in the tape slide presentation. The trainee is told that a decision task exists and is given situations to analyze. However, it is made exceptionally clear the the final choice of action rests with him (the pilot or the crewman) and that the basis for the decision is his own judgment and experience. These decision tasks are "obvious" in the sense that they are termed "decision tasks" in the instructional materials themselves. In other cases, a decision task is evident in the instructional materials but is not presented to the student as such. These decision tasks are "hidden" within established procedures for executing a particular operational plan.

The results of tape slide analysis for 49 Pilot/ATO and 34 Crewmen courses appear in Appendices C and D. Task number, type, and keyword columns are identical to the ones of objectives hierarchies analysis. The task name identifies the course title and the slide number represents the new codes replacing the previous coding system to identify different tape slides. The non-available tape slides are marked by NA. Some of the tasks are described in the notes following the result of the analysis. These tasks are marked by an asterisk on their slide numbers.

WORKBOOKS. A considerable portion of the LAMPS operational instructions are covered by workbooks. Figure 5(a) through 6(b) shows examples of workbook courses for a "Radar Offset" approach to an unidentified contact and procedures for an "Immediate Ditching" of the helicopter, respectively. In addition to the exercise and lesson number, the first page of a workbook course always contains the objective, a general list of actions, and an introduction describing the course material. The remainder of the lesson is usually divided into procedures, actions, and remarks or comments.

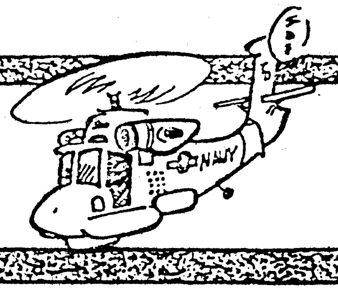
In Figure 5(b), the Radar Offset Approach lesson, the action performed for procedure 2 is "The ATO will decide if a direct or offset approach will be used." Guidelines for this decision are then given. This is an example of a Type 2 "obvious" decision in which the ATO must choose from among a specified set of two alternatives. However, Figure 6(b), the Immediate Ditching lesson, under Section 4.B.2 shows a hidden decision in which the pilot is not given guidelines or told how to choose an alternative.

The analysis of the Pilot/ATO workbooks included 187 lessons. The results of this analysis appear in Appendix E. However, a summary of results appear in Table 2.

EXPERT INTERVIEW

The information acquisition for the job analysis phase was completed by interviewing the LAMPS operational experts. Two LAMPS operation instructors as well as two LAMPS operation trainees participated in the interviews.

RADAR OFFSET



EXERCISE: F-11

LESSON: 2

SEGMENT: 2

MEDIA: Workbook

OBJECTIVE

State the procedures for performing a radar approach to a contact.

GENERALITY

The correct procedure for performing a radar approach to a contact is:

1. Find radar target.
2. Determine if a direct or offset approach will be used.
3. Compute estimated time on top.
4. Turn to an inbound course.
5. Radar as desired.
6. Mark on top contact.

INTRODUCTION

When flying a radar approach to a contact the senso will provide headings and distances to fly. You may deceive the contact into thinking that he has not been detected by flying an offset approach. (An offset approach entails flying parallel or perpendicular to the contact's course and then "cutting in" directly to him.) If you believe the contact will submerge before you reach him, a straight in approach is recommended. (It is easier to calculate the estimated time on top flying a straight in approach.)

Figure 5(a)

RADAR OFFSET

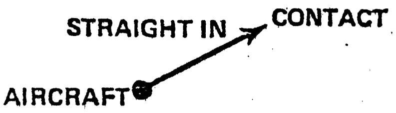
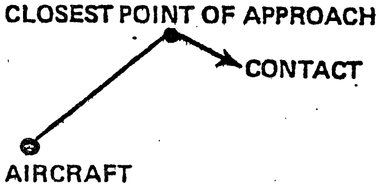
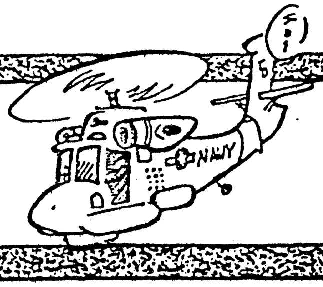
	PROCEDURE	ACTION PERFORMED	IMPORTANT NOTES AND COMMENTS
1	FIND RADAR TARGET	The senso should locate the contact and pass the bearing and range information to the cockpit.	
√2	DETERMINE IF A DIRECT OR OFFSET APPROACH WILL BE USED	<u>The ATO will decide if a direct or offset approach will be used.</u> a. A direct approach is flown directly from the aircraft's present position to the surface contact. b. The offset approach is flown to a position abeam the target to one side at the closest point of approach. From this point a direct leg is used.	a. This approach is recommended if you believe you have been detected.  b. If you think you are detected and wish to get closer to the contact prior to starting your direct run, you should use the offset approach. If the contact disappears from the radar during an offset approach, immediately perform a direct approach to the contact. 
3	COMPUTE THE ESTIMATED TIME ON TOP	Determine the distance from the aircraft to the contact and adjust for groundspeed.	Time on top is important in case your contact disappears from the radar screen.

Figure 5(b)

IMMEDIATE DITCHING



EXERCISE: F-7

LESSON: 2

SEGMENT: 7

MEDIA: Workbook

OBJECTIVE

State the steps to complete an immediate ditching.

GENERALITY

PILOT	COPILOT
1. Alert crew and passengers, harness locked. 2. Pilot's door - open 3. Transmit distress message 4. After water landing: A. Two engine fail 1. Full up collective 2. Rotor brake - on 3. Abandon aircraft B. Single Eng fail 1. Hold helicopter level ✓2. Either secure eng and rotors (release harness and abandon aircraft or) follow single eng water takeoff procedures.	1. Open copilot's door, harness locked. 2. Jettison all external cargo/ stores and sonobuoys. 3. When rotor stops, abandon aircraft.

INTRODUCTION

In the event of an immediate ditching situation it is critical that all of the people in the aircraft react to it and perform their NATOPS procedures. You will be required to know both the pilot and copilot duties since you will be serving in both functions during your training.

Figure 6(a)

IMMEDIATE DITCHING (PILOT)

	PROCEDURE	ACTION PERFORMED	IMPORTANT NOTES AND COMMENTS
1	ALERT CREW AND PASSENGERS, HARNESS LOCKED	Let the crew know you are going to ditch over the ICS.	If the Senso is on private, monitoring sonobuoys, you will have to use the call position of the ICS to talk to him.
2	PILOT'S DOOR – OPEN.		If door does not want to open, pull jettison "T" handle.
3	TRANSMIT DISTRESS MESSAGE	Switch to guard and tell them 1) I.D. 2) Position 3) Number of people on board 4) Problem	If time permits, repeat your distress call.
4	AFTER WATER LANDING: A. TWO ENGINE FAIL 1. COLLECTIVE: FULL UP 2. ROTOR BRAKE ON 3. ABANDON AIRCRAFT B. SINGLE ENG FAIL 1. HOLD HELICOPTER LEVEL 2. EITHER SECURE ENG AND ROTORS AND RELEASE HARNESS AND ABANDON AIRCRAFT OR FOLLOW SINGLE ENG WATER TAKEOFF PROCEDURES		1) Do not inflate floatation gear until clear of aircraft 2) Unplug helmet cords before trying to get out of the aircraft 3) WARNING-Do not abandon aircraft before the rotor has stopped turning.

Figure 6(b)

TABLE 2. RESULTS OF INSTRUCTIONAL MATERIAL ANALYSIS

OBVIOUS DECISIONS

- External Engine Fire (TS)
- Gear Box Oil Malfunction (TS)
- Determining Restart Feasibility (TS)
- Radar Offset Approach (WB)

HIDDEN DECISIONS

- Combining Gear Box Oil Malfunction (TS)
- Hydraulic System Malfunction (TS)
- Electrically-Caused Overspeed (TS)
- Loss of Tail Rotor Thrust (TS)
- Loss of Tail Rotor Control (TS)
- Immediate Ditching (WB)

A series of predesigned questionnaires was prepared from the specific tasks identified in objectives hierarchies and tape slide analysis. A sample questionnaire appears in Table 3. The questionnaire concerns the problem of a gearbox malfunction. It is classed as an emergency operation. Each question attempts to elicit information about the particular decision.

Question Q1 asks for a set of alternative actions which can be taken when a gearbox malfunction occurs. Q2 tries to locate attributes of each alternative which may be used in selection. Since limiting the initial set of alternatives can be a help in rapid decision making, question Q3 probes for situations which allow the deletion of one or more alternatives. Questions Q4 and Q5 request value judgments on relative utility and probability of occurrence, respectively. Only a linguistic value judgment is required in this case. Normally, however, numerical judgments are preferred. Q6 is a structural question. It determines if this is a "one shot" decision situation or if it is repetitive in nature. Questions Q7, Q8, and Q9 concern the "cues and alerts" for a gearbox malfunction. These are indicators that a malfunction is either about to happen or has already occurred. Question Q8 deals with completeness. That is, if there is an imminent gearbox malfunction, will all cues and alerts be observable? Question Q9, on the other hand, deals with uniqueness. That is, are there any other malfunctions with exactly the same cues and alerts as a gearbox malfunction? If this situation could occur, there would exist an ambiguity in the recognition of an emergency decision situation. In such cases, it would be beneficial to design a new alert (such as an emergency indicator light) to differentiate between the two ambiguous conditions.

Questions Q10, Q11, and Q12 produced the most valuable information for the selection of decision task areas for further study. Q10 required the participants to rank the gearbox malfunction with respect to other potentially critical areas. The only criteria given was "importance" and it was left to the participant to define this word in his own terms. Immediately after this ranking, the participant was asked to describe the major factors that he considered when thinking about "importance." Both instructors and both students gave the same list of criteria:

a. Personnel Safety

b. Mission Effectiveness

c. Equipment Salvage

This unanimous consensus is, of course, attributable to the fact that all participants were part of the same training program. However, all agreed that not only were these the most important, but also that there were no other major ones.

The last question, Q12, required the ranking of the potential decision areas in terms of each criteria separately. The detailed results of these rankings will be described in the next sections.

TABLE 3. SAMPLE OF EXPERT INTERVIEW QUESTIONNAIRE

(Q1) WHAT MAY BE DONE WHEN A GEARBOX MALFUNCTION HAPPENS?

(Q2) WHAT ARE THE ADVANTAGES AND DISADVANTAGES INVOLVED IN EACH ALTERNATIVE?

(Q3) IS THERE ANY SITUATION IN WHICH SOME OF THE ALTERNATIVES ARE USELESS? WHICH ONE AND IN WHAT SITUATION?

(Q4) ARE ANY OF THE ALTERNATIVES MORE PREFERABLE IN CERTAIN SITUATIONS? WHICH ONE AND IN WHAT SITUATION?

(Q5) WHAT IS THE CHANCE OF SUCCESS FOR EACH ALTERNATIVE? (GOOD, BAD, NOT LIKELY, ...)

(Q6) IF THE ATTEMPT TO PERFORM AN ALTERNATIVE FAILS, WILL THERE BE A CHANCE TO TRY ANOTHER? HOW?

(Q7) WHAT ARE THE CUES AND ALERTS FOR SUCH A MALFUNCTION?

(Q8) DO ALL CUES EXIST IN CASE OF THIS MALFUNCTION?

(Q9) IS THERE ANY OTHER MALFUNCTION WITH THE SAME CUES?

(Q10) HOW DO YOU RANK THE IMPORTANCE OF SUCH A MALFUNCTION?

(Q11) WHAT WAS THE CRITERIA FOR IMPORTANCE FOR THIS RANKING?

(Q12) RANK THE TASK FOR EACH CRITERION SEPARATELY.

CANDIDATE DECISION TASKS

Analysis of instructional materials identified the decision task areas. This information, together with the potential decision task areas detected in objectives hierarchies analysis (and confirmed in expert interviews), produce the list of final Pilot/ATO decision tasks. The list shown in Table 4 contains fifteen decision task areas covering a variety of operational procedures. The list formed the basis for the selection of two major areas for in-depth analysis in the next phase.

SELECTION CRITERIA AND ANALYSIS

Two classes of criteria were identified for the final selection of decision tasks. The first class contains the criteria of importance as judged by LAMPS/ASW operational experts. This class includes:

a. Safety criticality

b. Time criticality

c. Frequency of occurrence

d. Current decision making effectiveness

The second class concerns criteria for usefulness of the task to demonstrate the methodology of decision training. The two criteria of this class were:

a. Tractability

b. Demonstrability

where tractability is an aggregation of three basic components:

a. Representativeness

b. Size

c. Degree of Abstraction

Since all the criteria were equally important to the object of the task selection, an equal-weight (w=1) utility model was used to make the final selection. A weight of w=-1 was given for "current decision making effectiveness" since this reflects the negative effect of this criteria on the task selection.

The detailed analysis chart for the decision task selection appears in Table 5. The entries of each column are the result of the ranking of the candidate decision tasks by the interview participants with respect to the corresponding criteria. The last column, Mean Ranks, is an indication of priority for selection of each task according to the above criteria and evaluation scheme.

TABLE 4. FINAL CANDIDATE PILOT ATO DECISION TASKS

- FLYING METHOD (OH)
- MISSION SAFETY (II)
- TYPE OF LANDING (II)
- LAND OR WAVE OFF (II)
- ABORT OR CONTINUE THE MISSION (OH)
- DITCHING SITUATION (WB)
- RESTART FEASIBILITY
- RADAR APPROACH (WB)
- ENGINE QUITS (OH)
- EQUIPMENT MALFUNCTION (OH)
- GEARBOX MALFUNCTION (TS)
- HYDRAULIC SYSTEM MALFUNCTION (TS)
- LOSS OF ROTOR THRUST (TS)
- LOSS OF TAIL CONTROL (TS)
- FIRE (TS)

OH: OBJECTIVE HIERARCHY

II: INSTRUCTOR INTERVIEW

WB: WORK BOOK

TS: TAPE SLIDE

TABLE 5. ANALYSIS OF DECISION TASK SELECTION

Decision Task	Safety Criticality (w=1)	Time Criticality (w=1)	Frequency of Occurrence (w=1)	Current DM Effectiveness (w=-1)	Tractability (w=1)	Demonstrability (w=1)	Mean Ranks
Flying Method	14	12	9	4	7	8	46
Mission Safety	13	11	8	5	15	15	57
Type of Landing	12	13	1	3	6	7	35
Land or Wave Off	9	10	2	6	4	3	22
Abort or Continue the Mission	11	7	4	9	3	4	35
Ditching Situation	5	8	15	8	1	1	22
Restart Feasibility	7	9	13	7	8	5	35
Radar Approach	15	15	5	1	13	6	53
Engine Quits	1	3	12	13	2	2	7
Equipment Malfunction	10	14	3	2	5	9	39
Gearbox Malfunction	4	4	7	12	10	11	24
Hydraulic System Malfunction	8	5	6	11	11	12	31
Loss of Rotor Thrust	2	1	14	15	9	10	21
Loss of Tail Control	6	6	11	10	12	14	39
Fire	3	2	10	14	14	13	28

(w=weight)

The ranks in each column were obtained as follows. Three participants independently ranked the tasks under safety criticality. Two of these rankings were almost identical and one varied greatly. The ranking which was at variance was disregarded, and the other two were averaged and re-ranked. The three criteria, Time Criticality, Frequency of Occurrence, and Current Decision Making (DM) Effectiveness were ranked by one participant each. The two criteria, Tractability and Demonstrability, were ranked by Perceptronics' analysts before the interviews.

RECOMMENDED DECISION TASKS

An additive model with unit weights was used to determine the final composite ranking. The numbers in the Mean Ranks column in Table 5 are a result of adding together the rank values of each of the criteria columns with the exception of Current DM Effectiveness which was subtracted. The final ranking is shown in Table 6. "Engine Quits" was by far the most important with "Loss of Tail Rotor Thrust," "Land or Wave off," "Ditching Situation," and "Gearbox Malfunction" closely grouped. In this group, Land or Wave off was chosen since it would provide possible experimentation without danger. Loss of Tail Rotor Thrust and Gearbox Malfunction are technical tasks similar to Engine Quits. Ditching Situations are a direct result of Engine Quits and could benefit from this analysis. Table 7 presents characteristics of the two selected decision tasks and compares and contrasts them. The selection decision tasks for in-depth analysis: Engine Quits and Land or Wave off, represent a rich environment for application of decision training methodology.

TABLE 6. SELECTION ANALYSIS RESULTS AND RECOMMENDATION

*1. ENGINE QUITS
2. LOSS OF ROTOR THRUST
*3. LAND OR WAVE OFF
4. DITCH SITUATION
5. GEARBOX MALFUNCTION
6. FIRE
7. HYDRAULIC SYSTEM MALFUNCTION
8. RESTART FEASIBILITY
9. ABORT OR CONTINUE THE MISSION
10. TYPE OF LANDING
11. EQUIPMENT MALFUNCTION
12. LOSS OF TAIL CONTROL
13. FLYING METHODS
14. RADAR APPROACH
15. MISSION SAFETY

*Recommended Decision Tasks

TABLE 7. CHARACTERISTICS OF RECOMMENDED DECISION TASKS

TASK	CHARACTERISTICS
1. ENGINE QUITS	VERY HIGH SAFETY CRITICAL, VERY HIGH TIME CRITICAL, VERY LOW FREQUENCY OF OCCURRENCE, VERY LOW CURRENT DECISION MAKING EFFECTIVENESS, VERY GOOD DECISION TASK REPRESENTATIVE, VERY LARGE PROBLEM SIZE, LOW DEGREE OF ABSTRACTION, VERY HIGH DEGREE OF DEMONSTRABILITY, TECHNICAL
2. LAND OR WAVE OFF	MEDIUM SAFETY CRITICALITY, LOW TIME CRITICALITY, VERY HIGH FREQUENCY OF OCCURRENCE, MEDIUM CURRENT DECISION MAKING EFFECTIVENESS, VERY GOOD DECISION TASK REPRESENTATIVE, SMALL PROBLEM SIZE, MEDIUM DEGREE OF ABSTRACTION, VERY HIGH DEGREE OF DEMONSTRABILITY, OPERATIONAL

SECTION III

DECISION TASK ANALYSIS

GENERAL

To identify the characteristics of the decisions involved in each decision situation, a detailed decision task analysis was performed on the decision situations selected in the first phase. This analysis constituted the second phase of the project and provided detailed task specific information. This information may be regarded as secondary instructional content for the objective decision training program. Although the secondary instructional content is not vital to the training program, its inclusion may be desirable in some cases. The decision of whether to include the secondary instructional content will be made at the time of actual instructional material development by the instruction technologist and based on the desired level of detail and degree of task-dependency for the objective training program.

During the second phase of the contract, the "Decision Task Analysis" phase, a detailed analysis of the selected decision task areas was performed. The results of this analysis led the program into two groups of activities. The first group consisted of further research activities in the task areas in order to identify the characteristics of the decision tasks involved as well as the required facts and elements contributing to the decision making process. The second group involved theoretical analysis performed to reveal the underlying concepts, relevant decision rules, and optimal procedures for the process. The first group provides task-specific knowledge while the second provides the theoretical backup as well as domain-independent data required for the development of the guidelines for instructional materials design.

Figure 7 shows the work flow diagram of the Decision Task Analysis Phase. The following is a summary of the work accomplished during this period. The individual items are numerically indicated in Figure 7. Detailed description of major activities are presented in succeeding sections.

a. A detailed analysis of the selected decision task areas was performed. A complete study of the workbook materials as well as tape slides relating to the task areas supplied the formal data, which, together with the expert interview results, provided the background knowledge in the selected tasks. Since ditching was recognized as a critical task area related to engine quits, it was analyzed in this activity in addition to the two selected areas.

b. The decision elements involved in each decision task area were identified. The alternative courses of action for each decision and the possible outcomes for each action were specified.

c. Based on the identified decision elements, the decision trees for engine quits, land or wave off, and ditching decision task areas were constructed.

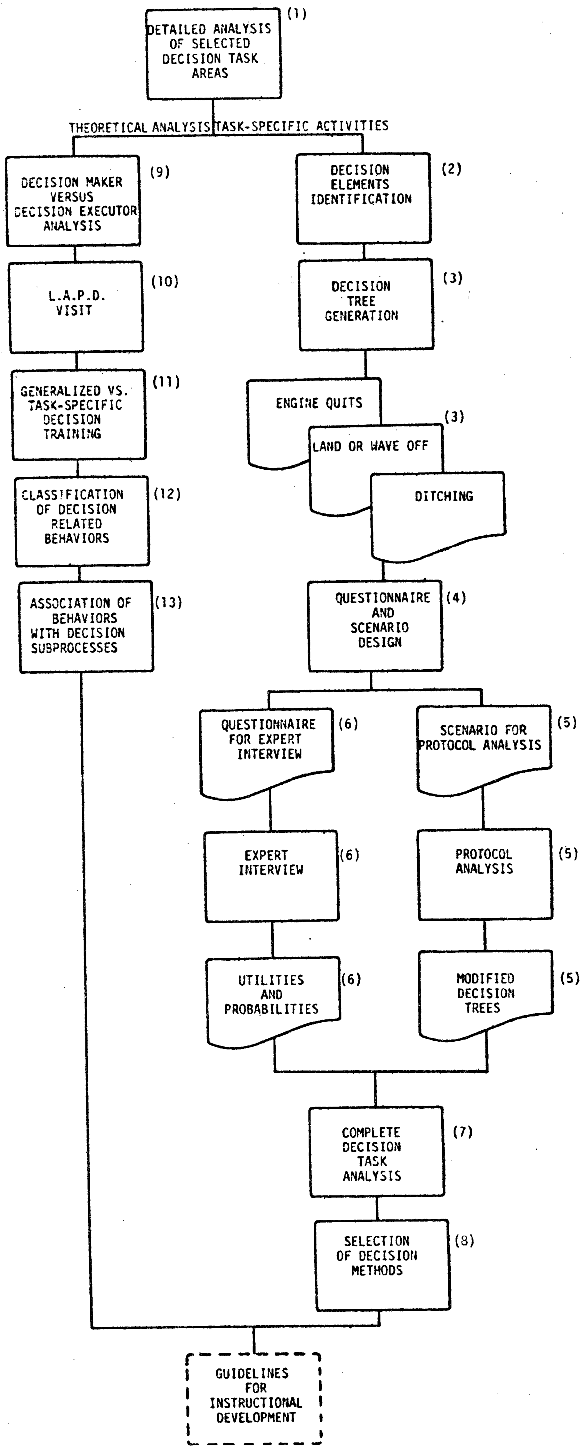


Figure 7. Work Flow For The Decision Task Analysis Phase

d. A set of questionnaires and a number of scenarios were designed to be used for examination, completion, and possible modification of the generated decision trees. The questionnaires are designed to provide the probabilities and utilities on the decision trees. The scenarios are designed to test the structure of the decision trees and acquire possible additional alternatives for decision tasks through a protocol analysis.

e. The developed scenarios were used in a protocol analysis to test the structure of the decision trees and acquire possible additional alternatives for decision tasks. LAMPS operation instructors were the participants of the protocol analysis.

f. The designed questionnaires were used to provide the probabilities and utilities on the decision trees. This information was acquired through a LAMPS operation expert interview.

g. Based on complete decision trees, all decision tasks involved in the selected decision task areas were identified. A complete decision solution for each one was directly produced from the task area decision trees.

h. Different decision making methods and procedures were analyzed and the ones suitable for identified decision tasks were selected. The analysis was heavily based on the domain-dependent knowledge acquired in the preceding activities to provide the task-specific knowledge required for development of the guidelines for instructional material design.

i. Two different roles for a human operator as a decision element were identified: an operator as a decision maker and an operator as a decision executor.

j. A visit to the Los Angeles Police Academy was made to review the "shoot/no shoot" program. The program is a decision training methodology by simulation focusing on the problem of <u>when</u> to shoot rather than <u>how</u> to shoot. Although there is no formal training in either probability theory or decision theory, there are extensive courses in the established important attributes that should be considered when deciding whether or not to shoot in a given situation. The application of a similar approach enriched with a better understanding of decision making elements was studied for the training of time-critical decision tasks (see Appendix I).

k. Two different approaches, generalized and task-specific decision training, were analyzed and the validity of each one for the decision training program was studied. In a task-specific decision training program, the task-domain knowledge is viewed as a nucleus around which decision training will be built. In this case, decision training development starts from the most task-dependent level and progresses by addition of less task-dependent levels. However, a generalized decision training program must be developed without an exact knowledge of the application domain. Therefore, the development of the training program must be such that it "contains" all possible application domains. In this approach, the program starts with the most general levels of decision training and progresses to the ones with a lower degree of generality.

l. A comprehensive list of words, phases, and terms were classified into two groups of decision related and unrelated "behaviors." The decision related group provides a list which should be used to define the instructional objectives of the decision program.

m. The decision making subprocesses were decomposed into relevant behaviors that the trainee must gain by the end of the decision training program. The list of relevant behaviors recognized by this decomposition will provide a task-independent set of data required to construct instructional objectives which, in turn, will be used in the development of instructional materials.

METHODOLOGY

A series of activites in the second phase of the project involved theoretical analysis. The activities include:

a. Identification of decision maker/decision executor

b. Identification of decision-related behaviors

c. Analysis of generalized/task-specific decision training

d. Decomposition of decision subprocesses into relevant behavioral objectives.

These activities constitute a basis for development of the methodology designed for the decision training program. Items (a) and (b) as well as an overview of decision tree representation are described in this section.

DECISION MAKER VERSUS DECISION EXECUTOR. Analysis of the possible roles of a human operator as a decision element provides information concerning the nature of the training task. Such an analysis was performed, and two different roles for a human operator as a decision element were identified: an operator as a decision maker and an operator as a decision executor. The distinction between the two roles can be defined by the degree of aiding that is provided to the operator at the time of interaction with the decision problem. If the decision problem has been analyzed prior to its actual occurrence and a general solution in terms of a reasonably specified procedure has been developed, the responsibility of the operator involved with the decision problem is to "execute" the procedure with the consideration of the problem-environmental conditions. However, if such a procedure does not exist, the operator will also be responsible for generating the procedure for selecting the decision solution (Figure 8). For critical decision tasks, the decision making performance can be increased by shifting the role of operator from decision maker to decision executor as much as possible. This objective may be partly accomplished through training.

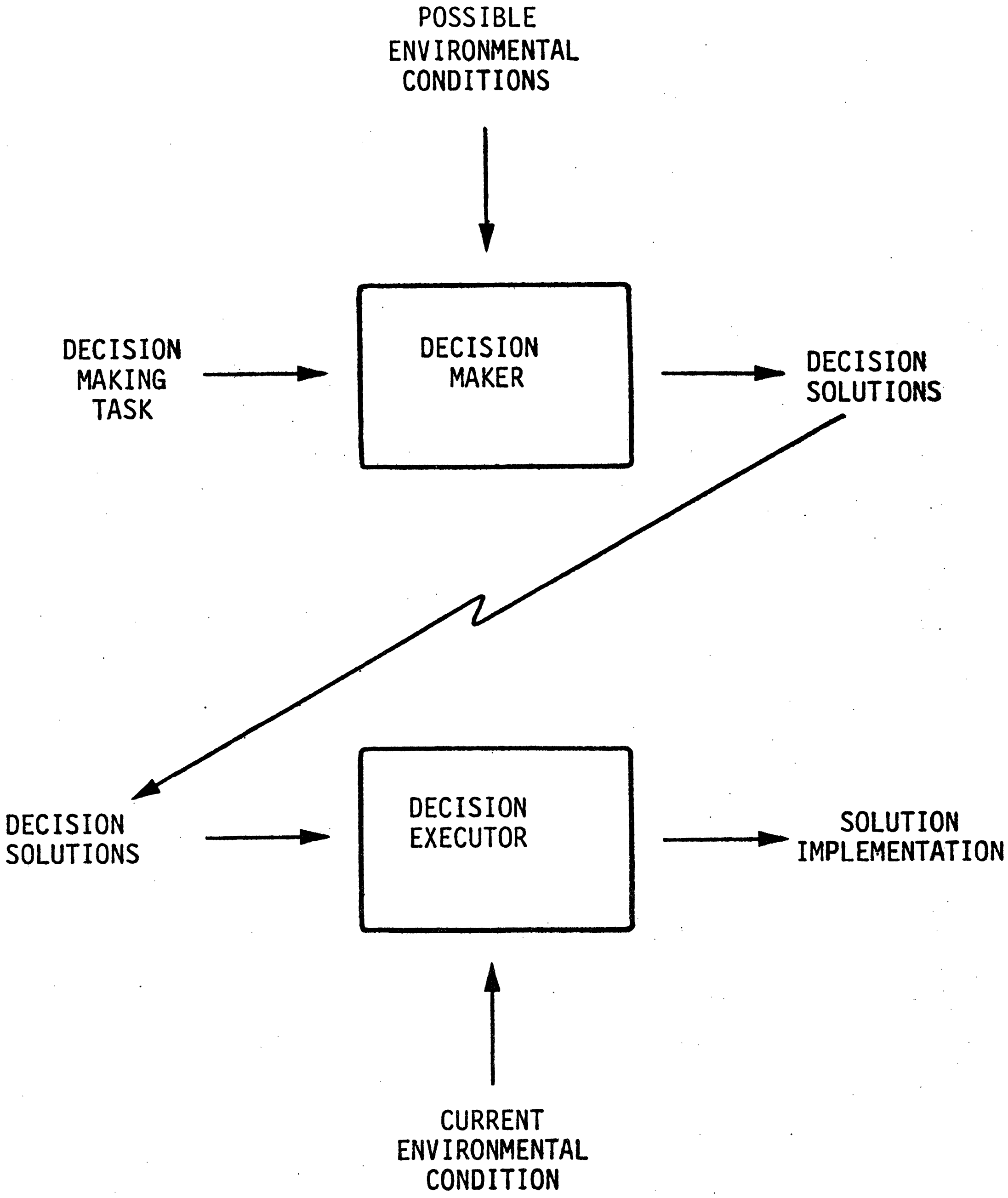


Figure 8. Decision Maker/Decision Executor

DECISION RELATED BEHAVIORS. The success of any decision training program can be evaluated by measuring the degree of improvements in a set of desirable behaviors provided by the training program at its conclusion. The set of behaviors includes the relevant cognitive abilities required to accomplish the goals of the training program: effective decision making in a specific environment. Such a set constitutes the decision training behavioral objectives. The first step to identify the decision training behavioral objectives is an analysis of different training behavioral terms. Such analysis was performed and decision-related behavioral terms for different classes of training were identified (Table 8).

DECISION TREE REPRESENTATION. A decision problem and its solution may be represented in different formats. Decision trees constitute a structured format for such a purpose. Since decision trees provide the most descriptive means for representation of decision problems, they were used to describe the results of the decision task analysis performed for each of the selected decision tasks. This method of representation is described briefly in this subsection.

A decision tree is a structural representation of sequences of anticipated decisions and events in a specific environment. A conventional decision tree is composed of three different nodes: decision nodes, event nodes, and terminal nodes. A decision node represents the alternative courses of action possible at a situation described by the path from the root of the tree to the decision node (normally indicated by a small square -- Figure 9a). An event node represents different outcomes which might occur as a result of application of a specific alternative course of action in a specific situation described by the path from the root of the tree to the preceding decision node. An event node is normally represented by a small circle (Figure 9b). A probability of occurrence is assigned to each branch emerging from an event of the corresponding event. The probabilities of events associated with each event node must sum to one. That is, the outcomes at each event node must be mutually exclusive and exhaustive. A terminal node represents an outcome which can be judgmentally assessed with reasonable accuracy. Such assessment provides a utility number which is a quantitative evaluation of the degree of desirability of the corresponding outcome in the context of the specific situation. In some cases, due to the ease of assessment, outcomes are assessed in terms of losses involved instead of utilities. In such cases, a loss number at each branch represents the degree of aversion for the corresponding outcome in the context of the specific situation. Terminal nodes are represented by a small triangle (Figure 9c).

Analysis of different decision tasks revealed the need for the introduction of a new type of node into decision trees. Such a node, called a "situation node," represents possible situations which might be encountered at a specific point on the decision tree. At the planning stage of a decision process, the involved person (the decision maker) has only a knowledge concerning all possible situations that may exist. However, unlike the case of event nodes, at the actual decision implementation time (immediately before the decision) the involved operator (the decision executor) will know with certainty which of the possible situations actually exists. Therefore, treatment of such situations was an event

TABLE 8. DECISION-RELATED BEHAVIORAL TERMS

General Instructional Objectives

Analyze
Apply
Compute
Use
Evaluate
Recognize
Think

Complex, Logical, Judgmental Behavior

Analyze
Decide
Formulate
Induce
Plan
Compare
Evaluate
Generate
Infer

Creative Behavior

Generalize
Predict
Rearrange
Modify
Question

General Discriminative Behaviors

Choose
Describe
Differentiate
Identify
Define
Detect
Distinguish
Select

Laboratory Science Behaviors

Apply
Conduct
Increase
Weigh
Calibrate
Decrease
Plan

Mathematical Behavior

Compute
Estimate
Verify
Count
Measure
Calculate

Miscellaneous

Consider
Discover
Determine

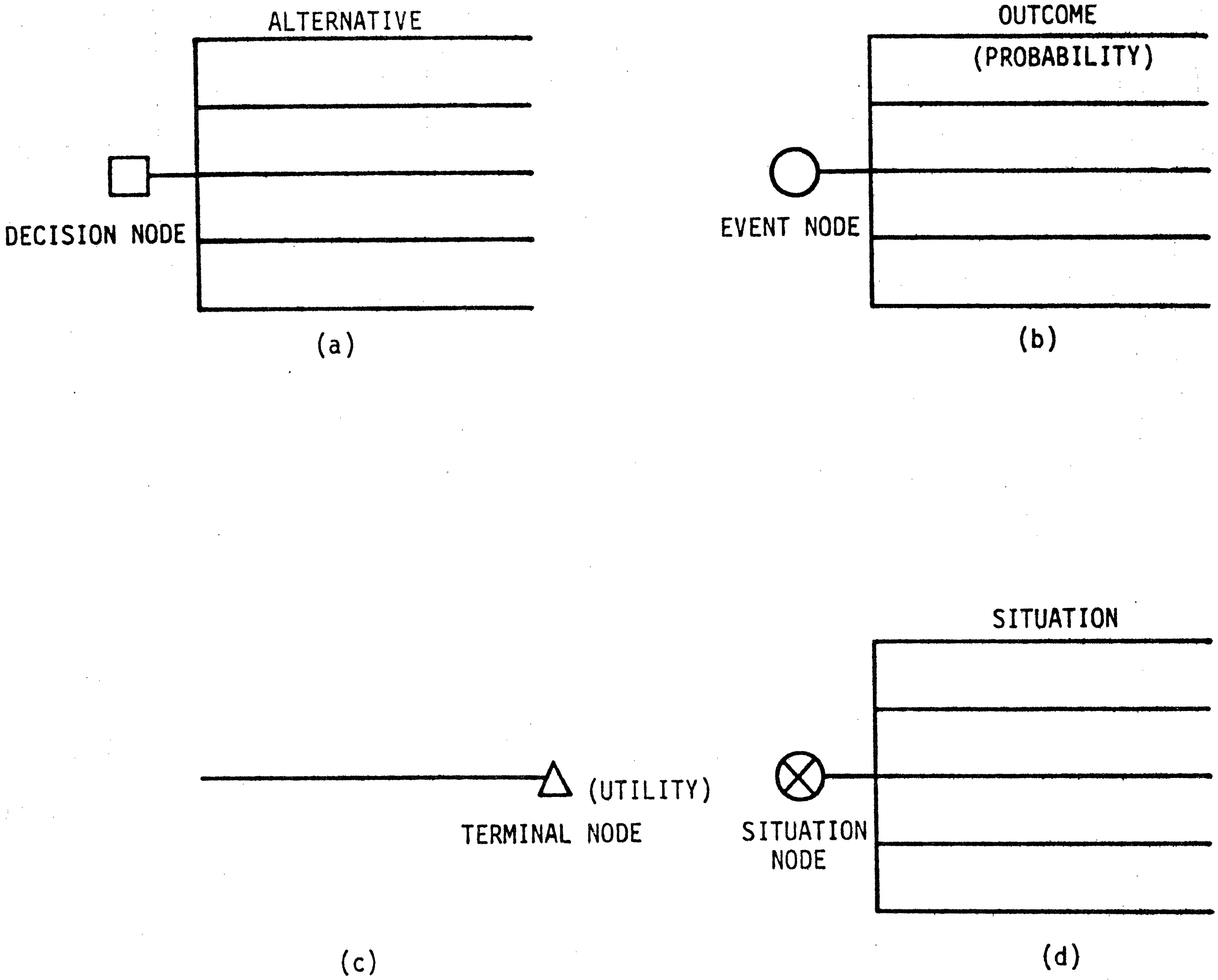


Figure 9. Decision Tree Components

node, and assignment of subjective probabilities will not provide a successful representation for the problem. Situation nodes are represented by a small circle surrounding an "X" (Figure 9d).

An example of a situation node arises when the "Engine Quits: situation is encountered. A decision maker (may be the pilot himself), who is analyzing this situation prior to actual occurrence, knows that such a situation may be caused by either a single engine failure, a dual engine failure, or a fuel starvation. He is also aware of the fact that each of these situations are different in nature and, although all may be represented by a single "Engine Quits" situation, different courses of action must be taken upon the occurrence of different situations. Therefore, this event must be divided into three possible situations (Figure 10). However, in such a case, assignment of subjective probabilities of occurrence to the three situations will not be helpful since at the time of actual occurrence of this situation, the pilot knows which of the three situations has occurred and will proceed on the branch representing that situation, regardless of the probabilities. In a way, a situation node may be viewed as an event node in which the probabilities of different branches emerging from it can not be assessed successfully at the time of decision analysis. However, at the actual decision time, just before the selection of the course of action, the probability of one of the branches becomes one and the rest will be zero. In other words, a simple observation will provide a masking scheme for the pilot to ignore the irrelevant portions of the tree and concentrate only on the subtree emerging from the branch representing the current situation. A simple example of a decision tree appears in Figure 10.

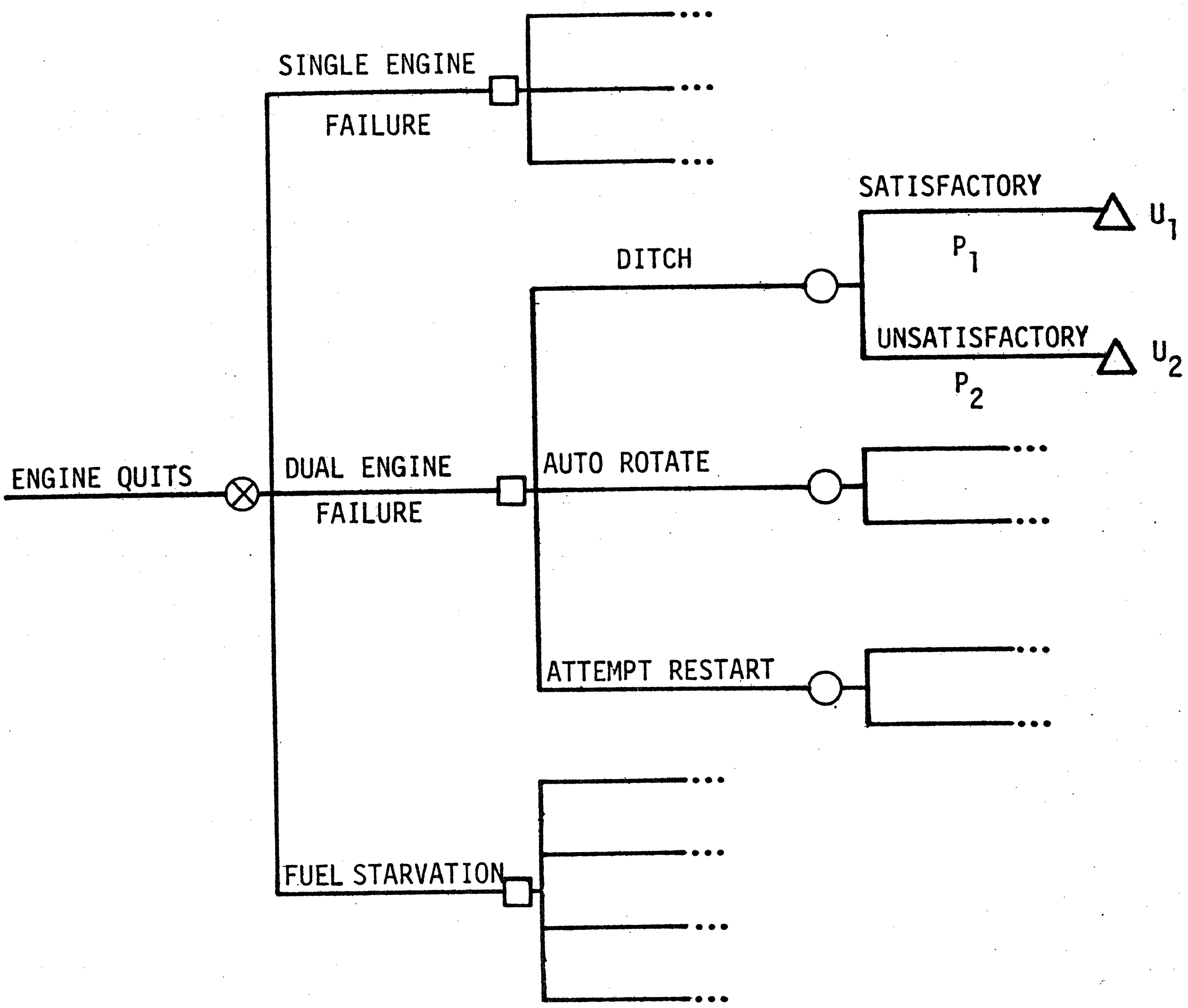
DECISION ELEMENT IDENTIFICATION

A detailed analysis of the relevant workbooks and tape slides as well as expert interviews identified the decision elements involved in the selected decision task areas. The alternative courses of action for each decision and the possible outcomes for each action were specified. The result was a large amount of data which was incorporated in the construction of preliminary decision trees for the decision task areas.

DECISION TREE ELICITATION

Bases on the results of the detailed analysis of the selected decision tasks, a preliminary decision tree was constructed for each of the decision tasks. These decision trees represent the relevant academic knowledge required for decision making in the selected areas. The structured decision tree representation provides a suitable perspective for inspecting these situations in terms of decision analysis. However, the development of the complete decision tree depends on the elicitation of non-academic pieces of knowledge from the experts. These pieces of knowledge result from experience, and since there is no formal way of teaching such items, they are usually not included in training materials. The process of decision tree elicitation from experts can capture such knowledge and represent it in a formal structure.

To implement this approach, a set of scenarios and a series of questionnaires were developed and used to elicit the complete decision



P_1 and P_2: Probabilities such that $P_1 + P_2 = 1$

U_1 and U_2: Utilities

Figure 10. Example Of A Decision Tree Structure

trees. The scenarios were used in protocol analyses to modify the structure of the trees, and the questionnaires were utilized in expert interviews to provide probabilities of different outcomes as well as the utilities of the terminal nodes. The protocol analyses and the expert interviews are described in the following subsections. The complete decision trees for "engine failure" and "land or wave off" appear in Appendices F and G, respectively.

PROTOCOL ANALYSIS. A protocol analysis was performed to check the structure of the preliminary decision tree. A scenario was developed to acquire alternative courses of action at each decision node, and possible outcomes at each event node. A sample scenario appears in Table 9. The complete list of scenarios and the questions to be answered by the protocol analysis is included in Appendix H. Four LAMPS ASW instructors were participants in the protocol analyses. The results of the analyses provided the experience-oriented knowledge which was utilized to modify the structure of the preliminary decision trees.

EXPERT INTERVIEW. Once the structures of the decision trees were completed, probabilities of different outcomes and utilities of different terminal nodes were judgmentally assessed. To accomplish this objective, four LAMPS ASW instructors were interviewed. To simplify the process of eliciting subjective probabilities the participants were asked to assign a number to each outcome such that the number represented the relative chance of occurrence of the corresponding outcome. In this case, the participants were not obliged to provide probabilities which add up to one. Therefore, the elicitation process proceeded more efficiently. Since the protocol analyses had provided the exhaustive list of all possible outcomes at each event node, a simple normalization procedure, using chances of outcomes emerging from each event node, calculated the final probabilities of the outcomes. To provide further simplification, the participants were asked to order the outcomes emerging from each event node according to their chance of occurrence prior to actual assessment of the probabilities. With such a procedure, the process of probability assessment was performed in an informal manner, and without too much emphasis on the theoretical notion of probabilities. Table 10 represents a sample questionnaire for probability assessment. The results of the probability assessment are indicated on the decision trees in Appendices F and G.

Five major elements were identified as basic attributes for the terminal outcomes. These include (1) total damage to the aircraft, (2) partial damage to the aircraft, (3) loss of pilot life, (4) loss of sensor operator's life, and (5) loss incurred from mission failure. At each terminal node, an informal multiattribute utility analysis was performed on the five attributes. To perform such analysis, the degree of severity of each attribute was elicited from each participant. The questionnaire used for this process appears in Table 11. In these situations, the assessment of the degree of aversion is more natural than the assessment of the degree of desirability. Therefore, instead of utilities, the losses incurred by different attributes were assessed. The results of this assessment by the four participants appear in Table 12. The degree of aversion for each of these situations is different in wartime compared to a training environment

TABLE 9. SAMPLE SCENARIO FOR PROTOCOL ANALYSIS

Consider yourself engaged in each of the following scenarios. Describe what might happen in terms of the possible alternative courses of action, possible states of nature, and the outcomes associated with each combination of a state of nature and a course of action.

- You have a single engine failure while flying over land. One engine is sufficient for the weight of the aircraft and there is a safe site in the area.

TABLE 10. SAMPLE QUESTIONNAIRE FOR PROBABILITY ASSESSMENT

We want to know the probability that each outcome occurs. You are asked to consider each outcome and tell me how often you think these situations occur. For example, in the land or wave off situation, you have decided on a running landing: under these conditions, how often are you going too fast, how often is the sink rate too high, how often is it OK?

Please use this scale for each event and try to give me a number to represent the relative chance of occurrence of each event.

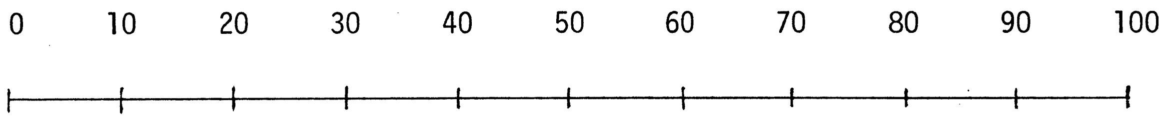


TABLE 11. LOSS ASSESSMENT FOR MAJOR OUTCOME ATTRIBUTES

Determine the value for each of the following components of loss on a scale from 0 to 1000.

1. A/C total damage
2. A/C partial damage
3. Loss of pilot's life
4. Loss of sensor operator's life
5. Loss incurred from mission failure

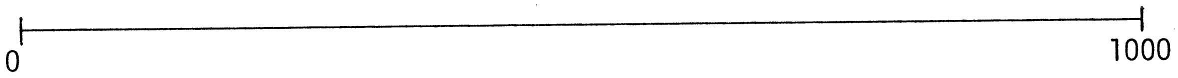
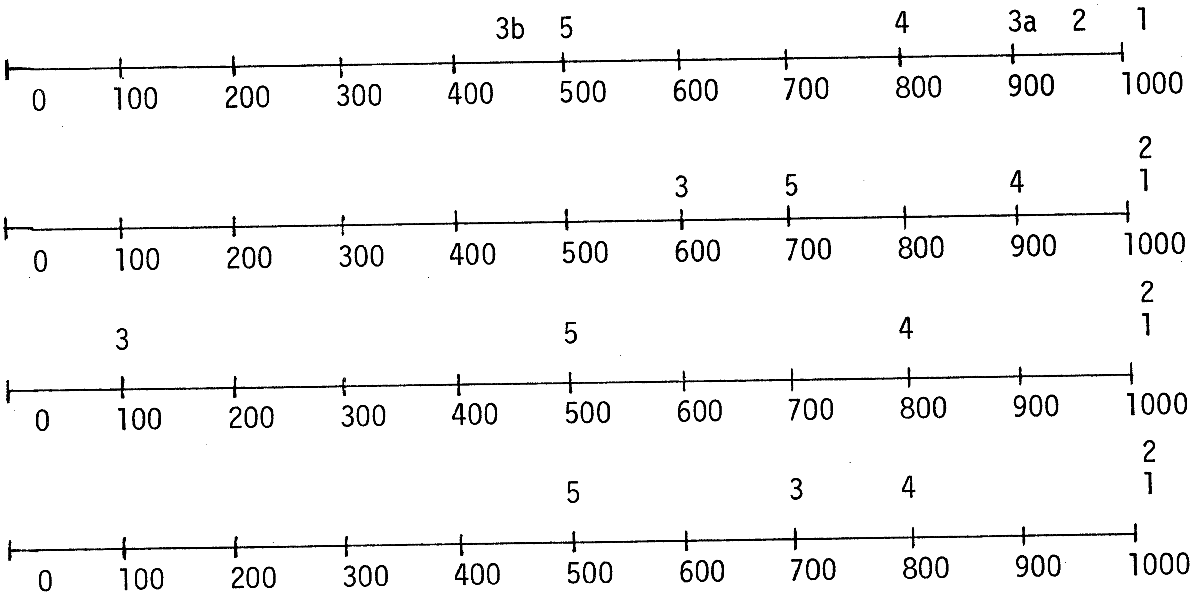


TABLE 12. THE RESULTS OF LOSS ASSESSMENT FOR THE FIVE MAJOR OUTCOME ATTRIBUTES

1. Loss of Pilot's Life
2. Loss of Sensor Operator's Life
3. Loss of Mission
   a. Major
   b. Minor
4. A/C Total Damage
5. A/C Partial Damage



in peacetime. Since the participants were the experts in a peacetime training environment, the losses were assessed for a peacetime condition. The results of the loss assessment also indicated the differences among different participants' scales. This information was incorporated in the aggregation of the losses assigned by different participants to the same outcome. A sample questionnaire for expert interview is presented in Table 13. The results of the loss assessments are indicated on the decision trees of Appendices F and G.

TABLE 13. SAMPLE QUESTIONNAIRE FOR EXPERT INTERVIEW

In a training environment (during peacetime) when one engine is not sufficient for the total weight of the aircraft, what is the chance that after jettisoning:

A) The aircraft will be light enough so that one engine is sufficient? ______________________________

B) The aircraft will not be light enough so that one engine is sufficient? ______________________

A dual engine failure occurs when flying over water. How do you assess the losses incurred from each of the following possible outcomes on a 0 to 1000 scale:

A) Loss of Aircraft? __________________________

B) Loss of Aircraft and Injury? _________________

C) Loss of Aircraft and Loss of Life? ____________

SECTION IV

INSTRUCTIONAL GUIDELINE DEVELOPMENT

GENERAL

The analysis of the selected decision tasks identified the characteristics of decision tasks involved in operational systems. Based on this information, a system for decision training guideline generation was designed to be used as a development aid for decision training programs in operational systems. The design objective was to develop a system to provide instructional guidelines presented in a form suitable for incorporation into the specification of instructional objectives, the planning of strategies, the selection of media, and the other steps required for the production of instructional materials for decision tasks. The system uses quantification schemes to incorporate expert knowledge into the guideline generation process. A systematic, step-by-step process identifies the system functions of the decision training guideline generator. The process involves (1) decision task identification, (2) decision type recognition, (3) decision task classification, (4) instructional content generation, (5) cognitive level weighting, (6) instructional method selection, (7) method/media relevance detection, and (8) instructional media selection. A description of the methodology, as well as the modules of the decision training guideline generation system, is the subject of the following:

METHODOLOGY

Current efforts in the development of decision training systems have usually evolved in the context of task-specific systems (e.g., medical, tactical, managerial, etc.). A training system for decision makers that is developed within the context of such a task-specific domain, without incorporation of general purpose decision training components, does not provide trainees with the skills required for making task-specific decisions within other domains. Furthermore, since the characteristics of decision tasks within any specific domain may be subject to change with time, such training systems will not even provide useful long-term guidelines within the trainee's own domain. In these systems, the decision maker learns a tailor-made set of conceptual components, procedures, techniques, heuristic rules, parameters, and values unique to that particular system at the time of training (Figure 11). The set of concepts that the potential decision maker learns is in reality a very specific subset of more general conceptual components, procedures, and techniques. Yet, he never becomes aware that, in fact, it is a subset of the more general set because it is outside the training boundary. Hence, if a decision maker is transferred to a new decision making domain, or the characteristics of the decision tasks within his decision domain change, he typically has two choices: he must either enter a new task-specific decision training program (and learn another unique conceptual subset again without realizing its relationship to the first subset learned), or he must learn to invent his own conceptual set without the benefit of a formal training program. In the latter case, the decision maker is without a formal guide, and often attempts to "cram" his new world into a conceptual subset learned for an entirely different decision task.

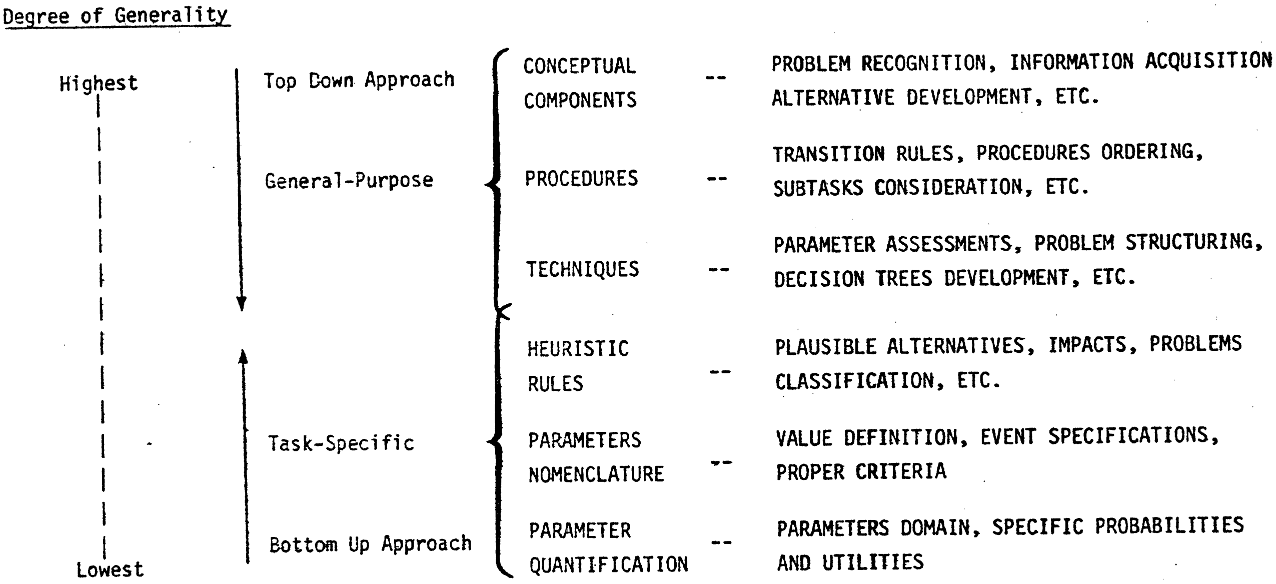


Figure 11. Levels of Decision Training

In the development of the decision training guideline generation system, transferability was one of the basic design considerations. Although the project has been initially aimed to develop a systematic procedure for providing instructional guidelines for decision tasks encountered in LAMPS ASW Operation, a generalized methodology was developed to underlie the design in order to make the application of the system to other task domains subject to minimal modification effort.

The project started with an analysis of tasks involved in the operator's job. Decision tasks were identified and analyzed. The result of the analysis was a detailed decision tree for each decision task which provided the task-specific knowledge. For each task, the parameters involved were identified and quantified. Heuristic rules and techniques relevant to decision making process for the tasks were selected and considered for the training program. However, a training system development approach based solely on the above task specific knowledge, without incorporation of general purpose decision training components, will limit the scope of the system. To avoid this problem and to provide for adaptability to new decision situations, information concerning general decision making behavioral objectives were included in the design of the system.

DECISION TRAINING BEHAVIORAL OBJECTIVES. Although a task specific decision training system is built around a nucleus of task specific knowledge, its primary objective is to create the required decision making "behaviors" in trainees. Since there is a common underlying set of skills required for performing every decision making task, a set of general decision making behaviors, associated with those skills, can be identified as behavioral objectives for any decision training system. These behavioral objectives will provide the required general purpose decision training components for the system. Identification of such decision training behavioral objectives is the subject of this section.

Different structures of conceptualizing decision processes have been proposed. Some conceptualizations emphasize differences among decision situations; other focus on the tasks that decision makers are required to perform. Nickerson and Ferhrer (1975) present an overview of these structures.

Adelson (1961) proposed a taxonomy of decision tasks that are carried out in modern command and control systems:

a. Characterization of the state of the world

b. Determination of the available action alternatives

c. Outcome prediction

d. Choice rationalization

Six steps for a business executive decision making process have been identified by Drucker (1967) as:

a. Classification of the problem

b. Definition of the problem

c. Specifications that the answer to the problem must satisfy

d. Decision as to what is right

e. Building into the decision, the action to carry it out

f. Feedback which tests the validity and effectiveness of the decision against actual course of events.

The following thirteen steps are suggested by Edwards (1965) as different categories of activities that must be carried out by any Bayesian decision maker:

a. Recognition of the existence of a decision problem

b. Identification of available actions

c. Identification of relevant states that determine payoff for actions

d. Identification of the value dimensions to be aggregated into the payoff matrix

e. Judgmental evaluation of each outcome and each dimension

f. Aggregation of value judgments into a composite payoff matrix

g. Identification of information sources relevant to discrimination among states

h. Data collected from information sources

i. Data filtration

j. Estimation of likelihood ratios

k. Aggregation of impact estimates

l. Selection of best alternative by expected value maximization

m. Implementation of the decision.

Hill and Martin (1971) have recognized six different steps involved in the decision making process.

a. Identification of concern

b. Diagnosis of situation

c. Formulation of action

d. Test of feasibility of selected alternatives

e. Adoption of alternative

f. Assessment of consequences of adopted alternative.

A more structured conceptualization of the decision making process has been performed by Schrenk (1969):

a. Problem recognition, involving:

- Information acquisition
- Objective recognition
- Decision need perception
- Problem urgency and importance assessment

b. Problem diagnosis, involving:

- Definition of possible situations
- Evaluation of situation likelihoods
- Determination of whether more information is needed
- Identification of possible data sources
- Judgment of value versus cost
- Seeking of information
- Diagnosis of decision situation
- Determination of whether alternatives under consideration account for all the data
- Diagnostic decision.

c. Action Selection, involving:

- Definition of action goals
- Specification of value and time criteria
- Weighting of decision criteria
- Specification of risk philosophy
- Consideration of operating doctrine
- Generation of action alternatives
- Prediction of possible outcomes
- Estimation of outcome gains and losses
- Estimation of outcome likelihoods
- Evaluation of expected values of action versus their costs
- Evaluation of actions by risk philosophy
- Determination of whether more information is needed
- Seeking of information
- Re-evaluation of action alternatives
- Determination of whether the action if acceptable
- Selection of course of action
- Implementation of course of action.

Soelberg (1966) suggests six aspects of the decision making process as:

a. Problem recognition
b. Problem definition
c. Planning

d. Search
e. Confirmation
f. Implementation

An analysis of these alternative conceptualizations reveals the common underlying structure existing in all of them. This common structure identifies a decision task to be composed of either or both of two major subtasks: problem structuring and alternative selection. Each major subtask, in turn, may be further subdivided into a number of smaller subtasks. Problem structuring can be divided into alternatives formulation and outcome identification; alternative selection can be partitioned into utility assessment, probability assessment, decision rule application, and best alternative selection (Figure 12). The possible transition between subtasks in a decision making process is outlined in Figure 13.

The six subtasks appearing as tip nodes in Figure 12 represent the general decision making components which must be included in a decision training program. These components are restated as instructional objectives:

a. Formulate alternative courses of action for a given decision situation.

b. Establish outcomes of a given course of action for a given decision situation.

c. Assess the utility of a given outcome in a given decision situation.

d. Assess probabilities of a given set of events which may occur as a result of a given alternative course of action in a given decision situation.

e. Apply a relevant decision rule to a given decision situation.

f. Select the best alternative course of action for a given decision situation.

Each instructional objective is defined in terms of specific learning outcomes, that is, a representative sample of specific types of behavior that is to be used as evidence that the objective has been achieved. The derived behavioral objectives associated with each instructional objective are shown in Table 14.

INSTRUCTIONAL GUIDELINE GENERATION SYSTEM

Based on the methodology developed in this chapter, a system was designed to provide guidelines for the development of training programs in the area of decision making. The guidelines include the suggestion of instructional contents, methods, and media compatible to the specific decision task as well as characteristics, requirements, and resources of the training center.

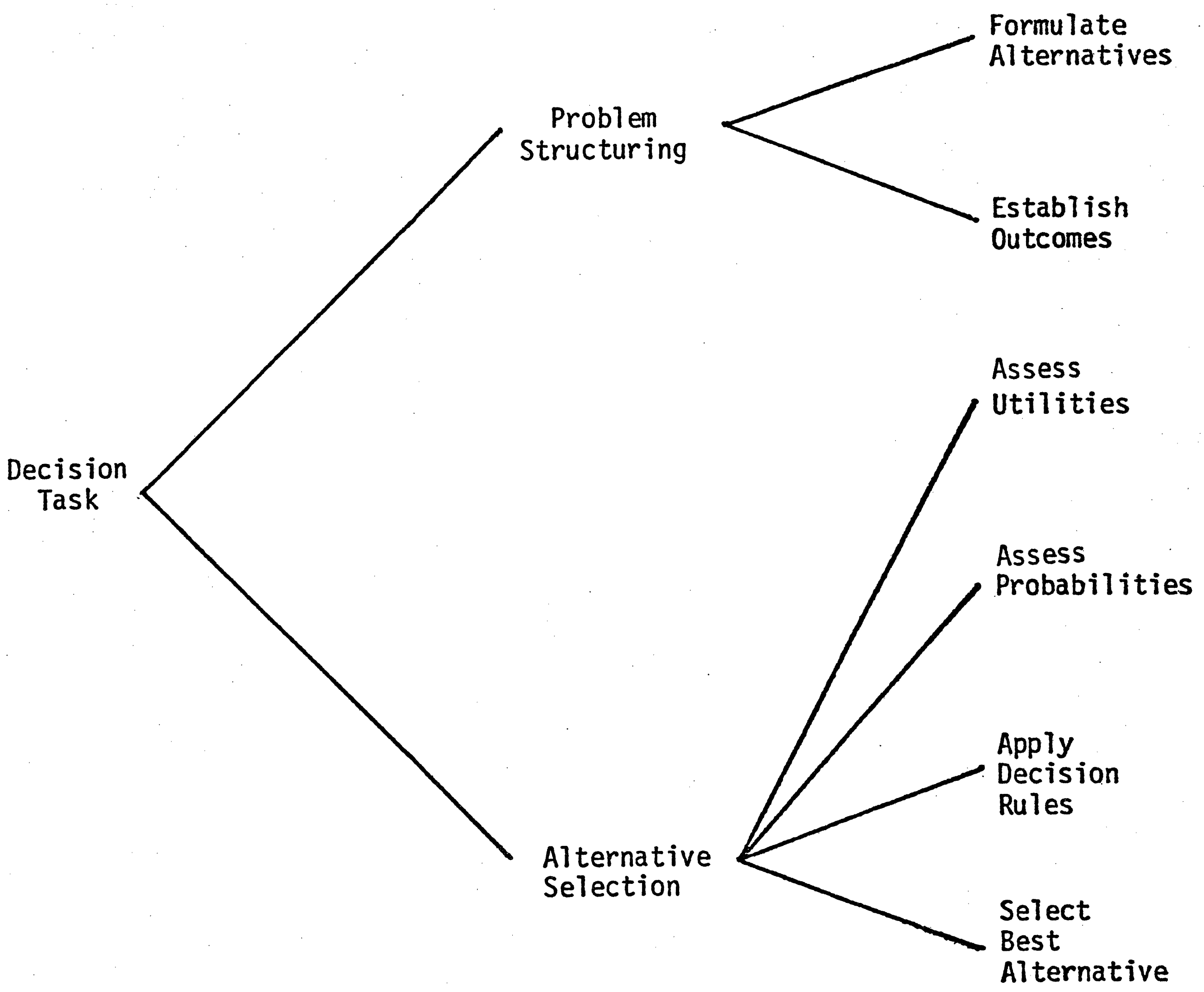


Figure 12. Decision Making Subtasks

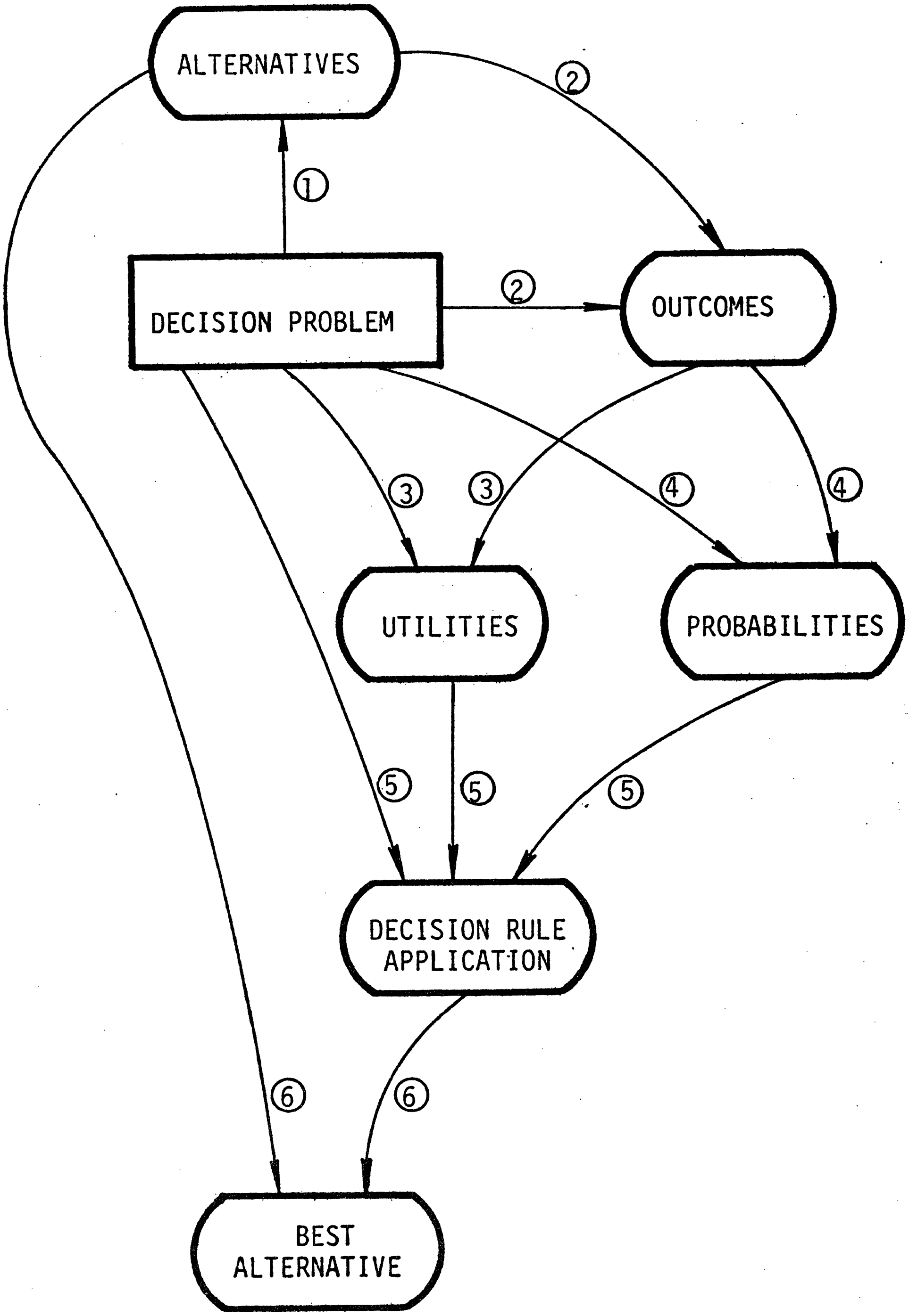


Figure 13. Transition Between Decision Making Subtasks

TABLE 14. DECISION TRAINING BEHAVIORAL OBJECTIVES

1. Formulate alternative courses of action for a given decision situation.

    1.1 Identify the variable(s) and parameter(s) in the decision situation.

    1.2 Classify each of the variables/parameters of a given set as relevant or irrelevant to the decision situation.

    1.3 Identify constraints on each variable/parameter based on the statement of decision situation and general domain knowledge.

    1.4 Define solution range (set) of the variable(s) for the decision situation.

    1.5 Generate a set of alternatives using some or all of the variables/parameters.

    1.6 Identify those alternatives which are feasible in light of constraints on individual variables, statement of decision situation, and general domain knowledge.

TABLE 14. DECISION TRAINING BEHAVIORAL OBJECTIVES (CONTINUED)

2. Establish outcomes of a given course of action for a given decision situation.

    2.1 State the possible events that may occur as a result of application of the alternative course of action to the decision situation.

    2.2 Identify the variables in the decision situation that will be affected if a particular event occurs as a result of application of the alternative course of action to the decision situation.

    2.3 State the resulting decision situation in terms of the variables when a particular event occurs as a result of application of the alternative course of action to the decision situation.

TABLE 14. DECISION TRAINING BEHAVIORAL OBJECTIVES (CONTINUED)

3. Assess the utility of a given outcome in a given decision situation.

    3.1 State the possible external effects of the outcome on the decision situation.

    3.2 State the likelihood that a given external effect will result from the given outcome in the decision situation.

    3.3 Identify whether a given effort of the outcome is favorable or unfavorable for the decision situation.

    3.4 State the degree of importance of a given external effect resulted from the outcome from the decision situation.

    3.5 Estimate the aggregate utility of the outcome based on the given possible external effects with given chances of occurrence, given direction of effect (negative effect or positive effect), and given magnitude of importance.

TABLE 14. DECISION TRAINING BEHAVIORAL OBJECTIVES (CONTINUED)

4. <u>Assess</u> probabilities of a given set of events which probably will occur as a result of a given alternative course of action in a given decision situation.

    4.1 <u>Identify</u> the event with the highest chance of occurrence among the set of events.

    4.2 <u>Sort</u> the set of events according to the order of likelihood of occurrence in the decision situation.

    4.3 <u>Assign</u> likelihood values to the given ordered list of events in relation to the decision situation.

    4.4 <u>Calculate</u> probabilities of events for the given ordered list of events with given likelihood values by normalizing the likelihood values.

TABLE 14. DECISION TRAINING BEHAVIORAL OBJECTIVES (CONTINUED)

5. Apply a relevant decision rule to a given decision situation.

    5.1 Name all decision rules.

    5.2 Describe the procedure for applying each decision rule.

    5.3 State the advantages and disadvantages involved in application of each decision rule.

    5.4 Define the criteria and procedure for selection of a decision rule based on the characteristics of the given decision situation and advantages/disadvantages of the available decision rules.

    5.5 Select the best decision rule for the given decision problem by comparing each decision rule in terms of the criteria defined and selecting the most desirable one on the basis of relative merits with respect to the decision problem.

    5.6 Apply a given decision rule to the given decision problem.

TABLE 14. DECISION TRAINING BEHAVIORAL OBJECTIVES (CONTINUED)

6. Select the best alternative course of action for a given decision situation.

    6.1 Name all selection criteria for the best alternative.

    6.2 State selection criteria relevant to a given decision rule.

    6.3 Select the best selection criterion for the given decision situation, based on a given decision rule.

    6.4 Apply a given selection criterion to the given decision situation after the application of a given decision rule.

The instructional guideline generation system is basically composed of two modules: Decision Task Classification, and Decision Training Guideline Generator (Figure 14). A task, which has been already identified as a decision task, enters the Decision Task Classification module. This module acts as a preprocessor which associates the task with one of the decision classes relevant to the training objectives. The output will be class information which enters the Decision Training Guideline Generator Module. Based on the classification result, as well as training environment characteristics, requirements, and resources, the module suggests the required instructional content and the best instructional methods and media for the input decision task.

A detailed diagram describing the relationships among different components of the system is shown in Figure 15. A brief description of the eight components and their interactions as well as the input/output of the system is described in the remainder of this section. In what follows, attention must be paid to the fact that the implicit procedure defined by the system is being performed (operated) by an instructional technologist.

Decision Task Identification receives any training task presented in the objective hierarchies and works as a filter which separates decision tasks from non-decision tasks. The specification of this component follows the definition of a decision task:

a. The objective of a decision task is to select an alternative from a specified set of alternatives.

b. This selection may require the formulation of alternatives (problem structuring).

c. There is a lack of completely specified criteria for either alternative formulation or alternative selection.

The output of the component is the identification of the input task either as a decision task, which causes the task to enter the Decision Type Recognition and Decision Task Classification components, or as a non-decision task, which results the initiation of a conventional ISD procedure.

Decision Type Recognition receives a decision task and identifies it as Type 1, Type 2, or Type 3. Type 1 represents decision tasks with processes requiring only problem structuring; Type 2 includes all decision tasks concerning only action selection; Type 3 is composed of all decision tasks which require both problem structuring and action selection. The information concerning the type of the decision task enters Decision Task Classification and Cognitive Level Weighting components.

Decision Task Classification is based on a procedure similar to that of discriminant analysis. To distinguish between classes of decision tasks, a collection of discriminating variables is selected that measures characteristics on which the classes are expected to differ, that is, training content requirements. Thirty different classes constitute the set of possible classes relevant to decision training. The decision task and

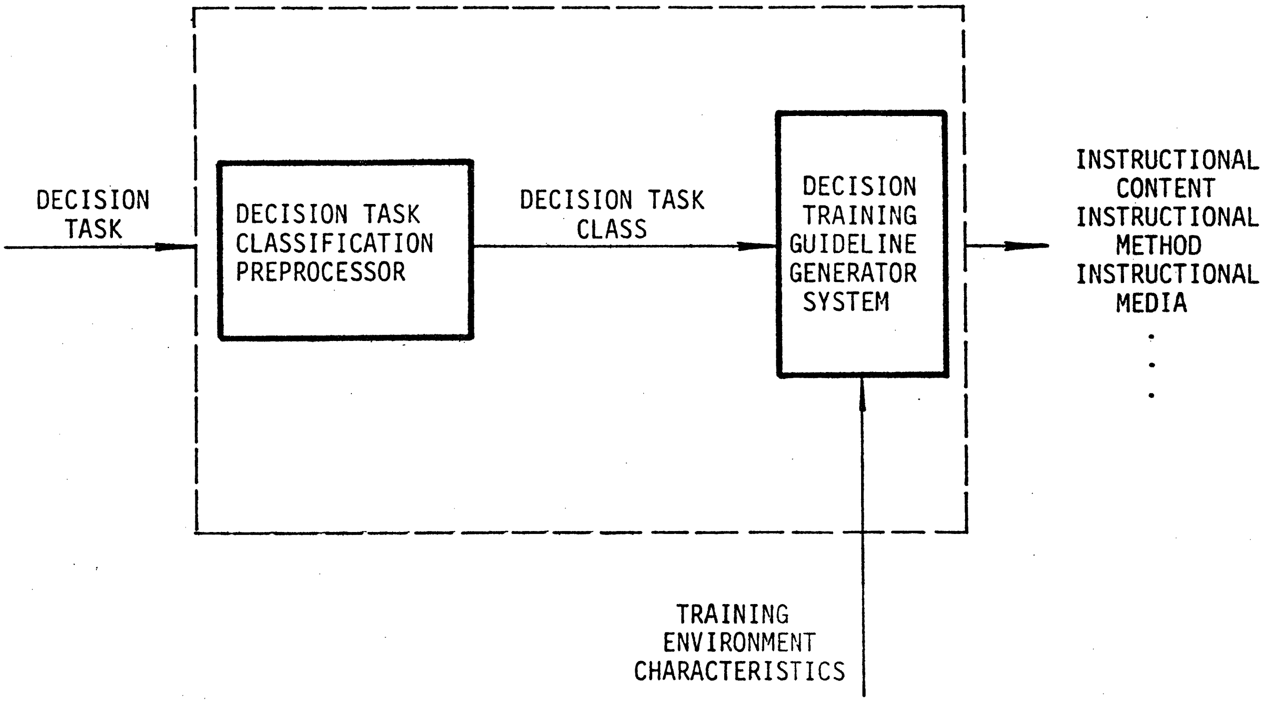


Figure 14. Overview of Instructional Guideline Generation System

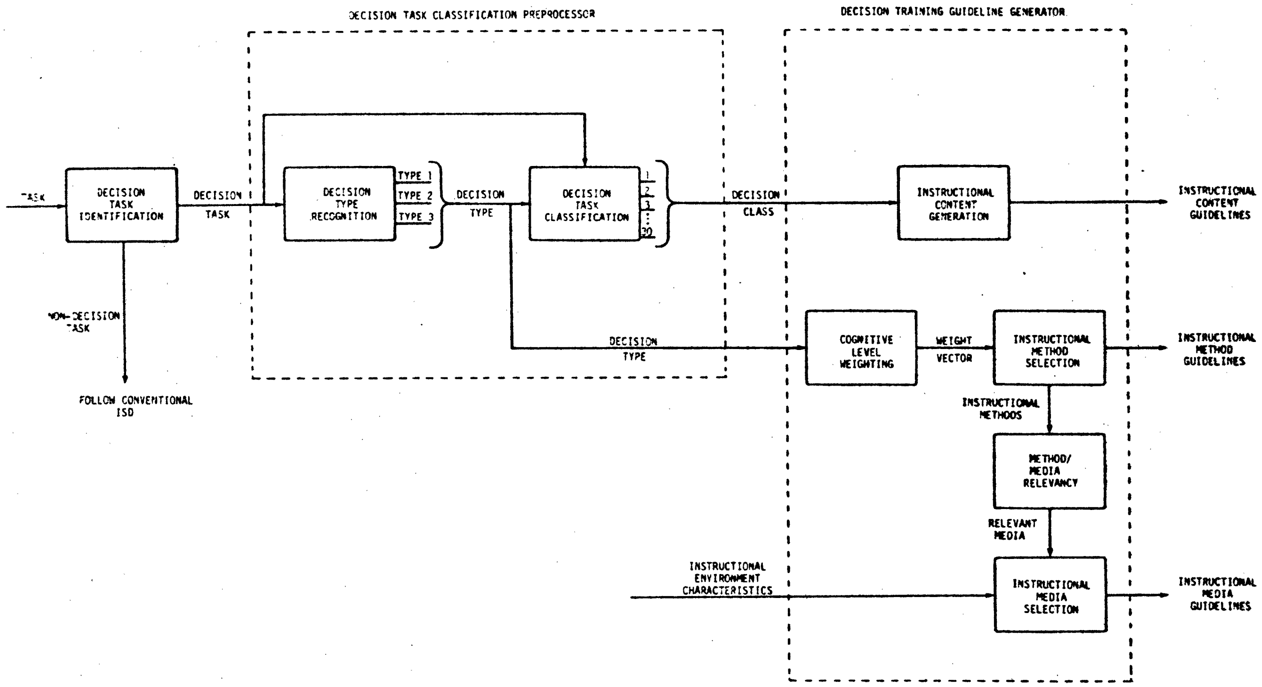


Figure 15. Decision Training Guideline Generation System

the information concerning its type enter the Decision Task Classification component. The output of the component represents the class of the decision task which is sent to the Instructional Content Generation component.

Instructional Content Generation receives the information about the class of the decision task and generates the required instructional contents. Since a set of basic instructional contents is associated with each class, the process involved is a simple table look-up. The basic instructional content appears as part of the system's output which together with the task-specific information presented in decision trees, constitute required instructional content for the decision training program.

Cognitive Level Weighting receives the decision type and selects a cognitive level weight vector. The idea of a cognitive level weight vector was initiated by the fact that the training objectives for different tasks with unequal cognitive complexity can be accomplished differently depending on the instructional method employed. Such dependency between cognitive complexity and instructional method suggested a detailed analysis of cognitive levels involved in the performance of each decision behavior. The result of the analysis was the identification of a cognitive level weight vector associated with each decision type. Each vector presents the degree of importance of the six cognitive levels with respect to the corresponding decision type. The six cognitive levels include: knowledge, comprehension, application, analysis, synthesis, and evaluation. Since a weight vector is assigned to each decision type, the process involved is a simple table look-up. The selected cognitive level weight vector is sent to Instructional Method Selection component.

Instructional Method Selection receives the cognitive level weight vector, incorporates it with the data in the method/attribute matrix, and results in the most effective instructional method. The method/attribute matrix represents the judgmental evaluation of the degree of effectiveness of fourteen major instructional methods with respect to the six cognitive levels. The judgmental data was provided by a training specialist and a psychologist. A weighted average procedure is used to calculate a degree of effectiveness for each instructional method with respect to the decision task. The method with the highest degree of effectiveness is selected as the most effective instructional method and appears as part of the system's output.

Method/Media Relevancy Detection receives the selected instructional method and, using the method/media relevancy matrix, identifies the media relevant to the selected method. Since some instructional media are not applicable to a training environment employing a specific instructional method, a study of the relevancy of each of the twelve instructional media with respect to each instructional method was performed. The result of the study dichotomized the relevant and irrelevant media for each instructional method. These results appear in the method/media relevancy matrix. The relevant instructional media are identified by a reference to the method/media relevancy matrix, and the information is sent to the Instructional Media Selection component.

Instructional Media Selection receives the relevant media and, using the media/attribute matrix and the weights of different attributes with respect to the training environment, selects the most effective media. The degree of effectiveness of each instructional media with respect to different attributes was judgmentally assessed by a training specialist. During system's application, the system user instructional technologist will provide a weight vector which identified the degree of importance of different attributes of the instructional method with respect to the specific training environment. Then, a weighted average procedure will be used to calculate the degree of effectiveness of each relevant instructional media with respect to the decision task. The media with the highest degree of effectiveness is selected as the most effective instructional media and appears as part of the system's output.

DECISION TASK CLASSIFICATION PREPROCESSOR

The decision task space can be divided into different classes such that each class represents a set of decision tasks with some degree of similarity with respect to their training requirements. The inter-class similarity will then suggest implementation of similar instructional content, method, and media for all decision tasks belonging to the same class. The classification scheme must be oriented toward training and its discriminant elements must be designed based on decision task differences which suggest different training strategies.

Such a classification scheme was designed with two components: decision type recognition and decision task classification. Decision type recognition is based on the methodology described in Chapter 2. Three different types of decision tasks are identified. Type 1 represents decision tasks with processes requiring only problem structuring; type 2 includes all decision tasks concerning only action selection; type 3 is composed of all decision tasks which require both problem structuring and action selection. Since the processes involved in problem structuring are of different cognitive complexity than the ones involved in action selection, the training processes for the tasks belonging to different decision types must be conducted differently. Such differences in training processes will be specified in terms of the guidelines for instructional content, method, and media.

In constructing the second component, decision task classification, the objective is to provide a procedure which assigns each decision task to a category associated with the most relevant instructional strategy. If all decision tasks can be so categorized into a given number of classes, and if training can be developed for each class, then any decision task may be easily categorized and appropriate training programs easily developed for it.

This procedure is similar to that of discriminate analysis. Discriminant analysis begins with the desire to statistically distinguish between two or more groups of cases (in this instance, a case would be decision task and discriminant analysis would be a means of distinguishing among two or more classes of decision tasks). To distinguish between classes, a collection of discriminating variables is selected that measures characteristics on which the classes are expected to differ. Ideally, discriminating variables are assigned to classes in such a way that the separation of the classes is maximized. A set of variables was designed which provides satisfactory discrimination for decision tasks with known class membership. The classes have been identified, and the classification of any new decision task with unknown membership can be accomplished.

The key to developing a decision task classification scheme is the identification of the variables or decision task attributes to be used as discriminating variables.

There are many attributes associated with decision making tasks. The following represents a preliminary listing of the ones most relevant to a training program.

a. Single attribute - multi-attribute

b. Individual - group

c. Static - dynamic

d. One shot - repetitive

e. Certainty - risk/uncertainty

f. Abstract (general) - concrete (task specific)

g. Well defined - ambiguous

h. Decision making - decision execution (Note: this characteristic follows a convention developed in this project.)

i. Time critical - time relaxed

j. Small probability high loss - normal ranges for probability and loss

k. Type 1 (problem structuring), type 2 (alternative selection), and type 3 (problem structuring and an alternative selection). (Note: This characteristic follows a convention developed in this project.)

l. Decision rule (SEU, EV, Mini-max, Maxi-min, etc.)

Each attribute describes a different dimension of decision making and represents a different "pigeon hole" in which a decision task could be categorized. Given this set of 12 attributes, and allowing for seven different and mutually exclusive types of decision rules provides a very modest listing of decision classes, compared to all possible classes that are potentially available to decision makers. However, even with such a list, the implications as to the number of classes into which decision tasks could be discriminated is enormous. Clearly, this many classes is neither feasible nor desirable. What assumptions can be reasonably made to reduce this number of classes to a more manageable number? First, since we are interested in training ATO's and

Pilots in the LAMPS ASW operation, we can assume that the decision tasks, and hence training, will focus on individual decision makers. Next, assume that all decisions are repetitive decisions. That is, although a decision is unique to a particular ASW mission and the parameters of that mission, an outside observer would find that there is a great deal of similarity in the decision tasks across all pilots and ATO's and across all ASW missions. For example, the decision of what sonobuoy pattern to drop occurs in each and every ASW mission. Also, assume that each decision is task specific rather than general. Each decision must contribute to overall mission effectiveness and, hence, must be task specific at the point in the mission at which it is made. Moreover, assume that since we are interested in training decision makers, we are not concerned here with decision executions that are the result of previously made decisions. It is also valid to assume that all decisions are made under risk and in normal ranges of probability and loss. At this point it is useful to refer to Figure 16 and Table 15 which is a more detailed representation of what a decision task classification preprocessor might look like. Note that a decision task follows one of three major flows: (1) type 1 decision, (2) type 2 decision, or (3) type 3 decision. Types 1 and 2 are of major interest, since type 3 is merely a combination of types 1 and 2. Type 1 focuses on problem structuring. The attributes of interest here are:

a. Single attribute - multi-attribute

b. Well defined - ambiguous

c. Time relaxed - time pressure

d. Static - dynamic

Since type 1 is only limited to problem structuring, decision rules are not relevant. The focus is on alternative generation and outcome estimation. Therefore, for the type 1 flow, there are 2 x 2 x 2 x 2 = 16 possible classes into which decision tasks may fall. For type 2 decision tasks, those that focus on alternative selection, the following attributes are relevant:

a. Time relaxed - time pressure

b. Decision rules

  . Subjective expected utility (SEU)
  . Maxi-min utility (MMN)
  . Maxi-max utility (MMX)
  . Mini-max regret (MMR)
  . Lexicography (LEX)
  . Hurwicz (HUR)
  . Satisfying (SAT)

Since the focus here is on alternative selection, there are 2 x 7 = 14 classes into which type 2 decision tasks may be sorted. Type 3 decision tasks can be sorted using the type 1 and type 2 classes in conjunction. There are, therefore, 16 x 24 = 224 classes into which type three decision tasks may be sorted, but since these classes are simply combinations of type 1 and type 2 tasks they do not need to be separately identified. When classifying decision

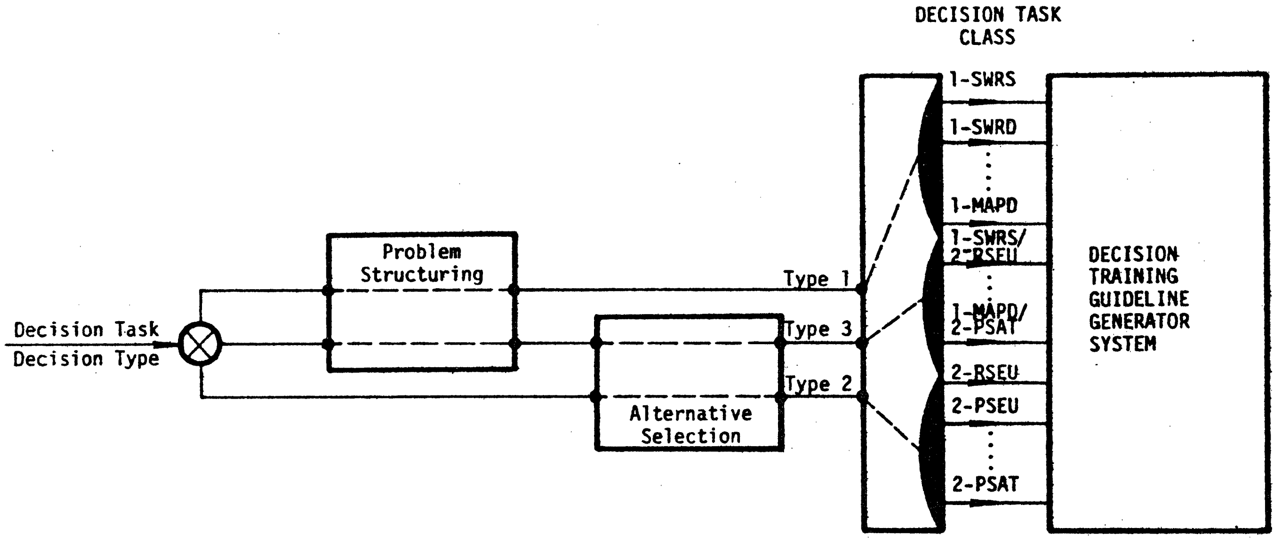


Figure 16. Decision Task Classification

TABLE 15. DECISION TASK CLASSES

CLASS NUMBER	DECISION TYPE	DECISION CLASS	ATTRIBUTE
1	1	SWRS	Single attribute, well defined, time relaxed, static
2	1	SWRD	Single attribute, well defined, time relaxed, dynamic
3	1	SWPS	Single attribute, well defined, time pressure, static
4	1	SWPD	Single attribute, well defined, time pressure, dynamic
5	1	SARS	Single attribute, ambiguous, relaxed, static
6	1	SARD	Single attribute, ambiguous, relaxed, dynamic
7	1	SAPS	Single attribute, ambiguous, pressure, static
8	1	SAPD	Single attribute, ambiguous, pressure, dynamic
9	1	MWRS	Multiattribute, well defined, time relaxed, static
10	1	MWRD	Multiattribute, well defined, time relaxed, dynamic
11	1	MWPS	Multiattribute, well defined, time pressure, static
12	1	MWPD	Multiattribute, well defined, time pressure, dynamic
13	1	MARS	Multiattribute, ambiguous, time relaxed, static
14	1	MARD	Multiattribute, ambiguous, time relaxed, dynamic
15	1	MAPS	Multiattribute, ambiguous, time pressure, static
16	1	MAPD	Multiattribute, ambiguous, time pressure, dynamic

TABLE 15. DECISION TASK CLASSES (CONTINUED)

		DECISION	
CLASS NUMBER	TYPE	CLASS	ATTRIBUTE
17	2	RSEU	Time relaxed, subjective expected utility
18	2	PSUE	Time pressure, subjective expected utility
19	2	RMMN	Time relaxed, Maxi-min utility
20	2	PMMN	Time pressure, Maxi-min utility
21	2	RMMS	Time relaxed, Maxi-max utility
22	2	PMMX	Time pressure, Maxi-max utility
23	2	RMMR	Time relaxed, Mini-max regret
24	2	PMMR	Time pressure, Mini-max regret
25	2	RLEX	Time relaxed, Lexicography
26	2	PLEX	Time pressure, Lexicography
27	2	RHUR	Time relaxed, Hurwicz
28	2	PHUR	Time pressure, Hurwicz
29	2	RSAT	Time relaxed, satisfying
30	2	PSAT	Time pressure, satisfying

tasks in this manner, 30 different classes are required provided that the decision tasks are initially presorted into type 1, 2, or 3 and that type 3 decision tasks can be trained by taking the relevant type 1 and type 2 tasks in conjunction. Thirty decision classes is a reasonable and manageable number of classes for which training materials can be developed and tested. The resulting decision classes are shown in Table 15.

Type 3 decision tasks that enter the system are diagnosed serially through the type 1 and type 2 decision classes. For example, a decision task that is type 3 could appear as 3-MMPS-PMMR which is (1) multiattribute, well defined, time pressure, static, for alternative generation and outcome estimation, and (2) time pressure, mini-max regret for alternative selection. Note that some combinations cannot exist (or are unlikely to exist) such as time pressure in type 1 and time relaxed in type 2. To train for type 3 - MWPS-PMMR, the system will simply take the training package for 1-MWPS and the training package for 2-PMMR and form one complete training package. The structure of the decision task space for training, resulting from the classification scheme, is shown in Figure 17.

INSTRUCTIONAL CONTENT GENERATOR

Identification of different implications of each decision class for training purposes is a task which must follow the development of the classification scheme. Such implications must reveal the basic content requirements for each class. Identification of these implications is the subject of the following. The training implications of each class are represented in terms of a set of modules corresponding to possible attributes of a decision task defined for the task classification scheme.

The basic instructional content of each class will be a combination of the contents associated with the attributes of that class. However, in a task-specific decision training context, such as the present program, the instructional content for each class will be affected by the task-specific information which serves as a vehicle for conveying the basic content. Such task-specific information is provided by decision trees constructed for each decision situation. For example, if utility is a basic training content and the task is sonobuoy patterns, then the utility of sonobuoy patterns must be included in the instructional content.

During this program, the implications of the relevant decision task attributes and decision rules were analyzed. The analysis emphasized the training aspects and included the selected eight attributes (Single Attribute, Multiattribute, Well Defined, Ambiguous, Time Relaxed, Time Pressured, Static, and Dynamic) and the seven decision rules (Subjective Expected Utility, Maxi-min Utility, Maxi-max Utility, Mini-max Regret, Lexicography, Hurwicz, and Satisfying). The result was the identification of the basic instructional content required for each decision attribute. This information was structured in fifteen modules, each module represents information concerning General Description, Amplification, Rules, Pitfalls/Limitations, Interacting with Other Decision Elements, and Prerequisites associated with the corresponding attribute or decision rule. Due to the large volume of the information, and to avoid the disparity of thought, the results are presented in Appendix J.

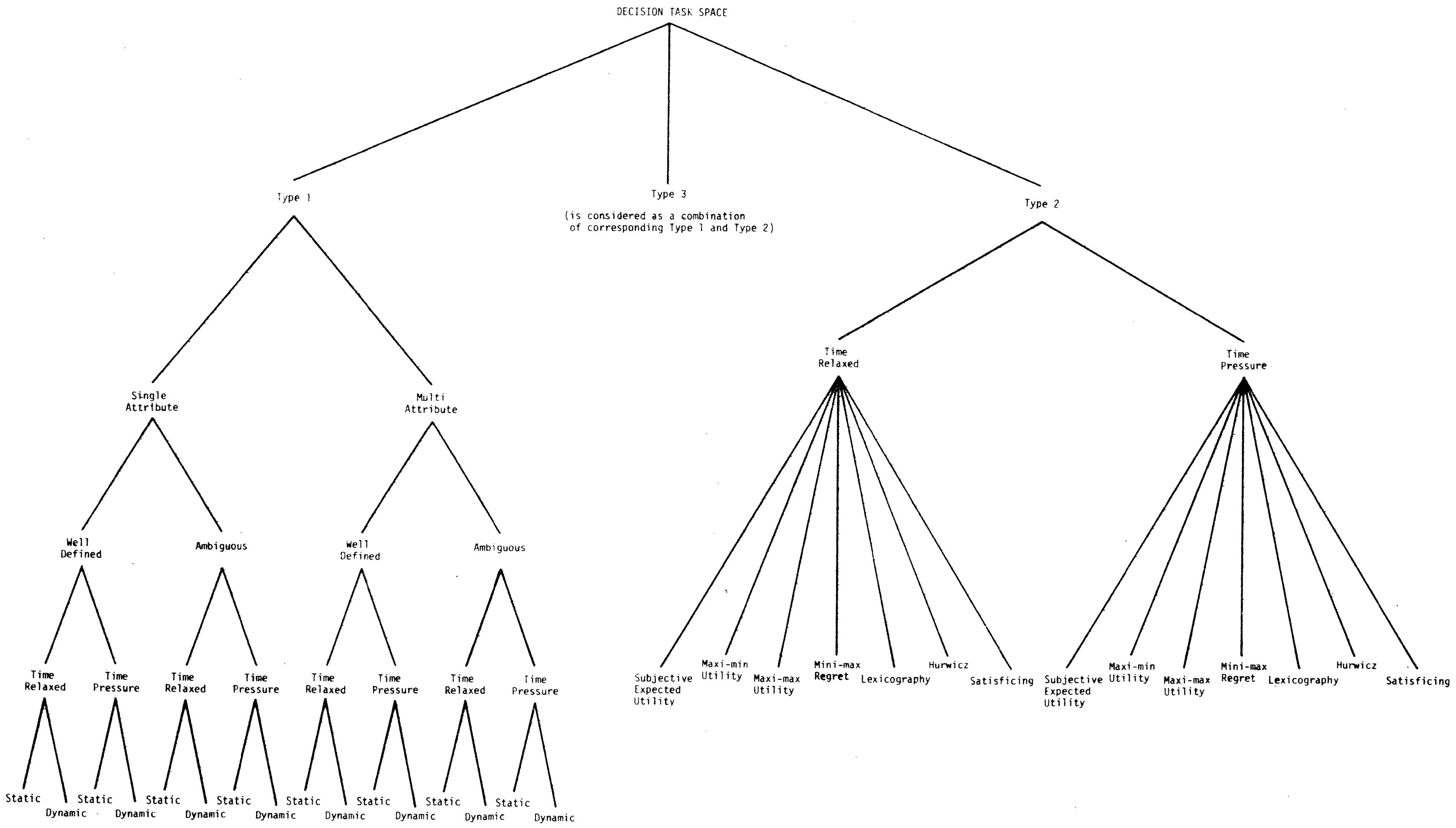


Figure 17. Structure of Decision Task Space For Training

COGNITIVE LEVEL WEIGHTING

The training objectives for different tasks with unequal cognitive complexity can be accomplished differently depending on the instructional methods employed. Such dependency between cognitive complexity and instructional method suggests a detailed analysis of cognitive levels involved in performance of each decision behavior required for different decision making components.

Such an analysis was performed to identify the highest cognitive level involved in the decision making behaviors. Six cognitive levels are considered as the major levels relevant to the process of decision training: knowledge, comprehension, application, analysis, synthesis, and evaluation. These levels are identical to the major categories in the cognitive domain of the taxonomy of educational objectives described in Bloom, 1956. We chose to call them cognitive levels instead of cognitive categories to establish, implicitly, a mental picture of the hierarchical cognitive complexity existing among different cognitive levels. The description of the six cognitive categories have been summarized in Gronlund, 1970:

> *"Knowledge is defined as the remembering of previously learned material. This may involve the recall of a wide range of material, from specific facts to complete theories, but all that is required is the bringing to mind of the appropriate information. Knowledge represents the lowest level of learning outcomes in the cognitive domains.*
>
> *"Comprehension is defined as the ability to grasp the meaning of material. This may be shown by translating material from one form to another (words to numbers), by interpreting material (explaining or summarizing), and by estimating future trends (predicting consequences or effects). These learning outcomes go one step beyond the simple remembering of material, and represent the lowest level of understanding.*
>
> *"Application refers to the ability to use learned material in new and concrete situations. This may include the application of such things as rules, methods, concepts, principles, laws, and theories. Learning outcomes in this area require a higher level of understanding than those under comprehension.*
>
> *"Analysis refers to the ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of the parts, analysis of the relationships between parts, and recognition of the organizational principles involved. Learning outcomes here represent a higher intellectual level than comprehension and application because they require an understanding of both the content and the structural form of the material.*

> *"Synthesis refers to the ability to put parts together to form a new whole. This may involve the production of a unique communication (theme or speech), a plan of operations (research proposal), or a set of abstract relations (scheme for classifying information). Learning outcomes in this area stress creative behaviors, with major emphasis on the formulation of new patterns or structures.*
>
> *"Evaluation is concerned with the ability to judge the value of material (statement, novel, poem, research report) for a given purpose. The judgments are to be based on definite criteria. These may be internal criteria (organization) or external criteria (relevance to the purpose) and the student may determine the criteria or be given them. Learning outcomes in this area are highest in the cognitive hierarchy because they contain elements of all of the other categories, plus conscious value judgments based on clearly defined criteria."*

The result of the analysis identified the highest cognitive level involved in each behavior as well as the degree of importance of that cognitive level for creating the corresponding behavior in a decision making context. The analysis was based on the decision training behavioral objectives developed previously (Table 14). The result of this analysis is summarized in Table 16. The column with entries identifies the highest cognitive level associated with the corresponding behavior. The entry itself represents the degree of importance of the corresponding cognitive level/decision behavior pair.

In order to assign the entries, the importance of each of the subtasks involved in a decision making process was analyzed and three different levels of importance were identifed. An entry equal to 1/2, 1 or 2 was assigned to the subtasks in low, middle or high level of importance, respectively. Such assignment of entries resulted in equal values for the summation of the weights assigned to each of the two major subtasks. Since problem structuring and alternative selection are of similar importance to a decision making process, resulting equal values can be considered as a confirming evidence to the validity of this method of assignment.

Since Type 1 decision tasks involve only alternative formulation and outcome estimation, the summation of all degrees of importance associated with each cognitive level corresponding to behaviors relevant to these two decision subtasks provides an element of a weight vector for cognitive levels associated with Type 1 decision tasks. Such a summation was performed for all cognitive levels to provide the complete cognitive level weight vector for Type 1 decision tasks. A similar procedure was performed on behaviors relevant to utility assessment, probability assessment, decision rule application, and best alternative selection subtasks to provide cognitive level weight vector for Type 2 decision tasks. Since Type 3 decision tasks involve the subtasks relevant to both Type 1 and Type 2 decisions, the cognitive level weight vector for Type 3 decision tasks was resulted by simply adding the corresponding weights obtained for Type 1 and Type 2 decision tasks. The weight vectors for the three decision types are shown in Table 17. The elements of each vector have been normalized such that the summation of elements adds up to one.

TABLE 16. HIGHEST COGNITIVE LEVEL IDENTIFICATION AND WEIGHT ASSIGNMENT FOR DECISION MAKING BEHAVIORS

Cognitive Level Decision Behavior	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
1. Formulate Alternatives						
1.1 Identify variables		2				
1.2 Classify variables				2		
1.3 Identify constraints				2		
1.4 Define solution range				2		
1.5 Generate alternatives					2	
1.6 Identify alternatives				2		
2. Establish Outcomes						
2.1 State events			2			
2.2 Identify variables				2		
2.3 State resulting situations			2			
3. Assess Utilities						
3.1 State effects				1		
3.2 State likelihoods				1		
3.3 Identify favorability			1			
3.4 State importance			1			
3.5 Estimate utilities			1			

TABLE 16. HIGHEST COGNITIVE LEVEL IDENTIFICATION AND WEIGHT ASSIGNMENT FOR DECISION MAKING BEHAVIORS (CONTINUED)

Cognitive Level Decision Behavior	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
4. Assess Probability						
4.1 Identify event				1		
4.2 Sort events			1			
4.3 Assign likelihoods						1
4.4 Calculate probabilities			1			
5. Apply Decision Rule						
5.1 Name rules	½					
5.2 Describe procedure		1				
5.3 State advantages		1				
5.4 Define criteria					1	
5.5 Select best rule		1				
5.6 Apply rule		2				
6. Select Best Alternative						
6.1 Name criteria	½					
6.2 State relevant criteria	½					
6.3 Select criteria		½				
6.4 Apply criteria		½				

TABLE 17. COGNITIVE LEVEL WEIGHT MATRIX

Cognitive Level / Decision Type	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Type 1	ε	0.1	0.2	0.5	0.2	ε
Type 2	0.09	0.11	0.51	0.17	0.06	0.06
Type 3	0.04	0.11	0.36	0.33	0.13	0.03

ε: very small weight, can be approximated by zero

A high value element represents a high degree of importance of the corresponding behavior with respect to the decision type. Lower value elements define a lesser degree of importance for the corresponding behaviors. The degrees of importance of the lowest cognitive level (knowledge) and the highest cognitive level (evaluation) for Type 1 decision tasks are very low. These degrees can be approximated by zero without resulting substantial inaccuracy. The cognitive level weights for the three decision types are plotted in Figures 18, 19, and 20. These figures indicate that the resulted weights correspond to intuitive judgment. The occurrence of the maximum degree of importance for Type 1 around Analysis level is justified by the fact that the process of problem structuring mainly involves analysis of the problem in order to identify the relevant elements of the problem as well as the anlaysis of possible outcomes in order to identify their effects on the problem elements. Since Type 2 decision tasks mostly involve application of certain rules and procedures, the maximum degree of importance for Type 2 decisions occurs around Application level. For Type 3 decision tasks the degrees of importance are spread along different cognitive levels with relatively lower variances. In general the process of decision making mainly concentrates around Analysis (of the problem and potential solution outcomes) and Application (of a set of rules and procedures).

INSTRUCTIONAL METHOD SELECTION

The approach to solving the problem of instructional method selection was to establish a quantification scheme which can be used to rank different instructional methods as to their effectiveness for the training of any decision task. To implement this approach, an analysis of different instructional methods was performed. Fourteen major instructional methods were selected and attributes of each method were identified. The methods include:

(a) Drill/Practice/Review

(b) Lecture

(c) Discussion - Individual Tutorial

(d) Discussion - Group

(e) Programmed Instruction

(f) Games

(g) Simulation

(h) Projects - Individual

(i) Projects - Group

(j) Laboratory

(k) Apprenticeship

(l) Demonstration

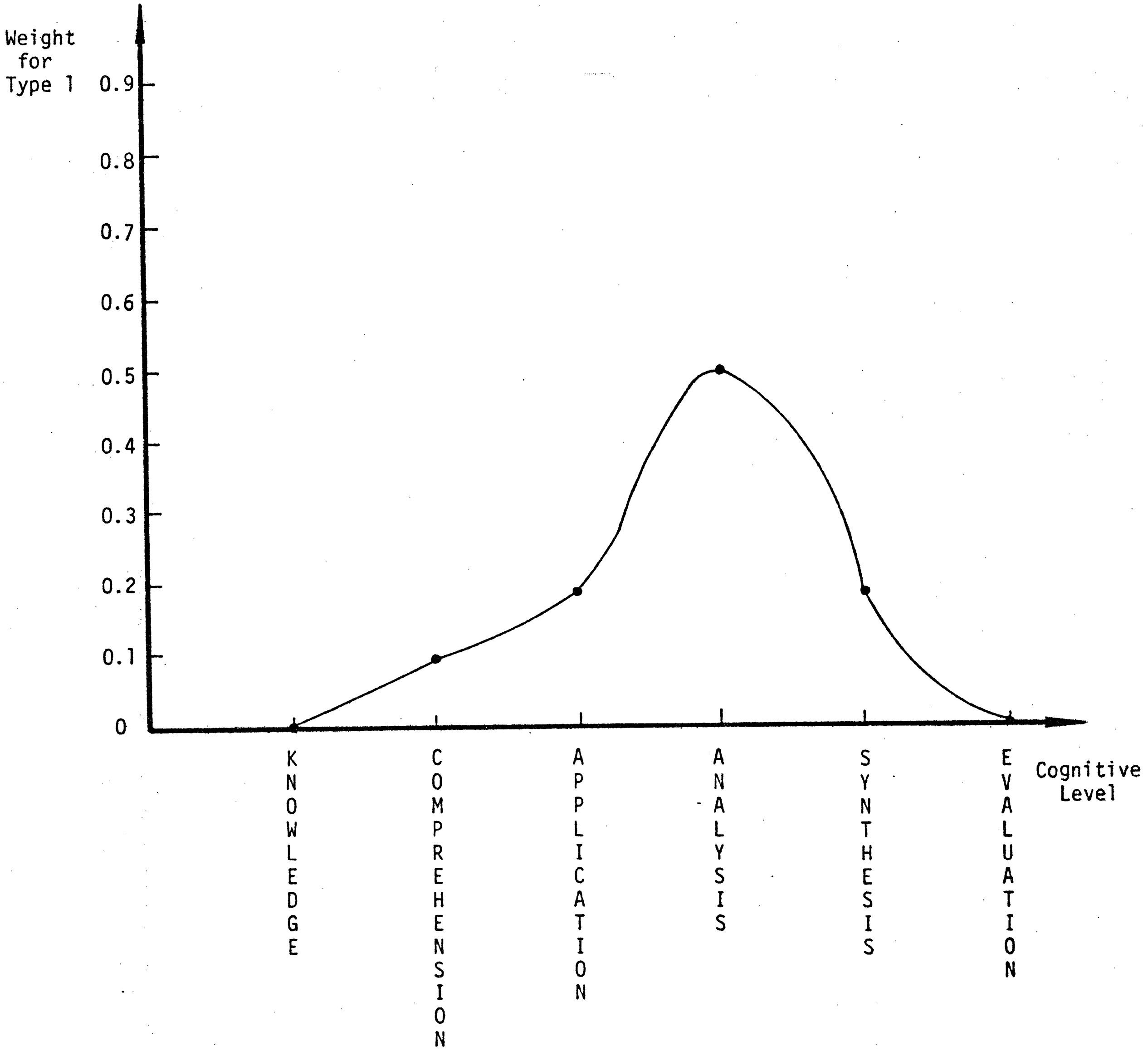


Figure 18. The Degrees Of Importance Of Different Cognitive Levels For Type 1 Decision Tasks

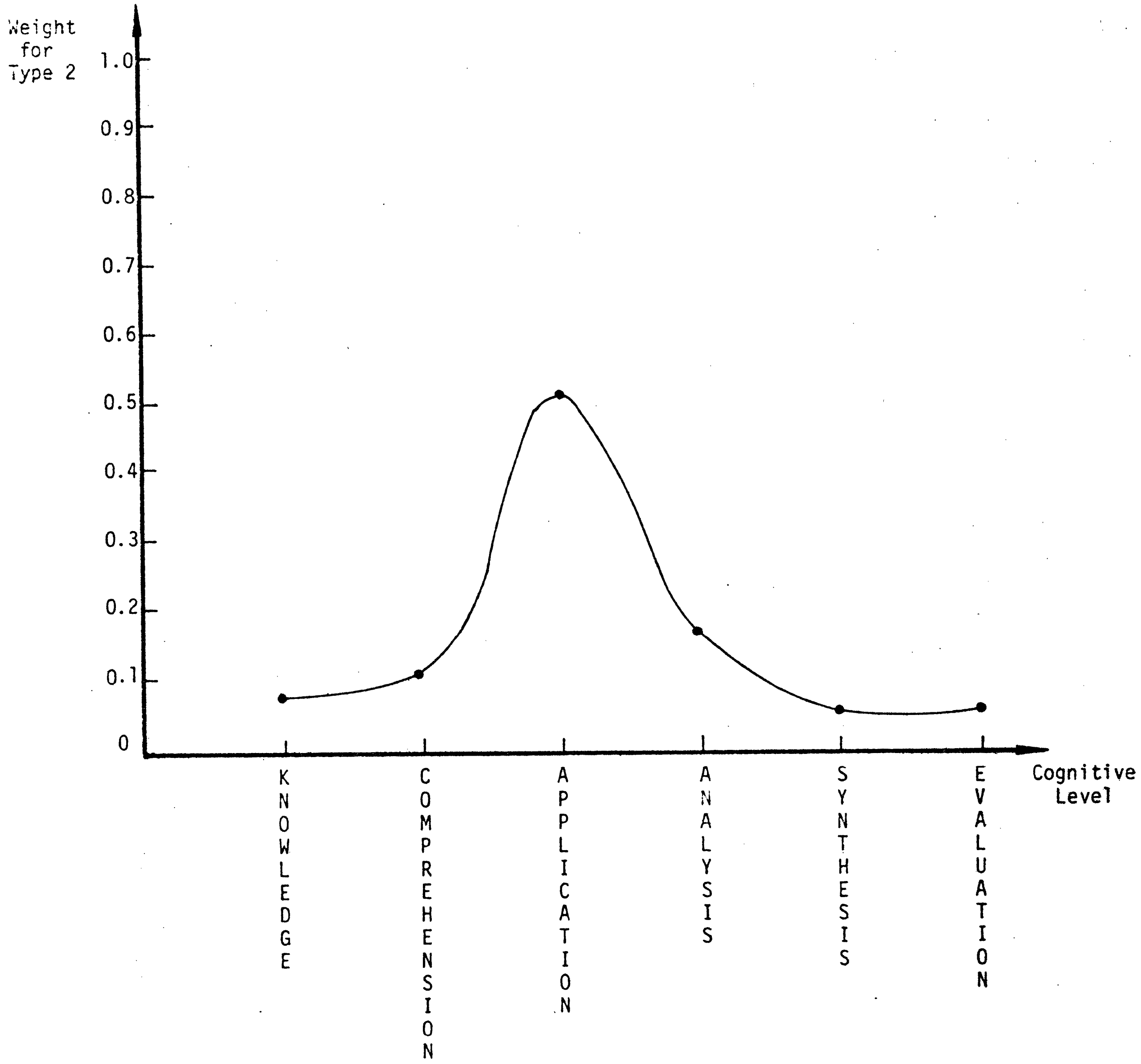


Figure 19. The Degrees Of Importance Of Different Cognitive Levels For Type 2 Decision Tasks

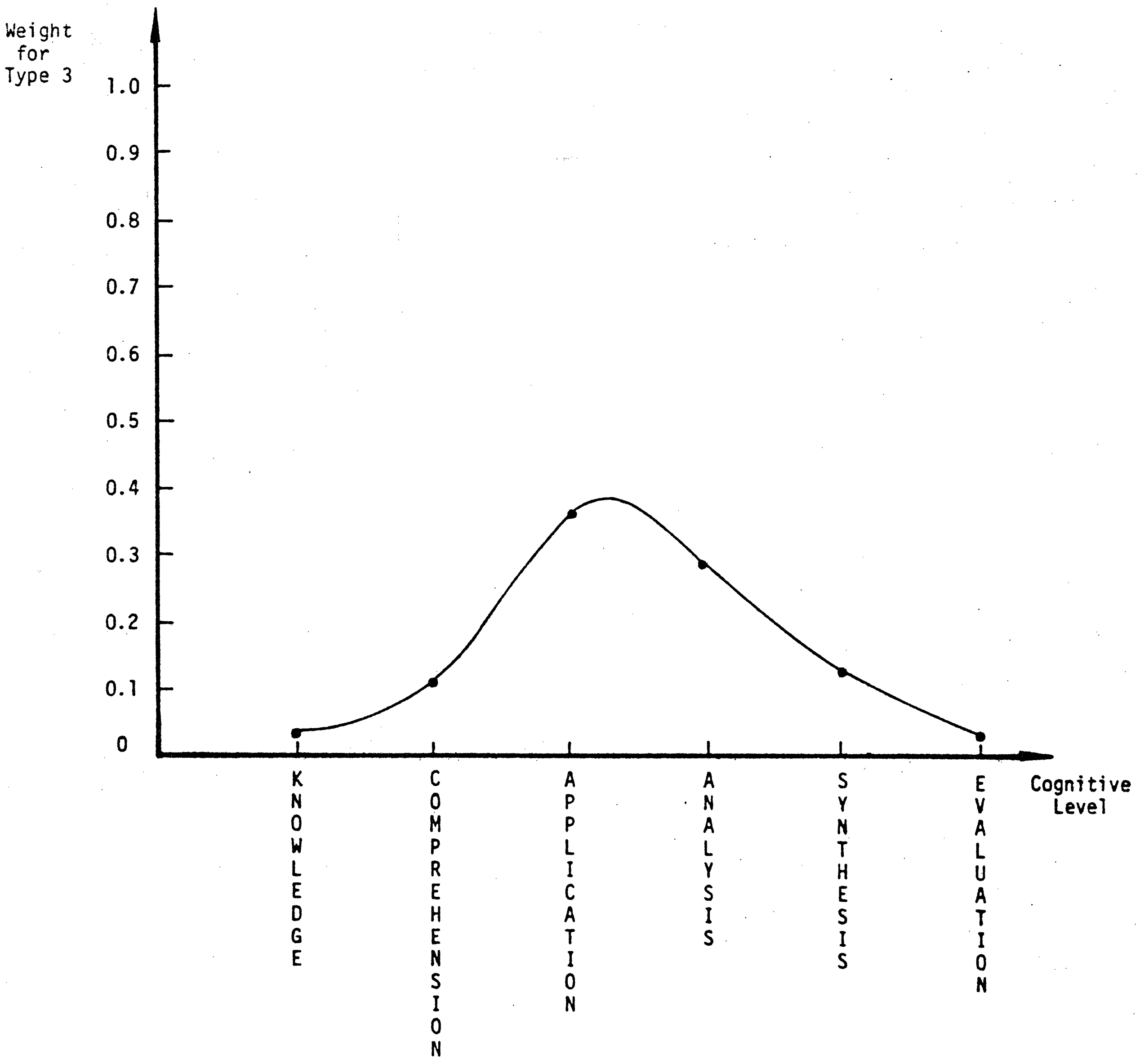


Figure 20. The Degrees Of Importance Of Different Cognitive Levels For Type 3 Decision Tasks

(m) Individual Investigation (Research)

(n) Text - Reading

Based on the characteristics of each instructional method, the degree of effectiveness of that method for training different tasks with different levels of cognitive complexity were judgmentally evaluated. The judgmental criteria were of two fold: (1) the effectiveness of the method judged by the expected result of applying the method in a prototype training environment and (2) the effectiveness of the method judged by implicit consideration of cognitive models of human learning. The judgmental data related to the first criterion was provided by a training specialist, and the data concerning the second criterion was provided by a psychologist. Lack of substantial variance between the corresponding judgmental values provided by the two criteria suggests itself as confirming evidence for the correctness of the judgments. However, an accurate assessment of these judgmental data demands a more refined procedure, performed in a controlled environment. Due to the importance of such data for research projects in the area of training cognitive processes, further research to elicit a more accurate assessment of the data appears to be needed.

The judgmental data resulting from the two criteria were averaged to provide an aggregate assessment. The expected cost and time of instruction for each method were also assessed by the training expert. The results of the assessment is shown in Table 18 as Method/Attribute Matrix. The entries of the matrix have value ranges from one to ten. The higher the value, the more effective the method for training a task with the corresponding level of cognitive complexity.

This information suggests a procedure for its utilization in instructional method selection. Once the type of the decision task to be taught becomes known, the cognitive level weighting vector relevant for the task is easily derived from the cognitive level weight matrix. Then, a linear evaluation procedure can be performed by a summation over the results of multiplication of the elements of the weight vector by corresponding elements of each vector associated with different methods. That is, if the cognitive level weight vector for the decision type associated with the task is defined as $(w_1, \ldots w_i, \ldots w_6)$,(the weights for "cost" and "time" with respect to the specific training environment are assigned by the system user instructional technologist during system application as (w_7, w_8)), and the vector associated with the jth method is defined as $(m_{j1}, \ldots, m_{ji}, \ldots, m_{j8})$, then the effectiveness value of the jth instructional method with respect to the decision task will be:

$$V_j = \sum_i m_{ji} \quad W_i$$

This procedure will provide an effective value assessment for each instructional method. Then the method with the highest effectiveness value will be selected as the most effective instructional method for training the decision tasks under consideration.

TABLE 18. METHOD/ATTRIBUTE MATRIX

METHOD \ ATTRIBUTES	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Cost (Low)	Time (Short)
Drill/Practice/Review	10	5	1	1	1	1	10	6
Lecture	7	7	3	3	3	1	8	6
Discussion-Individual Tutorial	7	10	9	10	9	8	2	6
Discussion-Group	4	9	7	8		7	5	3
Programmed Instruction	8	8	5	4	[illegible]	1	5	8
Games	3	3	8	7	5	4	4	3
Simulation	2	3	10	8	8	7	2	3
Projects-Individual	4	8	8	9	9	7	5	2
Projects-Group	3	8	7	8	6	6	5	4
Laboratory	4	6	10	9	5	8	2	4
Apprenticeship	5	6	[illegible]	6	5	6	2	2
Demonstration Visual Aid/Film	5	7	2	3	3	1	5	6
Individual Investigation	6	8	8	9	9	9	5	1
Text-Readings	8	7	3	4	3	2	10	7

If all the values involved in the procedure for selection of the best instructional method were invariant, a method could be selected as the best instructional method for each decision type. Then, identification of the type of a decision task would directly suggest the best instructional method for the decision task. However, there are some elements whose values depend on the characteristics of the training environment in which the training program will be implemented ("Cost" and "Time", in this case). The information concerning the characteristics of the training environment will be conveyed by the system user instructional technologist during system's application. This information will be presented in the form of judgmental importance weights assigned to a set of attributes. The set of attributes include: Learner paced control on the instructional media, instructional media to be self instructional, motion of the instructional media, fidelity of the instructional media in terms of situational details, learner control over the instructional speed, flexibility of the media for instructional sequencing, instruction readability, context creation, convenience for development of testing and evaluation, low cost of instruction, and simplicity of use and maintenance. Furthermore, introduction of the selection process as a dynamic procedure will provide for the possibility of modification of the judgmental values as well as addition or deletion of attributes.

METHOD/MEDIA RELEVANCY

Analysis of different instructional media identified twelve media of major interest:

a. Oral Representation (Lecture)

b. Textbook

c. Workbook/Problem Sets

d. Pictures, Slides, Transparencies

e. Audio Tape

f. Motion Picture

g. TV/VTR

h. Programmed Text

i. Computer Assisted Instruction (CAI)

j. Part-Task Trainer

k. Simulator

l. Natural Object

Since some of these instructional media are not applicable to a training environment employing a specific instructional method, a study of relevancy of each instructional media to each of the selected instructional methods was performed. The result of the study dichotomized the relevant and irrelevant media for each instructional method. These results appear in the Method/Media Relevancy Matrix, Table 19. The method/media relevancy matrix performs as a masking scheme. That is, each zero entry rules out the acceptability of an instructional media for the corresponding instructional method. A more detailed analysis can be performed to evaluate each method/media pair judgmentally. The result of such analysis will be a degree of relevancy for each method/media pair. In this case the process of dichotomization of media for each method will be replaced by a multilevel evaluation process which will provide more information. For example, although oral representation and textbook are both considered equally relevant to drill/practice/review by the dichotomization of media, a multilevel evaluation might also convey the information that text book would be more relevant to drill/practice/review by assigning numbers on a scale of 1 to 10 as the degree of relevancy for the two media with respect to the method.

INSTRUCTIONAL MEDIA SELECTION

Once the best instructional method for a decision task has been selected, the relevant instructional media for the selected method can be easily identified by reference to the method/media relevancy matrix. The information concerning relevant media together with the information about the characteristics of the instructional environment provide the required data for selection of the best media.

To design an instructional media selection methodology based on this information, an analysis of the characteristics, requirements, and resources of possible instructional environments was performed. The result of the analysis identified eleven attributes characterizing different instructional environments:

a. Learner Paced (control)

b. Self Instructional

c. Motion/Still

d. Situational Detail (Fidelity)

e. Control Over Time (Motion)

f. Flexible Sequencing

g. Repeatability

h. Context Creation

i. Potential for Test/Evaluation

j. Cost

k. Simplicity of Use and Maintenance

TABLE 19. METHOD/MEDIA RELEVANCY MATRIX

MEDIA METHOD	Oral Presentation (Lecture)	Textbook	Workbook Problem sets	Pictures, Slides, Transparencies	Audiotape	Motion Picture	TV/VTR	Programmed Text	CAI	Part-time Trainer	Simulator	Natural Object
Drill/Practice/ Review	1	1	1	1	1	1	1	1	1	1	1	1
Lecture	1	0	0	0	1	1	1	0	0	0	0	0
Discussion-Individual Tutorial	1	0	0	0	0	0	0	1	1	0	0	0
Discussion-Group	1	0	0	0	0	0	0	0	0	0	0	0
Programmed Instruction	0	0	1	1	1	1	1	1	1	1	1	0
Games	0	1	1	1	1	1	1	1	1	1	1	0
Simulation	0	0	0	1	1	1	1	0	1	1	1	1
Projects-Individual	0	0	0	0	0	0	0	0	0	0	0	1
Projects-Group	0	0	0	0	0	0	0	0	0	0	0	1
Laboratory	0	0	1	1	1	1	1	1	1	1	1	1
Apprenticeship	0	0	0	0	0	0	0	0	0	0	0	1
Demonstration	0	0	0	1	0	1	1	0	0	1	1	1
Individual Investigation (Research)	0	0	0	0	0	0	0	0	0	0	0	1
Text-Reading	0	1	0	1	0	0	0	0	0	0	0	0

The degree of effectiveness of each instructional media with respect to different attributes was judgmentally assessed by a training specialist. The criterion for assessment in this case was the effectiveness of the media judged by the expected result of applying the media in a prototype training environment characterized by the corresponding attribute. The results of this assessment appears in Table 20. The entries of the matrix have value ranges from one to ten. The higher the value, the more effective the media for a training environment characterized by the corresponding attribute. Although the assessment process was made as refined as possible within the time limit of this project, a more detailed research of this subject, for eliciting more accurate assessment of the degrees of effectiveness, seems advisable.

The Media/Attribute Matrix is used to select the best instructional media for a selected instructional method to be used in a specific instructional environment. The degrees of importance of attributes with respect to the training environment is defined as a vector presented by training designer. This vector acts as a weight vector which can be defined as $(C_1, \ldots, C_i, \ldots, C_{11})$. If the vector associated with the kth media in media/attribute matrix is defined as $(a_{k1}, \ldots, a_{ki}, \ldots, a_{k11})$, and the vector associated with the selected method in Method/Media relevancy matrix is defined as $(r_1, \ldots, r_k, \ldots, r_{12})$; then the degree of effectiveness for the kth media with respect to the selected method and the instructional environment will be calculated as:

$$E_i = r_k \sum_i C_i \, a_{ki}$$

The expression $\sum_i C_i \, a_{ki}$ is a simple weighted average which results a number to represent an overall effectiveness of the media with respect to the instructional environment. Depending on whether the media is compatible to the selected instructional method or not the value of r_k may be one or zero; this means that the value of E_k will be equal to either $\sum_i C_i \, a_{ki}$ or zero, respectively. Therefore, the result of applying this procedure to all twelve media will be twelve numbers each representing the overall effectiveness of a media based on both the characteristics of instructional environment and the selected instructional method. The method with the highest overall effectiveness value will be selected as the most effective media to be used with the selected instructional method in the specific instruction environment.

PROCEDURE FOR INSTRUCTIONAL GUIDELINE GENERATION

The process of instructional guideline generation for decision tasks is compatible with conventional Instructional System Development (ISD). This process can be considered as a module, within a structured ISD program, for recognition and classification of decision tasks as well as selection of the most effective instructional methods, media, and contents for those tasks. The process of instructional guideline generation can be defined as a systematic execution of a series of steps:

a. Define Objective Hierarchies for the Training Tasks. As in the case of any ISD program, the process of instructional guideline generation starts with identification of objective hierarchies for the training tasks.

TABLE 20. MEDIA/ATTRIBUTE MATRIX

ATTRIBUTES MEDIA	Learner Paced (Control)	Self Instructional	Motion/Skill	Situational Detail (fidelity)	Control over Time (motion)	Flexible Sequencing	Repeatable	Context Creation	Allows Testing/ Evaluation	Cost (Low)	Simplicity of Use, Maintenance
Lecture (oral presentation/chalk board)	1	1	1	1	1	7	1	2	7	8	8
Textbook	10	9	5	3	1	10	10	1	7	10	10
Workbook, Problem Sets	10	9	5	3	1	10	10	1	10	10	10
Pictures, Slides, Transparencies	10	7	5	10	1	10	10	5	5	7	5
Audiotapes	5	9	1	7	10	1	10	4	5	8	5
Motion Pictures	3	9	10	10	10	1	10	7	5	5	4
Television/Videotape Recording	3	9	10	9	10	2	8	7	5	3	3
Programmed Text	10	10	5	3	1	3	10	1	10	10	10
CAI	10	10	5	3	1	6	10	1	10	3	4
Part-task Trainer	10	7	10	7	10	7	10	7	10	4	4
Simulator	10	9	10	8	10	7	10	8	10	1	2
Natural Objects	3	10	10	10	1	7	5	10	2	1	1

b. Recognize Decision Tasks. The objective hierarchies are processed by the decision task identification scheme to recognize the decision tasks involved in the training tasks.

c. Identify Type and Class of the Decision Task. Using the method described as decision task classification preprocessor, the type and the class of each decision task are identified.

d. Select the Instructional Contents. The instructional content sections corresponding to different attributes of the class of decision task are combined to construct the basic instructional contents. The basic instruction content includes: general definition, amplification, rule, pitfalls and limitation, interactions with other decision elements, and prerequisites for each instructional content section. In addition to basic instructional content, the decision tree, representing each decision task, is constructed to provide the required task-specific information for instructional content.

e. Identify Cognitive Level Weights. The cognitive level weights vector associated with the decision type is identified by a simple table look-up procedure.

f. Select the Most Effective Instructional Method. A linear evaluation procedure is performed by a summation over the results of multiplication of elements of the cognitive levels weight vector by corresponding elements of each vector associated with different methods in the method/attribute relevancy matrix. This procedure provides an effective value assessment for each instructional method. The method with the highest effectiveness value will be selected as the most effective instructional method for training the decision task under consideration.

g. Identify the Instructional Media Incompatible with the Selected Method. The vector associated with the selected instructional method in the method/media relevancy matrix is identified by a simple table look-up. Those instructional media corresponding to zero-value entries in the vector are considered as the ones incompatible with the selected method.

h. Select the Most Effective Instructional Media. The degrees of importance of attributes, associated with each media, with respect to the training environment is defined in a weight vector. Then, a linear evaluation procedure, similar to the one used in item (f), is performed to select the most effective instructional media. A summation is performed on the results of multiplication of elements of the weight vector by corresponding elements of each vector associated with different media in the media/attribute matrix. The result of this summation will define the degree of effectiveness of the media if the media is compatible with the selected method. In the case that the media is not compatible the degree of effectiveness will be zero. The media with the highest degree of effectiveness will be selected as the most effective instructional method to be used with the selected instructional method in the specific instructional environment.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

A system to generate instructional guidelines for a task-specific decision training program, in any training environment, was developed. The system selects the most effective instructional method and media and provides required instructional contents for any specific decision task, subject to training in a specific training environment. The project has been aimed not only to develop a systematic procedure for providing instructional guidelines for decision tasks encountered in LAMPS ASW operation, but also to design a task-independent methodology in order to make application of the system in other task domains subject to minimal modification effort. Such a methodology allows incorporation of general purpose decision training components into task specific decision training programs. This incorporation provides trainees with the basic skills required for making task-specific decisions within a new domain, in case of their transfer to other task domains. Furthermore, since the characteristics of decision tasks within any specific domain are subject to change with time, the methodology will allow development of more effective training programs even in the case where there is no possibility of transferring the trainees to other task domains. Finally, the methodology will provide for the carry-over of the decision making capability into incidental functions, which are usually left untrained.

The instructional content was presented in two categories: task-specific information and basic instructional content. The task specific information is provided by decision trees resulting from a detailed analysis of the decision trees resulting from a detailed analysis of the decision tasks. The basic instructional content is generated through a classification of the decision tasks into one of the possible classes relevant to decision training. Instructional methods and media are selected by a quantified scheme which takes into account the characteristics of the training environment as well as the type of the decision tasks.

The Instructional Guideline Generation System provides a systematic procedure for incorporating a great deal of data into the process of selecting different components of a decision training program. These data are of great importance to any instructional system development and, theoretically, should all be considered in the development of any program. The procedure of instructional guideline generation, developed in this project, provides systematic means for the management of data and its effective utilization in the process of instructional system development. However, a more effective utilization of the instructional guideline generation system requires a more detailed look into three problems: (1) elicitation of more accurate judgmental data, (2) a control structure to guide the use in executing different steps of the procedure, and (3) a computational aid for calculations required in the procedure.

A computerized instructional guideline generation aid will provide a vehicle for analysis of all three problems. Such an aid and a plan for realization of it is addressed in the next section.

COMPUTERIZED INSTRUCTIONAL GUIDELINE GENERATION AID

Effectiveness of the instructional guideline generation system can be highly enhanced by improvement of the system in three dimensions:

a. elicitation of more accurate judgmental data

b. generation of a control structure to guide the user in executing different steps of the system

c. development of a computational aid for calculations required in the system.

A computerized instructional guideline generation aid can result in substantial improvements in all three dimensions.

The aiding system follows the design described in Chapter IV. It has the potential for working in two different modes: development mode and application mode. Development mode will provide access to judgmental data stored in the system. The accuracy of each element of the data will be assessed by an analysis of the guidelines generated for decision tasks used as test cases. The inaccurate data may be modified to adapt the system's output to desirable responses. Application mode represents a man/machine interactive session through which the information concerning the characteristics of the training environment, as well as the input decision task, is elicited from the user upon which the instruction guidelines for the decision task will be generated. During interactive sessions, the user will be guided by the sequence and content of a series of questions designed to elicit the required information. Furthermore, all calculations will be performed by the system without user's interaction. Such a system simplifies the process of instructional guideline generation into a series of judgmental evaluations of elementary attributes. While the process is highly simplified for the user, the system automatically incorporates all the information acquired from the user into the process which results in recommendations for the most effective instructional method and media as well as the required instructional contents.

A prototype application mode session of the system is simulated in the following pages. The user responses have been underlined.

Describe the characteristics of the instructional environment by assigning an important weight (between zero and one) to each of the following attributes.

1. Learner paced control on the instructional media.
   AT(1) = .7

2. Instructional media to be self instructional.
   AT(2) = .8

3. Motion of the instructional media.
   AT(3) = .3

```
4.  Fidelity of the instructional media in terms of situational details.
    AT(4) = .8

5.  Learner control over the instruction speed (motion).
    AT(5) = .6

6.  Flexibility of the media for instructional sequencing.
    AT(6) = .4

7.  Instruction readability.
    AT(7) = .3

8.  Context creation.
    AT(8) = .8

9.  Convenience for development of testing and evaluation.
    AT(9) = .6

10. Low cost of instruction.
    AT(10) = .3

11. Simplicity of use and maintenance.
    AT(11) = .9

     Here is the attribute list with the weights you assigned.

1.  WEIGHT = 0.70:  Learner paced control on the instructional media.
2.  WEIGHT = 0.80:  Instructional media to be self instructional.
3.  WEIGHT = 0.30:  Motion of the instructional media.
4.  WEIGHT = 0.80:  Fidelity of the instructional media in terms of situation.
5.  WEIGHT = 0.60:  Learner control over the instruction speed (motion).
6.  WEIGHT = 0.40:  Flexibility of the media for instructional sequencing.
7.  WEIGHT = 0.30:  Instruction readability.
8.  WEIGHT = 0.80:  Context creation.
9.  WEIGHT = 0.60:  Convenience for development of testing and evaluation.
10. WEIGHT = 0.30:  Low cost of instruction.
11. WEIGHT = 0.90:  Simplicity of use and maintenance.

             Options are                      Type

1.  Weights are satisfactory.                   q
2.  Change weight of an attribute.              c
3.  Display complete list.                      d

OPTION = c

10. WEIGHT = 0.30:  Low cost of instruction.

OPTION = q
```

Here is the attribute list with the weights you assigned

1. WEIGHT = 0.70: Learner paced control on the instructional media.
2. WEIGHT = 0.80: Instructional media to be self instructional.
3. WEIGHT = 0.30: Motion of the instructional media.
4. WEIGHT = 0.80: Fidelity of the instructional media in terms of situation.
5. WEIGHT = 0.60: Learner control over the instruction speed (motion).
6. WEIGHT = 0.40: Flexibility of the media for instructional sequencing.
7. WEIGHT = 0.30: Instruction readability.
8. WEIGHT = 0.80: Context creation.
9. WEIGHT = 0.60: Convenience for development of testing and evaluation.
10. WEIGHT = 0.50: Low cost of instruction.
11. WEIGHT = 0.90: Simplicity of use and maintenance.

Throughout this consultation session the above importance weights will be considered to represent the elements of the instructional environment. To present a new environment cancel the current session and start a new one.

Press RETURN when ready to continue.

Introduce the new instructional task by its instructional objective.

Enter description: press the ESC key then RETURN.

Classify the Contact as U.S. Ship, Enemy Ship, or Natural Object.

Do you want to change or correct the description? Type yes/no. No

What is the time pressure on course representation?
Specify it by a time pressure factor between zero and one.

Factor = .3

Does the objective of the task include selection of an alternative from a set of alternatives? Yes

Is the set of alternatives given? Yes

Is there a completely specified procedure for the alternative selection?
No

Once the alternatives are given, is there any critical time pressure on the operator for fast alternative selection? Yes

Which of the following decision rules is the most suitable one for the task?

1. Subjective Expected Utility (SEU)
2. Mini-max loss (MMX)
3. Mini-min loss (MMN)
4. Mini-max regret (MMR)
5. Lexicograph (LEX)
6. Hurwicz (HUR)
7. Satisficing (SAT)

Enter a number between 1 and 7? 2

INSTRUCTIONAL GUIDELINES

Instructional objective: classify the contact as U.S. Ship, Enemy Ship, or Natural Object.

The task to be taught is a decision task.

Decision Type: Type 2

Decision Class: 2-PMMX

Instructional Content Must Include the Following Items:

Collecting subjective utilities under time pressures. Translating outcomes into utilities. Aggregating utilities. Relation of loss and utility concept of minimizing maximum loss. Effect of time pressure on quality. Concept of payoff tables.

The Best Three Suggested Instructional Methods are:

1. Discussion-Individual Tutorial for which the best three instructional media are:
    1. Programmed Text
    2. CAI
    3. Lecture (oral presentation/chalkboard)
2. Individual Investigation (Research) for which the best three instructional media are:
    1. Natural Objects
    2. Textbook
    3. Workbook, problem sets
3. Projects - Individual for which the best three instructional media are:
    1. Natural objects
    2. Textbook
    3. Workbook, problem sets

Press RETURN when ready to continue.

EVALUATION PLAN

Two general evaluation areas should be reviewed in assessing the impact of the decision training guidelines described earlier in this report. They are: (1) evaluation of the impact on training system design, development and implementation, and (2) evaluation of the impact on trainees. It should be noted that as one proceeds from the initial instructional design stages to ultimate field performance more and more intervening variables enter into the picture. The topics identified below are presented with full recognition that the decision training guidelines are only one of several important variables which effect the overall instructional systems process.

a. Design. The design stage refers to the initial phase of instructional system development in which decision tasks are identified from among the full set of tasks which constitute LAMPS operator functions. At this stage a general approach to subject matter and instruction is defined. Relevant evaluation questions at this stage involve the areas of accuracy, complexity, time/effort, and expertise.

- Does the classification scheme accurately identify all tasks which are in fact decision tasks? What modifications are required to improve the accuracy of classification?

- Can the guidelines be applied easily, rapidly?

- What level of expertise in behavior decision theory is required to apply the guidelines.

- What level of expertise in instructional methods/media is required to apply the guidelines.

- Is the information provided to the instructional designed sufficient to develop a general approach to instruction which integrates all the decision tasks to be taught?

b. Development. Once decision tasks have been identified and characterized in terms of relevant decision theoretic and instructional guidelines, instructional materials are developed and tested. Questions of interest in the development stage involve the completeness and robustness of the guidance information provided.

- To what extent do the supporting conceptual materials meet the developer's needs for subject matter guidance? Conversely, how much time/effort is required to supplement content guidelines?

- To what extent do the guidelines provide direction to the developer in selection of an instructional strategy?

- What are the effects of environmental factors such as instructional setting and trainee groups on the utility of the content/instructional guidelines? How robust are the guidelines in the face of variations in trainee groups, training settings?

- How much assistance do the guidelines provide when making revisions to draft instructional materials subsequent to testing?

c. Implementation. This phase of instructional systems development includes the installation and management of the instructional system. It will be of interest at this stage to determine what problems exist in the areas of logistics and support, acceptance, instructor skills, management, and integration with related (non-decision) LAMPS training.

- What problems of acceptance of the instructional system occur for students, instructors?
- Are special skills in instructional technique or expertise in subject matter required of instructors?
- Does management of instruction pose special problems of data handling or analysis?
- Is decision training complementary to and supportive of the content of related (non-decision) LAMPS training?

d. Training Efficacy -- Didactic Instruction. At this stage of the instructional systems development process, full scale classroom instruction occurs. Major evaluation questions at this point deal with the level of attainment of training objectives by trainees, and the associated costs and time required for attainment of objectives.

- Do all trainees achieve minimally acceptable levels of knowledge and skill as defined in course objectives? What areas of weakness, strength can be identified for individual students? For the trainee group as a whole?
- What costs and how much time are associated with attainment of individual objectives? With completion of the course as a whole?

e. Training Efficacy -- Training Missions. In this stage, the LAMPS student pilot is exposed via training missions to a variety of in-flight situations some of which may test his decision skills as well as provide an opportunity for direct decision task instruction by a LAMPS instructor. The evaluation topics identified in the previous section apply here to any in-flight decision task instruction which may occur. In addition, the amount of transfer from the didactic situation is of interest to determine.

- What benefits (detriments) to decision task performance during in-flight training can be identified (for students who have had didactic decision training)?
- Has in-flight training been enhanced in terms of time/costs required as a result of transfer from the didactic situation?

(f) Post-Training Performance. Satisfactory on-the-job performance, subsequent to instruction, represents the end-point of the instructional system. Questions of interest here relate to the impact of the instructional system on long term performance of LAMPS pilots.

- What evidence exists that decision training has improved mission effectiveness or safety?
- Can general improvements (deficiencies) in decision performance as a result of decision training be demonstrated or are the benefits (detriments) restricted to specific tasks/situations for which training was provided?
- What is the retention level of decision skills three months after training? After one year? After two years?
- What major content deficiencies in pilot decision skills remain? What modifications to the content coverage of formal decision training seems necessary?

Acquisition of data to answer all of the evaluation questions identified above will involve a series of evaluation efforts, some formal and some informal. Table 21 summarizes the principal evaluation questions to be answered by stage together with an identification of sources/methods for acquiring necessary data. Much of the evaluation information identified will be of use in revision, either of the decision training guidelines or of the decision training itself. That is, formative use of the evaluation data is more likely to occur and will probably be of more benefit than summative evaluation, the overall assessment of the value of the guidelines and/or training. Summative evaluation will be difficult to carry out for a number of reasons, two of which are particularly important. First, training settings typically do not lend themselves to a true experimental or even a quasi-experimental analysis of instructional impact. Control of internal and external threats to validity (e.g., mortality, selection, history, maturation, testing, reactive effects, testing-training interaction, etc.) require experimental designs which usually depend on more freedom in selection of trainees and treatment conditions that the operational training setting will permit. Second, the time, costs, preserverance and cooperation required to obtain representative and comprehensive post-instructional performance data are great and, as a result, less useful proxy measures such as performance at time of exit/graduation from training are typically accepted as substitutes.

In spite of these considerations, Table 21 presents an overview of an idealized approach to evaluation in order to document the full scope of evaluation analysis which could be brought to bear. The actual evaluation effort that is mounted should represent a compromise between the value of the information sought for each of the six general areas identified and the cost and difficulty of obtaining it.

TABLE 21. OVERVIEW APPROACH FOR EVALUATING DECISION TRAINING GUIDELINES

STAGE	EVALUATION TOPIC	SOURCE OF DATA/METHOD	COMMENT/LIMITATIONS
Design	Accuracy of classification	Comparison to expert judgment	Inter-judge reliability should be demonstrated
	Ease of guidelines	Time, costs expended by designer	
	Expertise required to use guidelines	Identification of decision tasks or instructional methods which pose problems for designer	Dependent on skill of course designer
	Generality of approach afforded by guidelines	Opinion of designer, developer	Subjective
Development	Adequacy of guidelines	Identification of areas in which additional subject matter or instructional information is requires; include measures of time spent supplementing guidelines by developer	Dependent on skill of developer
	Robustness in face of varying training settings, trainee groups	Similar to above	Subjective
	Assistance in making revisions	Opinion of developer	Subjective

TABLE 21. OVERVIEW APPROACH FOR EVALUATING DECISION TRAINING GUIDELINES (CONTINUED)

STAGE	EVALUATION TOPIC	SOURCE OF DATA/METHOD	COMMENT/LIMITATIONS
Implementation	Coordination with related training	Identification of unusual logistical problems or requirements	Dependent on training site chosen
	Acceptance	Opinions of students, instructors	Subjective
	Instructor skills required	Opinions of instructors	Dependent on skills of instructors chosen; subjective
	Management of instructor	Special data handling/analysis requirements	
	Integration with related training	Opinions of students, instructors	Subjective
Didactic Training	Students achievement levels	Individual and group achievement of objectives (by objective and for course as a whole)	Requires well defined, comprehensive set of objectives; existence of an alternative treatment group comparison is unlikely; true-experimental design may be hard to implement in operational setting
	Costs, time	Same as above	Same as above; should include presentation costs as well as trainee costs
Training Missions	Transfer from didactic training	Performance of students on decision tasks encountered in-flight	See comments under "DIDACTIC TRAINING"

TABLE 21. OVERVIEW APPROACH FOR EVALUATING DECISION TRAINING GUIDELINES (CONTINUED)

STAGE	EVALUATION TOPIC	SOURCE OF DATA/METHOD	COMMENT/LIMITATIONS
	Reduced costs, time of in-flight training	Number of missions missions required to achieve proficiency	See comments under "DIDACTIC TRAINING"
Post-Training Performance	Improved mission effectiveness	Critical incidents, pilot opinion, mission logs	Difficulty of collecting operational data and subjective limitations
	Generality of effects	Pilot opinion	See above
	Retention of decision skills	Test trainees periodically after graduation	Follow-up difficult to implement
	Course areas requiring	Critical incidents, pilot opinion, mission logs, periodic tests of graduates	Combination of information from three categories above

DECISION AIDS

Analysis of the possible roles of a human operator as a decision maker identified two different roles: an operator as a decision maker and an operator as a decision executor. Although these two roles may be played by the same person, it is also possible that different individuals be responsible for each of the two roles. In this case, an individual makes the decision by providing the decision solutions which identifies the best couse of action to be taken under each possible environmental condition. The decision solution is then communicated to the second person who acts as a decision executor. At any decision time, the decision executor detects the current environmental condition and implements the decision solution corresponding to the detected condition. The communication media by which the information concerning decision solution is transmitted from the decision maker to the decision executor constitute the decision aid (Figure 21).

Analysis of Pilot/ATO's and Sensor Operator's jobs suggests the need for decision aids in critical decision situations. In many critical decision tasks there is not enough time for a reasonable decision making; furthermore, the knowledge of the criticality of the situation might further complicate any on the job decision making. Meanwhile, the operator can not afford any non-optimal decisions. A decision aid, in such a situation, will provide the operator with optimal solutions which have been provided in advance and under no time pressure.

In this context the term decision aid has a very broad meaning. Decision aids can range from pre-programmed "look-up" matrices and tables to computer driven displays. Some examples of decision aids are as follows: (1) Non-computer oriented. Tables and matrices, blank standardized forms to be filled out that structure the decision and its data, grease pencils and plastic status boards, warning lights in the cockpit, and the like, (2) Computer oriented. Visual displays and computer graphics, automatic warnings, CRT displays, adaptive decision aiding (e.g., ADDAM), and computerized sequence of interaction decision making, information entry, aggregation and display, and so on. Each decision aid can itself be characterized in terms of a number of attributes such as

- Maintainability
- Cost
- Completeness of aiding (disaggregation)
- Turn-around time
- Amount of manual input required
- Complexity of the information display

For example, a simple cockpit warning light provides very rapid and very aggregated decision aiding. Either the light is on or it is off. On the other hand, an interactive, computer based system that requires input from

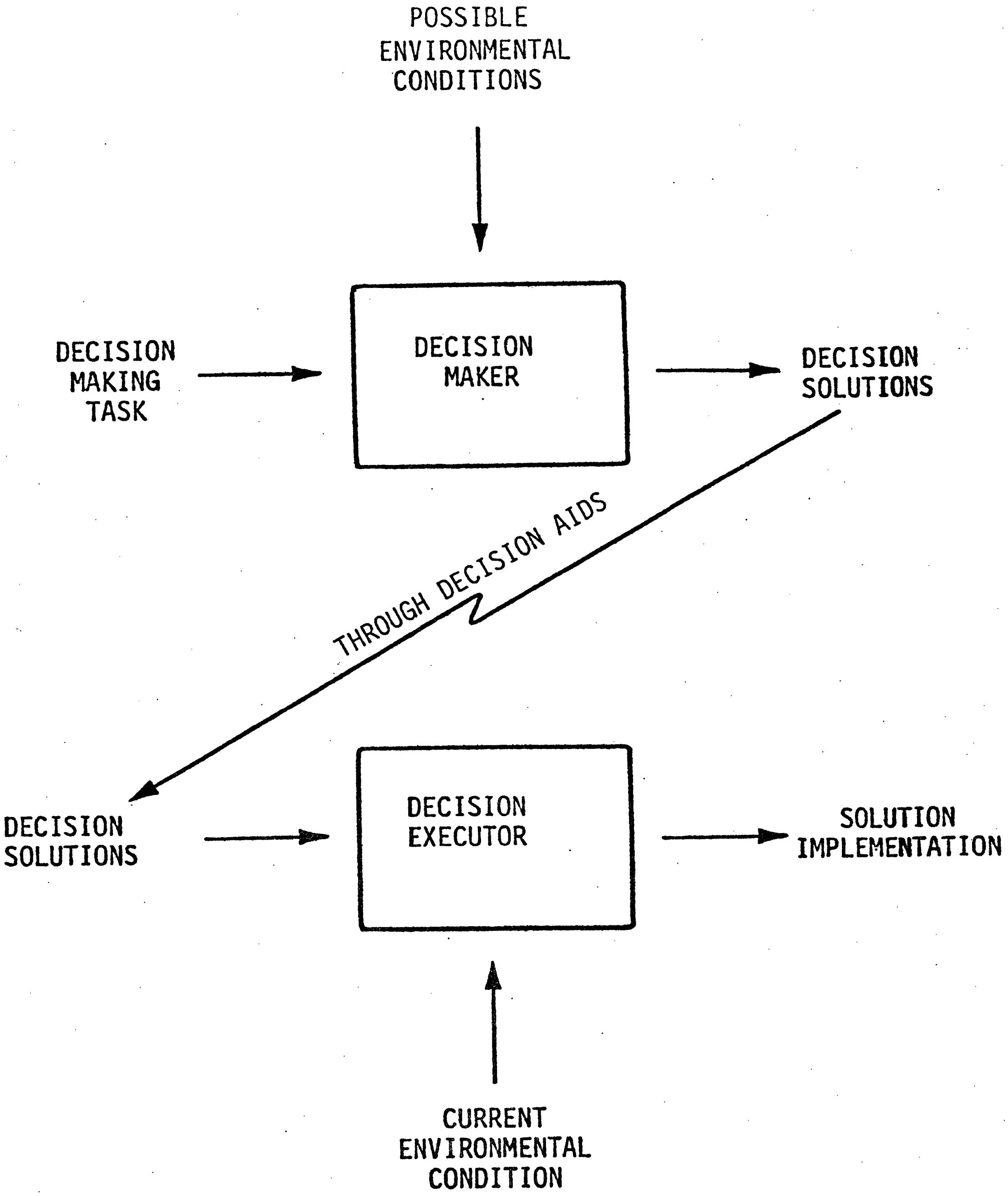


Figure 21. The Role Of Decision Aids In A Decision Making Process

a decision executor takes time, but it is more complete in its display (and also more complex than a single light). Prepackaged check lists are mid-way in terms of turn around time, complexity and input information required. In summary, each decision task can be supported with a decision aid and each decision aid can be developed with the desired aid characteristics in mind.

REFERENCES

Adelson, M. Human Decisions in Command Control Centers. Annals New York Academy of Science, 1961, 89, 726-731.

Allal, L.K. Training of Medical Students in a Problem Solving Skill: The Generation of Diagnostic Problem Formulations. Ph.D. Dissertation, Michigan State University, 1973.

Bloom, B.S., Krathwohl, D.R., and Englehart, M.D. (Eds.). Taxonomy of Educational Objectives: Cognitive Domain. New York: David McKay Company, Inc., 1956.

Dawes, R.M. Graduate Admission: A Case Study. Oregon Research Institute Technical Report 10(1), 1970.

Drucker, P.F. The Effective Decision. Harvard Business Review, 1967, 45, 92-98.

Edwards, W. Probabilistic Information Processing System for Diagnosis and Action Selection. In J. Spiegel and D. Walker (Eds.), Information System Sciences, Proceedings of the Second Congress, Washington, D.C. Spartan Books, Inc., 1965, 141-155.

Einhorn, H. and Hogarth, R. Unit Weighting Schemes for Decision Making. Organizational Behavior and Human Performance, 1975, 13:171-192.

Elstein, A.S., Shulman, L.S., and Sprafka, S.A. The Psychology of Medical Diagnosis. Harvard University Press, expected in 1977 (in press).

Freedy, A., Davis, K.B., Steeb, R., Samet, M.G., and Gardiner, P.C. Adaptive Computer Aiding in Dynamic Decision Processes: Methodology, Evaluation, and Application. Perceptronics Inc. (Woodland Hills, CA) Final Technical Report PFTR-1016-76-8/30, Contract N00014-73-C-0286/NR196-128, ARPA Order No. 2347, Code 455, Office of Naval Research, August 1976.

Gardiner, P.C. Decision Spaces. IEEE Special Issue on Decision Making. May 1977.

Gardiner, P.C. and Edwards, W. Public Values: Multi-Attribute Utility Measurement for Social Decision Making. In Schwartz & Kaplan (Eds.), Human Judgment & Decision Processes: Formal and Mathematical Approaches. New York: Academic Press, Inc., 1975.

Goodman, B., Fischhoff, B., Lichtenstein, S., and Slovic, P. The Training of Decision Makers. Report of a conference held at the Oregon Research Institute, July 8-9, 1976.

Gronlund, N.E. Stating Behavioral Objectives for Classroom Instruction. New York: The MacMillan Company, 1970.

Hammell, T.J. and Mara, T.D. Application of Decision Making and Team Training Research to Operational Training: A Translative Technique. Naval Training Device Center (Orlando, FL) Technical Report NAVTRADEVCEN 68-C-024201, 1970.

Hammond, K.R., Stewart, T.R., Brehmer, B., and Steinmann, D.O. Social Judgment Theory. In Kaplan, M.F. and Schwartz, S. (Eds.), Human Judgment and Decision Processes: Formal and Mathematical Approaches. New York: Academic Press, 1975.

Hill, J. and Martin, J.R. Training for Educational Decision Making. Journal of Teacher Education, 1971, 22(4), 443-447.

Howard, R.A. The Foundations of Decision Analysis. IEEE Transactions on Systems Science and Cybernetics, 1968, SSC-4, 211-219.

Kanarick, A.F. The Learning, Retention, and Transfer of Decision Making. Paper presented at meetings on Learning, Retention, and Transfer, sponsored by Honeywell Systems and Research Center and the Naval Training Devices Center, Winter Park, Florida, February 1969.

May, D.M., Crooks, W.H., and Freedy, A. Application of Adaptive Decision Aiding Systems to Computer-Assisted Instruction: Experimental Studies. Perceptronics Inc. (Woodland Hills, CA) Technical Report PATR-1023-76-1, Contract DAHC19-75-C-0013, U.S. Army Research Institute for the Behavioral and Social Sciences, March 1976.

Nickerson, R.S. and Feehrer, C.E. Decision Making and Training: A Review of Theoretical and Empirical Studies of Decision Making and Their Implications for the Training of Decision Makers. Naval Training Equipment Center (Orlando, FL) Technical Report NAVTRAEQUIPCEN 73-C-01281, July 1975.

Pesch, A.J., Hammell, T.J., and Ewalt, F.M. Tactical Decision-Making Training System Design. Naval Training Equipment Center (Orlando, FL) Technical Report NAVTRAEQUIPCEN 73-C-0158-1, November 1974.

Schrenk, L.P. Aiding the Decision Maker -- A Decision Process Model. Ergonomics, 1969, 12:543-557.

Selvidge, J. Rapid Screening of Decision Options. Decisions and Designs, Inc., (McLean, VA) Technical Report TR76-12, 1976.

Soelberg, P. First Generalizable Decision Process Model. MIT: Sloan School, 1966.

REFERENCES FOR ANALYSIS

Gibbons, A.S., et al. Instructional Design and Development, Objective Hierarchies for Pilot/ATO, SH-2F (LAMPS) Instructional Systems Development Project, Data Item No. A001, Courseware, Inc., San Diego, California, 1975.

Gibbons, A.S., et al. Instructional Design and Development, Objective Hierarchies for Sensor Operator, SH-2F (LAMPS) Instructional System Development Project, Data Item No. A0001, Courseware, Inc., San Diego, California, 1975.

Gibbons, A.S., et al. SH-2F, Fleet Replacement, Pilot Courses F-1.8.1 to F-11.2.2, Courseware, Inc., San Diego, California.

APPENDIX A

ANALYSIS OF OBJECTIVE HIERARCHIES FOR PILOT/ATO

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	2	1.1.7	Type 2	Classify, specify the degree	Contact Classification
└→	47	1.1.7.3	Type 2	Determine Whether	
	3	1.1.1.4	Type 2, Type 2	Determine What, Determine What	Equipment to Carry
	3	1.1.1.5	Type 1	State	Flying Methods
┌	3	1.1.1.6	Type 2	Determine whether	Mission safety
└→	3	1.1.1.6.1	Type 1	State all	
┌	3	1.1.1.6	Type 2	Determine whether	Mission safety
└→	3	1.1.1.6.4	Type 2	Determine whether	
	3	1.1.1.7.1	Type 1	State	Crew Briefing
┌	14	1.1.4.3.1	Type 3	Recognize	Malfunction Recognition
├→	16	1.1.4.3.1.1	Type 3	Recognize	
├→	16	1.1.4.3.1.1.1	Type 2	Indicate which	
├→	16	1.1.4.3.1.1.1.1	Type 1	Describe the components	
└→	17	1.1.4.3.1.1.1.1.2	Type 2	State the likely effect	
┌	14	1.1.4.3.2	Type 3	Recognize	Malfunction Recognition
└→	18	1.1.4.3.2.1.1	Type 2	Indicate which	
┌	14	1.1.4.3.3	Type 3	Recognize	Malfunction Recognition
└→	19	1.1.4.3.3.1.1	Type 2	Indicate which	
┌	14	1.1.4.3.4	Type 3	Recognize	Malfunction Recognition
└→	20	1.1.4.3.4.1.1	Type 2	Indicate which	
┌	14	1.1.4.3.5	Type 3	Recognize	Malfunction Recognition
└→	21	1.1.4.3.5.1.1	Type 2	Indicate which	
┌	14	1.1.4.3.6	Type 3	Recognize	Malfunction Recognition
└→	22	1.1.4.3.6.1.1	Type 2	Indicate Which	
┌	14	1.1.4.3.7	Type 3	Recognize	Malfunction Recognition
└→	23	1.1.4.3.7.1.1	Type 2	Indicate which	
┌	14	1.1.4.3.8	Type 3	Recognize	Malfunction Recognition
└→	24	1.1.4.3.8.1.1	Type 2	Indicate which	
┌	14	1.1.4.3.9	Type 3	Recognize	Malfunction Recognition
└→	25	1.1.4.3.9.1.1	Type 2	Indicate which	

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	14	1.1.4.3.10	ΣType 2	State, most likely	Type of Fire
└→	27	1.1.4.3.10.1	Type 1	State	
┌	14	1.1.4.3.10	ΣType 2	State, most likely	Type of Fire
└→	27	1.1.4.3.10.3	Type 1	State	
┌	14	1.1.4.3.10	ΣType 2	State most likely	Type of Fire
├→	27	1.1.4.3.10.5	ΣType 2	State the most likely	
└→	28	1.1.4.3.10.5.2	ΣType 2	State the likely effect	
	29	1.1.4.3.11.1.2	Type 2, Type 2	Determine the urgency, if	Mission Urgency
	29	1.1.4.3.11.3	Type 3	Recognize	Electric Failure Recognition
	31	1.1.4.3.12.1.1	Type 2	Indicate which	Malfunction Recognition
	32	1.1.4.3.12.3.2	ΣType 2	State likely effect	Fuel System Failure
	33	1.1.4.3.13.1.1	Type 2	Indicate which	Tire Blow-out
	34	1.1.4.3.14.1.1	Type 2	Indicate which	Tire Blow-out
	35	1.1.4.3.15.1.1	Type 2	Indicate which	Loss of Tail Rotor Control
┌	38	1.1.6.1	Type 3	Choose an appropriate	ASW Mission Tactic
├→	38	1.1.6.1.1	Type 2	Determine the likely identity	
└→	39	1.1.6.1.1.5	Type 2	Determine the likely identity	
┌	38	1.1.6.1	Type 3	Choose an appropriate	ASW Mission Tactic
├→	38	1.1.6.1.2	Type 1	Determine possible behavior	
└→	40	1.1.6.1.2.1	Type 3	Determine the most likely	
	42	1.1.6.1.2.2.3.1.2.3.4	Type 2	Classify	Sound/Velocity Profile Interpretation
┌	38	1.1.6.1	Type 3	Choose an appropriate	ASW Mission Tactic
├→	38	1.1.6.1.3	Type 1	State	
└→	45	1.1.6.1.3.3	Type 2	Determine the proportion	

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	38	1.1.6.1	Type 3	Choose an appropriate	ASE Mission Tactic
├→	38	1.1.6.1.3	Type 1	State	
└→	45	1.1.6.1.3.4	Type 2	Determine the depth	
┌	38	1.1.6.1	Type 3	Choose an appropriate	ASW Mission Tactic
├→	38	1.1.6.1.3	Type 1	State	
└→	45	1.1.6.1.3.5	Type 2	Determine if	
┌	38	1.1.6.2	Type 3	Revise plan	Tactic Revision
└→	38	1.1.6.2.1	Type 2	Determine whether	
┌	38	1.1.6.2	Type 3	Revise plan	Tactic Revision
└→	38	1.1.6.2.2	Type 3	Select an appropriate	
	48	1.1.7.1.1.3	Type 2	Determine if	Pattern Expansion
	48	1.1.7.1.1.4	Type 3	Prescribe an appropriate	Pattern Expansion
	48	1.1.7.1.1.5	Type 2	Determine which	Sonobuoys Monitoring
	49	1.1.7.1.2.4	Type 3	Determine an appropriate	Pattern Expansion
	51	1.1.7.2.2	Type 3	Select an appropriate	MAD Tracking Pattern
	53	1.1.9.6.1	Type 2	State the proper	Refueling
	53	1.1.9.6.2	Type 2	State the proper	Refueling
┌	55	1.1.10.1.1	Type 3	Identify	Engine Malfunction
├→	56	1.1.10.1.1.1	Type 3	Recognize	
└→	57	1.1.10.1.1.1.1.1	ΣType 2	Indicate which accompany	
┌	55	1.1.10.1.1	Type 3	Identify	Engine Malfunction
├→	56	1.1.10.1.1.2	Type 3	Recognize	
└→	58	1.1.10.1.1.2.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.1	Type 3	Identify	Engine Malfunction
├→	56	1.1.10.1.1.3	Type 3	Recognize	
└→	59	1.1.10.1.1.3.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.1	Type 3	Identify	Engine Malfunction
├→	56	1.1.10.1.1.4	Type 3	Recognize	
└→	60	1.1.10.1.1.4.1.1	ΣType 2	Indicate which	

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	55	1.1.10.1.1	Type 3	Identify	Engine Malfunction
├→	56	1.1.10.1.1.5	Type 3	Recognize	
└→	61	1.1.10.1.1.5.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.1	Type 3	Identify	Engine Malfunction
├→	56	1.1.10.1.1.6	Type 3	Recognize	
└→	62	1.1.10.1.1.6.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.1	Type 3	Identify	Engine Malfunction
├→	56	1.1.10.1.1.7	Type 3	Recognize	
└→	63	1.1.10.1.1.7.1.1	ΣType 2	Indicate which	
	64	1.1.10.1.1.8.2	ΣType 2	State the likely effects	Engine Malfunction
┌	55	1.1.10.1.2	Type 3	Identify	Drive System Malfunction
├→	65	1.1.10.1.2.1	Type 3	Recognize	
└→	66	1.1.10.1.2.1.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.2	Type 3	Identify	Drive System Malfunction
├→	65	1.1.10.1.2.2	Type 3	Recognize	
└→	67	1.1.10.1.2.2.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.2	Type 3	Identify	Drive System Malfunction
├→	65	1.1.10.1.2.3	Type 3	Recognize	
└→	68	1.1.10.1.2.3.1.1	ΣType 2	Indicate which	
	69	1.1.10.1.2.4.2	ΣType 2	State the likely effect	Transmission Malfunction
┌	55	1.1.10.1.3	Type 3	Identify	Electrical System Malfunction
├→	70	1.1.10.1.3.1	Type 3	Recognize	
└→	71	1.1.10.1.3.1.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.3	Type 3	Identify	Electrical System Malfunction
├→	70	1.1.10.1.3.2	Type 3	Recognize	
└→	72	1.1.10.1.3.2.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.3	Type 3	Identify	Electrical System Malfunction
├→	70	1.1.10.1.3.3	Type 3	Recognize	
└→	73	1.1.10.1.3.3.1.1	ΣType 2	Indicate which	

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	55	1.1.10.1.3	Type 3	Identify	Electrical System Malfunction
├→	70	1.1.10.1.3.4	Type 3	Recognize	
└→	74	1.1.10.1.3.4.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.4	Type 3	Identify	Fuel System Malfunction
├→	75	1.1.10.1.4.1	Type 3	Recognize	
└→	76	1.1.10.1.4.1.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.4	Type 3	Identify	Fuel System Malfunction
├→	75	1.1.10.1.4.2	Type 3	Recognize	
└→	77	1.1.10.1.4.2.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.4	Type 3	Identify	Fuel System Malfunction
├→	75	1.1.10.1.4.3	Type 3	Recognize	
└→	78	1.1.10.1.4.3.1.1	ΣType 2	Indicate which	
	79	1.1.10.1.4.4.2	ΣType 2	State the likely effects	Engine Oil System Malfunction
	80	1.1.10.1.4.5.2	ΣType 2	State the likely effect	Transmission Oil System Malfunction
┌	55	1.1.10.1.5	Type 3	Identify	Oil System Malfunction
├→	81	1.1.10.1.5.1	Type 3	Recognize	
└→	82	1.1.10.1.5.1.1.1	ΣType 2	Indicate which	
┌	55	1.1.10.1.5	Type 3	Identify	Oil System Malfunction
├→	81	1.1.10.1.5.2	Type 3	Recognize	
└→	83	1.1.10.1.5.2.1.1	ΣType 2	Indicate which	
	84	1.1.10.1.5.3.2	ΣType 2	State the likely effect	Main Rotor Malfunction
	85	1.1.10.1.5.4.2	ΣType 2	State the likely effect	Brake System Malfunction
	86	1.1.10.1.5.5.2	ΣType 2	State the likely effect	Blade Track System Malfunction
┌	55	1.1.10.1.6	Type 3	Identify	Flight Controls Malfunction
├→	87	1.1.10.1.6.1	Type 3	Recognize	
└→	88	1.1.10.1.6.1.1.1	ΣType 2	Indicate which	
	89	1.1.10.1.6.2.2	ΣType 2	State the likely effect	Hydraulic Power Supply Malfunction

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	55	1.1.10.1.7	Type 3	Identify	Hydraulic System Malfunction
↳	90	1.1.10.1.7.1	ΣType 2	Identify those	
	92	1.1.10.2.1.1	Type 2	Identify whether	Landing Methods
	93	1.1.10.2.2.3	Type 2	Determine the type (known possibilities)	Engine Failure
	95	1.1.11.1.1.3	Type 2	Determine whether	Landing Feasibility
	97	1.1.11.1.2.1.3	Type 2	Determine it	Land or Abort
	98	1.1.11.1.2.2.3	Type 2	Determine if	Land or Abort
	99	1.1.11.1.2.3.3	Type 2	Determine if	Land or Abort
	100	1.1.11.1.2.4.3	Type 2	Determine if	Land or Abort
	101	1.1.11.1.2.5.3	Type 2	Determine if	Land or Abort
	102	1.1.11.1.3.1	Type 2	Determine whether	Land or Abort
	104	1.1.11.1.3.2.3.2	Type 2	Determine if	Engine Failure
	106	1.1.11.2.1.3	Type 2	Determine whether	Landing Feasibility
	107	1.1.11.2.2.5	Type 2	Determine the min...	Flying Method
┌	107	1.1.11.2.2.6	Type 2	Determine whether	Land or Wave Off
↳	107	1.1.11.2.2.6.1	Type 3	State the criteria	
┌	107	1.1.11.2.2.7	Type 3	Determine which	Landing Method
↳	107	1.1.11.2.2.7.1	Type 1	State the alternative	
	108	1.1.11.2.2.1.3	Type 2	Determine if	Landing Safety
	109	1.1.11.2.2.2.3	Type 2	Determine if	Landing Safety
	110	1.1.11.2.2.3.6	Type 2	Determine if	Landing Safety
	111	1.1.11.2.2.4.3	Type 2	Determine when	Flying Method
	111	1.1.11.2.2.4.5	Type 2	Determine if	Landing Safety
	112	1.1.11.2.3.1	Type 2	Determine whether	Land or Abort
	112	1.1.11.2.3.2.1	ΣType 2	State the cues	Loss of Tail Control

Structure	Page	Task No.	Decision Type	Keyword	Task Area
	114	1.1.12.1.3.2	Type 2	Determine if	Postflight Inspection
	115	1.1.12.1.3.6.2	Type 2	Determine if	Postflight Inspection
	116	1.1.12.1.3.4.1.2	Type 3	Identify	Tail Wheel Lock Failure
	116	1.1.12.1.3.4.2.1	Type 3	Recognize	Total Electrical Failure
	116	1.1.12.1.3.4.3.1	Type 3	Recognize	Droop Stop Failure
	116	1.1.12.1.3.4.4.1	Type 3	Recognize	Internal Engine Fire
	116	1.1.12.1.3.4.5.1	Type 3	Identify	External Engine Fire
	118	1.1.13.2	ΣType 3	State	Intelligence Gathering
	118	1.1.13.3	ΣType 3	State	Tactics
	118	1.1.13.4	ΣType 3	State	Crew Briefing
	120	1.2.6.3	Type 2	Determine	Tactics
	120	1.2.6.4	Type 3	Determine the appropriate	Tactics
┌	120	1.2.6.5	Type 3, Type 3	Determine, determine	Tactics
↳	120	1.2.6.5.1	Type 3, Type 3, Type 3	Determine, determine, determine	
┌	120	1.2.6.5	Type 3, Type 3	Determine, determine	Tactics
↳	120	1.2.6.5.2	Type 3, Type 3	Determine, determine	
	120	1.2.6.6	ΣType 3	State the appropriate ref's	Tactics
	120	1.2.6.7	Type 3	State	Tactics
	123	1.3.5.4.2	Type 3	Classify	Tactics
	123	1.3.5.4.3	Type 3	Classify	Tactics
	123	1.3.5.4.4	Type 3	Classify	Tactics
┌	128	1.4.6.1.1.2	Type 3	Determine which	Search and Rescue
↳	128	1.4.6.1.1.2.1	Type 1	State	

Structure	Page	Task No.	Decision Type	Keywords	Task Area
	128	1.4.6.1.1.3	Type 2	Determine the best	Search and Rescue
	128	1.4.6.1.1.4	Type 3	State	Search and Rescue
	129	1.4.6.1.3.1.1	Type 3	Identify	Search and Rescue
	129	1.4.6.1.3.3.1.1	Type 3	State the cues	Search and Rescue
┌	131	1.4.6.2.1.2	Type 3	Determine which	Search and Rescue
↳	131	1.4.6.2.1.2.1	Type 1	State the major	
	132	1.4.6.2.2.2	Type 3	Determine which	Flying Method
	132	1.4.6.2.2.3	Type 1	State the major	Flying Method
	133	1.4.7.1.2.2	Type 2	Determine	Landing Feasibility
	134	1.4.7.2.3.1	Type 2	Determine	Search and Rescue
	135	1.4.7.3.1.1.1.2	Type 3	Locate	Search and Rescue
	136	1.4.7.5.1.1	Type 3	Identify	Doppler Failure
	136	1.4.7.5.2.1	Type 3	Identify	Radar Altimeter Failure
	139	1.5.5.1.6	Type 2	State all appropriate	External Cargo
	140	1.5.5.3.3	Type 2	State all appropriate	External Cargo
	142	1.6.1.1	Type 3	Determine	Internal Cargo
	142	1.6.1.2	Type 3	State	Internal Cargo
	145	1.7.5.5	Type 3	Determine	Gunfire Spotting
	150	1.8.2.2.4	ΣType 2	State likely effects	Lighting System Failure
	152	1.8.2.3.1.2	ΣType 2	State likely effect	Flight Instrument System Failure
	153	1.8.2.3.2.2	ΣType 2	State likely effect	AN/AYK-2 System Failure

Structure	Page	Task No.	Decision Type	Keywords	Task Area
	155	1.8.2.3.4.2	ΣType 2	State likely effects	Standby Compass Failure
	159	1.8.2.3.8.2	ΣType 2	State likely effects	AN/APN-182 System Failure
	160	1.8.2.3.9.2	ΣType 2	State likely effects	AN/ASN-50 System Failure
	163	1.8.2.4.1.4	ΣType 2	State likely effects	Sonobuoy Processing System Failure
	164	1.8.2.4.2.2	ΣType 2	State likely effects	Smoke Maker Dispenser System Failure
	165	1.8.2.4.3.2	ΣType 2	State likely effects	Torpedo Resease System Failure
	166	1.8.2.4.6.2	ΣType 2	State likely effects	Sonobuoy Launcher System Failure
	167	1.8.2.4.7.2	ΣType 2	State likely effects	MAD System Failure
	168	1.8.2.4.8.2	ΣType 2	State likely effects	ALR-54 System Failure
	171	1.8.2.5.2.2	ΣType 2	State likely effects	AN/ARC-159 System Failure
	174	1.8.2.5.5.2	ΣType 2	State likely effects	Juliet 28 System Failure
	182	1.8.5.3.2	ΣType 2	State likely effects	Anti-Ice System Failure

APPENDIX B
ANALYSIS OF OBJECTIVE HIERARCHY FOR SENSOR OPERATOR

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.1	Type 2	Determine if	
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.2	Type 2	Determine if	
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.3	Type 2	Determine if	
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.4	Type 2	Determine if	
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.5	Type 2	Determine if	
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.6	Type 2	Determine if	
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.7	Type 2	Determine if	
┌	3	2.1.1.2	Type 2	Determine if	Daily Inspection
↳	5	2.1.1.2.8	Type 2	Determine if	
	3	2.1.1.6	Type 2	Determine if	Fuel Acceptability
┌	6	2.1.2.2	Type 2	Determine if	Turnaround Inspection
↳	8	2.1.2.2.1	Type 2	Determine if	
┌	6	2.1.2.2	Type 2	Determine if	Turnaround Inspection
↳	8	2.1.2.2.2	Type 2	Determine if	
┌	6	2.1.2.2	Type 2	Determine if	Turnaround Inspection
↳	8	2.1.2.2.3	Type 2	Determine if	
┌	6	2.1.2.2	Type 2	Determine if	Turnaround Inspection
↳	8	2.1.2.2.4	Type 2	Determine if	
┌	6	2.1.2.2	Type 2	Determine if	Turnaround Inspection
↳	8	2.1.2.2.5	Type 2	Determine if	
┌	6	2.1.2.2	Type 2	Determine if	Turnaround Inspection
↳	8	2.1.2.2.6	Type 2	Determine if	
┌	6	2.1.2.2	Type 2	Determine if	Turnaround Inspection
↳	8	2.1.2.2.7	Type 2	Determine if	
	6	2.1.2.4	Type 3	Identify	Standard Safety Precaution

Structure	Page	Task No.	Decision Type	Keyword	Task Area
	6	2.1.2.6	Type 2	Determine if	Turnaround Inspection
┌	13	2.2.1.7	Type 2	Classify	Tactics, Target Classification
├→	41	2.2.1.7.1	Type 2	Perform all classification functions to identify	
└→	42	2.2.1.7.1.1	Type 2	Classify	
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.1	Type 2	Perform all classification functions to identify	
└→	42	2.2.1.7.1.2	Type 3	Identify	
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.1	Type 2	Perform all classification functions to identify	
└→	42	2.2.1.7.1.3	Type 3	Identify	
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.1	Type 2	Perform all classification functions to identify	
└→	42	2.2.1.7.1.4	Type 3	Identify	
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.1	Type 2	Perform all classification functions to identify	
└→	42	2.2.1.7.1.5	Type 3	Identify	
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.1	Type 2	Perform all classification functions to identify	
├→	42	2.2.1.7.1.6	Type 2	Determine as to	
└→	42	2.2.1.7.1.6.2	Type 2	Determine if	
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.2	Type 2	Perform all classification functions to identify	
└→	43	2.2.1.7.2.1	Type 3	Identify	

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.2	Type 2	Perform all classification functions to identify	
├→	43	2.2.1.7.2.3	Type 2	Report probability	
└→	43	2.2.1.7.2.3.1	Type 2	Determine the Prob.	
┌	13	2.2.1.7	Type 2	Classify	Target Classification
├→	41	2.2.1.7.3	Type 2	Perform all classification functions to identify	
├→	44	2.2.1.7.3.1	Type 2	Classify	
└→	44	2.2.1.7.3.1.3	Type 2	Classify	
	15	2.2.1.1.1.1	Type 2	Determine if	Flight Gear Inspection
┌	15	2.2.1.1.1.2	Type 2	Determine if	Flight Gear Inspection
└→	15	2.2.1.1.1.2.1	Type 2	Determine if	
┌	15	2.2.1.1.1.3	Type 2	Determine if	Flight Gear Inspection
└→	15	2.2.1.1.1.3.1	Type 2	Determine if	
┌	20	2.2.1.2.1	Type 2	Determine if	Mission Safety
└→	20	2.2.1.2.1.1	Type 3	Determine	
┌	20	2.2.1.2.1	Type 2	Determine if	Mission Safety
└→	20	2.2.1.2.1.2	ΣType 3	Determine	
	22	2.2.1.2.3.2.2	Type 2	Determine	Interior Inspection
┌	22	2.2.1.2.3.2.3	Type 2	Determine	SAR Inspection
└→	22	2.2.1.2.3.2.3.1	Type 2	State if	
	24	2.2.1.3.1.1	ΣType 3	Identify each	Prestart Inspection
	24	2.2.1.3.1.2	Type 2	Determine	Prestart Inspection
	30	2.2.1.5.2.2	Type 3	Identify	Radar Operation
	30	2.2.1.5.2.3	Type 3	Determine	Duration Estimation
	30	2.2.1.5.2.4	Type 3	Identify	Elevation & Obstruction
	30	2.2.1.5.2.6	ΣType 3	Determine	Magnetic Bearing
	33	2.2.1.6.2.2	Type 3	State the effects	MAD Operation
	33	2.2.1.6.2.4	Type 3	Determine	RO-32 Recorder Malfunction

Structure	Page	Task No.	Decision Type	Keyword	Task Area
	33	2.2.1.6.2.5	Type 3	Determine	ASQ-81 System Malfunction
	33	2.2.1.6.2.6	Type 3	Identify	Tactics, Initial Contact
	34	2.2.1.6.2.1.1	Type 3	State	ASQ-81 System Operation
	34	2.2.1.6.2.1.3.1	Type 3	Identify	ASQ-81 System Operation
	34	2.2.1.6.2.1.4	Type 3	Identify	ASQ-81 System Operation
	36	2.2.1.6.3.3.1	Type 3	State	LN-66 Radar Operation
	36	2.2.1.6.3.3.2	Type 3	State	LN-66 Radar Operation
	36	2.2.1.6.3.3.3	Type 3	State	LN-66 Radar Operation
	37	2.2.1.6.4.1.1.2	Type 3	State	ASA-26 System Operation
	39	2.2.1.6.5.1	Type 2	State the best	Visual Search
	46	2.2.1.8.1.1	Type 3	Identify	Tactics, Tracking with MAD
	47	2.2.1.8.2.1.1.2	Type 3, Type 3	Determine, select	Tactics, Master Sonobuoy Selection
	47	2.2.1.8.2.1.1.3	Type 3, Type 3	Determine, select	Tactics, Slave Sonobuoy Selection
	47	2.2.1.8.2.1.1.4.1	Type 2	Determine	Percentage of Attenuation
	47	2.2.1.8.2.1.1.4.3	Type 2	Determine	Percentage of Attenuation
	48	2.2.1.8.2.2.1	ΣType 2	Determine	Range of Target
	55	2.2.2.1.2.1	ΣType 2	List all info. pertaining	SAR Mission
	55	2.2.2.1.2.2	ΣType 2	List all info. pertaining	SAR Mission
	55	2.2.2.1.2.3	ΣType 2	List all info. pertaining	SAR Mission
	55	2.2.2.1.2.4	ΣType 2	List all info. pertaining	SAR Mission

Structure	Page	Task No.	Decision Type	Keyword	Task Area
	68	2.2.2.7.4.1.4.1	Type 3	Identify	Survival Hold Release
	70	2.2.2.12.1	ΣType 2	List all info. pertaining	SAR Mission
	70	2.2.2.12.2	ΣType 2	List all info. pertaining	SAR Mission
	70	2.2.2.12.3	ΣType 2	List all info. pertaining	SAR Mission
	72	2.2.3.1.1	ΣType 2	List the info.	SAR Mission
┌	75	2.2.4.8	Type 3	Identify	Vessel Classification
├→	80	2.2.4.8.1	Type 3	Identify	
└→	80	2.2.4.8.1.1	ΣType 2	List the critical...	
┌	75	2.2.4.8	Type 3	Identify	Vessel Classification
├→	80	2.2.4.8.2	Type 3	Identify	
├→	80	2.2.4.8.2.1	Type 3	Identify	
└→	80	2.2.4.8.2.1.1	ΣType 2	List the critical...	
┌	75	2.2.4.8	Type 3	Identify	Vessel Classification
├→	80	2.2.4.8.2	Type 3	Identify	
├→	80	2.2.4.8.2.2	Type 3	Identify	
└→	80	2.2.4.8.2.2.1	ΣType 2	State the critical...	
┌	75	2.2.4.8	Type 3	Identify	Vessel Classification
├→	80	2.2.4.8.3	Type 3	Identify	
├→	80	2.2.4.8.3.1	Type 3	Identify	
└→	80	2.2.4.8.3.1.1	ΣType 2	List the critical...	
┌	75	2.2.4.8	Type 3	Identify	Vessel Classification
├→	80	2.2.4.8.3	Type 3	Identify	
├→	80	2.2.4.8.3.2	Type 3	Identify	
└→	80	2.2.4.8.3.2.1	ΣType 2	List the critical...	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.1	Type 3	Identify	
└→	77	2.2.4.6.1.1.1	Type 2	State rules for deter.	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.2	Type 3	Identify	
└→	77	2.2.4.6.1.2.1	Type 2	Identify	

Structure	Page	Task No.	Decision Type	Keyword	Task Area
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.2	Type 3	Identify	
└→	77	2.2.4.6.1.2.2	Type 3	Identify	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.2	Type 3	Identify	
└→	77	2.2.4.6.1.2.3	Type 2	Identify	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.2	Type 3	Identify	
└→	77	2.2.4.6.1.2.4	Type 3	Identify	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.3	Type 3	Identify	
└→	77	2.2.4.6.1.3.1	Type 3	Identify	
┌	76	2.2.4.6.1	Type 3	Identify	
├→	77	2.2.4.6.1.4	Type 3	Identify	
├→	77	2.2.4.6.1.4.2	Type 2	Identify	
└→	77	2.2.4.6.1.4.2.1	ΣType 2	State the critical...	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.4	Type 3	Identify	
├→	77	2.2.4.6.1.4.3	Type 2	Identify	
└→	77	2.2.4.6.1.4.3	Type 2	State rules for identifying	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.4	Type 3	Identify	
└→	77	2.2.4.6.1.4.4	Type 2	Identify	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
├→	77	2.2.4.6.1.4	Type 3	Identify	
└→	77	2.2.4.6.1.4.5	Type 3	Identify	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
└→	77	2.2.4.6.1.5	Type 2	Identify	
┌	76	2.2.4.6.1	Type 3	Identify	Visual Rig
└→	78	2.2.4.6.1.6	Type 2	Identify	
	82	2.2.5.1.2.1	ΣType 2	List the info. pertaining...	Cargo Mission
	82	2.2.5.1.2.2	ΣType 2	List the info. pertaining...	Cargo Mission

Structure	Page	Task No.	Decision Type	Keyword	Task Area
	82	2.2.5.1.2.3	ΣType 2	List the Info. pertaining...	Cargo Mission
	82	2.2.5.1.2.4	ΣType 2	List the Info. pertaining...	Cargo Mission
	89	2.2.7.1.2.1	ΣType 2	List all ... pertaining...	Passenger Transfer Mission
	89	2.2.7.1.2.2	ΣType 2	List...needed by...	Passenger Transfer Mission
	89	2.2.7.1.2.3	ΣType 2	List info... that must...	Passenger Transfer Mission
	89	2.2.7.1.2.4	ΣType 2	List info... that must...	Passenger Transfer Mission
	90	2.2.7.6.2	Type 2	Determine if	Flight Equipment Inspection
	93	2.3.1.1.3.1	Type 2	Determine whether	Ordnance System Inspection
	93	2.3.1.1.3.2	ΣType 3	State	Ordnance System Inspection
	93	2.3.1.1.4	Type 2	Determine	Ordnance System Inspection
	93	2.3.1.2.2	Type 2	Determine	Ordnance System Inspection
	93	2.3.1.3.2	Type 2	Determine if	Ordnance System Inspection

APPENDIX C

PILOT/ATO (TS)

Analysis of PILOT/ATO Tape Slides

Task No.	Task Name	Slide No.	Old Slide No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
	Fuel System Malfunction Detection	F-1.5.1	SF-1.7.1	NA			
1.1.10.1.4.1.1.1	Boost Pump Malfunction	F-1.5.2	SF-1.7.3	DE			identify
1.1.10.1.4.2.1.1	Transfer Pump Malfunction	F-1.5.3	SF-1.7.4	ND			state
1.1.10.1.4.3.1.1	Compressor Malfunction	F-1.5.4	SF-1.7.5	ND			
1.1.4.3.12.1.1	Bypass Filter Malfunction	F-1.5.5	SF-1.7.6	ND			state
1.1.10.1.4.4.1.1	Emergency Pump Malfunction	F-1.5.6	SF-1.7.7	DM	obvious	Type 2	whether or
1.1.12.1.3.4.5.1	External Engine Fire	F-1.5.7*	SF-1.7.8	DE			identify
1.1.12.1.3.4.4.1	Internal Engine Fire	F-1.5.8	SF-1.7.9	DE			identify
	Internal Aircraft Fire	F-1.5.10*	SF-1.7.11	ND			identify
	Oil System Malfunction Detection	F-1.4.1	SF-1.5.2	NA			
1.1.10.1.5.2.1.1	Gear Box Oil Malfunction	F-1.4.2*	SF-1.5.3	DM	obvious	Type 2	identify
1.1.10.1.5.3.1.1	Engine Oil Malfunction	F-1.4.3	SF-1.5.4	DE			identify
1.1.10.1.2.3.1.1	Intermediate Gear Box Oil Malfunction	F-1.4.4	SF-1.5.5	ND			state
1.1.10.1.5.2.1.1	Combining Gear Box Oil Malfunction	F-1.4.5*	SF-1.5.7	DM	hidden	Type 2	identify
1.1.10.1.5.1.2	Speed Decreaser	F-1.4.6	SF-1.5.7	DE			identify
	Hydraulic System Malfunction Detection	F-3.5.1	SF-2.5.1	NA			
1.1.10.1.7.1	Hydraulic System Malfunction	F-3.5.2*	SF-2.5.3	DM	hidden		identify
	ASE Malfunction Detection	F-3.3.1	SF-2.3.1	NA			

* See notes which follow this appendix

Task No.	Task Name	Slide No.	Old Slide No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
1.1.4.3.1.1.1	ASE Malfunction	F-3.3.2	SF-2.3.3	DE			identify
	Landing Gear Failure to Lower	F-3.3.3	SF-2.3.5	DE			identify
1.1.4.3.14.1.1	Tire Blowout	F-3.3.4	SF-2.3.6	ND			state
1.1.12.1.3.6.2	Postflight Inspection	F-4.2.4	PE-3A.1.4	ND			name
1.1.12.1.3.4.3.1	Droop Stops Failure	F-4.1.1	PF-3.1.1	DE			identify
	Engine Malfunction Detection	F-5.3.1	SF-4.3.2	NA			
1.1.10.1.1.1.1	Engine Flameout	F-5.3.2*	SF-4.3.3	DE			identify
1.1.10.1.1.2.1.1	Throttle-Caused Power Oscillation	F-5.3.3*	SF-4.3.4	DE			identify
1.1.10.1.1.4.1.1	Partial Power Loss	F-5.3.4	SF-4.3.6	DE			identify
1.1.10.1.1.5.1.1	Compressor Stall	F-5.3.5*	SF-4.3.7	DE			identify
1.1.10.1.1.6.1.1	Electrically-Caused Overspeed	F-5.3.6*	SF-4.3.8	DM	hidden	Type 2	identify
1.1.10.1.1.7.1.1	Loss of Nf Signal	F-5.3.7	SF-4.3.9	DE			identify
	Flight Control Malfunction Detection	F-5.2.1	SF-4.2	NA			
1.1.4.3.9.1.1	Loss of Tail Rotor Thrust	F-5.2.2*	SF-4.2.3	DM	hidden	Type 2	identify
1.1.4.3.15.1.1	Loss of Tail Rotor Control	F-5.2.3*	SF-4.2.4	DM	hidden	Type 2	identify
	Elec'l System Malfunction Detection	F-7.3.1	SF-5.3.1	NA			
1.1.4.3.11.1.1.1	Generator Malfunction	F-7.3.2*	SF-5.3.3	DE			identify
1.1.4.3.11.4.1.1	Converter Malfunction	F-7.3.3	SF-5.3.5	DE			identify
1.1.4.3.11.3.1.1	Total Electrical Failure	F-7.3.4*	SF-5.3.6	DE			identify
	26-Volt AC Transformer Failure	F-7.3.5	SF-5.3.7	DE			identify

* See notes which follow this appendix

Task No.	Task Name	Slide No.	Old Slide No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
1.1.4.3.3.1.1	Torque Gauge Malfunction	F-7.3.6	SF-5.3.10	DE			identify
1.1.12.1.3.4.2.1	Shutdown with Total Electrical Failure	F-7.3.7	SF-5.3.11	ND			state
1.1.4.3.8.1.1	Dual Engine Failure	F-7.2.1	SF-5.2.1	ND			state
1.1.4.3.7.1.1	Single Engine Failure	F-7.2.2*	SF-5.2.2	DE			identify
	Electrical Fire Detection	F-7.2.4	SF-5.2.6	DE			identify
1.1.10.2.3.1	Determining Restart Feasibility	F-7.1.2*	SF-5.1.2	DM	obvious	Type 2	decide whether
1.1.4.3.4.1.1	Decaying Nr/Nf	F-9.2.1	SE-7.2.1	DE			identify
1.4.6.1.3.3.1.1	Settling with Power	F-9.2.2	SU-1.1.1	ND			define, name, state
1.4.6.1.3.1.1	Power Settling	F-9.2.3	SU-1.1.3	DE			identify
1.4.6.1.3.2.1.1	Blade Stall	F-11.1.1*	SF-8.1.1	DE			identify
1.1.12.1.3.4.1.2	Locked Tailwheel	F-11.1.2		ND			state

* See notes which follow this appendix

PILOT/ATO (TS)

Slide No.	Notes
F-1.5.7	Measure of criticality of a mission is considered by the pilot. This information is used to decide whether to continue the mission or to abort.
F-1.5.10	Identify cues and alerts for cabin fire by fumes, visible smoke, and/or fire.
F-1.4.2	The cues and symptoms are given and the pilot must decide whether or not there is a gearbox malfunction. Phrases such as "the first indication of malfunction in the oil system will probably be the transmission oil pressure caution light" are used. As it is indicated in the tape slide, this is a "no ask from ground" procedure.
F-1.4.5	Possible symptoms for a combining gearbox oil malfunction are discussed. The pilot must identify the malfunction. Phrases such as "a complete break in the oil line will probably cause these indications (1) the combining gear box caution light will illuminate, (2)..." are used.
F-3.5.2	Phrases such as "the hydraulic pressure caution light in the caution light panel will probably be your first indication of a malfunctioning, but remember a caution light could be accompanied by a sudden burst of flight in the event of a massive break in the line" are used.
F-5.3.2	The reaction speed is critical. The previously made decision is communicated to the pilot for execution via manuals and gauges.
F-5.3.3	Determine whether it is throttle-caused oscillation or engine-caused oscillation. The procedure to test and determine is given.
F-5.3.5	Symptoms are given but the procedure to obtain a diagnosis through the use of those symptoms is not mentioned.
F-5.3.6	Phrases such as "on the other hand, if the aircraft is on the descent or on deck, faulty electrical input to the fuel control will probably result in rotor overspeed. The symptoms for electrically caused rotor overspeed are: (1) NFNR for ..., (2)..." are used.

Slide No.	Notes
F-5.2.2	As symptoms,phrases such as "... depending upon flight condition, aerodynamic coupling may produce right roll and pitch down. The rate of yaw will depend upon the amount of torque applied to the ..." are used. It may be critical because it is said that "loss of tail rotor thrust demands immediate action". It may cause total loss of control which, in turn, may cause landing on the nose. Also there are phrases such as "(1) begin a 70 Ng minimum power descent or autorotation depending upon the intensity of the vibration".
F-5.2.3	Some alternatives are given for yaw controlling the aircraft with loss of tail rotor control, but the criteria for choosing any one of them is not mentioned.
F-7.3.2	The pilot must figure out how much gas is left without the use of working instruments (due to lack of generator).
F-7.3.4	Same as F-7.3.2
F-7.2.2	Phrases are used such as "the first indication of engine failure will probably be the sound of the engine unwinding. This will be followed by ...".
F-7.1.2	Whether or not to attempt a restart is investigated. Phrases are used such as "the ultimate decision as to whether or not a restart should be attempted rests with the pilot in command. In making this decision he must rely on his knowledge of NATOPS, his good judgment and his personal experience. There are no hard and fast rules of attempting to restart after an engine is flamed or has been secured in flight. But there are some general guidelines which can be followed. An engine restart should be attempted under the following conditions: (1)..., (2)..., (3)... Remember, do not attempt to restart if the engine is in flame because of an internal or external fire."
F-7.11.1.1	Critical. Requires rapid identification and correction action.

APPENDIX D
CREW (TS)
Analysis of Crewman Tape Slides

Task Name	Old Slide No.	NA/ND	Keyword
Planned Ditching	CRF-1.3.4	ND	state
Search & Rescue Equipment	CRF-1.5.5/6	ND	name, state
Crewman Safety Belt	CRF-1.6.3	ND	describe, name
Aircraft Handling #1	PF-3.2.1	ND	state
Aircraft Handling #2	PF-3.2.2	ND	state
Aircraft Movement Safety Rules	PF-3.2.4	ND	state
Signature Cards	PF-2.1.3	ND	demonstrate
Immediate Ditching Procedure	CRF-1.3.3	ND	state
Bailout Procedure	CRF-1.3.5	ND	state
Total Electrical Failure	CRF-1.3.7	ND	identify
Internal & External Engine Fire	CRF-1.3.9	ND	state
Hand Pressure Signals	CRH-1.3.3	ND	state
Cabin and/or Electrical Fire	CRF-1.3.11	ND	state
Hung Droop Stop	CRF-1.3.14	ND	state
Cargo Transfer Safety Precaution	CRH-1.4.1	ND	state
Cargo Rigging Safety Precaution	CRH-1.4.5	ND	state
Normal Hoisting Operations	CRH-1.3.7	ND	state
Connect/Disconnect Refueling Hose	CRH-2.1.4	ND	state
Passenger Survival Gear	CRH-2.1.4	ND	name
Swimmer's Equipment	CRW-1.2.1	ND	identify, state
Required Flight Gear	CRF-1.6.7	ND	name
Regaining Lost UHF Communication	SE-4.9.2	ND	name
LAMPS Frequency Circuits	SE-4.9.3	ND	name
Aircraft Positioning During HIFR	CRH-2.1.2	ND	state

Task Name	Old Slide No.	NA/ND	Keyword
Sonobuoy Loading Safety	OR-2.1.8	ND	state
Inspecting JAU-1B CAD	OR-1.1.5	ND	state
Inspecting Sonobuoy Launch Container	OR-1.1.3	ND	name
Major Preflight Inspection Areas	PF-3A.2.7	ND	name
Radar Interpretation - Land Mass	NA-2.1.1*	ND	name
Radar Interpretation - Heavy Weather Contact	NA-2.1.2*	ND	name
Radar Interpretation - Surface Contact	NA-2.1.3*	ND	name
Radar Interpretation - Airborne Contacts	NA-2.1.4*	ND	name
Sound Velocity	AC-1.2.11	ND	describe

*See notes which follow this appendix.

CREW (TS)

Slide No.	Notes
NA-2.1.1	This slide prepares the crewmen for distinguishing between a target and a land mass which itself is a classification and, therefore, a decision task. Only the attributes (features of a land mass on radar (one of the two classes) is listed and the crewman is supposed to classify the object as a land mass if he identifies those attributes.
NA-2.1.2	"Name three radar display characteristics of heavy weather" is the objective of this course. These characteristics (features) are listed.
NA-2.1.3	The three radar display characteristics of surface contact are listed.
NA-2.1.4	The three radar display characteristics of an airborne contact are listed. One of them (fast movement) is mentioned to be the distinguishing characteristics between airborne contact and surface contact.

APPENDIX E
PILOT/ATO (WB)
Analysis of PILOT/ATO Workbooks

Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
1.1.10.1.2.4.1.3	Transmission System	F-1.8.1	SF-1.10.1	ND			describe
1.1.10.1.2.4.1.2	"	F-1.8.2		ND			"
1.1.10.1.2.4.3	"	F-1.8.3		ND			"
1.1.10.1.2.4.2	"	F-1.8.4		ND			"
1.1.10.1.2.4.1	"	F-1.8.5		ND			"
1.1.10.1.2.4.1.1	"	F-1.8.6		ND			"
	Fire Detection and Extinguishing System	F-1.7.1	SF-1.9.1	ND			describe
1.1.4.3.10.6.1.2	"	F-1.7.2		ND			"
1.1.4.3.10.6.3	"	F-1.7.3		ND			"
1.1.4.3.10.6.4	"	F-1.7.4		ND			"
1.1.4.3.10.6.2	"	F-1.7.5		ND			"
1.1.4.3.10.6.1	"	F-1.7.6		ND			"
1.1.4.3.10.6.1.1	"	F-1.7.7		ND			"
1.1.4.3.12.4.1.3	Fuel System Operation	F-1.6.1	SF-1.8.1	ND			describe
1.1.4.3.12.4.1.2	"	F-1.6.2		ND			"
1.1.4.3.12.4.3	"	F-1.6.3		ND			"
1.1.4.3.12.4.4	"	F-1.6.4		ND			"
	"	F-1.6.5		ND			"
1.1.4.3.12.4.1	"	F-1.6.6		ND			"
1.1.4.3.12.4.1.1	"	F-1.6.7		ND			"
	Fuel Control Divider Setting	F-1.5.9	SF-1.7.10	ND			state
1.1.10.1.6.6	Flight Control System	F-1.3.1	SF-1.4.1	ND			describe
1.1.12.1.3.2	Disengage Rotor Envelope	F-1.2.7	SF-1.3.7	DE			determine if

Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
	Airspeed	F-1.2.6	SF-1.3.6	DE			calculate
1.1.10.2.1.3	Density	F-1.2.5	SF-1.3.5	DE			determine
1.1.10.2.1.3	Torque	F-1.2.4	SF-1.3.4	DE			determine
	Endurance	F-1.2.3*	SF-1.3.3	DE			determine
1.1.2.1.1	Gross Weight	F-1.2.2	SF-1.3.2	DE			calculate
1.1.2.1	Single Engine Airspeed	F-1.2.1	SF-1.3.1	DE			determine
1.1.11.2.1.1	VMC Recovery to Land	F-1.1.4*	SF-1.1.4	ND			state
	Land Recovery	F-1.1.3	SF-1.1.3	ND			state
1.1.4.2.1.1	Normal Take-Off	F-1.1.2	SF-1.1.2	ND			state
1.1.4.2.1.7.1	Taxi Procedure	F-1.1.1	SF-1.1.1	ND			state
	Airframe System	F-3.11.1	SF-2.11.1	ND			describe
1.1.10.6.3.1.2	"	F-3.11.2		ND			"
1.1.10.1.6.3.3	"	F-3.11.3		ND			"
1.1.10.1.6.3.2	"	F-3.11.4		ND			"
1.1.10.1.6.3.1	"	F-3.11.5		ND			"
1.1.10.1.6.3.1.1	"	F-3.11.6		ND			"
1.1.10.1.6.3.1	Rotor System Operation	F-3.10.1	SF-2.10.1	ND			describe
1.1.10.1.6.3.1.2	"	F-3.10.2		ND			"
1.1.10.1.6.3.3	"	F-3.10.3		ND			"
1.1.10.1.6.3.2	Rotor System Operation	F-3.10.4		ND			describe
1.1.10.1.6.3.1	"	F-3.10.5		"			"
1.1.10.1.6.3.1.1	"	F-3.10.6		"			"
1.1.10.1.6.4.1.2	Wheel Brakes System	F-3.9.1	SF-3.9.1	ND			describe
	"	F-3.9.2		"			"

* See notes which follow this appendix

Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
1.1.10.1.6.4.3	Wheel Brakes System	F-3.9.3		ND			describe
1.1.10.1.6.4.3	"	F-3.9.4		"			"
1.1.10.1.6.4.2	"	F-3.9.5		"			"
1.1.10.1.6.4.1	"	F-3.9.6		"			"
1.1.10.1.6.4.1.1	"	F-3.9.7		"			"
	Blade Track System	F-3.8.1	SF-2.8.1	ND			describe
	"	F-3.8.2		"			"
1.1.10.1.6.9.4	"	F-3.8.3		"			"
	"	F-3.8.4		"			"
1.1.10.1.6.9.1	Blade Track System	F-3.8.5		ND			describe
1.1.10.1.6.9.1.1	"	F-3.8.6		"			"
1.1.10.1.7.2.1.3	Hydraulic System	F-3.6.1	SF-2.6.1	ND			describe
1.1.10.1.7.2.1.2	"	F-3.6.2		"			"
1.1.10.1.7.2.3	"	F-3.6.3		"			"
1.1.10.1.7.2.4	"	F.3.6.4		"			"
1.1.10.1.7.2.2	"	F-3.6.5		"			"
1.1.10.1.7.2.1	"	F-3.6.6		"			"
1.1.10.1.7.2.1.1	"	F-3.6.7		"			"
1.1.4.3.1.1.1.1.1.2	ASE System	F-3.4.1	SF-2.4.1	ND			describe
1.1.4.3.1.1.1.1.3	"	F-3.4.2		"			"
1.1.4.3.1.1.1.4	"	F-3.4.3		"			"
1.1.4.3.1.1.1.1.2	"	F-3.4.4		"			"
1.1.4.3.1.1.1.1.1	"	F-3.4.5		"			"
1.1.4.3.1.1.1.1.1.1	"	F-3.4.6		"			"
1.1.3.2.4	Battery Start	F-3.2.1	SF-2.2.1	ND			state

Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
	Precision Approach	F-3.1.1	SF-2.1.3	ND			state
	Normal Approach	F-3.1.2	SF-2.1.4	ND			state
	Rustlick	F-4.2.3	PF-3A.1.3	ND			state
1.1.12.1.1.2	Vids Fill-Out	F-4.2.2	PF-3A.1.2	ND			Fill out
1.1.12.1.1.1	Yellow Sheet	F-4.2.1	PF-3A.1.1	ND			list
1.8.2.3.8.1.1	Navigation System	F-5.8.7		ND			describe
1.8.2.3.8.1	"	F-5.8.6		"			"
1.8.2.3.8.2	"	F-5.8.5		"			"
1.8.2.3.8.4	"	F-5.8.4		"			"
1.8.2.3.8.3	"	F-5.8.3		"			"
1.8.2.3.8.1.2	"	F-5.8.2		"			"
1.8.2.3.8.1.3	"	F-5.8.1	SF-4.6.1	"			"
1.8.2.3.1.1.1	Pitot Airspeed System	F-5.7.7		ND			describe
1.8.2.3.1.1	"	F.5.7.6		"			"
1.8.2.3.1.2	"	F.5.7.5		"			"
1.8.2.3.1.3	"	F.5.7.4		"			"
1.8.2.3.1.3	"	F.5.7.3		"			"
1.8.2.3.1.1.2	"	F-5.7.2		"			"
1.8.2.3.1.1.3	"	F-5.7.1	SF-4.7.1	"			"
1.1.10.1.1.8.1.1	Power Plant System	F-5.4.7		NA			
1.1.10.1.1.8.1	"	F-5.4.6		"			
1.1.10.1.1.8.2	"	F-5.4.5		"			
1.1.10.1.1.8.4	"	F-5.4.4		"			
1.1.10.1.1.8.3	"	F-5.4.3		"			
1.1.10.1.1.8.1.2	"	F-5.4.2		"			
1.1.10.1.1.8.1.3	"	F-5.4.1	SF-4.5.1	"			

Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
1.1.11.2.3.2.1	Recovery w/ loss of Tail Rotor Control	F-5.1.5*	SF-7.1.2	DE			state
1.1.10.2.2.2.1	Running Autorotation Landing	F-5.1.3	SF-4.1.3	ND			state
1.1.10.2.2.1.1	Fuel Flare Autorotation Landing	F-5.1.2	SF-4.1.2	ND			state
1.1.10.2.1.4	Emergency RPM Control Approach	F-5.1.1*	SF-4.1.1	DE			state
	Communications System	F-7.7.6		ND			describe
1.8.2.5.5.1	"	F-7.7.5		"			"
1.8.2.5.5.2	"	F-7.7.4		"			"
1.8.2.5.5.3	"	F-7.7.3		"			"
1.8.2.5.5.1.2	"	F-7.7.2		"			"
1.8.2.5.5.1.3	"	F-7.7.1	SF-5.6.1	"			"
	Caution Lights System	F-7.6.6		ND			describe
1.8.2.5.5.1	"	F-7.6.5		"			"
1.8.2.5.5.2	"	F-7.6.4		"			"
1.8.2.5.5.3	"	F-7.6.3		"			"
1.8.2.5.5.1.2	"	F-7.6.2		"			"
	"	F-7.6.1	SF-4.16.1	"			"
1.8.2.2.1	Lighting System	F-7.5.5		ND			describe
1.8.2.2.4	"	F-7.5.4		"			"
1.8.2.2.5	"	F-7.5.3		"			"
1.8.2.2.2	"	F-7.5.2		"			"
1.8.2.2.3	"	F-7.5.1	SF-5.5.1	"			"

* See notes which follow this appendix

Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
1.1.4.3.11.5.1.1	Electrical System	F-7.4.7		ND			describe
1.1.4.3.11.5.1	"	F-7.4.6		"			"
1.1.4.3.11.5.2	"	F-7.4.5		"			"
1.1.4.3.11.5.4	"	F-7.4.4		"			"
1.1.4.3.11.5.3	"	F-7.4.3		"			"
1.1.4.3.11.5.1.2	"	F-7.4.2		"			"
1.1.4.3.11.5.1.3	"	F-7.4.1	SF-5.4.1	"			"
1.1.10.2.4.1	Ditching Station	F-7.2.8*	SF-5.2.11	DE			state
1.1.10.2.4	Immediate Ditching	F-7.2.7*	SF-5.2.10	DM	hidden	Type 2	state
1.1.10.2.4.1	Controlled Ditching	F-7.2.6	SF-5.2.9	ND			state
1.1.10.2.6	Water Takeoff	F-7.2.5	SF-5.2.7	ND			state
1.1.4.3.10.5	Internal A/C Fire Likelihood	F-7.2.3	SF-5.2.3	ND			state
1.1.11.1.3.2.3.3	Single Engine Recovery	F-7.1.6	SF-5.1.6	ND			state
1.1.11.1.3.2.3.1	Jettisoning	F-7.1.3	SF-5.1.3	ND			state
1.1.10.2.3.2	Secured Engine Restart	F-7.1.1	SF-5.1.1	ND			state
1.8.2.4.2.1.1	Weapons Systems	F-9.8.7		NA			
1.8.2.4.2.1	"	F-9.8.6		"			
1.8.2.4.2.2	"	F-9.8.5		"			
1.8.2.4.2.4	"	F-9.8.4		"			
1.8.2.4.2.3	"	F-9.8.3		"			
1.8.2.4.2.1.2	"	F-9.8.2		"			
1.8.2.4.2.1.3	Weapons System	F-9.8.1		NA			
1.8.2.4.2.1.1	Electrical Release System	F-9.7.7		ND			describe

* See notes which follow this appendix

Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
1.8.2.4.2.1	Electrical Release System	F-9.7.6		ND			describe
1.8.2.4.2.1	"	F-9.7.5		"			"
1.8.2.4.2.4	"	F-9.7.4		"			"
1.8.2.4.2.3	"	F-9.7.3		"			"
1.8.2.4.2.1.2	"	F-9.7.2		"			"
1.8.2.4.2.1.3	"	F-9.7.1	SF-7.10.1	"			"
	Sonobuoy System	F-9.6.3		ND			describe
	"	F-9.6.2		"			"
	"	F-9.6.1	SF-5.9.1	"			"
1.8.2.4.8.1.1	ALR-54 System	F-9.5.7		ND			describe
1.8.2.4.8.1	"	F-9.5.6		"			"
1.8.2.4.8.2	"	F-9.5.5		"			"
1.8.2.4.8.4	"	F-9.5.4		"			"
1.8.2.4.8.3	"	F-9.5.3		"			"
1.8.2.4.8.1.2	"	F-9.5.2		"			"
1.8.2.4.8.1.3	"	F-9.5.1	SF-7.4.1	"			"
1.8.2.4.7.1.1	MAD System	F-9.4.7		ND			describe
1.8.2.4.7.1	"	F-9.4.6		"			"
1.8.2.4.7.2	"	F-9.4.5		"			"
1.8.2.4.7.4	"	F-9.4.4		"			"
1.8.2.4.7.3	"	F-9.4.3		"			"
1.8.2.4.7.1.2	"	F-9.4.2		"			"
1.8.2.4.7.1.3	"	F-9.4.1	SF-7.3.1	"			"
1.1.6.1.3.6	MAD Use	F-9.3.5*	SE-1.4.4	NA			

* See notes which follow this appendix

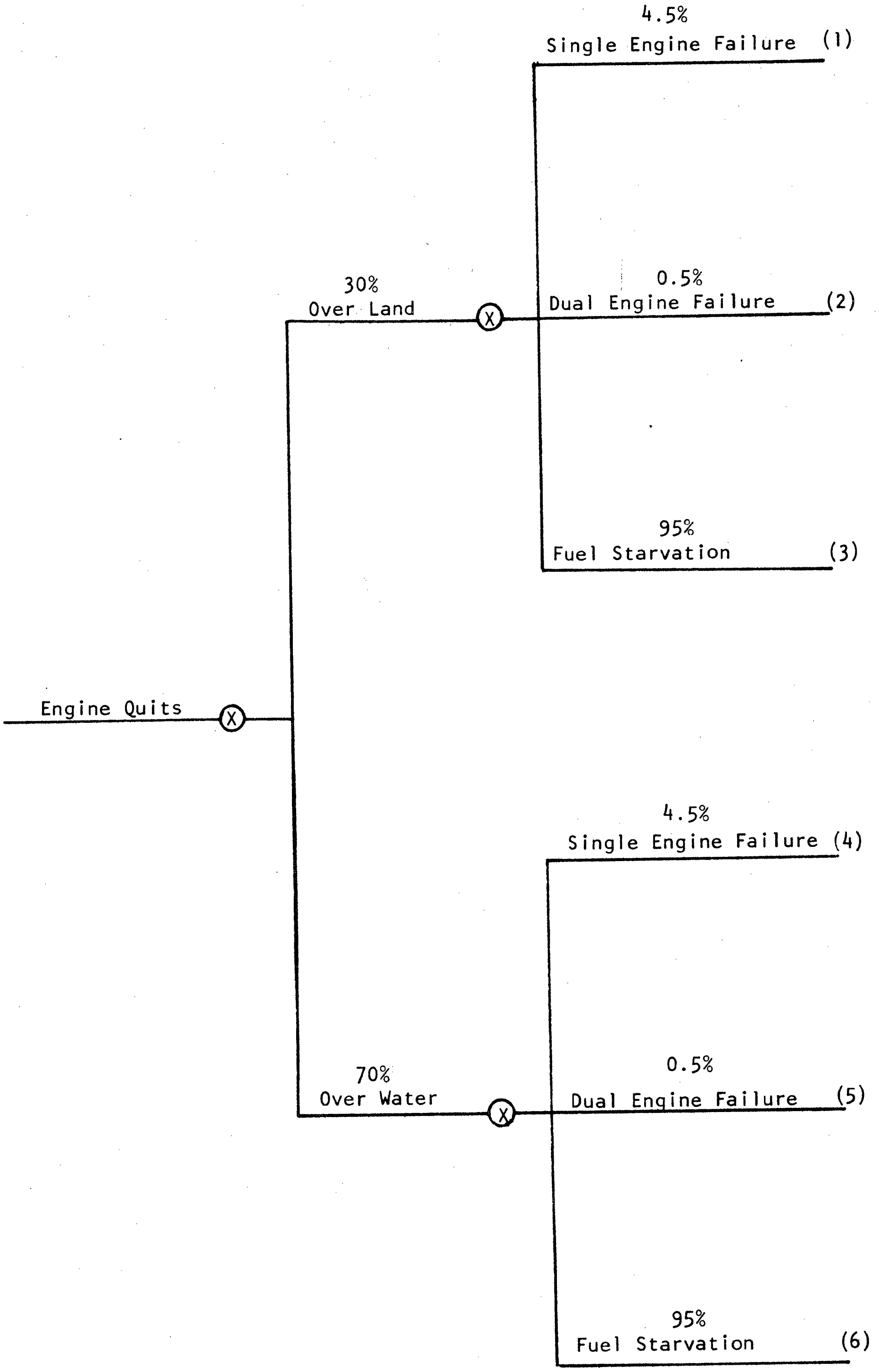
Task No.	Task Name	Section No.	Old Section No.	NA/ND DM/DE	Hidden/ Obvious	Type	Keyword
	MAD Pattern Strengths	F-9.3.4	SE-1.2.8	NA			
	MAD Localization	F-9.3.3*	SE-1.2.7	NA			
	MAD Procedures	F-9.3.1	SE-1.2.5	ND			state
1.1.4.2.3.1	Max. Gross Weight Takeoff	F-9.1.1	SF-7.1.1	ND			state
	LN66 HP Radar System	F-11.5.3		ND			describe
1.8.2.3.7.1	"	F-11.5.2		"			"
1.8.2.3.7.2	"	F-11.5.1	SF-4.12.1	"			"
1.8.4.2.1.1	Cargo Hook System	F-11.4.6		ND			describe
1.8.4.2.1	"	F-11.4.5		"			"
1.8.4.3	"	F-11.4.4		"			"
1.8.4.2.2	"	F-11.4.3		"			"
1.8.4.2.1.2	"	F-11.4.2		"			"
1.8.4.2.1.3	"	F-11.4.1	SF-8.4.1	"			"
1.8.5.3.1.1	Environmental System	F-11.3.7		ND			describe
1.8.5.3.1	"	F-11.3.6		"			"
1.8.5.3.2	"	F-11.3.5		"			"
1.8.5.3.4	"	F-11.3.4		"			"
1.8.5.3.3	"	F-11.3.3		"			"
1.8.5.3.1.2	"	F-11.3.2		"			"
1.8.5.3.1.3	"	F-11.3.1	SF-8.3.1	"			"
	Radar Offset Approach	F-11.2.2*	SE-4.8.3	DM	obvious	Type 2	state

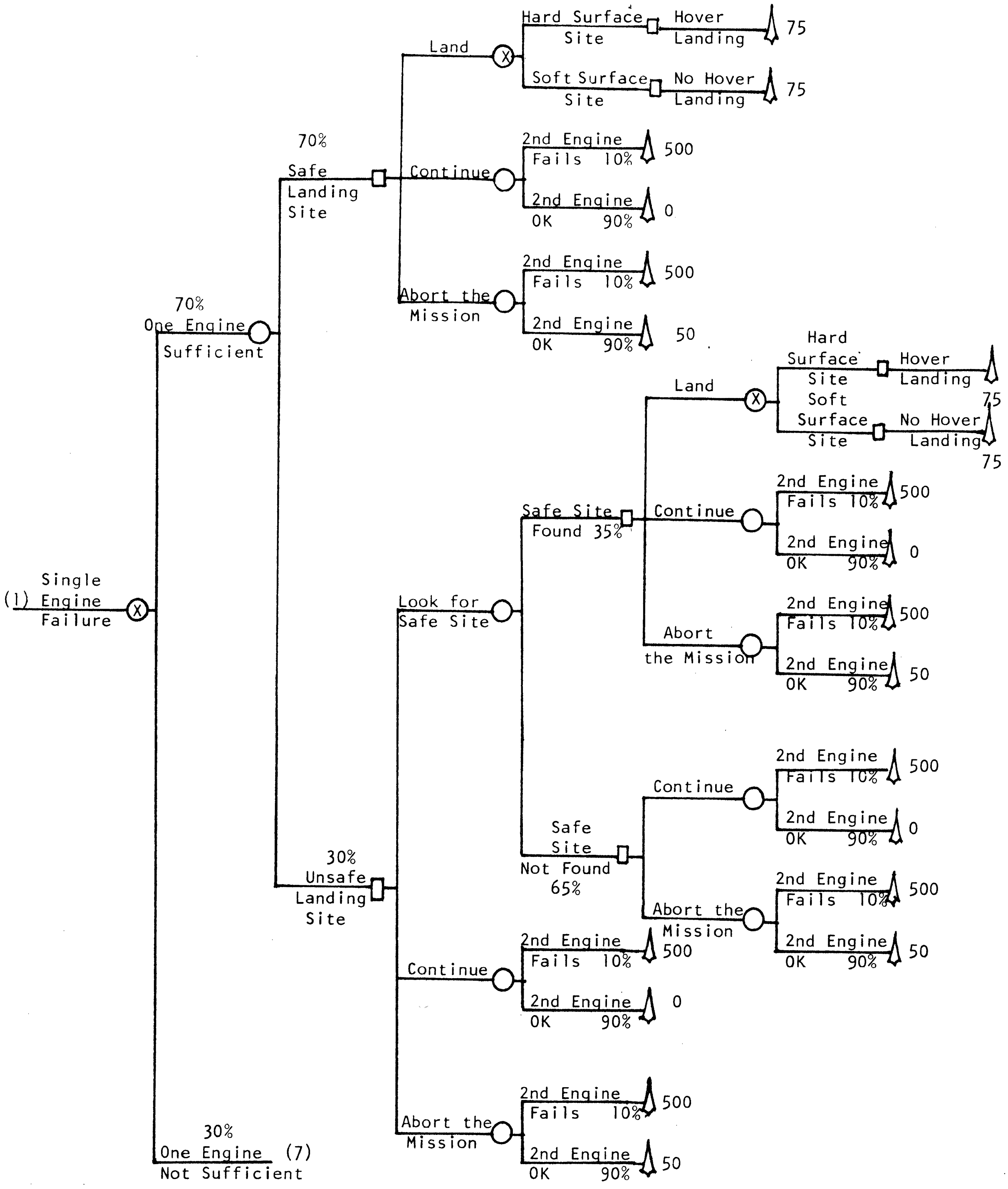
* See notes which follow this appendix

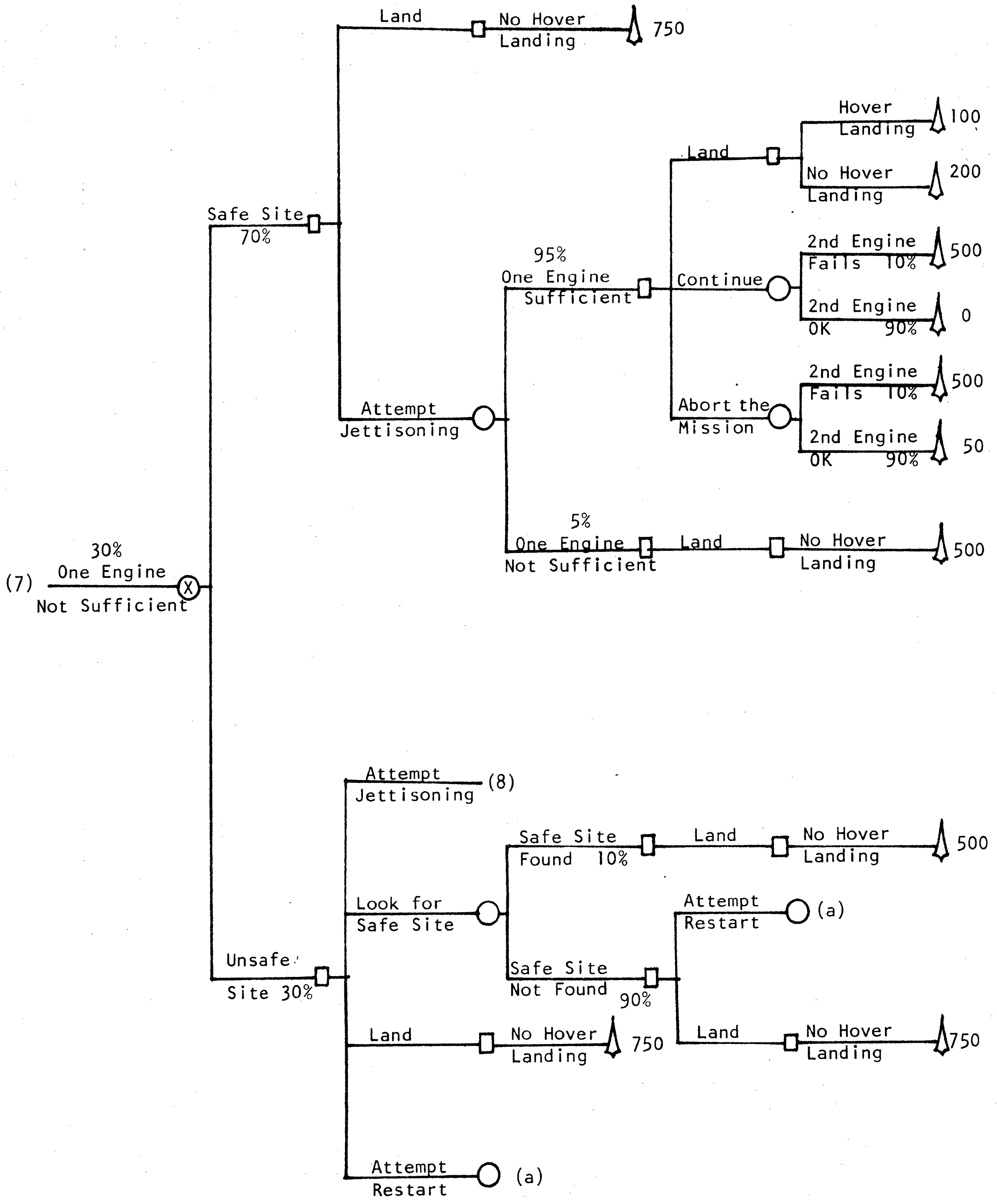
PILOT/ATO (WB)

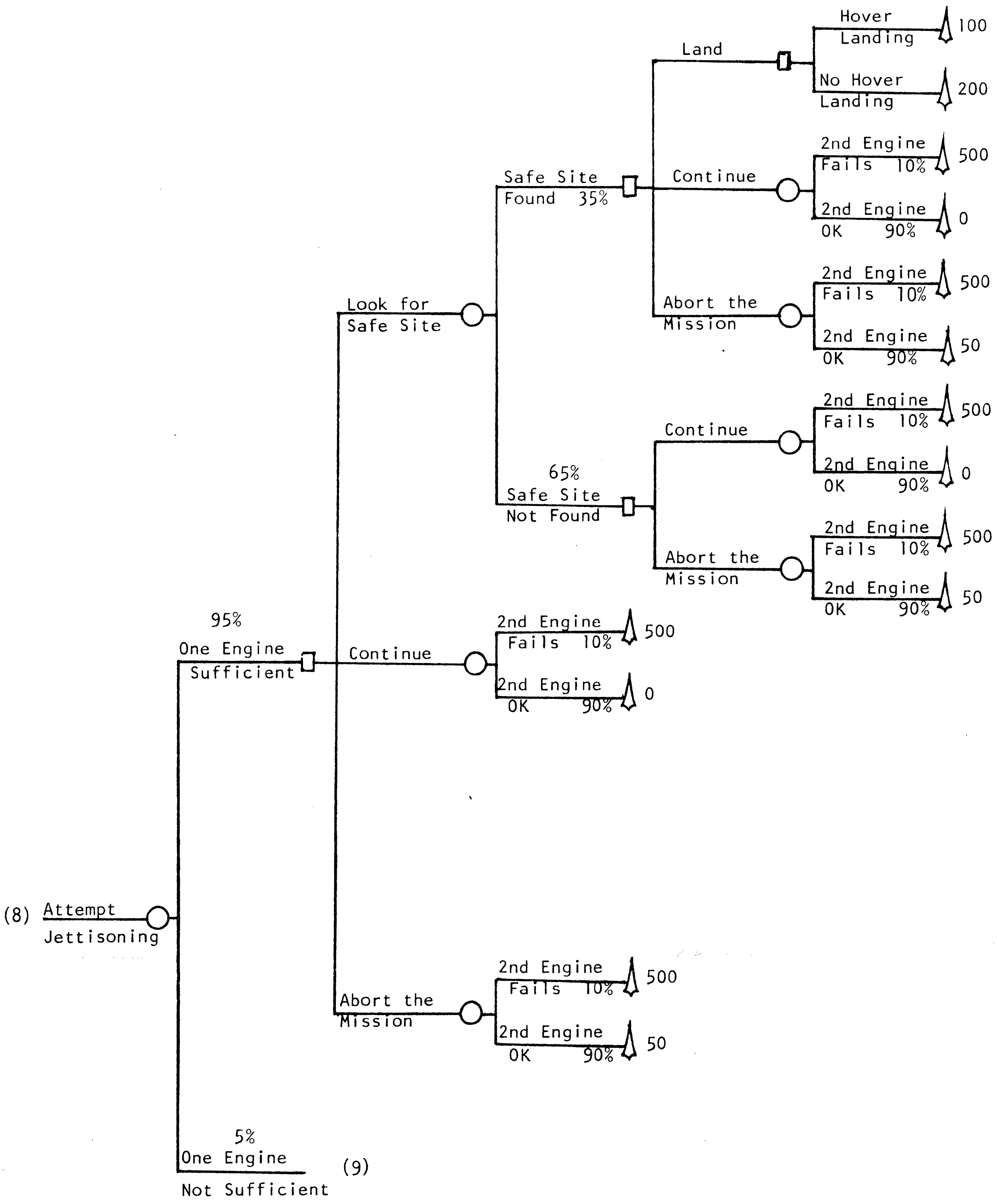
Section No.	Notes
F-1.2.3	There is a hidden decision making task inside the whole task "determine the required fuel reserve"; however, the procedure for its calculation is given "10% of fuel on board or 20 minutes of flight time, whichever is longer".
F-1.1.4	There are two hidden decision making tasks inside the whole task: (1) "Determine destination weather", and (2) "Determine traffic pattern", neither of which possesses a procedure. However, both are said to be "asked from the tower". Therefore, they are non-decision tasks with respect to the pilot.
F-5.1.5	The procedure is given in the form of "If (condition), then (action)", which is the translation of a table look up. This is a means of communicating a decision previously made to a decision executer.
F-5.1.1	There is a hidden decision "determine type of landing to be made"; however, the procedure to perform this determination is also given.
F-7.2.8	This task can be considered as a decision execution task. Since the decision as to "should an immediate ditching, planned ditching, or none be performed" has previously been made for all possible states of nature, the result of this decision is now being communicated to the pilot for execution.
F-7.2.7	Item B-2 of the procedure says, "Either secure engine and rotors (release harness and abandon aircraft) or follow single engine water takeoff procedure". However, it has not been suggested how to decide between these two alternatives. Therefore, this remains as a decision task to be performed by the pilot.
F-9.3.5	This task is potentially a very good technical and also critical (in terms of the objective of the mission) decision task. The course materials are not found in the workbook pack. (It might be classified.)
F-9.3.3	It is a potential decision task; however,the corresponding course material is not found in the workbook pack. (It might be classified.)
F-11.2.2	The item 2 of the procedure: "Determine if a direct or offset approach will be used" is a decision task. In the description of this item, it is said that "The ATO will decide if a direct or offset approach will be used". No completely specified criteria for this selection has been given.

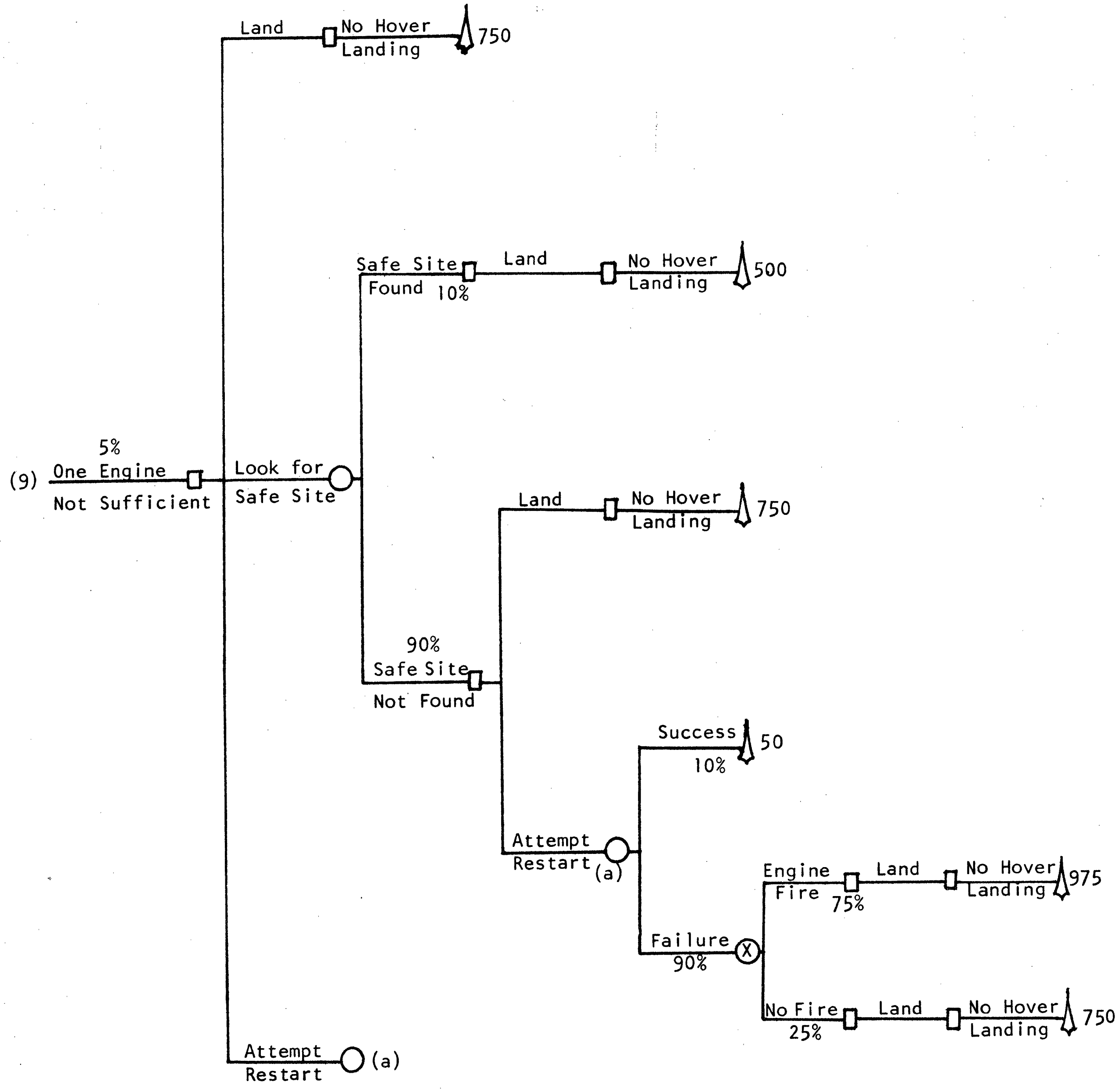
APPENDIX F

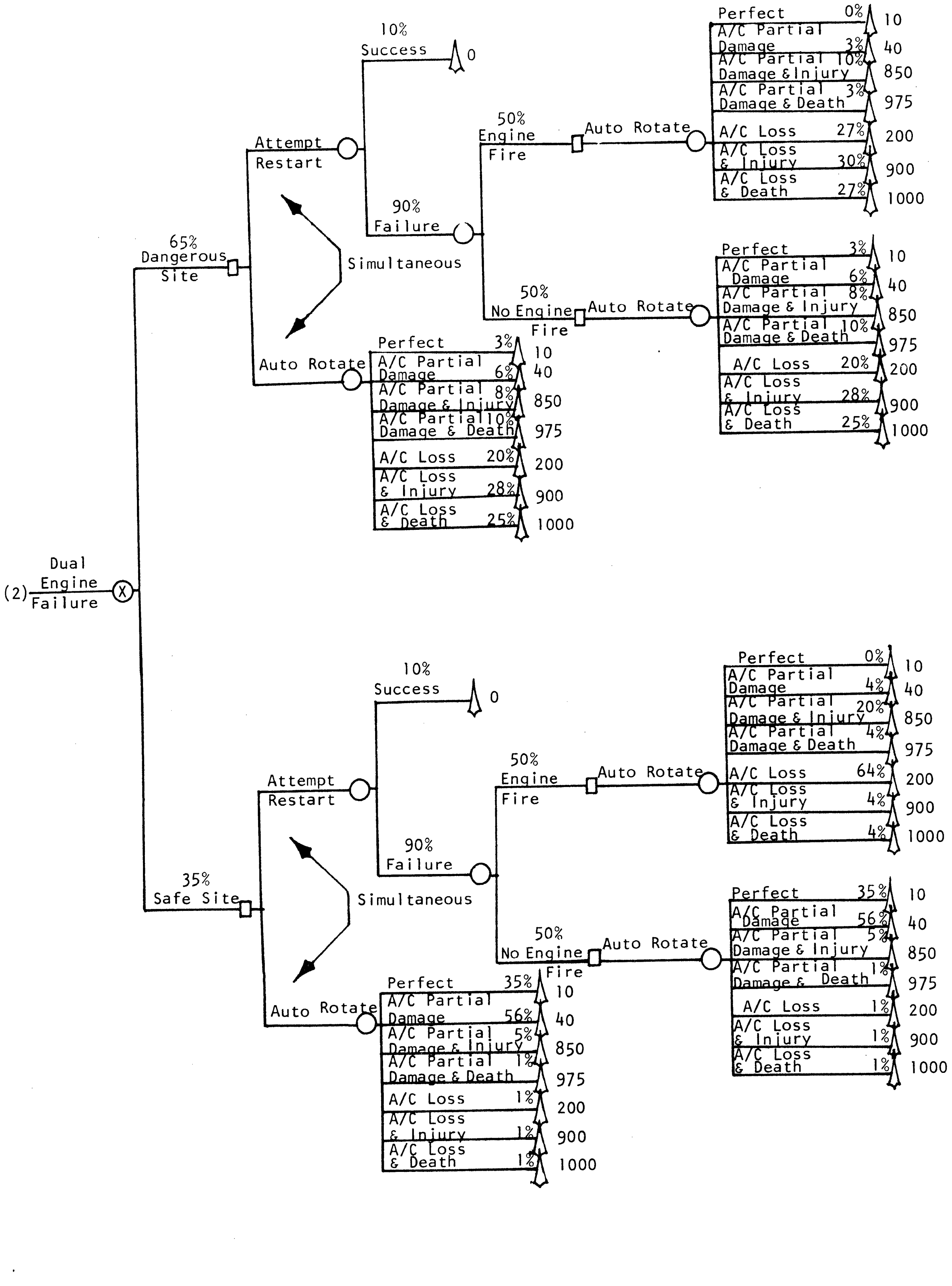

4.5%
Single Engine Failure (1)
30%
Over Land
X
0.5%
Dual Engine Failure (2)
95%
Fuel Starvation (3)
Engine Quits
X
4.5%
Single Engine Failure (4)
70%
Over Water
X
0.5%
Dual Engine Failure (5)
95%
Fuel Starvation (6)

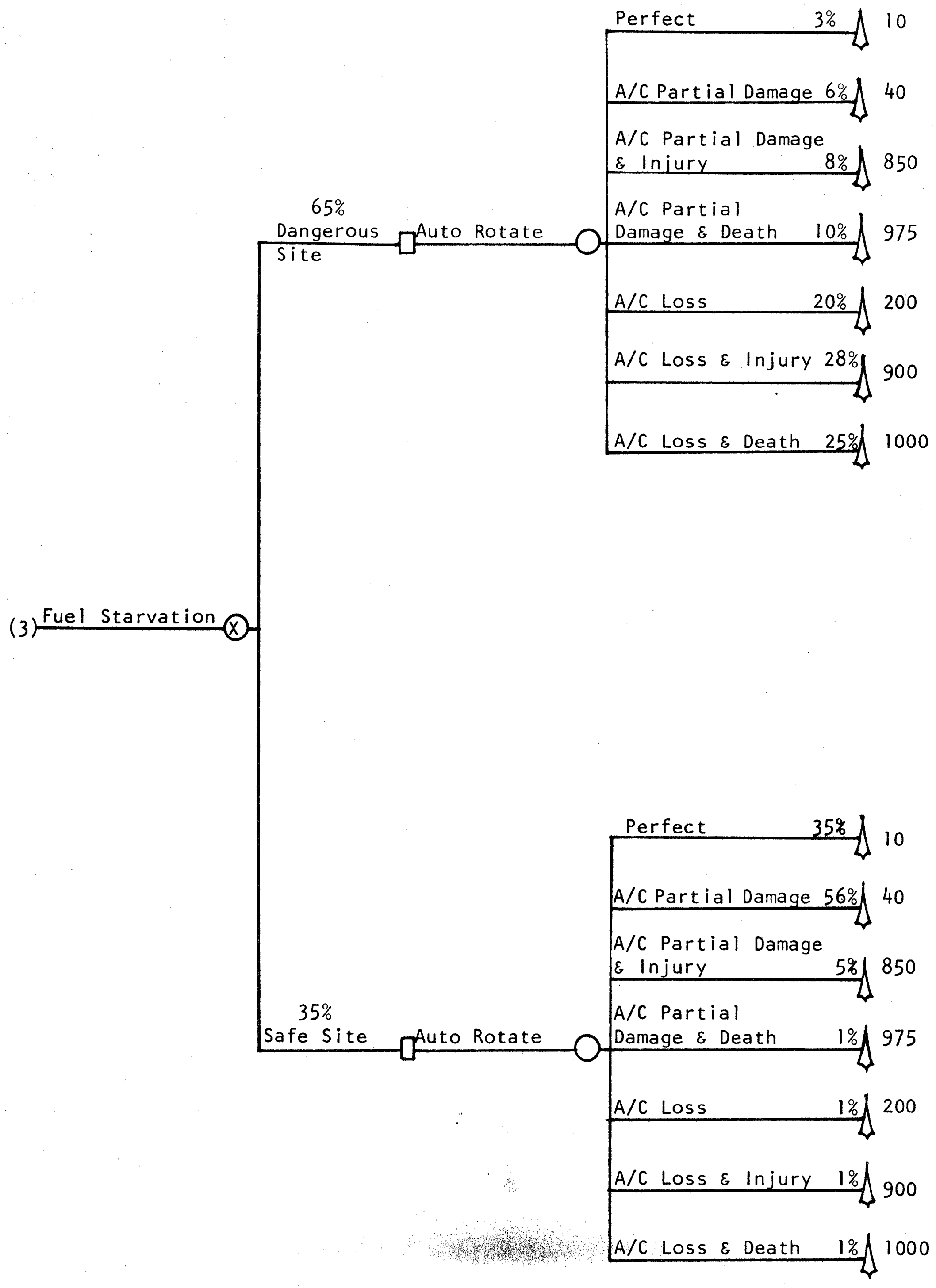

(1) Single Engine Failure
70% One Engine Sufficient
70% Safe Landing Site
Land
Hard Surface Site
Hover Landing
75
Soft Surface Site
No Hover Landing
75
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
30% Unsafe Landing Site
Look for Safe Site
Safe Site Found 35%
Land
Hard Surface Site
Hover Landing
75
Soft Surface Site
No Hover Landing
75
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
Safe Site Not Found 65%
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
30% One Engine Not Sufficient (7)

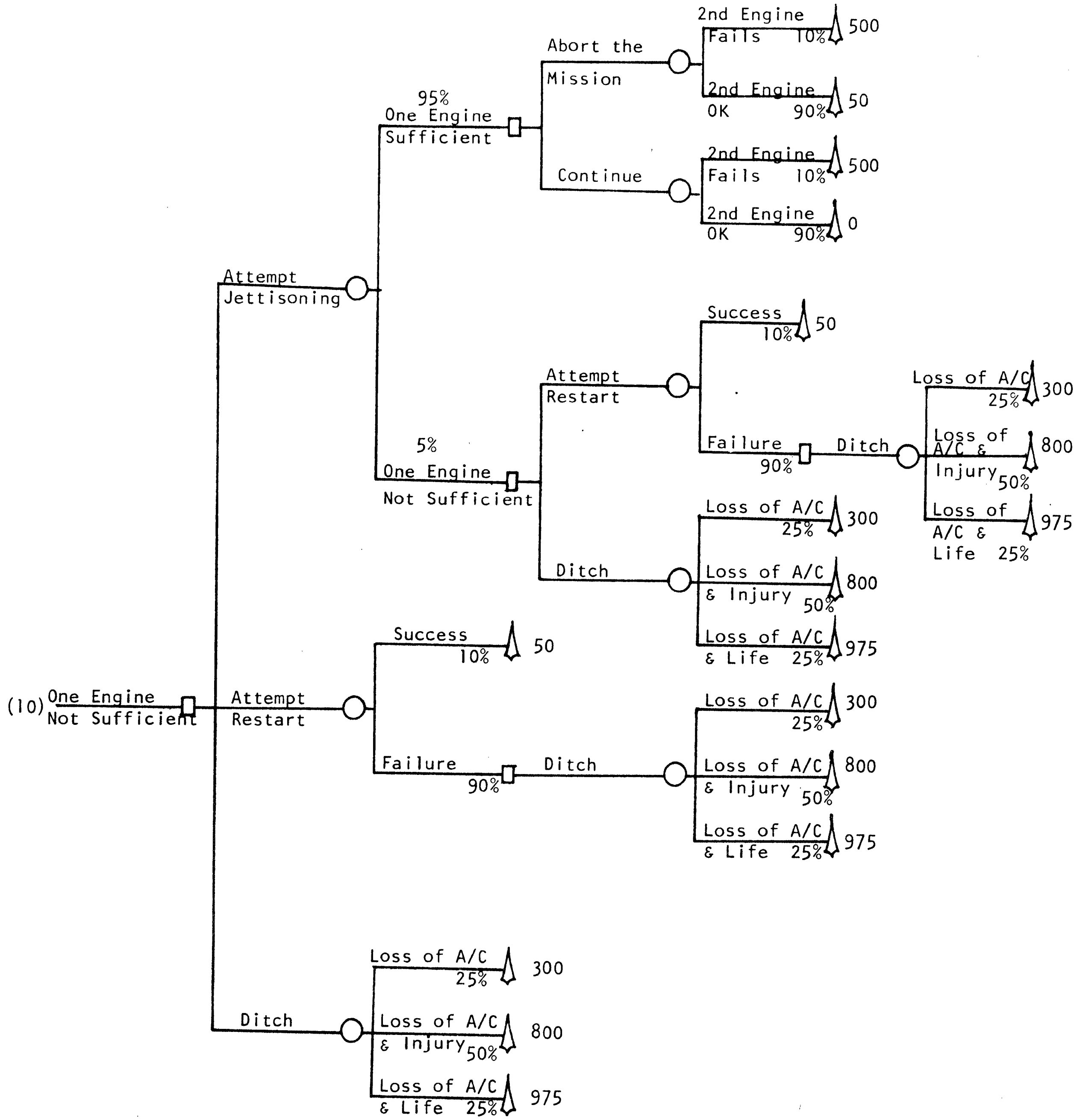

(7)
30%
One Engine
Not Sufficient
Safe Site
70%
Land
No Hover
Landing
750
Attempt
Jettisoning
95%
One Engine
Sufficient
Land
Hover
Landing
100
No Hover
Landing
200
Continue
2nd Engine
Fails 10%
500
2nd Engine
OK 90%
0
Abort the
Mission
2nd Engine
Fails 10%
500
2nd Engine
OK 90%
50
5%
One Engine
Not Sufficient
Land
No Hover
Landing
500
Unsafe
Site 30%
Attempt
Jettisoning
(8)
Look for
Safe Site
Safe Site
Found 10%
Land
No Hover
Landing
500
Safe Site
Not Found
90%
Attempt
Restart
(a)
Land
No Hover
Landing
750
Land
No Hover
Landing
750
Attempt
Restart
(a)

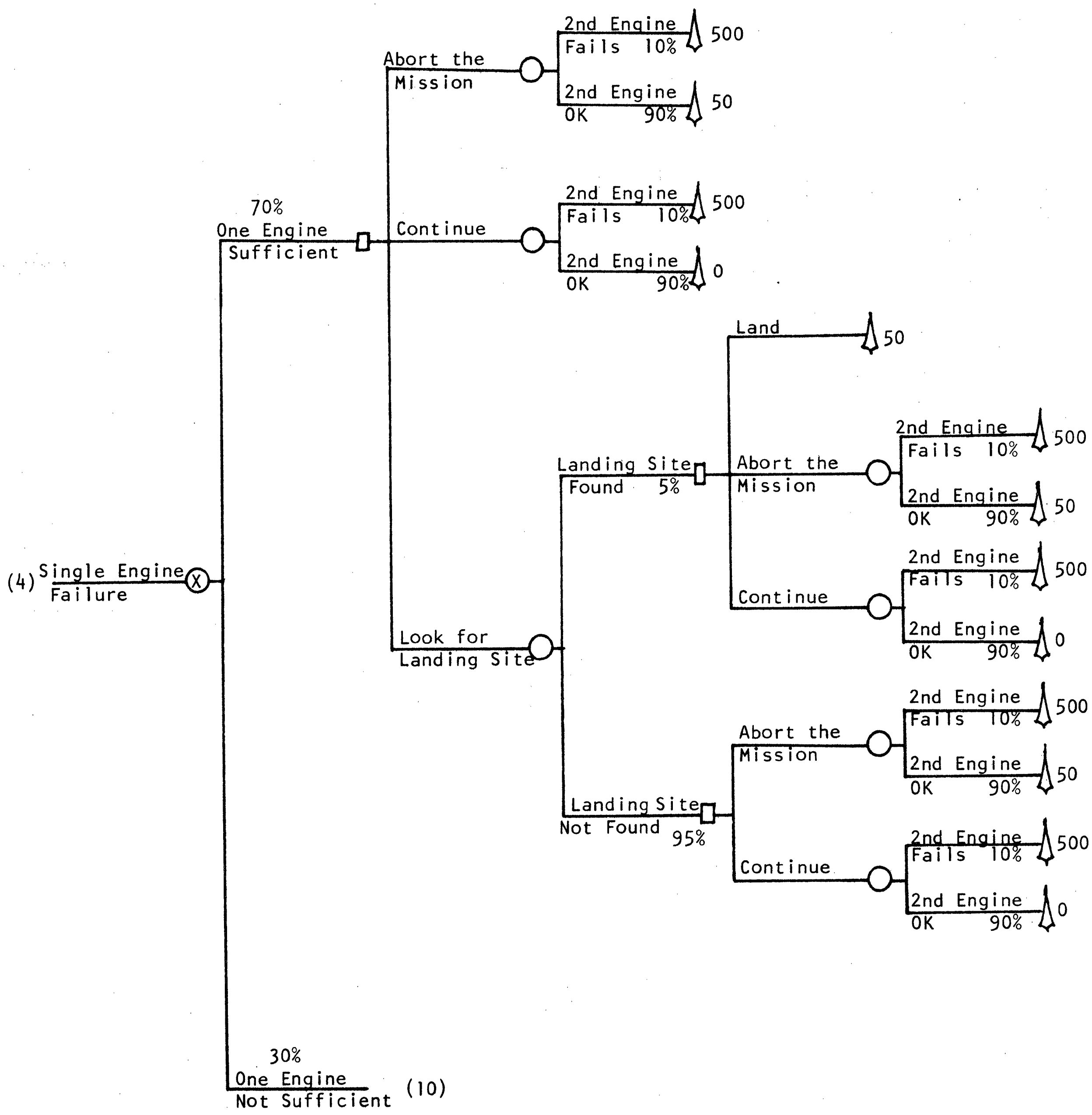

(8) Attempt Jettisoning
95% One Engine Sufficient
Look for Safe Site
Safe Site Found 35%
Land
Hover Landing
100
No Hover Landing
200
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
65% Safe Site Not Found
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
5% One Engine Not Sufficient
(9)

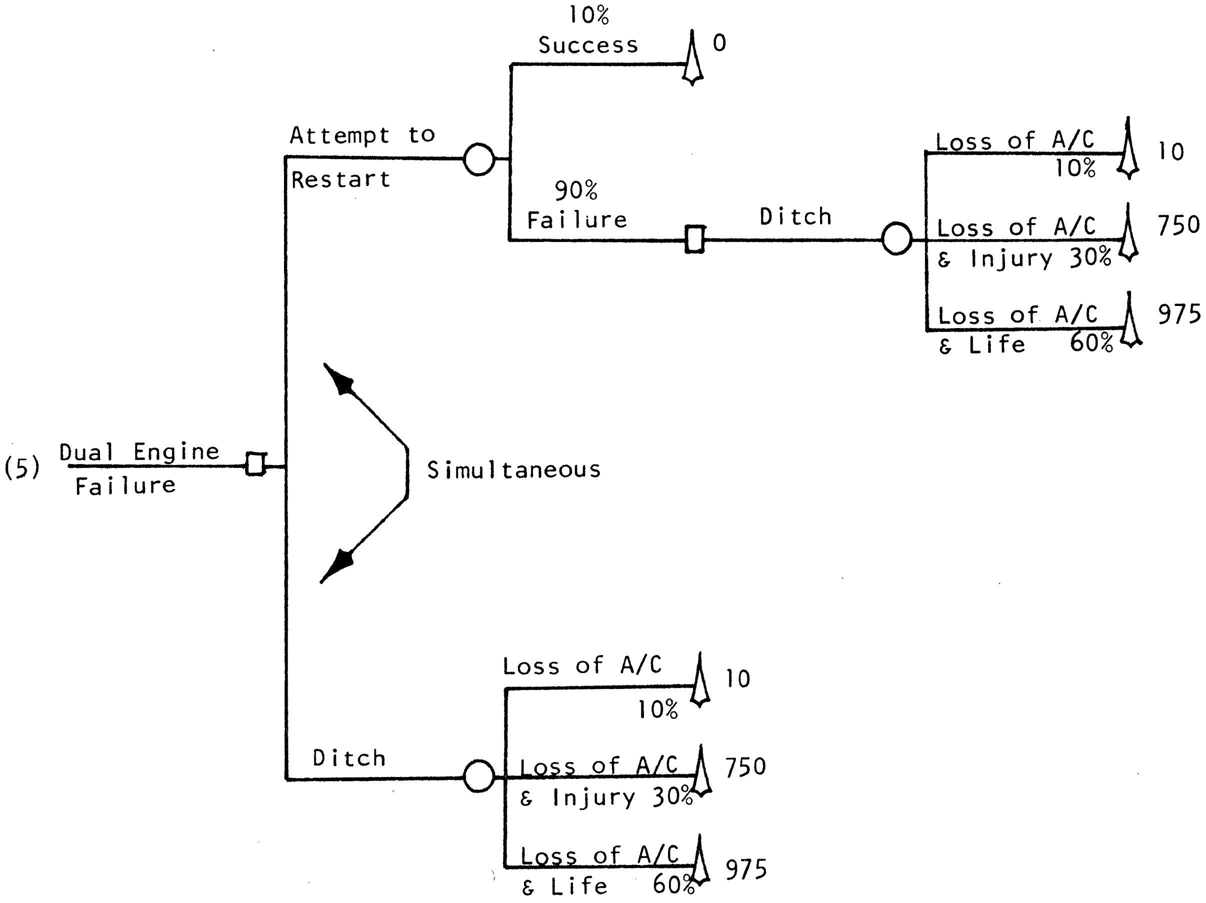

Land
No Hover
Landing
750
Safe Site
Found
10%
Land
No Hover
Landing
500
5%
(9)
One Engine
Not Sufficient
Look for
Safe Site
Land
No Hover
Landing
750
90%
Safe Site
Not Found
Success
10%
50
Attempt
Restart
(a)
Engine
Fire
75%
Land
No Hover
Landing
975
Failure
90%
X
No Fire
25%
Land
No Hover
Landing
750
Attempt
Restart
(a)

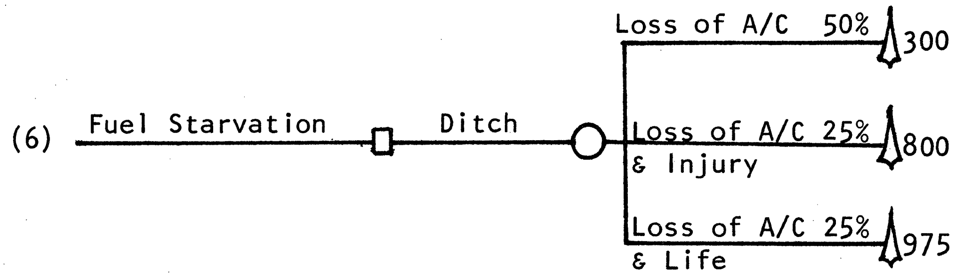

(2)
Dual Engine Failure
65% Dangerous Site
Attempt Restart
10% Success
0
90% Failure
50% Engine Fire
Auto Rotate
Perfect 0% 10
A/C Partial Damage 3% 40
A/C Partial Damage & Injury 10% 850
A/C Partial Damage & Death 3% 975
A/C Loss 27% 200
A/C Loss & Injury 30% 900
A/C Loss & Death 27% 1000
50% No Engine Fire
Auto Rotate
Perfect 3% 10
A/C Partial Damage 6% 40
A/C Partial Damage & Injury 8% 850
A/C Partial Damage & Death 10% 975
A/C Loss 20% 200
A/C Loss & Injury 28% 900
A/C Loss & Death 25% 1000
Simultaneous
Auto Rotate
Perfect 3% 10
A/C Partial Damage 6% 40
A/C Partial Damage & Injury 8% 850
A/C Partial Damage & Death 10% 975
A/C Loss 20% 200
A/C Loss & Injury 28% 900
A/C Loss & Death 25% 1000
35% Safe Site
Attempt Restart
10% Success
0
90% Failure
50% Engine Fire
Auto Rotate
Perfect 0% 10
A/C Partial Damage 4% 40
A/C Partial Damage & Injury 20% 850
A/C Partial Damage & Death 4% 975
A/C Loss 64% 200
A/C Loss & Injury 4% 900
A/C Loss & Death 4% 1000
50% No Engine Fire
Auto Rotate
Perfect 35% 10
A/C Partial Damage 56% 40
A/C Partial Damage & Injury 5% 850
A/C Partial Damage & Death 1% 975
A/C Loss 1% 200
A/C Loss & Injury 1% 900
A/C Loss & Death 1% 1000
Simultaneous
Auto Rotate
Perfect 35% 10
A/C Partial Damage 56% 40
A/C Partial Damage & Injury 5% 850
A/C Partial Damage & Death 1% 975
A/C Loss 1% 200
A/C Loss & Injury 1% 900
A/C Loss & Death 1% 1000


Perfect 3% 10
A/C Partial Damage 6% 40
A/C Partial Damage & Injury 8% 850
65% Dangerous Site
Auto Rotate
A/C Partial Damage & Death 10% 975
A/C Loss 20% 200
A/C Loss & Injury 28% 900
A/C Loss & Death 25% 1000
(3) Fuel Starvation
X
Perfect 35% 10
A/C Partial Damage 56% 40
A/C Partial Damage & Injury 5% 850
35% Safe Site
Auto Rotate
A/C Partial Damage & Death 1% 975
A/C Loss 1% 200
A/C Loss & Injury 1% 900
A/C Loss & Death 1% 1000


(10) One Engine Not Sufficient
Attempt Jettisoning
95% One Engine Sufficient
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
5% One Engine Not Sufficient
Attempt Restart
Success 10%
50
Failure 90%
Ditch
Loss of A/C 25%
300
Loss of A/C & Injury 50%
800
Loss of A/C & Life 25%
975
Ditch
Loss of A/C 25%
300
Loss of A/C & Injury 50%
800
Loss of A/C & Life 25%
975
Attempt Restart
Success 10%
50
Failure 90%
Ditch
Loss of A/C 25%
300
Loss of A/C & Injury 50%
800
Loss of A/C & Life 25%
975
Ditch
Loss of A/C 25%
300
Loss of A/C & Injury 50%
800
Loss of A/C & Life 25%
975

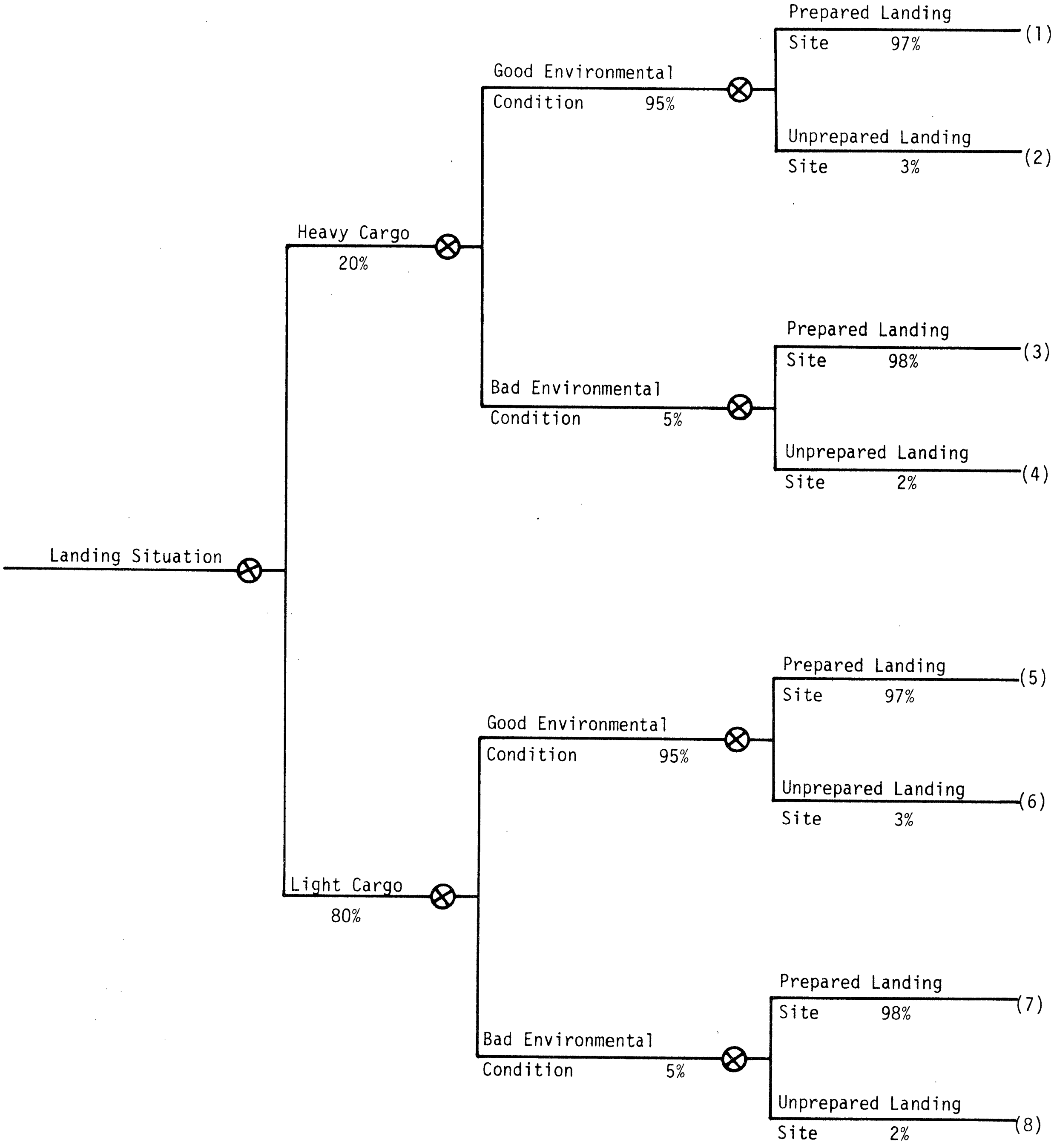

(4) Single Engine Failure
70% One Engine Sufficient
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Look for Landing Site
Landing Site Found 5%
Land
50
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
Landing Site Not Found 95%
Abort the Mission
2nd Engine Fails 10%
500
2nd Engine OK 90%
50
Continue
2nd Engine Fails 10%
500
2nd Engine OK 90%
0
30% One Engine Not Sufficient
(10)

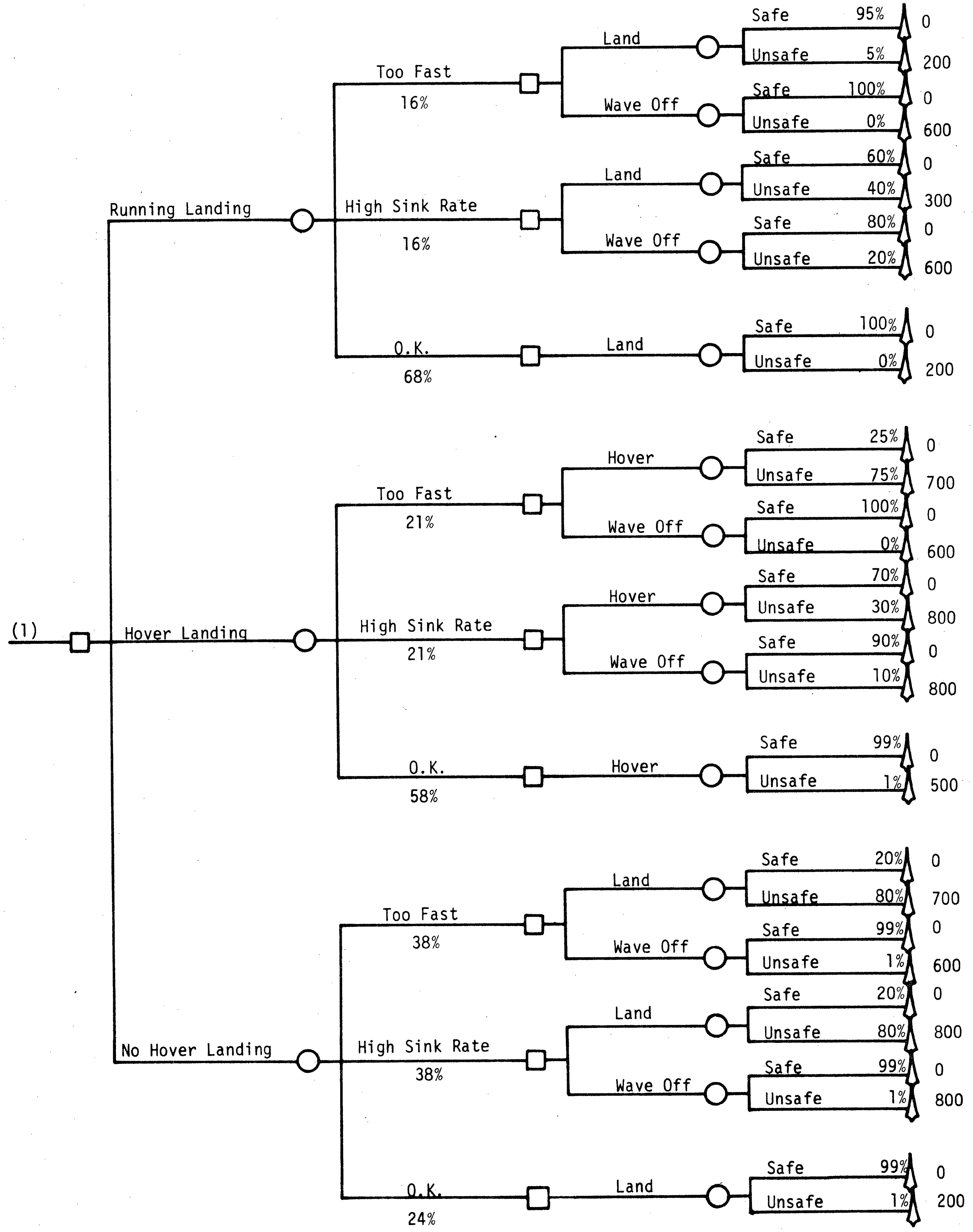

(5) Dual Engine Failure
Attempt to Restart
10% Success
0
90% Failure
Ditch
Loss of A/C 10%
10
Loss of A/C & Injury 30%
750
Loss of A/C & Life 60%
975
Simultaneous
Ditch
Loss of A/C 10%
10
Loss of A/C & Injury 30%
750
Loss of A/C & Life 60%
975

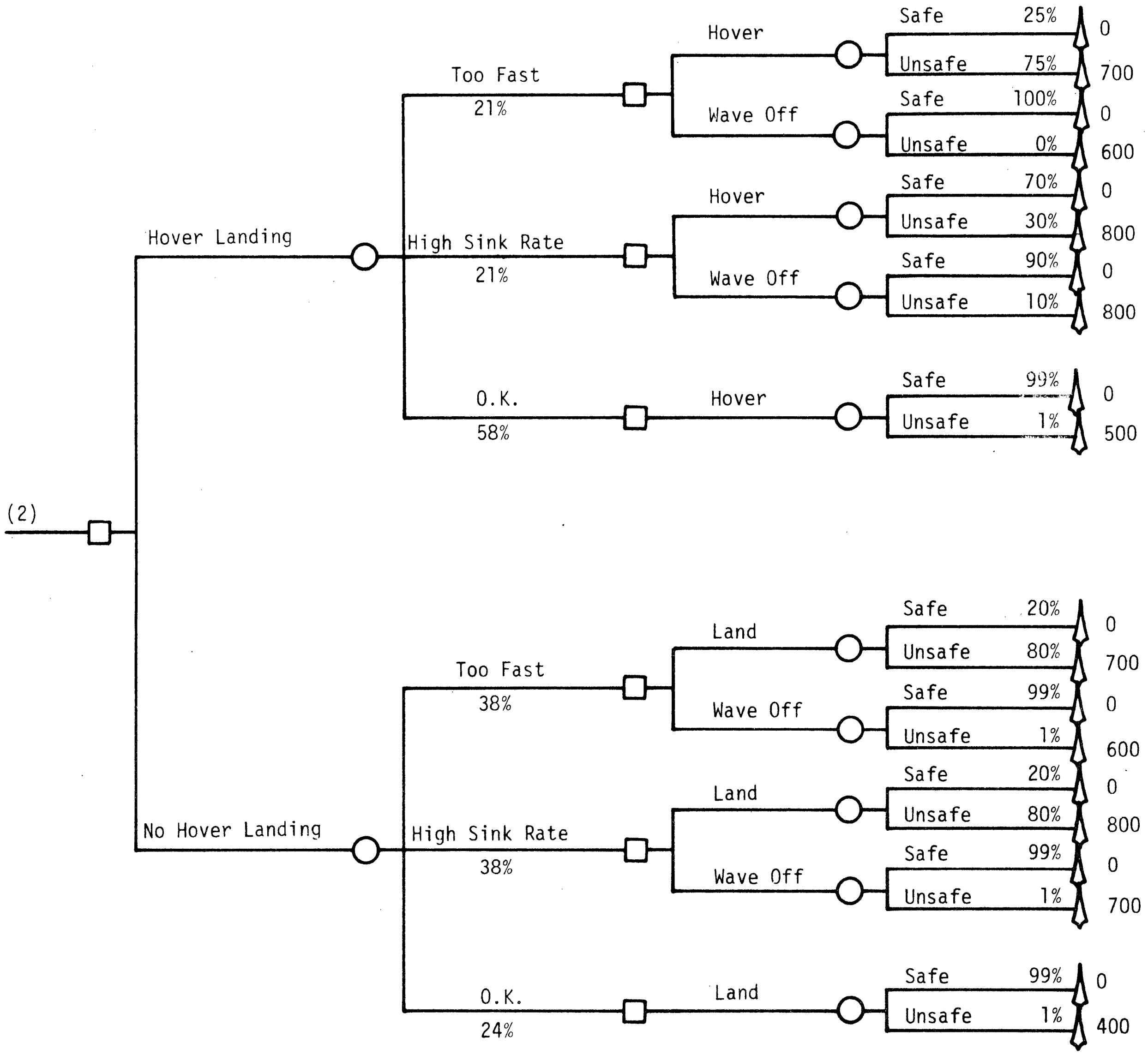

(6)
Fuel Starvation
Ditch
Loss of A/C 50%
300
Loss of A/C 25%
& Injury
800
Loss of A/C 25%
& Life
975

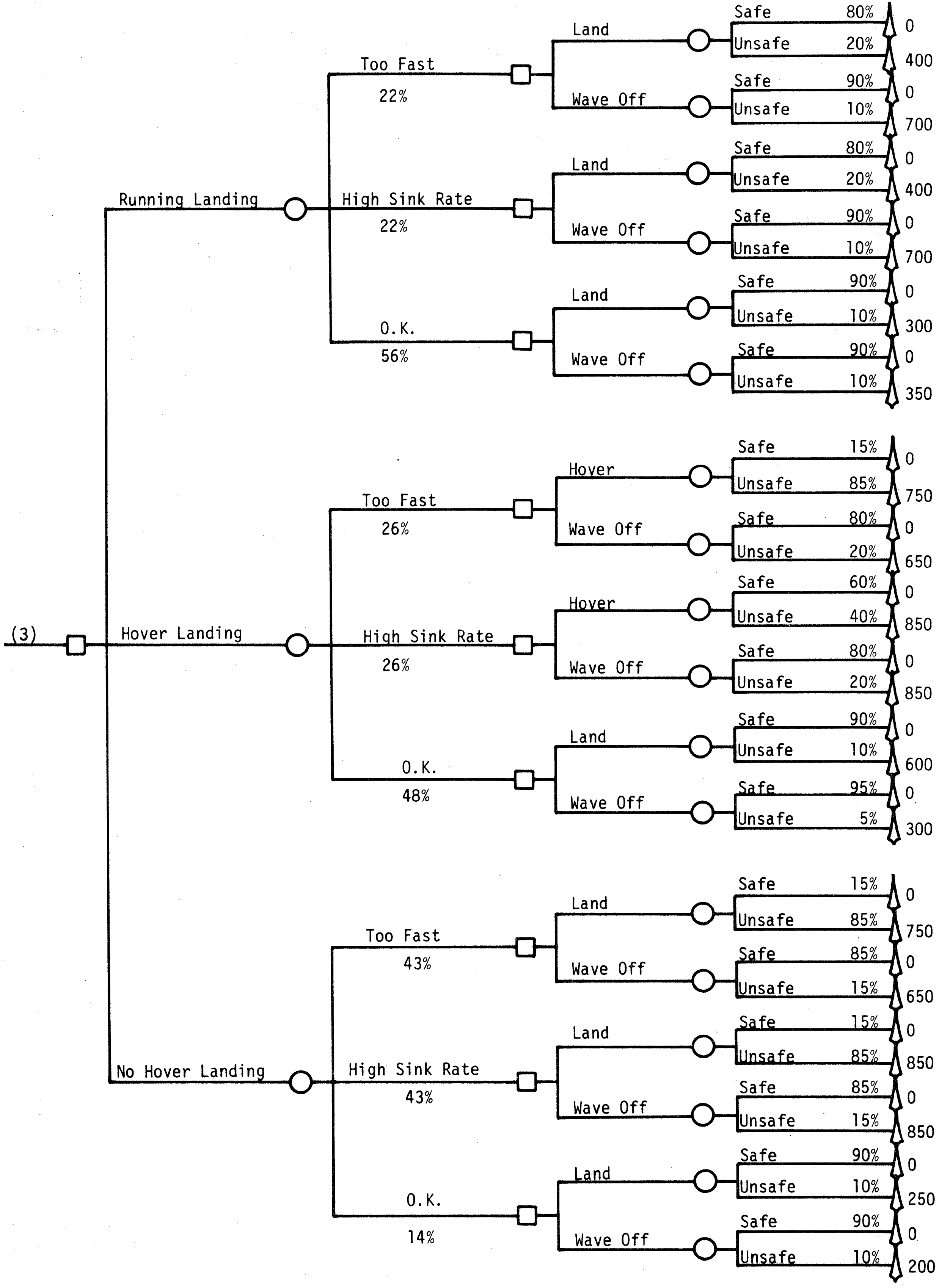
APPENDIX G

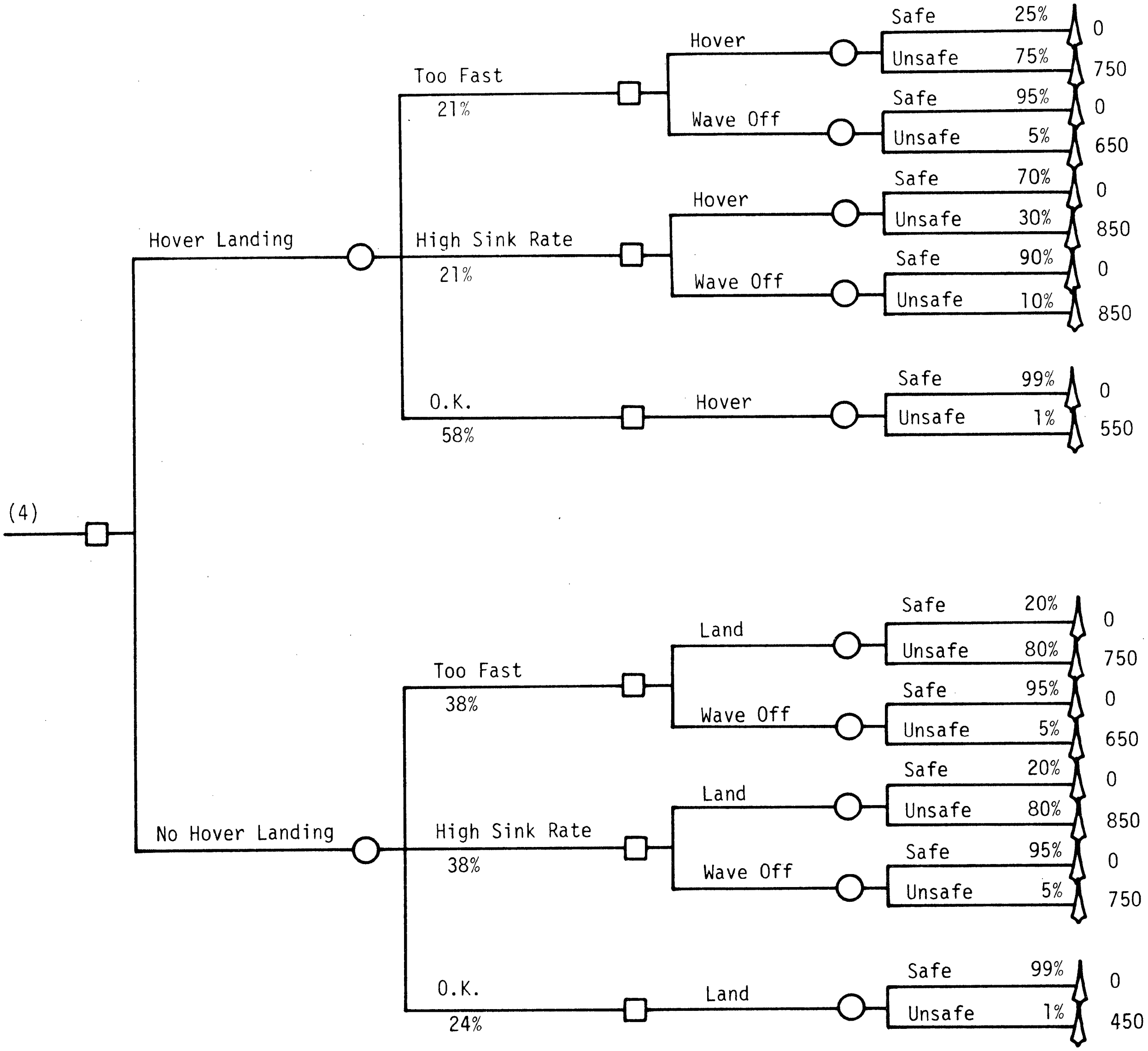
DECISION TREE FOR LAND/WAVE-OFF

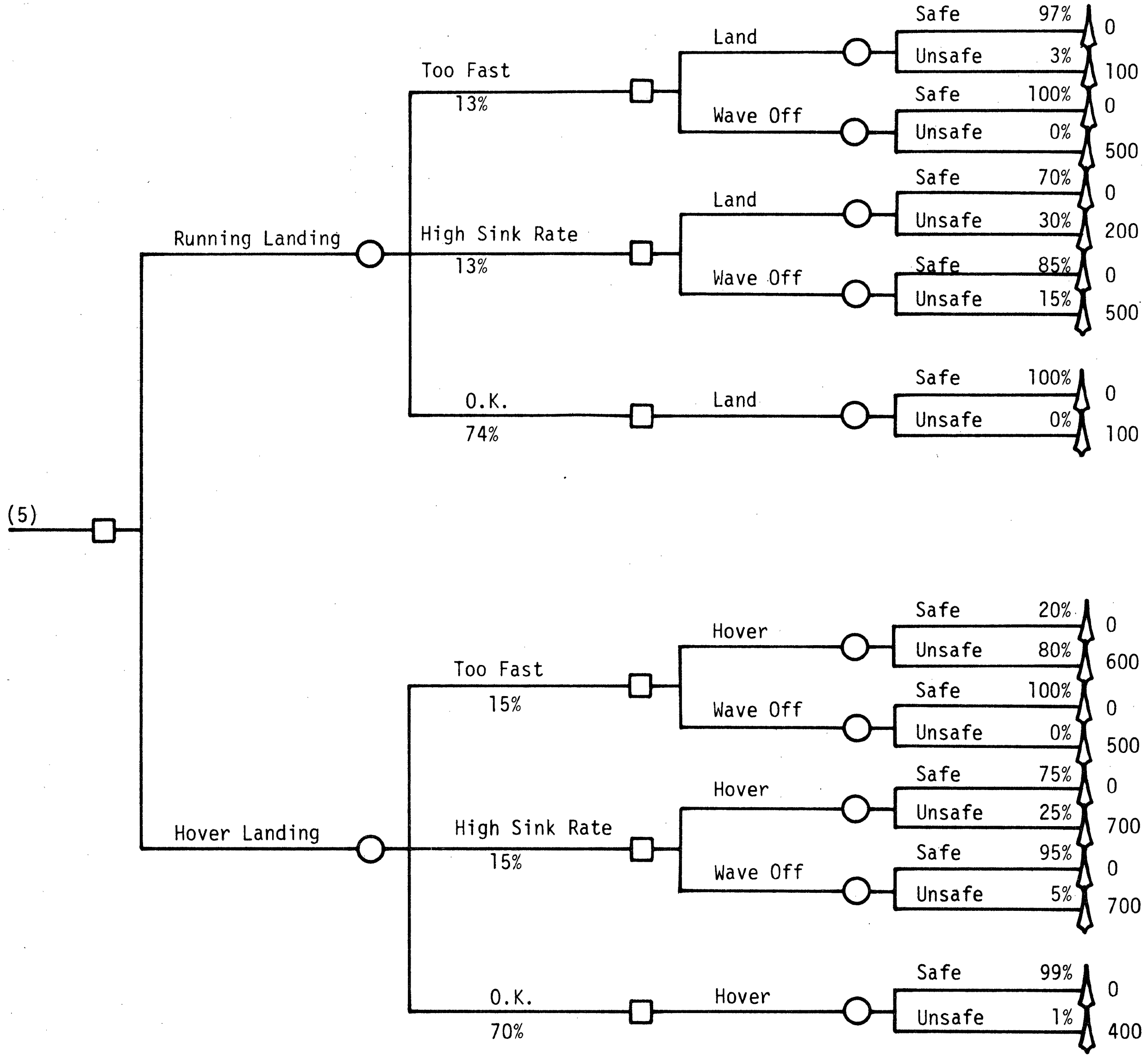


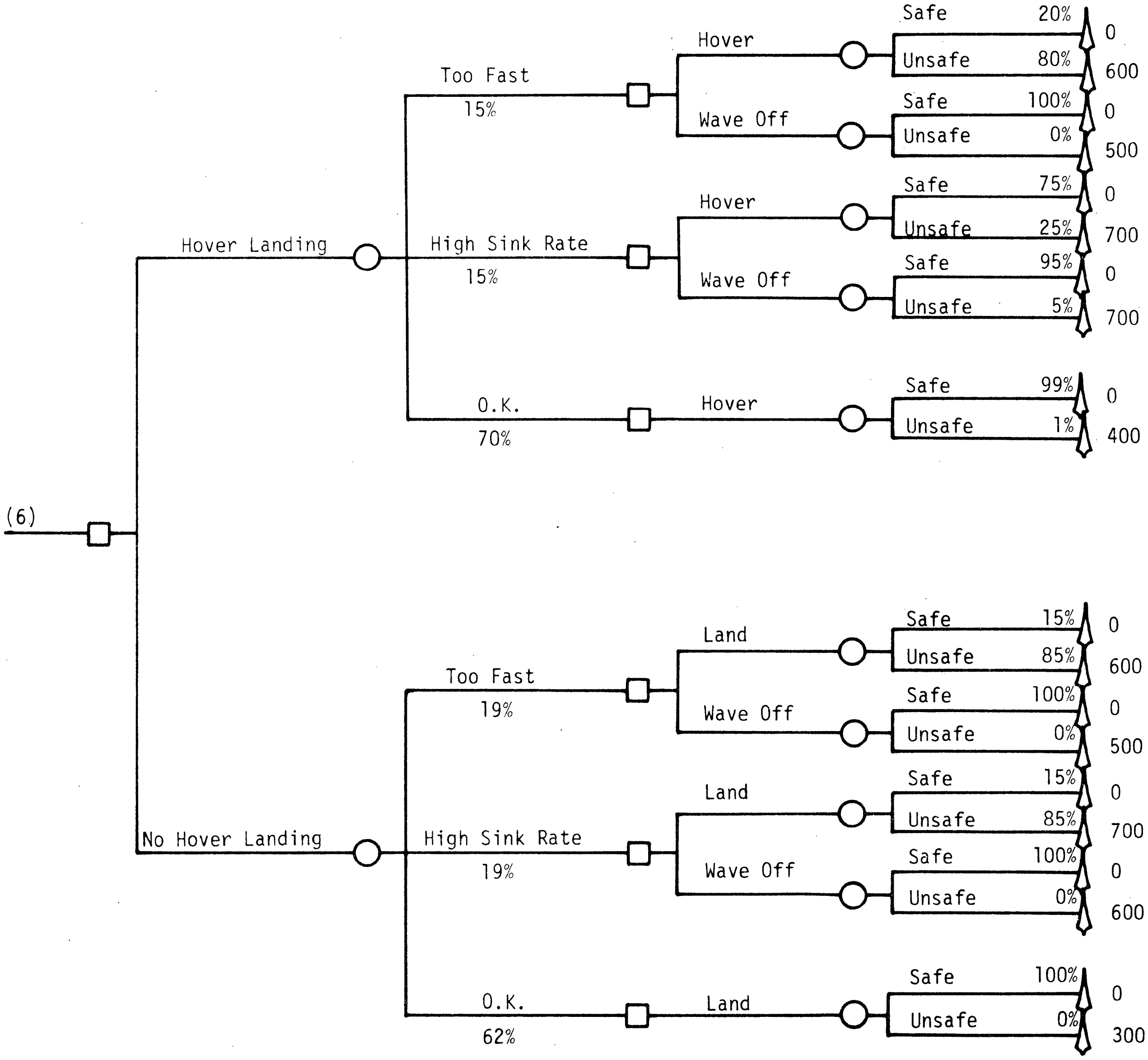

(1)
Running Landing
Too Fast
16%
Land
Safe 95% 0
Unsafe 5% 200
Wave Off
Safe 100% 0
Unsafe 0% 600
High Sink Rate
16%
Land
Safe 60% 0
Unsafe 40% 300
Wave Off
Safe 80% 0
Unsafe 20% 600
O.K.
68%
Land
Safe 100% 0
Unsafe 0% 200
Hover Landing
Too Fast
21%
Hover
Safe 25% 0
Unsafe 75% 700
Wave Off
Safe 100% 0
Unsafe 0% 600
High Sink Rate
21%
Hover
Safe 70% 0
Unsafe 30% 800
Wave Off
Safe 90% 0
Unsafe 10% 800
O.K.
58%
Hover
Safe 99% 0
Unsafe 1% 500
No Hover Landing
Too Fast
38%
Land
Safe 20% 0
Unsafe 80% 700
Wave Off
Safe 99% 0
Unsafe 1% 600
High Sink Rate
38%
Land
Safe 20% 0
Unsafe 80% 800
Wave Off
Safe 99% 0
Unsafe 1% 800
O.K.
24%
Land
Safe 99% 0
Unsafe 1% 200

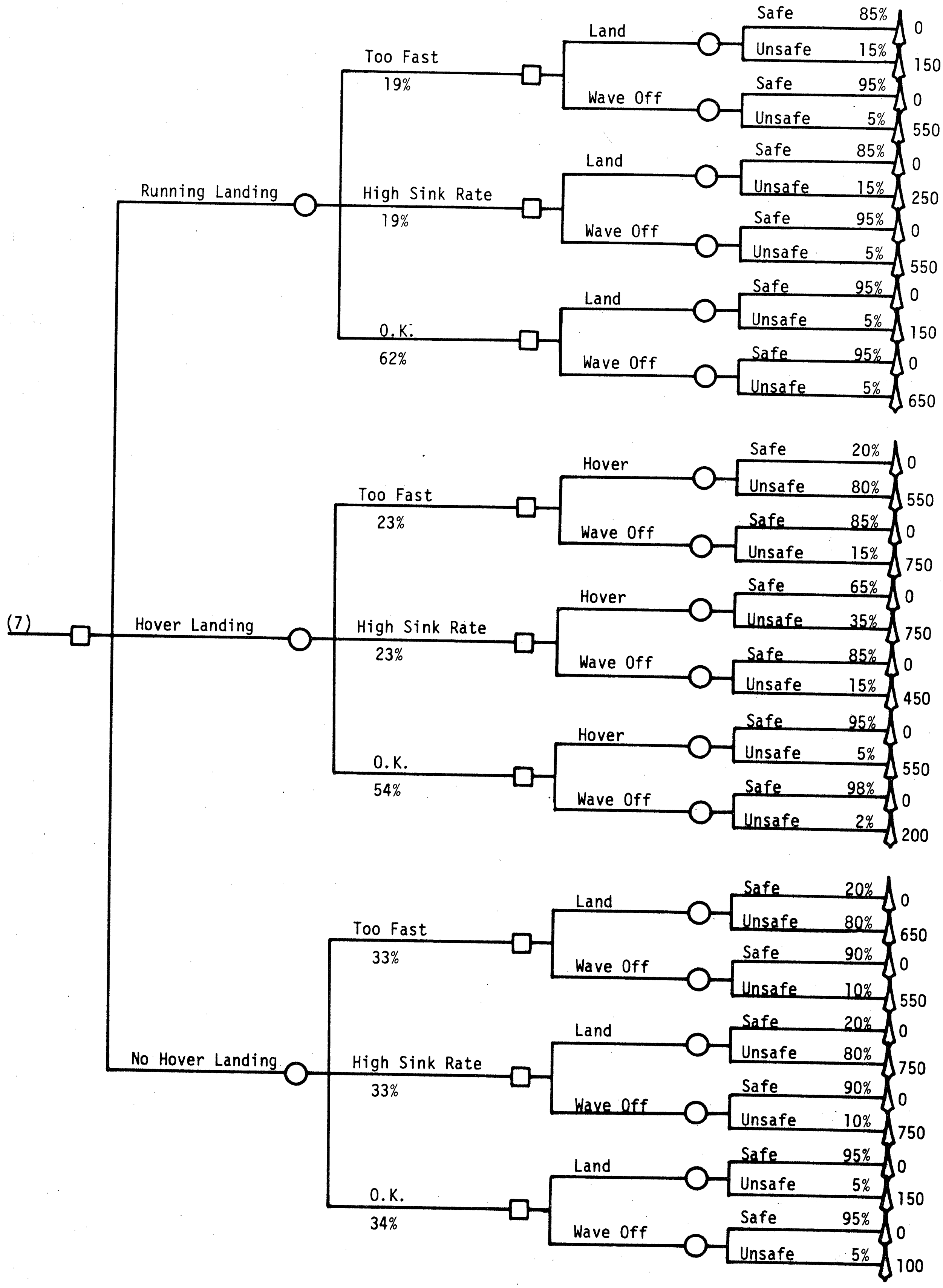

(2)
Hover Landing
Too Fast
21%
Hover
Safe 25%
0
Unsafe 75%
700
Wave Off
Safe 100%
0
Unsafe 0%
600
High Sink Rate
21%
Hover
Safe 70%
0
Unsafe 30%
800
Wave Off
Safe 90%
0
Unsafe 10%
800
O.K.
58%
Hover
Safe 99%
0
Unsafe 1%
500
No Hover Landing
Too Fast
38%
Land
Safe 20%
0
Unsafe 80%
700
Wave Off
Safe 99%
0
Unsafe 1%
600
High Sink Rate
38%
Land
Safe 20%
0
Unsafe 80%
800
Wave Off
Safe 99%
0
Unsafe 1%
700
O.K.
24%
Land
Safe 99%
0
Unsafe 1%
400

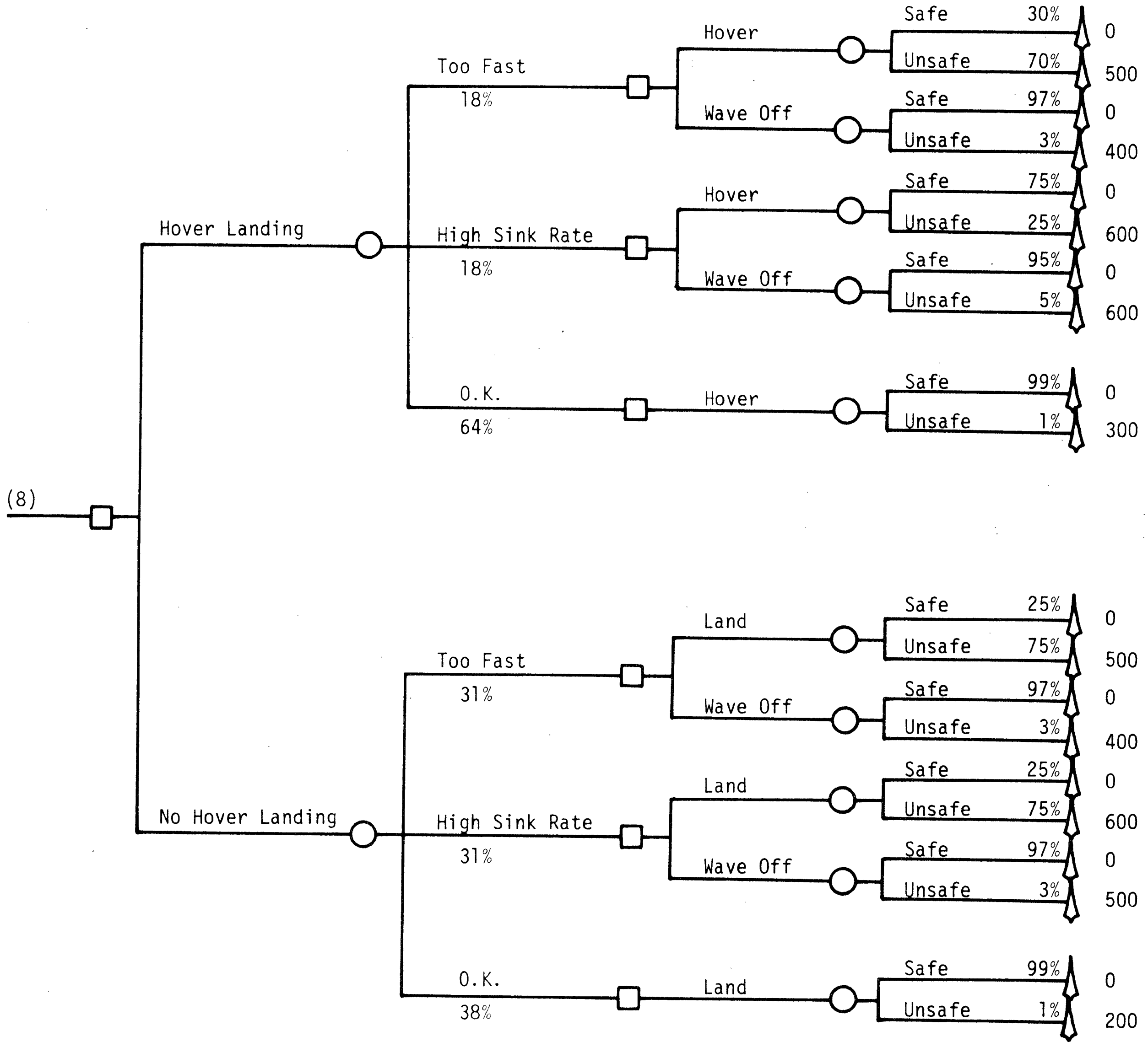

(3)
Running Landing
Too Fast
22%
Land
Safe 80% 0
Unsafe 20% 400
Wave Off
Safe 90% 0
Unsafe 10% 700
High Sink Rate
22%
Land
Safe 80% 0
Unsafe 20% 400
Wave Off
Safe 90% 0
Unsafe 10% 700
O.K.
56%
Land
Safe 90% 0
Unsafe 10% 300
Wave Off
Safe 90% 0
Unsafe 10% 350
Hover Landing
Too Fast
26%
Hover
Safe 15% 0
Unsafe 85% 750
Wave Off
Safe 80% 0
Unsafe 20% 650
High Sink Rate
26%
Hover
Safe 60% 0
Unsafe 40% 850
Wave Off
Safe 80% 0
Unsafe 20% 850
O.K.
48%
Land
Safe 90% 0
Unsafe 10% 600
Wave Off
Safe 95% 0
Unsafe 5% 300
No Hover Landing
Too Fast
43%
Land
Safe 15% 0
Unsafe 85% 750
Wave Off
Safe 85% 0
Unsafe 15% 650
High Sink Rate
43%
Land
Safe 15% 0
Unsafe 85% 850
Wave Off
Safe 85% 0
Unsafe 15% 850
O.K.
14%
Land
Safe 90% 0
Unsafe 10% 250
Wave Off
Safe 90% 0
Unsafe 10% 200


(4)
Hover Landing
Too Fast
21%
Hover
Safe 25% 0
Unsafe 75% 750
Wave Off
Safe 95% 0
Unsafe 5% 650
High Sink Rate
21%
Hover
Safe 70% 0
Unsafe 30% 850
Wave Off
Safe 90% 0
Unsafe 10% 850
O.K.
58%
Hover
Safe 99% 0
Unsafe 1% 550
No Hover Landing
Too Fast
38%
Land
Safe 20% 0
Unsafe 80% 750
Wave Off
Safe 95% 0
Unsafe 5% 650
High Sink Rate
38%
Land
Safe 20% 0
Unsafe 80% 850
Wave Off
Safe 95% 0
Unsafe 5% 750
O.K.
24%
Land
Safe 99% 0
Unsafe 1% 450


(5)
Running Landing
Too Fast
13%
Land
Safe 97% 0
Unsafe 3% 100
Wave Off
Safe 100% 0
Unsafe 0% 500
High Sink Rate
13%
Land
Safe 70% 0
Unsafe 30% 200
Wave Off
Safe 85% 0
Unsafe 15% 500
O.K.
74%
Land
Safe 100% 0
Unsafe 0% 100
Hover Landing
Too Fast
15%
Hover
Safe 20% 0
Unsafe 80% 600
Wave Off
Safe 100% 0
Unsafe 0% 500
High Sink Rate
15%
Hover
Safe 75% 0
Unsafe 25% 700
Wave Off
Safe 95% 0
Unsafe 5% 700
O.K.
70%
Hover
Safe 99% 0
Unsafe 1% 400


(6)
Hover Landing
Too Fast
15%
Hover
Safe 20% 0
Unsafe 80% 600
Wave Off
Safe 100% 0
Unsafe 0% 500
High Sink Rate
15%
Hover
Safe 75% 0
Unsafe 25% 700
Wave Off
Safe 95% 0
Unsafe 5% 700
O.K.
70%
Hover
Safe 99% 0
Unsafe 1% 400
No Hover Landing
Too Fast
19%
Land
Safe 15% 0
Unsafe 85% 600
Wave Off
Safe 100% 0
Unsafe 0% 500
High Sink Rate
19%
Land
Safe 15% 0
Unsafe 85% 700
Wave Off
Safe 100% 0
Unsafe 0% 600
O.K.
62%
Land
Safe 100% 0
Unsafe 0% 300


(7)
Running Landing
Too Fast
19%
Land
Safe 85%
0
Unsafe 15%
150
Wave Off
Safe 95%
0
Unsafe 5%
550
High Sink Rate
19%
Land
Safe 85%
0
Unsafe 15%
250
Wave Off
Safe 95%
0
Unsafe 5%
550
O.K.
62%
Land
Safe 95%
0
Unsafe 5%
150
Wave Off
Safe 95%
0
Unsafe 5%
650
Hover Landing
Too Fast
23%
Hover
Safe 20%
0
Unsafe 80%
550
Wave Off
Safe 85%
0
Unsafe 15%
750
High Sink Rate
23%
Hover
Safe 65%
0
Unsafe 35%
750
Wave Off
Safe 85%
0
Unsafe 15%
450
O.K.
54%
Hover
Safe 95%
0
Unsafe 5%
550
Wave Off
Safe 98%
0
Unsafe 2%
200
No Hover Landing
Too Fast
33%
Land
Safe 20%
0
Unsafe 80%
650
Wave Off
Safe 90%
0
Unsafe 10%
550
High Sink Rate
33%
Land
Safe 20%
0
Unsafe 80%
750
Wave Off
Safe 90%
0
Unsafe 10%
750
O.K.
34%
Land
Safe 95%
0
Unsafe 5%
150
Wave Off
Safe 95%
0
Unsafe 5%
100


(8)
Hover Landing
Too Fast
18%
Hover
Safe 30% 0
Unsafe 70% 500
Wave Off
Safe 97% 0
Unsafe 3% 400
High Sink Rate
18%
Hover
Safe 75% 0
Unsafe 25% 600
Wave Off
Safe 95% 0
Unsafe 5% 600
O.K.
64%
Hover
Safe 99% 0
Unsafe 1% 300
No Hover Landing
Too Fast
31%
Land
Safe 25% 0
Unsafe 75% 500
Wave Off
Safe 97% 0
Unsafe 3% 400
High Sink Rate
31%
Land
Safe 25% 0
Unsafe 75% 600
Wave Off
Safe 97% 0
Unsafe 3% 500
O.K.
38%
Land
Safe 99% 0
Unsafe 1% 200

APPENDIX H

SCENARIOS FOR PROTOCOL ANALYSIS

Consider yourself engaged in each of the following scenarios. Describe what might happen in terms of the possible alternative courses of action, possible states of nature, and the outcomes associated with each combination of a state of nature and a course of action.

A. Engine Quits

(1) You have a single engine failure while flying over land. One engine is sufficient for the weight of the aircraft and there is a safe landing site in the area.

(2) You have a single engine failure while flying over land. One engine is sufficient for the weight of the aircraft and there is an unsafe landing site in the area.

(3) You have a single engine failure while flying over land. One engine is not sufficient for the weight of the aircraft and there is a safe landing site in the area.

(4) You have a single engine failure while flying over land. One engine is not sufficient for the weight of the aircraft and there is an unsafe landing site in the area.

(5) You have a dual engine failure while flying over land.

(6) You have a fuel starvation while flying over land and you don't have enough altitude to bail out.

(7) You have fuel starvation while flying over land and you have enough altitude to bail out. However, the site is dangerous.

(8) You have fuel starvation while flying over land and you have enough altitude to bail out. The site is safe.

(9) You have a single engine failure while flying over water. One engine is suffucient for the weight of the aircraft.

(10) You have a single engine failure while flying over water. One engine is not sufficient for the weight of the aircraft.

(11) You have a dual engine failure while flying over water.

(12) You have fuel starvation while flying over water.

B. Land or Wave-Off

(1) You have attempted landing. The aircraft carries a heavy cargo and the environmental condition is good. The landing site is prepared.

(2) You have attempted landing. The aircraft carries a heavy cargo and the environmental condition is good, but the landing site is unprepared.

(3) You have attempted landing. The aircraft carries a heavy cargo and the environmental condition is bad, but the landing site is prepared.

(4) You have attempted landing. The aircraft carries a heavy cargo and the environmental condition is bad. There is an unprepared landing site.

(5) You have attempted landing. The aircraft carries a light cargo and the environmental condition is good. The landing site is prepared.

(6) You have attempted landing. The aircraft carries a light cargo and the environmental condition is good, but the landing site is unprepared.

(7) You have attempted landing. The aircraft carries a light cargo and the environmental condition is bad, but the landing site is prepared.

(8) You have attempted landing. The aircraft carries a light cargo and the environmental condition is bad. There is an unprepared landing site.

C. Ditching

(1) There is an alert which suggests an emergency ditching, but you are over the land.

(2) There is an alert which suggests an emergency ditching and you are over the water.

(3) There is an alert which suggests a planned ditching, but you are over the land.

(4) There is an alert which suggests a planned ditching and you are over the water.

In the protocol analysis performed, based on the above scenarios, the answer to the following questions were pursued.

Single Engine Failure - Over Land

1. Do you always know whether one engine will be sufficient to continue on the mission or not?
2. How do you know? (or) Why don't you know?
3. If one engine is sufficient, do you still look for a safe landing site?
4. Does the importance of the mission enter into your decision on what to do?
5. At what point do you decide whether to try to land or to continue?
6. If you find a safe landing site, what makes you decide whether to land or to continue?
7. If you continue, do you tend to make changes in the objectives of the mission? That is, if the mission has more than one purpose, do you try to accomplish some but not others?
8. If you continue, do you evaluate your chances of being successful? How?
9. If you can't find a safe landing site, do you continue looking for one or do you try something else?

10. If one engine is not sufficient to continue and you find a safe landing site, do you attempt to jettison or to land?

11. If one engine is not sufficient, what is usually the reason? Load?

12. (If Yes) In that case, would you always try to jettison first, and then decide whether one engine is sufficient to continue?

13. In general, what makes you decide whether to jettison or not?

14. Does the safety of the landing site make a difference?

15. How do you decide whether it is better to land and abort the mission, or to jettison and continue?

16. Can you generally place a monetary value on the loss incurred by jettisoning?

17. Is it generally the same each time? (i.e., you tend to get rid of the same things?)

18. (Depending on the cost involved in jettisoning) would you try to land in an unsafe landing site rather than to jettison?

19. Of different possibilities with single engine failure, one engine not sufficient, and unsafe landing site;

    (a) Which will you try first? Why?

    (b) What does it depend on?

    (c) Are the environmental conditions more important or the possible losses that you might incur?

20. At what point do you start thinking about bailing out?

21. You have attempted to jettison, one engine is still not sufficient, and you can't find a safe landing site, which will you do first: (1) try to land anyway, (2) bail out, or (3) attempt restart? What does it depend on?

22. (Same question following "attempt restart" and failure: land or bail out?)

Dual Engine Failure - Over Land

Discuss the possibilities as above:

What do you do first? Why? Are there other possibilities?

Do you always do the same thing first? What does it depend on?

If you have a small chance of landing safely by auto-rotating, do you take it? (rather than lose the helicopter?).

Over Water

Questions concerning the importance of the mission and the losses involved in jettisoning apply here.

Land or Wave-Off

1. What is your first consideration when deciding whether to land or wave off? Could you rank the following in terms of their importance in your decision?

  - (a) Weight of cargo
  - (b) Environmental conditions
  - (c) Landing site (prepared/unprepared)
  - (d) Speed of helicopter
  - (e) Sink rate
  - (f) Fuel amount

2. Are there other considerations?

3. How do you decide whether a particular situation is safe or not? Could you look at all the outcomes and rate them in terms of the dangers involved? For example, you have a heavy cargo, the environmental conditions are good, and you have decided on a running landing, but you are going too fast, would you try to land, or would you wave off? If you try to land (because of low fuel) is it safer (or less dangerous) than if you tried to land under the same conditions but with a high sink rate (rather than with high speed)?

   (a) If you have plenty of fuel, would you always wave-off on the first approach:

   If you are going too fast?
   If you have too high a sink rate?

   (b) Does each wave-off "cost" something? That is, aside from using up fuel, are there other dangers involved in waving off?

   How would you rate these dangers?

(c) Are your decisions different (re-land or wave-off) depending on whether you are planning a hover - or a running - landing?

How? Why?

Ditching

1. How many different types of alerts are there that suggest a ditching situation?

2. How different are they from each other?

3. Can you always tell whether the alert suggests an emergency versus a planned ditching? In general, how often does each happen?

4. If the alert suggests a planned ditching, in general, how long do you have until you have to make a decision?

5. Do you start looking for a landing site as soon as you become aware of the alert?

6. If you are over land, do you try to land as soon as possible?

7. If you are over water, how long do you wait until you decide to ditch?

8. When you first become aware of the alert, is there a way to estimate how likely it is that it is a correct (or an incorrect) alert?

9. Do the "alert" cues change over time, so that, for example, you may first decide to look for a proper landing site (over land, during planned ditching), and then change your mind and decide to land as soon as possible?

10. If so, what are the changes in the alert condition that produce this switch? Are they clear-cut changes or is it a matter of "judgment"?

11. If it is a matter of judgment, can you elaborate?

12. Do you consider what it will cost if you ditch? To you? To the Navy?

APPENDIX I

TRIP TO LOS ANGELES POLICE ACADEMY

The Los Angeles Police Academy in Pasadena has recently constructed a simulator for training decisions in "shoot/no shoot" situations. That is, the simulator focuses on the problem of when to shoot rather than how to shoot or at what target. The simulator is built in a one-room, two-story, cubic building. A giant movie screen fills one entire wall from floor to ceiling with movie projectors located in a small booth near the ceiling on the opposite wall. A quadraphonic sound system accompanies the films.

The police cadet stands in front of the screen with a special laser pistol that resembles his service revolver. The filmed scenario places the cadet in a situation in which he must decide whether or not to shoot at a criminal who is threatening his life. Two video cameras monitor the cadet during the scenario. One is located near the movie projector and the other is mounted directly above the screen itself in order to provide a front view.

As the cadet shoots, a light-sensing device located in the rear of the room pinpoints the location of the "shot" on the screen to an accuracy of one inch. This information, plus the exact movie frame that was showing at the time, are input to a Nova mini-computer and stored for later processing. At the end of the scenario, a videotape is prepared using "split screen" technique, of the critical portions of the exercise. The action on the screen is placed on the top half of the video image and the cadet is placed in the bottom half. This tape is used to review the cadet's actions at a later time. By using both the front and rear cameras, the location of the cadet and the location of his shot on the screen can be determined to an accuracy of one inch and within 1/24 of a second.

Although there is no formal training in either probability theory or decision theory, there are extensive courses in the established important attributes that should be considered when deciding whether or not to shoot in a given situation. Some of these attributes are:

(1) legal aspects;
(2) moral aspects; and
(3) personal safety, safety of bystanders, safety of fellow officers.

There is, thus, no relative weighting scheme for the attributes nor decision rules that translate the utilities of the attributes into a decision. There are, however, general guidelines that help the cadets make the decision. Since the shoot/no shoot decision must usually be made in less than one second, there is little or no time to consider attributes, utilities, or probabilities at that time. Consequently, the cadets are taught to prune the decision tree before the actual situation arises. The more aspects considered and dealt with early, the less to consider when the time comes to make the decision itself.

APPENDIX J

DECISION TASK CLASSES

SINGLE ATTRIBUTE DECISION MAKING

General Definition: A decision where the action taken and the state of the world in combination determines the outcome (payoff) where the outcome (payoff) is a single value dimension (attribute).

Amplification: A decision maker is frequently asked to choose between courses of action whose probable consequences are characterized by a single value attribute (for example, deciding on the number of sonobuoys of a particular type to take on a mission). The outcomes, depending on the number taken and the number of submarine contacts made (state of nature) will determine the single attributed outcome: adequacy of sonobuoy type supply on hand. Adequacy of supply is a single outcome ranging from some numerical shortage to a numerical surplus.

Rules: Identify the decision outcome for each action/state of the world. The outcome may be either estimated directly by experts, predicted by modeling, or predicted by experimental evidence. Each outcome may be either wholly subjective, subjective estimates on an objective scale, or objective measurements on an objective scale.

Pitfalls and Limitations: The most important pitfall is the representation of an outcome by a single point estimate when the outcome itself may have a range or may be a probability density function.

Interactions with Other Decision Elements. No major interactions.

Prerequisites. There must be a method or mechanism that permits (trains or projects) outcome estimation.

MULTIPLE ATTRIBUTE DECISION MAKING

General Definition: A decision situation where the action taken and the state of the world in combination determines the outcome (payoff) where the outcome (payoff) involves multiple value dimensions (attributes).

Amplifications: Decision makers frequently choose between courses of action whose probable consequences are each characterized by multiple value attributes. For example, the decision of whether or not to ditch a LAMPS helicopter involves a number of value relevant factors such as worth of aircraft, safety to individuals in the helicopter, safety to those on the ground, adverse reaction if it is shown later by investigation that the ditch was unnecessary, and so on. In making a decision in such a situation, all such value-relevant factors must be identified for each alternative/state of nature.

Rules: Identify, for each action alternative/state of nature, the set of outcomes across all value dimensions. Outcomes may be either estimated directly by experts, predicted by modeling, or predicted by experimental evidence. Each outcome may be either wholly subjective, subjective estimates on an objective scale, or objective measurement on an objective scale.

Pitfalls and Limitations: The most important pitfall is the representation of an outcome by a point estimate when in fact the outcome is a range or may itself be a probability density function.

Interactions with Other Decision Elements: No major interactions.

Prerequisites: There must be a method or mechanism for generating outcome estimates. This may involve training outcome estimation, providing standard lists of outcome estimation, and so on.

WELL DEFINED DECISION MAKING SITUATIONS

General Definition. A decision situation where the action alternatives, states of nature, and outcome set is completely describable, well defined, well understood in advance of the actual decision making situation.

Amplification. A key to any decision situation is problem structuring. The prerequisites for structuring are: (1) knowledge of the complete set of action alternatives to be considered, and (2) knowledge of all likely states of nature that will be involved in the situation. If these prerequisites are met, the situation is well defined and can easily be structured. For example, in the event of engine failure in the LAMPS helicopter, the craft may be over land or over water and the failure may be due to fuel starvation, dual engine failure, or single engine failure. The alternatives are clear if, for example, single engine failure occurs: the pilot may land, continue, abort the mission, or look for a safe site if the aircraft is over an unsafe landing site (state of nature). In this example, the decision situation is well defined.

Rules: There are two possible mechanisms used to present the detailed structure of well-defined decision making situations: (1) the payoff (or loss) table, and (2) the decision tree. The general procedure is to express the decision alternatives and, for each alternative, list consequences under each state of nature. In one case, the result is in matrix form, in the other the result is in tree diagram form. If there are a sequence of decisions, a decision tree is usually best for structuring.

Pitfalls and Limitations: A tree or matrix summarizing a decision situation forces closure in a specific decision situation. There is a tendency to view the decision in terms of the tree or matrix only, rather than realizing that the actual decision may involve more than what is just shown in the structure. That is, the closure may be in error with a major element of the decision omitted.

Interactions with Other Decision Elements: The outcomes to be displayed are either single or multiple and are generated as indicated earlier. Also, there may not be enough time to create a large structure.

Prerequisites: A tree or matrix structure should be developed or provided. If developed, the basic material for constructing such a structure must be provided. The set of possible action alternatives should be provided with the outcomes for each prespecified alternative state of nature. The set of action alternatives should be mutually exclusive and exhaustive.

AMBIGUOUS DECISION MAKING SITUATIONS

General Definition: A decision situation where the action alternatives, states of nature, and outcome set is neither well defined nor completely understood prior to or during the actual decision making situation.

Amplification: The prerequisite for structuring any decision situation as indicated previously are (1) knowledge of the complete set of possible action alternatives to be considered in the decision situation and (2) knowledge of all likely states of nature that will be involved in the situation. In ambiguous situations, either one or both of these preconditions for well defined decision making structuring fail. There are two distinct kinds of failure: (1) the set of states of nature or the set of possible action alternatives is so large that for practical purposes it cannot be represented in matrices or tree diagrams, (2) the set of states of nature of the set of possible action alternatives cannot be anticipated completely in advance of the actual decision situation. For example, what should the pilot or ATO do when the LAMPS looses contact with a submarine. While the general set of alternatives and states of nature are known, the complete sets are not. In any given situation, there may be alternatives or states of nature unique to that situation.

Rules: As in the case of well defined situations, structure what is known in matrices or decision trees and specify unknowns where appropriate. In addition, indicate that part of the structuring must occur at the time of the actual decision. The concept of closure must be firmly addressed as well as sufficiency of the alternative set. Sensitivity analysis should be conducted to determine decision sensitivity to structure.

Pitfalls and Limitations: In particular, any structure provided tends to take on more value than is warranted. Preliminary structuring may preclude additional structuring as an expedience. There are no complete rules for specifying when all the likely and relevant states of nature have been specified.

Interactions with Other Decision Elements: The outcomes to be displayed are either single or multiple and are generated as indicated earlier. Also there may not be enough time to create a large structure.

Prerequisites: A tree or matrix should be developed or provided. Particular attention should be given to providing methods for forcing consideration of additional states of nature and alternative combinations. The set of alternatives and states of nature provided, while not exhaustive, must be mutually exclusive.

TIME RELAXED DECISION MAKING

General Definition: A decision situation where the decision maker has sufficient time to completely structure the decision in terms of number of attributes, alternatives, states of nature, and outcomes as well as selecting the best alternative. In short, there are no time constraints.

Amplification. The decision making situations where a decision maker has literally "plenty" of time to structure and make a decision represent time relaxed decision making. For example, during pre-mission planning in LAMPS operations, there is often enough time for discussion and planning.

Rules: There are no specific rules except to be thorough in all aspects of decision structuring and alternative selection. Moreover, there is enough time to conduct sensitivity analyses on alternative selection and decision structuring as well as the quantification process itself.

Pitfalls and Limitations. With sufficient time to make a decision, decision makers often postpone the decision until it is no longer time relaxed. There is also a tendency to become "sloppy" if there is too much time. Moreover, if there is too much lead time, the decision situation may change substantially by the time the actual decision is to be made, thereby, negating all the decision making efforts. There is sometimes a temptation to do something, anything, rather than wait to take action.

Interactions with Other Decision Elements. No major interactions.

Prerequisites. None.

TIME PRESSURE DECISION MAKING

General Definition. A decision situation where the decision maker has insufficient time to completely structure the decision in terms of number of attributes, alternatives, states of nature, and outcome as well as alternative selection. In summary there are time constraints and the greater the constraints, the greater the pressure.

Amplification. In those situations where fast moving events preclude adequate consideration of structuring a decision and selecting an alternative, there is time pressured decision making. For example, when an engine quits in the LAMPS helicopter due to an engine fire, there is very little time to reflect on the alternative courses of action, their potential outcomes three or more steps ahead, to predict the various relevant states of nature, and then to select a decision rule and use it to select an optimal alternative course of action.

Rules: There are only rules of thumb under time pressure. The most obvious one is "Don't take longer than the time available to structure the decision and select an action." If this happens, the decision is out of the decision maker's control. The general rule is to spend time on structuring the decision at the expense of a hasty action selection. In most cases, the wrong decision following a correct structuring is easier to recover from than the correct decision on the wrong problem. Also, try to focus on the major decision elements immediately, foregoing a close look at the secondary considerations.

Pitfalls and Limitations: The idea of the optimal decision under time pressure is illusory. The best that one can hope for in many instances is to avoid making a "big" mistake by utilizing the knowledge provided in previous trainings. Decision analysis is thought to be worse than making some (or any) decision.

Interaction with Other Decision Elements: Time pressure normally effects all other decision elements adversely.

Prerequisites: Training in decision making under pressure can help enormously.

STATIC DECISION MAKING

General Definition. A decision situation is static if the consequences of the decision specified through the outcome set are constant over time (i.e., not a function of time).

Amplification. Consider the time horizon over which the consequences of a decision unfold. If the consequences (outcome set) remain constant over that time horizon, the decision is static. This issue is critical since the outcome set is estimated in advance of the decision and correct representation is required for properly structuring the decision. For example, in deciding about the number of sonobuoys to drop in a particular pattern, we consider that each number of sonobuoys will generate a specific "listening" coverage on the ocean surface. This listening coverage remains constant over the time horizon of the decision which, in this example, is the lifetime of the particular sonobuoys used.

Rules: Determine the pattern of decision consequences (outcome) over time and if the response pattern is constant, the situation is static and a point estimate may be used to represent the outcome. In essence, a "snapshot" of the consequence may be taken at any point in time to represent the outcome.

Pitfalls and Limitations. In some instances, there will be outcomes that are both static and dynamic (vary with time) and they must be identified and treated separately. Confusion can be minimized if the consequence magnitude is plotted over time to determine if magnitude is a function of time.

Interactions with Other Decision Elements. There is some interaction with outcome estimation that follows from attribute (value dimension) specification. In some instances, dynamic patterns can be represented by static attributes by careful wording in identifying the static attribute. For example, peak response takes a characteristic of a dynamic response and represents it by a static attribute.

Prerequisites: An understanding of how behavior varies as a function of time.

DYNAMIC DECISION MAKING

General Definition: A decision situation where the action taken produces consequences that vary as a function of time.

Amplification: Consider the time horizon over which the consequences of a decision unfold. If the consequences (outcome set) are not constant (i.e., display of pattern over the time horizon) the decision is dynamic. This has critical implications for outcome specification since the pattern cannot be captured by a single number. The outcome, in fact, may have a number of transient states and an eventual equilibrium, each state effecting the decision to be made in different ways. For example, the ratio of the number of active sonobuoys to passive sonobuoys may vary over the time horizon of a mission. This is particularly true if the initial ratio of buoys (active to passive) is "ideal" for one particular mission scenario in the initial phases, but becomes worse if the scenario unfolds later in a manner other than anticipated. The operator then is faced with a new "situation" and may have to reorient his decision attitude. In the event of engine failure, the "dangerousness" of the decision outcome will change as the craft passes from over water to over land. If the initial failure occurs over water and the pilot decides to try and make it home on one engine, the decision outcome is at one "level of danger" over water and another, lower "level of danger" over land. Care must be given to using the respective durations in trying to develop numbers to represent the decision outcomes, not just a single point estimate.

Rules: Determine the pattern of decision consequences (outcomes) over time and if the response pattern changes over time, the situation is dynamic and the entire response pattern and its characteristics must be considered in order to represent the outcome. Characteristics of response patterns such as peak and valley magnitudes, durations of peaks

MAXI-MIN UTILITY

General Description: A payoff table is constructed (with any multiattribute outcomes aggregated to a single utility) and expressed in utilities, then the alternative is chosen that maximizes the minimum utility.

Amplification: Each alternative is arrayed for each state of nature. The outcomes are all expressed in utilities. Since nothing is known or assumed (or estimated) about the probabilities of the various states of nature, each alternative is examined to find the worst outcome. When the worst case utility is identified for each alternative, the alternative with maximum "worst" utility is chosen. Therefore, no matter what state of nature eventually occurs, the utility of the outcomes can be no less than the minimum utility of the alternative chosen. The decision rule guarantees the best of the worst, or maximizes the minimum utility. Hence, a pessimistic decision maker is always covered against the worst case.

Rules: Construct the payoff matrix and estimate the utilities of each alternative under each state of nature. Then identify the lowest utility for each alternative under any state of nature for each alternative and select the alternative with the highest utility.

Pitfalls and Limitations: The method assumes that nothing is known about the relative probabilities of the states of nature and, hence, assumes that each are equally likely. This may not be so in a given decision situation. Also, the method does not lead to an optimal decision in the expected utility sense.

Prerequisites: Training in utility estimation and aggregation and payoff table construction are prerequisites.

MAXI-MAX UTILITY

General Description: A payoff table is constructed with all outcomes (single and multiattribute) represented by a single utility and then the alternative that maximizes the maximum utility is chosen.

Amplification: Each alternative is arrayed for each state of nature and the outcomes are all expressed in utilities. Since nothing is known, assumed, or estimated about the probabilities of the various states of nature, each alternative is examined to find the best outcome (i.e., the maximum utility). Then the highest utility is identified for each alternative (regardless of the state of nature under which it occurs) the alternative with the maximum, highest utility is chosen. This decision rule optimistically assumes that if the best happens, the alternative will have been chosen to deliver the maximum utility.

Rules: Construct the payoff matrix and estimate the utilities of each alternative under each state of nature. Then identify the highest utility for each alternative regardless of the state of nature under which it occurs, and select the alternative with the maximum (highest) utility.

Pitfalls and Limitations: This method again assumes that nothing is known about the probabilities associated with the various states of nature, and this may not be so. Also, this method may reward optimists, but there is no guarantee against losses or even that the optimal alternative is chosen in a SEU sense.

Interaction with Other Decision Elements: Under time relaxed, no interactions. Under time pressure, this method has similar advantages computationally to those of maxi-min utility.

Prerequisites: Training is utility assessment and aggregation and in payoff table construction.

MINI-MAX REGRET

General Description: A payoff table is constructed and from it, a regret matrix is constructed showing how much "regret" the decision maker would have if he made the wrong decision. The alternative is chosen that minimizes the maximum regret of the decision maker.

Amplification: Each alternative is arrayed in a payoff table as in maxi-min utility. A regret matrix is constructed by finding the best possible alternative action under any state of nature. If that state of nature turned up, the decision maker would have no regret. If he had chosen any other alternative under that state of nature, he would regret it by the amount of the difference between the best he could do and the amount for the chosen alternative. A regret matrix is constructed comparing how much a decision maker would regret his decision if the best occurred under each state of nature (i.e., he had chosen the best alternative for state of nature). The regrets for each alternative under each state of nature form the regret matrix. Each alternative is scanned to find the maximum regret. The alternative with the smallest maximum regret is selected.

Rules: Construct the payoff table. Then, construct the regret matrix, identify the maximum regrets, and select the alternative with smallest maximum regret.

Pitfalls and Limitations: In this method, the addition of a new alternative that itself is not eventually chosen, can shift the decision to a different alternative other than the one chosen before the addition. Also, the method assumes that nothing is known about probabilities of states of nature.

<u>Interaction with Other Decision Elements</u>: Under time relaxed, no significant interactions. Under time pressure the computations are time consuming.

<u>Prerequisites</u>: Training in utility assessment and aggregation and in payoff and regret matrix construction.

LEXICOGRAPHY

General Description: Lexicography, as used here, is a procedure whereby the most important attribute of a decision situation is considered for each alternative and the decision is made on the basis of which alternative scores the highest in this attribute. In the event of a tie on the most important, the next most important attribute is identified and the alternative that scores the highest on it is selected. In the event of a tie the third most important attribute is identified and the process repeats until an alternative is chosen. Only those alternatives that tie are considered in subsequent rounds.

Amplification: Lexicography is like looking up a word in the dictionary. You start with the first letter, then the second and so on until you have found the word you are looking for. Similarly in lexicographical decision making you identify the most important attribute, and then make a decision on it unless there is a tie. In the event of a tie the process repeats on the second most important then the third, and so on. The process works when there are multiattribute alternatives. For example, in the event of an engine fire in a LAMPS helicopter, the pilot must consider safety, mission completion, and so on in deciding whether to ditch, or attempt to restart. If safety is the most important factor, the decision would be made by selecting the alternative (ditching or restart in this example) that scores the highest on this attribute. If the decision cannot be made on the basis of safety alone, mission completion would then be considered, etc.

Rules: Identify the relative importance of each attribute. Follow the lexicographical procedures.

Pitfalls and Limitations: A serious limitation in this technique is that the second and third most important attributes together may outweigh the first most important one. Hence, clearly suboptimal alternatives may be selected. This method assumes that only one dimension at a time is relevant for decision making, and that it is more important than all the others.

Interaction with Other Decision Elements: Under time relaxed, no significant interactions. Under time pressure the computations are so easy that there are no significant interactions.

Prerequisites: Training is establishing the relative importance of the attribute dimensions in multiattributed decision alternatives.

HURWICZ

General Description: A payoff table is constructed so that each alternative is represented by a single utility number of each state of nature. Then, for each alternative the best and worse (highest and lowest) utilities are identified. This represents the best and worst case (most optimistic and most pessimistic). The alternative that has the best "combination" of best and worst utilities is selected.

Amplification: The attempt here is to combine a pessimistic and optimistic approach. The decision maker establishes how likely the best and worst cases are to occur (by establishing probabilities that sum to one for both). The expected utility is then calculated using only the best and worst utilities and their respective probability estimates.

Rules: Establish the payoff table and identify the best and worst utility for each outcome. Estimate the probabilities for each (sum to one). Then calculate the expected utility for each alternative.

Pitfalls and Limitations: This approach examines only the best and worst. The other outcomes are ignored. Also, the estimate of the probabilities of each of the best and worst occurring is subject to error.

Interaction with Other Decision Elements: Under time relaxed, no interactions. Under time pressure, there may not be time to properly measure the probabilities.

Prerequisites: Constructing payoff table. Assigning and aggregating utilities. Estimating coefficients of optimism and pessimism (the probabilities).

SATISFYING

General Description: Establish the feasible domain for all alternatives. Select the first alternative screened that falls into the feasible domain.

Amplification: For multi-attribute alternatives, establish the minimum (or maximum) acceptable boundaries of performance for each attribute. This defines the feasible domain. Any alternative screened that falls outside of these limits on any attribute dimensions is eliminated from further consideration. The first alternative that meets all the limits stated is selected without further consideration of any additional alternatives.

Rules: Establish the minimum and/or maximum thresholds for each attribute value dimension. Plot each alternative considered on the feasible domain and select the first to fall completely within the feasible domain.

Pitfalls and Limitations: The method produces an alternative, but it may be the worst of all possible alternative that are feasible, and hence far from optimal.

Interaction with Other Decision Elements: Under time relaxed, no interactions. Under time pressure, if the feasible domain boundaries can be established in time, the method will produce a rapid decision on an alternative that is feasible and meets all minimums (maximums) required.

Prerequisites: Training at establishing standard minimums and maximums for alternative dimensions.

DISTRIBUTION LIST

Naval Training Equipment Center
Orlando, Florida 32813 40

Defense Documentation Center
Cameron Station
Alexandria, VA 22310 12

All other addressees receive 1 copy.

Naval Air Systems Command
Patrol-Transport Branch
Attn: Mr. B. Holt (AIR 4133)
Washington, DC 20361

Naval Air Systems Command
Attack Branch
Attn: Mr. D. B. Adams (AIR 4131)
Washington, DC 20361

Naval Air Systems Command
Helicopter Branch
Attn: Mr. J. Grubb (AIR 4134D)
Washington, DC 20361

Naval Air Systems Command
Research and Technology Group
Attn: CDR P. R. Chatelier (AIR 340F)
Washington, DC 20361

Chief of Naval Operations
OP-593C Navy Department
Attn: Major W. Simpson
Washington, DC 20350

Chief of Naval Operations
Attn: Mr. M. K. Malehorn
OP-593C Navy Department
Washington, DC 20350

Commander
ASW Wing, US Pacific Fleet
NAS, North Island
San Diego, CA 92135

Helicopter Antisubmarine Squadron
Light 31-HSL31
Attn: ISD Officer
NAS North Island
San Diego, CA 92135

Commander, Naval Air Force
US Pacific Fleet
Attn: Mr. J. Bolwerk (Code 316B)
Naval Air Station North Island
San Diego, CA 92135

Chief of Naval Air Training
Naval Air Station
Attn: Dr. J. Shufletoski
Corpus Christi, TX 78419

Air Force Human Resources Laboratory
Attn: Mr. B. W. Cream
Wright-Patterson AFB, OH 45433

Air Force Human Resources Lab/FT
Attn: Dr. E. Eddowes
Williams AFB, AZ 85224

Calspan Corporation
Human Factors Section
Attn: Dr. R. Sugarman
P.O. Box 235
Buffalo, NY 14221

Veda, Inc.
Building E. Suite 320
7851 Mission Court
San Diego, CA 92108

Dunlap and Associates
7765 Girard Ave
Suite 204
LaJolla, CA 92037

Grumman Aerospace Corp.
Training Systems Dept.
Attn: Mr. G. L. Graham
Great River, NY 11739

Hageman Consulting Services
Attn: Mr. K. Hageman
P.O. Box 11409
Ft Worth, TX 76109

Seville Research Corp
Attn: Dr. W. Prophet
400 Plaza Building
Pace Blvd at Fairfield Drive
Pensacola, FL 32505

Technical Reports Center
(911A816 -- K1112)
IBM Corporation
Federal Systems Div
Owego, NY 13827

McDonnell Douglas Astronautics Co.
Engineering Psychology Department
Attn: Dr. E. Jones
St Louis, MO 63166

Telcom Systems, Inc.
3165 McCrory Place
Suite 235
Attn: Mr. T. Widener
Orlando, FL 32803

Xyzyx Information Corp.
21116 Vanowen St.
Attn: F. Fuchs
Canoga Park, CA 91303

Mathetics, Inc.
9816 Caminito Doha
San Diego, CA 92131

Courseware, Inc
9820 Willow Creek Rd
San Diego, CA 92131

COL A. I. Warczakowski
Marine Corps Tactical Systems
Support Activity
Marine Corps Base
Camp Pendleton, CA 92055

Mr. John Brock
Navy Personnel R&D Center
Manned Systems Design, Code 311
San Diego, CA 92152

LCDR P. M. Curran
Human Factors Engineering Branch
Crew Systems Dept
Naval Air Development Center
Warminster, PA 18974

Dr. Martin A. Tolcott, Director
Engineering Psychology Programs
Office of Naval Research, Code 455
800 N. Quincy St
Arlington, VA 22217